Network Slicing for Emergency Communications

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EAGER: US Ignite: Network Slicing for Emergency Communications, NSF Award ID: 1258486
Overview

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   • Technologies, goals, partners, events, apps

II. Part II – NSEC
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      • Implementation
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Part I: US Ignite
Developing Gigabit-ready digital experiences and applications.
Public-private partnership

501(c)(3)
NextGen Technologies

Next-Gen Infrastructure

Next-Gen Apps

Gig.U

INTERNET®
OUR GOALS

1. 60 next-generation applications
2. 200 community test beds
3. Coordinate best practices
US Ignite fosters the creation of next-generation Internet applications that provide transformative public benefit

STRATEGIES:

A. Assemble and maintain a community of public-private partners that support US Ignite

B. Suggest opportunities for sustainable new business(es) built on the networking revolution.

C. Stimulate the development of compelling next-generation applications that deliver on national priorities
Calling all developers, network engineers and community catalysts...

BUILD APPS FROM THE FUTURE

Design and build apps for the faster, smarter internet of the future. Mozilla and the National Science Foundation invite you to take part in an open innovation challenge. The goal: show how next-generation networks can revolutionize healthcare, education, public safety, energy and more.

Explore
Browse through the ideas submitted in the brainstorm phase,

Collaborate
Meet like-minded collaborators at code sprints, design jams and

Build
Submit code prototypes to earn funding and support. $485,000 in
Selected Events
White House Launch Developer Workshop
Gig Tank 2012
KC Hackathon
Hackanooga
Cajun Codefest
Fiber to the Home Council
FCC Gigabit Challenge
Application Summit
Typical App Characteristics

• Real-time (apparently instantaneous)
• Very low latency
• Reliable (no hiccups)
• Cyberphysical interactions
• Big data
• Collaborative (in the moment)
• Distributed
Industry

- Gets
  - Compelling applications for their technology innovations (SDN, Net virtualization, etc.)
  - Introductions to new markets
- Gives
  - Funding for the non-profit
  - Engineering, lab, and equipment resources
Carriers and ISPs

• Gets
  – Compelling new applications for their service innovations
  – Opportunities for new revenue streams

• Gives
  – Funding for the non-profit
  – Engineering, lab, and last-mile resources
R & E Networks

• Gets
  – Compelling new applications for their service innovations (layer 2, SDN, etc.)
  – Recognition for their leadership

• Gives
  – Access to pre-commercial services
  – Expertise in advanced networking
More info:

- Mozilla Ignite Challenge: [https://mozillaignite.org/](https://mozillaignite.org/)
- US Ignite Application Summit 2013: [https://www.youtube.com/watch?v=2QgOgRbKY-E](https://www.youtube.com/watch?v=2QgOgRbKY-E)
Part II: NSEC
Introduction
Welcome to the Modern Heuristic Research Group webpage

Our research group focuses on theoretical and applied research in Computational Intelligence algorithms, such as Artificial Neural Networks, Fuzzy Logic Systems, and Unsupervised Learning techniques. We are applying these methods in areas of Energy, Cyber Security, Human-Machine Interfacing, Intelligent Control Systems, Software Defined Networks, Robotics, Visualizations, and others. Please check the list of publications of our recently published conference and journal papers.
Today’s talk

• Will not provide all the answers…,
  but will point out to big challenges…and
  how the problems can be solved…

• Not WHAT but WHY…
  EAS or SDN or OF…
  we need a paradigm shift…
  SDN can be a path forward…
Software Defined Networks (SDN)
What is SDN?

• What SDN is not:
  – SDN is not a new architecture
  – SDN is not a new network protocol
  – SDN is not a new hardware specification

• What SDN is:

  **SDN IS an entirely new way of thinking (managing) about networks.**
Network Structure

Network

• **Edge**
  – Applications and hosts

• **Core**
  – Interconnected routers
  – Network of networks
What makes SDN revolutionary?

• **Bottleneck!**
  – Evolution of computer networking has created a bottleneck effect!

• **Where?**
  – Protocol innovation is fast at the edge, but slow in the middle

• **Why?**
  – Internet layer protocols are tied directly to hardware.
  – Innovation requires large scale replacement of hardware.
  – R&D of new protocols are prohibitively costly to test and implement.
What makes SDN revolutionary?

- **Solution:** “Virtualize the network.”
  - *Separate the control from the hardware.*
  - *Allow control to be handled where innovation happens fastest: the network edge*
What makes SDN revolutionary?

- The control plane moves from hardware to software
- Innovation shifts from a hardware design problem to a software design problem
- SDN separates the control plane from the data plane

=> Control can be handled from the network edge!
What makes SDN revolutionary?

Must be answering some important questions!

• Large-scale SW systems?
  – How to build?
  – Abstractions -> build modular systems
    • *Now concerns separated*
  – How to come up with abstractions?
    • *Decompose the problem, focus on interface related to subproblem,*
    • *If that does not work, go back, decompose further*

• Abstractions in networking today?
  – Data plane - done well (layers, forwarding state + packet header)
  – Control plane – the only mechanism without abstraction!
    • *Must compute forwarding state (based on low-level hw/sw, entire network topology, for all routers/switches).*
    • *We see it as a natural set of requirements – WRONG!*
  – Programming analogy!
Software Defined Networks

Control Program

Global Network View

Network OS

Diagram showing the structure of Software Defined Networks with a focus on the relationship between control programs, global network views, and network operating systems.
Software Defined Networks

- Control Program
- Abstract Network View
- Virtualization Layer
- Global Network View
- Network OS

Clear Separation of Concerns
OpenFlow Standard
OpenFlow

• If the control plane is separate from hardware, we need to define how communication between the two is handled.

• Solution: OpenFlow
  – Open standard
  – Allows easy deployment of innovative routing and switching protocols
  – Data path presented as a clean flow table abstraction
  – Traffic “flows” are defined using simple rules
Videos of Research Demos

These videos demonstrate different research experiments that build on top of OpenFlow. If you have similar videos that demonstrate your research and are interested in hosting them here, please contact Nikhil Handigol.

openflow.org/videos/
Applications

Reaching to customers in controlled, low delay fashion

- **Distributed control**
  - Significantly reduced delay

- **Separation of services**
  - ex. CAES and three IT

- **Video streaming**
  - Guaranteed bandwidth/QoS, directed traffic, own slice

- **Seamless Wi-Fi sharing**
  - No login, separated traffic

- **Smart-Grid**
  - Client-Utility communication

- **Vehicle fleet**
  - Wirelessly communicating via routers on the road

- **Emergency Alert Systems**
Open Networking Foundation (ONF)
www.opennetworking.org

- Continues standardization of OpenFlow and SDN interfaces/AP

- Current ONF Members

- Board Members
Industry Embracing SDN

Largest Network Providers/Operators
- BT
- Google
- Internet
- Level3
- NTT Docomo
- Microsoft
- Amazon
- Facebook
- More...

Vendors and start-ups
- Broadcom
- Juniper Networks
- Ericsson
- HP
- NEC
- Ciena
- Dell
- Netgear
- Extreme Networks
- More...

Url from: http://cenic2012.cenic.org/program/slides/CenicOpenFlow-3-9-12-submit.pdf
Google’s OpenFlow WAN
Google in 2012, but before that…

• Before 2012…

  Scott Shenker, Nick McKeown, Teemu Koponen
  2004 Stanford/Berkeley projects
  2008 SDN such as NOX and open flow switch defined
  2011 ONF started, big board members
  2012 SDN trade show (Latest Open Networking Summit)
  2012 Google's WAN

  World’s largest production network, now using SDN connected data centers

Why such rapid acceptance?

  =>Answers important questions!
Real World Use: Google’s OpenFlow WAN

(Apr. 2012)
Google’s OpenFlow WAN

“If Google were an ISP, as of this month it would rank as the second largest carrier on the planet.”

-ATLAS 2010 Traffic Report, Arbor Networks

• Google operates two large backbone networks
  – Internet-facing backbone (user traffic)
  – Datacenter backbone (internal traffic)

• Decided in 2009 to investigate using SDN as replacement for Datacenter backbone (largest production network at Google).

• As of early 2012, all of Google’s Datacenter traffic is carried by an OpenFlow SDN.

• Network now operates from 25 to 50 times faster
Network Slicing for Emergency Communications: General Architecture

The University of Idaho and Ammon are teaming up to develop a new way to dispatch emergency communications after receiving a nearly $276,000 grant.

One day, Ammon residents could receive all emergency notifications via email, text, or face-to-face video communication. Residents could choose how they would receive such information. They no longer would be limited to land-line telephones or local news outlets for emergency information.

The National Science Foundation awarded University of Idaho Professor Mansi Manic and the city a grant of more than $275,000 to study how best to tap into broadband networks for emergency purposes. The money will arrive Oct. 1.

"People drop land lines, but everyone has broadband connections," Ammon technology director Bruce Patterson said. "We believe there is technology to use broadband to get emergency information to residents. That technology will allow emergency operators to use any virtual network to reach all residents, regardless of where they buy Internet service," Manic said. "We will design a system where one channel is devoted to 911 and the (operator) of the channel can give priority and override (every other communication)," Manic said.

Transforming the idea from the conceptual stage to a practical technology that everyone can use will take time and more money, Patterson said. A group of cities in Utah, part of the Utah Telecommunication Open Infrastructure Agency, is testing the technology once it is developed, he said. "This is a national priority," Patterson said. "It is a real need, and it will only get worse as time goes on if we don’t address it.”
Why NSEC?

• People are going away from:
  – Local TV channels
  – Landlines

• People are going towards the Internet:
  – So...can we use broadband for EAS?

First...let us look at the existing EAS....
E911+VoIP+Cell+Reverse 911

Caller Edge

Responder Edge

Public Safety Answering Point

PSTN

ANI

ALI

ROUTER

Cell Network

Public Internet

Packet Network

LOC

CADS

Caller Location Information

DB

DB
E911+VoIP+Cell+Reverse 911+SMS
Emergency Responder’s Statement

• Stacy Hyde, Fire Chief, City of Ammon
  – In 2012: 134 calls, ~ $130K, or $945 per call
  – On average, fire doubles in size per minute
  – Long communication chain
    • Arriving at a scene w/o information, key to operations!
    • Cost of loss of property
      – Average response time increase of 3-5 min may mean the difference between recoverable fire and total loss of property!
  – Direct communication chain
    • Streamline the system
    • Get on scene faster,
    • greater abilities on scene,
    • decreased response time,
    • decreased cost per call.
Existing EAS...

• **Current systems too complex/expensive!**
  • Current City of Ammon cost per call ~ $1,000
  • Problems solved by adding more hardware – complexity further increases
  • Dispatcher centers deal with complex equipment – raises the cost further to keep up & running
  • Calls treated as analogue (voice), currently via public internet

• **Questions & Challenges**
  • Who makes the choice where the call goes, who answers the call?
  • Changing the paradigm (how people think) – entrenched way of doing things!
  • Phone companies dictate how communication goes
How about SDN based approach…?
SDN based EMS?

- **SDN based approach**
  - Common dispatch server
    - Easier to manage
    - More resilient
  - No consideration for the carrier anymore
    - Once they support SDN and let us across the network
  - Move intelligence to the edge
    - Control the core
    - The core does not make decisions
  - Go digital
    - Convert edge devices communication into digital
    - Cell, landline, computer treated equally -> connection handed over directly
  - OnStar example:
    - Call does not have to go through dispatch
    - Call can go to a EMS responder directly
    - EMS responder can be dynamically determined (mobile – fire truck, closest – fire station or fire truck)
1. Manager Server provides basic management of User Devices
2. Service Servers provide applications/content to User Devices
   1. Each Service is on its own private virtual network
3. User Devices would be installed in a home or business
   1. Have 1 physical network connection, multiple virtual network connections
4. Network is managed by Network Operators, e.g. ISPs
Overall Architecture – Managers

Manager Manager

Service 1 Manager

Service 2 Manager

Service N Manager

Manager Server

Service 1 Server

Service 2 Server

Service N Server

Network

Service-Server Management
Overall Architecture

OpenFlow Network Management

OpenFlow Controllers – EA agencies need contracts with OFC to provide priority when needed;
Overall Architecture - Services

Manager

Service 1 Manager

Service 1 Server

User 1 Device

Manager Server

Select Service

Manager

Server

Service 2 Manager

Service 2 Server

User 2 Device

VLAN 101

VLAN 102

VLAN 10N

Service N Manager

Server

Service N Server

User N Device

VLAN 100

Isolation of Services!

The Manager Server says “all user devices switch to weather service. It talks to the client machine in total (not to the individual VMs within client; It is the hypervisor within each client machine pauses all the VMs except the one requested (Weather Alert); Service server has tftp within it; Client has within PXE tftp as well; both communicate via tftp, so service server sends a binary image to a client VM. This is what is called PXE boot; So now we have VM running with a particular service, i.e. browser or linphone;
Overall Architecture - Server-Client Communication

Management
- DHCP Server
- Manager Server

Service 1
- DHCP Server
- LTSP Server

Service 2
- DHCP Server
- LTSP Server

Service N
- DHCP Server
- LTSP Server

Network Appearance from User Device Perspective

Slicing End-to-End!

Network

Open vSwitch/VLAN tagging

Hypervisor

VM1, VM2, ..., VMN

HARDWARE

User Access Point
Server-(On the Client) Service Communication

Service provider's servers provide addresses and applications/content to the user devices. From this perspective, everything appears to be on one private network. Service providers have complete control over how that network is set up. At the bottom we have - user devices attached to the network; In reality each of these machines is a virtual machine on a user device.

Service X LTSP Server is practically a hard drive for all user machines (that are running thin client Ubuntu 12.10). Everything on a picture is running on a same vlan (here for ex. 101 for weather, or generically, for a 10X vlan); Each PXE Boot exists within a different home device (laptop 1 - service 1, laptop 2 – service 2, laptop 3 – service 3).
Implementation
NSEC Demo Cart

NSEC Demo Rack
A: Client Devices
B: OF Switch, Virtual Server (VS), OF Controller (OFC), Display switching between VS/OFC (KVM)
C: Manager Manager
D: Service Manager (alternated among 3 services, Weather Alert/911/EAS)
NSEC Demo Cart

[Diagram showing network components and VLAN setups]
NSEC Demo Cart

Virtual Machines

Open vSwitch

Client Device

Network

User Access Point
NSEC Demo Cart
NSEC Demo Cart

Isolation of Services!

NSEC Demo Rack
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Advantages of this architecture

• **Network slicing**
  – Separation of services
  – Bandwidth and QoS
  – Security
  – Facilitates easier management

• **Isolation of services**
  – Each service is on its own VLAN
  – Fault isolation (if one service crashes, does not bring down the others)

• **End-to-End Virtualization**
  – Everything *virtualized* (server, client, the path in between)
  – Facilitates *remote* reboots, updates (full control of client’s machine)
  – Enables *consistency* of client software (all clients running the exact same software - same binaries)
  – Enables *scalability* (easy to add additional services across all clients)

• **Emergency Alert Services (EAS)**
  – All digital
  – Faster response time
  – Reduced complexity and cost
NSEC Video Demo

- NSEC Demo Cart Video
  - Components, Network manager, Service provider, Clients, Weather alert and 911 (Linphone) demo
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Network Slicing for Emergency Communication

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Thank You…Questions?

"Simplicity is the ultimate sophistication."
~ Leonardo da Vinci