Imperial College

The London Centre for the History of Science, Medicine and Technology

Explaining the success of the Internet:

Proto-networks & other primordial cyberspace soup

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for the degree of Master of Science

21 September 2000

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Acknowledgements

I owe much to those who have made this year of study possible. Besides many others who have provided moral support, I would like to offer gratitude on all who have provided me with the material support, in particular Paul Boulle and the staff of PCB Technologies and The MilkyWay Internet Café, as well as Janet Mackenzie, Phillip & Fiona Sewell and Nelio & Ela de Freitas.

On the academic side, I would like to thank my tutor and mentor Professor David Edgerton at the London Centre at Imperial College for guidance and direction, as well as tempering my enthusiasm for certain dissertation topics to more sober and attainable choices. I would also like to thank Dr. Hasok Chang at UCL for his friendship and guidance during this momentous and challenging period, as well as all the teaching staff whose wisdom and knowledge I have had the privileged to draw upon.

A glossary of Terms

Auto-dial The first modems had to be manually connected, that is a telephone number manually dialled on a telephone, and then the modem connection enabled. Auto-dial was a facility where a telephone number could be programmed into the modem and it would establish the connection automatically. This was as a ersult of the development of microprocessors and facilitated automatic connections between computers

BBS This an abbreviation for Bulletin Boards Service. A computer running the BBS software acted as a host to which many users connected via modems, where they could leave messages for each and participate in group discussions and read information posted up.

Bandwidth The speed of data transfer on a data communication circuit is referred to as bandwidth.

Email Electronic Mail is a message typed in a computer and sent as a data file encoded in digital electronic data

Hypertext A system of linking objects together, and enabling a mechanism to move between them

PSTN The Public Switched Telephone Network
Modem This devices prepares digital information for transmission over analog circuits, normally the PSTN. It stands for **Mo**dulator / **dem**odulator.

Open source This is a movement in computer culture where the instructions or source of a software program is published for others to improve on or use in anyway. The rapid proliferation of Internet is a result of this.

Telcos The Telecommunication Corporations. In some countries they are state institutions whilst in others they are private companies.

TCP/IP Transmission Control Protocol / Internet Protocol, the ‘language’ of the Internet.

UUCP User to User Copy Program, a feature introduced into the Unix operating system which led to the automated information transfer of the Usenet network.

VDU Video Display Unit, the screen where data is display. This was an adaptation of Television technology.

Introduction

The Internet has been widely associated with a communication revolution. This global electronic digital data network experienced exponential growth in the 1990's, and has become ubiquitous in most developed nations. Synonymous with the growth of this data communication system has been a proliferation of related services. This universal data network and allied public services, which are mediated through computers, are collectively termed the Internet. Authors have written that the Internet has brought about an information revolution (Mark Stefik, 1997), even a new information age (John Feather, 1994). Others such as Poster (1995) believe that these developments may alter our habits of communications and so deeply reposition our identities that a new designation, a second new media age is justified. Feather takes the more radical view that "the computer has been responsible for the most important change in human communication since the invention of printing, and, arguably, since the invention of writing itself".[1]

Post-modern speculation aside, recent studies have shown mass media habits are changing. A survey published by Le Fargio showed that the Internet is slowly changing the shopping and reading habits of the French.[2] Despite this, interactive user-driven multimedia information browsing and electronic messaging have not posed a direct challenge to the more traditional mass media or radio, television and printed media. Despite a drop in overall audience figures, a recent survey has shown that television and radio continue to reign supreme.[3] Instead the technological tools of the Internet have been socially constructed to supplement and complement traditional media and communications systems and indeed define new terrain for mass communication.

However, despite its borderless nature, the Internet cannot address the systematic inequalities that have resulted through globalisation. The nation-state still survives, as discussed by Everard (2000) in *Virtual*

[1]J. Feather, *The Information Society, A study of continuity and change*, (Lbrary Associated Publishing, London, 1994), p.155

[2]*French Habits Changing with Internet Use* (Nua Internet Surveys, http://www.nua.ie/surveys, 2000)

[3]*Traditional Media Survives Net Revolution* (Nua Internet Surveys, http://www.nua.ie/surveys, 2000)

States.[4] Given these and other limitations, it is generally believed the Internet has brought about a new paradigm in communication and social interaction. The term *cyberspace* was popularised by science fiction author William Gibson in *Neuromancer* (1984), where information technology and human culture merges, creating the symbiosis that Licklider has written about in his seminal paper "Man-Computer Symbiosis" (1960).[5] However, cyberspace talk is often the flavour of what Wilhelm (2000) calls neo-futurists, whose uncritical faith in progress more than often has to do with marketing hype and short term annual profit margins than reality. Despite the pessimism of naysayers, the emergence of the Internet as a mass communication technological system must be seen as phenomenal.

The technical history of the Internet has been adequately and comprehensively dealt with by Janet Abbate (1999) and others. It essentially grew out of the military-funded ARPANET project in the USA, which has its origins in the need for reliable computer resource sharing during the 1960's mid-Cold War era. This was a period when computers were prohibitively expensive, and means were sought to broaden access for economical and practical reasons. Abbate shows that there were many technical and infrastructural aspects that led to architectural rigidity and scalability, and ultimately contributed to its successful proliferation. The ARPANET was based on Packet Switching, at the time an unproven and revolutionary concept of data transmission. The pioneering development, deployment and later transition of the military ARPANET to civilian control, and ultimately its commercialisation, is well documented by Abbate and others. However, Abbate raises a broader and important question in her work, in that the success of the Internet needs to be explained beyond a technical history. This dissertation will explore some of the factors that contributed to this success.

Whilst historical accounts of the transition of ARPANET to the Internet are valid, the ARPANET was just one of many data networks that preceded the Internet. There were many other alternatives, which included business-orientated, academic, semi-public and private networks that existed pre-1990. Most were packet-switching spinoffs and clones of the original ARPANET, others were based on proprietary systems controlled by the large computer manufacturers. The response by the traditional

[4] J. Everard, *Virtual States, The Internet and the boundaries of the Nation-State,* (Rouledge, New York, 2000)

[5] J.C.R. Licklider, "Man-Computer Symbiosis", *IRE Transactions on Human Factors in Engineering* I, No.1 (March 1960)

telephone & telecommunications corporations and allied standards organisations to this growing industry will also be covered. Their technologies stemmed from the tradition of public communication services, and were oriented as an extension of these. These telecommunication organisations also attempted to control and derive revenue from the data communication industry. In many instances they were designed to supplement and replace the predecessors of the Internet. I will be looking at the growth and extent of these networks, the attempts to impose standards, and the factors that led to convergence to the Internet. Why this succeeded where others failed will be analysed and the porcess of technological lock-in will be discussed in this context.

Several public information technology developments predated and preempted many of the features that are popularly attributed to the Internet. I will be showing that public data services such as Prestel in the UK and Minitel in France existed before and independently of the Internet. Although varied in their functionality, these services broke the conceptual ground for personal electronic communication, public data access and the creation of virtual communities. These services provided links between the information consumers and information providers, where searching and scrolling through data banks by remote users on computer terminals was possible. They also introduced on-line facilities such as electronic commerce. User communities developed around these services long before the Internet became public knowledge. These services will be examined to show their relations and influence to the later emergence of the Internet.

Presently Electronic Mail (email) is universally associated with Internet. There were 569 million email accounts globally at year-end 1999, projected to one billion by the year 2002[6]. However, before the Internet became the de-facto email system, many public and private electronic mail systems were in use. Research has shown that whilst universal addressing and interconnection were a limiting factor, mailboxes grew at a significant rate prior to adoption and convergence to the Internet. Many alternatives existed. The emergence of international standards such as the X.400 Message Handling System, which were designed to supercede the Internet standards will be discussed. I will show why these Internet standards came to dominate despite many attempts to steer electronic data

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[6] *One Billion Email Account by 2002* (Nua Internet Surveys, http://www.nua.ie/surveys, 2000)

communication away from them. This provides an important argument for the later success of the Internet as a globally dominant standard.

There are many other factors that led to the success of the Internet, and some of these will be briefly discussed here. Any data communication network is simply the plumbing for the flow of data between electronic computers. The rise and widespread proliferation of the Personal Computer and a spectrum of application software ultimately drove data communications technology. As volumes increased, micro electronics technology advanced rapidly, largely due to economics of scale and insatiable consumer demand. The personal computer became more powerful as it became more versatile. The price/performance ratio of personal computers changed as well as the growth of application software that facilitated the rapid emergence of Internet phenomena such as the World Wide Web. These are significant factors, as was the technological momentum of the microelectronic industry in broader considerations of the success of the Internet. The Internet relies on many independently functional components, most of which rely on microelectronics. The scale of the development in this industry in this period is a significant factor for the success of the Internet.

The successful proliferation of the Personal Computer is followed closely by their interconnection into Local Area Networks. This technology closely followed the commercial success of the Personal Computer, both in commercial and academic environments. Primarily used for sharing of expensive resources, application software emerged that facilitated collaboration and teamwork, using electronic messaging. In many cases this was the basis of the sub-networks that collectively went to comprise the Internet, which was in fact a meta-network. Connection of these networks to the Internet accounted for a significant portion of the explosive growth of the Internet. These networking technologies will be discussed to some extent, as well as the factors that drove migration towards the Internet.

Lastly, I will be taking a look at other factors that contributed to the success of the Internet. The technology of the Internet will be analysed with a view to explaining the way it permitted rapid social shaping of its functional elements. Comparisons will be made to networks and information systems that predated the Internet, and with which it competed. The intention will be to draw an understanding as to why it became dominant, long after its fate in antiquity had been decided by the international standards bodies. I shall be applying the theories of technological momentum, the social construction of technological systems and technological determinism analyses in this discussion. Comparisons to other large technological systems will be made, and I will also be drawing comparisons to other mass communication systems. This will reveal more factors that contributed to its unprecedented proliferation as well it's uniqueness as a technological system,

Chapter 1 - Data Networking before the Internet

The Internet, and the diverse information technology systems that are associated with it, reached popular acceptance and widespread diffusion by the late 1990's. As discussed by Hughes[7], it is a monumental technological achievement. However, Winston[8] regards it as simply the next in the sequence of mass communication systems, which will suffer the same fate as what he terms a 'Law of the suppression of radical potential'. As he shows in his analysis of public radio and telephony, this ultimately comes into effect and curtails the success of the technology, which only reaches widespread diffusion after a significant period of time, if at all. However, the Internet was not invented as a large technological system, as these authors have written. There were many alternative data networks that predated and preceded the emergence of the Internet. This chapter will investigate these alternatives and show the extent of them. The factors that resulted in technological lock-in on the TCP/IP data communication protocol of the Internet will be discussed in this context.

I will be discussing the plethora of network protocols that existed prior to convergence to TCP/IP in order to understand this lock-in. In order to do so, a technical understanding of the underlying structure of electronic data communication, namely the data communication protocol, needs to be developed. Many of the alternative data protocols to TCP/IP were proprietary, in that they were developed by computer manufactures to serve their needs. In many cases, these were attempts to create the technological lock-in that ensures market dominance and monopoly. Some of these protocols were patented and available to others by way of licensing fees. The specifications and inner workings of thse were tightly controlled by the license holders. I will also be looking at attempts by the international telecommunication standards' bodies to impose standardisation, and the failure of these attempts.

Data networks are classified and organised by what protocols are used to communicate information. This is analogous to a language in speech. Information is conveyed by human speech, and can be translated from one to another by interpreters. The same applies with data protocols. Data can be

[7]Thomas P. Hughes, *Rescuing Prometheus, Four monumental projects that changed the world* (Vintage Books, New York, 1998), pp.255-300

[8]*Brian Winston, Media Technology and Society, A History: From the Telegraph to the Internet,* (Routledge, London, 1998)

translated and repackaged from one protocol to another: the essence of the information is not confined to the language, as information conveyed by digital electronic data communications is not confined to one protocol.[9] What is unique about most information data transfer protocols, compared to other classical telecommunications systems, is that data streams are separated into packets or cells, and then sent off individually. This is referred to as a connectionless circuit and contrasts with the more traditional connection-oriented one, where a circuit is established between two corresponding parties which is kept open whilst communication continues. This introduced a new paradigm of communications. The concept of packet switching was pioneered by Paul Baran for the ARPANET project in the early 1960's,[10] and ultimately resulted in the TCP/IP protocol. The predecessor of TCP/IP was developed by the ARPANET team including Robert Kahn and Vint Cerf during the course of the 1970's. The development of this has been dealt with comprehensively by Abbate and Quarterman, and took place largely under the cloud of the middle Cold War period. Other data transmission protocols originated from the large computer manufacturers such as IBM and Digital Equipment Corporation (DEC). These were tailored to accommodate the data transmission needs of their sectors of the industry, and will be discussed in more detail later. These and other data protocols competed for dominance during the emergence of national and global data networks, which can be assigned to the period 1970-1995. A data communication protocol not only determines how data is transferred over a network, it also provides a foundation for the objects and mechanisms which provides the services to users of that network. These services are then unique to that data system.

There were many competitors in the global data transmission arena before the Internet and its underlying protocol TCP/IP became dominant. These alternatives originated in private computer corporations in the USA. They attempted to encourage widespread use of their proprietary protocols to create lock-in, and ultimately market dominance. Strategies differed: some protocols such as DECNET were made available via licensing to other manufacturers, whilst IBM used its market influence to try and swing institutional and national decisions on protocols their way.[11] These suites of

[9] If fact multiple protocols can exist on the same communication medium. However, this is not a significant factor in this discussion.

[10] Abbate, *Inventing the Internet* (1999), pp.17-20

[11] Abbate, *Inventing the Internet* (1999), p.153. IBM tried to have it's SNA protocol standardised on in Canada however this was resisted.

protocols were generally incompatible, although passage of data could be achieved through gateways as discussed. However, what should be considered are the concerted efforts of the International Standards Organisation to steer the global data industry towards its standards, and the subsequent failure of these standards to be adopted despite widespread agreement to do so. All these issues will be examined in this chapter with the intention of developing an understanding of the factors that led to the dominance of the Internet technology.

Several other data communication protocols were developed by computer manufacturers to meet their specific needs. Generally these were not open standards: they were proprietary, sometimes even secret, in that the specifications of the protocols and other details were tightly controlled, although some made the technology available to others via licensing deals. This made it difficult for other vendors to offer products compatible with their own. The most dominant of example of this was IBM with their SNA (Systems Network Architecture) protocol. Another was Digital Equipment Corporation with DECNET. In the field of Local Area Networks, which linked together the mass of personal computers that characterised the late 1980's. Once again, proprietary protocols were developed to meet the needs of that market. These include NETBIOS from IBM and the IPX protocol developed by Novell Corporation. The industrial context in which these developments took place was entirely outside of the environment which TCP/IP had been developed. This diversity in all areas of networks continued well into the early 1990's before a final convergence to TCP/IP, although alternatives did continue to exist.

The attempts by standards organisations to impose standardisation, and their subsequent failure, reveal the extent of lock-in of the TCP/IP protocol. Reviewing the chain of events in this regard as documented by other authors, as well as through archival material, some answers are provided. It was not only a technical issue, although the extent to which the TCP/IP protocol was embedded is apparent. It also had to do with the culture and context surrounding this technology, which was untypically uncommercial. Two organisations shared authority for networking standards. These were the International Standards Organisation (ISO), and the Consultative Committee on International Telegraphy and Telephony (CCITT) of the International Telecommunications Union, which had European origins and a mandate by the United Nations to research and develop worldwide technical standards for telegraphy and telephony. As early as 1973, the CCITT had begun looking at standards for public data networks. Draft standards were circulated to member nations for comment and revision and then voted on by a plenary that meets once every four years. Although superficially this seems to be a purely technical issue, as Abbate shows, many other cultural, political and economic factors underpin decision-making in these bodies. The data communication standards produced by these bodies stemmed from the tradition of providing encapsulated point-to-point connection oriented and metered services, which were seen as an extension of their traditional telephony markets.

This first data communication standard produced was the X.25 Recommendation, which was hastily prepared and rushed through a plenary in 1976.[12] Whilst not mutually exclusive to TCP/IP, these standards had not been designed to work together. In developing these standards, the computer industry's data communication work was ignored. As Abbate illustrates, these standards became symbols of their sponsors alternative approach to networking. The technical decisions embodied in these standards reflected the beliefs, values and agendas of the people who designed and used these networks. X.25 represented an attempt by the telcos to establish control of the data communication from the computer industry, which at that stage had extensive networks in place. Specifically, X.25 was connection-orientated since a point-to-point 'virtual' circuit had to be set up before data communication could take place. This was in contrast to the packet switching nature of TCP/IP and other protocols from the computer industry, where a packet of data is sent of into the network and left to find it way to the destination. This is achieved via a series of other networks connected together by routers. Another important consideration was metering, that is being able to count how much data is being transferred and thus being able to levy a charge for this volume. Not much attention had been given to charging for the amount of data transferred with TCP/IP and the other computer industry protocols. However, the telecommunication carriers were concerned with this in order to derive income for their services. Furthermore, the carriers preferred to create their own standards because they feared domination of the likes of IBM, which would lock them into buying equipment from a particular supplier. According to Abbate, the introduction of X.25 caused intense debate and a direct challenge to the established data communications industry. However, as I will show the X.25 was less of an issue than the later, higher level networking standards the ISO tried to get the network world to standardise on.

[12] Abatte, *Inventing the Internet* (1999), p.154

Although X.25 had been mandated for national public data networks, ultimately this system was not really a competitor of the other data protocols. TCP/IP networks could in fact used X.25 circuits as a data transport mechanism to create a bridge. This is done by encapsulating the TCP/IP data into an X.25 packet, and then unwrapping it on the other side. In this way, X.25 in fact provided a path for proliferation of existing TCP/IP networks. It was also possible to have multiple data communications protocol on the same communications medium, that is DECNET and TCP/IP could coexist over any type of network communication medium which is used to communicate the data. This is in contrast to the traditional communication systems such as the Telephone System, where only one type of electrical signal could be propagated on a transmission medium at any one time.

The ISO's X.25 was developed for a point-to-point reliable data service. The way that data and transport protocols can be repackaged with little overhead is an important consideration when considering the history of data communications and the Internet. This abstraction has particular relevance when comparing the Internet as a large technological system to Hughes' study of the late 19^{th} and early 20^{th} century electrical power distribution systems as detailed in *Networks of Power* (1983).[13]

The development of data communication systems is generally best dealt with by conceptually arranging functionality in layers, with the lowest layer dealing with physical communication of the data, and the highest level standardising on ways that application programmes can communicate with the network. The concept of layers was first introduced by the ARPANET team who introduced a two-layer stack that separated the Host functions from the Communications.[14] The International Standards Organisation (ISO) ultimately defined a seven-layered Open System Interconnect (OSI) model (Fig.1) which was influential on a conceptual level in categorising the services of the various protocols. This was developed by a multinational committee that was concerned with proprietary protocols from computer manufacturers becoming locked in and 'closed'.[15]

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[13] Thomas P. Hughes, *Networks of Power, Electrification in Western Society 1880-1890,* (John Hopkins University Press, Baltimore, 1983)

[14] Abatte, *Inventing the Internet* (1999), pp.52-54

[15] Abatte, *Inventing the Internet* (1999), p.168

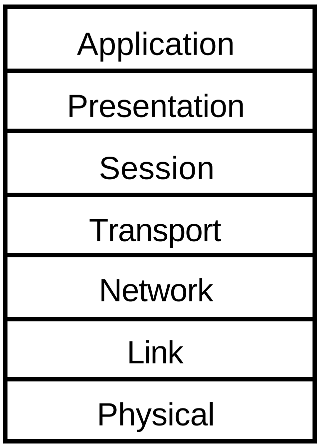

Figure 1 The OSI Model

As elaborately shown by Abbate, the ARPANET community collaboratively developed the TCP/IP protocol. It was not controlled by any commercial interests, and was used widely as will be shown. However, the ISO pressed ahead with defining its own version of a data communicational protocol, which it called the OSI stack. This was highly influenced by TCP/IP but higher level functions, such as the X.400 message transfer system and directory services were defined. The ISO authority in the field of standards was such that the OSI protocols rapidly received endorsement by standard bodies in all the countries that were involved in computer networking.[16] As will be shown later by the survey of networks in North America prior to 1990, it was widely believed that the ISO standards would be widely implemented, displacing TCP/IP and the other proprietary data protocols. For example, the US Department of Defence declared in 1987 that OSI protocols would eventually be adopted as military standards. Similar moves were made by European governments such as the French who feared that:[17]

> If IBM became master of the network market, it would have a share - willing or unwilling - of the world power structure.

Table 1 in the appendices compares TCP/IP and the OSI protocol stacks. The conceptual similarity is apparent, yet they were incompatible. In a sense, they OSI was re-inventing the wheel, although the

[16] Abatte, *Inventing the Internet* (1999), p.171

[17] Abatte, *Inventing the Internet* (1999), p.172

TCP/IP wheel was perfectly adequate as it was. The OSI specifications included higher level service for file transfer (FTAM) and terminal access (VTP) which were meant to supercede the TCP/IP ones of FTP and TELNET. However, many software applications had developed around these, and they were deeply embedded in the Internet culture.

Despite the attempts by these influential powers to establish the OSI protocols globally, it failed to displace TCP/IP. Furthermore, there was a major convergence towards the TCP/IP protocol both in public, private and academic networks which led to the sustained exponential growth of the global Internet. To understand the background to this, a study was done of all the major data networks that existed in the USA prior to 1990. A summary of 33 of these networks appears in Table 2 in the Appendices. These data networks served a variety of purposes. However, most were academic and industrial research networks that were modelled on and inspired by the original ARPANET. These networks provided the basis for electronic communications, of which email was perhaps the most popular facility embraced by users. In fact, some of these networks only catered for the conveying of email. Resource sharing was another demand that drove computer networking, with the establishment of supercomputer centres, the need for remote access increased. Most of these networks were established in the late 1970's and early 1980's. With a few exceptions, they all used the established with the TCP/IP protocol and associated technology, which were open source and freely available. Second in popularity was DEC's DECNET and then IBM's SNA. There were also a few one-off custom-built protocols, one of which dated back to the early 1970's when ARPANET was still in development.

By looking at how extensively embedded the TCP/IP protocol was in this plethora of networks, it becomes apparent that associated with this protocol was a technological inertia, more specifically a resistance to change. As discussed above, translating between one data protocol and another could be easily be accomplished by the software-programmed computing equipment that performs the communication tasks. However, the context in which a technology exists has to be considered when understanding lock-in. An extensive community of developers and 'hackers'[18] existed around this technology. This dates back to the beginning days of the ARPANET, as well as the unique project

[18]A hacker is a term for a computer whiz who 'hacks' away at a problem until it is resolved. It normally refers to the computer programming or software environment.

management style that was used. Communities of peers worked together to develop new functions and solve existing problems in a cooperative way. They were geographically separated, but in constant contact using the same system, usually via email and threaded discussion lists. This was unique in that this process was largely absent of hierarchical management and control. Abbate describes the informal and decentralised management style as an essential characteristic of the ARPANET.[19] All technical decisions were made by consensus of the participants. Although the members of this community were confined to the elite institutions that were selected to participate in the ARPANET project, these practices formed a strong tradition, which proliferated as the number of TCP/IP networks grew. Gateways were introduced, which allowed communications between the networks, allowing the community to grow beyond that of the immediate and exclusive ARPANET. The technology of the ARPANET network was simply duplicated in other localities which faced the same data networking needs. Along with the cloning of technology, there was a growth in the community that developed and enhanced the core protocols and applications. Not only was the technology of TCP/IP entrenched, so was the culture that surrounded it. And as discussed, the tools that made use of the underlying services of TCP/IP networks were developed by this same user community, and shared with others in this same spirit of co-operativeness. This further entrenched that technology in those communities.

The TCP/IP community has to be contrasted with the way the ISO worked. This was a culture of bureaucrats, centralised decision making by a committee that only sat to make decisions every four years. The protocols were designed by engineers in a deterministic way: they sought to establish how data networking should be, believing that once these standards were promulgated they would be adopted since their decision making power was absolute. They were used to dictating to an obedient audience (the telcos). Although the OSI protocol suite was influenced by the functionality of TCP/IP, it must be seen as reflecting an entirely separate culture, one that had no hold over the growing, diverse and grassroots TCP/IP community.

As is evident from Table 1 in the appendices, the OSI and TCP/IP protocol suites offered similar functions. For instance, one of the most popular uses of networking is email. The TCP/IP specifications for email are RFC822 whilst the OSI equivalent was the X.400 specification which described a

[19] Abatte, *Inventing the Internet* (1999), p.50

Message Handling System. Functionally these standards were equivalent, but the TCP/IP-based one had been in use since the early days of ARPANET. X..400 MHS, which was finalised in 1984, was hailed to be the great unifying factor for myriads of non-Internet email systems, such as those used on proprietary networks. At an Electronic Message Systems strategy conference held in London in October 1986, it was held that X.400 within the OSI environment would produce a standard framework which would make possible a single worldwide store and forward messaging electronic communications system for personal messages, complex documents, voice messages, facsimile and graphics.[20] This was a period when electronic mail usage was proliferating extremely rapidly with in-house commercial systems. It was held that with interconnection, public data services would link all of the many "islands of messaging" together.[21] This growth is largely undocumented since it consisted of mainly private commercial electronic mail systems. These included systems based on Personal Computers connected to Local Area Networks, minicomputer-based systems such as All-in-One and CEO, and electronic mailbox systems used on an international basis by organisations such as Citicorp and DEC.[22]

As a result of the belief that X.400 was the path to follow towards unity, major computer manufacturers such as ICL, DEC, LDR Systems and IBM announced X.400 gateways for their systems. Many of the Personal Computer-based Local Area Networks software companies such as Novell Inc. and Banyan Vines followed suite and produced X.400 MHS gateway software for their communication systems in the belief that it would provide unification. Generally a "Bright a new world of X.400" was perceived.[23]

However, X.400 along with a lot of the other ISO X. protocols and standards, failed to achieve critical technological mass and widespread diffusion, and thus withered from the futuristic speak of those marketeers who so enthusiastically espoused them earlier. In the post-Cold War 1990 period, the

[20] *Electronic Message Systems, Proceedings of the international business strategy conference held in London, October 1986* (Online Publications, London, 1986), p.iii

[21] *Electronic Message Systems, Proceedings of the international business strategy conference held in London, October 1986* (Online Publications, London, 1986), p.1, Michael Cavanagh

[22] *Electronic Message Systems, Proceedings of the international business strategy conference held in London, October 1986* (Online Publications, London, 1986), p.14

[23] *Electronic Message Systems, Proceedings of the international business strategy conference held in London, October 1986* (Online Publications, London, 1986), p.163

TCP/IP-based Internet proliferated globally at an astounding rate, growing from its base of academic institutions and research organisations into general commerce and industry globally. The ability of personal computers to connect to the Internet across the public telephone network further popularised it. Like X.25, the existing infrastructure of the telcos simply became complimentary components of the communication infrastructure of the Internet. In the wake of the phenomenal growth of the Internet, the OSI protocols became redundant. This included the much promoted X.400 Message Handling System. The TCP/IP Internet protocols, and all the technological and cultural mechanisms came to dominate without design or intention. The ramifications of this success are well known, and I will not attempt to cover this in any more detail. What needs to be appreciated is the amount of resources spent on alternatives that did not ultimately have any influence. Despite the influence and power of the ISO throughout the world, Internet technology had taken firm hold at a grassroots level. This powerful international standards body, which governed international telecommunications, was unable to steer the path of the global electronic data network towards its standards. This reveals the depth of lock-in of the Internet-based protocols, systems and culture.

Chapter 2. Other Primordial Soup of Cyberspace

In this chapter I will be examining digital electronic technologies that preceded and generally predated what was to be known as the Internet in the mid-1990. This will go beyond a technical discussion of data networks and communication protocols and will deal with examples of technology that implemented the concepts such as on-line forums, large-scale public data access, electronic banking as well as the generalised concept of electronic commerce. Many of these concepts, which generally are considered to be Internet developments, go back to the early days of computing. The much-espoused Information Revolution and creation of a Cyberspace are generally dealt with by authors such as Kevin Robins and Frank Webster[24] in glowing futuristic terms, with little histographical content. Most of these accounts are present-centred, attributing the inception date of a cyberspace to the likes of the invention of the World Wide Web at CERN in 1990.[25] It is therefore implied that these electronic corridors of cyberspace are recent inventions. Although popular knowledge and mass appeal of these might have only been attained after the Internet reached its global critical mass, a lot of this functionality had in fact been in use for years in lesser publicised and more culturally isolated communities. Some of these were technologically flawed from the beginning, others could not scale successfully with growth, or keep pace with the phenomenal and rapid evolution of the electronics industry.[26] Others created significant techno-cultural momentum that when the Internet reached widespread diffusion, these earlier technologies and ingrained communities migrated onto the resources of the Internet, adding significantly to its popularity and momentum.

I shall be looking at **Prestel**, the British pioneering public access data system that hooked up data consumers with data suppliers and introduced many electronic commerce facilities, **Minitel**, a similar but more successful system from the French, **Listserv,** a facility that introduced and popularised one-to-many e-mail communication, **Usenet**, a treaded personal electronic messaging system which spread rapidly globally and lastly the origins of **hypertext,** which was so powerfully employed in the World Wide Web. All of these were developed outside and independently of the Internet. There were many

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[24]Kevin Robbins, Frank Webster, *Times of Technoculture - From the information society to the virtual life* (Routledge, London, 1999)

[25]Abatte, *Inventing the Internet* (1999), p.214

[26]John Peter Collett, 'The History of Electronics' in *Science in the Twentieth Century,* (Harwood Academic Publishers, The Netherlands, 1997)

other important examples of computing and telecommunications technology that where to constitute essential elements of the Internet, such as the Bulletin Board, however they will not be dealt with here. The above have been selected because they covered a diverse range of functionality, and although disparate and independent, together they can be considered to constitute a broad range of technological services that are popularly ascribed to the Internet.

The Prestel viewdata service

The British Post Office conducted research in the late 1960's into what was to become broadly known as Viewdata.[27] This work ultimately resulted in the Prestel system. This was an interactive data service that involved three separate technological disciplines: television broadcasting and display, computer storage and retrieval and telephone transmission. They system used the common household television set as a video display, together with a terminal unit and a keyboard. A link to a data server was made via a modem over the PSTN. Data was not offered directly by the Post Office since this was a service they offered to Information Providers, which would either store the data on the Post Office's servers, or through a gateway to the own data hosts. The Prestel facilities acted as a resource between information consumers and information providers. The Systems Operator (the PTT) had no control over what information is put on its computer and made available to the public (except where it broke the law of the land) - becomes a 'publishing medium unlike any other' and 'became meshed with the notions of a free society, right of anyone to speak what he will to anyone, of an information society where the trade in information is perhaps the dominant activity, where the right to know is buttressed by technology as well as the law'.[28]

In comparison to traditional broadcast mass media, it was the first to provide an individualised service, where the information consumers can be selective about what is viewed. The capacity to be selective and personalise information was unique, and it even went beyond individual selection of information,

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[27]Efrem Sigel, *The Future of Videotext, Worldwide Prospects for Home/Office Electronic Information Services* (Knowledge Industry Publications, White Plains, 1983), p.1

[28]Rex Winsbury (ed) *Viewdata in Action, A comparative Study of Prestel* (McGraw-HILL, London, 1981), p.6

providing the capacity to be alerted by new information. These facilities arose out of the use of computing technology. It was considered to be the world's first full data service.[29]

It was envisaged by the developers that a global market would develop for this technology, and being first to the market, the Viewdata technology would dominate. By April 1982, this British standard of Viewdata had proliferated to 15 countries, and constituted 98% of the market.[30] However, other data services were also emerging, some of them making use of the more flexible personal computer technology, dissociating the service from the confines of a particular technology. In the USA, where this Viewdata technology was being punted, AT&T's developed Presentation Level Protocol (1981) for videotext, with more advanced graphics, and software technology that included scalable fonts.[31] Other interactive data services in the USA included Compuserve, Dow Jones, Field Enterprises, Knight Rider, The Source, and Time Incorporated.[32] The French Minitel system was a direct competitor, and is covered below.

Although Prestel was the largest commercial service in the world in 1981, it wasn't financially successful, losing four million UK Pounds per quarter as of mid-1981.[33] Plans for the predicted growth had to be considerably scaled back in this period. The then privatised British Telcom had to cut back Prestel staff and eliminated 14 regional computer centres in response to lagging demand,[34] largely due to what was considered 'misplaced expectations'.[35] However, there were severe technological limitations with Prestel/Viewdata technology. Although it was the first service to offer graphics, the resolution of this was limited by the price of semiconductor memory as well as by modem bandwidth, which was confined to the V.21bis standard of 300bps download and 75 bps upload. The terminal equipment was expensive, generally costing over UK £1000 terminals at the time. The scope of information offered tended to be limited. The number of information providers remained constant at 140

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[29] Rex Winsbury (ed) *Viewdata in Action, A comparative Study of Prestel*, pp.81-109

[30] Rex Winsbury (ed) *Viewdata in Action, A comparative Study of Prestel*, p.27

[31] Rex Winsbury (ed) *Viewdata in Action, A comparative Study of Prestel*, p.28

[32] Rex Winsbury (ed) *Viewdata in Action, A comparative Study of Prestel*, pp.59-76

[33] Rex Winsbury (ed) *Viewdata in Action, A comparative Study of Prestel*, p.162

[34] Efrem Sigel, *The Future of Videotext, Worldwide Prospects for Home/Office Electronic Information Services* (Knowledge Industry Publications, White Plains, 1983), p.2

[35] Efrem Sigel, *The Future of Videotext, Worldwide Prospects for Home/Office Electronic Information Services*, p .108

since the early days of the service.[36] Although the services offered included gateways to Information Providers for electronic commerce such as shopping and banking, this failed to inspire the masses of consumers to abandon their more traditional habits. Although attempts were made to solicit Information Providers for the popular cultural activities such as sport, these were not successful.[37] The way that charges were levied, that is a unit charge for each frame accessed, was considered to be a hindering factor as well.

When viewed in retrospect, Prestel was a conceptual success, not a commercial one. It was the first to provide many the electronic data services that were to later proliferate under the infrastructure of the Internet. Although Viewdata technology rapidly became antiquated with the phenomenal developments of microelectronic and data telecommunication technology during this period, it was used by a loyal user base until well into the 1990's. It introduced and made public the conceptual terrain of cyberspace, and many of the users would take this experience and apply it later to more universal and versatile technologies, such as the Internet.

Minitel

The French Minitel system was conceptually the same as the British Prestel, but where Prestel failed, Minitel succeeded. The French joint research centre for television and telecommunications (the CCETT[38]) began looking at teletext in 1973, with a view to improving the British CEEFAX system. The French had lagged considerably in widespread implementation of the telephone system compared to other European countries, and the 1970's brought in an era of the enthusiastic embracing of new technologies in attempts to modernise.[39] Work on an on-line viewdata-type service followed, with a prototype system, the Télétel 3V, being tested in households in 1981. Various configurations were tested, including television/keyboard combinations and a standalone integrated terminal that included a VDU. The ultimate aim was to get this on-line information system into every French home.

[36] Efrem Sigel, *The Future of Videotext, Worldwide Prospects for Home/Office Electronic Information Services*, p.94

[37] Efrem Sigel, *The Future of Videotext, Worldwide Prospects for Home/Office Electronic Information Services*, p.94

[38] CCETT stands for Centre Commun d'Etudes de Télévision et Télécommunication

[39] Renate Mayntz, Thomas Hughes (editors) The Development of Large Technological Systems (Campus, Frankfurt, 1988), pp.155-178

This ‘telematique’[40] system made use of the French data network TRANSPAC to route information from the communication centre that handled the telephone data connection to the Information Providers. More than 40 public agencies and over 100 private organisations participated in the Télétel 3V trail based in the Velizy suburb of Paris.[41] These included news and sports, train timetables, stock quotations, listings of organisations, services and tradesmen, government-supplied data on education, taxes, health and transportation. An email facility was also included. The trial concluded at the end of 1982. Extensive research was conducted to ascertain usage patterns which showed that 20 per cent of the users were responsible for 60 percent of the connection time and 30 per cent of the users ignored the device.[42] Another trail was held in the region of Rennes, which focussed on providing electronic telephone directory services. The intention of this was to do away with the costly printing of telephone directories as well as to develop an indigenous French manufacturing industry for producing electronic terminals in large quantities.[43] The initial 1500 terminals were installed in May 1981.

Although initially the plan was to only offer on-line telephone directory services, the new government under Mitterand backed down from imposing this, and gave subscribers the choice of the more traditional hard-copy telephone directory. This reflected an acknowledgement that mass consumer habits would and could not change overnight. Some commentators used the opportunity to question the underlying assumptions of a mass conversion to an age of electronic information retrieval.[44]

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[40] A word coined for the integration of computer and telecommunication technology.

[41] Efrem Sigel, *The Future of Videotext, Worldwide Prospects for Home/Office Electronic Information Services*, p.144

[42] Andre Lemos “The Labyrinth of Minitel”, *Cultures of the Internet* (Sage Publications, London, 1996), p.39

[43] Efrem Sigel, *The Future of Videotext, Worldwide Prospects for Home/Office Electronic Information Services*, p.147

[44] Efrem Sigel, *The Future of Videotext, Worldwide Prospects for Home/Office Electronic Information Services*, p.147

Fig. 2 **The Minitel Terminal**

Andre Lemos “The Labyrinth of Minitel”, *Cultures of the Internet*

(Sage Publications, London, 1996), p.36

In order to ensure widespread use, it was decided not to charge customers for the Minitel terminals (Fig 2). The Télétel system was generally referred to as Minitel. Distribution of these started at the end of 1982. Giving away free terminals and supplying free access to the electronic phone book (for the first three minutes) was to be a crucial factor in the success of the system.[45] Billing for services was introduced some time same later for **Kiosque** services, which billed not only on the serviced used, but also the connection time. This was independent of distance the data had to travel to arrive to the consumers. Cahrges were scaled according to the type of service.

Minitel was successful. In 1987 it was the world’s largest email system and 6.5 million terminals were in use by 1995.[46] However, it was not only the above factors that contribute to this success. From 1985 the services expanded to allow more social activities, including games, social bulleting boards and the first erotic bulletin boards, all of which reflected and satisfied broader cultural needs and aspirations. The *messageries rose* (the Pink Minitel) had broad support. When it became the object of moral sanction after controversy over on-line sex, a 1991 survey showed 89 percent of the French were

[45] Andre Lemos “The Labyrinth of Minitel”, *Cultures of the Internet* (Sage Publications, London, 1996), p.39

[46] Andre Lemos “The Labyrinth of Minitel”, *Cultures of the Internet*, p.41

against its prohibition.[47] Lemos argues that it was "in reality a social expression of the vitalism which struggles to maintain technique".[48]

Another factor which contributed to its popularity was that in parallel with the official system, a network of alternative activity emerged on what was called the RTC servers. The first of these, operating on hacked server software running on personal computers, emerged in the early 1980's in the form of Bulletin Boards (BBS). Access to these were free, since they were accessed through the '3614' services of Télétel.[49] The RTC servers provided a haven for cyber anarchism: open discussions on many on-line forums, real time chat and email services, and the electronic downloading of software. The effervescence of the alternative networks made the Minitel cheaper and more sociable that the official Kiosque system. These networks were not controlled by the French Télécom.[50] This is what came to result in a Minitel cyberspace:[51]

> 'The Minitel cyberspace is thus a complex ecosystem where the macro-system (the network administered by France Télécom) and the microsystem (the daily dynamics of users) are interdependent. This ecosystem is constructed through the dissemination of information, through a flux of data'

As has been shown, the Minitel system offered vast scope for the social construction of this technology. The Internet, once popularised and extensive, provided the same environment more than 10 years later. With Minitel, ordinary users (Information consumers) had the opportunity and power to become Information Providers, another key aspect which was to contribute to the success of the Internet.

List Servers

An electronic mail message is normally a one to one process. A person with an email account sends a message to another person reflects a traditional one-to-one type of correspondence. Email has the

[47] Andre Lemos "The Labyrinth of Minitel", *Cultures of the Internet*, p.40
[48] Andre Lemos "The Labyrinth of Minitel", *Cultures of the Internet*, p.41
[49] Andre Lemos "The Labyrinth of Minitel", *Cultures of the Internet*, p.41
[50] Andre Lemos "The Labyrinth of Minitel", *Cultures of the Internet*, p.42
[51] Andre Lemos "The Labyrinth of Minitel", *Cultures of the Internet*, p.42

major success story of electronic data networking, right from the early days of ARPANET where it made an inconspicious entry and the first service to actually generate data traffic[52]. It reflects a broader sociological need, and one that was rapidly embraced by users wherever it was made available. This one-to-one system developed into a one-to-many through the development of software such as Listserv. It was a simple list management system, where a group of people could be communicated with by a single email message. This group is maintained by Listserv, and members and join and leave at their own will, although many there were many other ways of configuring the Listserv service.[53] Electronic communication facilities like these resulted in the creation of virtual communities, groups of people who communicate via email and have a sense of belonging to something.

List servers proliferated at a phenomenal rate on the Internet with its popularisation in the 1990's. However, the concept goes back to a network and community of users that were entirely independent of the ARPANET developments. That was the Bitnet network, which primarily linked IBM computers at academic installations. This was initiated in 1981 as a technical cooperative between universities on the East Coast of the USA, and whilst the bandwidth of the connections was limited, it was suitable for the transfer of email. By 1984 Bitnet connected 157 computers, and underwent continued growth until the emergence of the Internet as dominant in 1992.[54] There were more than 200 copies of Listserv supporting over 3000 discussion groups. Besides the ever-popular email, the introduction of Listserv in 1987 proved to be a lasting legacy of Bitnet. Users did not need any special software to use it, since all communications were done through the standard email client software application. It was easy to configure new groups, allowing a rapid proliferation of cyber-communities, linked via interest groups. The options for members allowed them to participate in a number of ways which suited them, including receiving a daily digest of all communications.

As discussed by Grier and Campbell, the archives show that discussion in certain technical groups centred around facilitation of the growth of the Bitnet network. The Listserv hosted discussions where members could make propositions regarding development and expansion of the network, discuss them

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[52] Abbate, *Inventing the Internet*, p.106

[53] These included the ability to create closed groups where members ship is more tightly controlled, and the control over who can send messages to the list.

[54] David Grier, Mary Campbell, “A Social History of Bitnet and Listserv, 1985-1991", *IEEE Annals of the History of Computing*, (Vol 22 #2, April 2000), pp.33-41

thoroughly, and by common consensus agree on them. It could thus be considered self-perpetuating, a characteristic generally thought to be unique to the Internet.

As TCP/IP networks became more dominant in the early 1990's, the Bitnet/Listserv communities began to wane. However, the Listserv program was ported over to the Unix operating system in 1991, freeing it from the proprietary hold of the IBM mainframe. The Listserv communities ultimately migrated over to the Internet, where they proliferated, but on a much grander scale, for the same reasons as they did on the Bitnet network.

Usenet

Different types of communication emerged from electronic data networks, email was just one. Parallel to the development of the ARPANET, other methods of exchanging electronic information on a personal or group basis were developed.

Usenet was a grassroots system built with no formal funding. The first instance of this network was setup n 1979 at Duke University, where graduate students a programmed their Unix computer to automatically and periodically link up with other Unix systems. They used homemade auto-dial modems, the Unix-to-Unix copy program (uucp) and some shell programming, to build a system that automatically replicated files over a series of computers. After some development, the final system was presented at a Summer 1980 Usenix conference, where a handout explained "A goal of Usenet has been to give UNIX systems the opportunity to join and benefit from a computer network (a poor man's ARPANET if you will)".[55] It was described as such since only the most elite academic institutions formed part of the ARPANET. In contrast, Usenet was available to all who were interested, as long as they had access to the Unix operating system, which was available at low cost to the academic and computer research community.

[55] Michael Hauben, Ronda Hauben, *Netizens, On the history and impact of Usenet and the Internet,* (IEEE Computer Society Press, Los Alamitos, 1997), p.41

Usenet was more than just a system to transfer files between computers. It was used to distribute email, as well as a structured group discussion system called netnews, more broadly known as newsgroups. These emulated an interactive newspaper, but allowing the reader to be selective. More importantly, readers could participate in discussion threads, therefore contributing to the flow of information. The Unix developers at AT&T's Bell Labs provided a lot of support for Usenet, since they realized savings of millions of dollars on development by using the Usenet community for help with debugging their software.[56] This in turn enabled the network to further proliferate, since Bell Labs provided a lot of resources that helped with the distributional logistics of the network. Digital Equipment Corporation (DEC) also supported Usenet, and ultimately the spread of Usenet and Unix encouraged the sale of computers that ran the Unix operating system. The Usenet newsgroups communities provided considerable technical help for peers.

By 1982, the Usenet network was growing rapidly. Its growth measured in number of sites and articles per day, almost double yearly until 1988.[57] The scale of this growth took the original Usenet community by surprise since it was not anticipated. In fact, the pioneers of the Usenet community feared that the growth was too rapid and could not be sustained. However, seemingly insurmountable problems were investigated and solved by the Usenet community. They referred to Usenet as 'the Net' and were often referred to as 'netizens', terms popularly ascribed to the Internet. Many communities in the USA and around the world established Free-Nets, based on free Usenet software. The popularity of the mass produced Personal Computers and modem of this period meant that Usenet became more accessible to individuals and small organisations via dial-up UUCP connections. Some of these Free-Nets had access to the worldwide newsgroups of Usenet.

Besides Bell Labs involvement, Usenet was noncommercial. It was felt by the community of users that it "should not be allowed to be abused as a profit-making venture for anyone individual or group. Rather, people are fighting to keep it a resource that is helpful to society as a whole".[58] Any form of commercial advertising was rebuked strongly by users, who did not want to see the forums clogged and congested.

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[56] Michael Hauben, Ronda Hauben, *Netizens, On the history and impact of Usenet and the Internet,* (IEEE Computer Society Press, Los Alamitos, 1997), p.43

[57] Michael Hauben, Ronda Hauben, *Netizens, On the history and impact of Usenet and the Internet,* p.44

[58] Michael Hauben, Ronda Hauben, *Netizens, On the history and impact of Usenet and the Internet,* p.55

A gateway through to the ARPANET was established in 1981 at The University of California at Berkeley.[59] Initially this provided a communication path from a similar service on the ARPANET, with the Usenet community only having read-only access to ARPANET news. At first this was illegitimate, since the ARPANET had strict policies against interconnection. However, this gateway with Usenet ultimately forced a reexamination of these policies, resulting in more interconnection between independent networks and the ARPANET.[60] As TCP/IP-based networks proliferated, the demands for Usenet newsgroups on these networks increased. The Network News Transport Protocol (NNTP) was made an Internet service with RFC977[61] in February 1986, and enabled the Usenet newsgroups to be stored and accessed on TCP/IP networks. Ultimately the migration over to the Internet was complete, however in 1992 whilst 60 per cent of the Usenet traffic was carried over the Internet via NNTP, the remainder of 40 percent was still being carried on the slower UUCP connections.[62]

Hypertext

The concept of hypertext is taken to an inventive component of the World Wide Web (WWW), the application that brought the phenomenal popularity to the Internet in the 1990's. However, hypertext dates back to the mid-1960's.[63] In the ARPA-funded 'Augmentation Research Centre' in California, researchers developed a 3D user interface commanded by a mouse. An 'automatic link-jump' was performed by selecting a specific icon which took the user from one document to another. This was a significant conceptual leap because this function implied virtual activity, that is selecting that hypertext icon took the users to another 'place'.

Further important conceptual work with computer-user interfaces was done at the XEROX PARC by American scientists who became disenchanted with legislation during the Vietnam war era. This legislation sought to limit ARPA funding only to weapons research laboratories and caused an exodus of scientists who opposed this policy. It remained dormant until the founder of Apple Computers, Steve

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[59] Michael Hauben, Ronda Hauben, *Netizens, On the history and impact of Usenet and the Internet,* p.52
[60] Michael Hauben, Ronda Hauben, *Netizens, On the history and impact of Usenet and the Internet,* p.52
[61] http://www.ietf.org/rfc/rfc0977.txt
[62] Michael Hauben, Ronda Hauben, *Netizens, On the history and impact of Usenet and the Internet,* p.54
[63] Ken Hillis "A Geography of the Eye: The Technologies of Virtual Reality", *Cultures of the Internet* (Sage Publications, London, 1996), p.81

Jobs, toured the facility. This inspired the Apple Mackintosh computer, which reached the market in 1984. Software applications developed by Apple for this computer made use of, and popularised the concept of hypertext.

Conclusion & Discussion

In Chapter 1, the alternative data networks that predated and ultimately gave rise to the emergence of the Internet as the dominant global data communication system were discussed. The issue of technological lock-in of the TCP/IP protocol in global data networks were considered. As shown, the essential ingredient in both these issues was predominantly the extensive and independent system of data networks that proliferated in the mid to late 1980's. Path dependency is an important factor in understanding technological lock-in this instance, and this study reveals the extent to which the TCP/IP permeated in many sectors. Despite the attempts of the global telecommunications industry, represented by the International Standards Organisation and the CCITT, to impose the OSI standards, the TCP/IP protocols that constituted the Internet continued to flourish. The OSI protocols failed.

Although it had its origins is the seminal ARPANET, the growth to the Internet was not a continuos and linear one, where the military system was transformed into a civilian and commercial one. Whilst this process is comprehensively described by Abbate, the span of networks that grew independently have not been given due consideration by historians. The rapid proliferation of TCP/IP networks as described in Chapter 1 shows how extensively this technology proliferated, independently of the ARPANET. In addition to the TCP/IP networks, there were many other networking systems. However inter-translation between these systems through gateways meant that they did not have operate in isolation and could participate in the organic whole of a meta network. The Internet arose from the inter-networking of many independent networks. This growth was unanticipated and unplanned.

To understand the success of the Internet, we must look beyond purely technical considerations. The culture in which this technology was embedded needs to be understood and acknowledged. A substantial community grew and existed around this computer communications technology, which included human resources, industrial resources, as well as the non-hierarchical cooperative style of development that most of the technology originated from. When considered holistically, this resulted in a substantial technological and cultural momentum that not only resulted in the Internet's phenomenal growth, but also resilience from the ISO's attempt to impose the OSI standards. Furthermore, this momentum carried the technology into other sectors. For instance, skills developed by students at the academic institutions where a lot of the initial development took place, proliferated into industry and commerce when these graduates took up professional positions. The basis of all of these developments can be further understood by acknowledging that the history of electronic computer development is steeply entrenched in academic and research institutions, as elaborated by Herman Goldstine.[64] The communication technologies of the Internet largely originated from this environment.

The Internet spans an interesting period in the late 20th Century science and technology. That the resilient design of the initial ARPANET stemmed from Cold War fears of nuclear annihilation, and is well documented by Hughes and Abbate. However, the counterculture movement in the mid to late1960's spurned a generation of students who were inspired by Lickliders influential 1960's paper on “Man-Computer Symbios”. With the proliferation of computing technology at their disposal, they proceeded to make use of these resources to create a communication system that bypassed traditional authority figures and their inherent tendencies to control information. Although this was initially elitist, with resources being confined to a selection of academic and research institutions, it rapidly disseminated and proliferated in the late Cold War period. The explosive growth of the Internet took place in the post-Cold War period, when restrictions on technological export regulations from the USA were relaxed, and the international community embraced the flow of unhindered and uncensored information in a climate of international freedom..

In Chapter 2, some of the many developments in Information Technology that preceded and predated the Internet were examined. These were selected because with many of these, the features, facilities and services provided are synonymous with the broad public perception of the Internet as it is known. However the Internet was not invented as a complete technological system. Many of the vital ingredients that led to its popularity and public embrace predated it by more than 20 years. As Edgerton discusses, the focus of historians when writing about technological developments is generally on invention, not change nor failure.[65] This holds true for most accounts of the Internet, since the many features that give that system its value originated from other alternative information technological

[64] Herman Goldstine *The Computer from Pascal to von Neumann*, (Princeton University Press, Princeton, 1972), p.251

[65] David Edgerton, *"Ten (eclectic) thesis on the historiography of technique"* Annales HSS (1998) - English typescript

systems. As shown, these systems either failed (for reasons mostly other than the value of the services offered), became redundant with the growth of the Internet, or ultimately merged with it. Generally they were the product of pioneering visionaries, whose innovations merged the rapidly proliferating Information Technology with general public needs and aspirations. The public data access system of British Prestel was shown to be a conceptual ground breaker in this regard. However, it was not the success its innovators had anticipated. This was partly due to technological limitations, the limited participation by information providers and even cultural indifference. However, in comparison to the vastly successful French Minitel system, other limitations become apparent. The facilities of Minitel, much like the Internet more than 10 years later, provided scope for the users to construct and shape the services of the system according to their needs. The success of Minitel illustrates that when the trajectory of a technology is such that it can facilitate participation from a social group, it is shaped to suit their needs. The immediate result of this is that the chances of that technology being accepted by that community are much higher, and therefore the probability of its success. This is social construction of technology systems aspects, where social groups construct and shape a technological system to meets their needs and is comprehensive described by Bjiker, Hughes and Pinch[66]. This same analysis applies on an even grander scale to the Internet, where most of the functionality and resources were created and provided by the user community, and must be seen as a crucial factor in explaining the success of the Internet.

The Usenet and Listserv systems discussed are excellent examples of services built on digital electronic communications technology that developed and proliferated extensively and independently of the Internet's predecessor, the ARPANET. However, both of these are popularly associated with the Internet. Due to the portability of computer software, these services were able to migrate to Internet technology when it became appropriate, taking with them the large community of users that had been established well before then. These systems then went onto constitute crucial components of the Internet, and could be regarded as substantial factors in it's popularity and rapid proliferation. This is an example of how popular accounts of history of the Internet omit these alternatives, and portray all that

[66]Wiebe Bijker, Thomas Hughes, Trevor Pinch (editors), *The Social Construction of Technological Systems*, (MIT Press, Cambridge, Massachusetts, 1989)

makes the Internet as being developed or invented along with it. Instead, as shown, many independent technologies converged together to form this system.

Undoubtably there are many other considerations to be made in explaining the success of the Internet, which have not been dealt with here. However, two important aspects have been covered. Firstly, the culture of Internet development that gave rise to the TCP/IP protocol being locked-in and extensively proliferating, despite the threatening OSI standards. Secondly, some of the alternative public information technology systems that developed independent of ARPANET. These broke cultural barriers, and established and entrenched these services within these communities.

I have discussed the importance of a social construction of technology analyses when understanding the success of the Internet. However, there are also Technological Deterministic aspects. For example C.R. Licklider two extraordinary papers, Man-Computer Symbiosis (1960) and The Computer as a Communications Device (1968, coauthored with Robert Taylor), Licklider described his vision of computing (1960), which led to the funding priorities of the unit that funded ARPANET, which helps explain why the Internet was built. In the second (1968), he discusses the future, presciently arguing that by the Year 2000 millions of people would be on-line, connected by a global network.[67] Ultimately these vision were realised, and therefore this technology did drive history. Whilst much of the Internet's growth was organic and socially constructed, these pioneer's visions have largely been realised. However the visionaries contributions were to provide the framework and foundations for users to further construct the system. This is what makes the Internet unique in comparison to the other classical mass communication and other large technological systems. The facility for user-driven organic growth ultimately led to a Darwinian 'fit' with society, in the sense that the technology which worked or fulfilled a need, survived to proliferate.

Lastly, in comparison with other technological systems, it should be noted that the history of the Internet is characterised by the lack of patents. In fact, the ethos of development with the ARPANET was one of openness, collaboration and sharing of information with non-hierarchical management in a non-commercial environment. This culture, embedded in the various mechanisms of development, was

[67]http://memex.org/licklider.html

carried forward to the Internet once it was commercialised and popularised. In this the Internet stands well apart when compared to the controlled flow of technology of other mass communication systems where Winston's 'Law of the suppression of radical potential'[68] can be applied in many instances. For example, the suppression of high fidelity FM radio technology by RCA in the 1930's.[69] The lack of patents implies lack of control over a technology. This is not only in purely monetary or manufacturing terms, but also from an innovation point of view. The essential mechanisms of the Internet provided a basis for the freedom of innovation, largely because they were not subject to proprietors, patentees or in fact any control. This unprecedented phenomena must therefore be seen as unique in the history of technology.

[68]Winston holds that this law curtails the success of the mass communication technology, and it only reaches widespread diffusion after a significant period of time.

[69]Brian Winston, *Media Technology and Society, A History: From the Telegraph to the Internet,* (Routledge, London, 1998), pp.78-79, This led ultimately to the inventors (Edwin Armstrong) suicide

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Appendices

1) **The TCP/IP and OSI protocol stacks compared**

Protocol	RFC	MIL-STD	Description
Presentation layer			
ASN.1	X.208, X.209	DIS 8824, DIS 8825	Abstract Syntax Notation One
XDR	1014		Sun External Data Representation
RPC	1057		Sun Remote Procedure Call Protocol
Applications			
TELNET	854, 930, 1041, 1043	1782	Remote login
FTP	959	1780	File Transfer Protocol
NTP	1059		Network Time Protocol
SMTP	821, 974	1781	Simple Mail Transfer Protocol
Mail	822		Basic mail format
DNS	1034, 1035, 1032, 1033, 974		Domain Name System
X.400	987, 1026		X.400/RFC822 address conversion
Network management			
SNMP	1067, 1065, 1066		Simple Network Management Protocol

Table 1 The TCP/IP Higher level protocols. Quaterman, *The Matrix* (Digital Press, 1990), p.50

Protocol	CCITT (IEEE, RFC)	ISO (ANSI)	Description
5. Session layer			
	X.215, X.225	ISO8326, 8327	Connection-oriented
6. Presentation layer			
ASN.1	X.208, X.209	ISO8824, 8825	Abstract Syntax Notation One
		DIS 8822, 8823	Connection-oriented
	X.409		MHS Presentation
7. Application layer			
VTP		ISO9040, 9041	Virtual Terminal Protocol
FTAM		ISO8571, 8572	File Transfer, Access and Manipulation
JTM		ISO8831, 8832	Job Transfer and Manipulation
MHS	X.400		Message Handling System
MOTIS	X.400		Message-Oriented Text Interchange System
	X.500		Directory service for X.400
Network management			
CMIP		DP 9595/2, 9596/2	Common Management Information Protocol

Table 2 The OSI Higher level protocols. Quaterman, *The Matrix* (Digital Press, 1990), p.52

2) **Summary of 33 major public and private data networks in North America prior to 1990.**

Summarised from John S. Quarterman, *The Matrix, Computer Networks and Conferencing Systems Worldwide* (1989) unless otherwise specified.

Table 3

Network name	Historical summary
AMPRNET	The Amateur Packet Radio Network was developed and used by short wave radio amateurs globally. By 1985 there were 30000 with on this network The KA9Q suite of Internet utilities were developed and were available for free distribution for non-commercial use. This work led to the discovery of problems with TCP protocol, and solutions were implemented in 1985. It's low cost meant that extensive use with the amateur radio community, though this technology does not seem to have gone further than that sector due to it low speed and latency.
BARRNet	This was the San Francisco Bay Area Regional Research Network which consisted of non-profit educational organisations, government research facilities and other affiliate institutions. This included famous infamous research institutions such as the NASA Ames Research Centre and the Lawrence Livermore National Laboratory. It was established mid-1986. Included in 1988 were the networks of Apple Computer, Hewlett-Packard Labs, 3Com and other Silicon Valley IT corporate research labs. TCP/IP was used exclusively with high speed T1 links. Several gateways existed to other nets although this was carefully controlled by a technical committee. It was the last regional network to connect to the NFSNET backbone on in 1988.
BITNET	Although generally limited to academic institutions, BITNET had grown to over 2300 hosts in 32 countries by August 1988, and was one of the largest worldwide networks at that time. It was never supported by government funding but was linked to IBM installations at academic institutions and widely used by academics outside the ARPANET. It's major services were email, mailing lists and file transfer, but remote login and general file transfer were not supported. The underlying protocol was IBM's NJE (Network Job Entry). Although this network originated in the USA, it incorporated similar networks in Canada (NetNorth), EARN in Europe and ILAN in Israel. There was gateways to most other networks

Network name	Historical summary
CERFnet	The California Education and Research Foundation initially (1988) consisted of about 180 hosts. It was founded to advance science and education by assisting the interchange of information by high-speed data communications. More specifically, it was intended to provide high speed access to the supercomputer centres, which permitted many scientific projects that could not be previously undertaken. It extended beyond purely academic institutions, and was partially funded by the NSF. Link speeds varied from 9600 bps to T1.
CICNet	CICNet was the Committee on Institutional Cooperation Network which consisted of 11 institutions of higher education in the mid western states of the USA. Planning begun in 1987 and it became operation in January 1989. It was funded by the NSF.
CSNET	This was established with initial funding by the NSF in 1981 to facilitate research and advanced development in computer science and engineering in the USA and Canada. Initially it was built to facilitate email only to provide that highly popular service to institution that were not connect to the exclusive ARPANET. It's membership comprised of industrial, academic, governmental and non-profit institutions engaged in this work. It is comprised of several physical networks. Connection through to the Internet was one the principal benefit offered. It consisted of 180 hosts in 1989. The physical connections span multiple media, which include public data networks, dedicated leased lines and personal dial-up SLIP accounts. The success of CSNET led to the proposal of the NFSNET. It later merged with BITNET to become ONEnet.
Defence Data Network	This was a TCP/IP network operated by the U.S. Department of Defence. It was composed of the former ARPANET and MILNET and other military networks. It is used for operational organisation, and is global. In 1989 it consisted of 1500 hosts.
EASYnet	Even thought Digital Equipment Corporation was a contractor for ARPANET, they developed their own network protocols and software called DECNET. This was used as a corporate international network from 1978. This not only included the standard networks services such as email and file transfer, but corporate organisational tools such as ELF (Employee Locator Facility), a Videotext database and online network conferencing. It grew to 34000 hosts and 80000 users by 1989.

Network name	Historical summary
FidoNet	FidoNet was a very popular network based on the MS-DOS personal computers, and in operation since1983. It offered simple email and conferencing. All traffic travelled as email via routing nodes. It was not designed to be a commercial venture and was widely used by the United Nations and non-governmental and development organisations around the world.. In 1989, it had 220 conferencing areas and 2500 hosts connected. The zones it was divided into extended across the world. Although originally it was confined to the MS-DOS operating system, it was ported to other PC operating systems including the Apple, Amiga and other personal computers. Connections were made via dialup modems over the PSTN but utilised the proprietary Fido protocol. Post-1987, a gateway became available to UUCP mail and the Internet.
HEPnet	This was a high speed network which originated in the United States and spread to most places where High Energy Physics (HEP) was done. This meant that is was a major European network and it spread to Japan as well. There were 1000 hosts by the end of 1987 and 5000 by the end of 1988. The DECNET protocols were used widely on HEPnet, since Digital mini-computers were used widely by physicists. Ethernet and X.25 was used widely though TCP/IP was not used since it was believed that it was not suitable for transferring the large data files physicists used. There was interconnections to the Internet, BITNET, EASYnet and Starlink
Hewlett-Packard	Hewlett-Packard ran a global corporate network called the HP Internet. It was based on the TCP/IP protocol and was considered in 1989 to be the largest TCP/IP network outside the Internet. It consisted of 12000 hosts and 200 routers in 1989, up from 6500 hosts in 1988. On top of the staff communications, it was used for software distribution, source code development and collaboration and project management. The TCP/IP network was also used as a testbed for HP networking products, a market which it began to develop an increasing share in. A variety of communication links were used, initial UUCP links were phased out in 1985, and later use was made of X.25 links and their own microwave and satellite services. communication services. A gateway to the Internet was added in 1987 and CSNET in 1988.
JVNCNet	This was a consortium network connecting several supercomputers at the John von Neumann Supercomputer Centre (JVNC) in Princeton, New Jersey to a regional research community consisting of 24 sites. It was interconnected to the ARPANET, BITNET, TYMNET and NORDUnet by 1989.

Network name	Historical summary
Los Nettos	This was a regional TCP/IP network that was funded and used by academic institutions in the Southern California area in 1988. The initial members included Caltech, Trusted Information Systems (TIS), the Computer Science department of UCLA and the University of South California and the Information Systems Institute (ISI). It was part of the Internet but had no financial or administrative ties to DARPA or the NSF or any other federal government agency. All the links were high speed (1.5Mbps). It is managed co-operatively by its members.
Merit	This was a region network of a consortium of Michigan Universities. It began in 1972 using a proprietary protocol and was contracted out to a private company, Merit, Inc. Initial funding was by the NSF though operational costs were covered by member universities. By 1986 it consisted over 300 nodes. A move towards implementing TCP/IP was made only in the late 1980's. X.25 services were provided.
MIDnet	MIDnet consisted of 15 mid western Universities and was initiated in 1985. Although TCP/IP was predominant, other protocols were used including DECNET and SNA, however the participating organisation were responsible for protocol conversion. The original funding came from the NSF.
PRNETAMPRNETLos NettosMRNet	The Minnesota Regional Network was initiated in 1987. It connected academic institutions and research organisations and corporates including the Control Data Corp., Cray Research, Honeywell, 3M Corp and others. Organisations with resources such as the Minnesota Supercomputer Centre were connected as well. There were more than a 1000 hosts on MRNet in 1989. There were ARPANET, BITNET and USENET gateways.
NCSANet	This was a regional network that connected the resources of the National Centre for Supercomputing Applications. By November 1988 there were ten sites in Indiana, Illinois, and Wisconsin. The links were high speed T1 and the TCP/IP protocol was used exclusively. The NCSAnet was one of the sites on the original NFSNET backbone.
NorthWest Net	This provided data services to academic and research organisations in six northwestern states. This included industrial giants such as the Computer Services division of Boeing. It was initiated in 1987. The protocol used was TCP/IP although DECNET was supported on some routes. The circuits included a satellite link to Alaska. It was connected to the NSFNET via a T1 digital radio link

Network name	Historical summary
NYSERNet	This was initiated in 1985 as a collaboration between universities and several commercial corporations in the State of New York. There were 27 sites connected in August 1988 which included the Cornell National Supercomputer Centre and the NorthEast Parallel Architecture Centre. TCP/IP was used since inception. There are direct links to ARPANET and NFSNET and a gateway to BITNET. What is interesting about NYSERNet is that it contributed significantly towards the development of protocols for the management of networks. The Simple Gateway Monitoring Protocol (SGMP) and the later de-facto Simple Network Management Protocol was implement by NYSENet. They also worked towards developing electronic library access protocols.
OARnet	This was a general-purpose network that connected academic institutions in the state of Ohio, which became operation in 1987. However, it was primarily conceived to facilitate remote super computer access from the Ohio Supercomputer Access Centre. Three protocols that were supported initially were TCP/IP, DECNET and NJE, although the stated preferred protocol was ISO-OSI. TCP/IP was used as the migration path for networks using DECNET and NJE.
PHYSNET	This was the Physics Community Network and was a combination of many DECNET-based physics research networks thus could be considered an internet. This included HEPnet, SPAN and NYRO as well as CITNET and THEnet. It was used by NASA and the ESA, which co-ordinated numbering for it.
PRNET	PRNET was the Experimental Packet Radio Network established in the San Francisco Bay Area for experimental purposes. It was proposed in 1979 and developed over a period of four years. It was funded by ARPA and was important in shaping the functioning of TCP/IP. It use and growth is not documented.
SDSCnet	This was the consortium network of the San Diego Supercomputer Centre (SDSC). It was initiated in 1986 to provide access to supercomputers. It was connected to MFEnet, HEPnet, SPAN, BITNET and TYMNET. The MFEnet NSP protocols were used since this is what was used at the SDSC, although TCP/IP and DECNET were catered for in a limited way. This network actually lost sited to other NSFNET regionals that had better support for TCP/IP. It was envisaged that migration to ISO-OSI would take place.
Sesquinet	This connected research site in the state of Texas together and to the NSFNET backbone. The TCP/IP protocol was used exclusively. Initially it linked up six nodes primarily in the Houston area. It was first proposed in 1986 , implement in 1987 and by the end of 1988 consisted of 15 sites.

Network name	Historical summary
SURAnet	This was the network of the Southeastern Universities Research Associations Network in the 12 southeastern states initially to provide remote access to supercomputers at the member universities. SURA consisted of 35 research universities. It was operation since 1987.
Tandem	This was a global corporate network of the Tandem Computer Company. It that ran a proprietary protocol (EXPAND) and was unique in that there were no incoming connections from any other network. The network is implemented as a large distributed operating system. In-house software application suites were developed which made extensive use of the network and rapidly became a indispensable part of the corporation. There were gateways to other services, for instance employees could make use of Bank of America’s electronic banking services.
THEnet	This was the network of the Texas Higher Education Authority, which in 1989 consisted of several thousand hosts in academic, medical, research and corporate institutions in Texas. Close to a thousand of these used DECNET as a protocol thought the rest (particularly on campus networks) used TCP/IP. The merger of three smaller networks, two of which went back to 1984, formed THEnet. Several links to other networks were established, including NSFNET, BITNET, CSNET and SPAN.
USAN	The University Satellite Network connects eight universities and research organisations via satellite utilising Very Small Aperture Terminal (VSAT) Technology. They are connected to the NSF backbone at NCAR. This technology provided relatively fast download speed from the NCAR central node and a slightly faster upload speed. There was also a gateway to BITNET and SPAN.

Network name	Historical summary
USENET	USENET is unique in that only one service was offered, that is structured and threaded discussion lists. It developed by academic institutions in the USA independently and in response to the ARPANET, which was confined to campus contracted by Defence Agencies. It was known as the 'Poor man's ARPANET'[70]. It began in 1979 and is one of the oldest cooperative networks. In 1989 there were 265000 users and 9700 hosts on five continents. USENET was built on Unix and uses the UUCP protocol to transfer information between hosts over dial-up modems and standard telephone lines. It had a decentralised architecture with no central funding: each host paid it's own way. Commercial use was frowned upon and discouraged. Gateways were eventually established to a similar service on ARPANET (The Internet), BITNET, and EASYnet. Initially the gateway to ARPANET was read-only, that is USENET users could only read ARPANET newsgroups. USENET was widely used by the developers of the UNIX operating system (Bell Labs) for participation of the user community in development and debugging of features. User growth and use exceeded technological capacity during the period 1983-1986 and it's demise was often predicted. However, Network New Transfer Protocol (NNTP) was developed for transporting news over TCP/IP, and eventually the entire USENET migrated over to the Internet.
UUCP	Unix to Unix Copy Program (UUCP) protocol was first distributed with the 7th edition of UNIX from AT&T Bell Laboratories in 1978. It provided the facility to automatically transfer electronic mail across a large area via inter-connection of adjacent hosts and was commonly used for international connections. The UUCP network was claimed to be 'the most distributed network in the world'[71]. The was no central authority determining access, all that was required was a connection to a nearby host via a modem. Setting up a connection was relatively simple. The UUCP network connected a diverse range of computer equipment, from mainframes to minicomputers to workstations to personal computers. It was estimated that in 1989 there was 10 000 hosts on this network and more than a million users. The UUCP protocol was used mainly over dialup on the PSTN, using the RS-232C Interface on a the computer. There were later adaptations that permitted use of X.25 and TCP/IP

[70] Michael Hauben, Ronda Hauben, *Netizens, On the history and impact of Usenet and the Internet,*
[71] Quarterman, *The Matrix,* p.251

Network name	Historical summary
VNET	Formed in 1978, this was IBM’s Internet network which provided a suite of services such as email, remote login and file transfer to employees world wide. It consisted of around 2300 hosts at the end of 1986. Whilst it had links to external networks, users has to register to be able to communicate via email to accounts outside the network. It used the proprietary NJE protocol
WESTNET	This network covered the five mountain states of Colorado, New Mexico, Arizona, Utah, and Wyoming. There were 16 academic sites and four research sites including the Los Alamos National Laboratory, the Air Force Weapons Laboratory. The protocol used was exclusively TCP/IP. It was primarily set up to relieve congestion on the NSFNET backbone. It was setup in 1988.
XEROX	The XEROX network started off in 1976 and spread rapidly to connect many offices around the world. By 1984 it consisted of over 12 000 users. A proprietary protocol XNS was used, together with PUP and TCP/IP. There were email and Telnet and FTP gateways to the Internet.