uPVN
User-Centric Programmable Virtual Networks

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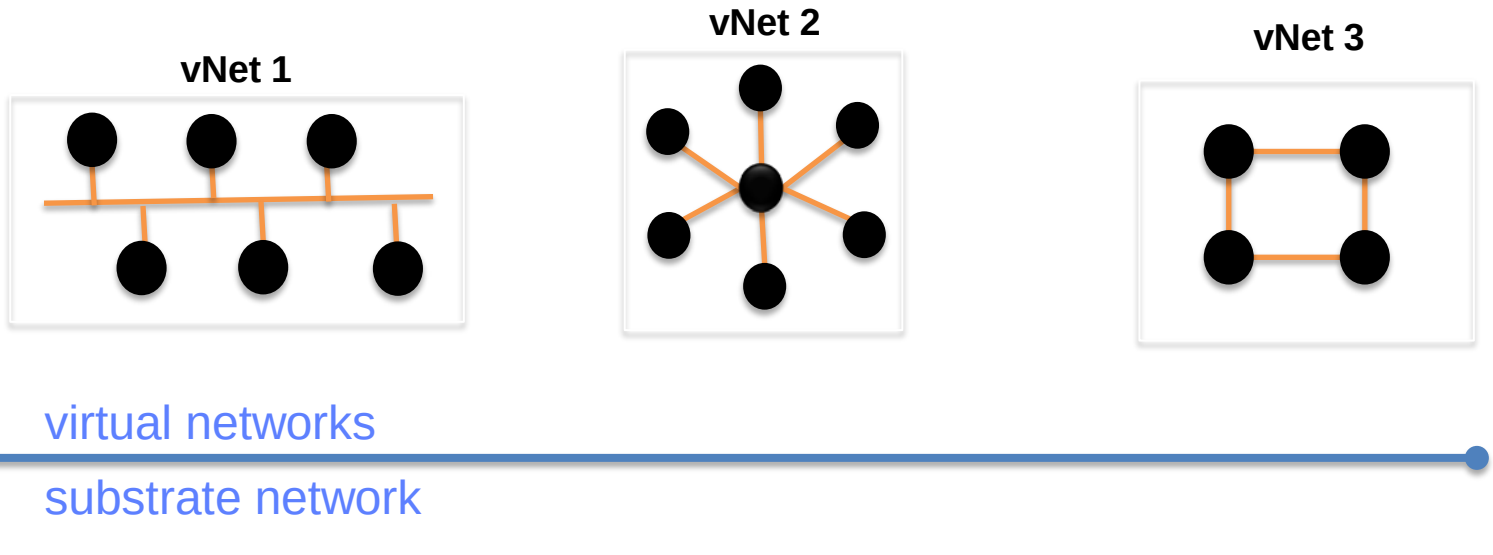
Virtualisation has revolutionized computing

- 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

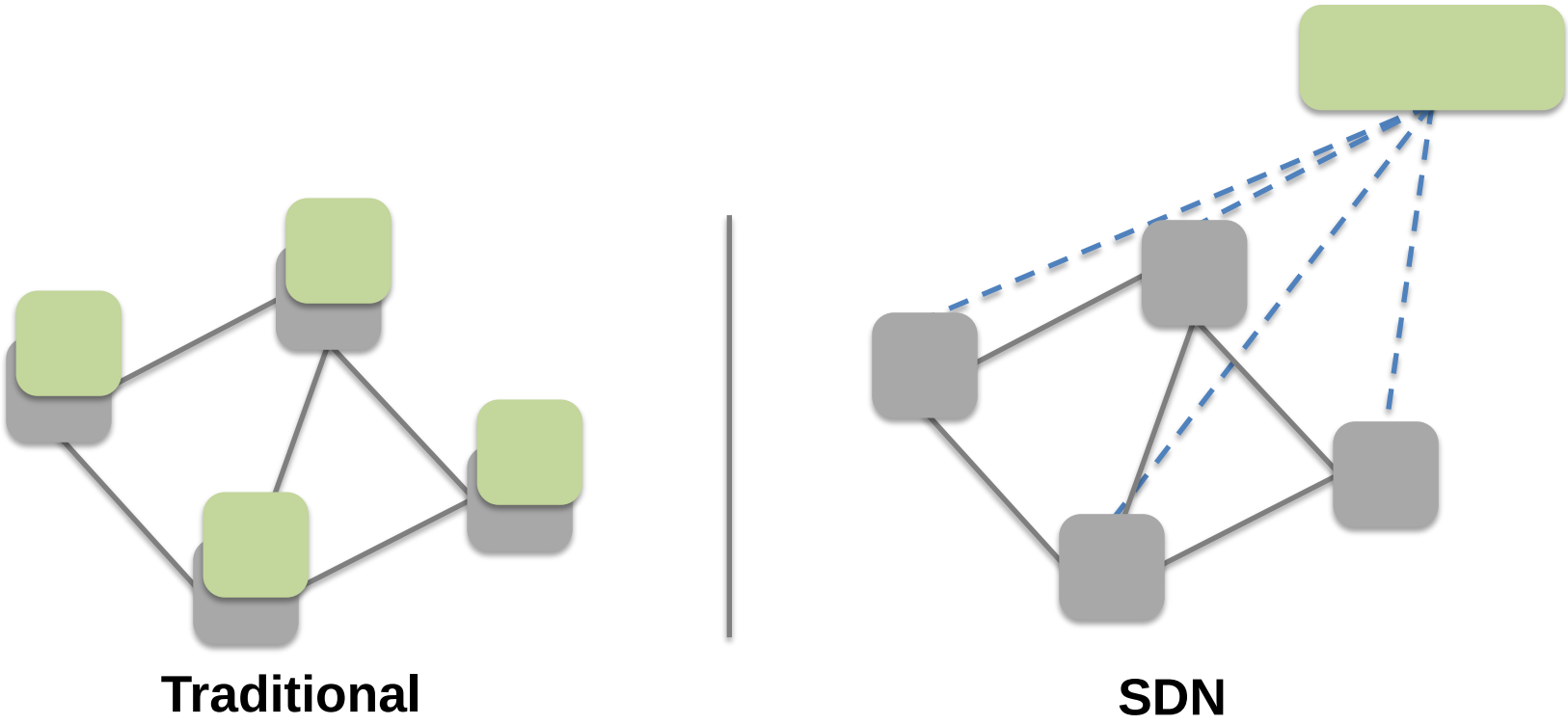


Virtualisation has revolutionized computing

- 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
  - …

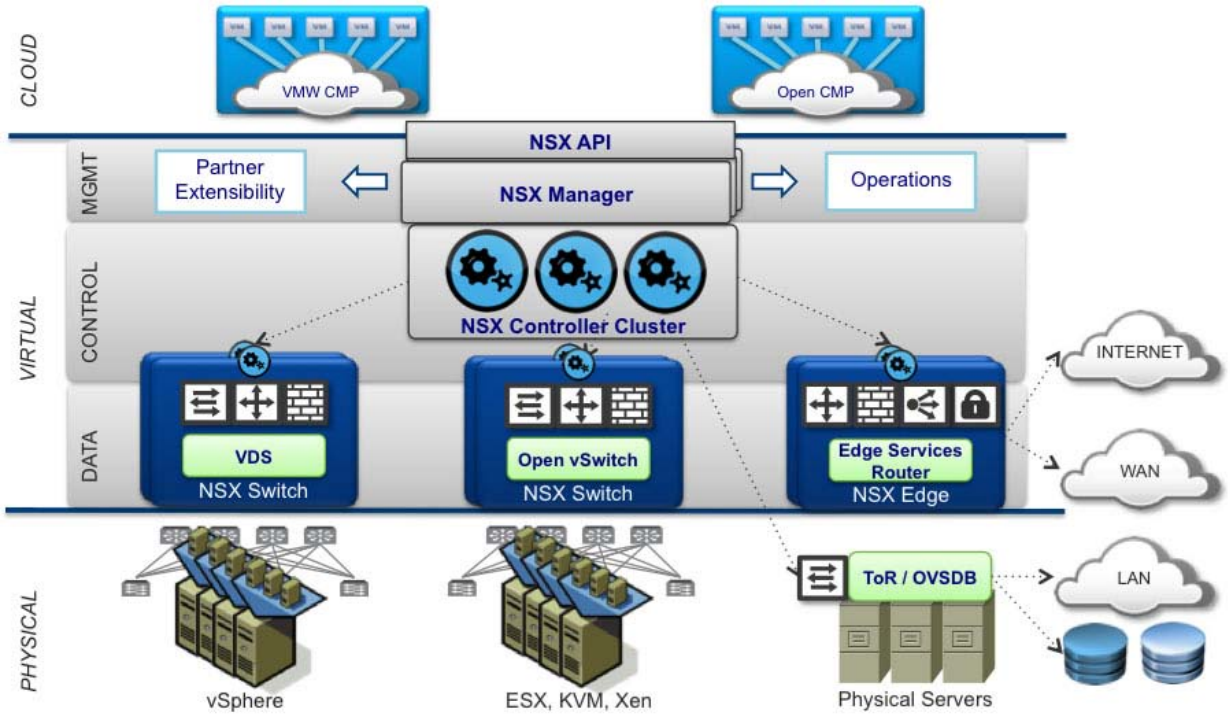
Game changer: Software-Defined Networking

- 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



Source: VMware

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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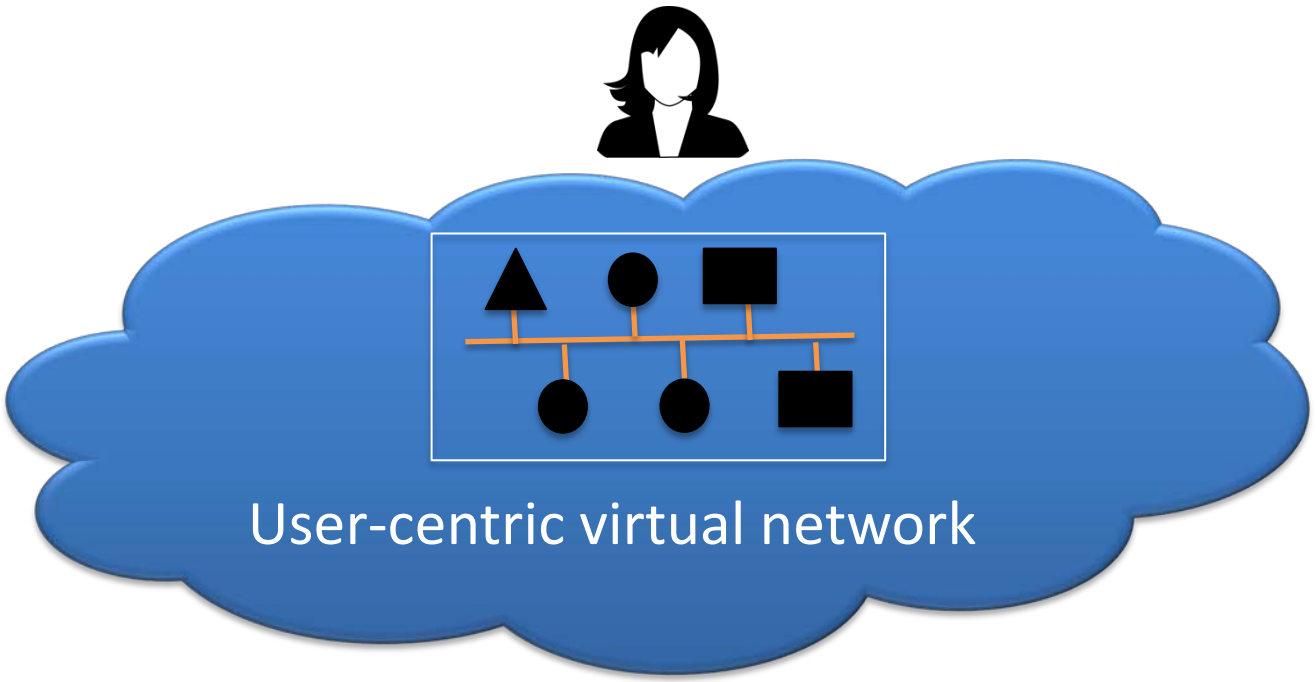
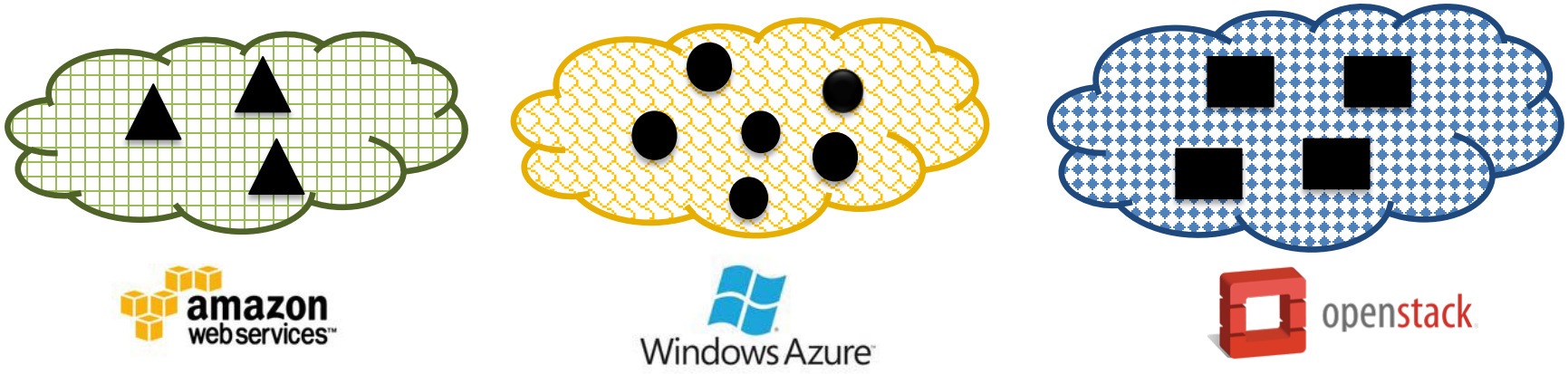
User-centric virtual networks

- User-centric
  - Substrate = public clouds + private datacenters

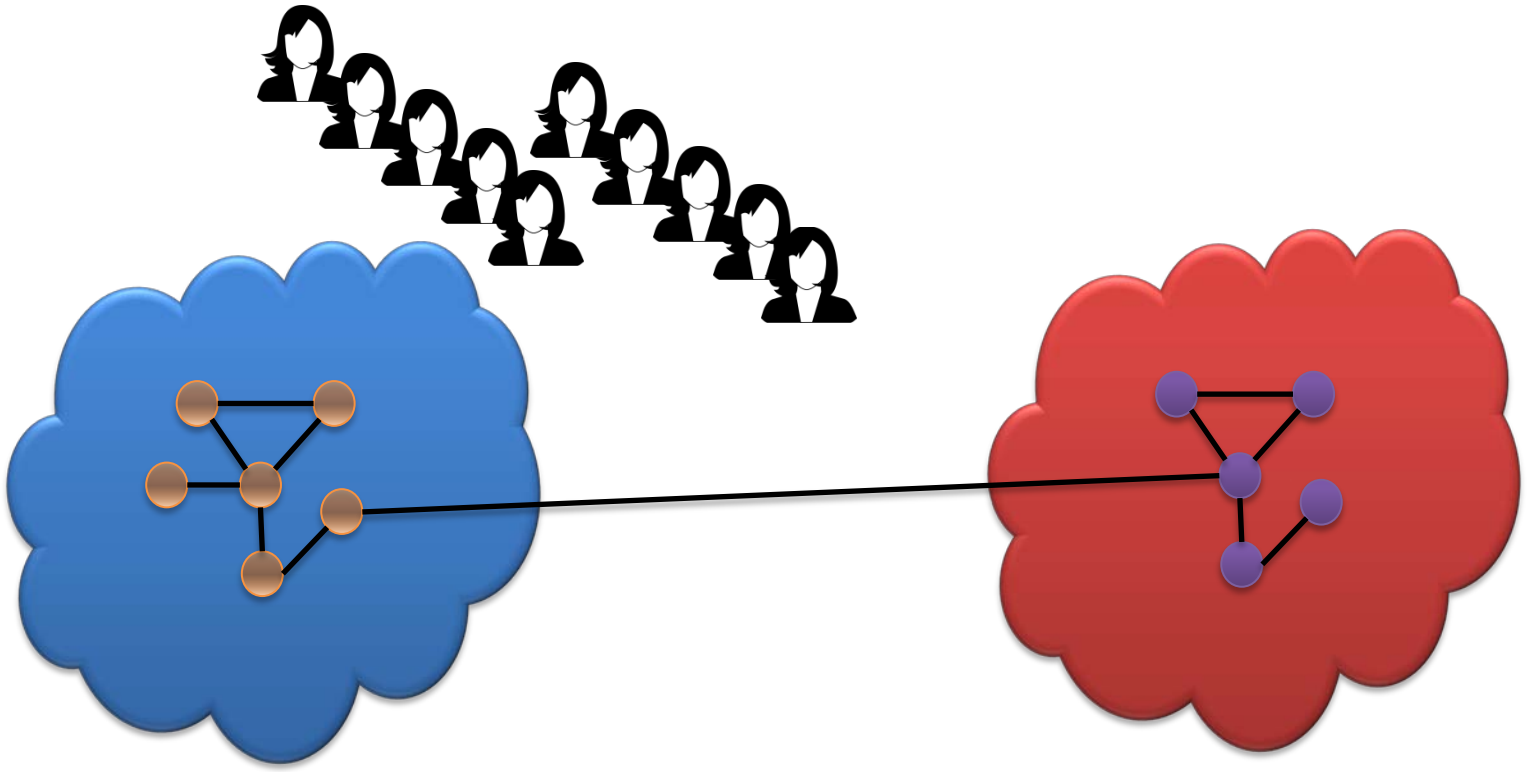
High level view





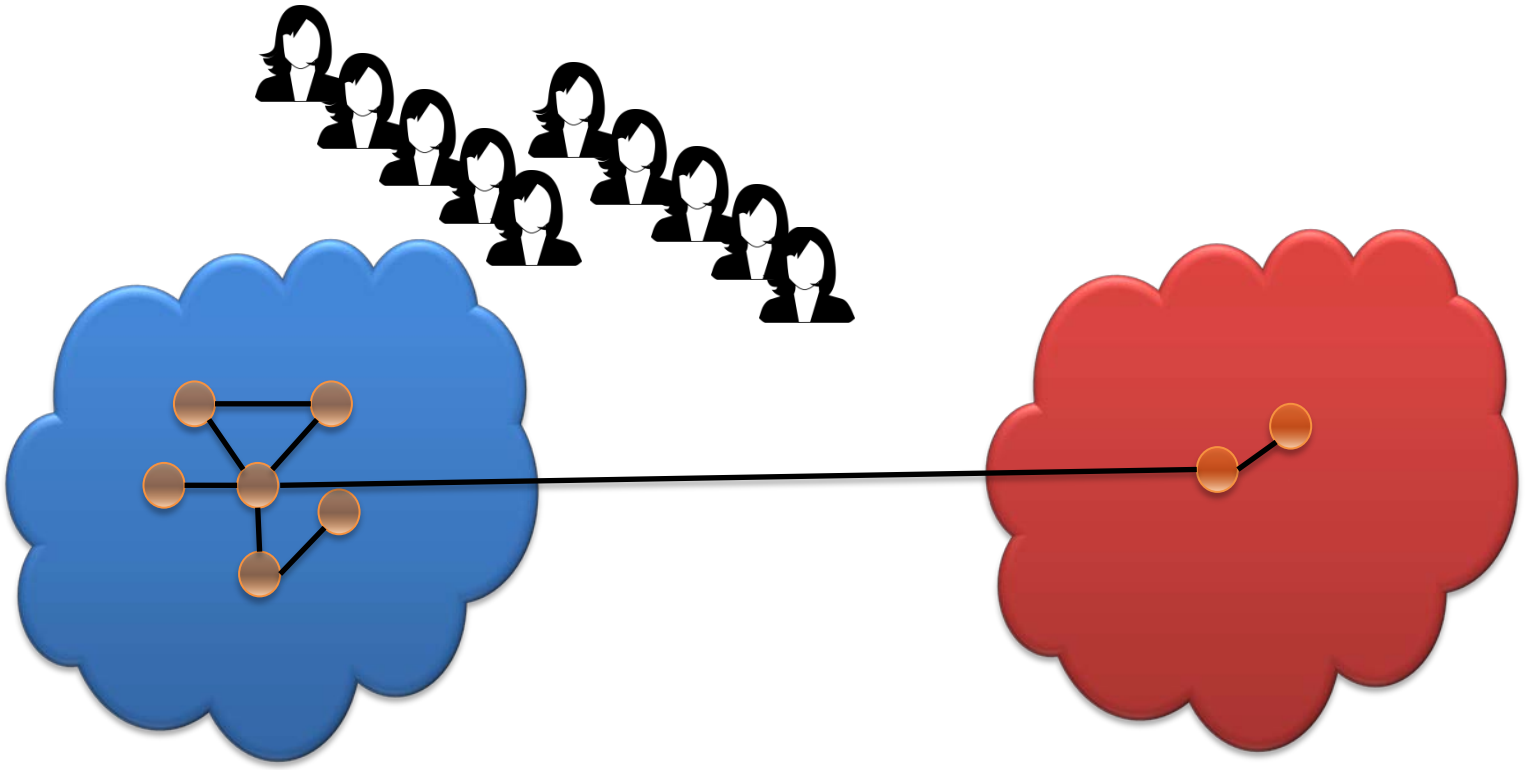
Motivation

Scalability



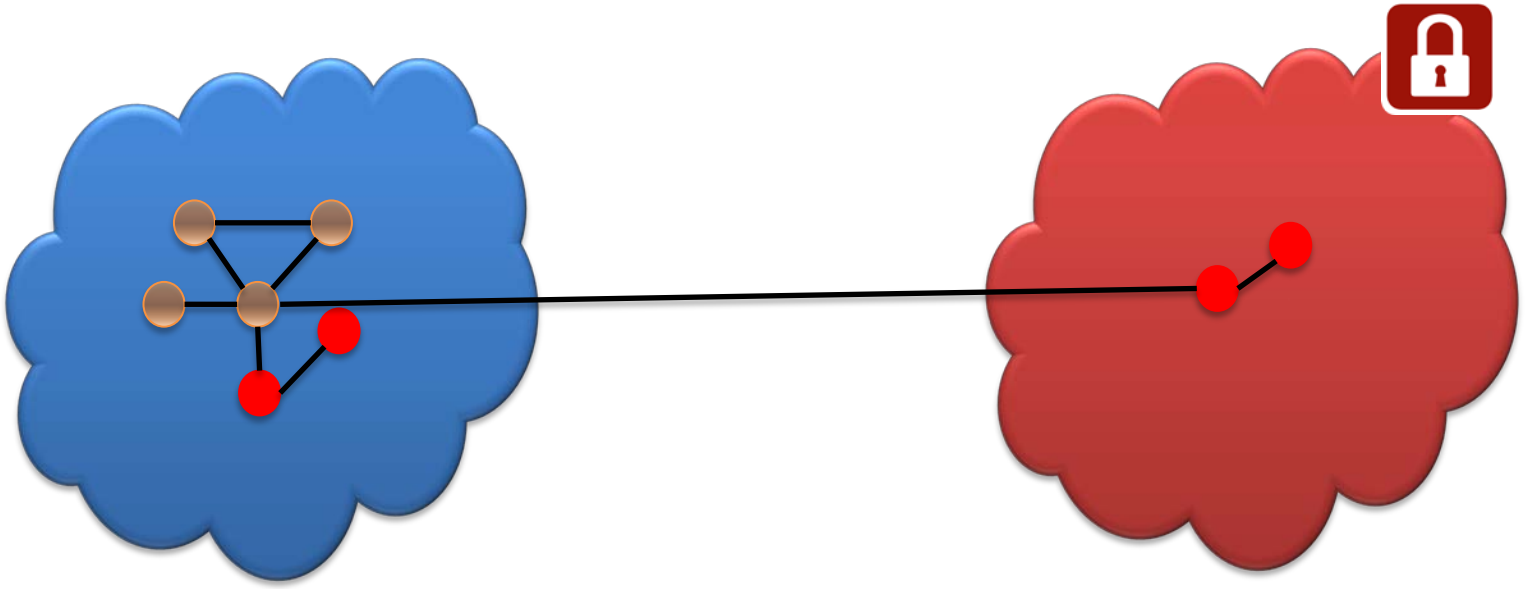
Scale out the infrastructure to accommodate growth

Performance



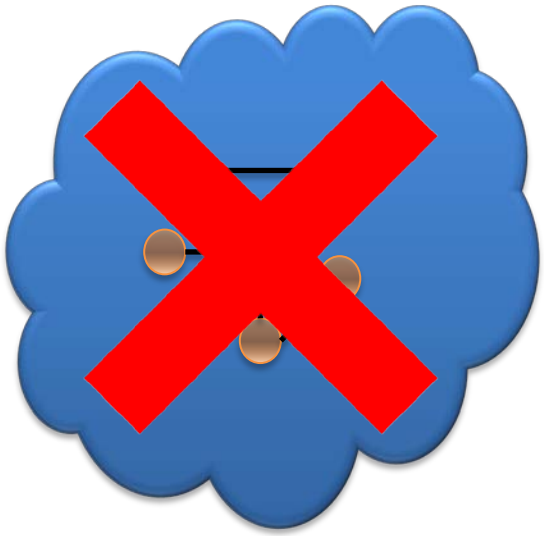
Bring the infrastructure closer to the customers

Security

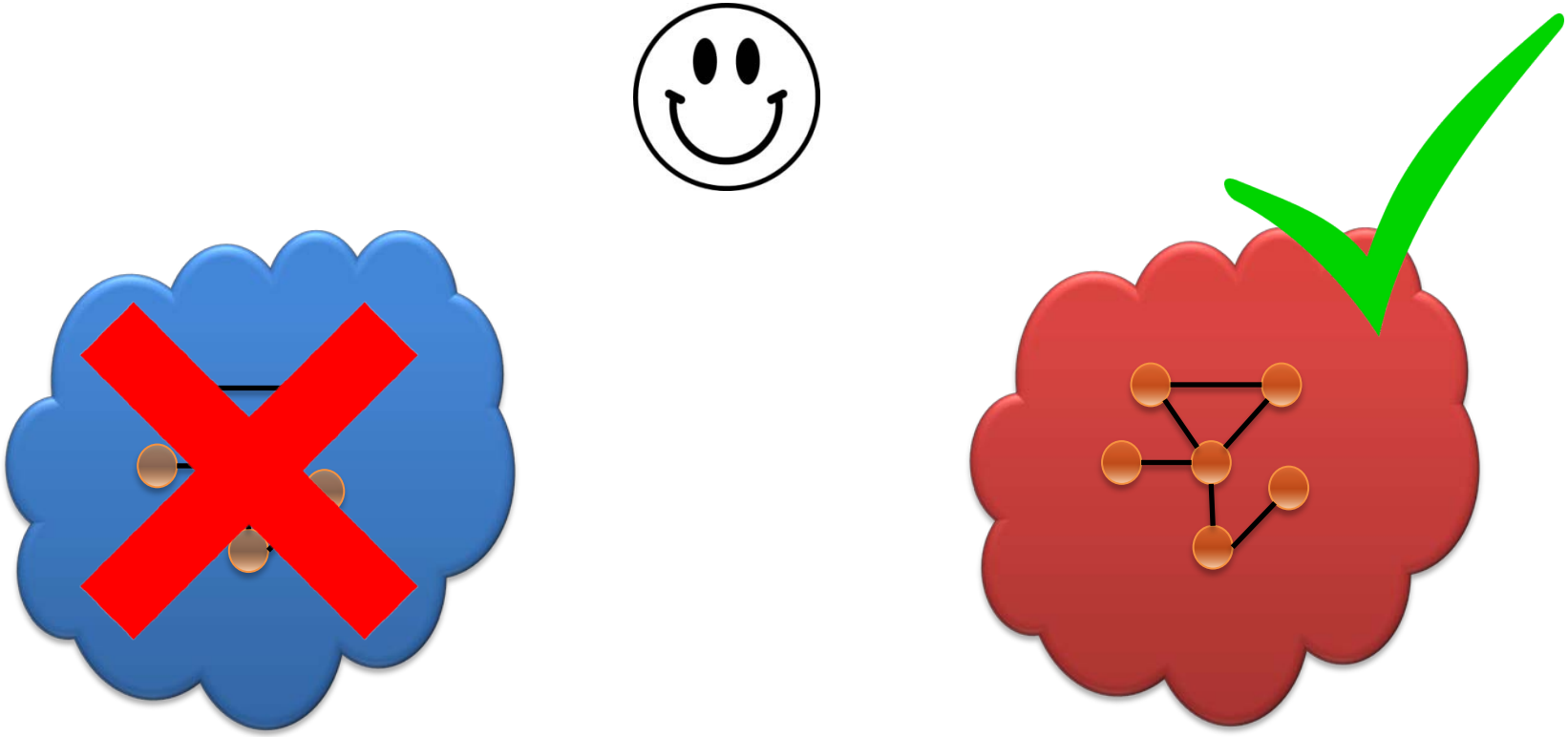


More options to secure your infrastructure

Dependability



Dependability



Cloud replication for fault-tolerance

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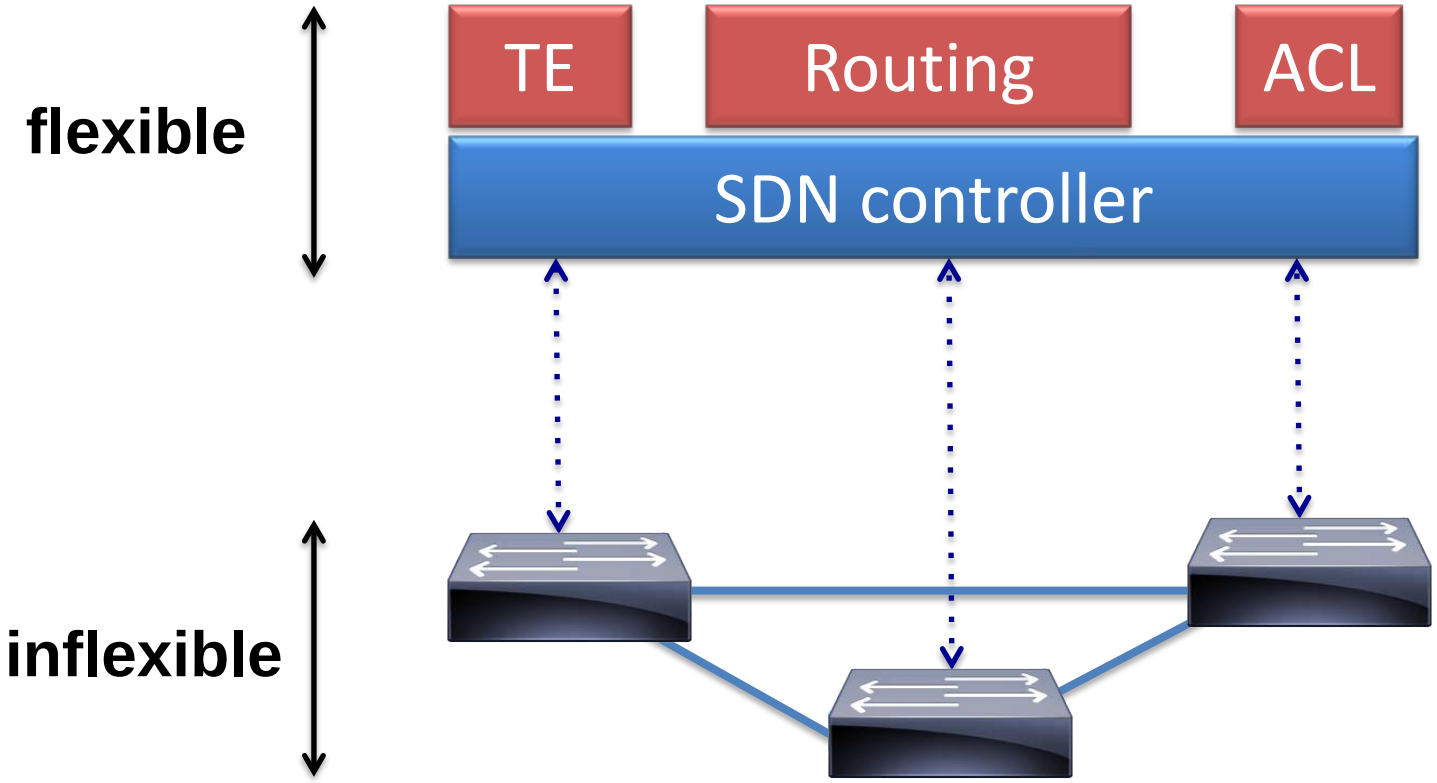
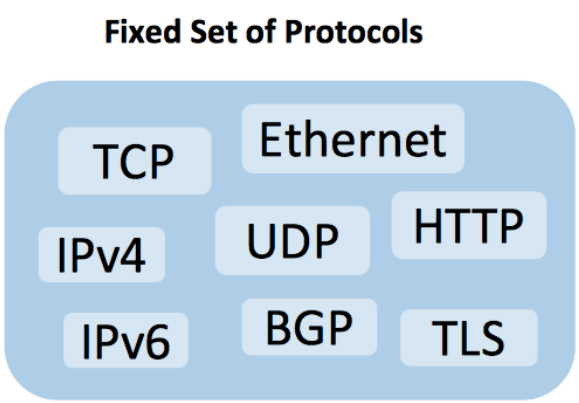
Network programmability

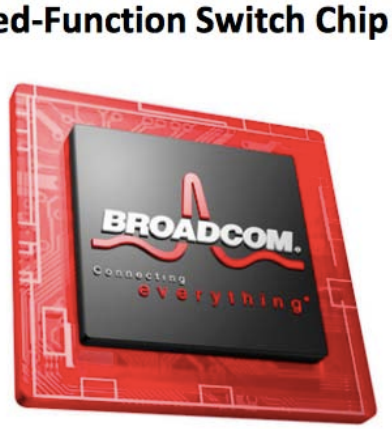
- With SDN we can program the network control plane!
  - Not the data plane



Problem

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

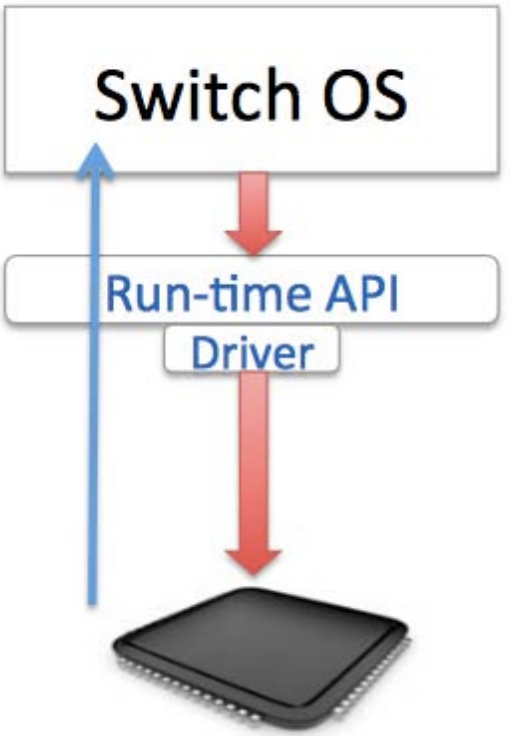




- What if you want a new protocol in your network?
  - Convince the manufacturer
    - If you're lucky they'll do it
    - In a few years…

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

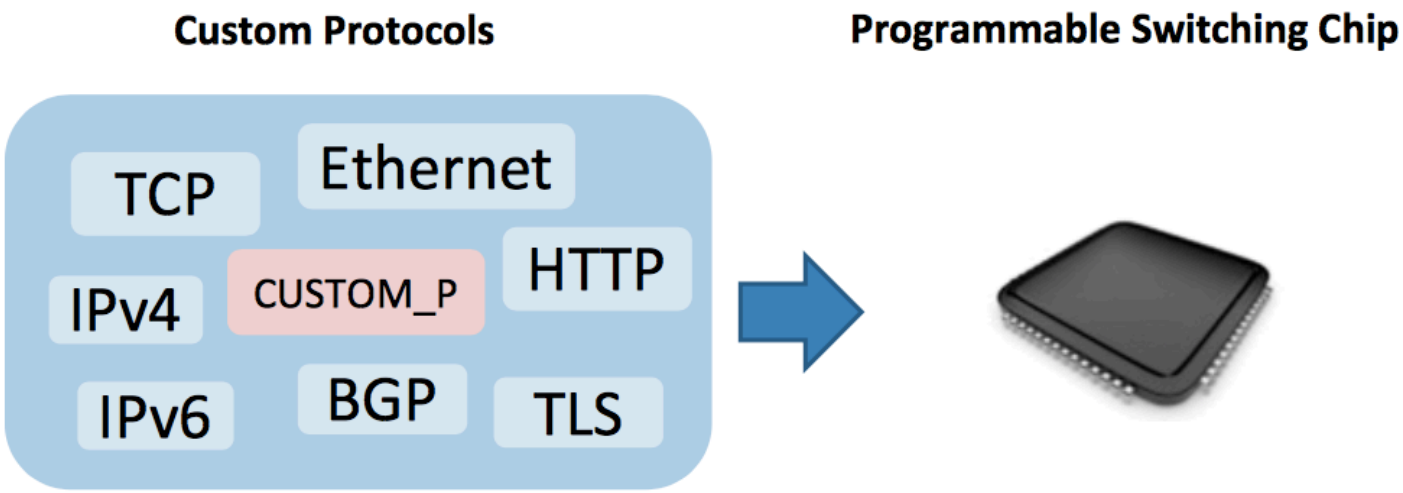


Fixed function switch

"This is how I process packets"

Programmable switches

- Build your own custom protocol



- This is already a reality today

intel

Xpliant

BAREFOOT NETWORKS

P4 high level language

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

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

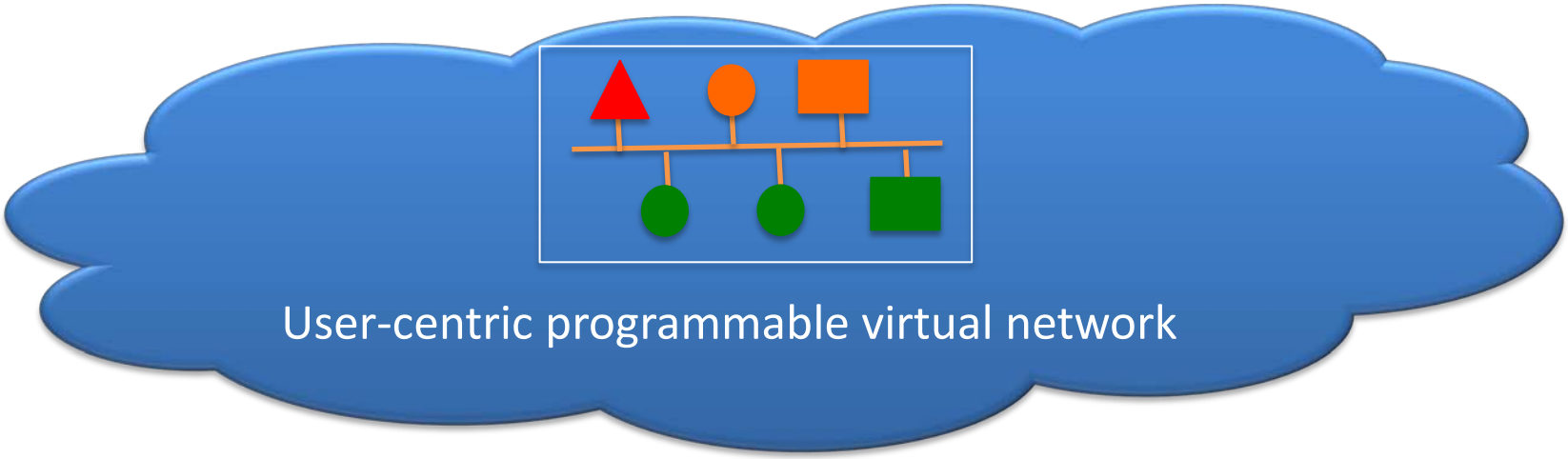
Programmable Switching Chip

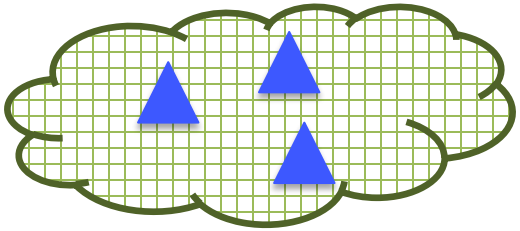
http://p4.org

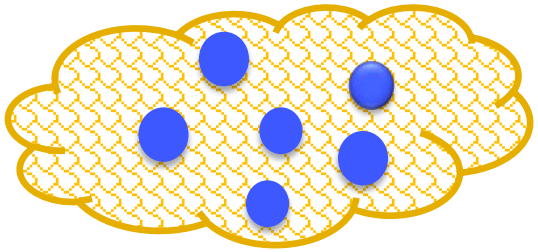
User-centric programmable virtual networks

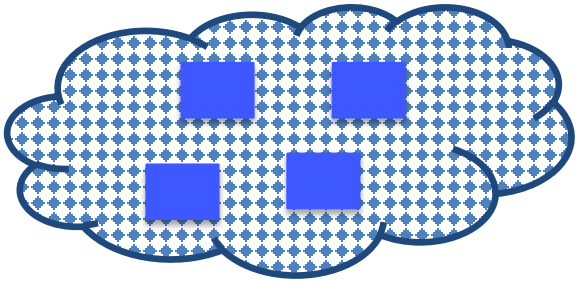
- User-centric
  - Substrate: Public clouds + private datacenters
- Networking services: fully programmable
  - Full virtualisation of topology, addressing and service models
  - Use of a high level language (e.g., P4) to program how packets should be processed exactly in your virtual network

uPVN: High level view









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!

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