Radoslav Pavlov • Peter Stanchev
Editors

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The Future of the Next-Generation Internet and Possible Applications into Education and Culture Heritage

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Abstract. There are several initiatives such as: US Ignite, Software Defined Networking (SDN), OpenFlow, Global Environment for Network Innovation (GENI), WiMAX and Internet 2 dealing with the future of the internet. The goal of the paper is to understand the goals, intricacies, and nuances of some of these techniques and show some of the possibilities of next-generation high-speed networking and their applications into education and culture heritage.

Keywords: Next-Generation Internet, US-Ignite, GENI, Software Defined Networking, OpenFlow, WiMAX, Internet 2, Education, Culture Heritage

1 Introduction

In this chapter we highlight several initiatives for the future of the next-generation internet.

1.1 US Ignite

US Ignite is a public-private nonprofit partnership of nation-wide scope initiated by White House Office of Science and Technology Policy (OSTP) to " … accelerate the development of applications that can take advantage of ultra-high-speed programmable broadband to bring innovative new products and services to the American people." The primary goal of the US Ignite Partnership is to catalyze approximately 60 advanced, next-gen applications over the next five years in six areas of national priority: education and workforce development, advanced manufacturing, health, transportation, public safety, and clean energy. Responsibilities of the Partnership include connecting, convening, and supporting startups, local and state government, universities, industry leaders, federal agencies, foundations, and community and carrier initiatives in conceptualizing and building new applications. The resulting new applications should have a significant impact on the U.S. economy, including providing a broad range of job and investment opportunities.

US Ignite is seeking applications with high societal impact using next generation, high-speed networking. It includes the "programmable broadband", high-speed internet (1Gbs+), a networking infrastructure to research, develop, test, prototype, and deploy, next-generation Software Defined Networking applications; a consortium of potential diverse partners. The four most important technical parts of the US Ignite technology include [1]:

High symmetric bandwidth allows for things like uncompressed high definition video transmission – which has huge advantages over the IP based transmission commonly used as it minimizes delays in things like video conferencing. For truly interactive experiences, uncompressed video with its high bandwidth requirements is best, and a number of Ignite applications use uncompressed video particularly in areas like healthcare and education.

The next-generation Internet will take advantage of **Software Defined Networks**, which takes the "intelligence" of routing data out of the switches and routers on shelves, and puts more of it into the cloud. SDN tricks servers into thinking that they've got network gear all to themselves, configured exactly the way they like it, when they are really sharing that gear with other servers. More servers can share less network gear, and they can also be moved around easier — a big plus for applications like cloud computing.

Distributed Cloud Resources (e.g., US Ignite racks) are a kind of cloud computing in which the cloud is itself distributed throughout the network. This has distinct advantages including pre-staging information where it's needed, processing data traffic more locally, and dramatically improving responsiveness while reducing latency.

Virtual Networks are tailored to match specific advanced applications as well as provide unique Access to Advanced Resources, such as advanced computational, sensor, storage and data resources provided by the owners and operators of new technology. The collection of network, distributed, and advanced resources available in a virtual network to an application is called a "slice." Slices are an important concept because they can be thought of as the delivery mechanism for an application.

1.2 Software Defined Networking (SDN)

The key architectural principles of the existing internet are: TCP/IP protocol. Potential Internet roadblocks are: IP networks are based on Autonomous Systems (AS). An autonomous system is a contiguous set of networks and routers under control of one "administrative authority." The basic IP forwarding paradigm is that all traffic from a given source to a given destination always follows the same path. The forwarding table in a router only contains one entry for a given destination.

Software-defined networking (SDN) is an approach to building computer networking equipment and software that allows network administrators to have programmable central control of network traffic without requiring physical access to the network's hardware devices. Conceptually, a router or switch is divided into two parts: Control plane: performs configuration and control and Data Plane: handles packet processing. Vendors tightly couple these two planes. SDN avoid using embedded routing protocols and specify how to handle specific critical cases.

In Figure 1 from [2] shows the old and the new architecture of the networks devices.

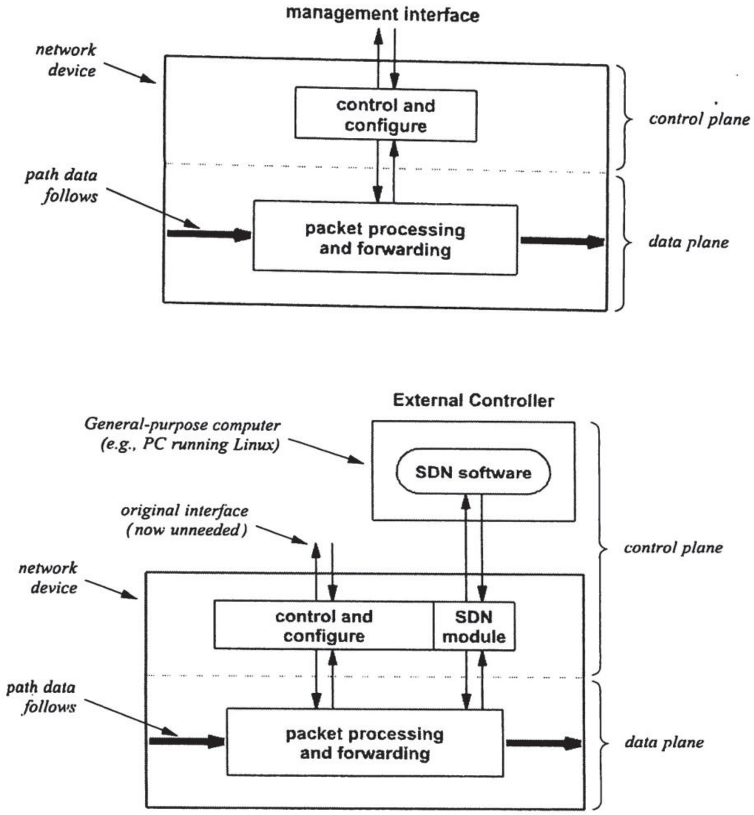

Fig. 1. a. Control and Data Plane, b. SDN Architecture

1.3 OpenFlow

OpenFlow is a new protocol, an instantiation of SDN. OpenFlow [3] enables networks to evolve, by giving a remote controller the power to modify the behavior of network devices, through a well-defined "forwarding instruction set". The growing OpenFlow ecosystem now includes routers, switches, virtual switches, and access points from a range of vendors. OpenFlow is based on an Ethernet switch, with an internal flow-table, and a standardized interface to add and remove flow entries. In Figure 2 an example from [4] is given.

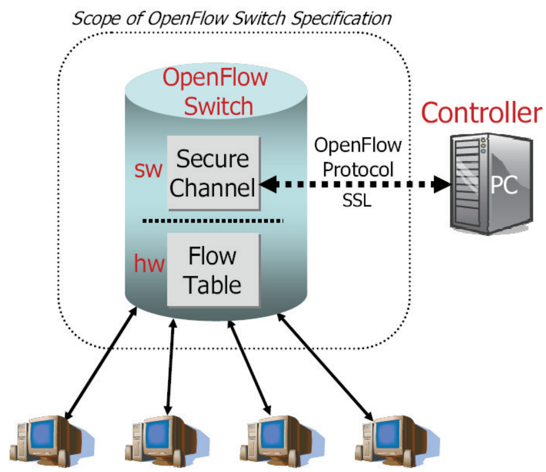

Fig. 2. Idealized OpenFlow Switch. The Flow Idealized OpenFlow Switch. The Flow Table is controlled by a remote controller via the Secure Channel

1.4 Global Environment for Network Innovation (GENI)

The Global Environment for Network Innovations (GENI) [5] is a project sponsored by the National Science Foundation. It is open and broadly inclusive, providing collaborative and exploratory environments for academia, industry and the public to catalyze groundbreaking discoveries and innovation in emerging global networks. GENI is a virtual laboratory at the frontiers of network science and engineering for exploring future internets at scale. GENI creates major opportunities to understand, innovate and transform global networks and their interactions with society.

GENI, a virtual laboratory for exploring future internets at scale, creates major opportunities to understand, innovate and transform global networks and their interactions with society. Dynamic and adaptive, GENI opens up new areas of research at the frontiers of network science and engineering, and increases the opportunity for significant socio-economic impact. GENI:

- support at-scale experimentation on shared, heterogeneous, highly instrumented infrastructure;
- enable deep programmability throughout the network, promoting innovations in network science, security, technologies, services and applications; and
- provide collaborative and exploratory environments for academia, industry and the public to catalyze groundbreaking discoveries and innovation.

1.5 WiMAX

As the first 4G wireless technology, WiMAX [6] combines the performance of WiFi with the range and quality of service (QOS) of a carrier-grade cellular technology. WiMAX can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3-10 miles (5 - 15 km) for mobile stations. In contrast, the WiFi/802.11 wireless local area network standard is limited in most cases to only 100-300 feet (30-100m).

In emerging markets and rural areas, WiMAX is being deployed as a fixed wireless technology to provide basic internet connectivity to residential and business users, without the cost and difficulty of deploying fiber or DSL. In this fixed capacity, the technology can provide backhaul connectivity for Wi-Fi hotspots and other IP enabled devices such as VoIP phones and video surveillance cameras. In more developed markets, WiMAX is being used as a mobile wireless technology by large carriers and operators. The GENI WiMAX projects are creating open, programmable, GENI enabled "cellular-like" infrastructure on university campuses. The WiMAX base station provides network researchers with wide-area coverage and the ability to support both mobile and fixed end users.

1.6 Internet2

Internet2 is an exceptional community of U.S. and international leaders in research, academia, industry and government who create and collaborate via innovative technologies [7]. Internet2 operates the Internet2 Network, a next-generation Internet Protocol and optical network that delivers production network services to meet the high-performance demands of research and education, and provides a secure network testing and research environment. The Internet2 Network, through its regional network and connector members, connects over 60,000 U.S. educational, research, government and "community anchor" institutions, from primary and secondary schools to community colleges and universities, public libraries and museums to health care organizations. The Internet2 community is actively engaged in developing and deploying emerging network technologies beyond the scope of single institutions and critical to the future of the Internet. These technologies include large-scale network performance measurement and management tools, simple and secure identity and access management tools and advanced capabilities such as the on-demand creation and scheduling of high-bandwidth, high-performance circuits.

The infrastructure, services and collaborative environment of the Internet2 community represent tremendous assets for researchers nationwide. Together they create a platform reliable enough for the most exacting production applications, robust and flexible enough for the most extreme research, development and experimentation our community can imagine.

2 Possible Applications of the Next-Generation Internet into Education and Culture Heritage

US Ignite initiative highlights library and museum potential for high-speed broadband applications [8] such as:

- Cuyahoga County Public Library is partnering with Case Western Reserve University and One Community to bring a one-gigabit broadband connection to the new Warrensville Height branch, serving 20,000 residents from an economically disadvantaged community;
- Rutgers University Libraries is a lead partner on the Video Mosaic Collaborative (VMC), an NSF-funded initiative to create a portal to enable teachers and researchers to analyze and use over 20 years of classroom videos to transform mathematics research, teaching, and learning;
- San Francisco Public Library is developing a Teen Media Learning Lab in partnership with local education, museum, technology, and media organizations, to create a free, seven-day-per-week, interactive digital media learning space for youth;
- Graduate School of Library and Information Science (GSLIS) at the University of Illinois Urbana-Champaign hold a series of four continuing education forums to enhance understanding of how libraries can adopt and use next-generation internet networks to address social inclusion through the organization US Ignite. The project aims to help libraries develop applications and services that will meet the needs of the public, particularly underserved populations. Case studies are examining efforts to leverage ultra-high-speed internet service to deliver socially inclusive library experiences that meet critical human development needs. The forums will give library leaders an opportunity to shape the next generation of the internet.

Holograms, lenticulars and 3D television systems are the latest additions to high tech museum displays enabling the viewer to see museum artifacts in a whole new light. To bring these apps to life, developers leverage the unique capabilities of next-generation networks, including:

- High speed, multiple bi-directional streams of uncompressed video;
- Software-defined networks (e.g. OpenFlow), promising dramatically-improved control over network routing and optimization;
- Networks with capabilities such as virtual network “slices” matched to application requirements and distributed programmable resources throughout the network;
- Integrated wireless networks to facilitate, for example, sensor networks and continuous remote monitoring;
- Applications built to be open, shared, and extendable.

Applications in this area are developed in the frame of US Ignite are:

- High Quality Open Source Web Conferencing: Combining high-speed networks with new web standards like HTML5 and WebRTC results in a robust, remote classroom experience and high-quality education for any student equipped with a

simple web browser, no matter where they are located. Big Blue Button System will gives remote students multiple HD camera angles, high-quality audio and synchronized slides;
- Engage3D Conferencing: This in-browser application can bring the Aquarium's educational offerings – live, interactive, and in 3D – into these classrooms at no additional cost to the school. Unlike a simple video, this application allows students to interact with the content – moving, seeing, exploring. The engage 3D application leverages the most current web technologies to provide an immersive, engaging opportunity for students to interact with video in a way that has not been seen before. They don't just sit back and watch the video stream – they can move the content and select their own viewpoints;
- Lynx Laboratories, Real-Time 3D Modeling Cameras. 3D Creation – A camera for all your 3D creations that is as easy to use as a point-and-shoot (http://www.engadget.com/2013/02/02/lynx-a/);
- Hyperaudio Pad – It is a transcript for audio and video based media, making them more accessible, searchable, navigable and index able. Hyperaudio Pad allows people to assemble and remix media as easily as they would a document (http://www.youtube.com/watch?v=Y-hZk4GI6a0);
- LITE Virtual Reality Workforce Development - Workforce development is based on virtual learning and interactive digital media technology. The use of advanced networking allows interactive training with several sites simultaneously;
- Luminosity - Easily creates interactive scientific visualizations in a web application focusing on simplicity. This web application enables a wider audience to participate in scientific research, data exploration and discovery.

3 Conclusion and Future Work

A vision of a new kind of global virtual museum of the future starts with exhibits anywhere, anytime. Example of such museums is the Vatican Museum. It provides visitors with the opportunity to take virtual tour of some of the dozen of museums and galleries from the Vatican collection. The visitors can view a three dimension video of the Sistine Chapel. We are trying to experiment some of the new techniques in the museum of Parzardjik. Historical Museum in Pazardjik is one of the most popular museums in Bulgaria. He is among the leaders of Bulgaria in attendance and is one of the first museums in the country and it is divided into several sections: Archaeology, History of Bulgaria XV-XIX century Ethnography, Modern History, Contemporary History, Foundations and scientific records. In profile Archaeology will meet the moral culture of the region reflected in the pottery of the Stone Age, Middle and Western coins, weapons, ornaments. It is at one of the most complete collection of the Thracian artifacts.

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