uPVN
User-Centric Programmable Virtual Networks

Fernando M. V. Ramos
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Virtualisation has revolutionized computing

- Completely changed the way resources are managed
- Is this true for networking?
  - Many virtualisation primitives (VLAN, NAT, MPLS, etc.) but no network virtualisation *per se*
Network virtualisation => full decoupling

vNet 1

vNet 2

vNet 3

virtual networks

substrate network
Virtualisation has revolutionized computing

• Completely changed the way resources are managed

• Is this true for networking?
  – Many virtualisation primitives (VLAN, NAT, MPLS, etc.) but no network virtualisation *per se*

• Result:
  – Network provisioning is slow
  – Mobility is limited
  – ...
Game changer: Software-Defined Networking

- SDN
  - decoupling of networking planes
  - logical centralisation of control
  - network-wide visibility & direct control
Result: network virtualisation

• VMware NSX [Koponen2014]
  – A production-level, cloud-scale network virtualisation platform
Characteristics of existing platforms

• Provider-centric
  – Single operator, single provider

• Networking services: traditional
  – Full virtualisation of topology, addressing and service models
  – Traditional services
    • flat L2, L3 routing, ACL filtering
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User-centric virtual networks

• **User-centric**
  
  – Substrate = public clouds + private datacenters
High level view

User-centric virtual network
Motivation
Scalability

Scale out the infrastructure to accommodate growth
Bring the infrastructure closer to the customers
More options to secure your infrastructure
Dependability
Dependability

Cloud replication for fault-tolerance
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Network programmability

• With SDN we can **program** the network control plane!
  – Not the data plane

![Diagram showing SDN controller and its flexible and inflexible connections to TE, Routing, and ACL]
Problem

• Current switch chips are **fixed-function**
  – They run a fixed set of protocols, defined at manufacturing time

![Fixed Set of Protocols]

• What if you want a **new protocol** in your network?
  – Convince the manufacturer
    • If you’re lucky they’ll do it
    • In a few years...
Problems of fixed-function switches

• **Slow innovation**
  – Several months or years to add a new feature or protocol

• **Inefficient**
  – Match tables hardwired to specific purpose

• **Complicated**
  – Switch implements superset of all features

“This is how I process packets”
Programmable switches

• Build your own **custom** protocol

- Custom Protocols
  - TCP
  - Ethernet
  - CUSTOM_P
  - IPv4
  - HTTP
  - IPv6
  - BGP
  - TLS

• This is already a reality **today**
P4 high level language

```
table routing {
  reads {
    ipv4.dstAddr : lpm;
  }
  actions {
    do_drop;
    route_ipv4;
  }
  size: 2048;
}

control ingress {
  apply(routing);
}
```

http://p4.org
User-centric programmable virtual networks

• User-centric
  – Substrate: Public clouds + private datacenters

• Networking services: fully programmable
  – Full virtualisation of topology, addressing and service models
  – Use of a high level language (e.g., P4) to program how packets should be processed exactly in your virtual network
uPVPN: High level view

User-centric programmable virtual network

amazon web services
Windows Azure
openstack
Challenges
Selected research topics

• uPVN
  – Efficient compilation of user programs to a variety of different substrate elements (sw+hw)
  – Virtual network embedding algorithms
  – Orchestration of stateless (L2, L3) and stateful (e.g., middleboxes) network functions

• Programmable networks in general
  – Network-wide, global abstractions to program networks of programmable elements
  – Advanced monitoring capabilities
  – Security
  – Debugging and verification
Conclusions
Conclusions

• Current network virtualisation platforms have limitations
  – They are provider-centric
  – The services offered are limited to traditional networking functionality

• We propose uPVN: User-Centric Programmable Virtual Networks
  – User-centric, built over a substrate of multiple clouds
  – All network elements are fully programmable with a high level language (e.g., P4)

• Many exciting challenges ahead to make this vision a reality!