FACULDADE DE ENGENHARIA
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Arquitetura de Sistemas de Software
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Homework #02

"Design the Internet, part 2"

Team 21

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Introduction

In this assignment we were subjected to reading an article called “Extracting The Essential Simplicity of the Internet” written by James Mccauley, Scott Shenker, and George Varghese. This paper focuses on some simple decisions that played fundamental roles in the success of the internet.

By reading this article, it was possible to make a comparison with the internet design that we had proposed in the previous homework delivery.

Therefore, in this assignment, in addition to pointing out and reflecting on some real aspects of the internet architecture, we note the main differences between our architecture and the real one.

Article analysis

1. Secrets to the Internet’s Success

In addition to highlighting a few essential design choices of the internet, such as a service model, a four layer architecture, and three mechanisms (routing, reliability , and resolution), the article denotes the importance of other crucial decisions that guarantee the success of its services.

Two of these crucial aspects that the paper reflects on are: **modesty** and the **assumption that failure is the normal case**.

Modesty: The adoption of a general model, that is, one that was not guided based on specific requirements of certain applications, allowed the internet to expand into something that was capable of supporting diverse services. With this modesty of the internet without guarantees, it became possible for new applications to emerge for the most diverse areas.

On the other hand, the simplicity of the model, based on smart hosts communicating through non-smart networks, allowed the internet to increase its network speed, taking advantage of the hosts' flexibility to deal with challenges associated with best-effort service, such as rate adaptation, buffering, and retransmission.

Thus, with the adoption of this simple model, the internet was able to evolve over time both in performance and delivery and to increase its range of applications.

Assuming failure is the normal case: With the increase of the size of the internet, through the integration of new services and the emergence of more and more applications, the probability of failures occurring increases.

Thus, by dealing with failures as if they were common occurrences, for example through techniques such as basic routing algorithms and transport protocols, the model allows failures to be handled in a transparent manner, without the need for specific interventions, which guarantees robustness and resilience in the face of disturbances.

This design philosophy not only makes the internet more reliable and effective, but also facilitates its maintenance and scaling.

2. “Why?” instead of “how?”

One of the main objectives of this article is to explain the fundamental Internet design choices from first principles without delving into all the ensuing complications, this means that the article focuses on why was the Internet built like this, not how it was built.

This article also emphasizes the logic behind every decision taken, providing valuable insights into the real reason why the Internet was shaped and structured in this certain way. Now, let’s look into some examples that help us understand the

“why” instead of the “how” of some decisions.

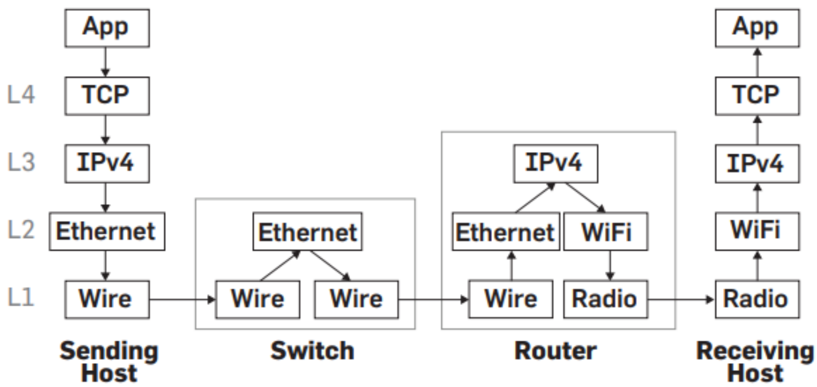

Figure 1. A packet’s path through the layers in hosts, routers, and switches.

The first example is the **modularity of the Internet’s four-layer architecture**, which can be defined as a clean division of responsibility where the network infrastructure (L1/L2/L3) supports better packet delivery, while applications (assisted by L4) create new functionality for users based on this packet-delivery service model. The article explains that this separation facilitated innovation and development both in the network infrastructure and in the applications.

This division of responsibilities also allowed flexibility and scalability because if a new protocol or technology wants to join the architecture there would be no problems doing that. Now that we have this insight into the "why" of modularity, we are able to highlight the Internet's ability to accommodate different types of technology and apps while keeping the constant interoperability and scalability.

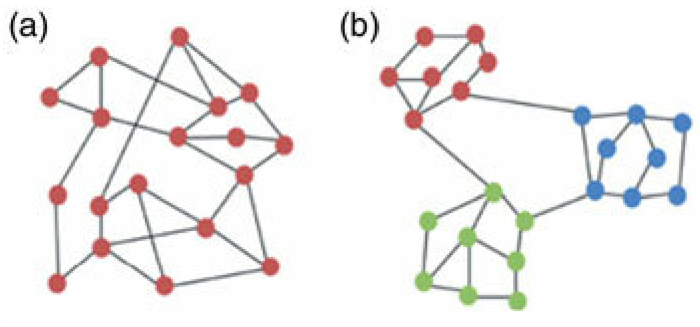

Figure 2. a) Random network; b) Modular Network

The second example where the “why” gave us additional insight into the Internet is the **rough consensus and running code**, which is basically the encouragement of smaller groups to build designs that work, and then choose, as a community, which designs to adopt. This approach was chosen because it allowed community collaboration along the network, decentralization of the Internet, flexibility and quick iteration (by prioritizing running code).

This insight into the "why" of the design process highlighted the Internet's ability to evolve organically and respond effectively to changing needs and challenges.

3. "Extracting the Essential Simplicity of the Internet"

The article's title, "Extracting the Essential Simplicity of the Internet" expresses the authors' goal to identify the fundamental ideas and strategic decisions that contributed to the development of the Internet.

It describes the process of separating out/”extracting” the essential components/”essential simplicity” from the intricate web of technologies and protocols that make up the Internet as we know it today. It also alludes to the basic ideas and precepts that underpin the architecture of the Internet and its fundamental simplicity.

The Internet started off as a simple network that connected research and academic institutions. It eventually encountered a difficult choice between sticking to its core values of transparency and simplicity and adjusting to the growing complexity brought about by advancements in technology and user demands. The evolution of the Internet has been greatly influenced by this underlying tension.

The title may allude to the early Internet era, when openness and simplicity were valued highly. Global connectivity and knowledge sharing were made possible by the decentralized, highly flexible structure that the Internet's early inventors envisioned. In light of this, the title might allude to a return to these founding principles in the context of today's intricate Internet environment, emphasizing the simplicity that lies beneath the system's seeming complexity in order to better comprehend how it operates internally and the factors that have contributed to its enduring success.

4. Our Internet design vs real design

This article provided a clear view about the Internet design and why it was built like that, and after reading this article we can compare the real solution with the one we proposed in the previous work.

We thought of our design as a very first implementation idea of the Internet and that led to a series of scalability problems and weak data communication because we thought of it as if we were living back in the 1970's.

Comparing both design solutions, there was one idea that was similar to the real Internet design, which was the separation in groups. In this article it is explained why the modularity of the four-layer architecture was chosen and it's basically because it allows flexibility and scalability to the network.

On the other hand, the fact that only some specific computers can decrypt messages ("One-Time Pad (OTP)" encryption) makes parallelism impractical or almost infeasible.

Although being secure, reliable and easy to use, the One-Time Pad (OTP) system has insufficient key integrity verification, and the use of each key only once is often out of the question with internet communication.

Therefore, as mentioned in the paper, there are now some modern cryptographic protocols (based on new algorithms like AES and RSA, for example) that combined with mitigation methods would offer a higher level of security for internet-based systems.

Also referred to in the article, the domain name system (DNS) features an important hierarchical model in the actual implementation of the Internet design. This hierarchy is a naming system that provides easy IP to domain name conversion and decentralized control over administration. Although our design could have used some hierarchical elements like layering network components, it might not have thoroughly exploited the powers of hierarchy with regards to naming and routing. Therefore, using more extensive hierarchical structures would improve scalability and manageability in our design.

Moreover, the actual design of the internet acknowledges that in-network packet processing, such as firewalling, WAN optimization, and load balancing, is common. In our design, we might have paid more attention to end-to-end principles, ignoring the value of in-network support to enhance performance and efficiency. The inclusion of support for in-network processing capabilities can result in better scalability and performance attributes, especially in large-scale deployments (this aspect was one of the points we didn't explore deeply enough in our previous assignment, and it received criticism as a result).