

L7 Packet Switch: Packet Classification applying Regular Expression to Packet Payload

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Outline

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3. Design
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5. Evaluation
6. Conclusion

1. Background

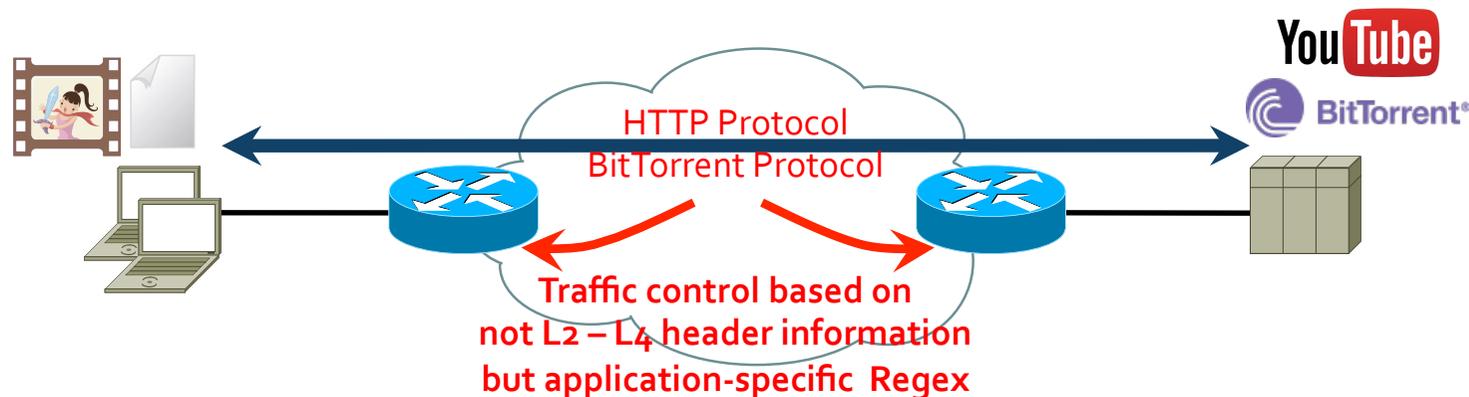
Limitations with the existing SDN

- + Need to specify L2 –L4 header information
 - + End users use the Internet through applications
 - + Interpret from traffic generated by application to the L2 - L4 header information
- + **Unable to control some popular applications e.g., P2P / Video traffic**
 - + The same server (address) serves many applications
 - + Same server distributes the different types of traffic (e.g. text or video)
 - + IP address and port of hosts (servers) varies for the same application
 - + IP addresses and ports of hosts (servers) may vary for the same application
 - + Especially with P2P applications

Our Proposal: L7 Packet Switch Traffic Control

- + Controls the traffic according to L7 payload of packets
 - + Performs regular expression (Regex) matching over the packet payload
 - + Generates flow information and corresponding actions for traffic control

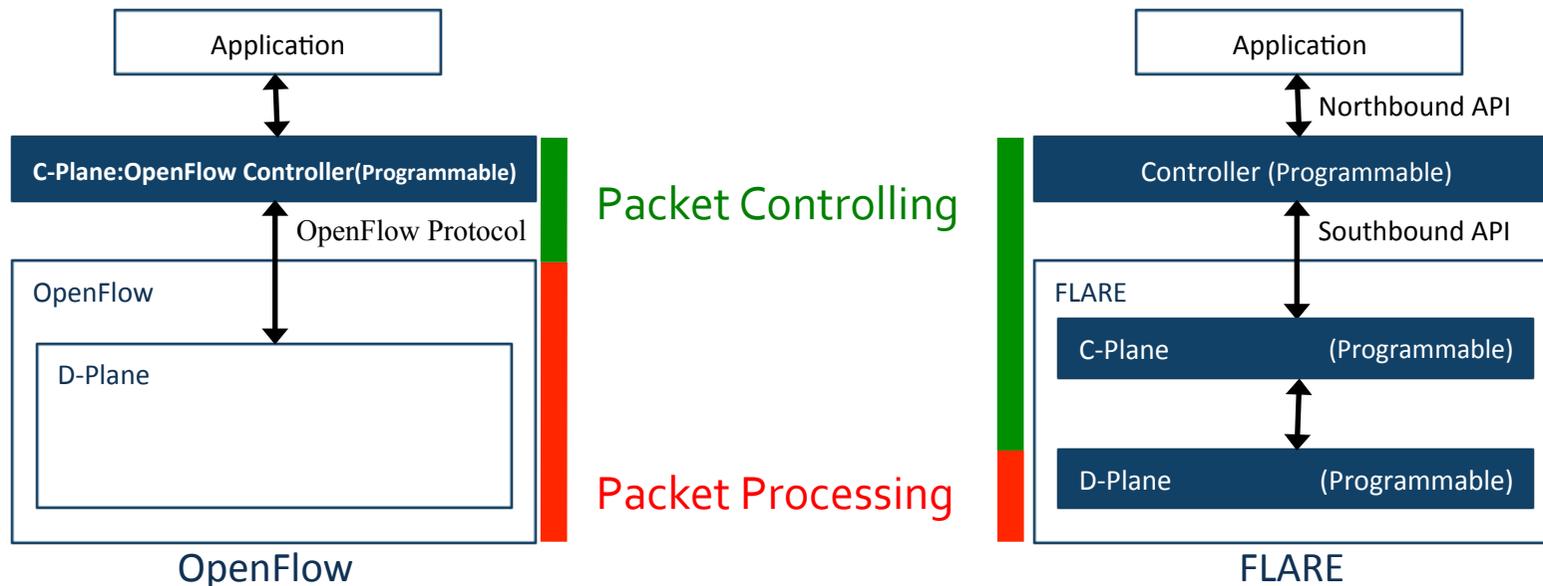
Provides straightforward application-level traffic classifier
Achieves high performance traffic control



2. Related Work

FLARE^[1] Architecture

- + Deeply programmable network node
 - + Enables the programmability for C-Plane, D-Plane and Southbound API
- + D-Plane can execute Click binary and achieves 10 Gbps packet forwarding
 - + with many-core network processors by utilizing the parallelism



Application-aware Traffic Control

- + ATLAS^[2] : Application-aware Traffic Control
 - + Application classification system in SDM
 - + Identifies mobile application traffic by machine learning (ML)
 - + Controls the traffic using the result of ML on top of OpenFlow
- + Problems
 - + Requires multiple equipments
 - + OpenFlow Switch, OpenFlow Controller, ML handling software
 - + No packet transfer performance evaluation
 - + Only ML accuracy is evaluated

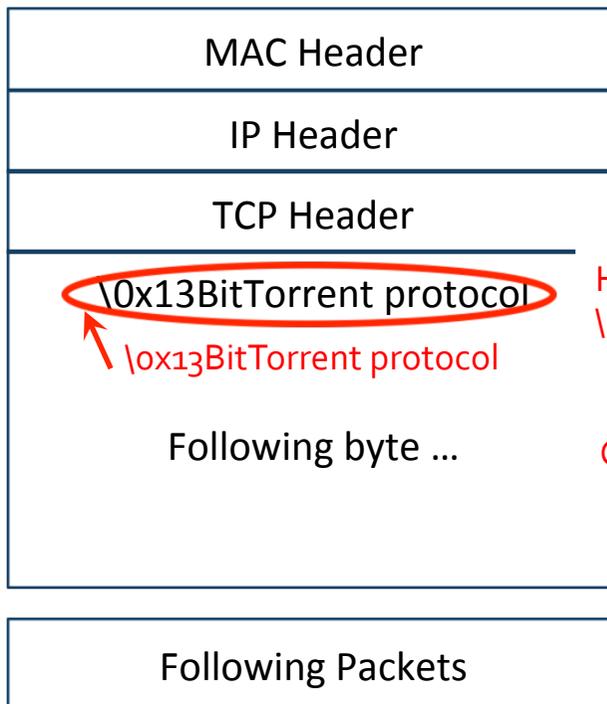
3. Design

L7 Packet Switch Overview

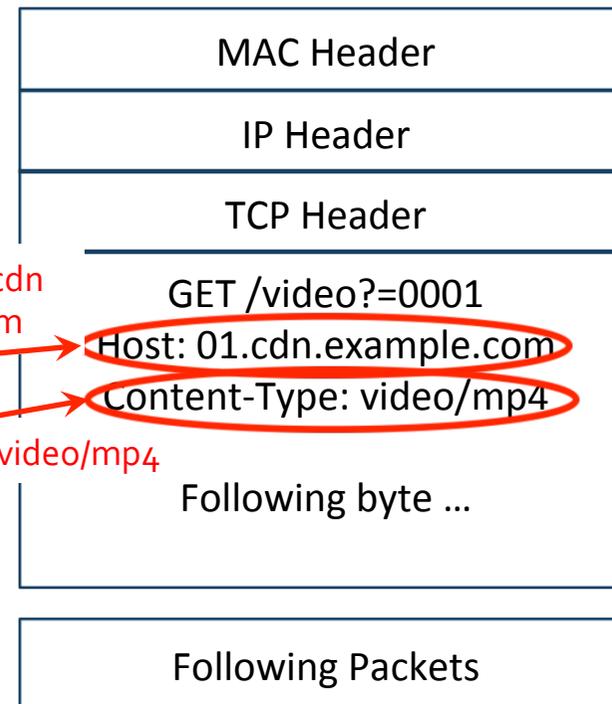
- + Identifies applications from packet payload and controls the traffic belonging to specific flows
 - + Network administrator specifies application-specific Regex and corresponding actions
 - + for example, Regex: "Host: .*\.example\.com", action: "output port: 1"
 - + Traffic is controlled by a flow table with flow information and actions
 - + Flow information: source/destination IP addresses, source/destination ports
- + Once a packet matches a specified Regex, the flow it belongs to will be assigned with a specific action

L7 Packet Switch Usage Example

+ P2P application



+ Specific HTTP application



Host: [0-9]+\.cdn
\.example\.com
Content-Type: video/mp4

Application with L7 Packet Switch

- + In-Network Cache
 - + Cache P2P and Video Traffic
- + Redirection (QoS)
 - + Streaming Video and File Download
- + In-Network Security
 - + In-Network IDS

The difference between OpenFlow and L7 Packet Switch

OpenFlow^[3]

SRC IP	DST IP	SRC PORT	DST PORT	ACTION
AAA	BBBB	AA	BB	OUTPUT ₁

Direct registration IP addresses and port Num

L7 Packet Switch

SRC IP	DST IP	SRC PORT	DST PORT	ACTION
AAA	BBB	AA	BB	

hide the flow information

To register Regex specifying packet payload
Indirect registration IP addresses and port Num



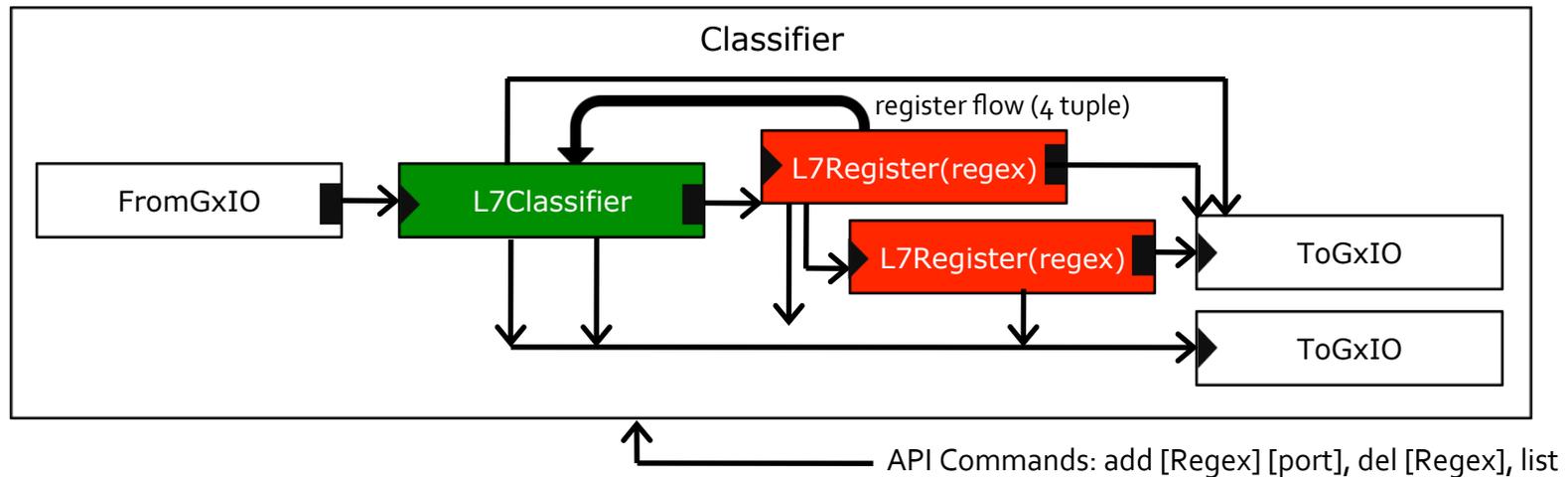
- + For example, if you want to control the traffic of YouTube video
 - + OpenFlow : Direct register the IP address and port number of all servers
 - + L7 Packet Switch: Specify the Regex conditions corresponding to the traffic from the payload

4. Implementation

L7 Packet Switch Implemented on FLARE

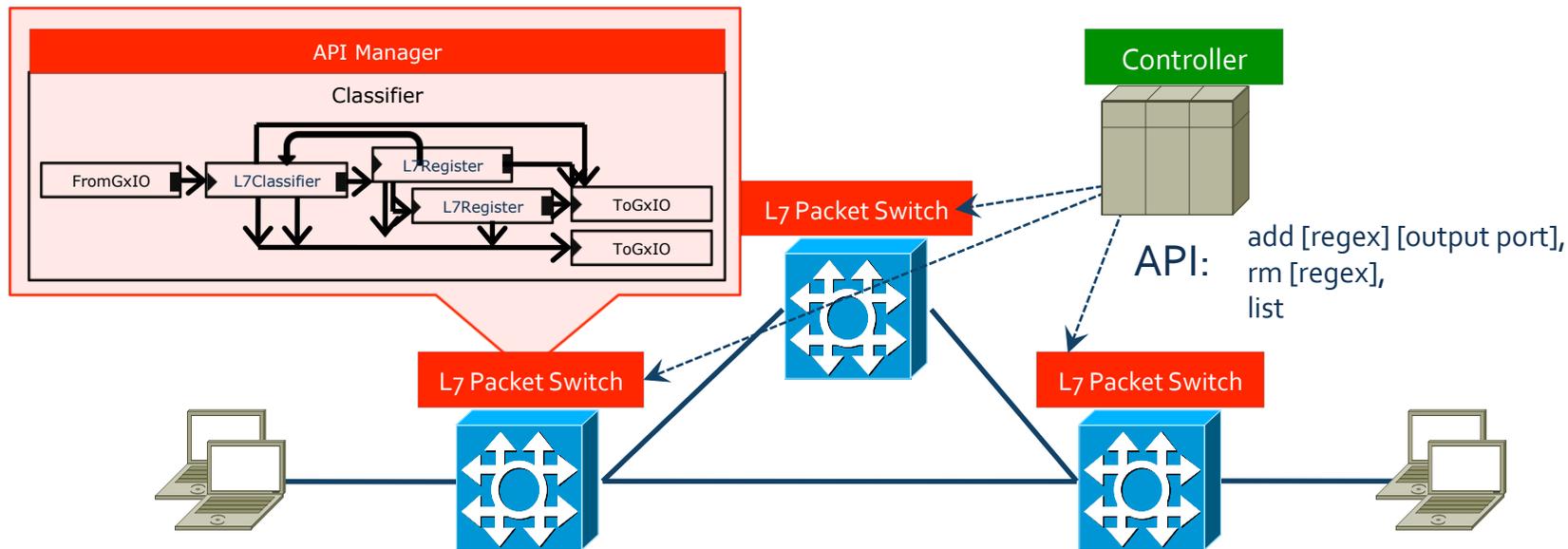
- + L7 Packet Switch is implemented as elements of Click^[4]
 - + Click can implement network function by connecting Element
 - + Click works on Linux, but x86 Click is difficult to perform 10 Gbps
- + FLARE node adopts a many-core network-processor
 - + it can process packet processing in Click at 10 Gbps
- + To achieve 10 Gbps packet processing, L7 Packet Switch is implemented on a FLARE node

L7 Packet Switch Implementation



- + In each L7Register Element, a single Regex is registered and its matching is performed
- + L7Classifier implements the packet classification function
- + L7Register executes the flow registration function

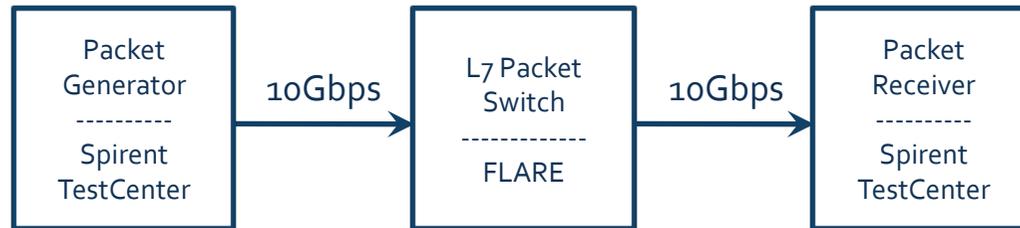
L7 Packet Switch API Manager



- + API Manager manages regex and output port
- + Controller control L7 Packet Switch by using API
 - + Commands: add, rm, list
- + Generates Click configuration and reload when setting is changed

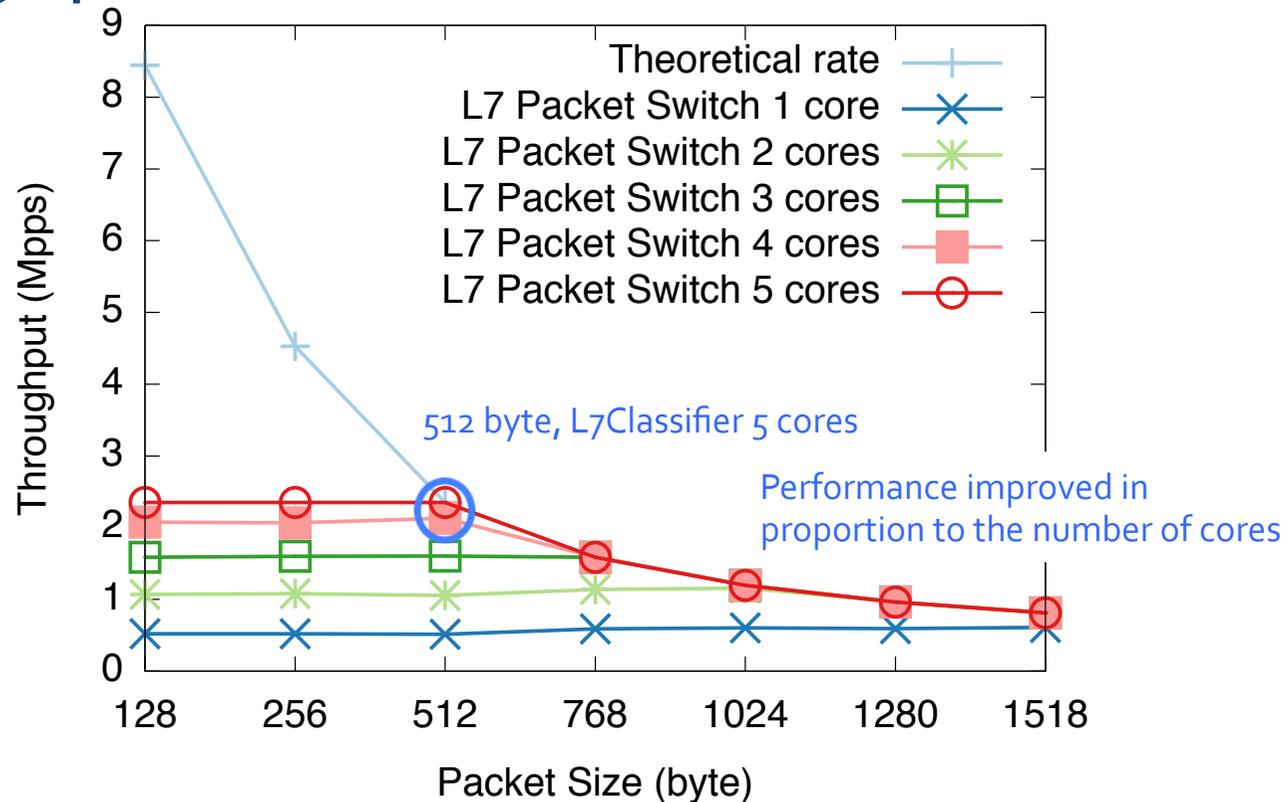
5. Evaluation

Evaluation Environment



- + L7 Packet Switch Throughput Evaluation Environment
- + Packets are generated by 10 Gbps using Spirent TestCenter
 - + Packets are constituted by 65536 TCP flows

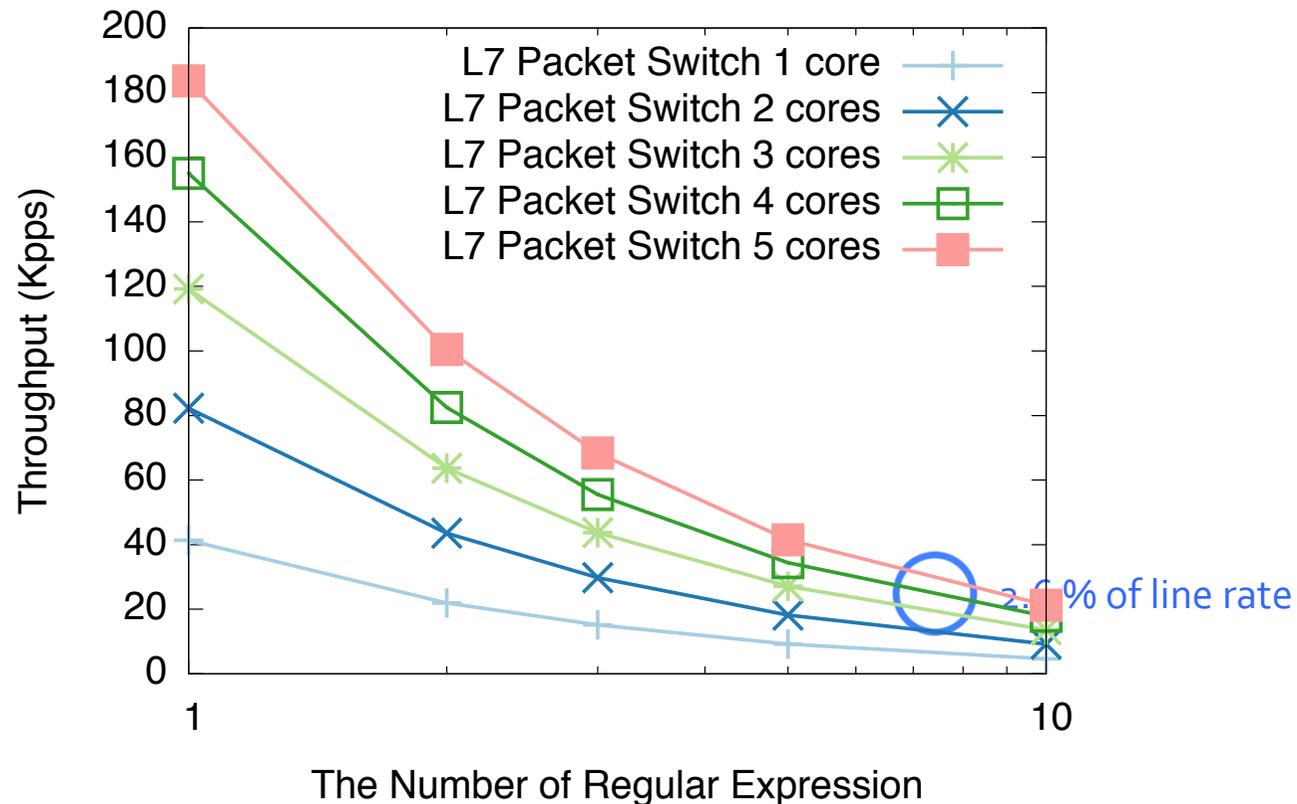
Throughput with Different Packet Size



Packets can be forwarded at line speed (10Gbps)
when average packet size is larger than 512 bytes

Long packets (e.g., web traffic) can be classified at 10Gbps

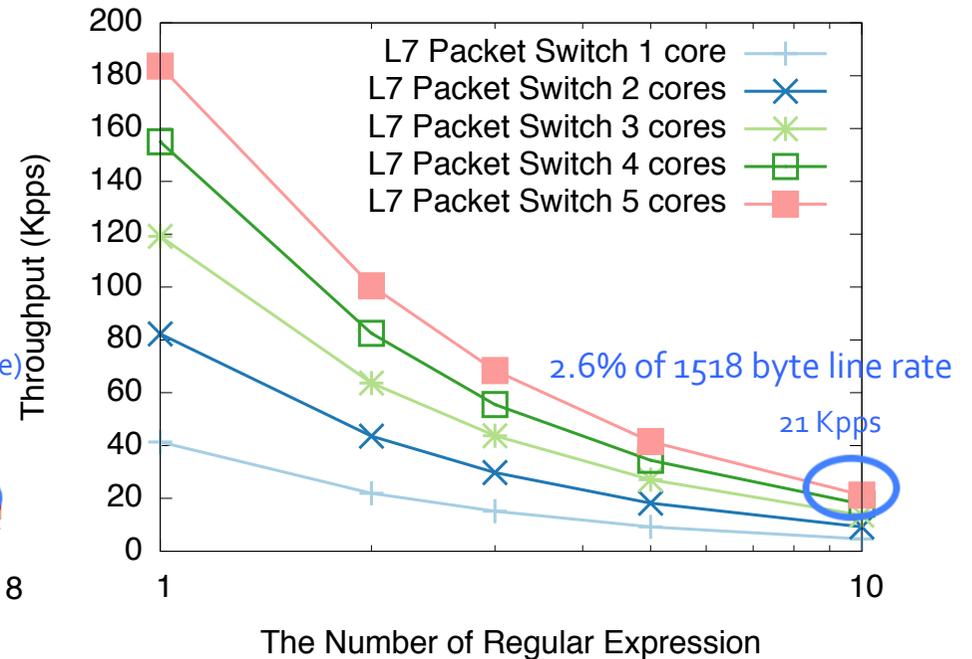
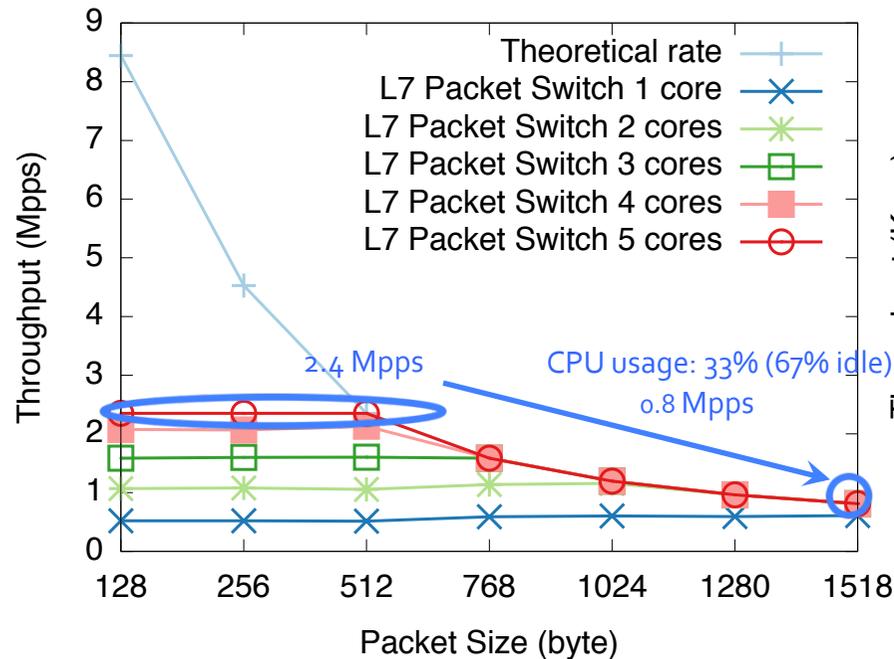
Throughput with Different Number of Regex



L7 Packet Switch can match 10 regex and register flows with 5 cores at 2.6% of line speed

L7 Packet Switch can match and register at 10 Gbps since new flows occupy 1.4% of our campus traffic

Overall Performance Estimation



Linespeed (10Gbps) can be achieved for long packet with 10 Regexp if there are less than 1.7% ($2.6\% \times 67\%$) of packets initiating new flows 1.4% of our campus traffic

6. Conclusion

Conclusion

- + L7 Packet Switch: straightforward application-level traffic control
 - + Applying regular expression to packet payload
 - + Controlling packet behavior with the granularity of flows
 - + Components: Classifier and API Manager
 - + Implemented using Click
 - + Performance evaluation on FLARE node
 - + Can achieve traffic control at **10Gbps with 10 Regex** if there are less than 1.7% of packets initiating new flows such as u-tokyo (1.4%)
- + Future Work
 - + Enable UDP flow support
 - + Integration with OpenFlow

References

- [1] Nakao Akihiro. Flare : Open deeply programmable network node architecture. http://netseminar.stanford.edu/10_18_12.html.
- [2] Eddie Kohler, Robert Morris, Benjie Chen, John Jannotti, and M. Frans Kaashoek. The click modular router. *ACM Trans. Comput. Syst.*, 18(3):263–297, August 2000.
- [3] Z.A. Qazi, J. Lee, T. Jin, G. Bellala, M. Arndt, and G. Noubir, “Application-awareness in sdn,”
Proceedings of the ACM SIGCOMM 2013 Conference on SIGCOMM, pp.487–488, New York, NY, USA, 2013, ACM.
- [4] N. McKeown, T. Anderson, H. Balakrishnan, G. Parulkar, L. Peterson, J. Rexford, S. Shenker, and J. Turner. OpenFlow: enabling innovation in campus networks. *SIGCOMM Comput. Commun. Rev.*, 38(2):69–74, 2008

Thank You for Listening

Backup Slides

Software-Defined Network

- + Software-Defined Network (SDN)
 - + Flexible equipment management by the separation of Control Plane and Data Plane
 - + Enabled by hardware evolution of network devices

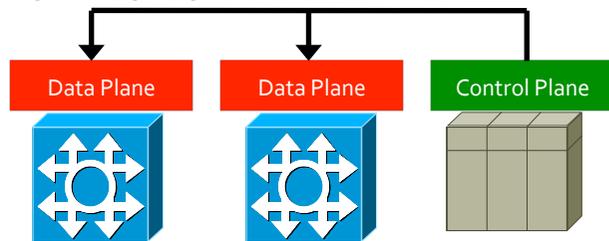
- + Sales of SDN^[1]
 - + \$10 million in 2007 -> \$252 million in 2012
 - + Expected to reach \$35 billion in 2018

- + SDN is becoming widely spread in the world

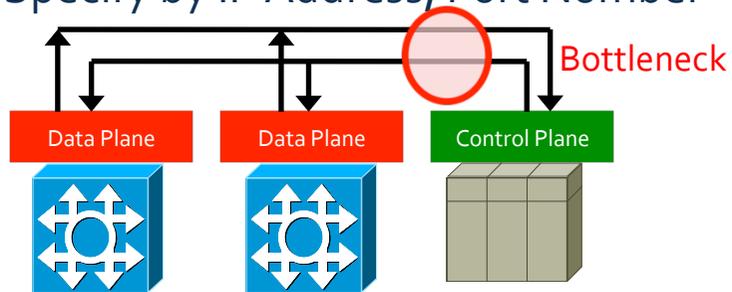
The difference between OpenFlow and L7 Packet Switch

OpenFlow

Specify by IP Address, Port Number

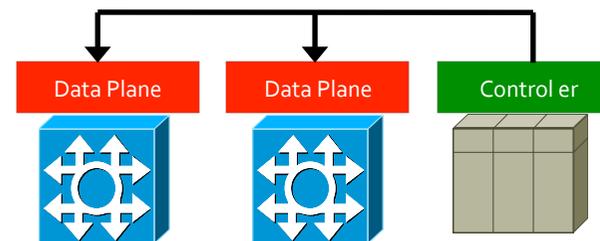


Packets are Transfer to C-Plane,
C-Plane identifies Flow,
Specify by IP Address, Port Number



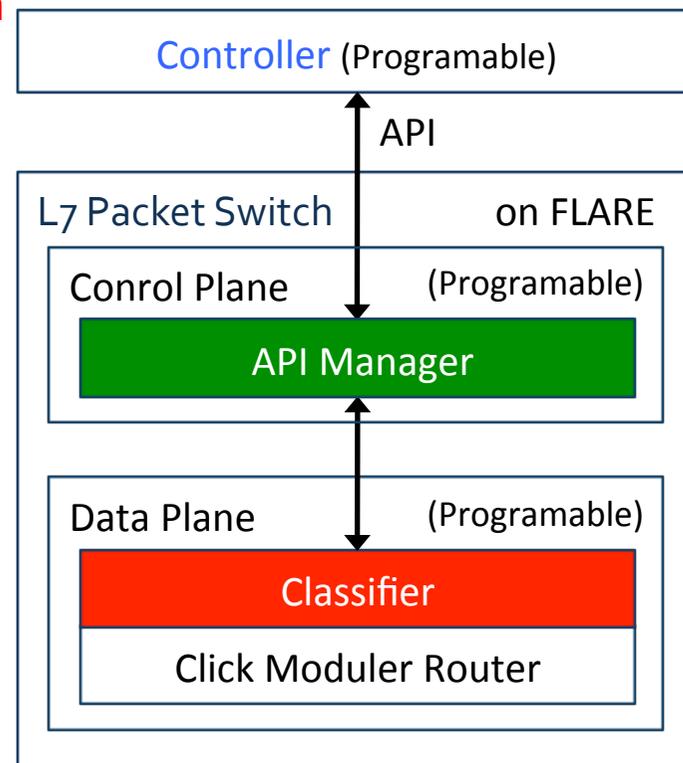
L7 Packet Switch

Specify by Regex,
Flow Identification on D-Plane by Regex
Hide IP Address, Port Number



L7 Packet Switch Design Structure

- + L7 Packet Switch consists of **Classifier on D-Plane** and **API Manager on C-Plane**
 - + **Classifier on D-Plane**
 - + manages its flow table
 - + forward packet search L7 payload applying Regex
 - + registers this result to the flow table
 - + **API Manager on C-Plane**
 - + Controls Classifier
 - + Manages set of Regex and output port
 - + Hides complexity of the generation of Classifier on D-Plane
 - + **Controller**
 - + Controls L7 Packet Switch via API

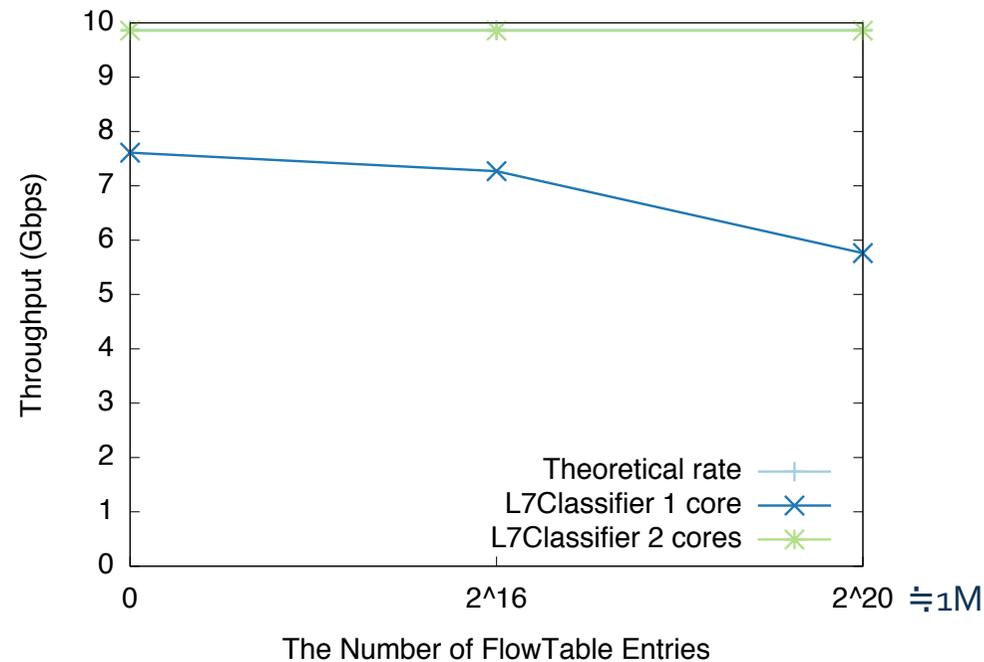


Fast Packet Processing

- + For fast packet processing, set "maxtargetpkt N" parameter
 - + Regex match are executed for only "N" packets belonging to flow
 - + A beginning portion of traffic contains a application-specific string (e.g. URL, domain, Content-Type in HTTP header or BitTorrent)
- + Many applications contains application-specific regex at the beginning of traffic
- + L7 Packet Switch supports to set "maxtargetpkt N" parameter
 - + Regex match is executed for only "N" packets at the beginning of a flow



Throughput with Different Number of Flow Table Entry



L7 Packet Switch can handle 1M flow entry with 2 cores
(packet size: 1518 byte)

No performance degradation with 2 cores 1M entries