Present Day Internet Design, Architecture, Performance and an Improved Design

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Abstract- Internet design has to do with its architecture. Internet architecture is a meta-network that constantly changes collection of thousands of individual network that intercommunicate with common protocol. The success of the present day internet has been hindered by many sophisticated network attacks because of its security challenges embedded in the original architecture. The original architecture is hard to modify and new functions have to be implemented via myopic and clumsy adhoc patches on top of the existing architecture. This work aimed at analyzing the present day internet design, emphasizing on its architecture, performance and then proposing an improved design with clear reasons for the improvement.

Index Terms- Internet Design, Internet Architecture, MobilityFirst, NEBULA, FIRE.

I. Introduction

Internet design has to do with internet architecture. Internet architecture is a Meta - network that constantly changes collection of thousands of individual network that intercommunicate with common protocol [1]. It can also be defined as internetworking and it is based in TCP/IP specification protocol that is designed to connect any two networks that could be really different in internal hardware, technical design and software. When there is interconnection between two networks, communication with the TCP/IP is enabled end-to-end to permit nodes on the internet that possesses the capacity to communicate any other irrespective of their location. Internet architecture has grown to global standard because of the nature of the design [1].

Practically, the technical aspect of the internet architecture looks like multi-dimensional river system, with minute tributaries that feeds medium-sized streams, feeding large rivers. For instance when an individual access a network it is most times from home through a modem to connect with a local internet service provider that mostly connects to a regional network that is connected to a national network [1], while in an establishment an individual can connect their desktop computers to a Local Area Network (LAN) via company connection to a corporate intranet, to many national network service providers.

In a nutshell, local internet service providers connects to medium-sized regional networks in order to connect to large national networks, which connects to very large bandwidth networks on the internet backbone. Many internet providers have many network cross-connections that are redundant to other providers to make sure that there is continuous availability. Companies who runs internet backbone administers higher rate of bandwidth networks relied on by large establishments, government, internet service provider and corporations. The companies' technical infrastructure mostly are global connections via underwater cables and satellite links to enable communication between countries and continents. Larger scale which introduces new phenomena; the amounts of packets that flows via the switches on the backbone is very large and it shows the kind of complex non-linear patterns that is mainly found in natural, analog systems which is like water flow or development of the rings of Saturn [2]. Each communication, in order to get its destination network where local network routing takes over to deliver it to the addressee, packets, goes up the hierarchy of internet networks irrespective of the distance. Relatively each level in the hierarchy pays the next level for the bandwidth they have used. Moreover, large backbone companies settle up with one another.

This paper aimed at analyzing the present day internet design, emphasizing on its architecture, performance and then proposing an improved design with clear reasons for the improvement. In order to achieve this aim we will be looking at the present day internet architecture and its performance, Innovations in various aspects of the internet, Collaborative projects putting multiple innovations into an overall networking architecture, and Testbeds for real-scale experimentation; after which we will be designing an improved internet architecture with better performance.

II. PRESENT DAY INTERNET DESIGN

The present day internet was designed over 40years ago, it is facing different challenges especially commercial challenges. The demands for mobility, security [3] and content distribution, need to be met. Incremental changes through ad-hoc patches cannot handle this challenges. In order to handle this challenges, there's need for an improved design based on new design principles [3].The internet has evolved from an academic network to a large commercial plat-form. It has aid our day to day transaction, it is indispensable.

Technically, the present day internet, its continuing success has been hindered by many sophisticated network attacks because of its security challenges embedded in the original architecture. The original architecture is hard to modify, and new functions have to be implemented via myopic and clumsy ad hoc patches on top of the existing architecture.

However, it has really become difficult to support the increasing demands for security, performance reliability, social content distribution and mobility via such incremental changes [3]. Due to the challenges of this present day internet architecture, there's need for an improved design of the internet. From a non-technical aspect, commercial usage requires fine-grained security enforcement as opposed to the current "perimeter- based" enforcement. There is need for security to be an inherent feature and integral part of the architecture. "There's a demand to transform the internet from simple "host-to-host" packet delivery paradigm into a more diverse paradigm built around the data, content, and users instead of the machines", [3]. The above challenges have led to the research for an improved internet architecture.

The present day internet in terms of its performance contains; web, email, VoIP, eBusiness, HTTP, RTP, SMTP, TCP, UDP,SCTP, IP, Ethernet, WIFi, CSMA, ADSL, Sonet, Optical fiber, copper, and radio.

III. Improved Internet Architecture

In order to propose an improved internet design we will be looking at research topics handled by different research projects on internet architecture.

Efforts in obtaining an improved internet architecture (design) can be based on their technical and geographical diversity or targets at individual topics, some researchers aimed at holistic architecture by creating collaboration and synergy among individual projects.

The research topics handled by different research projects on internet design are: Experimental testbeds, mobility and ubiquitous access to networks, cloud – computing-centric architectures, security and content-or-data-oriented paradigms.

Experimental Testbeds: Testbeds research are; multiple testbeds with different virtualization technologies, and coordination among these testbeds [3].

Mobility and Ubiquitous Access to Networks: Mobility is a key driver for the future internet in as much as the internet is improving from PC-based computing to mobile computing. Demands for heterogeneous networks such as cellular, IP, and wireless ad-hoc or sensor networks that have different technical standards and business models are increasing rapidly. "Putting mobility as the norm instead of an exception of the architecture potentially nurtures future internet architecture with innovative scenarios applications", [3].

Cloud-Computing-Centric Architectures: A trend that demands new internet services and applications migrates storage and computation into the cloud and creates a computing utility [3]. It creates new ways to provide global-scale resource provisioning in a "utility like" manner. Data centers are the key components of such new architectures [3]. It is important to create secure, trustworthy, extensible, and robust architecture to interconnect data, control, and management planes of data centers [3]. Perspective of cloud computing has attracted considerable research effort and industry projects toward these goals. How to guarantee trustworthiness of users while maintaining persistent service availability is a major technical challenge [3].

Security: In the original internet security was added as an additional overlay instead of an inherent part of the Internet architecture [3]. Now security has become an important design goal for the future Internet architecture. The research is related to both the technical context and the economic and public policy context. From the technical aspect, it has to provide multiple granularities like; encryption, authentication, authorization, for any potential use case. It needs to be open and extensible to future new security related solutions [3]. From the non-technical aspect, it should ensure a trustworthy interface among the participants like users, infrastructure providers, and content providers. There are many research projects and working groups related to security [3]. The challenges on this topic are very diverse, and multiple participants make the issue complicated [3].

Content-or-Data-Oriented Paradigms: Present day internet builds around the "narrow waist" of IP, which brings the elegance of diverse design above and below IP, but also makes it hard to change the IP layer to adapt for future requirements [3]. Since the primary usage of present day Internet has changed from host-to-host communication to content distribution, it is desirable to change the architecture's narrow waist from IP to the data or content distribution [3]. Efficiency of new paradigm, scalability of naming and aggregation, data and content security and privacy, compatibility and co-working with IP are challenges introduced by the new category of paradigm [3].

A. Research Projects Handled on Future Internet Architecture

The projects handled on Future Internet Architecture are; MobilityFirst, Named Data Networking (NDN), FIA AND FIND, Nebula and eXpressive Internet Architecture (XIA). These projects were done by researchers from U.S. In order to propose an improved internet design we will be looking at the MobilityFirst future internet architecture and the NABULA future Internet architecture.

MobilityFirst: The MobilityFirst project is led by Rutgers University with seven other universities. Its motivation is that the present day Internet is designed for interconnecting fixed endpoints and fails to address trend of increasing demands of mobile devices and services. The demand change and usage of the internet is a key driver for providing mobility from the architectural level for the future internet. MobilityFirst is a future internet architecture with mobility and trust worthiness as central design goals. Mobility means that all endpoints-devices, services, contentment, and networks-should be able to frequently change network attachment points in a seamless manner [5].

Design Principle Adopted by MobilityFirst: The MobilityFirst project is led by Rutgers University with seven other universities. Its motivation is that the present day Internet is designed for interconnecting fixed endpoints and fails to address trend of increasing demands of mobile devices and services. The demand change and usage of the internet is a key driver for providing mobility from the architectural level for the future internet. MobilityFirst is a future internet architecture with mobility and trust worthiness as central design goals. Mobility means that all endpoints-devices, services, contentment, and networks-should be able to frequently change network attachment points in a seamless manner [5].

Key Protocol Features of MobilityFirst: Key protocol features of mobility first are; separation of naming and addressing, fast global naming service, storage –aware (GDTN) routing, self-certifying public key names, support for content/context/ location, programmable computing layer, separate network mgmt plane and Hop-by-hop (segmented) transport [4].

The aim of MobilityFirst is to address the cellular convergence trend motivated by the huge mobile population of 4 to 5 billion cellular devices, for the near time. It provides mobile peer-to-pear (P2P) and infestation (delay-tolerant network [DTN]) application services which offer robustness in case of link/network disconnection. In terms of long term, in the future, MobilityFirst has the ambition of connecting millions of cars via vehicle-to-vehicle (V2V) and vehicle-to-infrastructure V2I) modes, which involve capabilities such as location services, georouting, and reliable multicast [3].

Challenges of MobilityFirst: The challenges of mobilityFirst are; Trade-off between mobility and scalability, content caching and opportunistic data delivery, higher security and privacy requirements, robustness and fault tolerance. The Figure below is the diagram of MobilityFirst.

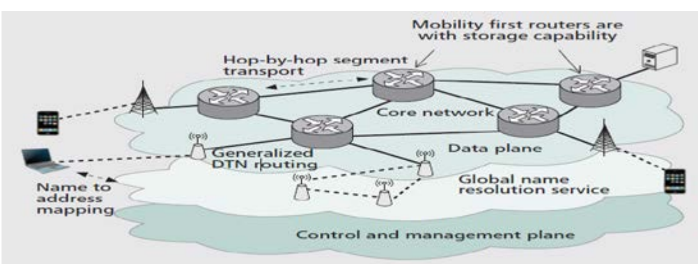

Figure 1 Architecture of MobilityFirst
Source: [3].

NEBULA Internet Architecture: NEBULA is a future Internet architecture focuses on building a cloud –computing-centric network architecture. NEBULA is led by the University of Pennysylvania with 11 other universities. It seeks for a future internet with high available and extensible core network interconnecting data centers to provide services like utility. In NEBULA multiple cloud providers can make use of replication by themselves and cloud comply with the agreement for mobile "roaming" users to connect to the nearest data center with variety of access mechanisms such as wired and wireless links.

Design Principle Adopted by NEBULA: NEBULA design principles are; ultra-reliable, high-speed core interconnecting data centers, secure access and transit, authentication during connection establishment, parallel paths between data center and core router, and policy-based path selection.

Design Goals of NEBULA (What it seeks to achieve): NEBULA design principles are; ultra-reliable, high-speed core interconnecting data centers, secure access and transit, authentication during connection establishment, parallel paths between data center and core router, and policy-based path selection.

How NEBULA is designed to work: NEBULA uses multiple dynamically allocated paths and reliable transport. Its NVENT/NDP is designed to be easy to automate and used as DHCP/IP [4]. NEBULA policies is implemented with NDP and NVENT; its NDP sends packets by encapsulation and its NVENT networks by virtualization. Its NCORE places resources where it is needed architecturally, regulatory and also where its policy can be analyzed [4].

NEBULA Internet Architectural Paths: NABULA Architectural path includes, NDP, NVENT, and Ncore. The NABULA data plane (NDP) establishes policy-compliant paths with flexible access control and defense mechanisms. NABULA Virtual and Extensible Networking Techniques (NVENT) is a control plane providing access to application selectable service and network abstractions like redundancy, consistency, and policy routing. The NABULA Core (NCore), redundantly interconnects data centers with ultrahigh-availability routers. NVENT also offers control plane security with policy-selectable network abstraction including multipath routing and use of new networks. NDP has to do with a novel approach for network path establishment and policy-controlled trustworthy paths establishment among NEBULA router. Below is the architecture of NABULA and how the NDP, NVENT, and NCore interacts with each other.

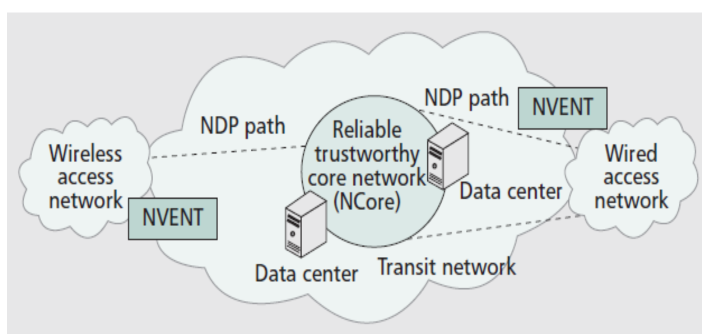

Figure 2: Architectural Components of NEBULA and their Interactions
Source: [3].

B. Future Internet Research Experiment

NEBULA is a future Internet architecture focuses on building a cloud –computing- centric network architecture. NEBULA is led by the University of Pennsylvania with 11 other universities. It seeks for a future internet with high available and extensible core network interconnecting data centers to provide services like utility. In NEBULA multiple cloud providers can make use of replication by themselves and cloud comply with the agreement for mobile "roaming" users to connect to the nearest data center with variety of access mechanisms such as wired and wireless links.

FIRE: FIRE is one of the European Union's research projects on testbeds. FIRE started in 2006 in FP6 and has continued via several consecutive cycles of funding. It involves efforts from both industries and academia. Currently it is in third wave focusing on providing federation and sustainability.

Two interrelated dimensions of FIRE are; to support long-term experimentally driven research on new paradigms and concepts of architectures for the future internet and to build a large scale experimentation facility by gradually federating existing and future emerging testsbeds. It changes internet in both technical and socio-economic terms by treating socio-economic requirements in parallel with technical requirements [3].

"A major goal of FIRE is federation, which by definition is to unify different self-governing testbeds by a central control entity under a common set of objectives", [3]. FIRE project can be cluttered in a layered way as shown in the figure below. It consist of three basic clusters which includes; the Top-Level cluster, the bottom cluster and the middle cluster [3]. The top-level cluster consists of a bundle of novel individual architectures for routing and transferring data. The bottom cluster consists of projects providing support for federation. The middle contains federation cluster that consists of existing testbeds to be federated [3]. The small and medium sized testbeds can be federated gradually to meet the requirements for emerging future internet technologies. The figure below is the diagram of Fire clustering Projects.

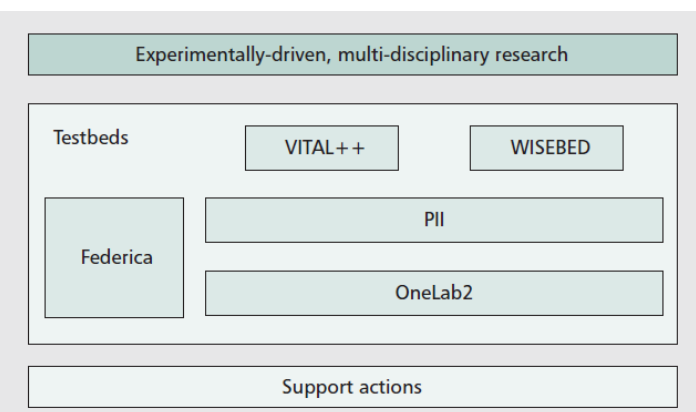

Figure 3: Fire clustering of projects
Source: [3].

IV. THE INTERNET ARCHITECTURE IMPROVED DESIGN

Due to the short comings of the present day internet architecture discussed earlier, there is need for an improved internet architecture. This improved architecture is a hybrid architecture. It is the combination of the NEBULA and MobilityFirst Internet Architecture. Its design principles adopted are; visibility and choice, usability, manageability, simplicity, reliability, technology-awareness, high-speed core interconnecting data centers, secure access and transit, authentication during connection establishment, parallel paths between data center and core router, and policy-based path selection. This improved internet architecture is an internet architecture with mobility and trustworthiness, its end points; devices, content, services and networks has the capability of changing network attachment points in a better way. This improved internet architecture also has the capability of securing and addressing threats to the emerging computer utility capacities which is known as cloud computing. The figure below is the diagram of the proposed internet architecture.

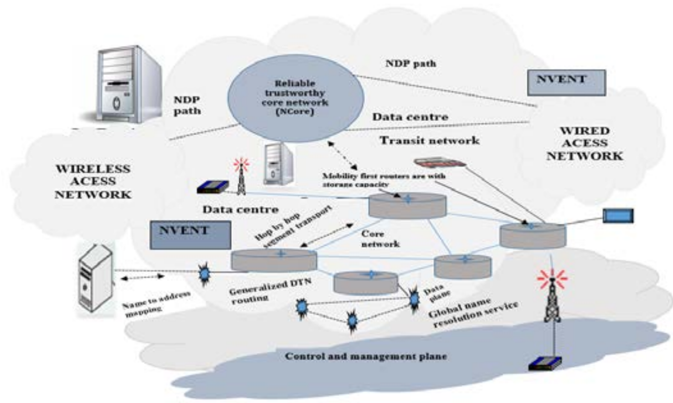

Figure 4: The Proposed Internet Architecture (Improved Design)

V. CONCLUSION

In conclusion, internet has brought massive change in our world today, it has invaded most aspect of life and society; communications, work, social interaction and changing life. The internet brings increasing benefits but also threats. Government is on the watch about the defects of internet. This is why there is need for an improved internet architecture. Our present day internet fails to cob the issue of cybercrime because of its shortcomings in its architectural design. The Improved internet architecture has the capability of handling the shortcomings of the present day internet design.

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