Granular Computing and Network Intensive Applications: Friends or Foes?

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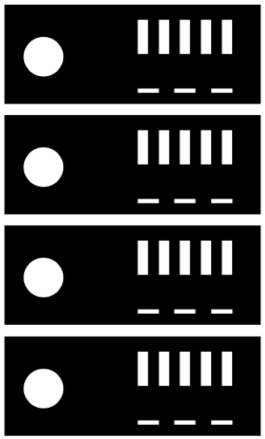
Evolution of Computing Services

Decrease user involvement in management tasks



Bare Metal

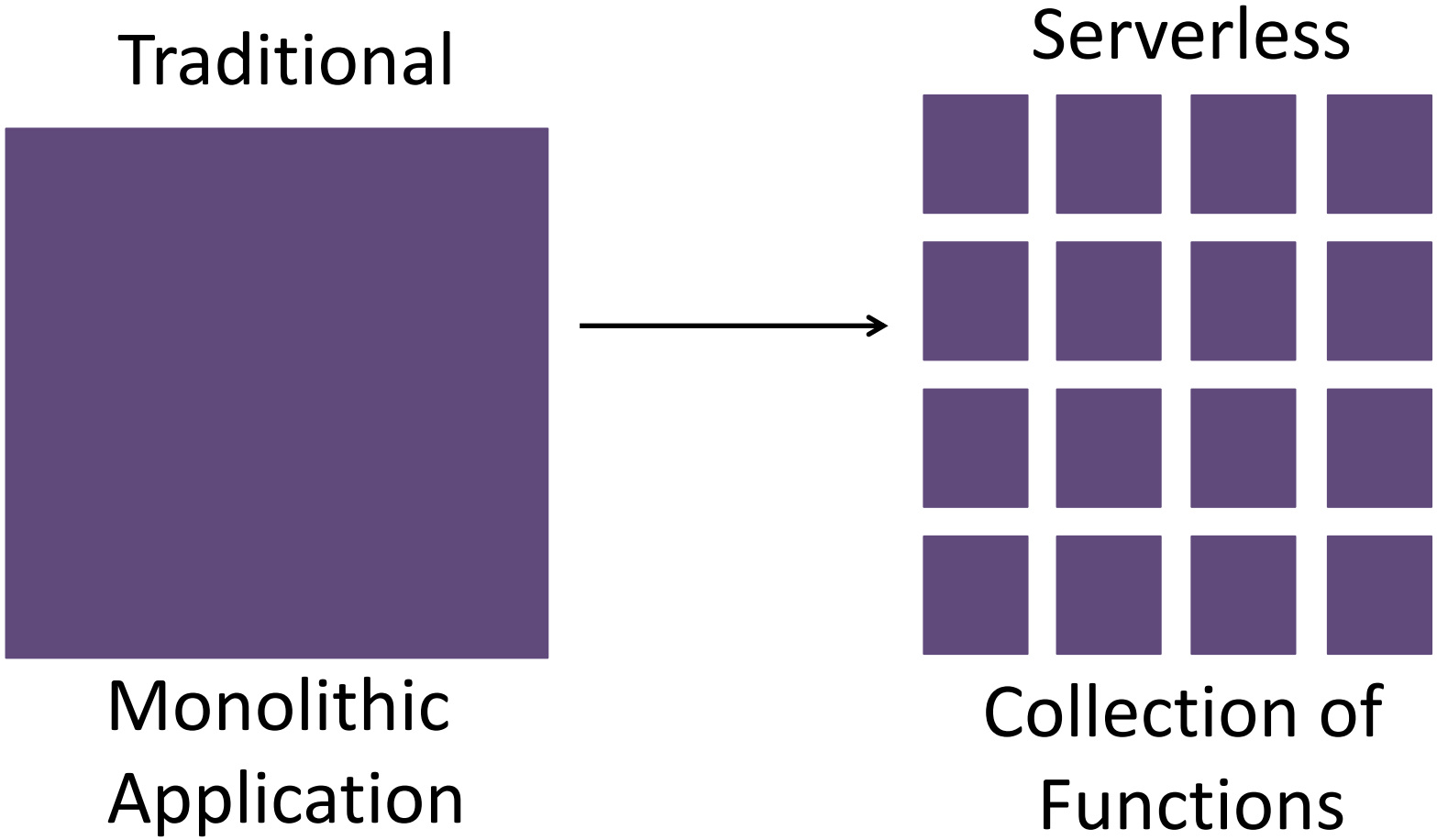
Virtual Machines

Containers

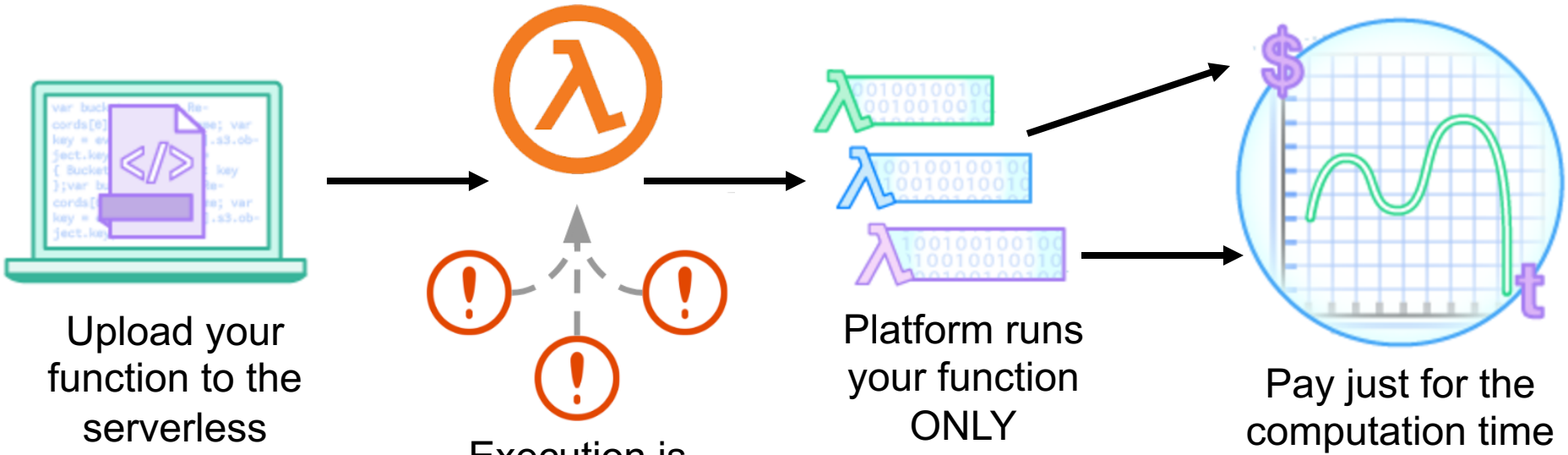
Granular Serverless Computing

Allow more user focus on application logic

Programming Paradigm Shift



Serverless Computing Control Flow



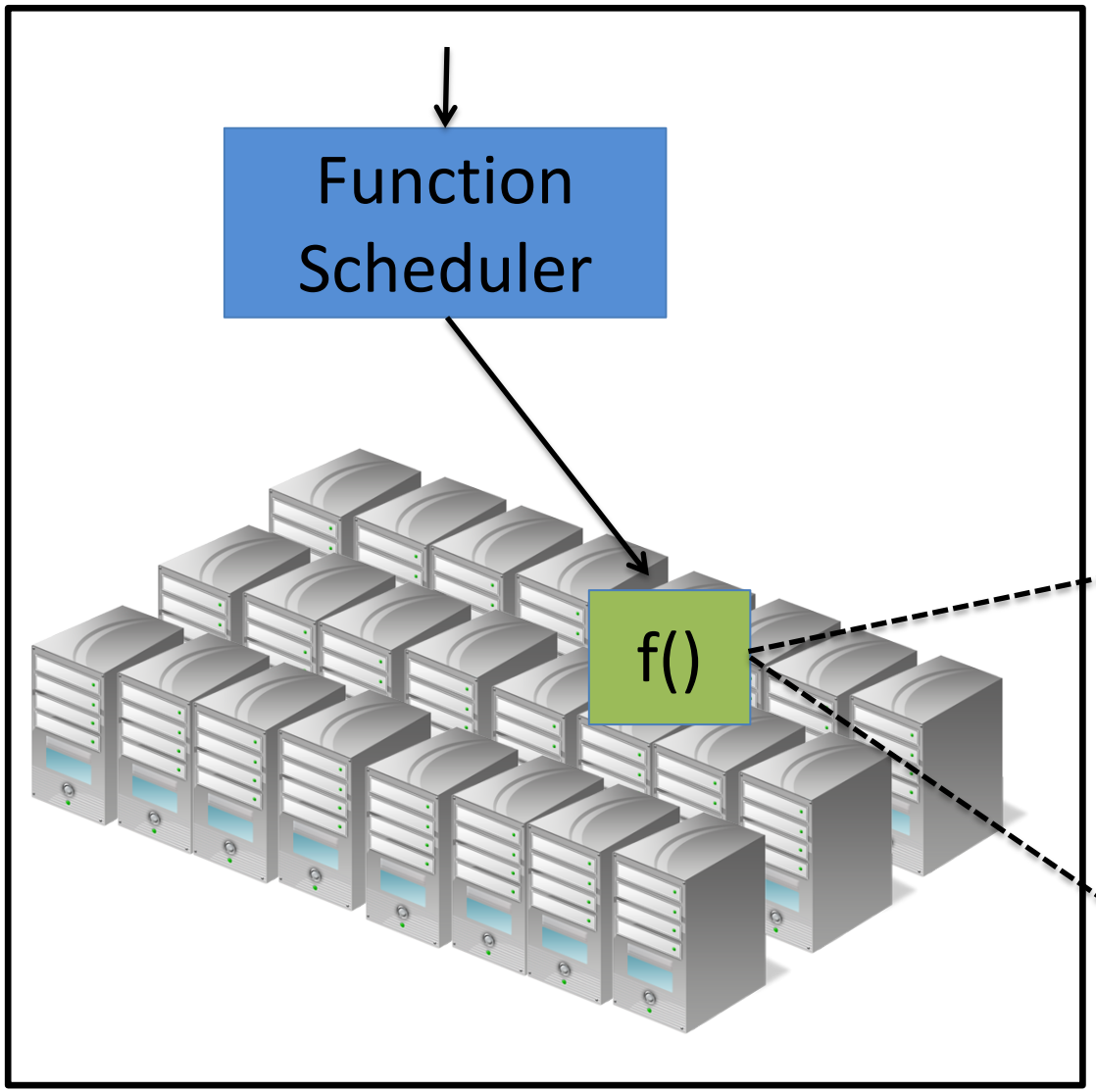
Upload your function to the serverless computing platform and register for event-based triggers

Execution is triggered when an event occurs

Platform runs your function ONLY when triggered

Pay just for the computation time

Serverless Computing Building Blocks



Serverless Functions are Stateless!

Key Value Store

Blob Store

Serverless Computing Platforms

Amazon

Google

Microsoft

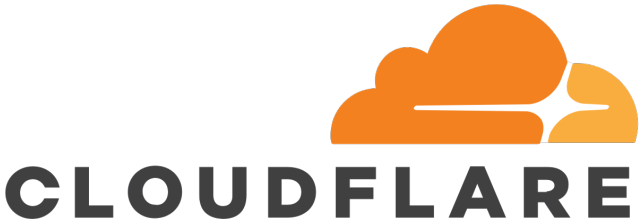
IBM

OPENFAAS

BINARIS

UW-Madison

VMware

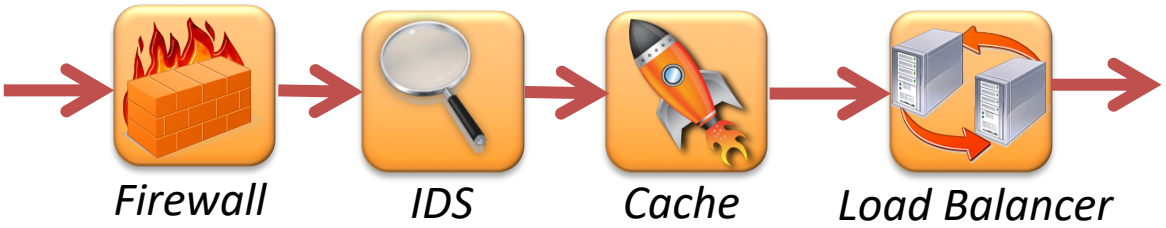


Research on Serverless Computing

- Video Processing Applications
  - ExCamera (NSDI ’17)
- Distributed Computing Applications
  - PyWren (SoCC ’17)
- Network Intensive Applications -> Network Functions
  - Our Work (HotNets ‘17)

Network Functions

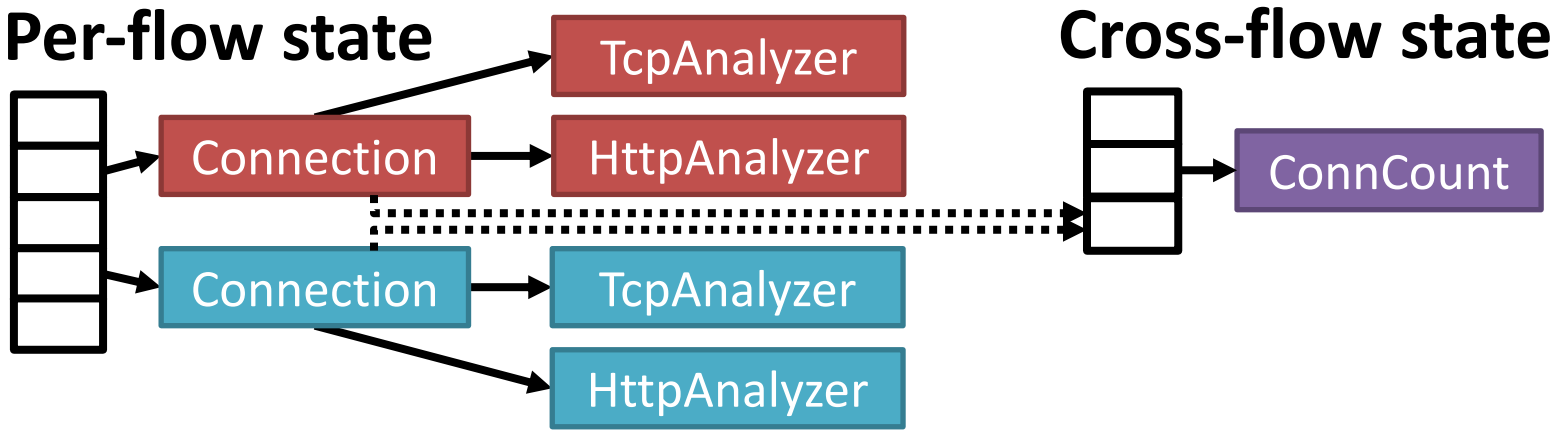
- Examine and perform *stateful* actions on packets/flows
- Ensure security, improve performance and provide other network-related functionality



- Lie in the critical path between source and destination
- Should be capable of handling packet bursts and failures

Network Functions State Taxonomy

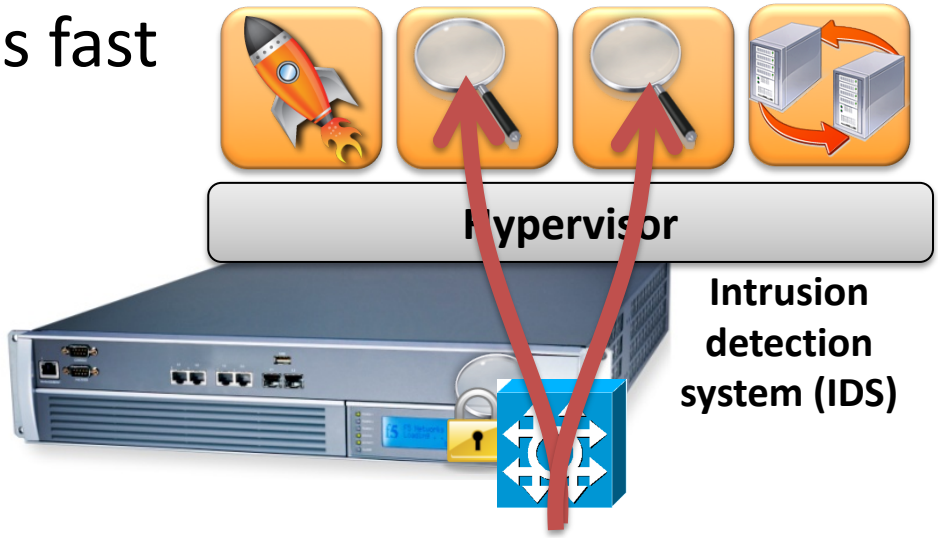
State created or updated by an NF applies to either a **single flow** or a **collection of flows**



Network Functions Virtualization

- Leverage cloud computing and SDN in Telco infrastructures
  - Utilize commodity hardware
  - Reduce costs
  - Dynamically allocate NF instances
  - Introduce new services fast

Caching proxy



Intrusion detection system (IDS)

Why Network Functions?

- Network Functions are a demanding class of applications
- Trend of pushing Network Functions to the cloud
  - APLOMB (SIGCOMM ‘12), EMBARK (NSDI ‘16), AT&T Domain 2.0
- In the future, if serverless computing becomes the de-facto cloud standard

Why is it challenging to run network functions atop serverless computing platforms?

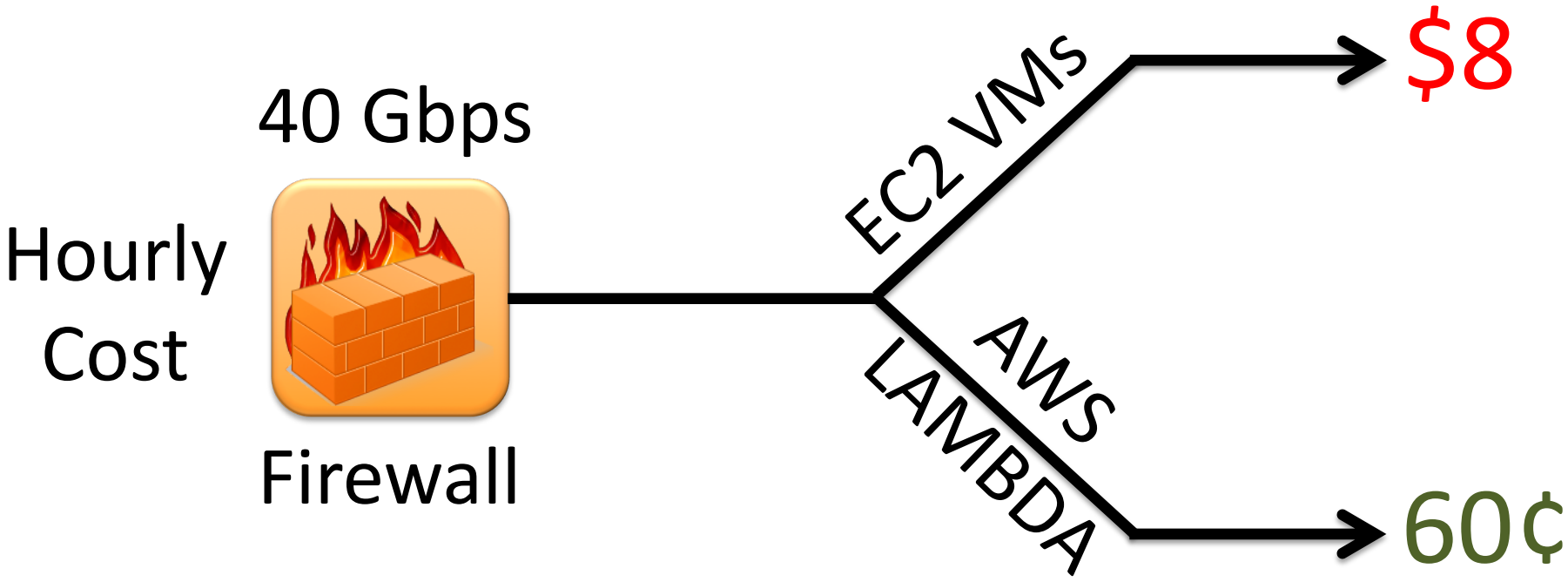
Foes?

Serverless Computing	**Network Functions**
Short-lived	Long-lived
Stateless	Stateful
No support for efficient chaining	Needs efficient chaining
No QoS guarantees	Need QoS guarantees

What opportunities do serverless computing platforms provide to run network functions?

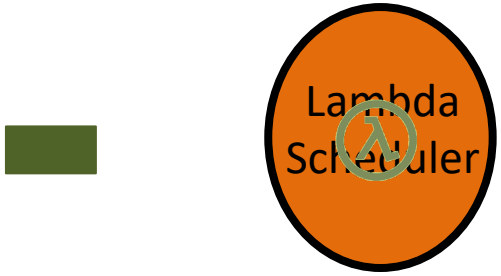
Friends?

- Network Functions Vision – Micro-service based architecture that scales dynamically
  - Better resource utilization
  - Scale components independently
  - Reuse across chains
  - Reduce the costs
- Serverless Computing provides the building blocks
  - Has the capability to scale based on load
  - Encourages developers to design their applications in terms of micro-services
  - Reduces the costs


Hourly Cost
40 Gbps
Firewall
EC2 VMs
$8
AWS LAMBDA
60¢

Serverless Packet Processing Design

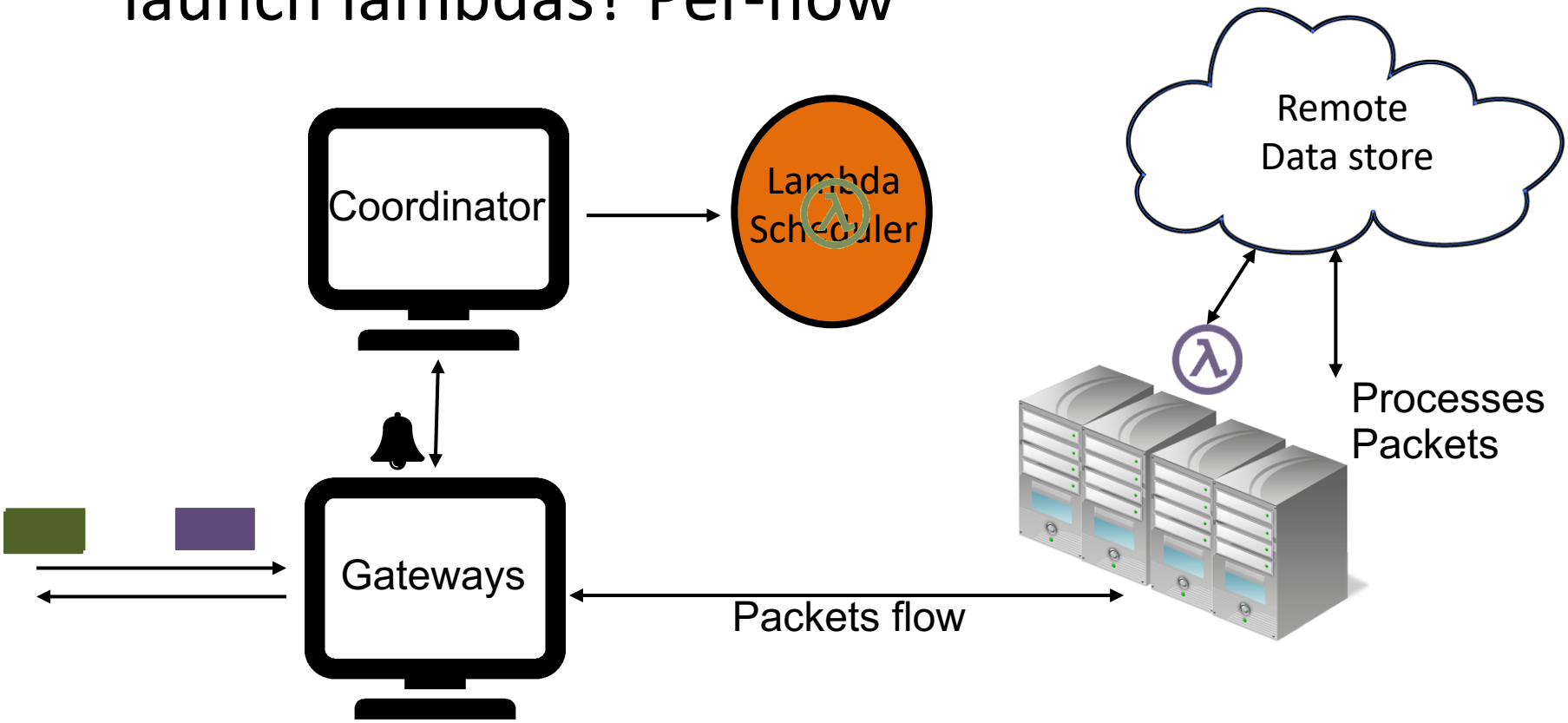
- What is the granularity at which we want to launch lambdas? Per-packet



- Not viable
  - Cost
  - Performance

Serverless Packet Processing Design

- What is the granularity at which we want to launch lambdas? Per-flow



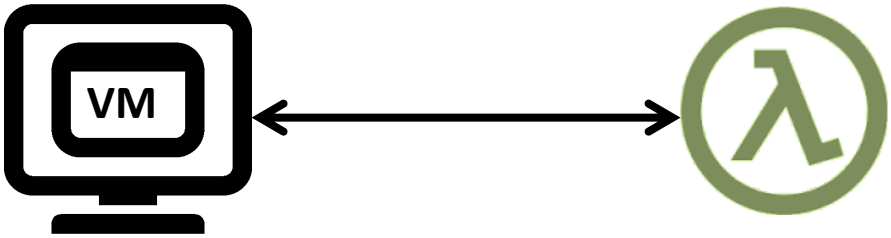
Per-flow Vs. Per-packet

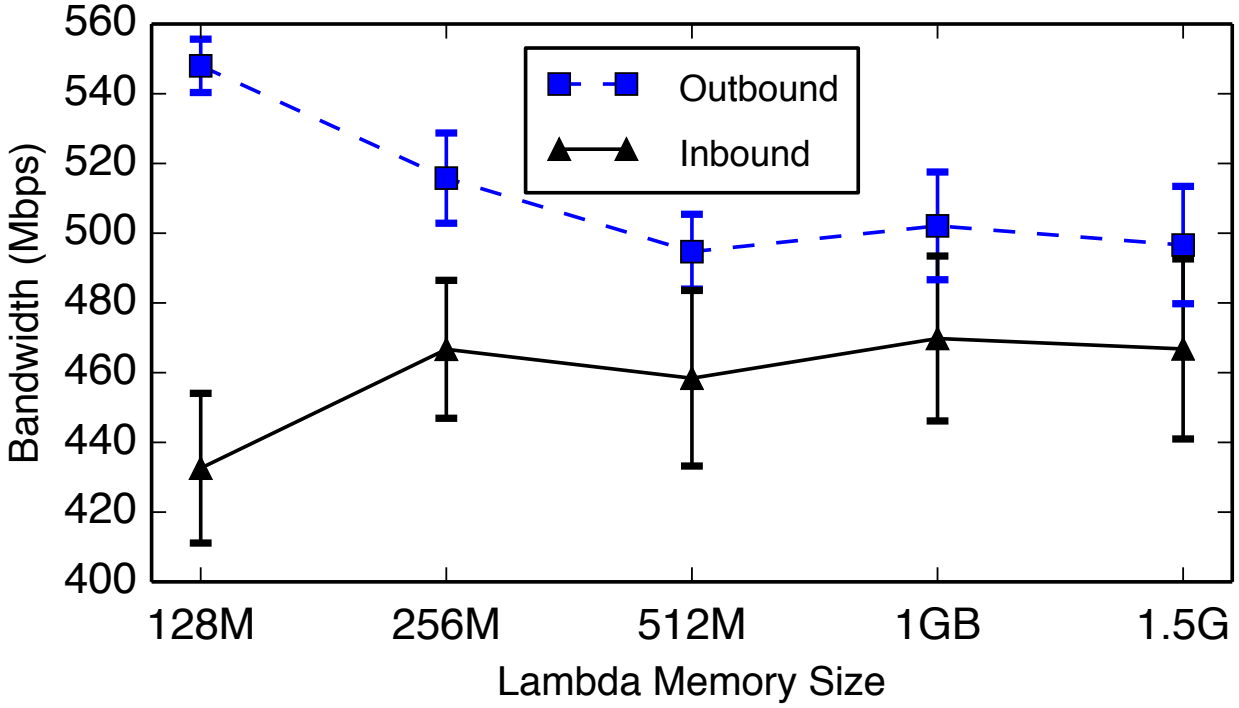
- Pros –
  -  Cost effective
  -  State management easier
- Cons –
  -  Needs additional infrastructure to coordinate launching of new lambdas
  -  Cannot natively leverage what serverless platforms provides

AWS Lambda Benchmarking Study

- Within an AWS region
- EC2 VMs act as TCP traffic sources and sinks
- Three Click-based NFs –
  - Packet Counter
  - Firewall
  - Intrusion Detection System

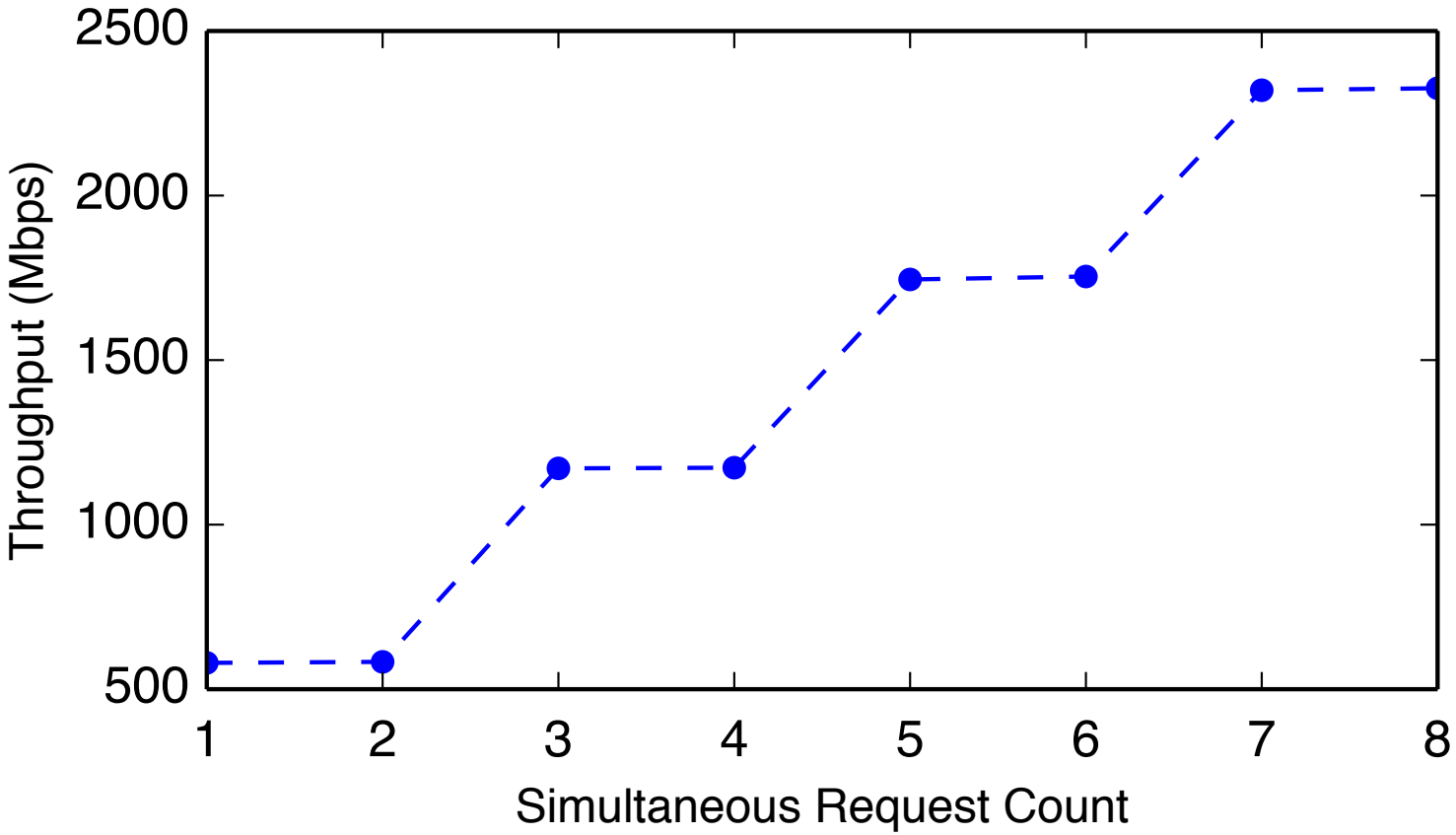
AWS Lambda – Network Provisioning





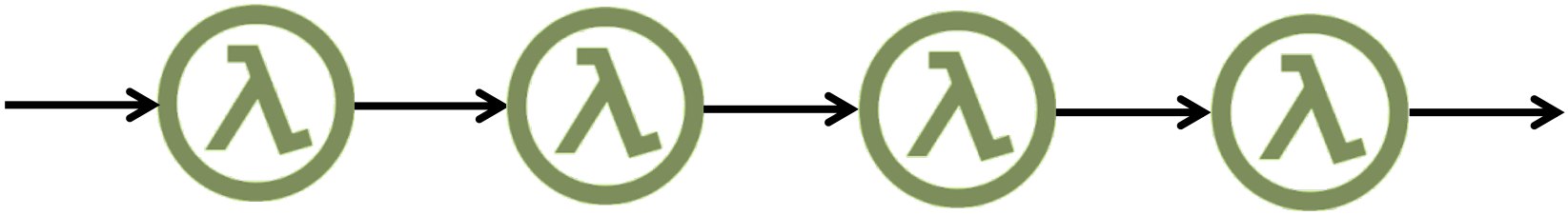
Bidirectional Bandwidth of around 500 Mbps

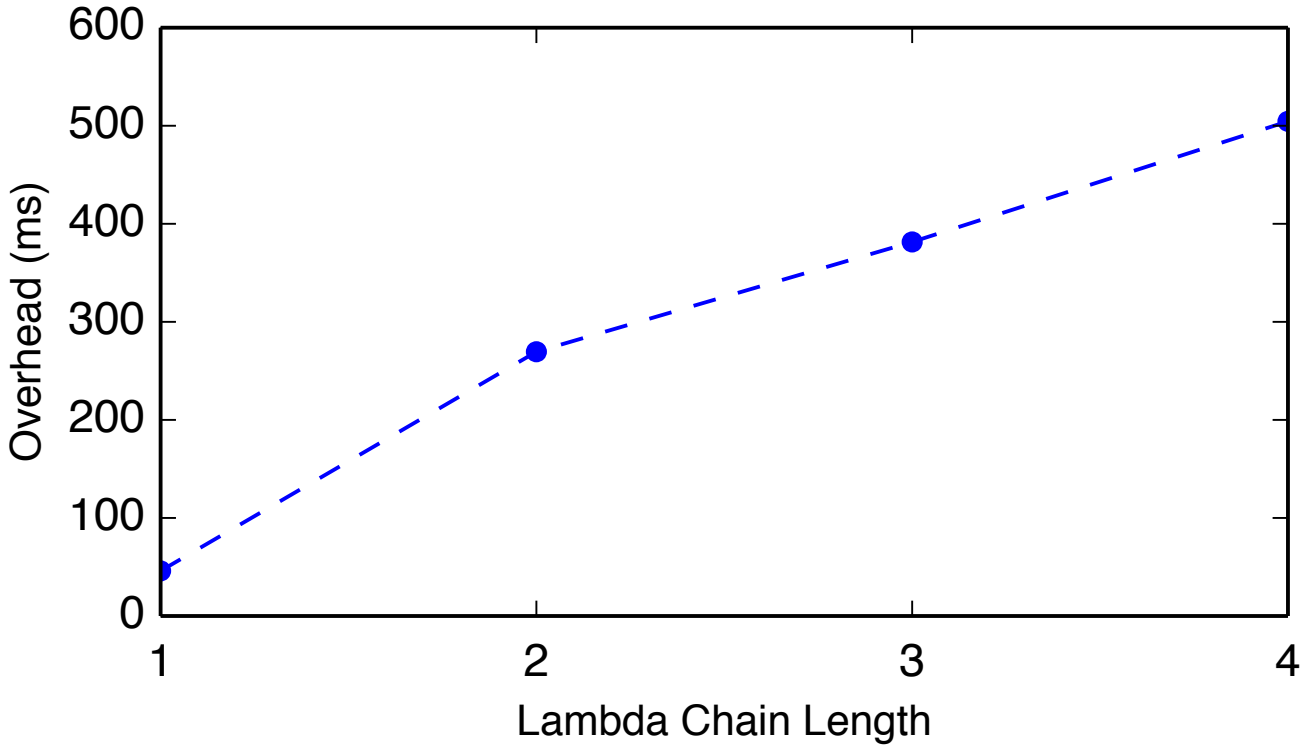
AWS Lambda – Network Provisioning



- Bandwidth does not scale linearly
- No per lambda request network guarantees

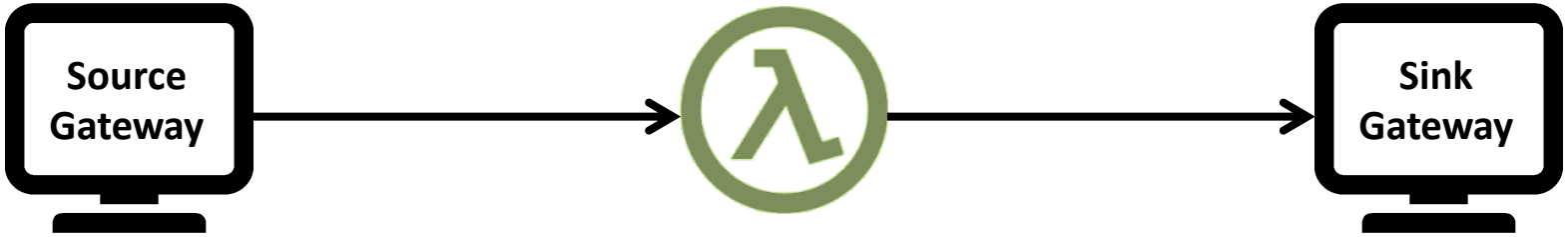
AWS Lambda – Chaining Overhead





High chaining overhead observed

AWS Lambda – NF Framework



Network Function	Mean (Mbps)	Std-Dev (Mbps)	Mean (msec)	Std-Dev (msec)
Packet Counter	367.14	18.34	2.89	1.14
Firewall	355.90	18.72	3.39	1.41
IDS	339.03	21.85	3.40	1.79

Modest results; but give us a hope as to what future serverless platforms may enable

Conclusion

- Serverless Computing Platforms are not perfect yet – are continuously evolving!
- Packet processing applications are not a natural fit; need –
  - Efficient in-network triggers
  - Efficient chaining support
  - Bandwidth guarantees

Open Questions

- Scalable remote storage service that meets our requirements?
- Better fault tolerance support?
- Faster control plane decisions?
- And many more …

How to effectively support demanding stateful applications atop serverless platforms?