Internet Invariants: What Really Matters
An Internet Society Public Policy Briefing

26 September 2016

Introduction

We place an enormous amount of faith in the Internet, largely because it facilitates our everyday lives. We instinctively trust that when we send an email, it will be received by the intended recipient. When we type a domain name into a browser, we presume that the results will be what we are looking for. We can make these assumptions because Internet invariants ensure that if we send data, it arrives; and if we seek content, it will be located.

Starting in the 1970s, a variety of protocols and network architectures were developed, but none became the driver of economic and social development that the Internet did. IBM's Systems Network Architecture, for example, failed to take off because it could only connect with hardware manufactured by IBM. The technical system that proliferated instead, and which remains at the foundation of the Internet, was TCP/IP because of its decentralized nature and underlying values of interoperability, flexibility, resilience, and global reach.

The Internet is a global network of networks built on open standards[1]. Only by looking at it as a whole can we fully understand why it fosters seemingly limitless innovation and opportunity and what the implications of certain decisions are. The task of the Internet's core communication infrastructure is to pass packets from one node to another; networks do not ensure against loss of packets. This simplifies the core infrastructure, making it more robust, scalable, and resilient. All the intelligence necessary to ensure that applications can exchange data according to their requirements (e.g., reliable data delivery) is distributed within the network or at the edge. In this way, innovation is decentralized and opportunities to devise new applications are available to the billions of Internet users around the world. And as a result, more novel and innovative applications compete on a level playing field with dominant market players. Because data flows uniformly, the status quo can be challenged.

Today's Internet has transformed how more than two billion people connect and communicate. And it will continue to transform our economy, infrastructure, and social lives as cloud computing, the Internet of Things, and mobile devices evolve in ways we cannot yet imagine. We don't often talk about how the network behind this technology works, just as most of us don't concern ourselves with where electricity comes from, so long as our lights turn on. But as the Internet becomes an increasingly more pervasive and critical piece of infrastructure, we need to understand both the network's challenges and opportunities if we want it to continue to serve as a vehicle for social empowerment and economic growth. This means knowing why the Internet works the way it does and why we should not interfere with its fundamental properties, called Internet invariants1—properties that do not change even as the Internet does. These consistent architectural principles and structural rules facilitate the Internet's undisturbed evolution.

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[1] "RFC 1122: Requirements for Internet Hosts–Communication Layers", Internet Engineering Task Force, October 1989. https://tools.ietf.org/html/rfc1122.
[2] *Internetworking* is the practice of connecting separate networks that are built with differing hardware,

Key Considerations

Internet invariants enable us to critically assess how changes to the Internet's core might impact its use, performance, and integrity, without getting mired in how every piece of technology works.

The key Internet invariants are:

- **Global reach and integrity.** Any endpoint of the Internet can address any other endpoint and the information received will be as intended by the sender, wherever in the world the receiver connects to the Internet. Implicit in this is the requirement of global, managed addressing and naming services.

- **General purpose.** The Internet was not built for any one application and is capable of supporting a wide range of demands for its use. While networks within it may be optimized for certain traffic patterns or expected uses, Internet technology does not place inherent limitations on the applications or services that make use of it. More important, it does not place limitations on the future: applications and services that are hard to imagine today may come along, transform our world, and challenge our expectations at any time.

- **Innovation without requiring permission**. Using the Internet means more than connecting to existing services. It also entails being able to build new parts. 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 asking permission. An example of this is the World Wide Web, which was created by Sir Tim Berners-Lee in Switzerland, who made his software available for others to run. The rest, as they say, is history.

- **Accessibility**. Anyone can get on the Internet to consume and contribute content, put up a server, and attach new networks.

In addition, the Internet requires the following basic agreements and patterns of social behavior:

- **Interoperability and mutual agreement.** The key to enabling internetworking[2] is defining the context for interoperation via open standards for technologies and mutual agreements between operators of autonomous pieces of the Internet.

- **Collaboration.** A spirit of cooperation is crucial. Beyond the initial basis of interoperation and bilateral agreements, the best solutions to new issues arise from willing collaboration among stakeholders. Although there may be differing perspectives on the best path forward, experience shows that the more difficult and interconnected the problem is, the more important it is that stakeholders from different backgrounds are involved in the solution. This is often referred to as *multistakeholderism*.

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[2] *Internetworking* is the practice of connecting separate networks that are built with differing hardware, so they can communicate consistently.

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

- **Technology, reusable building blocks.** Many technologies have been built and deployed on the Internet for one purpose, only to be used later to support another function. Conversely, operational restrictions on the functionality of technologies can impact their viability as building blocks for future solutions.

- **No permanent favorites.** While some technologies, companies, and regions have flourished, their continued success depends on continued relevance and utility—not favored status. For example, AltaVista was the preeminent search service in the 1990s, but has long-since been forgotten. Good ideas will always be overtaken by better ideas; to hold on to one technology or to remove competition from operators is to stand in the way of the Internet's natural evolution.

Challenges

Internet invariants go hand-in-hand with sound policy making. If we want new services to challenge our expectations, we must have access to a reliable, global, interconnected network of networks, regardless of what hardware we own or operating system we use. Ideally, this is achieved via collaboration and interoperable services based on reusable technological building blocks. Would you use online banking if you weren't sure that the transfer would go through? Or if a photograph shared on social media could only be viewed from certain types of mobile phones? The Internet is built on trust that it works. Our challenge now is to uphold the trust that Internet invariants have fostered as new technologies, stakeholders, and dilemmas arise.

The answer lies in the collaborative spirit of the many stakeholders that seek to preserve the fundamental values of the Internet. The participants in this multistakeholder framework know that any degradation of the Internet invariants could impact the economy, human rights, and even world security.

This kind of stable architecture has enabled both unfettered interpersonal communication and the exchange of knowledge through collaborative portals such as Wikipedia[3]. However, the potential exists that the Internet will change as more challenges emerge. For example, if encryption is threatened or backdoors are built into the Internet's technology, there could be security impacts.

Internet invariants make the Internet we use every day reliable. They enable us to consider the impacts of change to the Internet "without having to delve into the intricate details of the technology that drives the Internet"[4]. With this awareness, it is possible for policymakers to make decisions about perceived problems without stifling innovation by making it costly and difficult for new technological solutions to enter the

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[3] "Free, Transboundary Flow of Information on the Internet: Recommendation CM/REC(2015)6", Adopted by the Committee of Ministers of the Council of Europe, 1 April 2015. https://edoc.coe.int/en/index.php?controller=get-file&freeid=6806.

[4] "On the Nature of the Internet", Leslie Daigle, GCIG paper No. 7, Series: Global Commission on Internet Governance Paper Series, 16 March 2015. https://www.ourinternet.org/research/nature-internet.

market. After all, every technological intervention has positive and negative aspects. A small change to the core of the Internet might help one country to look out for its own national security interests, but help another country erode the rights of its citizens.

Guiding Principles

In order to ensure the Internet continues to positively impact social development and underpin the global economy, Internet invariants must be protected and upheld—even as new challenges, threats, and inventions come along. Arguably, the Internet's role in our daily life is only going to grow in importance, and its value for governments, businesses, and civil society groups will only increase. As stakeholders place more requirements on its access and use, it is essential that we be able to distinguish between those aspects that need to be safeguarded and those that are simply passing through.

Conclusion

While the Internet comprises autonomous heterogeneous networks, it is the Internet invariants that glue everything together. They constitute an inseparable part of the Internet's existence and future. There is great value to the existing architecture of the Internet—it has produced a single, global, interoperable network of networks that has cultivated open communication and fostered seemingly limitless innovation. It's impossible to predict what the Internet of 2020, 2030, or 2040 will look like. What we can predict, however, is that if we do not protect its invariant conditions and properties, there will be less innovation, less communication, less information-sharing, and restricted creativity. Simply put, there will be no Internet as we know it today.

Additional Resources

The Internet Society has published a number of papers and additional content related to this issue.

These are available for free access on the Internet Society website.

- Internet Invariants: What really matters.
  https://www.internetsociety.org/internet-invariants-what-really-matters.

- "On the Nature of the Internet", Leslie Daigle, GCIG paper No. 7, Series: Global Commission on Internet Governance Paper Series, 16 March 2015.
  https://www.ourinternet.org/research/nature-internet.