ASIC: An Architecture for Scalable Intra-domain Control in OpenFlow

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Outline

- The understanding of OpenFlow and SDN
- Scalability problem in OpenFlow control plane
- Related solutions
- The ASIC architecture
- Experimental results and analysis

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Software Defined Networking (SDN)

- Software defined networking (SDN)
  - separates the control and data plane
  - moves the network intelligence in control plane to a logically centralized controller
  - opens up the control plane and its protocol implementation.
- Architecture in network device is disclosed.
- The idea is well received by academic and industry researchers.
- OpenFlow, the most popular instance, is deployed by many universities and research institutions.

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The Scalability Problem

- OpenFlow is a centralized control model.
- All the routes are determined by the controller.
- The first packet (initialization request) of each data flow is sent to the central controller.
- Controller computes the routing path and install it to the related OpenFlow switches.

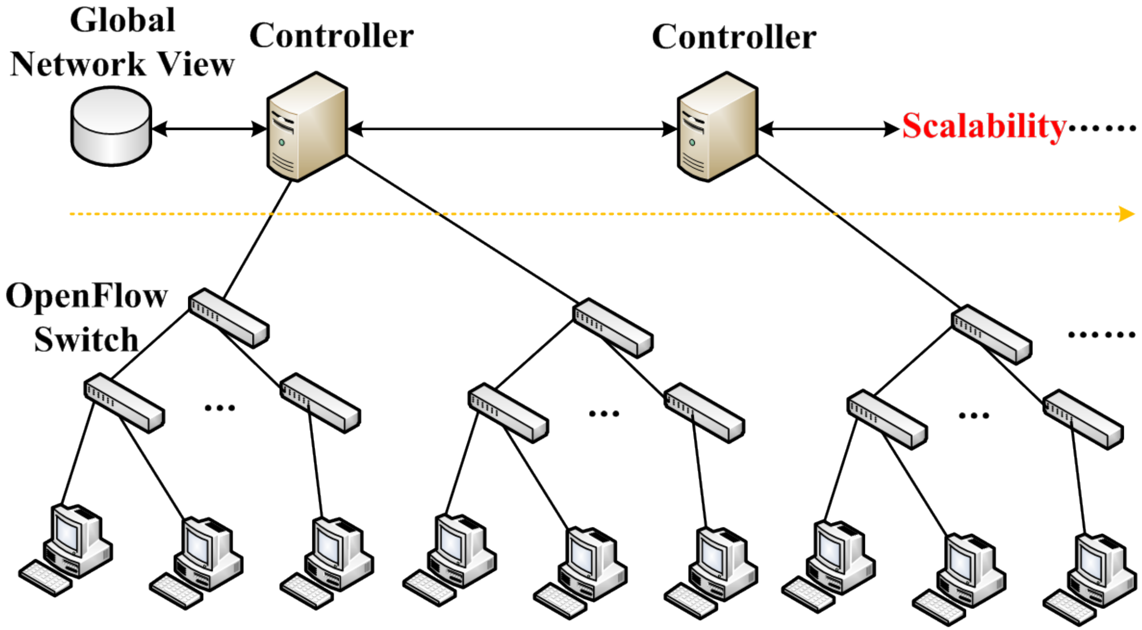
The Scalability Problem

- The request processing capability of a single controller is limited:
  - NOX could process about 30K requests/s;
  - Maestro could process about 600K requests/s.

- Large-scale network environments always have vast amounts of data flows:
  - 1) a 1500 server cluster might generate 100K requests per second;
  - 2) a 100 switch data center might generate 10000K requests per second.

The Scalability Problem

- With the increasing scale of deployment, the scalability becomes obvious.



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Related Solutions

Name	Method	shortcomings

HyperFlow	Multiple controllers;
	Each handles local OF switches;
	Sharing the global information by WheelFS.
		can only deal with not occur frequently events

DevoFlow	clustering or fuzzy matching technology; each of the controller processes is a class of data flows;	classification number ←compromise→ control burden
DIFANE	returns some control right to the OpenFlow switch; pre-installing several forwarding rules.	sacrifices real-time visibility of the global data flow status
ONIX	treats each partition network as a logical node when make global routing decisions; each partition network makes local routing decisions.	sacrifices real-time visibility of the global data flow status

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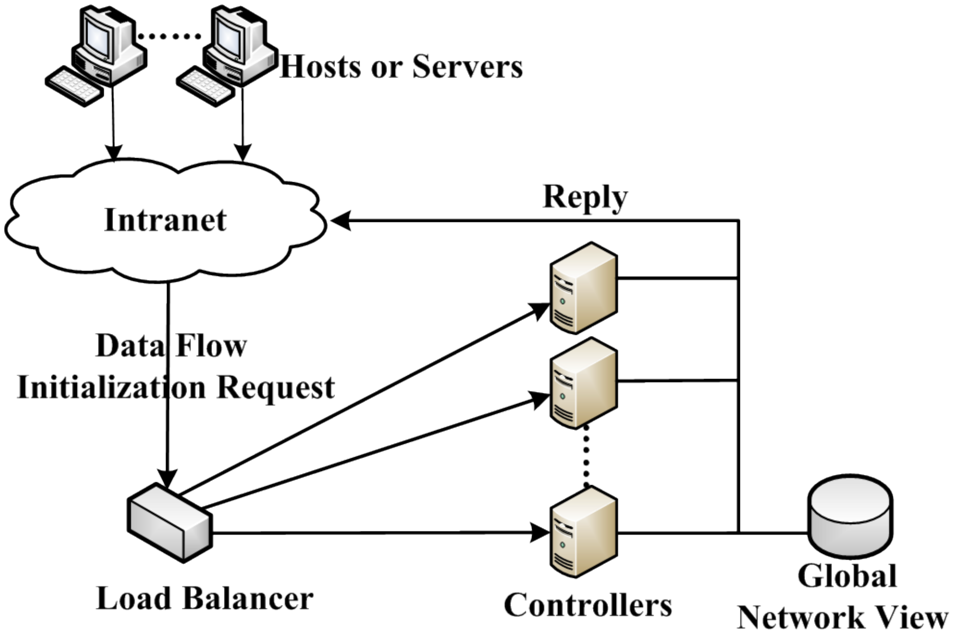
Load Balancing to Initialization Requests



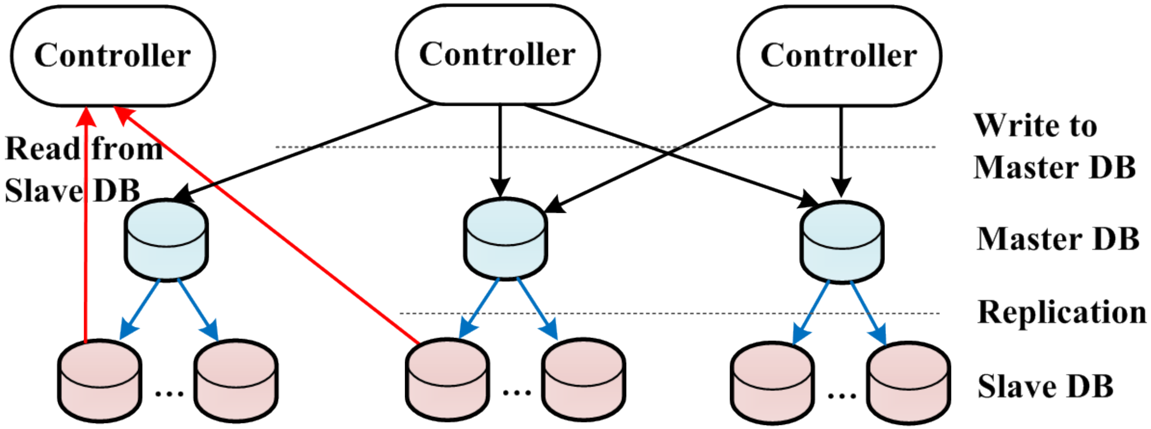
- Initialization requests are distributed (varieties of algorithms) to different controllers by load balancing equipment
- All the physical controllers are equivalent.
- Load balancer can be: router, OF switch, professional Web load balancer, professional Web load balancer…

Storage Cluster for Data Sharing

- To provide a consistent global view for each controller, this paper suggests adopting a mature data storage system which must include at least two parts:
  - 1) persistent storage (support transaction);
  - 2) caching storage.
- Controllers directly deal with the caching storage in both reading and writing.
- The persistent storage could be used for data analysis or maintain network status during a reboot process.

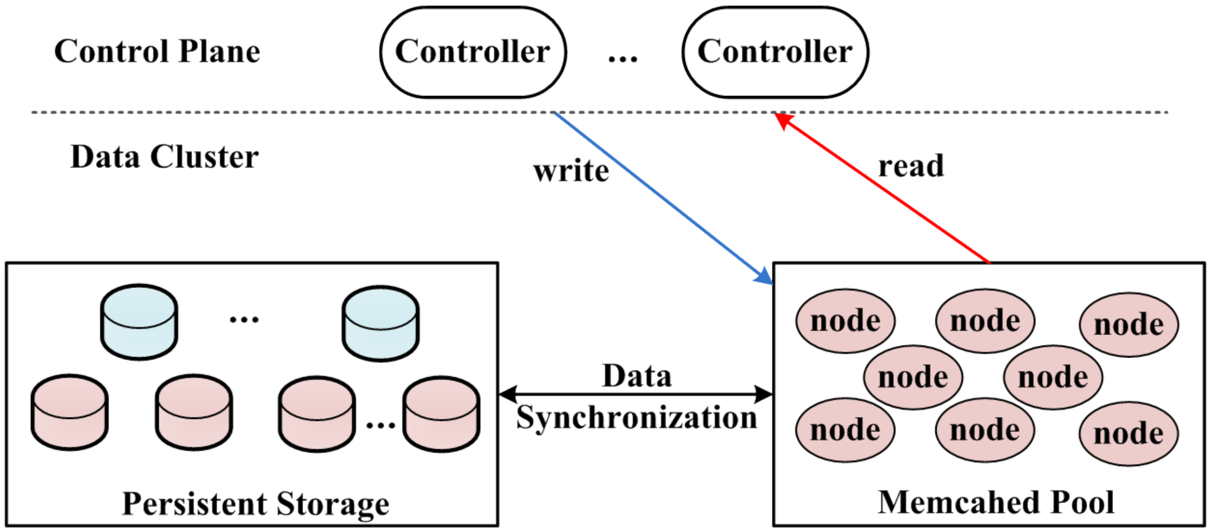
Storage Cluster for Data Sharing

- To give a concrete picture, this paper takes the MySQL database for example.
- **Step 1:**
- Writing and reading mechanism to the distributed storage of the shared data:



Storage Cluster for Data Sharing

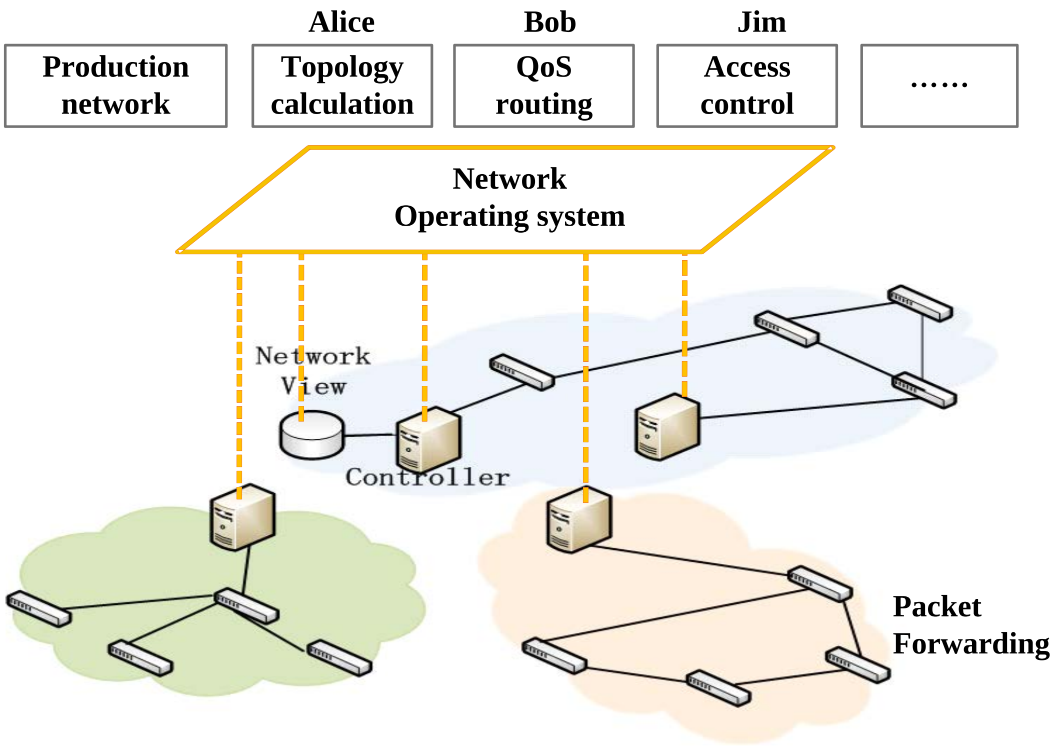
- **Step 2:**
- The data cluster in ASIC further adds a memory caching pool to the data sharing mechanism:
- Memcahed pool and the persistent storage should synchronize the data from time to time.



Scalability Analysis of the ASIC

- Each of the three levels in ASIC has its own scalable solution and could be extended to meet the requirements of large-scale networks:
  - The selection of the load balancing equipment can range from the software balancer to the current Internet backbone router.
  - ASIC can also increase the corresponding number of the physical controllers. (Different controllers could run different controller software)
  - The number of databases should also increase correspondingly.

Application Deployment in Control Plane



- Developers selectively install their applications according to their preference of developing language or to the functions of different controllers.

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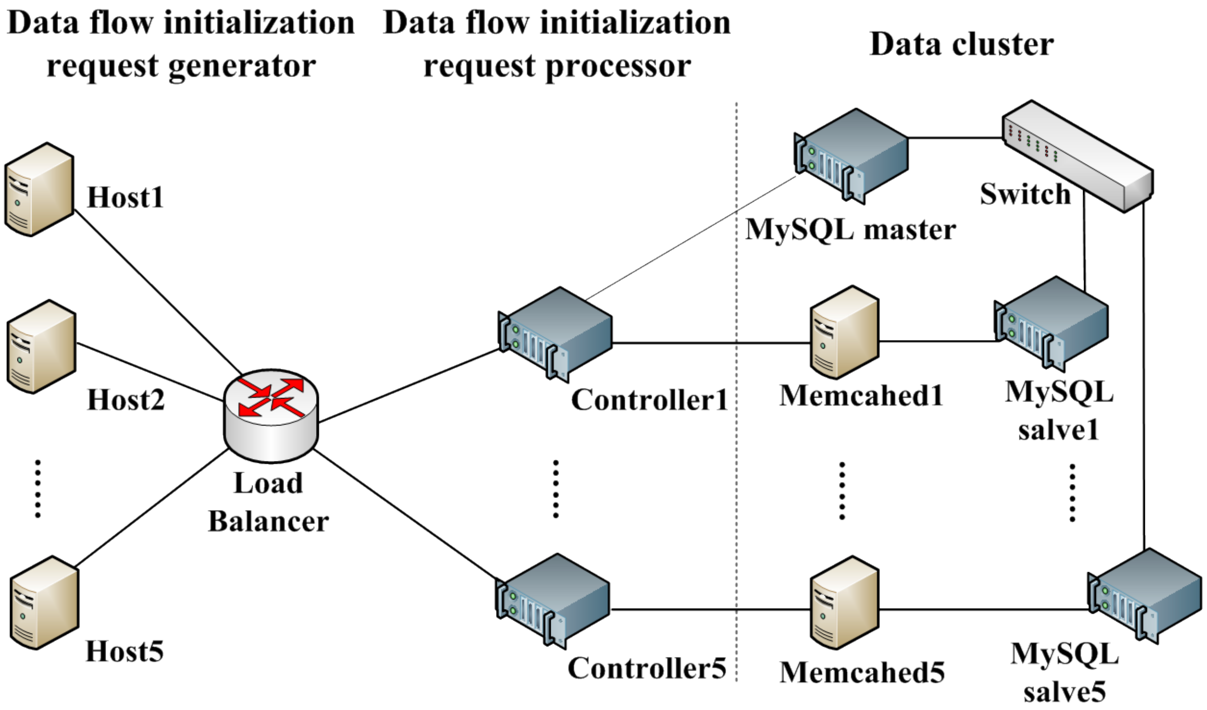
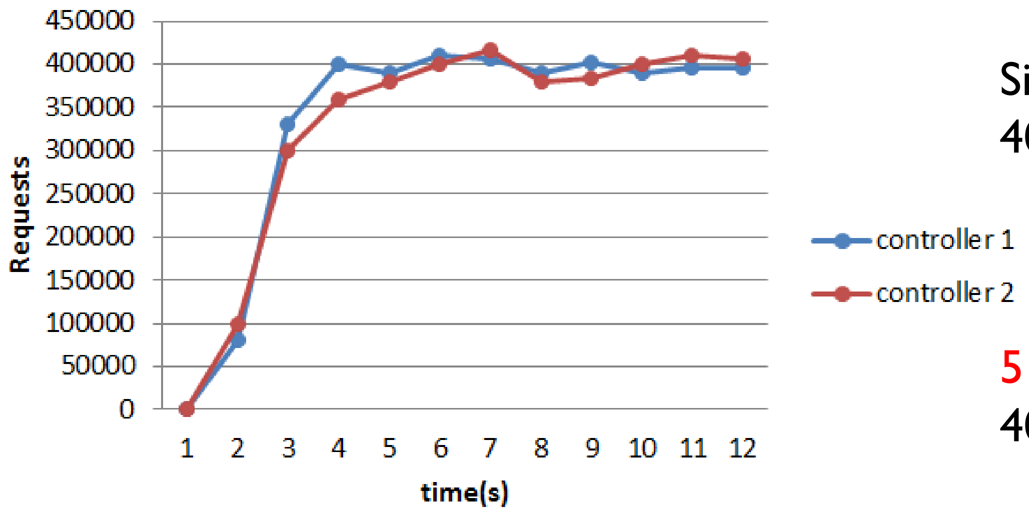
Experiment Environment and Design



- Five requests generating hosts are connected to five different ports of the router.
- The router cascades five controllers in the right direction.

Throughput

- Performance metrics:
  - request processing throughput, data flow setup latency.
- Throughput



Single controller is about 400,000 request/s.

5 controllers(X > 5) :
400,000 x 5 = 2,000,000.

Controller	1	2	3	4	5
Speed Requests/s	414,598	403,470	425,553	383,376	394,511

Latency Analysis

- The time delayed in ASIC is $O(h) + O(f(n))$
- *1) h* is the hops of balancers in the balancing system.
  - The time for traversing a balancer is equal to traversing an ordinary switch(acceptable).
- *2)* $f(n)$ represents the time consumed to fetch the global network view data from the shared data storage.
  - n means the number of nodes where the data segments located.
  - Storage is cached in the memory
  - Data can be fetched by multi-thread in a parallel
  - Drops to $f(n / num(threads))$(negligible).

Conclusion and Future Work

- The computer field adopted a common underlying hardware (x86 instruction set).
- OpenFlow can be considered as "the x86 instruction set of the network".
- This paper adopts the idea of load balancing, parallel processing, data sharing and clustering to solve the scalability problem in the OpenFlow control plane.
- Future work focuses on deploying the ASIC to the actual OpenFlow network and monitoring its behavior.

Thank you!

Questions & Comments?