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Design the Internet, part 2

Software Systems Architecture

Group 4 - Class 3

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Introduction

The paper titled "Extracting The Essential Simplicity of the Internet" discusses the core design principles that gave us the Internet we have today. It outlines the key decisions made during the ideation and development of the Internet, focusing on how these choices have contributed to its longevity, adaptability, and scalability.

In this essay we aim to explore some of the critical aspects highlighted in the paper, focusing on the meaning of "Simplicity" in the title, the design choices, and the rationale behind these decisions. After analyzing the paper, we will then compare the real internet architecture with the system we developed in the first homework assignment.

Extracting The Essential Simplicity of the Internet - Analysis

Simplicity of the Internet

Firstly, the title "Simplicity of the Internet" likely refers to the efficiency of the Internet's core design principles despite its vast and complex functionality. The authors may be suggesting that even though the Internet, nowadays, supports complex services and applications, its fundamental architecture remains rooted in simplicity.

Historically, the early Internet design philosophy was to prioritize simplicity and flexibility over complexity. The idea behind this philosophy is that the architects in the 1970s did not know where the internet was headed so they designed a system that could adapt and scale to accommodate technological advancements and future user demands. By adhering to simple yet robust design principles such as the end-to-end principle and modular architecture, they laid the groundwork for a network that could evolve and scale while maintaining its essential simplicity.

In essence, the title likely reflects the author's assertion that the Internet, even as it continues to grow and evolve, is still able to work on top of a simple architecture thought of in the late 1970s.

Critical Decisions in the Internet Design

Moving on from the simplicity found in the Internet's architecture, we will now dive into some critical decisions that facilitated the success of the Internet. We will look mostly at the Routing mechanisms and the implementation of a modular architecture.

Both design choices highly contributed to the success of the Internet. Routing, through dynamic protocols, optimizes data transmission, while the four-layer modular design ensures scalability and adaptability. The separation of concerns and autonomy granted to Internet systems contribute to the Internet's evolvability, ability to accommodate diverse technologies and applications, and making it a robust and globally useful communication network.

Routing

Routing in the context of Internet architecture refers to the process of determining the optimal path for data packets to travel from a source to a destination across interconnected networks. It encompasses the mechanism by which routers make decisions regarding packet forwarding based on information such as network topology, available paths, and routing policies.

Internet routing operates primarily at the network layer (Layer 3) of the OSI model, where routers use routing protocols to exchange routing information and build routing tables. These protocols include Border Gateway Protocol (BGP) for inter-domain routing and Interior Gateway Protocols (IGPs) like OSPF and IS-IS for intra-domain routing.

Routing decisions are made based on metrics such as hop count, link cost, and network congestion levels. The goal is to optimize factors like latency, throughput, and reliability while ensuring efficient utilization of network resources. This is important because one of the goals of the internet is the ability to have millions of users active at the same time.

Modularity

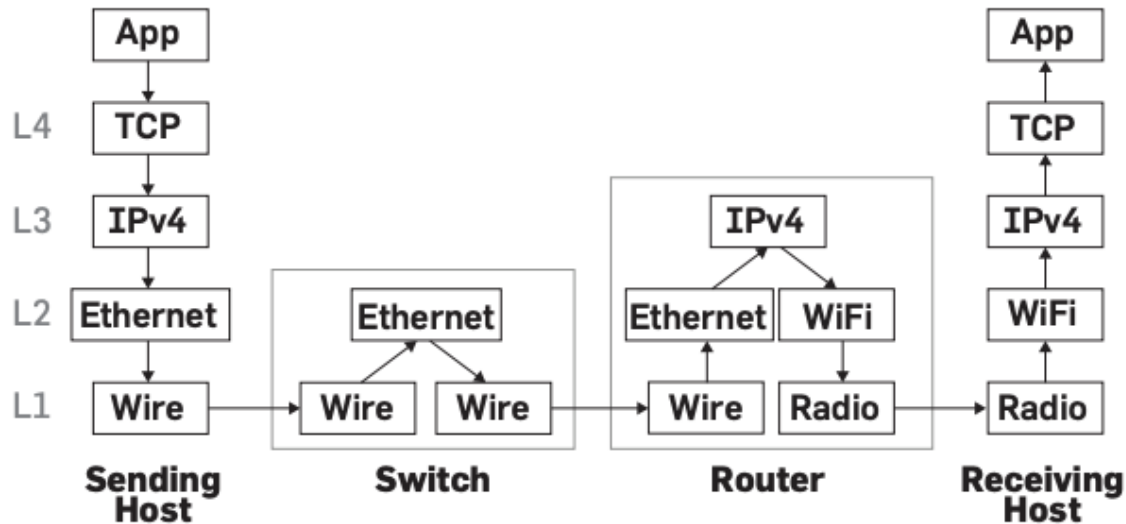


Figure 1: How the different Layers connect and make up the Internet

Modularity in Internet architecture refers to the principle of dividing the system into distinct, self-contained components with well-defined interfaces and responsibilities. It allows for the independent development, deployment, and evolution of different components without affecting the overall system functionality.

In the Internet's four-layer architecture, modularity is evident in the separation of concerns between the physical layer (Layer 1), data link layer (Layer 2), network layer (Layer 3), and transport layer (Layer 4). Each layer performs specific functions and interacts with adjacent layers through standardized interfaces.

At the network infrastructure level, modularity extends to the autonomy of autonomous systems (ASes) and the diversity of network technologies and protocols they can employ. ASes can choose their routing policies, link technologies, and interior routing protocols while adhering to the common IP protocol for inter-domain communication.

How our architecture compares to the real Internet design

The comparative analysis between the real Internet design, as documented, and our proposed design provides valuable insights into the evolution and fundamental principles of Internet architecture. While both designs emphasize modularity, fault tolerance, and scalability, disparities arise in their infrastructure approaches, device identification, and addressing methodologies. This examination emphasizes key distinctions and similarities, contributing to a deeper understanding of the underlying principles shaping contemporary network architectures.

Infrastructure Design Approach

The real Internet design, leveraging existing telephone communication infrastructure, was a pragmatic approach given the technological landscape at the time of its inception. It relied on hierarchical routing, mirroring the centralized nature of traditional telecommunication networks. In contrast, our proposed design advocated for a more decentralized approach with a hierarchical system of WANs. The shift towards distributed architectures is driven by a need to improve scalability and reduce dependence on centralized infrastructure. Our design also aims to enhance routing efficiency and network resilience by aligning network topology with geographical scopes.

Device Identification and Addressing

While both designs prioritize addressing uniqueness and reliability, they diverge significantly in their implementation strategies. The real Internet design employed cryptographic protocols and intricate addressing schemes, reflecting a robust yet complex approach to device identification and security. Conversely, the architecture we created opted for a hierarchical addressing system inspired by telephone networks, simplifying the addressing process while potentially compromising on cryptographic security. This trade-off underscores differing priorities between the two designs, with the real Internet design prioritizing better security measures and our design emphasizing simplicity and ease of implementation.

Emphasis on Modularity, Fault Tolerance, and Scalability

Despite differences in infrastructure and addressing, both designs share a common emphasis on modularity, fault tolerance, and scalability. The real Internet design embraces modularity through its layered architecture, facilitating independent evolution and innovation within each layer. Similarly, our design emphasizes scalability through its hierarchical structure, enabling seamless connectivity across diverse geographical regions.

Importance of Simplicity and Practicality

Moreover, both designs underscore the importance of simplicity and practicality in Internet architecture. The real Internet design seeks to extract the essential simplicity of the Internet's core principles, emphasizing the elegance and coherence of its design choices. Similarly, our proposed design aims to address prevailing needs with an innovative and practical approach, considering the technological constraints of the 1970s.

Assuming Failure as the Normal Case

The real Internet design's emphasis on assuming failure as commonplace led to the development of robust fault tolerance mechanisms, ensuring network resilience in the face of disruptions. Conversely, while our design did not explicitly address failure handling, its hierarchical structure and routing mechanisms inherently contribute to fault tolerance. By compartmentalizing network traffic into distinct geographical scopes, the design we proposed minimizes the impact of localized failures, thereby enhancing overall network reliability. However, the absence of explicit fault tolerance mechanisms may leave our design vulnerable to systemic failures, necessitating further exploration and refinement in this aspect.

Conclusion

In conclusion, the exploration of the internet architecture presented in the paper was incredibly valuable to better understand how architectures are ideated, as well as, have a better understanding of how the internet works.

Comparing the established architecture with our proposed one has allowed us to see how we overlooked certain aspects of our architecture that turned out to be crucial in the existing internet architecture.

Nevertheless, it was interesting how the authors of the paper managed to simplify something rather complex like the internet while still giving a concrete explanation of how everything works.