Acinonyx: Dynamic Flow Scheduling for Virtual Machine Migration in SDN-enabled Clouds

The 16th IEEE International Symposium on Parallel and Distributed Processing with Applications

Adel Nadjaran Toosi

Faculty of Information Technology
Monash University
Email: adel.n.toosi [AT] monash.edu
Homepage: http://adelnadjarantoosi.info

Rajkumar Buyya

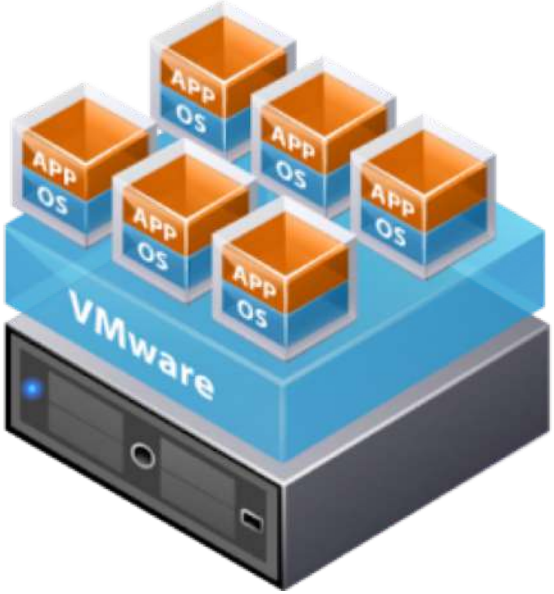
CLOUDS Laboratory
School of Computing and Information Systems
The University of Melbourne

Outline

- Virtualization and Live VM Migration
- SDN and SND-enabled Cloud Data Centres
- Research Question
- ACINONYX
  - Dynamic Flow Scheduling for VM migration
- System Architecture
- Performance Evaluation
  - with a Prototype and a real-world testbed
- Summary and future directions

Virtualization

- Virtualization
  - Critical building block of the **operation** and **maintenance** in cloud data centres
- Virtual Machine (VM)
  - A substitute for a real machine
  - Allowing for multiple OS (isolated from one another), on the same physical machine.
- Live VM migration
  - Relocating running VMs between servers with no or minimum impact on the VM's availability.
  - hardware maintenance, load balancing and consolidation, energy saving, and disaster recovery.

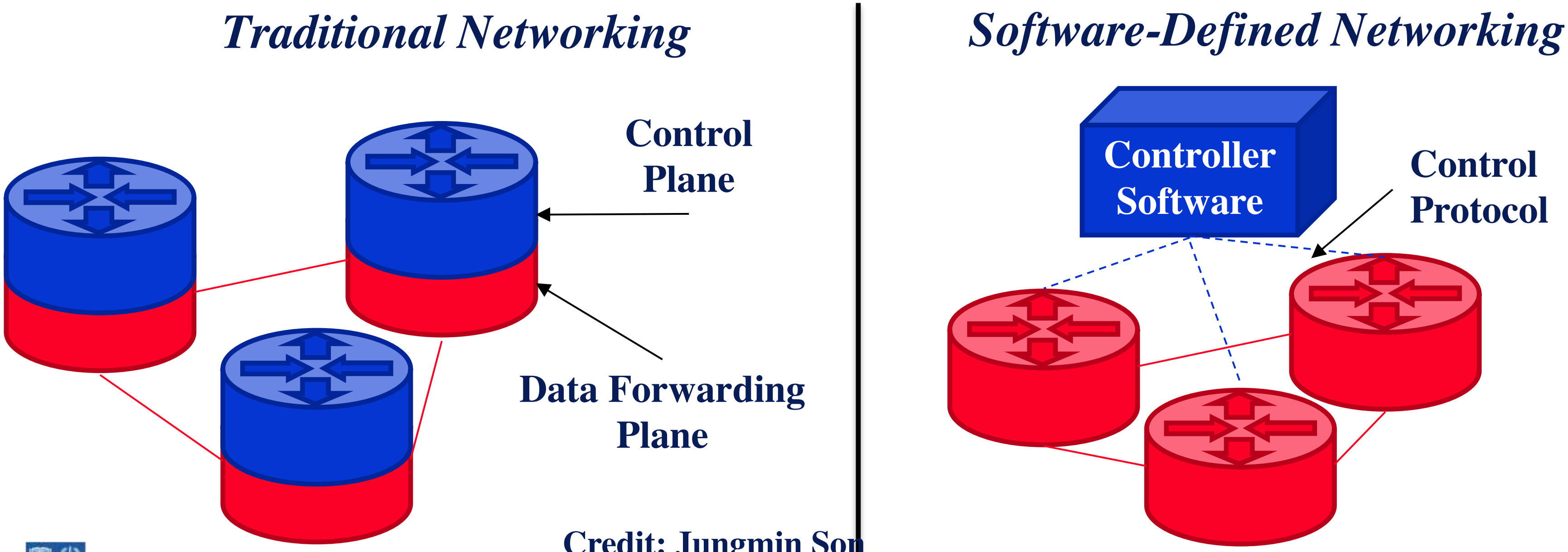


VM Migration Impacts on the Network

- Live VM migration
  - Transfer from Source to Destination
    - VM’s CPU state
    - All memory pages
    - Disks
- Adverse Impacts on network
  - Elephant flows over the network links
  - Causing network congestion for other applications
- Focus of this work
  - The selection of network paths for VM migration to avoid network congestion.
  - Is possible to reduce live VM migration time and network overhead by dynamically scheduling flows in a cloud data centre?

Software-Defined Networking

- Separation of control plane from data forwarding plane
- Platform is decoupled from infrastructure
- Centralized controller, network-wide control by controller SW that performs routing and traffic engineering



Traditional Networking

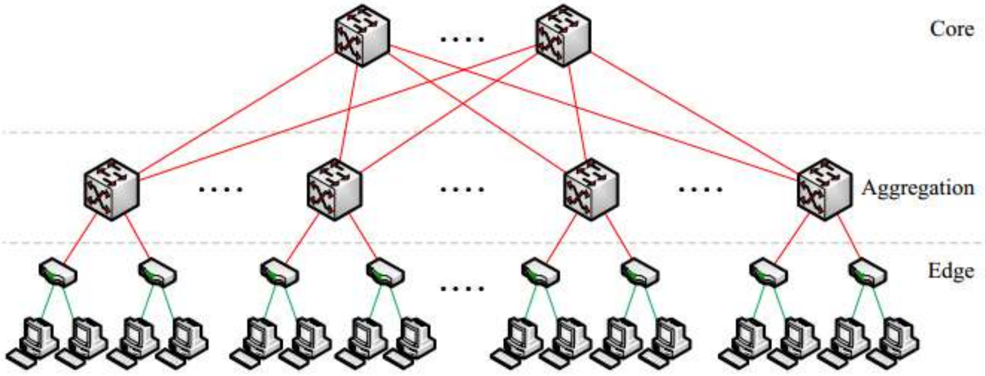
Software-Defined Networking

Credit: Jungmin Son

SDN Benefits

- Programmable network
- Enables dynamic configuration of networking
- Open opportunities for innovation

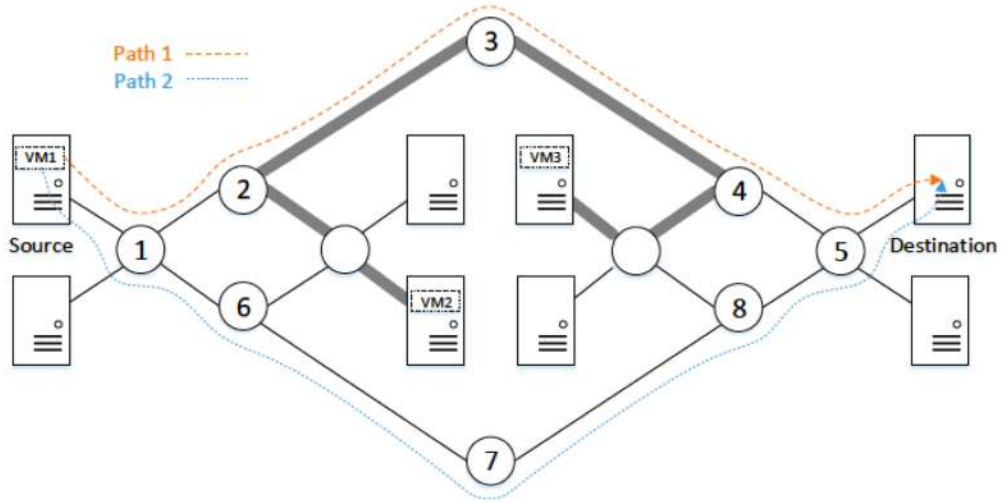
Data Centre Network



- Network topology
  - Fat tree, VL2, PortLand, and Bcube
  - Specialized hardware (middleboxes) implementing networking functions
  - NAT, load balancing, WAN optimization, firewall…
- Specialized communication protocols for top tiers
- Communication patterns between hosts change frequently

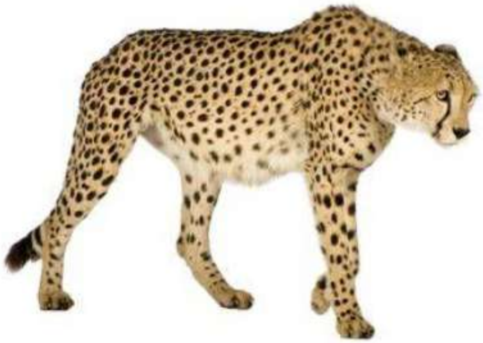
Dynamic Flow Scheduling for Virtual Machine Migration

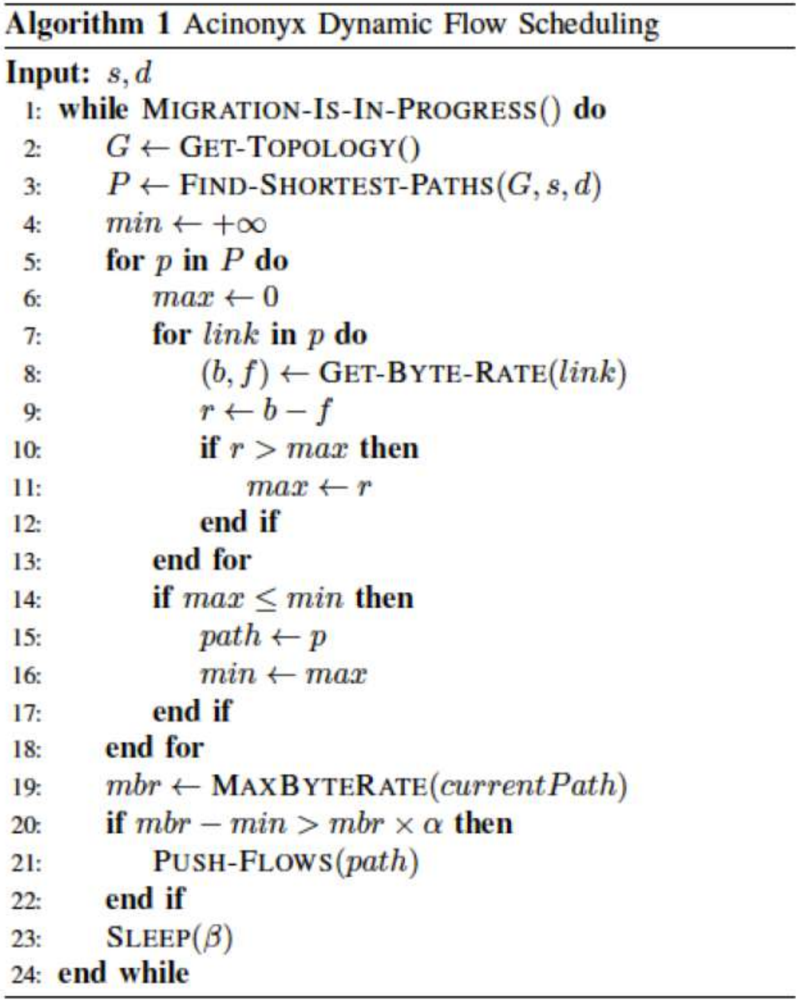
- "Is it possible to reduce **live VM migration time** and **overhead** by dynamically scheduling flows in a cloud data center with multiple paths available between a given pair of physical hosts?"



Adel Nadjaran Toosi

ACINONYX: Dynamic Flow Scheduling

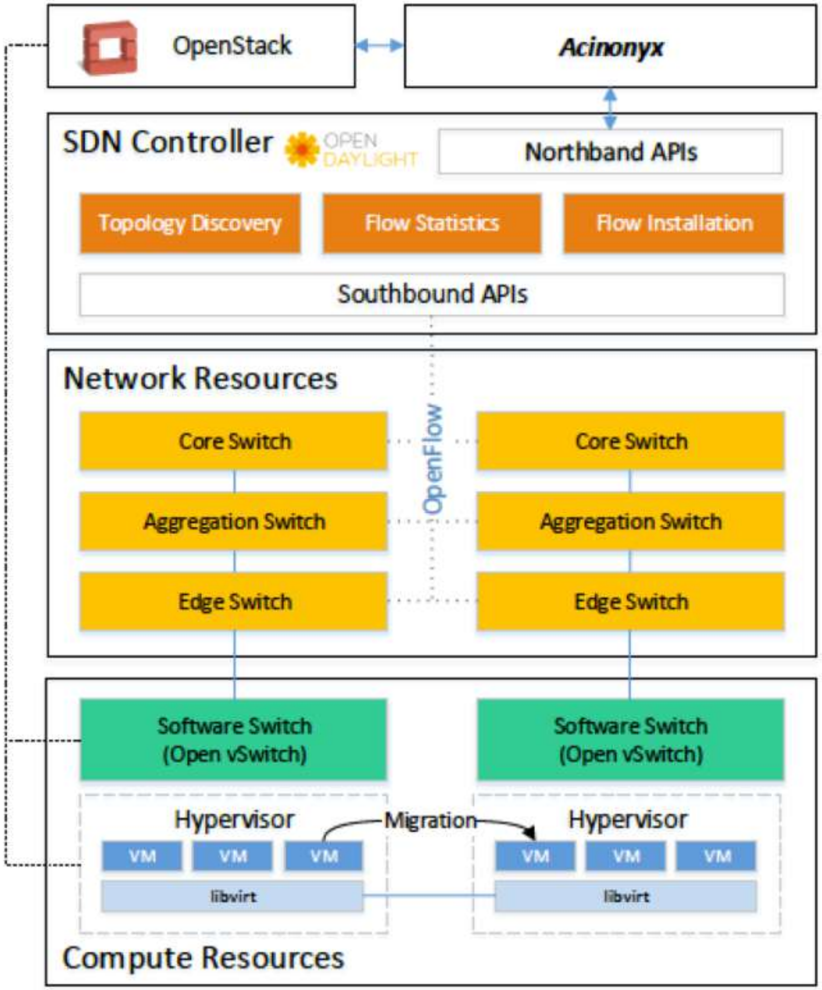




Algorithm 1 Acinonyx Dynamic Flow Scheduling

```
Input: $s, d$
while MIGRATION-IS-IN-PROGRESS() do
    $G \leftarrow$ GET-TOPOLOGY()
    $P \leftarrow$ FIND-SHORTEST-PATHS($G, s, d$)
    $min \leftarrow +\infty$
    for $p$ in $P$ do
        $max \leftarrow 0$
        for $link$ in $p$ do
            $(b, f) \leftarrow$ GET-BYTE-RATE($link$)
            $r \leftarrow b - f$
            if $r > max$ then
                $max \leftarrow r$
            end if
        end for
        if $max \leq min$ then
            $path \leftarrow p$
            $min \leftarrow max$
        end if
    end for
    $mbr \leftarrow$ MAXBYTERATE($currentPath$)
    if $mbr - min > mbr \times \alpha$ then
        PUSH-FLOWS($path$)
    end if
    SLEEP($\beta$)
end while
```

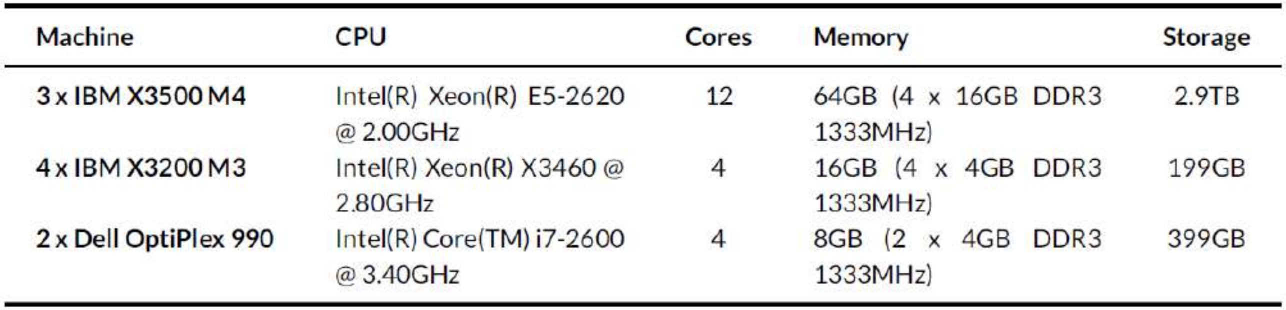
System Architecture



Performance Evaluation

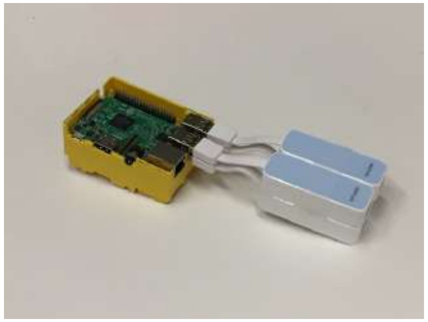
- Real-world testbed for SDN-enabled cloud computing
- 8 heterogeneous servers
- **Fat-tree** topology
- **Raspberry Pis** (Pi 3 Model B) with Open vSwitch (OVS) as Switch
- **OpenStack** (Ocata release) as cloud platform
- **OpenDaylight** (ODL) as SDN controller

Hardware

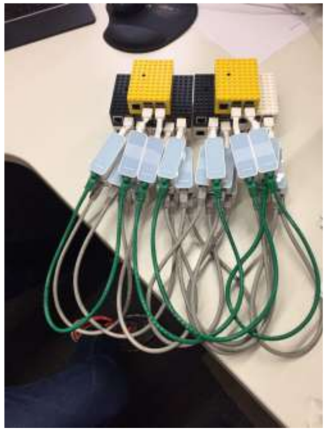


Machine	CPU	Cores	Memory	Storage
3 x IBM X3500 M4	Intel(R) Xeon(R) E5-2620 @ 2.00GHz	12	64GB (4 x 16GB DDR3 1333MHz)	2.9TB
4 x IBM X3200 M3	Intel(R) Xeon(R) X3460 @ 2.80GHz	4	16GB (4 x 4GB DDR3 1333MHz)	199GB
2 x Dell OptiPlex 990	Intel(R) Core(TM) i7-2600 @ 3.40GHz	4	8GB (2 x 4GB DDR3 1333MHz)	399GB

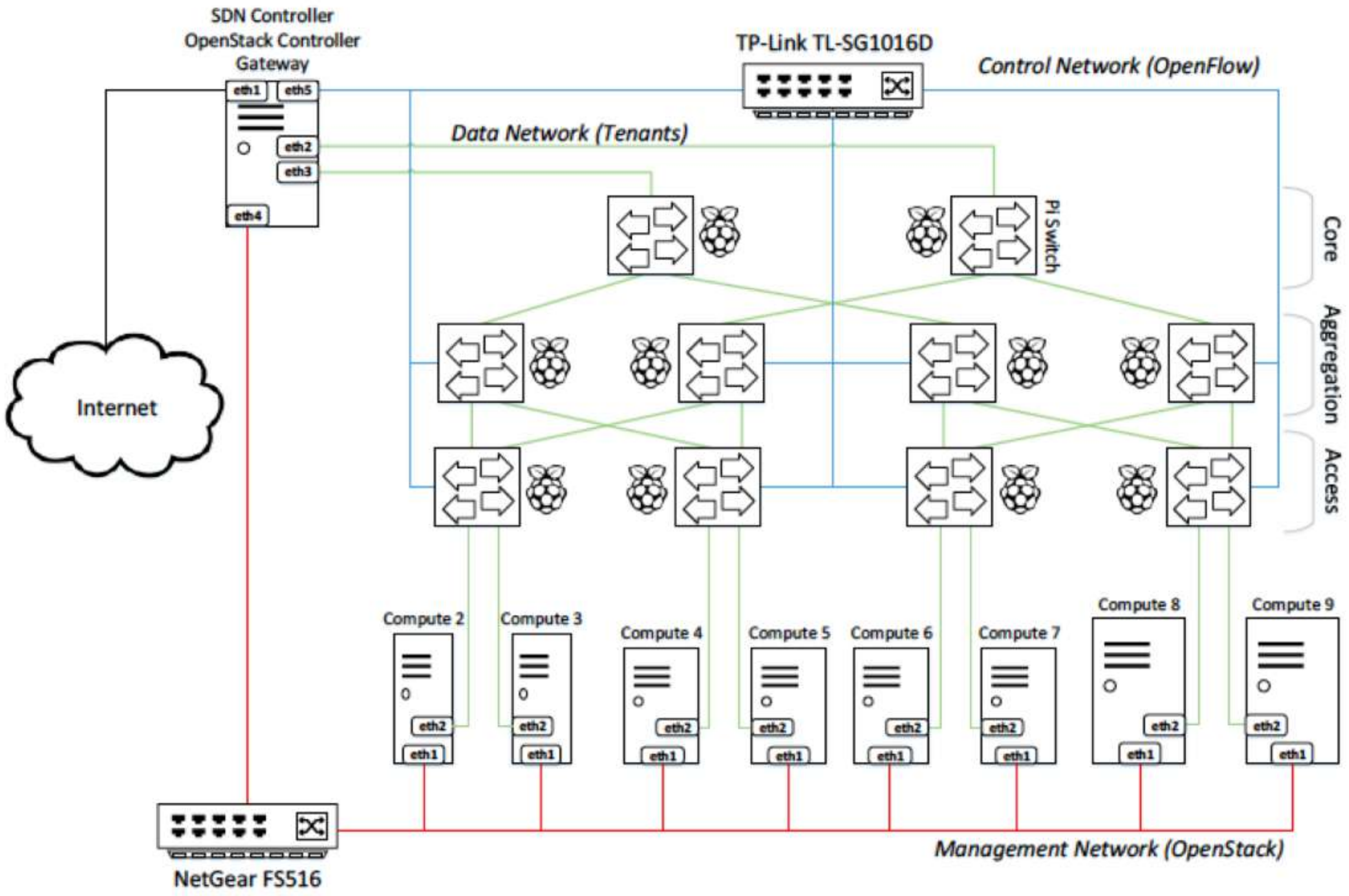
USB 2.0 to 100Mbps
Ethernet adapters



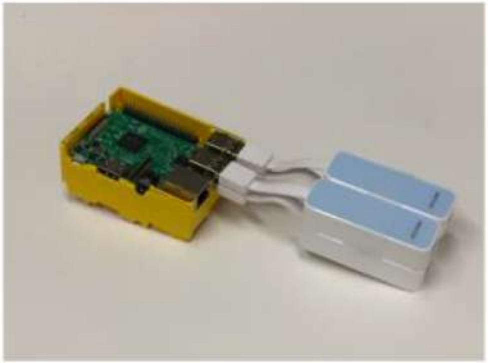
Raspberry Pis
(Pi 3 MODEL B)

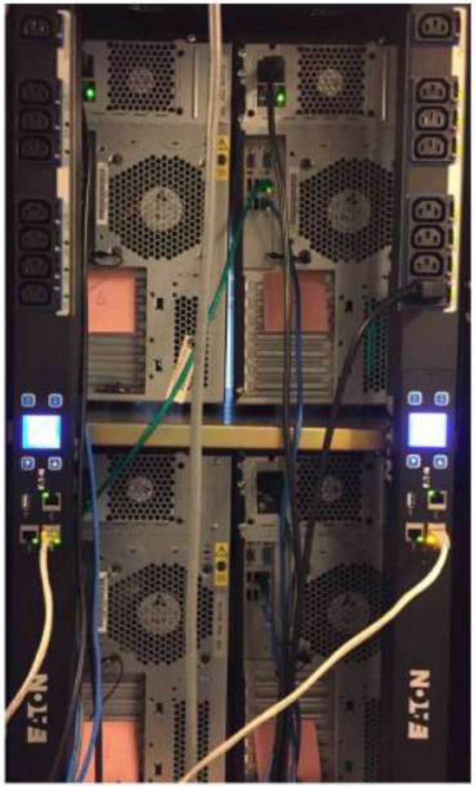


Testbed


SDN Controller
OpenStack Controller
Gateway
eth1
eth5
eth2
eth3
eth4
TP-Link TL-SG1016D
Control Network (OpenFlow)
Data Network (Tenants)
Pi Switch
Core
Aggregation
Access
Internet
Compute 2
Compute 3
Compute 4
Compute 5
Compute 6
Compute 7
Compute 8
Compute 9
eth2
eth1
NetGear FS516
Management Network (OpenStack)

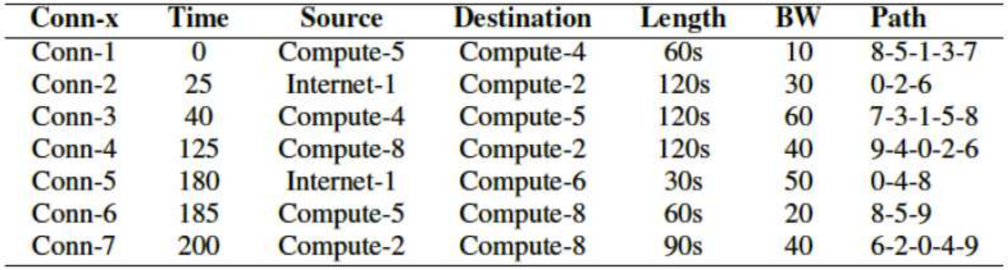
More Photos



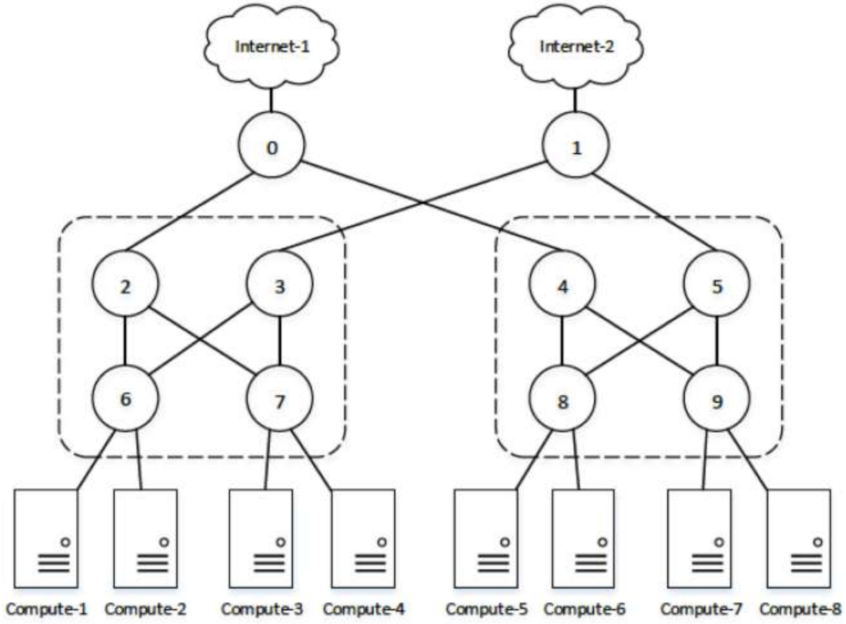


Traffic Generation and Routing

- Iperf3 tool

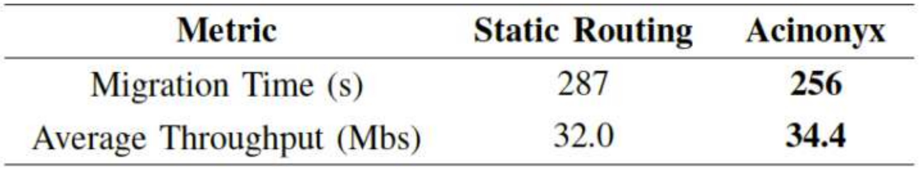


Conn-x	Time	Source	Destination	Length	BW	Path
Conn-1	0	Compute-5	Compute-4	60s	10	8-5-1-3-7
Conn-2	25	Internet-1	Compute-2	120s	30	0-2-6
Conn-3	40	Compute-4	Compute-5	120s	60	7-3-1-5-8
Conn-4	125	Compute-8	Compute-2	120s	40	9-4-0-2-6
Conn-5	180	Internet-1	Compute-6	30s	50	0-4-8
Conn-6	185	Compute-5	Compute-8	60s	20	8-5-9
Conn-7	200	Compute-2	Compute-8	90s	40	6-2-0-4-9

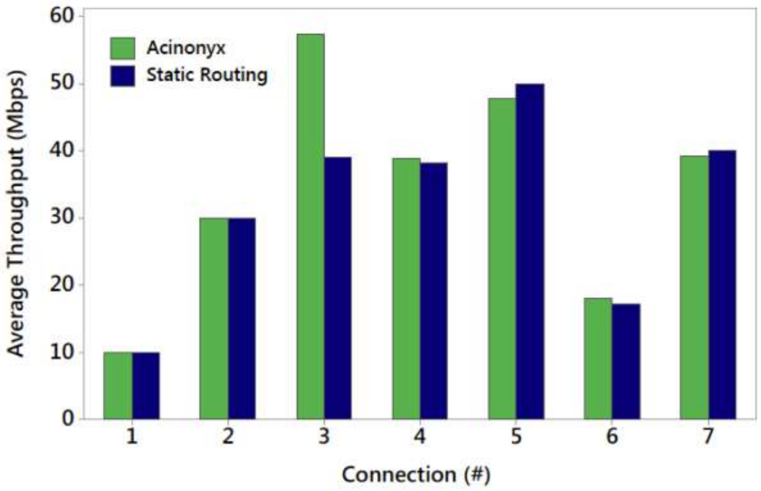


Experimental Results (EXP-1)

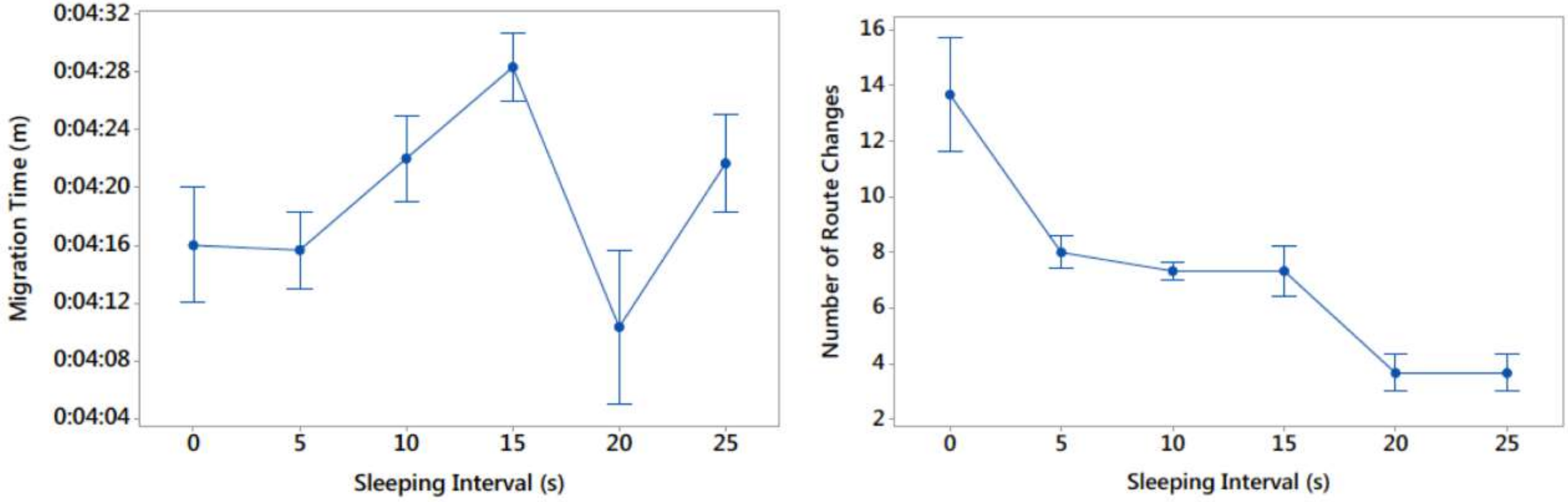
- A live VM migration in OpenStack
  - m1.small VM with Ubuntu-16.04 image
  - from Compute-1 to Compute-7
- Results:



Metric	Static Routing	Acinonyx
Migration Time (s)	287	**256**
Average Throughput (Mbs)	32.0	**34.4**



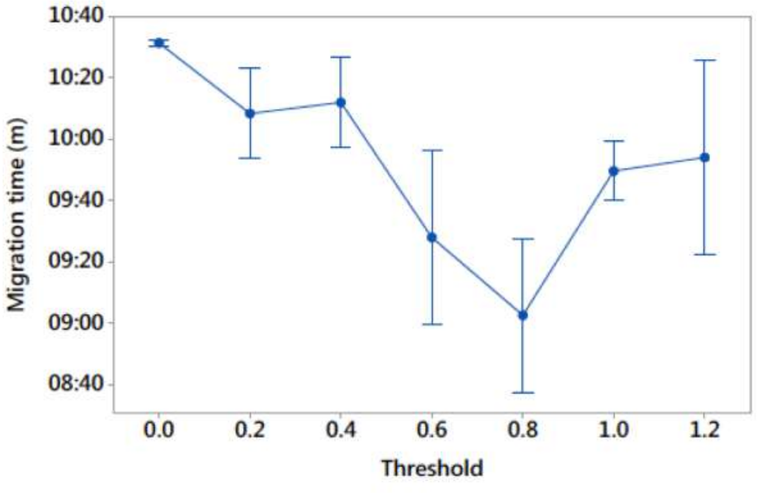
The impact of the Sleeping Interval



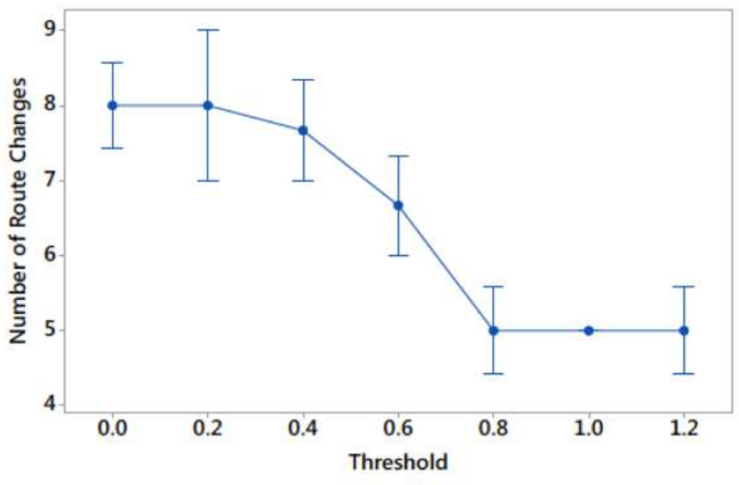
(a)

(b)

The impact of Switching Ratio Factor



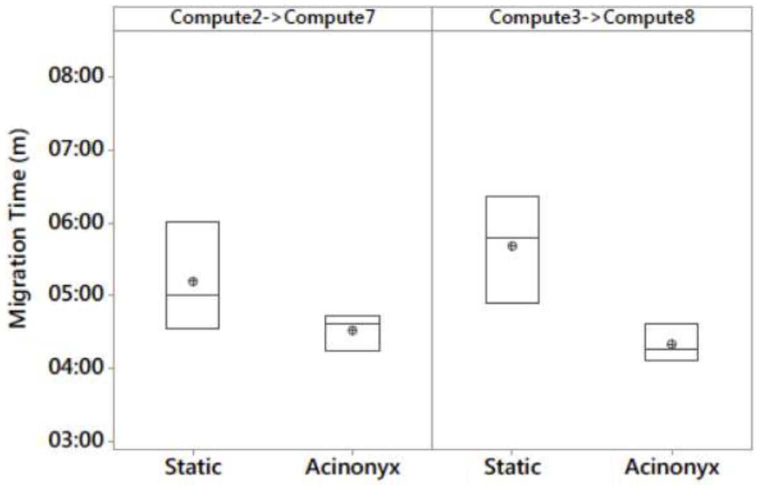
(a)



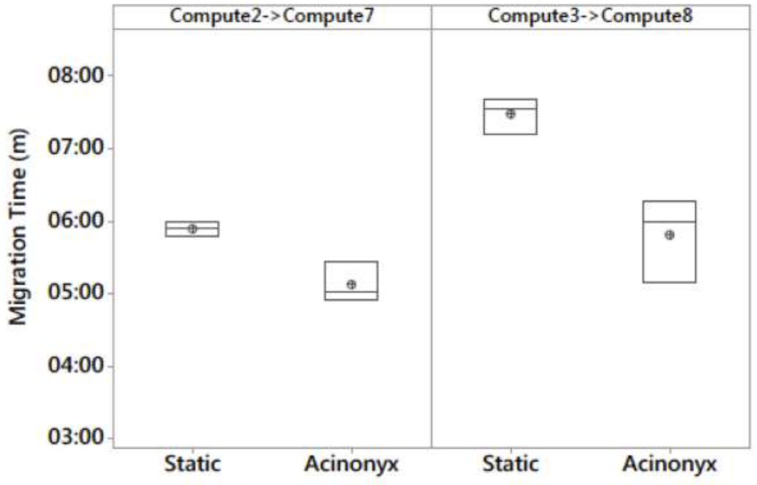
(b)

Multiple Migrations

- m1.small VMs,
  - One from Compute-2 to Compute-7 and
  - One from Compute-3 to Compute-8.



(a) No Background Traffic.



(b) With Background Traffic

- Live VM migration is frequently used in cloud data centers
- Proposed a dynamic flow scheduling for live VM migration in SDN-enabled cloud data centers
- Showed live VM migration time can be reduced up to 10% compared to existing static routing
- Demonstrated the feasibility by building a working prototype over a practical testbed.

Future work

- To explore the impact *Acynonix* on the flows of applications running in the migrating VM.
- To extend our approach for efficient flow scheduling of combined multiple migrations.
- Study the performance under the deployment of real-world applications exhibiting various network traffic characteristics
  - stream processing, data analytics, web applications, scientific workflows

THANK YOU

Questions?