Is SDN the De-constraining Constraint of the Future Internet?

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Introduction

- Which way that future network will be constructed?
- What are the major challenges to implement the future network?

Which way that future network will be constructed?

- Clean-slate
- Evolutionary approach

What is the major challenges to implement the future network?

- Network design
- Virtualization
- Experimental Research

Network Design

- Architectural guidelines:
  - Layered reference
  - End-to-end arguments
- Restrictions:
  - Mobility
  - Security
  - Quality of service

Virtualization:

- Pros
- Usage Areas
- Needed future modifications

Experimental Research:

- Needs:
- Tests:
  - SDN(Software Defined Network)

Presciptive Network Theory

- Deals with “What should be?”
- Not with “What is being done?”
- Explains uncertainty; Axiomatic
- High level, does not go into detail
- It is opposing Descriptive Theory

What do we focus on?

- Internet, rather than general Networking concepts
- Protocols, rather than principles
- Backwards compatibility and incremental deployment, rather than more general theories such as Teletraffic Theory, Graph Theory
- The difficulty of uncertainty is faced

What has been done at the seminar in Dagstuhl, March 2013?

- 1 of out 3 days has been spent
- Group discussions have been accomplished and following decisions were achieved

Quality

- There can not be a single, all-containing network theory
- Networking has a tight relationship with neighboring theories like Information and Coding Theory
- Quality is rooted on well-defined axioms
- Prescriptive Network Theory: accepted as less formal high-level guidelines for the design of networks
- Does not go into detailed design patterns

Multi Mechanisms

- Set of mechanisms that serve the same functional purpose and are interchangeable with each other
- The composition of todays mechanisms offer significant opportunities for the Future Internet
- Dynamic and requirement-based mechanism combinations

De-constraining Constraints

- D. L. Alderson and J. C. Doyle. Contrasting views of complexity and their implications for network-centric infrastructures. IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans, 40(4):839–852, July 2010.
- Hourglass figure (commonly used to visualize the protocol stack of Internet)
- The narrow spine of the hourglass has an releasing effect
- Copied from the DNA (how it leads to variety)
- The core of the hourglass is the IP
- Alternatives may spread above as well as below

Middleboxes

- Significant increase of middle boxes (NAT, firewalls, rate limiters, proxies)
- Internet layer: 4 plus interconnection of IP networks
- Bypassing is risky: Middle boxes may block applications
- On the other hand, Middleboxes bring big potential for innovation and may be handled as de-constraining constraints

Latency

- Major issue for the Future Internet
- Propagation delays may ultimately be fixed
- From architectural viewpoint: the light can not be sped up
- Distances may be reduced (by caches, proxies, etc.)
- Other improvements like removing handshakes and trading security with delay

Experimental Research

- Much Future Internet research is mostly depends on experimentations
- Research is mostly implemented as testbeds
  - overlays, virtual and/or software defined networks
  - Their use for development of new networking principles and paradigms is hard to observe
- The goal was gathering lessons learned and best practices

Experimental Research

- The answers of the following questions are searched:
  - Is there something like ‘experimentally driven knowledge gain’ and what is the scientific method?
  - Which insights can be experimental, testbed-based approach reveal?
  - What are meaningful use cases of testbeds, e.g., engineering details, concepts weakly understood, prototyping?
  - How should a testbed platform look like, which properties must be provided to achieve comparability an validity?
  - What makes (research) overlays special (pros & cons)?

Insights From Testbeds

- Brad Karp asked and discussed two important questions about testbed-based research:
  - Is the act of building a testbed research?
  - Do the testbeds yield fundamental research insights?

Insights From Testbeds

- For the first question:
  - The act of building a testbed is research only when a great care is taken in deciding whether to build it or not because the need for significant amount of fund an labor.
- For the second question:
  - A test is proposed by Brad Karp
    - Asks “what relevant phenomena cannot you simulate?”
    - Possible answers include user behavior, feedback, non-perfect behavior of systems, or a lack of knowing what to simulate at all.

The engineering loop

- In his talk, Jörg Liebeherr defined the engineering process as the implementation of a system design for experimental evaluation to support, discard or improve an idea
- General concern:
  - Generally, design and experimentation are done by the same, interested party and this may cause lack of objectivity

Scalability of Testbeds

- Scalability which includes the size and the inclusion of real users is an important aspect that must be discussed and resolved.
- Brad Karp argued that The resulting effects (e.g. latencies) make testbeds most useful.
  - Latencies are results of real-word behaviors, coming from either from people or from machines.
- There is a need for testing systems with millions of real users to be able to observe latency related aspects such as signaling storms (Markus Hoffmann)

Scalability of Testbeds
Social Approach

- According to the social scientists, At different group sizes (2-3, 15, 50, 100 and over 150) user behavior changes.
- This information is hard to observe in the digital domain.
- With this information we can observe user behaviors at the scale from millions of users to small groups that contains a handful of people.

Scalability of Testbeds
Final Note

- Testbeds, simulations and analysis must be exist side by side to be able to trade detail for scalability (Phuoc Tran-Gia)

General Purpose Testbeds

- Two opposed realities:
  - Powerful insights can be gained from overlay-based testbeds and they are highly valued.
  - There is a risk of testbeds' falling short of one's expectations because of the discordant requirements

Contact with Reality

- Meeting the goal of reproduce real-word behavior might be troublesome and causes the following challenges:
  - Supporting and maintaining heterogeneous devices in testbeds is inconvenient
  - Programming interfaces may evolve quickly
  - Including real users is difficult
  - Realistic traffic, mobility patterns or user behavior are hard to obtain
  - Privacy concerns persist even after anonymization due to risk of de-anonymization
  - Anonymized data may be hard to work with
  - Re-engineering systems and mechanisms to obtain desired data can be questioned and faces the risk that an update may just change the mechanism under investigation

SDN, Virtualisation, OpenFlow

- Advances in computer science lead to developing safer programs much more quickly
- Due to advances in:
  - Operating Systems
  - Developing Tools
  - Virtualisation
  - Isolation
- These advances may be used to improve the dependence of the Internet rather than incrementally patching it.

- In the past, the internal components of network – switches, routers, etc. – evolved in a separate software and hardware ecosystem from end-systems.
- There fore the following benefited from the advances in computer science:
  - Commodity price
  - Performance
  - Production of smartphones
  - Desktops & servers
- While the infrastructure of the Internet became a set of specialized businesses generating specialized technologies.

- SDN is aiming to reverse this trend by moving some parts of the data and control plane into computer science area

- Thus, aiming to have a platform similar to Android, iPhone and Windows for applications.

Some use-cases of SDN

1. Multi-tenant data centers providing specialized services to tenants with different needs
2. Multi-user VR and MMORPG: large scale dynamic network requirements
3. VM migration during maintenance: causes high loads on networks
4. Internet of Things: deployment of IPv6. Security is an issue.
5. Content Distribution Networks: P2P content sharing causes heavy load

Some use-cases of SDN (Contd.)

6. Middlebox management: inability to deploy transport layer protocols due to ad-hoc nature of middleboxes (firewalls, WAN optimizers etc.). SDN brings these in a coherent network.
7. Management of multiple SDNs is a challenge itself
8. Hybrid cloud: applications and specialized support for SDN apps
9. Flexible networks for enterprise intranets

Motivation for Use-Cases

- **Overcommit:** Economics of multi-tenancy depend on invisible overcommit. Tenant should not realize anything else being scheduled in the gaps of their usage
- **Latency:** VR and online gaming requires low latency
- **Flow based I/O:** All of them cause heavy load. Balancing required.
  - VMs ~ netwok flow (TCP/SSL)
  - CDN ~ VM migration
  - Middlebox management
- **Global Identity:** Internet of Things require naming in addition to addressing.

Thanks for listening..