Revisiting the Origins: The Internet and its Early Governance

The universe of services, business models, and innovations built on the Internet was—and continues to be—made possible by the technical architecture of the network, as well as the political commitment to its development. Both of these are tightly linked to the early history of the Internet, which is explored in this chapter. The birth of the Internet was the result of a series of relatively informal interactions, as part of an academic effort mainly driven by computer scientists contracted to work for the US Advanced Research Projects Agency (ARPA) in both technical and leadership positions. The early days of the Internet encapsulate much more than prima facie efforts to create a physical network of computers able to communicate with each other. They also elucidate the origins of governance activities in this field. Various functions, performed by different coordination bodies, amounted to direct or indirect decision-making with global implications, right from the start. All of these pre-date the very concept of ‘Internet governance’ (Abbate 1999), and are key to understanding how this field of inquiry emerged.

Contrary to how this may be portrayed nowadays, how the Internet came about is not without controversy. As Bing notes, despite its recent birth, the history of the Internet is ‘shrouded in myths and anecdotes’ (2009, 8) and partisan accounts have become widespread. Goldsmith and Wu talk about the Internet pioneers ‘in effect building strains of American liberalism, even a 1960s idealism, into the Universal language of the Internet’ (2006, 23). McCarthy refers to the ‘creation of an Internet biased towards a free flow of information as the product of a culturally specific American context’ (2015, 92). In this chapter, I explore the lineage of the Internet through constructivist lenses. After outlining the heterogeneity of ideas that stood at the basis

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1 The Advanced Research Projects Agency (ARPA) changed its name to Defense Advanced Research Projects Agency (DARPA) in 1971 and again in 1997 and went back to ARPA between 1993 and 1996.
of creating an interconnected network of computers, the development of problem-solving working groups is explored, followed by an analysis of the political environment that allowed for this network’s expansion. The role of the US government in subsidizing developments and encouraging the privatization of the Internet in the mid-1990s is discussed subsequently. For Abbate, the history of the Internet is ‘a tale of collaboration and conflict among a remarkable variety of players’ (1999, 3), but it is also a tale of informal governance, with key individuals and networks at the forefront, as presented here.

The global network of networks known as the Internet came out of a subsidized project by (D)ARPA and later by the National Science Foundation (NSF), which funded the ‘NSFNET’, the basis for the current backbone of the Internet. Essential Internet Protocols still in use today, including File Transfer and TCP/IP, date all the way back to the ARPANET experiment. Developments like the World Wide Web and the Border Control Gateway make the Internet a global network able to connect different types of systems using Internet Protocol datagrams. From laying the infrastructure to the content of web applications, the Internet has, from the start, been subject to various forms of governance, in addition to being an object of contention internationally and domestically. The latter is further illustrated by the competing projects of the different US agencies, in particular DARPA and the NSF.

To reconstruct the political dimensions of the debates around the creation and design of the Internet, I draw on a multiplicity of sources and historical accounts on both sides of the Atlantic (including scholarly publications, original documents, and personal conversations) in an attempt to provide a full(er) picture of the tensions between the different technological camps and the type of action they structured. In this chapter, I divide the Internet’s early history into two parts: first, I explore the pre-Internet developments that established the structural conditions necessary for a computer networking experiment. Second, I analyse the TCP/IP-related developments, the distinguishing protocol also known as the ‘Internet’ and delineate its different phases, from ARPANET to NSFNET, looking at the early governance practices and formalized arrangements.

Setting the Stage: Pre-Internet Developments

In the 1970s, humankind started to fulfil a long-time aspiration: a global communication network sharing, storing, and sorting the largest amount of
information ever amassed. Scientists on both sides of the Atlantic were essential to the development of the features that constitute the modern Internet. Military and political support, extensive funding, light touch management, and long-term vision were all required to make this dream a reality. In 1837, the British mathematician Charles Babbage proposed a mechanical general-purpose computer with integrated memory and conditional branching, laying the foundations for modern computers. The invention, which was program-controlled by punched cards, was called the Analytical Engine and raised great interest in Europe, but not enough funding to ever be completed. Working on this with Babbage, Ada Lovelace published in 1862 the first algorithm for implementation on the engine. To show the full potential of the programming capacities of the machine, the algorithm was designed to compute Bernoulli numbers, but it never got tested during her lifetime.

Among the first to envision a central repository of human knowledge was the British futurist and science fiction author H. G. Wells (1866–1946), but the list of pioneer thinkers is long and spans various disciplines. The American librarian and educator Mervil Dewey (1851–1931) proposed a system of classification that revolutionized and unified the cataloguing of books across the network of US libraries. Still widely deployed around the world, the Dewey system uses a topic-based decimal system with further subdivisions. Card indexing for easily finding references in book storage and, later on, the idea of a ‘universal book’ are credited to the Belgian Paul Otlet (1868–1944), who elaborated on this in his 1934 ‘Traité de documentation: le livre sur le livre, théorie et pratique’. Together with Henri La Fontaine, he created the Universal Bibliographic Repertory in 1895 and later worked with Robert Goldschmidt to create an encyclopaedia printed on microfilm.

Technical developments during the Second World War also played a crucial role in the birth of the Internet. Considered the father of the modern computer, the English mathematician and cryptanalyst Alan Turing developed the first electromechanical machine capable of performing multiple programmable tasks and learning from the stored information, with inspiration from Babbage. Working independently, the German Konrad Zuse developed the first programmable computer (Z3) in 1938. The Universal Turing Machine was launched in 1939 and laid the foundations for the machine called ‘the Bombe’ employed by the British to decipher the encrypted messages of the German intelligence.

With the war over in July 1945, Vannevar Bush, then-director of the US Office of Scientific Research and Development of the Defence Nuclear Research Committee (behind the Manhattan Project), called for a post-war research agenda in information management. After coordinating the work of more than 6,000 American scientists on transferring advancements from
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science to warfare, Bush pushed for a concerted effort to make the rapidly growing store of knowledge widely and easily accessible. In his 1945 essay ‘As We May Think’ published in the *Atlantic Monthly*, he elaborates on his idea of a ‘memex’, a document management system very similar to today’s personal computer.

Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and, to coin one at random, ‘memex’ will do. A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory. (Bush 1945)

To address the concerns of a potential nuclear war, US scientists were preoccupied with finding a solution for long-distance telecommunication within the Department of Defense, primarily for linking launch control facilities to the Strategic Air Command. The Russian launch of Sputnik I in 1957 brought new impetus for funding technological research that could better position the United States in space exploration and military command. In 1958, President Eisenhower authorized the creation of two special agencies for space research under the Department of Defense: the National Aeronautics and Space Administration (NASA) and ARPA. ARPA’s original mandate—with an initial budget of $520 million—was ‘to prevent technological surprise like the launch of Sputnik, which signalled that the Soviets had beaten the US into space’, and thus fund universities and research institutions to conduct complex research on science and technology useful for the defence industry, though not always explicitly linked to military applications.

**ARPA, Internetworking, and the Military Agenda**

ARPA’s focus on space research faded out shortly after its establishment and the agency began working on computer technology. As Stephen J. Lukasik, Deputy Director and Director of DARPA between 1967 and 1974, later explained:

The goal was to exploit new computer technologies to meet the needs of military command and control against nuclear threats, achieve survivable control of US nuclear forces, and improve military tactical and management decision making. (Lukasik 2011)

For the first years in ARPA’s operation, efforts were concentrated on computer-simulated war games. This changed when Joseph C. R. (‘Lick’) Licklider (1915–90) joined ARPA in 1962 to lead its newly established Information Processing Techniques Office (IPTO). Licklider, a Harvard-trained
psychologist and computer scientist, published in 1960 his famous paper 'Man–Computer Symbiosis', proposing technology that would ‘enable men and computers to cooperate in making decisions and controlling complex situations without inflexible dependence on predetermined programs’. In 1965, Licklider’s ‘Libraries of the Future’ commissioned research introduced the concept of digital libraries as ‘procognitive systems’. Building on Bush’s memex work, Licklider noted:

the concept of a ‘desk’ may have changed from passive to active: a desk may be primarily a display-and-control station in a telecommunication—telecomputation system—and its most vital part may be the cable (‘umbilical cord’) that connects it, via a wall socket, into the procognitive utility net. (Licklider 1965, 33)

Under Licklider’s lead at IPTO, the research focus shifted to time-sharing, computer language, and computer graphics, and cooperation with computer research centres around the United States was prioritized. Licklider referred to this cooperation as the ‘Intergalactic Computer Network’—later shortened to InterNet. For its implementation, he reached out to a private company based in Boston—Bolt, Beranek, and Newman (BBN)—to develop network technology.2 Within the span of nine months, BBN, under the lead of Frank Heart, built a network of four computers, each operating on a different system and using the Interface Message Processors (IMPs). Licklider knew BBN well, having served as its vice-president in 1957. To a large extent, the digital direction chosen by the BBN was his idea: ‘If BBN is going to be an important company in the future, it must be in computers’ (Beranek 2005, 10). Frank Heart and Licklider were both emeriti alumni of the Lincoln Laboratory. The successors of Licklider at the IPTO were hand-picked from the same academic environment. The first was Ivan Sutherland (1964–66), who ran the IPTO when its budget was approximately $15 million (National Research Council 1999, 100), between 1964 and 1966. The second was Lawrence Roberts, who came from MIT and the Lincoln Laboratory to IPTO between 1964 and 1966. The third was Robert Taylor, who formerly worked at NASA, taking office with IPTO from 1966 until 1968.

Working independently, in the early 1960s, Paul Baran at the RAND Corporation in the United States and Donald Davies at the National Physical Laboratory (NPL) in the United Kingdom developed the message block system that set the basis of modern packet switching and dynamic routing, the foundation of the Internet infrastructure today. Packet switching allowed for breaking a message into smaller blocks of data that Davies called ‘packets’

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2 All major telecom and computer companies dismissed the idea when he presented it in front of 100 business representatives.
and for routing them separately (‘switch’) via the network, yet ready to be recomposed by the computer at the receiving end. The significance of this breakthrough was compared to the advent circuit switching system used in the early days of the telephone, which enabled telephone exchanges—with human operators manually connecting calls—to create a single continuous connection between two telephones.

Baran’s three-fold categorization of communications networks—centralized, decentralized, and distributed networks—set the stage for future work. Baran conducted the largest part of this work while employed by RAND from 1959 to roughly 1962. Although his ideas—summarized in eleven reports and supported by mathematical evidence and graphs—were never implemented, they were later picked up by ARPA scientists (Shapiro 1967). A key advancement in computing came from MIT in 1961, when the time-sharing mechanism became operational, allowing several users to share the capacities of a single computer, which were full-room machines at the time. That same year, MIT’s Leonard Kleinrock completed his PhD thesis on packet switching, proposing the transmission of data by dividing messages into smaller ‘chunks’ lined up at the nodes of a communication system based on two principles: demand access and distributed control (Kleinrock 1962). Originally, advanced level work like Kleinrock’s was funded through the division of mathematical sciences, yet as of 1970, the theoretical computer science program was born as the NSF established its Office of Computing Activities. By 1980, the NSF already funded around 400 individual projects in computational theory. Alongside DARPA, it became the main source of funding for computing research during that decade.

**ARPANET, its Alternatives and Successors**

The first operational packet switching network was ARPANET, a project started with a budget of $1 million at ARPA. A plan to experiment with connecting sixteen sites (ARPANET) across the United States was revealed at the 1967 symposium of the Association for Computing Machinery (ACM) in Tennessee. A year later, ARPA funded its first graduate student conference at the University of Illinois, inviting a few students from each university working on computing research to cross-fertilize ideas. By 1968, to document the work undertaken on the ARPANET, a fast-paced experimentation network, the Network Working Group (NWG) was established under the leadership of Steve Crocker from UCLA. On 7 April 1969, Crocker sent the first
Request for Comments (RFC) to the other NWG participants using conventional mail. On 2 September 1969, the BBN Interface Message Processor was connected to UCLA. According to Crocker (2012), the RFC was initially thought of as a temporary tool to share information, independent of the level of formality envisioned for each document.

Beyond documentation purposes, the RFCs also embedded a ‘hope to promote the exchange and discussion of considerably less than authoritative ideas’ (Crocker 1969). In December 1970, the NWG completed the first interconnection protocol, the Network Control Protocol (NCP). The protocols used started to be documented in a series called RFCs, which became the standard decision-making procedure in the Internet Engineering Task Force (IETF), a body created in 1986 to oversee the development of protocols for the first layer of internetworking. Over time, the RFC became an anchoring practice around which the community coalesced, as discussed towards the end of this chapter.

On 29 October 1969, the first ARPANET link was established between UCLA and the Stanford Research Institute. The latter remains central to the history of ARPANET, hosting the first formal coordination body, the Network Information Center (NIC) established in 1971 at the SRI Augmentation Research Center (Engelbart’s lab) in Menlo Park, California. Starting in 1972, it was led by Elizabeth J. Feinler, known as ‘Jake’, who managed it under a contract with the Department of Defense (DoD). In its early days, the NIC handled user services (via phone and conventional mail at first) and maintained a directory of people (‘white pages’), resources (‘yellow pages’), and protocols. Once the network expanded, the NIC started registering terminals and financial information, such as auditing and billing.

A number of Internet pioneers discussed the open, relaxed atmosphere of work at the outset, rather unusual under contracts with the DoD. The involvement of young graduates on par with military staff indicated the importance given to the experiment. As only a small number of people had access to this project, no in-built security was prioritized in the early days of the network. Notably, ARPANET was not restricted to military use. Access to the network was limited to ARPA contractors, yet those who had permission to work were not under rigorous scrutiny. Nonetheless, there was a clear recognition among researchers and especially among managers that what was

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4 Kleinrock’s early development of packet switching theory determined the choice for the first node on the ARPANET: his Network Measurement Center at UCLA.

5 As Crocker (2012) recalled: ‘We were a group of young graduates . . . we were handed the task of trying to see what to do with this network that was going to be given to us, or imposed on us, depending on your point of view, so we had to organize from scratch. And it was an interesting technical challenge, open field, I mean no direction.’
at stake was more than the development of a research network, as Lukasik revealed:

So in that environment, I would have been hard pressed to plow a lot of money into the network just to improve the productivity of the researchers. The rationale just wouldn’t have been strong enough. What was strong enough was this idea that packet switching would be more survivable, more robust under damage to the network . . . So I can assure you, to the extent that I was signing the checks, which I was from 1967 on, I was signing them because that was the need I was convinced of. (Waldrop 2001, 279–80)

Despite its heavy DoD funding, ARPANET never functioned as a military network in the strict sense, with the exception of a few international connections, such as the one with Norway, limited to defence use. As Townes (2012) shows, some elements of the research conducted at the time on ARPANET were kept outside of the reports to the funding authorities. For example, the transnational spread of the network was constantly minimized in order to stay within the scope of the military mandate. The British and Norwegian nodes of the network were not represented in one of the most reproduced maps of the ARPANET published in 1985, and a footnote explained that experimental satellite connections were not shown on the map. Back in 1972, the Defense Communications Agency (DCA) established another packet switching network—WIN—used for operational command and control purposes. It was around that time that the idea of transferring control of ARPANET to a private organization consolidated (Abbate 1999).

The work environment remained open all throughout the ARPANET experiment, with scientists taking the lead for developments and funding streams. Part of it had to do with the research tradition and the technical challenges, meaning that there were frequent exchanges about what worked, what had to be fixed, and what could be improved. The developments that would come on top of this were not envisioned at that point, therefore the scientists working on it preferred an open format (Crocker 2012). However, political sensitivities existed; some were carefully mediated by those in charge, as an endeavour to create a community of practice that gave no attention to what was happening outside the technical space. As Elizabeth Feinler explains:

In the early days we put out the directory, which was sort of a phone book of the internet. And there were a lot of military people, there were a lot of graduate students, so there was a spectrum of users and developers. In the 1970s, there were [ . . . ] lots of strong feelings about the Vietnam war and what not. So I took it upon myself not to put anybody’s title in the directory, so that meant that everyone was talking to everybody and they didn’t know whom they were talking to. (Feinler 2012)
While the concept of internetworking was developed at ARPA (Leiner et al. 2009), linking computers in a network was an experiment tried in several other parts of the world, most importantly in France and the United Kingdom, where packet switching technologies were tested in the early 1970s. In 1971, plans for a European Informatics Network for research and scientific purposes under the direction of Derek Barber from NPL were announced by the European Common Market. That same year, at the French Research Laboratory IRIA, Louis Pouzin launched the Cyclades packet switched system based on datagrams. Despite concrete advancements in Pouzin’s project, the funding from the French government was discontinued at the end of 1978.

The ARPANET project provided inspiration for a number of similar projects in other parts of the world. While physical connections were only established directly with Europe (first with Norway and the United Kingdom), academic networks were set up in Australia and later in Japan. By 1980, six main networking experiments were underway and by 1988 their number more than doubled.

While the overwhelming majority had an academic purpose, the networks were generally subsidised by states. A few internetworking experiments, such as USENET, EUNET, BITNET, FIDONET, and EARN received direct user contributions.

In October 1972, scientists working on packet switching networks on both sides of the Atlantic convened at the first International Conference on Computer Communication held in Washington. ARPANET was successfully tested publicly, connecting twenty-nine sites in a demonstration organized by Robert E. Kahn of BBN (Townes 2012, 49). A group of network designers volunteered to explore how these networks could be interconnected in the framework of a newly established International Packet Network Working Group (INWG), similar to the ARPANET NWG, using the request for comments format for distributing the INWG notes. DARPA’s Larry Roberts proposed to share the notes via the ARPANET NIC, and Vint Cerf, a graduate student working on one of the first ARPANET nodes at UCLA, volunteered to be temporary chairman. The group divided into two subgroups to consider ‘Communication System Requirements’ and ‘HOST-HOST Protocol Requirements’. In June 1973, the first international node to the ARPANET was established, via satellite link, at Kjeller in Norway, in turn providing a cable link to University College London in the United Kingdom shortly after (Bing 2009).

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6 This included NPLNET in the United Kingdom, ARPANET, SATNET, and USENET in the United States, CYCLADES in France, CERNet as a joint research initiative of European governments at CERN in Geneva.

7 For a discussion about the spread of TCP/IP along Cold War lines, see Townes (2012).
In 1972, Robert Kahn joined the ARPA team to develop network technologies and to initiate the billion-dollar Strategic Computing Program, the largest computer research and development program funded by the US government. Kahn played a key role in the development of the ARPANET and is credited for the open-architecture networking and for coining the phrase ‘National Information Infrastructure’. In 1973, together with Cerf, by then an assistant professor at Stanford, Kahn developed the Transmission Control Protocol (TCP), which encapsulated and decapsulated messages sent over the network, with gateways able to read the capsules, but not the content, decrypted only on end-computers. This protocol, meant to replace the ARPANET’s original NCP, was presented in the paper published in April 1974 and entitled ‘A Protocol for Packet Networks Intercommunication’. Working on the datagram network and a connectionless packet switching protocol, the French scientist Louis Pouzin joined Vint Cerf and his colleagues at INWG to propose a transport protocol across different networks. In 1975, they submitted their proposal to the standard-setting body in charge of telecommunications, the International Telegraph and Telephone Consultative Committee (CCITT).

Private Initiative and Competing Protocols

In parallel with the work conducted at ARPA, major computer companies in the United States proposed their own proprietary products, such as IBM’s Systems Network Architecture, Xerox’s Network Services, or Digital Equipment Corporation’s DECNET, which were all in operation in the mid-1970s. It was around that time that IBM, Xerox, and several national European post, telephone, and telegraph organizations (PTT)—functioning as monopolies at the national level—proposed their own packet-switched common-user data networks, for example in the United Kingdom, France, and Norway. These were based on ‘virtual circuits’, able to make use of the routines of circuit switching employed by telephone exchanges. The virtual circuits solution and TCP/IP had a different architecture and were proposed by distinct groups of specialists: on the one hand, there were the engineers and scientists that worked on voice telecommunications; on the other, computer scientists explored data traffic via the transmission control protocol. Their references and terminology were different, they attended different conferences and they read other journals. There was scepticism in both camps regarding the technological upgrades needed to make packets communicate effectively.

In 1977, representatives of the British computer industry, supported by the US and French representatives, called for the establishment of a committee
for packet switching standards within the International Organization for Standardization (ISO), an independent nongovernmental association whose work did not focus exclusively on telecommunications. The Open Systems Interconnection (OSI) committee was set in place and led by Charles Bachman, the American developer of a database management system called Integrated Data Store. After long negotiations, two camps consolidated within the OSI committee: on one side, Bachman and former members of the INWG pushed for the Pouzin-inspired connectionless protocols, whereas the IBM representatives and some of the industry delegates favoured the ‘virtual circuits’ option. Their proposed interconnection solution, designed as a universal standard, was published by the CCITT in its Recommendation X.25 and became the international standard. This standard required a reliable network, unlike what Cerf and Pouzin proposed. Their solution did not place any substantial function on the network and ensured that processing was performed directly at the edges, on end-computers (McCarthy 2015). The work on the TCP continued amidst international negotiations for the adopted standards.

At the outset, the developments at ARPA and those originating in private computer labs remained completely separate. A few years passed before the important advances in different camps would converge, in particular to bridge the private–public gap. The email system was developed by Raymond Tomlinson from BBN in 1972, while the Ethernet system was the outcome of the work of Robert Metcalfe\(^8\) and his team at Xerox’s Palo Alto Research Center in 1977. That year, the Apple II personal computer (PC) was launched at the West Coast Computer Fair, offering, for the first time, a ready-made unit,\(^9\) easy to access and operate. The Apple II PC was accompanied by a reference manual detailing its source code and providing machine specifications. This trend for publishing the source code was also followed by IBM, when their first PC was released in 1981 (Ryan 2010). A number of other services were made available to go along with developments in PCs, including network mailing lists and multiplayer games (e.g. Adventure). The first mobile phones were also developed in the 1970s. Moreover, the UNIX operating system, with its kernel in C programming, was publicly released outside the AT&T’s Bell Labs in October 1973 and became widely adopted by programmers as a portable, multitasking, and multi-user configuration.

By the mid-1970s, a number of technical breakthroughs from private labs started to be integrated into ARPANET through its contractor

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8 Metcalfe was the graduate student who connected the MIT site to ARPANET.
9 Prior to the Apple II computer, PC manufacturers were selling parts to be assembled, meaning that access was also restricted to the technical savvy.
network. Among these, the case of the UNIX operating system is poignant. UNIX was developed at Bell Labs in the early 1970s and quickly became widespread in universities as its source code was made available, allowing computer scientists to experiment with different features. In 1975, Ken Thompson from Bell Labs took a sabbatical as visiting professor at Berkeley, where he contributed to installing Version 6 Unix and began a Pascal implementation project on computers bought with money from the Ingres database project. Version 6 UNIX was further developed by two graduate students, Chuck Haley and Bill Joy, and publicly released as part of the Berkeley Software Distribution (BSD) in 1978. By 1981, (D)ARPA was funding the Computer Systems Research Group at UC-Berkeley to produce a version of BSD that would integrate TCP/IP, to be released publicly in August 1983.

Similarly, the Data Encryption Standard developed at IBM for businesses received the endorsement of the National Bureau of Standards in 1977, making available to a wider public what was formerly proprietary information. Local area networks such as Ethernet and dial-up connections at a maximum speed of 64 Kbps became more widely spread in the 1980s. In 1981, IBM started selling their first PC with the following specifications: 4.77 MHz Intel 8088 microprocessor, 16 kb of memory (expandable to 256 k), two 160 k floppy disk drives, and an optional colour monitor. Its price started at US$1,565 and it was the ‘first to be built from off-the-shelf parts and marketed by outside distributors’ (Bing 2009, 34).

As access to computers grew, the OSI work got rapid traction among computer vendors like IBM and garnered political support from national governments, including from the European Economic Community. By 1985, CERN opened a ‘TCP/IP Coordinator’ position as part of a formal agreement, which restricted the use of TCP/IP to the CERN site and mandated the ISO protocol for external connections (until 1989). According to Ben Segal, who occupied the position until 1988, the Internet protocol was introduced at CERN a few years before via the Berkeley UNIX system. Around that time, CERN became the Swiss backbone for USENET, the UNIX users’ network that carried most of the email and news between the US side and the European side, EUnet.

Notably, the US government was also among the first adopters of the OSI standard. In 1985, two years after the publication of the ISO 7498 international standard, the US National Research Council recommended that the ARPANET move from TCP/IP to OSI; by the same token, in 1988, the Department of Commerce requested that the OSI standard be implemented on all US government computers after August 1990.
TCP/IP and the Birth of the Internet

As of 1977, the TCP was used for cross-network connections at ARPA. The Internet Protocol (IP) was added a year later to facilitate the routing of messages. The IP solved the problem of locating computers in a network, by designating them concomitantly as both ‘hosts’ and ‘receivers’. Each connected device was assigned a unique 32-bit number (represented in dotted decimal form: 92.123.44.92) that a user could employ to send a message to his or her desired destination. In the early days, each computer was also given a name, in addition to a corresponding IP address. Each computer received a copy of a database (hosts.txt) file, so a user would be able to copy the numeric address into the designated header of the message before sending it. The ‘hosts.txt’, performing a similar function to that of a phone book, together with a list of technical parameters, was maintained at the NIC based at the Stanford Research Institute and was managed by Jon Postel at the Information Sciences Institute at the University of Southern California. This set of functions later evolved into the so-called Internet Assigned Numbers Authority (IANA) functions, playing a key role in future political disputes, as detailed in Chapter 4.

Despite increased complexity as the network grew bigger and bigger, the tasks continued to be performed by individuals. Between 1977 and 1982, a set of technical documents entitled ‘Internet Experiment Notes’ (IENs) were released in order to discuss the implementation of Kahn–Cerf protocols, modelled on the RFC series that Crocker initiated at ARPANET. Jon Postel helped to revise the TCP/IP version in 1978 and again in 1979. The specifications of the protocol were open to everyone. In 1979, ARPA founded the Internet Configuration Control Board (ICCB) to assist with TCP/IP software creation. The editor of IENs was Jon Postel, and about 206 documents were published in the series before it was discontinued.

ARPA’s TCP/IP network became known as the ‘Internet’. In 1981, the TCP/IP was integrated into the Berkeley version of UNIX developed by Bill Joy, thus expanding the reach of the ARPA-born communication protocol. Looking back at the early days, Vint Cerf located the birth of the Internet on 1 January 1983, when the transition plan to migrate the 400 hosts of the ARPANET to TCP/IP was completed. That year, the domain name system (DNS) was invented by Paul Mockapetris, together with Jon Postel and Craig Partridge and was announced in RFC 882. The DNS converted IP addresses consisting of numbers only into letters and words that could be easily remembered by Internet users. The DNS represented a hierarchical system allowing for instant database queries and information retrieval for turning names into
numbers and replicating the structure at each level: the 2nd-level domain maintains a name server containing the zone file with the IP Addresses for all 3rd-level domains. In the early days, SRI was one of three hosts of the root zone file.\(^\text{10}\) According to RFC 920 from 1984, the initial set of generic top level domains (gTLDs) included .com, .edu, .gov, .mil, .org, with .net being added later. In 1988, .int was introduced for international organizations, following a request from NATO.

The expansion and growth of the ARPANET was no longer easy to contain. By 1983 it had over 100 nodes and was further divided into two parts: an operational component, the military network (MILNET), to serve the operational needs of the DoD, and a research component that retained the ARPANET name. After the network split, the MILNET expanded, and it reached over 250 nodes within a year. In 1985, two important decisions were made: first, two-letter country-code top level domains (cc-TLDs) specific to each jurisdiction were incorporated in the DNS, based on a pre-defined ISO 3166-1 list;\(^\text{11}\) second, the adoption of the DNS was made mandatory by ARPA. A year later the general adoption of the DNS was ensured at a major congress held on the West Coast in the presence of all major network representatives (Hafner and Lyon 1999). At that point, the running cost of ARPANET was around $14 million per year (McCarthy 2015) and its decommissioning was in sight. By 1989, the early packet switching network was dismantled into smaller networks (detailed in Table 1), most of which were moved under the local administration of universities.

Similar to ARPANET, DARPA also funded other computer-related projects of high impact. Between the 1960s and 1990s, it sponsored studies on artificial intelligence (AI)—in particular at MIT and Carnegie Tech—at first for research purposes only and, later, for military applications. With the MILNET split on the ARPANET, all unclassified military communication underwent increased protection. A number of gateways made possible email exchange via ARPANET, but disconnection was facilitated for security reasons.

A large part of the work on ARPANET was entrusted to graduate students engaged in ground-breaking projects from the beginning and able to develop

\(^\text{10}\) Until 1987, only four root name servers were in operation, but their number increased to thirteen, of which ten are located in the United States and three in Sweden, the Netherlands, and Japan. The root zone file was maintained and updated on a master root server called, as of 1995, ‘authoritative root server’ or ‘A’ root server.

\(^\text{11}\) According to Jon Postel (1994), ‘the IANA is not in the business of deciding what is and what is not a country. The selection of the ISO 3166 list as a basis for country code top-level domain names was made with the knowledge that ISO has a procedure for determining which entities should be and should not be on that list’. 
and grow a community of practice, subsequently involved in running the successor networks. The co-existence of policy practitioners and scientists, rotating in leading positions, unified the vision for how ARPANET could develop. This mutual influence, while not resulting in equal power, created a hierarchy of preferred solutions and policy directions. As soon as the network developed, special measures were introduced for military communication and that was clearly distinguished from ARPANET’s academic research and public use.

Table 1: ARPANET and its successors

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<tr>
<th>Start</th>
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<th>Protocol used</th>
<th>Purpose</th>
<th>End of operations</th>
<th>Department in charge/funding</th>
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<tbody>
<tr>
<td>1972</td>
<td>ARPANET</td>
<td>TCP/IP</td>
<td>research</td>
<td>1990</td>
<td>DARPA, under DoD users</td>
</tr>
<tr>
<td>1981</td>
<td>BITNET</td>
<td>IBM RSCS</td>
<td>university network research</td>
<td>merged into CREN in 1991</td>
<td>NSF, member organizations funding</td>
</tr>
<tr>
<td>1982</td>
<td>CSNET</td>
<td>PhoneNET MMDF, TCP/IP</td>
<td>research</td>
<td>1995</td>
<td>NSF</td>
</tr>
<tr>
<td>1985</td>
<td>NSFNET</td>
<td>TCP/IP</td>
<td>research</td>
<td>1995</td>
<td>NSF</td>
</tr>
<tr>
<td>1983</td>
<td>MILNET (military network)—split from ARPANET</td>
<td>TCP/IP</td>
<td>unclassified DoD traffic</td>
<td>became the Defense Data Network</td>
<td>DoD</td>
</tr>
<tr>
<td>1990s</td>
<td>NIPRNET (Non-classified Internet Protocol Router Network)—building on MILNET</td>
<td>TCP/IP</td>
<td>sensitive, unclassified data between internal DoD users</td>
<td>still active</td>
<td>DoD</td>
</tr>
<tr>
<td>1994</td>
<td>SIPRNET (Secret [formerly Secure] Internet Protocol Router Network)</td>
<td>TCP/IP</td>
<td>classified data (up to and including information classified SECRET)</td>
<td>still active; replaced the Defense Data Network</td>
<td>DoD and Department of State</td>
</tr>
</tbody>
</table>
From ARPANET to NSFNET

Alongside the DoD investment in ARPANET, the US NSF began funding the establishment of the Computer Science Network (CSNET) in the early 1980s. The project—a awarded $5 million for its first five years—aimed to link computer science departments at academic and research institutions that could not be directly connected to ARPANET. The proposal for the grant was prepared by Lawrence Landweber from the University of Wisconsin-Madison on behalf of a consortium of universities, after receiving seed funding of $136,000 from the NSF. As the concern for sustainability became more apparent, the NSF tied to the CSNET funding a clause that the network would be self-sufficient after five years.

By 1984, CSNET included eighty-three sites in the United States and one in Israel, expanding to computer science departments internationally in Korea, Australia, Canada, France, Germany, and Japan. At its peak, the network had 180 institutions with independently operated networks. Starting in 1985, CSNET charged universities an annual fee of $2,000 to $5,000 and industrial sites (e.g., DEC, IBM) a fee of $30,000 to participate. By 1989, CSNET merged with BITNET and created a larger network managed by the new Corporation for Research and Educational Networking (CREN).

Moreover, the NSF also supported research that no other agency agreed to fund, such as cryptography. Work on public-key cryptography—in particular by Martin Hellman and Whitfield Diffie at Stanford University—started in the early 1970s. Partnering with the Office of Naval Research, the NSF continued to support this stream of research by funding the work of Ronald Rivest, Adi Shamir, and Leonard Adleman at MIT on public-key method using number theory. Openly shared, these advances in cryptography became fundamental for computer security textbooks, despite the National Security Agency pressure to keep this research secret (National Research Council 1999).

The NSF also provided funding for the creation and interconnection of five supercomputer centres across the United States at top universities. To

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12 The consortium comprised: Georgia Tech, University of Minnesota, University of New Mexico, University of Oklahoma, Purdue University, University of California-Berkeley, University of Utah, University of Virginia, University of Washington, University of Wisconsin, and Yale University.

13 The five supercomputer centres established in the mid-1980s were: the John von Neumann Center at Princeton University, the San Diego Supercomputer Center on the campus of the University of California at San Diego, the National Center for Supercomputing Applications at the University of Illinois, the Cornell Theory Center, a production and experimental supercomputer center, and the Pittsburgh Supercomputing Center, jointly operated by Westinghouse, Carnegie-Mellon University, and the University of Pittsburgh.
connect these centres, the CSNET technology and framework were upgraded to a higher speed and the extended network evolved into the National Science Foundation Network (NSFNET), eventually the backbone of the modern Internet. NSFNET was developed by three private firms: IBM, MCI, and MERIT. The total funding allocated to NSFNET from 1986 to 1995 was $200 million (Leiner et al. 1997).

On its network, the NSF implemented the ‘Acceptable Use Policy’, specifying that the use of the network must be consistent with the purposes of NSFNET: research, instruction, and support activities (for academia and not-for-profit institutions of research\textsuperscript{14}). Importantly, this provided access to research facilities, universities, academic networks, and centres beyond computer science departments, linking different areas of work and expanding resource sharing. In this context, non-military domains would no longer be funded by the DoD and a number of responsibilities were transferred from the DoD to the NSF. The latter established, through a competitive bidding process in 1992, to entrust domain name registration (at no charge until 1995), directory management, information services to three companies (Network Solutions, AT&T, and General Atomic, respectively), which formed InterNIC in 1993. These responsibilities were partly taken over by the Internet Corporation for Assigned Names and Numbers (ICANN) in 1998.\textsuperscript{15}

The distinction between ‘Internet’ and ‘internet’ dates back to the 1980s, when attempts were made to distinguish between the federally sponsored network and any other network using TCP/IP (Bing 2009). Concepts like ‘cyberspace’ or ‘the knowledge society’ also became popular in that decade. The term ‘cyberspace’ was first used by Gibson (1984) in his sci-fi novel \textit{Neuromancer}, where he described it as ‘a consensual hallucination . . . A graphic representation of data abstracted from the bank of every computer in the human system. Unthinkable complexity’ (1984, 51). The French social critic Jean-François Lyotard is credited for coining ‘the knowledge society’ (1979) and highlighting the central role of information and computerization in its consolidation. Yet, by the time the decision to commercialize the Internet was taken, the US administration gave currency to the ‘information superhighway’ discourse, promoted by Al Gore (Broad 1992).

\textsuperscript{14} The exact formulation was: ‘use for research or instruction at for-profit institutions may or may not be consistent with the purposes of NSFNET, and will be reviewed by the NSF Project Office on a case-by-case basis’.

\textsuperscript{15} Chapter 4 discusses in detail the formation of the organization and the transfer of responsibilities from Jon Postel to the new entity.
Mechanisms of Governance

It is difficult to disentangle the early mechanisms of governance from the informal network that set them into motion and the key individuals taking the lead in the creation of standards and institutional structures. The first two decades of networking experiments, resulting in the development of the Internet as we know it today, share a number of characteristics that structured—constrained and favoured—the future evolution of the field. Most important among these are the transversal links between academia, government, and, eventually, the computer industry. Equally significant for the evolution of the Internet in the first decades was the highly permissive regulatory milieu in the United States, discussed in detail later. These two dynamics enabled the development of a strong culture of volunteerism and innovation that crossed the US border when the Internet globalized in the early 1990s.

Research Funding: Basis for the Emergence of Multidisciplinary Cooperation

The strong involvement of scientists from elite universities in both technical and leadership positions at ARPA created an environment of sharing and collaboration, further enabling the open exchange with and among graduate students. While access to the network remained restricted to contractors, ARPANET benefited from the movement of leading figures from research and teaching to implementation teams and finally to decision-making posts. Among the key strategists at ARPA were pioneers Kleinrock from UCLA and Licklider from MIT and Lincoln Lab, who envisioned a network of networks that would later be opened up to a larger community through the work of Lawrence Landweber from the University of Wisconsin-Madison. Landweber proposed the creation of CSNET to link computer science departments in the United States and abroad. Formerly working for the Irish Higher Education Authority (HEAnet) and for the Trinity College Dublin, Dennis Jennings started acting as Program Director for Networking to lead the establishment of the NSFNET in 1985, enabling general purpose access to a wide network. With very few exceptions (such as ‘Jake’ Feinler), women were mostly absent from this early community.

Earlier on, experimentation with internetworking at ARPANET was supported by the DoD, which awarded research contracts to academic teams (rather than individuals) for developing projects that would then be carried out by industrial groups. A key element in the success of the Information
Processing Techniques Office was its leadership style: programme managers brought in from academia for two-year-long positions were given broad latitude in deciding strategic directions and funding. They were carefully selected for their expertise and were able to work closely with the researchers they contracted, providing intellectual leadership. This management style also eliminated the need for a separate monitoring and evaluation track of activities, giving enough flexibility to managers to adjust financial support according to the progress made and to respond quickly to developments (National Research Council 1999). Unlike the DARPA practices of restricted access (generally limited to the military and to contractors from selected universities), the NSF operated on an open, accessible research basis. Complementing this approach, the NSF also supported the public dissemination of results and funded participation in conferences, thus investing in building a robust research community, just like ARPA did in the early years, in particular by organizing student conferences on internetworking.

The success of the CSNET—which was open to all computer science researchers—also influenced the decision to fund NSFNET, further expanding access to other research facilities. On NSFNET, the regional academic networks initially connected were also encouraged to seek commercial customers and open their facilities to them (Leiner et al. 2009). Yet, the NSF budget dedicated to computer-related activities as part of its Computer and Information Sciences and Engineering Directorate continued to grow between 1987 and 1995 (National Research Council 1999).

**Domestic Regulation: New Rules for Computing Services**

In addition to sustained funding from DoD and NSF, the development of the Internet in the American context was facilitated by the minimal state ideology, dominant at the time. In 1988, the Federal Communications Commission (FCC) created the special category of ‘value-added’ services, which left computer-mediated information virtually unregulated by the government. This created a permissive environment for the creation and development of *sui generis* institutions for its technical management (Mueller 2004), in charge of protocols and standards of operability. As the chairman of the FCC said in his speech before the World Economic Development Forum in September 1999:

> Our hands-off approach wasn’t entirely a choice. The reality is that the Internet grew so fast that policy-makers could not have written a code to govern it even if they wanted to. (Kennard 1999)
This regulatory direction was prefaced by a set of developments aimed at addressing the technological evolution and convergence challenges, in a context of national telecommunications monopoly.\footnote{For an extensive discussion of this transformation, see Rioux (2014).} In 1966, the FCC commenced its Computer Inquiries, an investigation trio into data transfers and the conditions for a related competitive market, thus providing rules and regulations for computing services. Adjusting an earlier categorization, the 1976 Computer Inquiries II distinguished between basic and enhanced services. Basic services referred to processing the movement of information and computer processing, which included protocol conversion, security, and memory storage. Enhanced services, on the other hand, altered a subscriber’s information or electronic signals (any service transmitted over common carrier facilities employing computer processing applications acting on the format, content, code, protocol, or similar aspects of the subscriber’s transmitted information, that restructured information or involved interaction with stored information). Services developed around that time, such as protocol processing, email, or newsgroup fell in the ‘enhanced services’ category.

In 1985, the third FCC Computer Inquiry aimed to structure the conditions of the market before the deployment of the Internet to a broader audience. Accordingly, the FCC established two safeguards: the Comparatively Efficient Interconnection and Open Network Architecture, which removed the structural remedies previously imposed on incumbent players from the telephone industry, in particular AT&T and its Bell System, which functioned as a legally sanctioned monopoly.\footnote{A noteworthy development prior to Computer Inquiry III was the 1982 finalization of the eight-year-long antitrust suit by the US government against AT&T, resulting in the separation of the local exchanges component of AT&T (where the natural monopoly continued to apply) and the Bell System long distance, manufacturing, and research and development open to competition from that point on. This led to the divestiture of the company in 1984 and the creation of a reformed AT&T and seven regional Bell operating companies.} In Europe, a similar constraint was imposed via the principle of interoperability plus physical interconnection between networks (Coates 2011).

Up to the late 1970s, the developments at ARPANET and those in the industry remained separate, each conducting research according to different priorities. By the 1980s, the trend changed, and developments from different sectors started to build on one another, sometimes as a result of joint teams. While NSFNET, operating on TCP/IP, implemented restrictions against the commercial use of the newly established public infrastructure, it granted, in 1988, limited access to MCI Communications Corp. to experiment with commercial email services (Shah and Kesan 2007).\footnote{The person facilitating this was Vint Cerf. As vice-president of MCI Digital Information Services from 1982 to 1986, he led the engineering of MCI Mail, the first commercial email service} Moreover, starting in
1988, NSF initiated a series of conferences at Harvard’s Kennedy School of Government on ‘The Commercialization and Privatization of the Internet’, as well as on the ‘com-priv’ list on the net itself, meant to enable dialogue on privately funded networks (Leiner et al. 1997). In 1992, the NSF started a bidding process for the organization and maintenance of the DNS registry and related services resulting in the creation of the Internet Network Information Center (InterNIC) in 1993.

The transition from ARPANET to NSFNET was important not only in terms of expanding access, but also for the perpetuation of particular organizational forms. Just like during the ARPANET era, collaboration between academic networks involved a mix of informal governance alongside formalized arrangements and emulation of a set of practices. NSF took on the organizational infrastructure developed at DARPA under the Internet Activities Board (IAB). The joint authorship by the IAB’s Internet Engineering and Architecture Task Forces and by NSF’s Network Technical Advisory Group of RFC 985 (Requirements for Internet Gateways) ensured that DARPA and the NSF segments remained interoperable. When the Internet was privatized, these institutional forms endured.

International Governance

The history of the Internet explored so far indicates that international legal constraints were near-absent in the early days of the Internet. But that does not mean there was no governance. While the practice of standard-setting goes back to 1865, Internet-specific organizations tasked with it emerged in the 1980s to respond to functional needs for coordination. To ensure the stability and development of the network, the architecture set in place was the primary vehicle of regulation, and it was mostly the business of technologists. Yet this became a hot topic of debate a decade later, when certain features of the architecture were understood to have far-reaching policy implications, for aspects such as anonymity or innovation at the edges. Lessig (2006) referred to this as ‘regulation by code’ or the ‘<built environment> of social life in cyberspace’ (2006, 121) with long-ranging effects on what could

to be connected to the Internet. Prior to re-joining MCI in 1994, Cerf was vice president of the Corporation for National Research Initiatives.

19 This practice stood at the basis of cooperation for the creation of the first international organization: International Telegraph Union (later renamed the International Telecommunication Union, ITU).
and could not be done online. In that sense, Lessig perceived code writers as 'lawmakers'.

Globally, until the 1990s, the governance of global telecommunications was carried out mainly through interaction among governments, who owned and controlled national incumbent operators, and the ITU, which was in charge of regulating issues related to interconnection. UNESCO’s New World Information and Communication Order (NWICO) placed on the global agenda a set of issues of relevance to the spread of new technologies. Building on the 1980 MacBride Report—which documented the emergence of global communications governance dominated by industrialized nation-led commercial and military infrastructure—the NWICO agenda raised the first serious controversies at the international level (Zehle 2012) between the US principle of ‘free flow of information’ and the demands of the Soviet Union and of the Non-Aligned Movement of independent states. In particular, the unequal distribution of radio spectrum and the restricted spread of satellite and computer technologies to developing countries were perceived as key imbalances in global information flows. The Soviet Union, China, India, Cuba, and Tunisia were key players in the NWICO movement, covering the period spanning from the heights of decolonization to the collapse of communism. The pursuit of this agenda by the UNESCO leadership in the first part of the 1980s led to a few countries withdrawing from the organization: United States (1984–2003), United Kingdom (1985–97), and Singapore (1986–2007).

De facto, the landscape change resulting from technological development and convergence, hinted at in the NWICO agenda, would continue to affect the balance between developed and developing countries over the years to come. The analysis of governance mechanisms at the outset reveals that treaties, conventions, and agreements constituted the preferred form of regulation (36 per cent prevalence), followed by operative international and regional guidelines (20 per cent), and the formation of specialized bodies. Table 2 provides an overview of the governance landscape between 1970 and 1993, with examples on the hard–soft law continuum using the tripartite framework introduced in Chapter 2, consisting of legal enshrinement, institutional solidification, and modelling instruments. Notably, with institutional consolidation in its infancy, monitoring mechanisms were not given priority at the outset. General rules for telecommunications were designed to remain broad and applied to the Internet in a non-specific manner, be it as part of

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20 In Lessig’s words: ‘code writers are increasingly lawmakers. They determine what the defaults of the Internet will be; whether privacy will be protected; the degree to which anonymity will be allowed; the extent to which access will be guaranteed’ (2006, 79).
Mechanisms of Governance

Table 2 Governance mechanisms (global and regional) from 1970s to 1993 (based on a total of twenty-five instruments recorded in the database)

<table>
<thead>
<tr>
<th>Mechanisms</th>
<th>Instruments</th>
<th>%</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal enshrinement</td>
<td>Treaties, conventions, agreements</td>
<td>36%</td>
<td>1981 CoE Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1988 ITU International Telecommunication Regulations</td>
</tr>
<tr>
<td></td>
<td>Court judgments</td>
<td>12%</td>
<td>1984 ECtHR Malone v United Kingdom</td>
</tr>
<tr>
<td>Institutional solidification</td>
<td>Specialized bodies</td>
<td>16%</td>
<td>1986 High Technology Crime Investigation Association</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1988 TMFORUM Industry Association</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1990 APEC Telecommunications and Information Working Group</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1993 UN Commission for Science and Technology Development</td>
</tr>
<tr>
<td>Strategic framework/ agenda</td>
<td></td>
<td>12%</td>
<td>1980 UNESCO NWICO</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1993 UNDP Sustainable Development Networking Program</td>
</tr>
<tr>
<td>Monitoring and benchmarking</td>
<td></td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Modelling</td>
<td>Discursive</td>
<td>4%</td>
<td>1985 OECD Declaration on Transborder Data Flows</td>
</tr>
<tr>
<td></td>
<td>Operative</td>
<td>20%</td>
<td>1990 UN Model Treaty on Mutual Assistance in Criminal Matters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1990 UN Guidelines for the regulation of computerized personal data files</td>
</tr>
</tbody>
</table>

transborder data flows, privacy and personal data protection, or information systems security.

In 1988, ITU’s member states adopted, at the World Administrative Telegraph and Telephone Conference in Melbourne, a treaty to ‘establish general principles which relate to the provision and operation of international telecommunication services offered to the public as well as to the underlying international telecommunication transport means used to provide such
Revisiting the Origins

services’ (ITU 1988). The treaty, entitled ‘International Telecommunication Regulations’ (ITRs), came into force in 1990 and facilitated the liberalization of pricing and services, encouraging a more innovative use of basic services, such as international leased lines. The ITRs established an international regime for the exchange of telecommunications traffic across borders, promoting interoperability and interconnection. Their revision would come under discussion again in 2012 in light of the accelerated digital transformation (see Chapter 5).

A number of international organizations started to establish committees whose work covered Internet-related aspects, such as the Directorate for Science, Technology and Industry within the OECD, the Telecommunications and Information Working Group in APEC (dating back to 1990), or policy commissions within ICC, whose activities remained ascribed to a broader mandate. In the UN system, in 1993, the Commission for Science and Technology for Development was formed under the UN Conference on Trade and Development (UNCTAD), and the United Nations Development Programme (UNDP) received funding for their Sustainable Development Networking Program. These developments set the stage for the quick expansion of the Internet as a social and political medium in the subsequent decade, enabling the involvement of developing countries to various degrees.

Actors

A number of technical bodies exclusively concerned with the Internet—equipped with their own modus operandi—emerged during the first decades of internetworking. The most important of them grew into global entities and continued to function largely unchanged. Some of the practices established back then continue to shape the way in which decisions are taken with regard to protocols and standards. Informality and open communication remain key features of the community, modelled extensively on the interactions during the ARPANET period.

The small community which formed around the (D)ARPA project revealed a high degree of informality manifested through cherry-picked collaborators and informal agreements. Personal relationships—primarily formed in the university environment—and limited access to the network gave ARPANET contractors a strong sense of ownership and commitment. The cross-sectoral work conducted through early networks and, later, through NSFNET for both advanced research and education networking put forward complementary strengths, a high degree of flexibility, and space for open-ended
experimentation. It is around these values that an early community began to form.

This progress was also backed by the development of a new discipline, computer science, and related departments in the United States and abroad. Between 1968 and 1994, the number of PhD dissertations submitted annually in computer science in the United States grew from one to almost 3,000 (National Research Council 1999, 221). As part of the efforts to lower the technical barrier of entry through knowledge creation and sharing, common language and expertise were codified in textbooks for computer science programs. A key test which revealed the extent of this consolidation was the TCP/IP versus OSI dispute, in which it became clear that the community of computer scientists on the one hand and engineers and telecommunications experts on the other proposed different solutions informed by their specialized jargon and references.

Trust and cooperation appeared as the underlying values of the emerging community, alongside the idea that anyone could initiate work on any project that would add to the common network. The latter, closely rooted in the American distinctive culture of volunteerism, shaped the collective action outcomes. Open standards and architecture, sharing and collaboration allowed for user-developed functionalities to be added to the network. This is the case with the development of the first email program that Raymond Tomlinson, who was working for BBN to develop ARPANET, coded in his free time. Another example of volunteerism was the original distribution of cc-TLDs to whomever in a national jurisdiction offered to administer the delegation. In Australia, .au was given to Robert Elz of the University of Melbourne (Malcolm 2008).

The number of individual players who were at the forefront of innovations with long-lasting impact grew in time, in both academia and the private sector. The development that steered this further came in 1991, when Tim Berners-Lee announced the public release of the World Wide Web (WWW), an application he developed together with his colleagues while working at the European Organization for Nuclear Research (CERN) on the Swiss-French border. The Hypertext Transfer Protocol (HTTP) they proposed made the Internet easier to navigate with point-and-click programs, based on the CERN code library. The WWW was a game-changer as of 1993, when CERN made it available in the public domain. To further improve the WWW, Berners-Lee created, in 1994, the World Wide Web Consortium (W3C), where he continues to act as director.

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21 This was funded by European governments participating in the programme.
Other institutional forms dating back to the first two decades of the Internet persisted over time, building on the legacy of personal involvement and dedication of some of the key figures. The IANA was informally established in the early 1980s. Prior to it, the central numbering authority of the network, in charge of keeping records and assigning host names (the famous HOSTS.TXT file) was the NIC, based at the Stanford Research Institute and managed by Jon Postel at the Information Sciences Institute, University of Southern California, under a contract with (D)ARPA. IANA functions evolved to include the allocation of unique names and numbers in the global network, including the cc-TLDs and gTLDs, but continued to be managed by Postel until 1998. IANA represents a textbook example of informal governance, generally understood to ‘prevail when informal influence overrides legal procedures, or when important rules are unwritten’ (Stone 2013). For the latter, the DNS is a case-in-point. It was innovative for its time as it made use of datagrams, but was not perceived as a major development, and important work around it was left in the hands of graduate students. As Paul Mockapetris recalled:

People got the job to do something and it was so much fun doing it because nobody at the time thought it was important. And it was clear, because I was a recent graduate and this was a nice little project while all the important people were off doing other things. Now, it turned out to be a very important thing, but nobody at the time thought it was. (Mockapetris 2009)

Another technical body, the Internet Architecture Board was created in 1984 as the Internet Activities Board to coordinate the work on the development of the Internet suite of protocols (changed to its current name in 1992). It currently oversees and advises the IETF, which was formed after the 1986 meeting of fifteen researchers sponsored by the US government. The IETF developed as a voluntary open standards network for promoting Internet usability and currently functions as a consensus-based organization comprising technical experts, network operators, hardware and software implementers, and researchers. Entirely private, not-for-profit oriented from the outset, both the IAB and the IETF continue to involve members in their personal capacity rather than based on their affiliation. This is a legacy of the early days in which a limited community of computer scientists and academics interacted on a daily basis for the purpose of operating the Internet seamlessly. During the early 1990s, the IETF became an independent international body.

22 IANA is currently incorporated in ICANN, whose first Chief Technology Officer was supposed to be Jon Postel, but he died unexpectedly in October 1998, just a month after ICANN was founded.
under the umbrella of the Internet Society (ISOC), which continues to provide its legal framework and coordinate sponsorship to this day. As of 1991, it holds three annual meetings on different continents that are open to everyone contributing to the standard development process, conducted through the RFC—the only documents issued by the IETF.

It is in the CSNET context that the Landweber seminars developed as a venue for people to meet annually and, starting in 1984, CSNET-related discussions took place in Paris, Stockholm, Dublin, Princeton, Jerusalem, and Sydney. In 1990, in Sydney, it was decided that the seminar should become a conference, and the next year INET 91 was held in Copenhagen. At INET 92, in Kobe, Japan, the conference also marked the first annual meeting of ISOC. Together with Robert Kahn, Vint Cerf established ISOC in 1992, to provide an institutional home and a legal framework to the various task forces, including the IAB and the IETF. Cerf was the founding president of ISOC from 1992 to 1995 and in 1999 served a term as chairman of the Board.

In a short time-span, the roles of scientists and of the limited number of network users grew, including by formal representation in coordination committees. In 1990, selected members of such communities were invited to join an advisory committee for the newly created Federal Networking Council (FNC), a body established by the NSF for consolidating the coordination of oversight for Internet administration and funding. The FNC brought together representatives from federal agencies that participated in the development of the Internet, including NASA and the Department of Energy. The FNC mission was to ‘provide a forum for networking collaborations among Federal agencies to meet their research, education, and operational mission goals and to bridge the gap between the advanced networking technologies being developed by FNC research agencies and the ultimate acquisition of mature versions of these technologies from the commercial sector’ (FNC 1990), signalling the privatization trends in the 1990s.

Underlying this multidisciplinary collaboration was a strong emphasis on common values, standards, and protocols, perpetuated from the outset of internetworking by all key players, from funders to developers. The early Internet standards stemmed from a sheer need for coordination: to send information from one computer to another, multiple ways could be employed, but choosing to perform the task in the same manner had obvious benefits. Standardization was of practical value to the early NWG. Based on early decisions and practices in the ARPANET group, standards continue to be open, free of cost, and available in a simple format. The next section explores how we got there through the ‘request for comments’ enduring routine.
Anchoring Practice: RFCs

The process of establishing standards and protocols was—and continues to be—an exercise in reaching consensus among a community of Internet enthusiasts who volunteer their time to the process. Standards are generally discussed in a layered approach, allowing work in one layer while abstracting the other, and thus respecting the end-to-end principle. While not all specifications of protocols or services for the Internet ‘should or will’ become Internet standards (according to RFC 1310 from 1992), RFCs may be initiated from early discussions of new research concepts or from status memos about the Internet and they would be marked as ‘experimental’ or ‘informational’. The standards are summarized periodically in the ‘IAB Official Protocol Standards’. To reach the final stage, they need to match the following criteria: high quality, prior implementation and testing, openness and fairness, and timeliness. When they are published, they offer specifications that manufacturers of equipment and software can integrate into their production processes.

The RFC process to design standards was born out of sheer need and contingency. Steve Crocker, who coined the term, summarized this clearly in 2012:

As our ideas started to permeate, we knew we had to write them down and we also knew that the mere act of writing them down was going to trigger some reaction, and possibly, even a negative reaction. We were just graduate students, nobody put us in charge, we had no authority. And it came to me to organize these notes that we were going to write and I found myself extremely nervous ... so I hit upon this ... silly trick ... saying we're just going to call every one of them, no matter what they are, they might be super formal or they might be completely informal, but we're just going to call every one of them a Request for Comments. I thought that this was a temporary device that would last a few months until the network was built and we had organized manuals and documentation and so forth. So here we are, more than 40 years later, requests for comments are still the lingua franca for the standards process, RFC is in the Oxford English Dictionary.

To minimize any claim of authority, Crocker, who graduated from UCLA a year before, drafted the first RFC on behalf of the NWG. It was 1969, and internetworking was in its inception phase, consisting of a network established between four research centres: UCLA, SRI, the University of California, Santa Barbara; and the University of Utah in Salt Lake City. Dedicated to the IMP host software, RFC 1 had open questions and diagrams. The idea of an unfinished product on which the others could comment meant cooperation and collective input were welcome. The culture of the rather small community of
computer scientists (less than 100) clashed directly with that of the engineers in the telephone networks, where special approvals to introduce new features were needed from hierarchy.

The drafting of RFCs started before email was invented, and in order to reach the members of the group, a copy was sent by post to each research group lead, who would then photocopy more for the rest of the group. As a shared practice, the RFCs became influential across dispersed memberships, at first only in the United States and subsequently across the world. Deciding to avoid patents, restrictions, or financial incentives on the side of the proposers of RFCs meant that agreement could be reached much more easily. As the community became larger, more formal meetings had to be organized. A legitimating purpose was intrinsic to this functional exercise. Until today, the RFCs invite comments from everyone in their first phase as proposed standards, then they become draft standards and finally Internet standards.

The main characteristics of the dominant practice embedded in the RFCs are telling of the in-built values: agreement around the appropriateness of this method, a need for replication and wider adoption. Yet the implementation of standards, just like their creation, is voluntary; they become operational if they are functional and deliver what is needed. The IETF standards are authoritative, being widely adopted despite lacking legal or enforcement powers. Apart from functionality, they are influential because they mobilize the expertise and the support of a larger group beyond the proposers. The decision-making process around RFCs is based on ‘rough consensus and running code’ (as explained in RFC 7282), in practice designating a majority agreement and a proof of reliable and replicable work. Sometimes rough consensus is determined by participants ‘humming’ when prompted by the chair of a working group; used as a means to get a ‘sense of the room’, having either everyone present at the discussion or the separate sides in a discussion humming in favour or keeping silent on a certain proposal.

RFCs are thus also used as a consensus-building ritual. In the vocabulary of technical bodies that have adopted similar consensus-oriented practices, this is equivalent to substantial support for a position or proposal and indicates the absence of substantial hostility. In the wording of RFC 1603 formalizing the process in 1994, a separation is needed between procedural disagreement (for which a review and appeal system was designed) and disagreement on technical decisions:

Technical disagreements may be about specific details or about basic approach. When an issue pertains to preference, it should be resolved within the working group. When a matter pertains to the technical adequacy of a decision, review is encouraged
Whenever the perceived deficiency is noted. For matters having to do with preference, working group rough consensus will dominate. (Huizer and Crocker 1994)

When the IETF community expanded, the practice of reaching rough consensus needed not only formalization, but also further specification. The creators’ imprint was apparent in the way opinions based on preference or interest could be overridden by rough consensus to achieve a functional, user-oriented solution inside an organization with no formal membership. The status of the RFC has consolidated over time into a publication mechanism (RFC series) comprising the totality of drafts discussed, independent of whether they turn into standards or not. As a communal reference point, it re-enacts a specific way of building a community around a shared purpose.

More than documenting developments and enabling dialogue, RFCs also represented a mechanism to include individuals outside established relationships (the small group of people in ARPA-related projects), as they could follow the progress at ARPANET and keep abreast of the technical advances from the sidelines. The NIC, based at the Stanford Research Institute, played a key role as a dissemination node, and its example was followed by successor organizations. Through the work of the NIC, more and more decisions, from ad-hoc groups to formalized procedures, started to be documented, in response to the need for ‘getting things done’ when a higher number of people became involved; it also created a domestic and an international audience, as attention was focused on successful experiments; and it increased transparency.

Yet the early Internet was overwhelmingly based on English-language content, limited access to outsiders, and was mostly dominated by male researchers and technologists. Most of the information transmitted was textual, making the environment relatively homogenous. The term ‘open Internet’—though in many cases open standards were a necessity of the time—was not formally introduced until March 1992, when Lyman Chapin, the chairman of the IAB, published the RFC 1310 entitled ‘Internet Standards Process’ (Russell 2014). The document outlined procedures ‘intended to provide a clear, open, and objective basis for developing, evaluating, and adopting Internet Standards for protocols and services’ and identified openness and fairness as a key goal for Internet standardization.

Characteristic of Internet standard-setting organizations was a certain emulation of existing practices in the small community forming at the time: the NWG model was followed when establishing the INWG, and the IENs were modelled on the RFCs format. Moreover, the tradition of delegating decision-making to specialized committees for different purposes (providing...
information, legal, technical matters, etc.) continued to be observed by technical bodies. Among these, the IETF remains a relatively informal and loosely institutionalized standardization body, with no membership, no fees, and no board of directors, preserving the principles developed in the early days of the Internet.

As an anchoring routine shared more broadly by the technical community based on the IETF practice, the RFC series reveals the like-mindedness of the initial group of practitioners who could thus reaffirm the joint enterprise they took part in. Importantly, it shows how practice fostered learning among old and new members, transforming identities and institutionalizing the norm of open and inclusive participation in discussions. This pattern of engagement is central to the evolution of the field, inspiring wide adoption in the Internet governance community.

**Synopsis**

This chapter showed that in the early days, the Internet was a rather homogeneous domain, closely linked to computer science and networking experiments. Different forms of governance, combining public and private initiatives, were profiling, and that initial interaction shaped the way in which the Internet evolved. Until the commercial Internet in the mid-1990s, the predominant governance route for Internet-related decisions was the creation of standards and protocols to make different networks interoperable. Such processes were regulated via informal interactions among a relatively small group of pioneers able to cross sectoral boundaries.

Around this, a set of institutions formed—at first completely informal, later formalized—performing different functions as part of governing the network. In that sense, governance activities—primarily coordination and standardization—were set in place without being referred to as such. Notably, hybrid arrangements between academia, governmental funding agencies, and large computer companies, such as NSFNET, expanded the reach of the network. The process of governance diversification and transformation was led by a number of scientists-cum-practitioners, such as Vint Cerf, Bob Kahn, and Tim Berners-Lee, who were at the forefront of ad-hoc groups formed to answer functional problems. At the international level, through their leadership work and the founding of institutions, a transnational policy network started to form. Prior to 1993, with the exception of the work conducted
around the OSI standard, most governance mechanisms at the global level remained telecommunications-specific and included more instruments with binding character than soft law.23

Despite the sustained funding directed first to ARPANET and later to NSFNET, the divergent agendas of funding agencies and their prioritization of various interests allowed for supporting innovative, complementary areas of research, such as AI, database management, and cryptography. This fragmentation of resources opened up the space for collaboration. When the transfer of responsibilities towards NSF started, infrastructure costs continued to be shared. While ARPA funded research groups rather than individuals, involving the same scientists ensured that developments could build on each other and that an early community could be formed. The management style also reflected trust-based contracting and long-term relationships with private providers, at first with BBN and later with IBM, MERIT, and NSI, contracted to do the high-speed upgrade for NSFNET in 1987.

The majority of pioneers continued to play key roles in the development of the network and the institutional architecture evolving around it. Kahn and Cerf formed ISOC in 1992 as an institutional home for IAB and IETF; Postel continued to run IANA and prepared its transition to the ICANN. Academic networks and universities—in particular those that developed computer science departments such as MIT, Stanford, UC Berkeley, UCLA—remained strongly involved in Internet advancements. The ARPA computer network benefited from generous funding and a wide degree of autonomy for the researchers, mostly brought in through peer-selection, via personal networks and scientific conferences (Hafner 1998; Abbate 1999). The network expanded to include a number of university centres not connected with ARPANET initially. Later on, a set of functionalities developed in the private sector were added to what became a public use network. Yet, as early as the first decade of ARPANET, politicization trends emerged: the high stakes were indicated by a number of instances of contestation, such as the early protocol ‘war’ (TCP/IP vs. OSI), the efforts to create interconnected networks in the private sector, and the push towards commercialization.

23 In addition to their Declaration on Transborder Data Flows (1985), OECD prepared its Guidelines for the security of information systems as early as 1992.