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# Key characteristics that distinguish the Internet

Source: Richard Hill, APIG - Member of Informal Expert Group

The Internet as a collection of protocols, services and applications is obviously different from previous communications technologies, for a number of reasons which we will analyse in more detail below. From the user’s perspective, it offers an amazing breadth and depth of services and information, at very low cost—in developed countries: as we will see below, the cost is relatively higher in developing countries. The services and information can be accessed from anywhere in the world, usually easily and usually with reasonably fast response times—again, in the developed world: access speed is typically much lower in the developing world.

In many ways, this can lead to thinking that the Internet is somehow “borderless”. But, as we will see below, this is not the case. Nor is the Internet immune from state actions, even if its routing is not based on national borders and thus it may be more difficult for states to enforce certain laws.

It is sometimes said that end-to-end, packet-switching, and connectionless operation are unique characteristics of the Internet. As we will see below, this is not so *per se*. The world’s oldest electronic communication system, telegraphy, had exactly the same characteristics. But of course the meaning of end-to-end has changed dramatically, since telegraphy could be used only to transmit directly written messages between people, while the Internet offers a far richer array of services, in particular enabling communications between computers. Indeed the use of the Internet in conjunction with computers used by end-users is what makes the current situation different from past situations.

As we will see below, lack of strong authentication is a distinguishing feature of the Internet, as is routing that is not based on national borders, as is a highly centralized naming system and these characteristics are extremely important when combined with the use by end-users of computers that are interconnected through the Internet.

And two other characteristics also distinguish the Internet from other communication systems: Internet users mostly pay for the traffic that they receive, not for the traffic that they send; and the world-wide-web provides all users with the capability to publish information at costs that are much lower than the publication costs for other broadcast services.

Thus it can be said that the key characteristics that distinguish the Internet are that it is the first public communication system that:

1. Interconnects personal computers.
2. Is prevalently funded on the basis of the principle of “receiver pays”.
3. Does not impose identification of the originator of communications.
4. Allows anybody to publish at very low cost information that can be accessed anywhere in the world (unless steps are taken to impede access[[1]](#footnote-1)).
5. Is routed primarily without reference to national borders.
6. Uses a highly centralized naming system, the Domain Name System (DNS).

We will now analyze in more detail various characteristics of the Internet and various claims that have been made regarding those characteristics.

**1 Preliminary remarks**

As noted elsewhere it cannot be said that the paradigm of Internet as a model for unfettered borderless communications is widely accepted, thus it cannot be said that this paradigm is an accepted key characteristic that distinguishes the Internet.

This paper uses the term “Internet” to refer to a complex set of protocols, services, and applications. In that sense, the Internet comprises at least the following (the list is non-exclusive, non-exhaustive and some items may overlap):

1. *Protocols*
   1. Standards for the physical layer such as DSL, WiFi, etc.
   2. Standards for the network and transport layer such as TCP/IP, etc.
   3. Standards at the presentation layer such as HTML, MPEG, PKI, etc.
   4. Hardware and software to implement those protocols
2. *Services and applications*
   1. Domain name resolution
   2. World-wide-web, including numerous corporate and personal web sites, blogs, etc.
   3. E-Mail
   4. Search engines
   5. Music, video, game, etc. download services
   6. e-commerce, in particular for airline transport, books, videos, etc.
   7. Social networks
   8. Voice communications (both retail and wholesale)
   9. Audio and video conferencing
   10. Instant messaging
   11. Hardware and software to implement those services and applications

There has been a tendency to compare this complex collection of protocols, services, and applications to the telephone network of the 1960s. For example, it has been stated that “In telephony the terminal device, the handset, is a very simple pair of analogue transducers, namely a speaker and a microphone.”[[2]](#footnote-2)

That was true in 1960, and even in 1970 (when the transducers for computers were a keyboard and a printer or at best a low-resolution screen), but it is no longer true for the vast majority of telephone terminals, which are mobile phones whose embedded computing power is greater than that of most computers deployed in 1960 or in 1970 (this is true even of mobile phones that are not smart phones). Indeed, a mobile phone must contain hardware and software that implements the Signalling System 7 protocol, which protocol underpins the world’s largest (in terms of number of users) connectionless packet-switched network (whose switching and routing are, however, not comparable to those of the Internet). Thus a significant part of today’s telephone communications function is contained within end-user elements such as the handset and relatively decentralized elements such as mobile base stations.

Some Internet services could be provided (and indeed were originally provided) without relying on TCP/IP or other Internet protocols. Of course domain name resolution is not in that category, nor is the world-wide-web. Thus it cannot be said that all the services *per se* are a distinghishing characterstic of the Internet, but what is new and distinct from the past is the availability of certain new services (in particular the web[[3]](#footnote-3)) and the availability of such a variety of services around the world.

**2 Analysis of specific architectural characteristics**

In order to move beyond comparisons which do not appear to be particularly useful, we turn to the descriptions of Internet provided some of its architects. A good description of the key characteristics of the Internet is[[4]](#footnote-4):

In essence, the Internet is an architecture, although many people confuse it with its implementation. When the Internet is looked at as an architecture, it manifests two different abstractions. One abstraction deals with communications connectivity, packet delivery and a variety of end-end communication services. The other abstraction deals with the Internet as an information system, independent of its underlying communications infrastructure, which allows creation, storage and access to a wide range of information resources, including digital objects and related services at various levels of abstraction.

…

… the evolution of the Internet was based on two technologies and a research dream. The technologies were packet switching and computer technology … The research dream was to share information and computational resources. …

…

A key architectural construct was the introduction of gateways (now called routers) between the networks to handle the disparities such as different data rates, packet sizes, error conditions, and interface specifications. The gateways would also check the destination Internet addresses of each packet to determine the gateway to which it should be forwarded. These functions would be combined with certain end-end functions to produce the reliable communication from source to destination.

Thus, according to this description, the key characteristics of the Internet are:

1. Packet-switching
2. Connecting computers
3. End-to-end communication services
4. Gateways to route information

We will now examine these characteristics in more detail.

## *2.1 Packet switching*

Packet-switching *per se* is not a characteristic that distinguishes Internet from other networks, because X.25 is a packet-switched network, as is Signalling System 7, as was telegraphy. However, the way in which the switching and routing are performed is different, see 2.4 below.

## *2.2 Connecting computers*

At first glance, one might think that connecting computers is not, *per se*, a characteristic that distinguishes Internet from other networks, since several proprietary networks had been developed and deployed by computer manufacturers, the internationally standardized X.25 network was developed and used to connect computers, and the mobile telephone network connects handsets that are computers (albeit with less generic functionality than the personal computers used by most people).

Howver, the way in which the computers are connected is indeed different, see 2.3 below. And, in practice, computers are always the intermediaries between communictions that use the Internet: people communicate via the Internet mostly by using general-purpose computers that are connected to the Internet, not by using dedicated devices with limited functionality (as was the case for the traditional analog telephone network). And many users use personal computers, as opposed to the central computers that were interconnected using the older networks such as X.25.

Thus the distinguishing feature of the Internet is not so much that it *can* be used to connect computers, but that it is *mostly* used to connect personal computers.

## *2.3 End-to-end*

At first glance, one might think that end-to-end communication services is not, *per se*, a distinguishing feature of Internet, because the goal of most communication services is to enable communication between two end users (whether people or machines). For example, telephony is clearly an end-to-end communication service.

However, what is meant by “the end-to-end principle” in the context of Internet is more sophisticated. One way of putting is that *“ intelligence is end to end rather than hidden in the network”[[5]](#footnote-5)*. Or *“the complexity of the Internet belongs at the edges”[[6]](#footnote-6)*. More specifically[[7]](#footnote-7):

The basic argument is that, as a first principle, certain required end-to-end functions can only be performed correctly by the end-systems themselves. A specific case is that any network, however carefully designed, will be subject to failures of transmission at some statistically determined rate. The best way to cope with this is to accept it, and give responsibility for the integrity of communication to the end systems. Another specific case is end-to-end security.

This does indeed distinguish the Internet from other networks in which security and quality of service functions are provided by the network itself.

It has been stated[[8]](#footnote-8) that “transactions within the Internet are not defined and supported by the network; rather, they are defined from end-to-end, and do not require the specialised support of the intervening telecommunications networks”. But this is not correct unless one defines the “intervening telecommunications networks” to exclude essential services such as the resolution of domain names, PKI certificates, network address translation of IP addresses, etc., which are not provided entirely by the end-systems.

For sure the Internet has dramatically facilitated the trend towards decentralized computing, even if this is not one of its unique characteristics: other networks were used in the past for the same purpose. And it should be noted that some Internet services do require some centralized components. For example, airline reservation systems available on the Internet depend on centralized databases; use of the IMAP E-Mail protocol depends on a centralized E-Mail server; and many e-commerce services depend on centralized servers and databases (for sure there many be several of these, as opposed to only one, but each server/database centralizes a portion of the activity).

In summary, unique characteristics of the Internet include its widespread use to connect personal computers, and the fact that is does not provide, at the network level, security and quality of service functions. In particular, the security function should be provided by the end-devices, that is, the computers connected to the network (but are not always provided, due to the weaknesses of the security of many personal computers, see 2.5.2 below).

## *2.4 Routing gateways*

At first glance, one might say that gateways to route information are present in essentially all large networks, so this is not, *per se*, a distinguishing characteristic of Internet. However, the way in which the gateways work differs significantly depending on the type of network[[9]](#footnote-9).

And indeed, the inter-network routing of the Internet differs from that of other packet-switched networks, in particular with respect to its topology, which is not based on national borders, and this does distinguish the Internet from other networks.

## *2.5 Other suggested characteristics*

Other characteristics have been suggested as being unique to the Internet. These are explored below.

## *2.5.1 No centralized control*

It has been said that “nobody owns the Internet, there is no centralized control, and nobody can turn it off”[[10]](#footnote-10). This is of course empty rhetoric. The physical connections that underpin the Internet can be cut (and have been during wars), and that makes Internet unavailable at least in some geographical areas. The Domain Name System (DNS) is highly centralized and controlled by a single organization, ICANN, whereas the equivalent functionality in the telephone system (the E.164 numbering plan) is decentralized. Of course no single entity owns the entire Internet, but that is equally true of all other communications systems: for example, no single entity owns the telephone network.

It might be easier to shut down a telephone network, because such networks do rely on central switching centers (in particular for the Signalling System 7 functions), but that is just a matter of required effort, not a fundamental characteristic. Indeed, in many countries, there are very few (often only 2 or 3) international Internet connections, so connectivity to the outside world can be cut off rather easily.

In summary, it can be said that the Internet’s highly centralized naming system (the DNS) is a distinguishing feature with respect to other telecommunications networks.

## *2.5.2 Lack of strong authentication*

It has been said that *“It is highly desirable that Internet carriers protect the privacy and authenticity of all traffic, but this is not a requirement of the architecture. Confidentiality and authentication are the responsibility of end users and must be implemented in the protocols used by the end users.”*[[11]](#footnote-11) This is indeed a key characteristic that distinguishes the Internet from other networks (such as the telephone network) which typically require that a terminal authenticates itself before it can connect to the network. [[12]](#footnote-12)

The relative lack of security of the Internet itself has been exacerbated by the relatively weak security achieved in practice by the end-user devices that are most often connected to the network, namely the Personal Computer (PC), but it must be noted that the security of PCs is improving.[[13]](#footnote-13)

It must be stressed that there is an important trade-off between safety and security and other public policy goals such as innovation and competition. For example, there would be much more innovation in the pharmaceutical market if safety and effectiveness requirements were relaxed. But policy makers have decided that certain safety standards are mandatory, even if this does hinder innovation. The same holds for many other industries, such as air transport, automobiles, electrical appliances, etc.

The lack of mandatory security and safety standards for the Internet surely encourages positive innovation (such as new business models for the retail sale of books or discount airlines) but it also encourages less desirable innovations (such as web sites offering illegal products or services).

## *2.5.3 Borderless*

It has been stated that the Internet is fundamentally borderless.[[14]](#footnote-14) Indeed the protocols (standards) used for the Internet are the same around the world, but this is largely true for all telecommunications networks: it is precisely the global implementation of agreed standards that makes telecommunications possible (and indeed the ITU was created precisely to facilitate this).

So, in this sense, the Internet is no more or less borderless than any other telecommunications technology.

However, the Internet protocols relating to routing are, as noted above, different from other routing protocols, because Internet routing is not based on national borders. In this sense, the Internet is indeed borderless.

But the expression “the Internet is borderless” is at times used to refer to a paradigm in which national governments would not (or should not) assert authority over some portions of the Internet.

But national governments can and do impose national laws on Internet, in particular copyright, trademark, defamation, prohibitions on sale of controlled/illegal substances, prohibitions on sales of pharmaceutics, prohibitions on gambling, prohibitions on pornography (in particular child pornography), prohibitions on certain types of political speech (hate speech, negation of genocide, promotion of illegal political parties), etc.[[15]](#footnote-15) For sure, such laws may be harder to enforce on the Internet that on other networks, but that is a practical matter, not a matter of principle. Surely one would not argue that sales of illegal drugs should be allowed if the drugs are flown in by stealth helicopters, merely because that technology makes it harder to intercept the transportation of the illegal drugs? Similarly, one cannot argue that existing laws should not be applied to the Internet merely because it may be harder to apply them. Of course one can argue that existing laws are no longer appropriate (in particular because of technological evolution) and should be changed, but that is a different matter.

It is however the case that some national actions may well have global impacts that are greater than the global impacts for other communications technologies. For example, the US seizure domain names used for well-known poker sites prevented people outside the US from using those sites[[16]](#footnote-16) (the sites were later restored with the stipulation that they could not be accessed from within the US).

Thus, it can be said that certain Internet services do have extraterritorial impacts and are “borderless” in that sense, often more so that the services commonly provided through other communication technologies.[[17]](#footnote-17)

The issues of the so-called borderless nature of the Internet and free speech have often been conflated. For example, a group of Internet experts has stated[[18]](#footnote-18): “The implications for freedom of speech and the media are easy to recognize as a direct reflection of the Internet as a communications platform”.

This statement seems to assume that (1) the Internet as a communications platform is not subject to national laws and therefore (2) the rules for freedom of speech applicable to the Internet are not those that are applicable to the off-line world.

As noted above, national governments and national courts have not adopted this approach, and there is no international instrument that enshrines this approach. That is, global acceptance of global technical standards does not translate (or at least has not yet translated) into global acceptance of laws, rules, or regulations relating to non-technical matters such as what is or is not a crime or what is or is not permissible free speech.

# 3 Summary

As noted at the beginning of this paper, the Internet is indeed different, and those differences are outlined at the beginning of this paper.

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1. Such as the various legal actions taken by the US to block access to online poker sites; or the screening systems imposed in some countries to prevent access to gambling, pornographic, etc., web sites; or criminal actions against paedophile content; etc. See also Jason Potin, “Free Speech in The Era of Its Technological Amplification” (2012) *MIT Technology Review*, vol. 115, no.2, March-April 2013, p. 61, available at:  
   <http://www.technologyreview.com/featuredstory/511276/free-speech-in-the-era-of-its-technological-amplification/>, who documents some of the effects of the consequences of universal access to information through the Internet. [↑](#footnote-ref-1)
2. Geoff Huston, “An End-to-End View of Telecommunications Policy Frameworks”, available at:  
   <http://www.itu.int/md/S13-WTPF13IEG3-INF-0001/en> [↑](#footnote-ref-2)
3. And even the web had, in some respects, a precursor, albeit crude because of the limitations of the end-user terminals available at the time, the French Minitel system, see Richard Hill "Electronic Commerce, the World Wide Web, Minitel, and EDI", *EDI Forum* (Vol. 9, No. 2), p. 89; and *The Information Society* (Vol 13, No. 1, Jan-Mar 1997), p. 33 [↑](#footnote-ref-3)
4. Robert E. Kahn and Vinton G. Cerf **. “**What Is The Internet (And What Makes It Work)” December, 1999, available at: <http://www.cnri.reston.va.us/what_is_internet.html> [↑](#footnote-ref-4)
5. IETF RFC 1958 [↑](#footnote-ref-5)
6. IETF RFC 3439, which balances that statement by noting that *“today's Internet backbone routers are extremely complex”*; and that *“Finally, many circuit switched networks combine relatively static configuration with out-of-band control planes (e.g., SS7), which greatly simplifies data-plane switching. The bottom line is that as data rates get large, it becomes more and more complex to switch packets, while circuit switching scales more or less linearly.”* [↑](#footnote-ref-6)
7. IETF RFC 1958 [↑](#footnote-ref-7)
8. Geoff Huston, “An End-to-End View of Telecommunications Policy Frameworks”, available at:  
   <http://www.itu.int/md/S13-WTPF13IEG3-INF-0001/en> [↑](#footnote-ref-8)
9. Anectodally, towards the end of its life, telegraphy developed an automated routing system that is conceptually and funtionally similar (at a high level) to the Internet routing system, see Recommendation ITU-T F.31. [↑](#footnote-ref-9)
10. RFC 1958 [↑](#footnote-ref-10)
11. RFC 1958 [↑](#footnote-ref-11)
12. See Anna Vamialis, “Online defamation: confronting anonymity”, *International Journal of Law and Information Technology*, vol. 21, no. 1, spring 2013, p. 31 ff. [↑](#footnote-ref-12)
13. See <http://en.wikipedia.org/wiki/Microsoft_Windows#Security> [↑](#footnote-ref-13)
14. Sally Wentworth, “Testimony”, *5 February 2013 Hearing: Fighting for Internet Freedom, Dubai and Beyond, U.S. House of Representatives Committee on Energy and Commerce’s Subcommittee on Communications and Technology*, available at: <http://docs.house.gov/meetings/IF/IF16/20130205/100221/HHRG-113-IF16-Wstate-ShipmanWentworthS-20130205.pdf> [↑](#footnote-ref-14)
15. But the means by which such restrictions are imposed differ drastically. For example, some countries block, at the national level, pornographic or gambling sites. Other countries rely on civil and criminal law to prevent illegal sites (such as gambling sites) to be offered to their citizens. [↑](#footnote-ref-15)
16. See <http://en.wikipedia.org/wiki/United_States_v._Scheinberg> [↑](#footnote-ref-16)
17. See also See also Jeremy Malcolm, *“Internet Freedom in a World of States”*, available at:  
     <http://www.digitalnewsasia.com/insights/internet-freedom-in-a-world-of-states> ;  
    a longer version is available at:  
     <http://www.igfwatch.org/discussion-board/three-false-assumptions-internet-freedom-in-a-world-of-states-part-1> [↑](#footnote-ref-17)
18. Draft opinion from the Internet Systems Consortium submitted to WTPF, available at: <http://www.itu.int/md/S13-WTPF13IEG3-C-0049/en> [↑](#footnote-ref-18)