Internet Invariants: What Really Matters

Introduction

The Internet has seen significant change since it was established as a research network more than forty years ago. On one front, it has gone from being a network run by government agencies and researchers to facilitate their collaboration, to being run by a mixture of research and commercial interests as a curiosity, an informal electronic communications medium, and latterly a cornerstone of considerable importance for both commerce and individuals' daily lives. On another front, the technology supporting the network has evolved commensurately with computing power, and network architectures have followed the changing requirements and uses. And on yet another front, Internet applications and services have been transformative, continuously challenging expectations (for example, no one predicted the impact and popularity of Facebook).

In the light of those considerations, it's important to understand what is actually important and *unchanging* about the Internet – the *invariants* that have been true to date. This paper describes several invariant properties of the Internet, which are interesting for what they include, as well as what they omit. These characteristics, which have enabled the Internet to serve as a platform for seemingly limitless innovation, outline not only its technology, but also its shape in terms of global impact and social structures.

What really matters about the Internet

The Internet is a worldwide interconnection of computers and computer networks that facilitate the sharing of information among users. The unchanging properties of that system have included features of the underlying networks, technologies and standards, as well as emergent properties that impact users and uses of the Internet.

The Internet has global reach and integrity, and is not constrained in terms of supported services and applications:

- ***Global reach, integrity:*** Any endpoint of the Internet can address any other endpoint, and the information received at one endpoint is as intended by the sender, wherever the receiver connects to the Internet. Implicit in this is the requirement of global, managed addressing and naming services.
- ***General purpose:*** The Internet is capable of supporting a wide range of demands for its use. While some networks within it may be optimized for certain traffic patterns or expected uses, the technology does not place inherent limitations on the applications or services that make use of it.

The Internet is for everyone – there is no central authority that designates or permits different classes of Internet activities:

- ***Supports innovation without requiring permission (by anyone):*** Any person or organization can set up a new service, that abides by the existing standards and best practices, and make it available to the rest of the Internet, without requiring special permission. The best example of this is the World Wide Web – which was created by a researcher in Switzerland, who made his software available for others to run, and the rest, as they say, is history. Or, consider Facebook – if there was a business approval board for new Internet services, would it have correctly assessed Facebook's potential and given it a green light?
- ***Accessible – it's possible to connect to it, build new parts of it, and study it overall:*** Anyone can "get on" the Internet – not just to consume content from others, but also to contribute content on existing services, put up a server (Internet node), and attach new networks.

The Internet requires some basic agreements and social behaviour – between technologies and between humans:

- ***Based on interoperability and mutual agreement:*** The key to enabling *inter*-networking is to define the context for interoperation – through open standards for the technologies, and mutual agreements between operators of autonomous pieces of the Internet.
- ***Collaboration:*** Overall, a spirit of collaboration is required – beyond the initial basis of interoperation and bi-lateral agreements, the best solutions to new issues that arise stem from willing collaboration between stakeholders. These are sometimes competitive business interests, and sometimes different stakeholders altogether (*e.g.,* technology and policy).

Although no specific technology defines the Internet, there are some basic characteristics that describe what works:

- ***Technology – reusable building blocks:*** Technologies have been built and deployed on the Internet for one purpose, only to be used at a later date to support some other important function. This isn't possible with vertically integrated, closed solutions. And, operational restrictions on the generalized functionality of technologies as originally designed have an impact on their viability as building blocks for future solutions.

And, finally, the more the Internet stays the same, the more it changes:

- ***There are no permanent favourites:*** While some technologies, companies and regions have flourished, their continued success depends on continued relevance and utility, not strictly some favoured status. AltaVista emerged as the pre-eminent search service in the 1990's, but has long-since been forgotten. Good ideas are overtaken by better ideas; to hold on to one technology or remove competition from operators is to stand in the way of the Internet's natural evolution.

Conclusion

As the Internet is increasingly important to everyday life, and more requirements are placed on it by a broader range of stakeholders, it is important to be able to distinguish between aspects that need to be preserved and things that are simply the flavour of the moment. These invariant properties of the Internet need to be preserved, even as the way in which they are achieved changes continuously and drastically over the coming years. As an example of the range of thinking this can enable, note that the Internet's basic protocol (Internet Protocol – IP), is not an invariant feature of the Internet. It emerged, 40 years ago, as the right technology of the time to ensure that there could be a general purpose network with global reach and integrity, accessible and supporting innovation through collaboration and interoperable services based on reusable technology building blocks. But, not even that is a permanent favourite, and 40 years from now, a future generation of the Internet could exist, with all of these invariant properties intact, but based on some completely different protocol. The Internet's effect is not tied to its technology.

What does matter for the future health of the Internet is that these basic properties are upheld and fostered as new technologies, operators, and stakeholders emerge.

Acknowledgements

These invariants were inspired by discussions with panelists and other experts on the occasion of the Internet Society's briefing panel, "Internet evolution—Where is 'there' and how do we get 'there' from here?"[1]. See the IETF Journal article[2] describing the public panel.

[1] Panel details are available at: http://www.internetsociety.org/internet-society-panel-internet-evolution-ietf-81

[2] The article from IETF Journal Volume 7, Issue 2 is available at http://www.internetsociety.org/articles/isoc-panel-addresses-regulation-innovation-and-internet

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