Routing in the Future Internet

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Graduate Course (Slideset 10c)

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Outline

1. Assignment of final works for course approval
2. Software Defined Networks (SDNs).
3. Open APIs:
   - OpenFlow
   - JUNOS SDK
   - Cisco ONE
   - OPENER
   - .....
4. Outsourcing to the Cloud and its impact on routing, etc.

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Outsourcing Middleboxes to Cloud

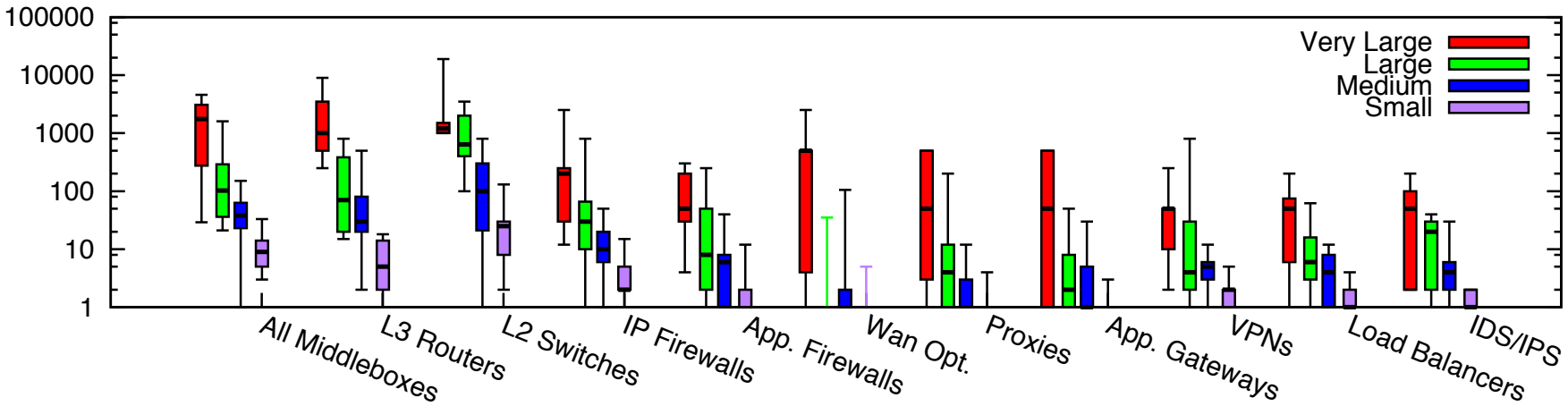

Figure 1: Box plot of middlebox deployments for small (fewer than 1k hosts), medium (1k-10k hosts), large (10k-100k hosts), and very large (more than 100k hosts) enterprise networks. Y-axis is in log scale.

- J. Sherry et al., "Making Middleboxes Someone Else's Problem: Network Processing as a Cloud Service," ACM SIGCOMM 2012, Helsinki, Finland, August 2012.

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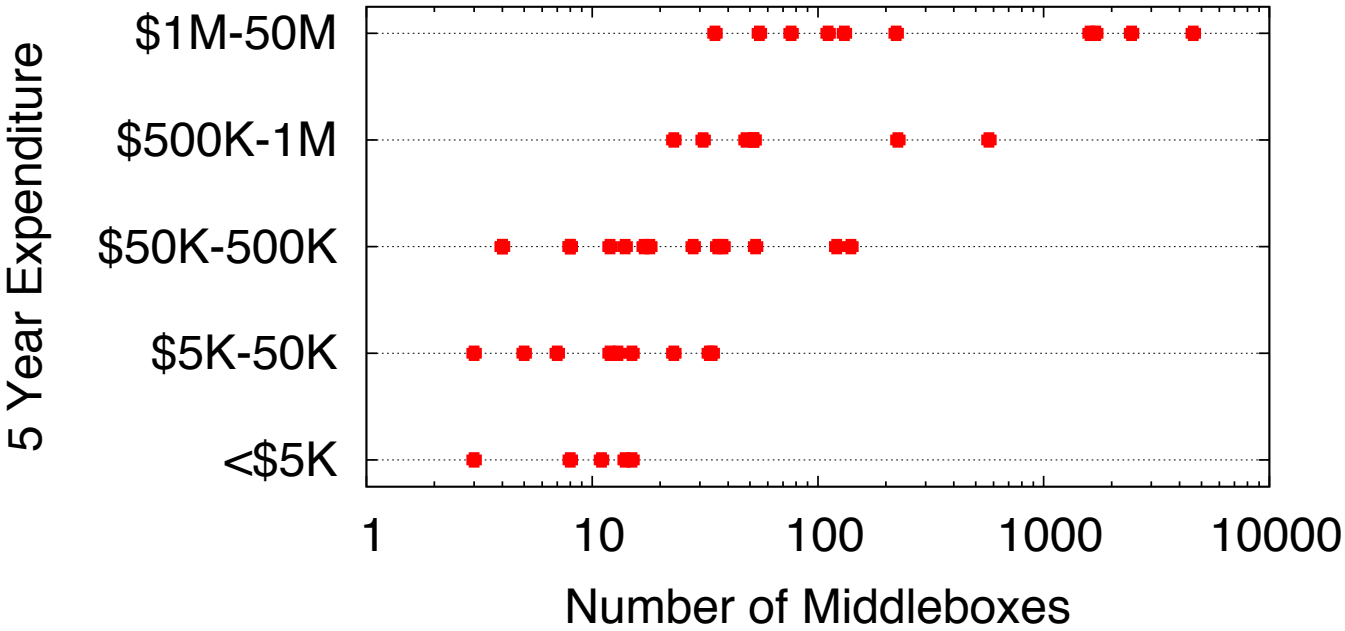

Figure 2: Administrator-estimated spending on middlebox hardware per network.

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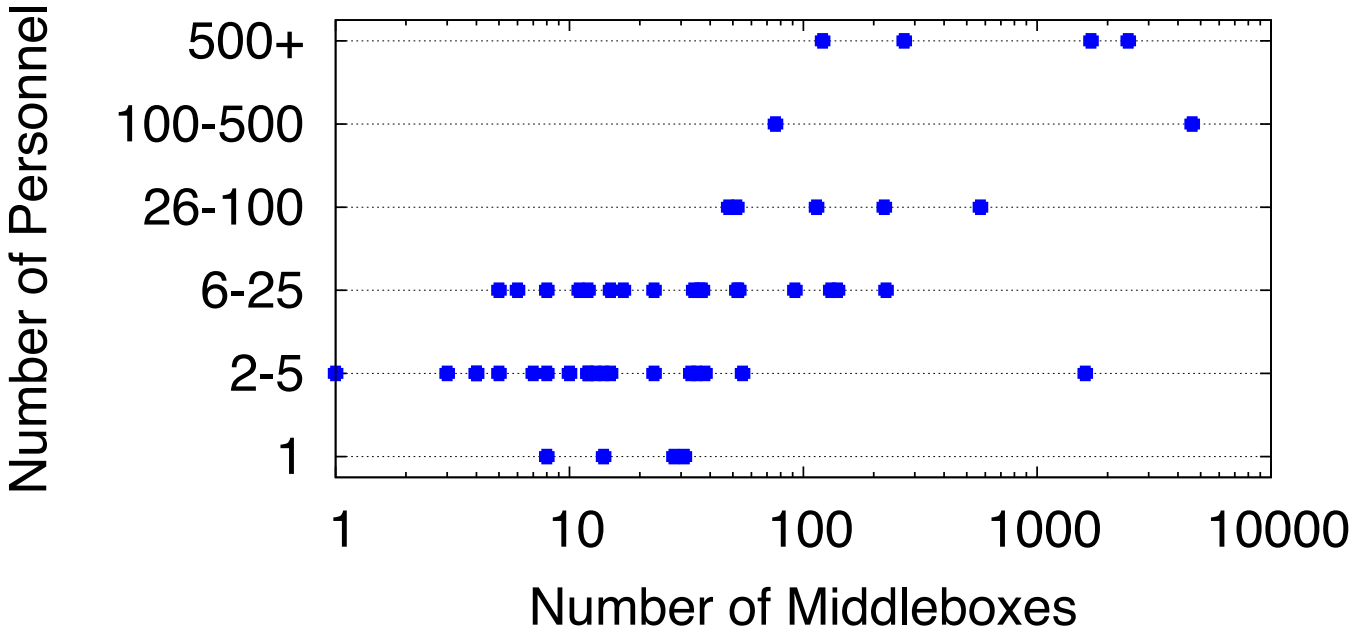

Figure 3: Administrator-estimated number of personnel per network.

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	Misconfig.	Overload	Physical/Electric
Firewalls	67.3%	16.3%	16.3%
Proxies	63.2%	15.7%	21.1%
IDS	54.5%	11.4%	34%

Table 1: Fraction of network administrators who estimated misconfiguration, overload, or physical/electrical failure as the most common cause of middlebox failure.

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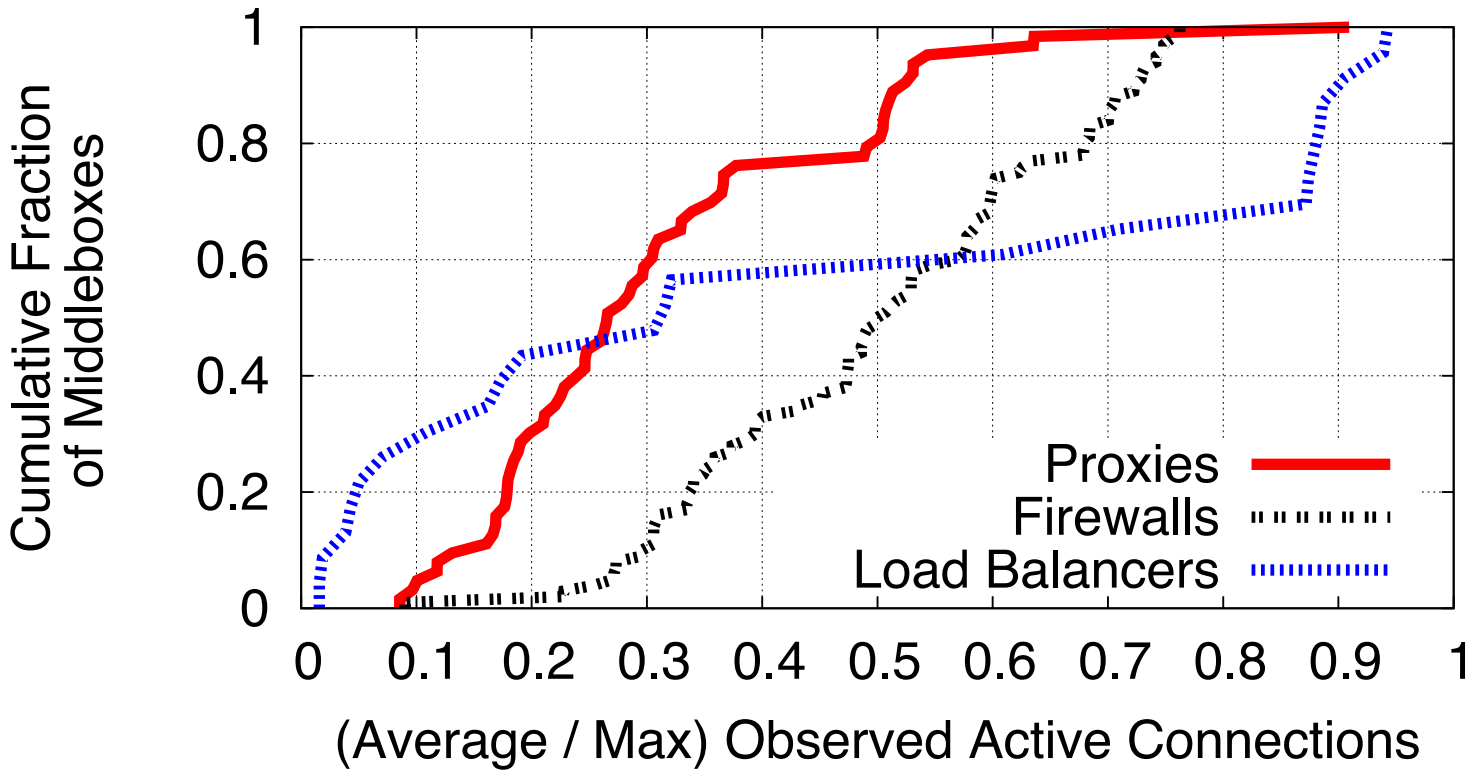

Figure 4: Ratio of average to peak active connections for all proxies, firewalls, and load balancers in the very large enterprise dataset.

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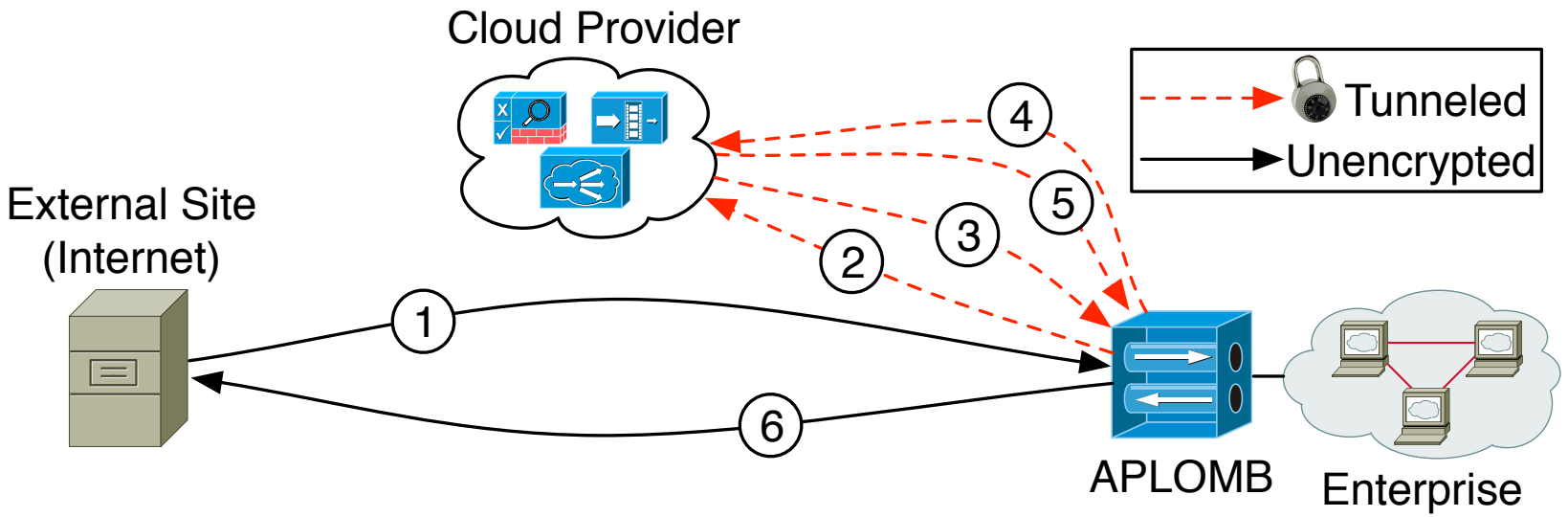
Appliance for Outsourcing Middleboxes (APLOMB)



(a) "Bounce" redirection inflates latency.

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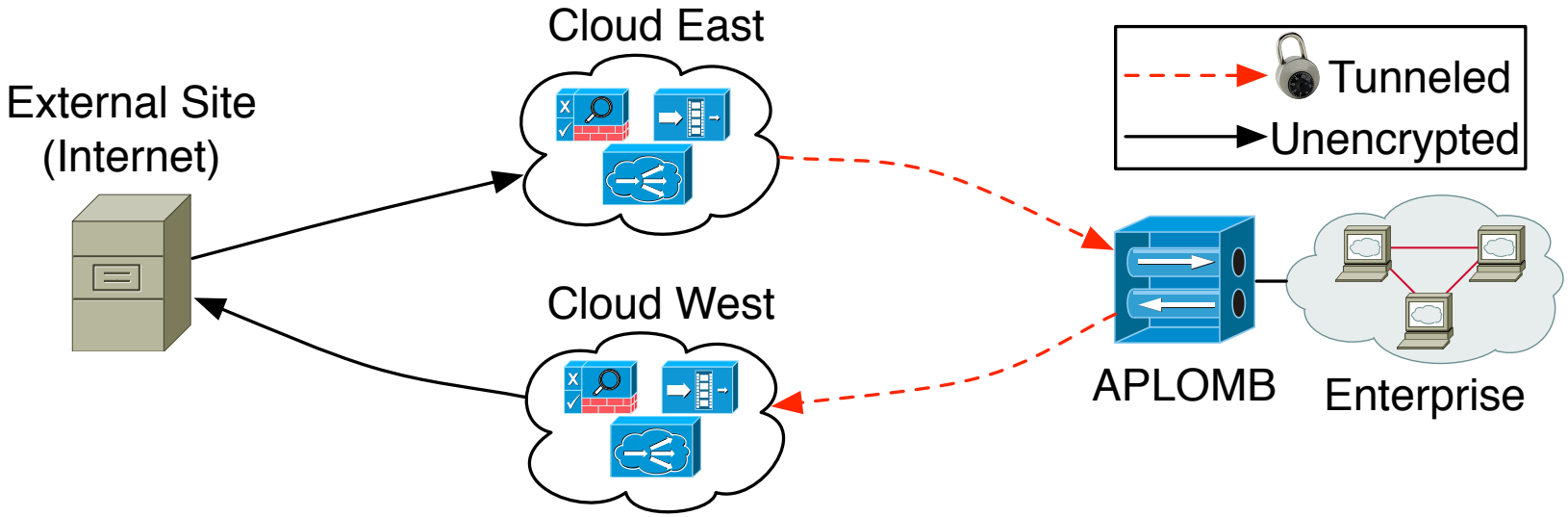

(b) Direct IP redirection in multi-PoP deployments cannot ensure that bidirectional traffic traverses the same PoP.

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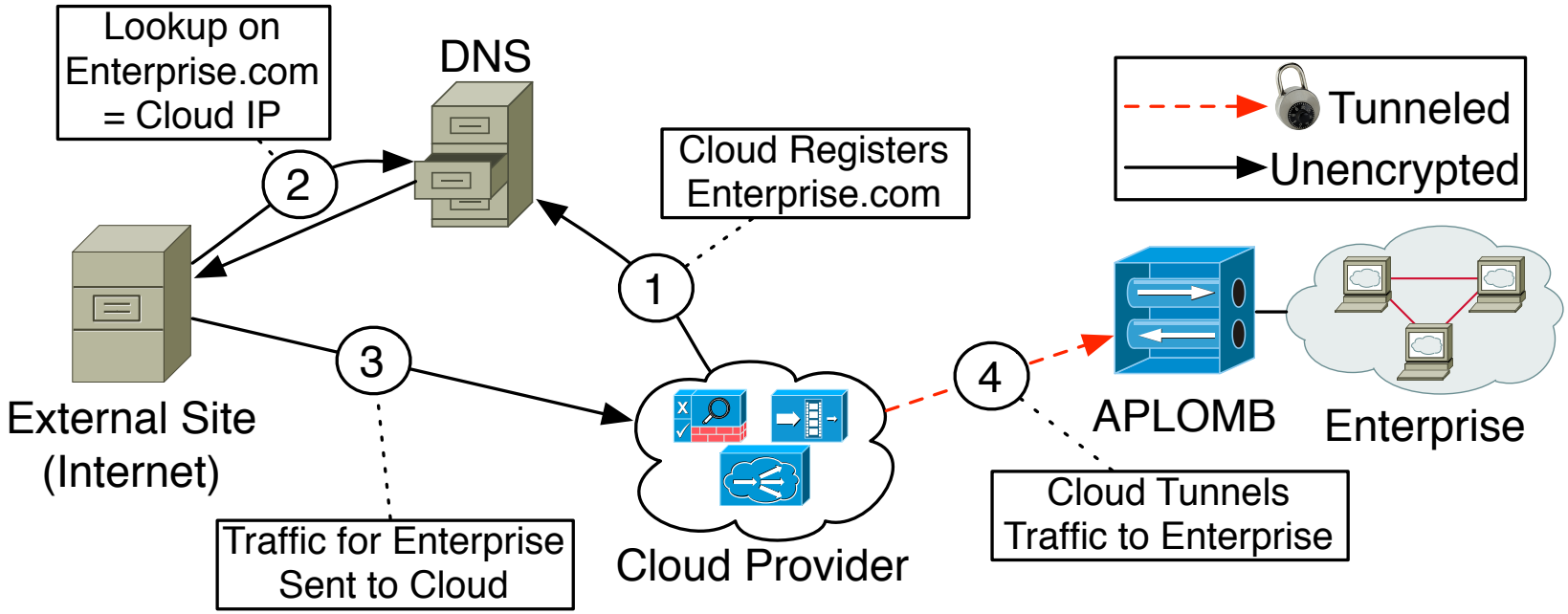

(c) DNS-based redirection minimizes latency and allows providers to control PoP selection for each request.

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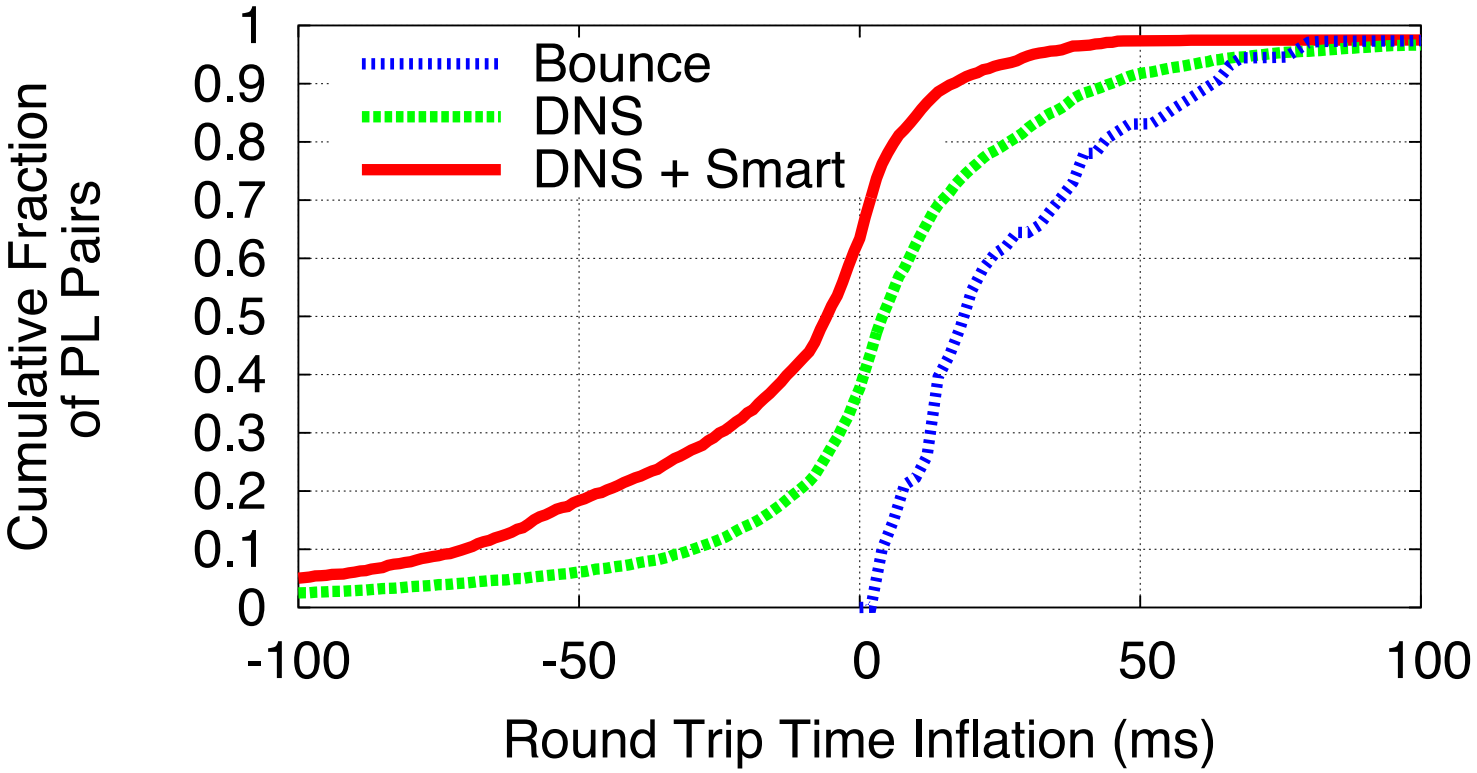

Figure 6: Round Trip Time (RTT) inflation when redirecting traffic between US PlanetLab nodes through Amazon PoPs.

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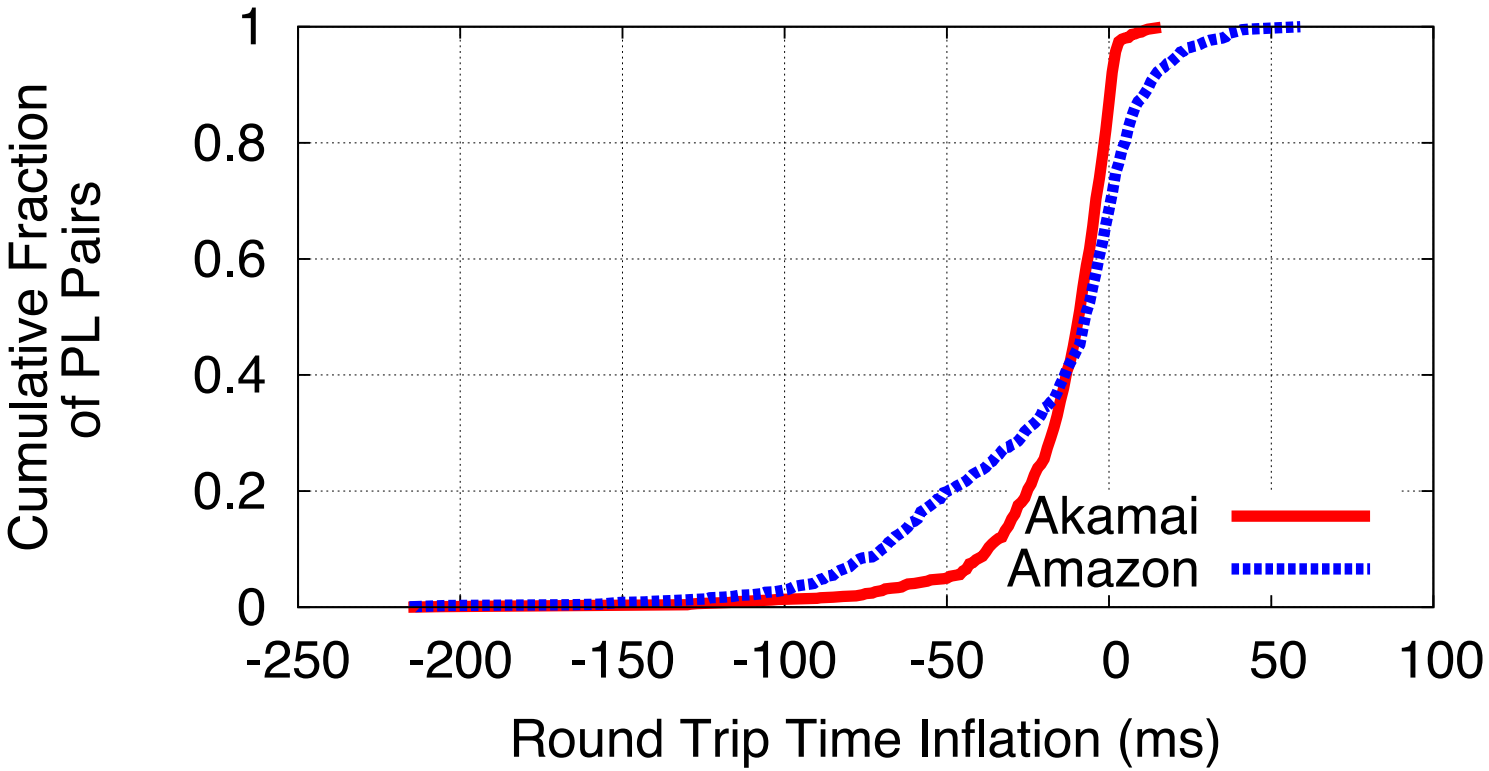

Figure 7: PlanetLab-to-PlanetLab RTTs with APLOMB redirection through Amazon and Akamai.

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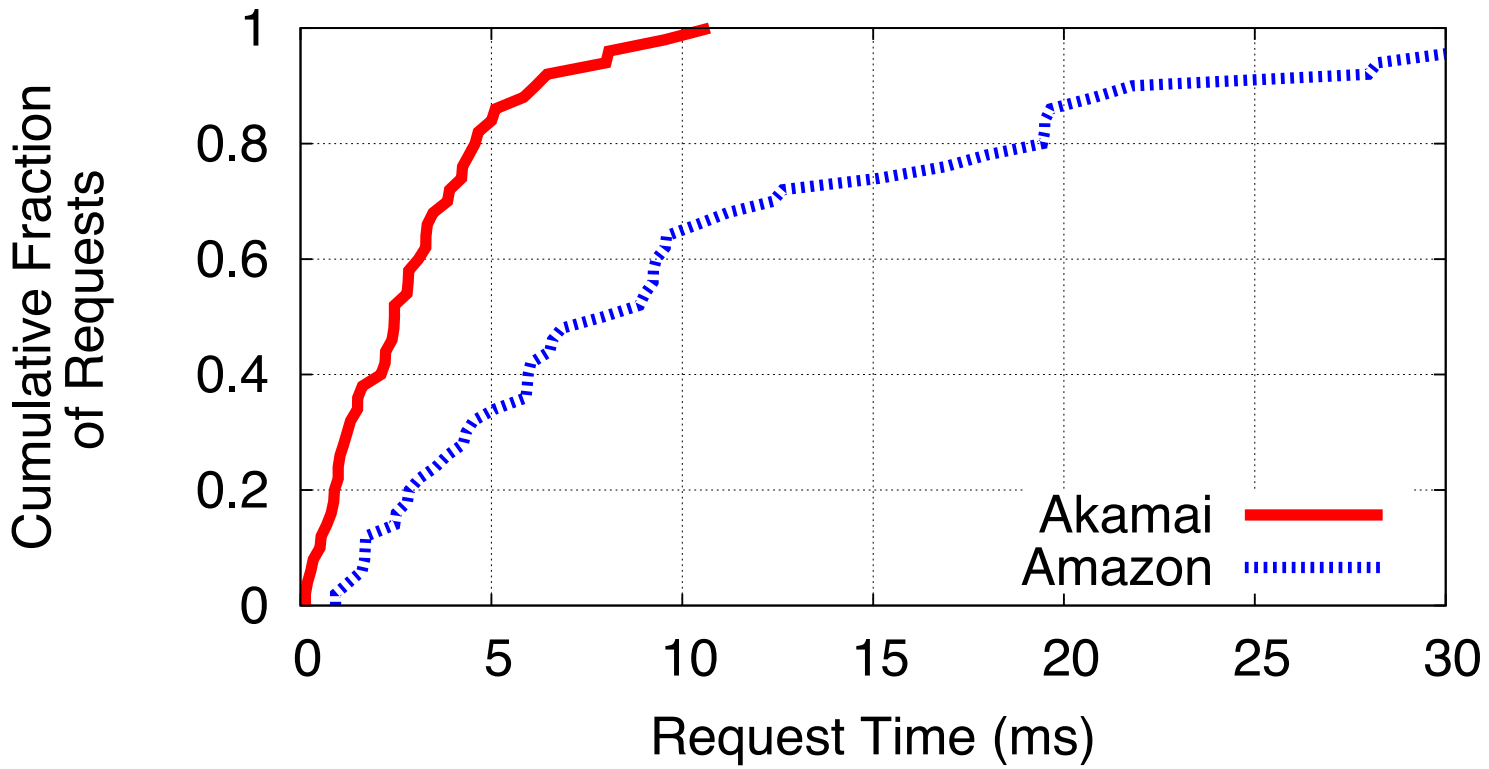

Figure 8: Direct RTTs from PlanetLab to nearest Akamai or Amazon redirection node.

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Outsourcing Middleboxes to Cloud

Type of Middlebox	Enterprise Device	Cloud Footprint
IP Firewalls	Basic APLOMB	Multi-PoP
Application Firewalls	Basic APLOMB	Multi-PoP
VPN Gateways	Basic APLOMB	Multi-PoP
Load Balancers	Basic APLOMB	Multi-PoP
IDS/IPS	Basic APLOMB	Multi-PoP
WAN optimizers	APLOMB+	CDN
Proxies	APLOMB+	CDN

Table 2: Complexity of design and cloud footprint required to outsource different types of middleboxes.

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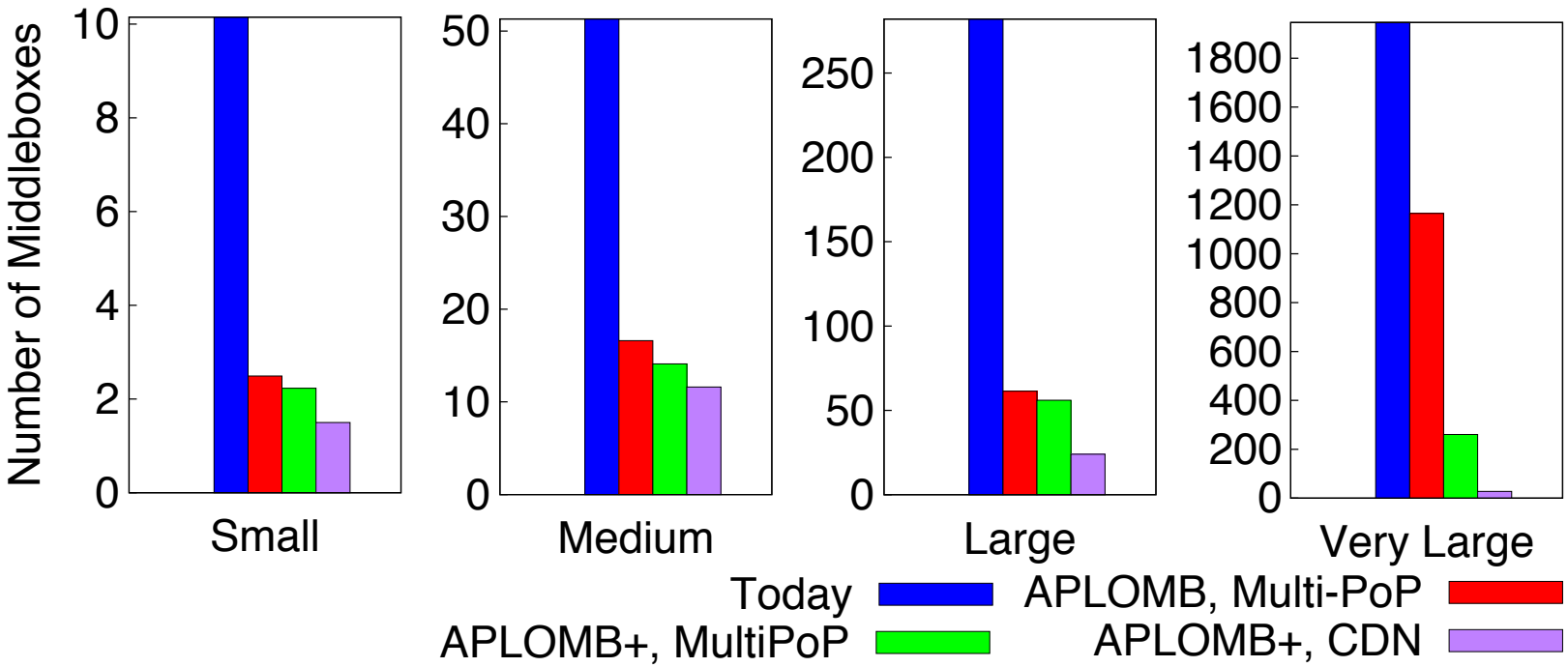

Figure 9: Average number of middleboxes remaining in enterprise under different outsourcing options.

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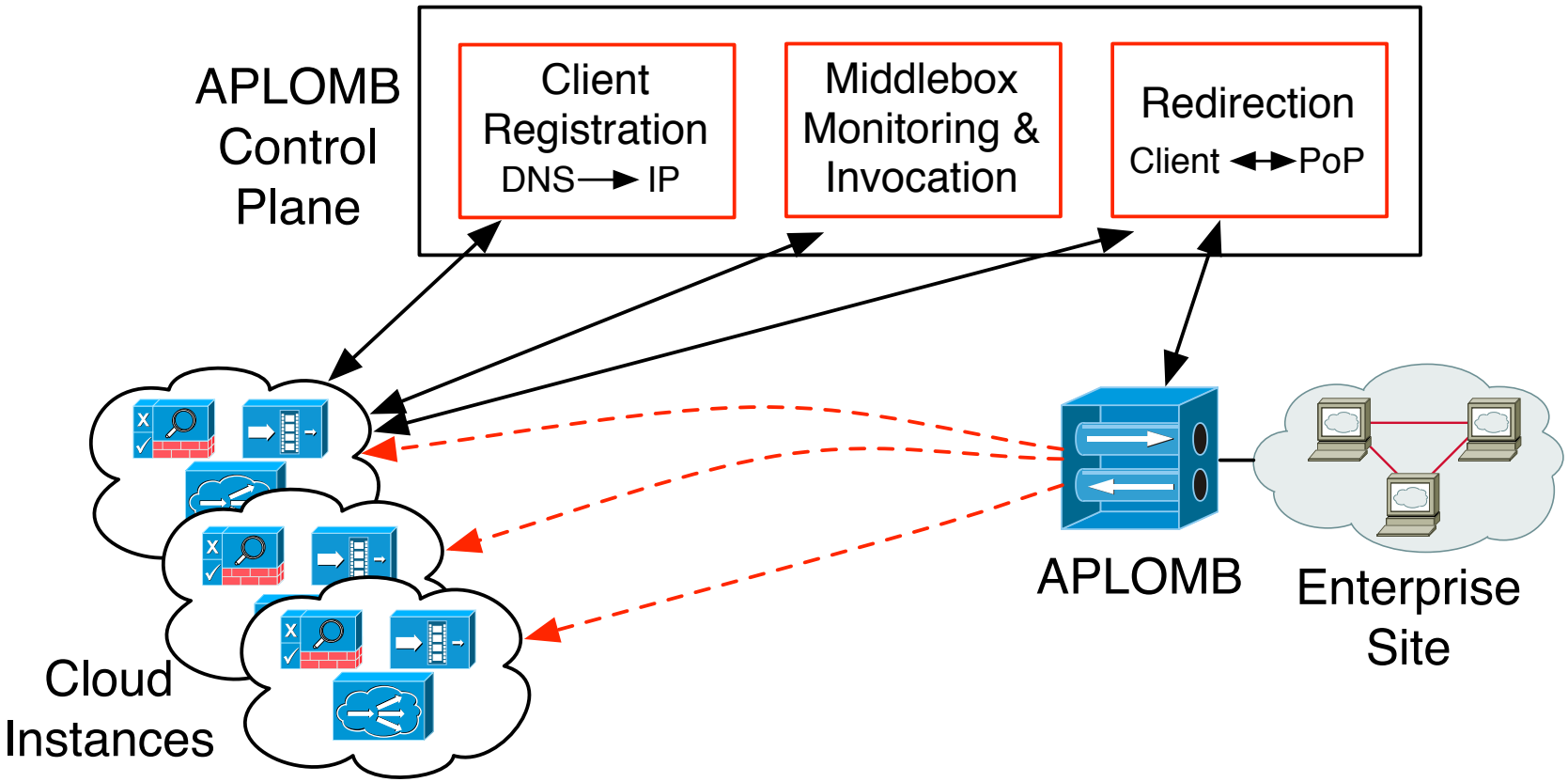

Figure 10: Architectural components of APLOMB.

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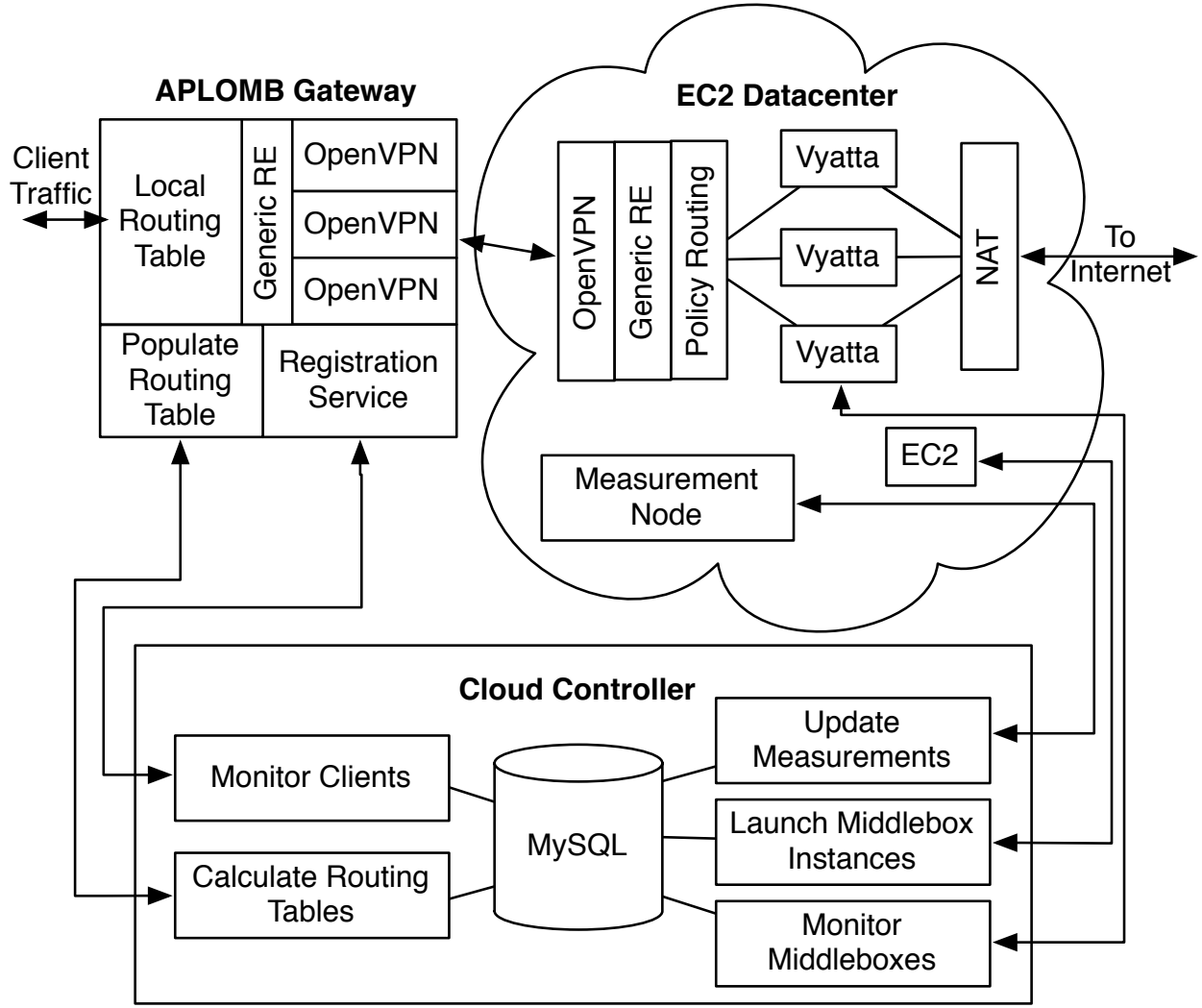

Figure 11: Software architecture of APLOMB.

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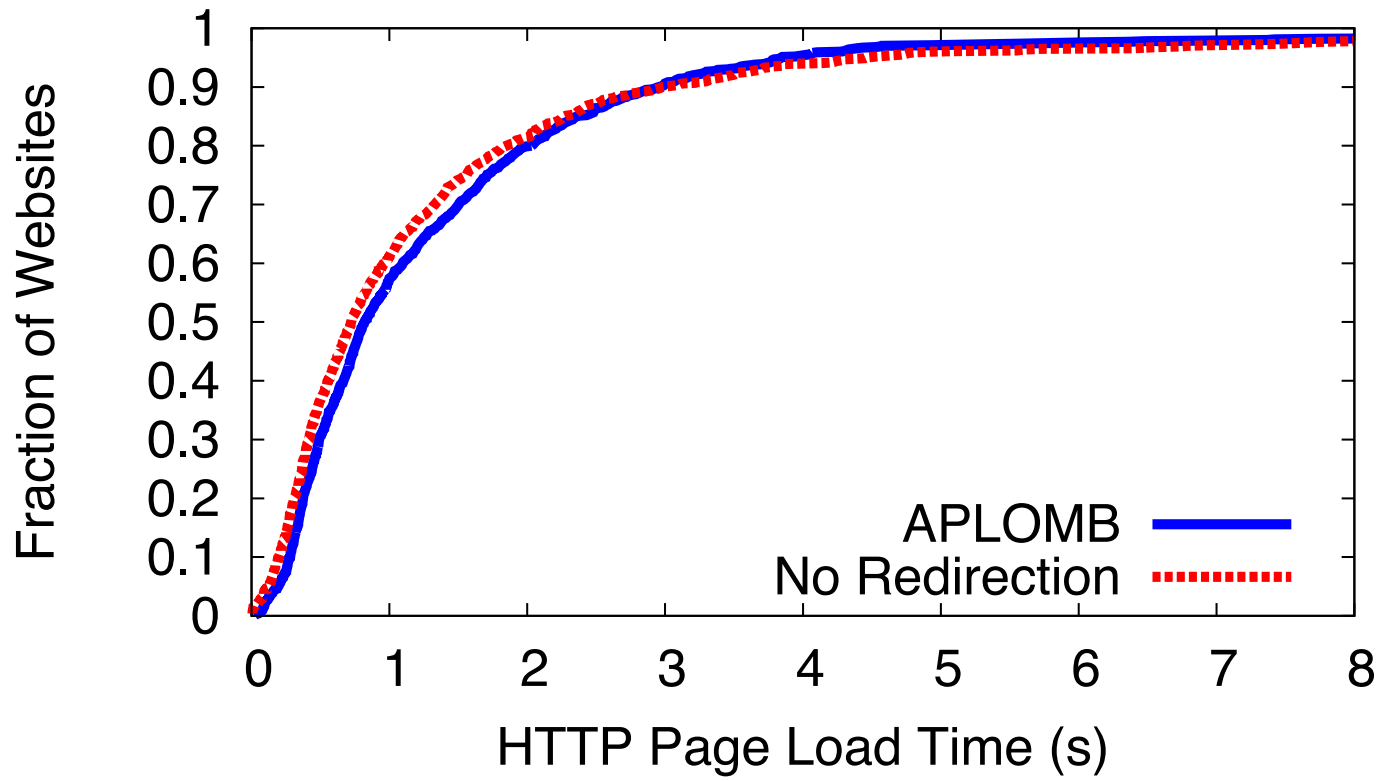

Figure 12: CDF of HTTP Page Load times for Alexa top 1,000 sites with and without APLOMB.

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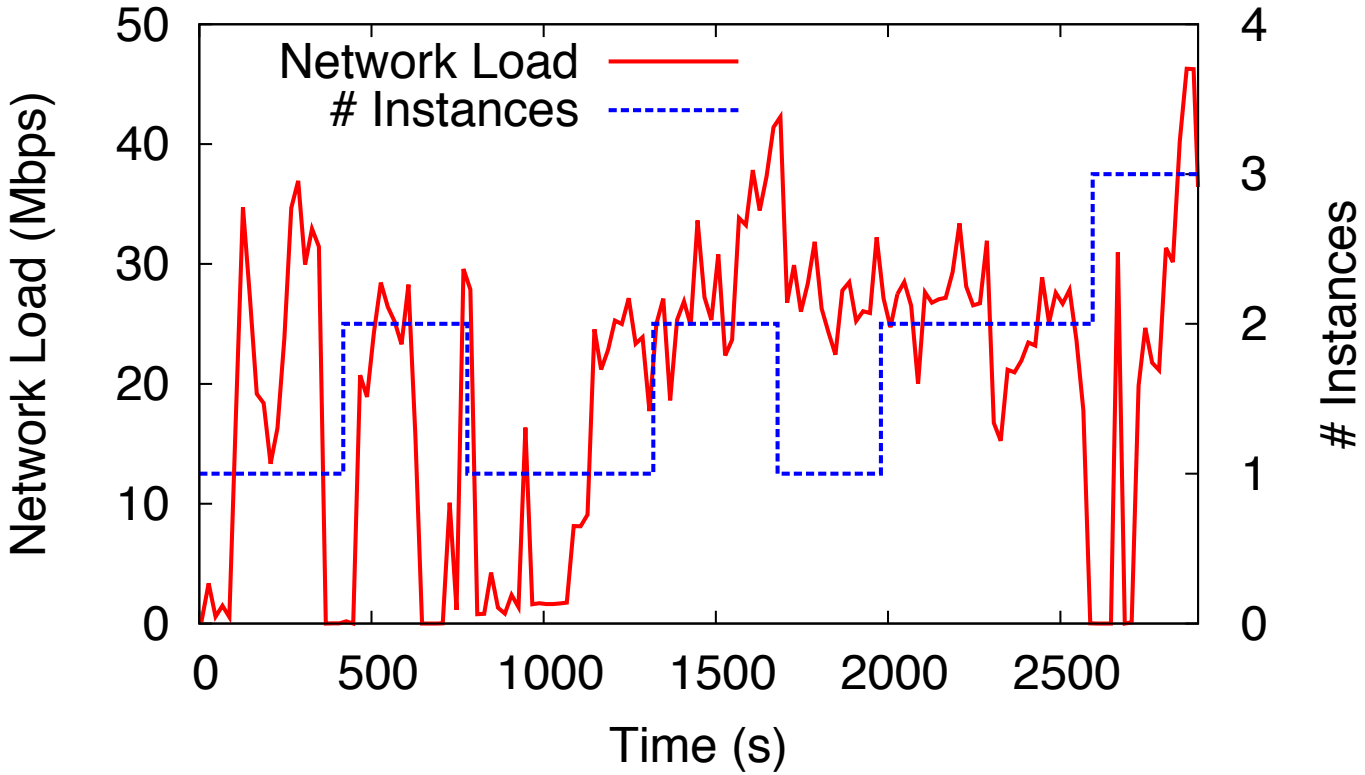

Figure 13: Network load (Y_1) and number of software middlebox instances (Y_2) under load. Experiment used low-capacity instances to highlight scaling dynamics.

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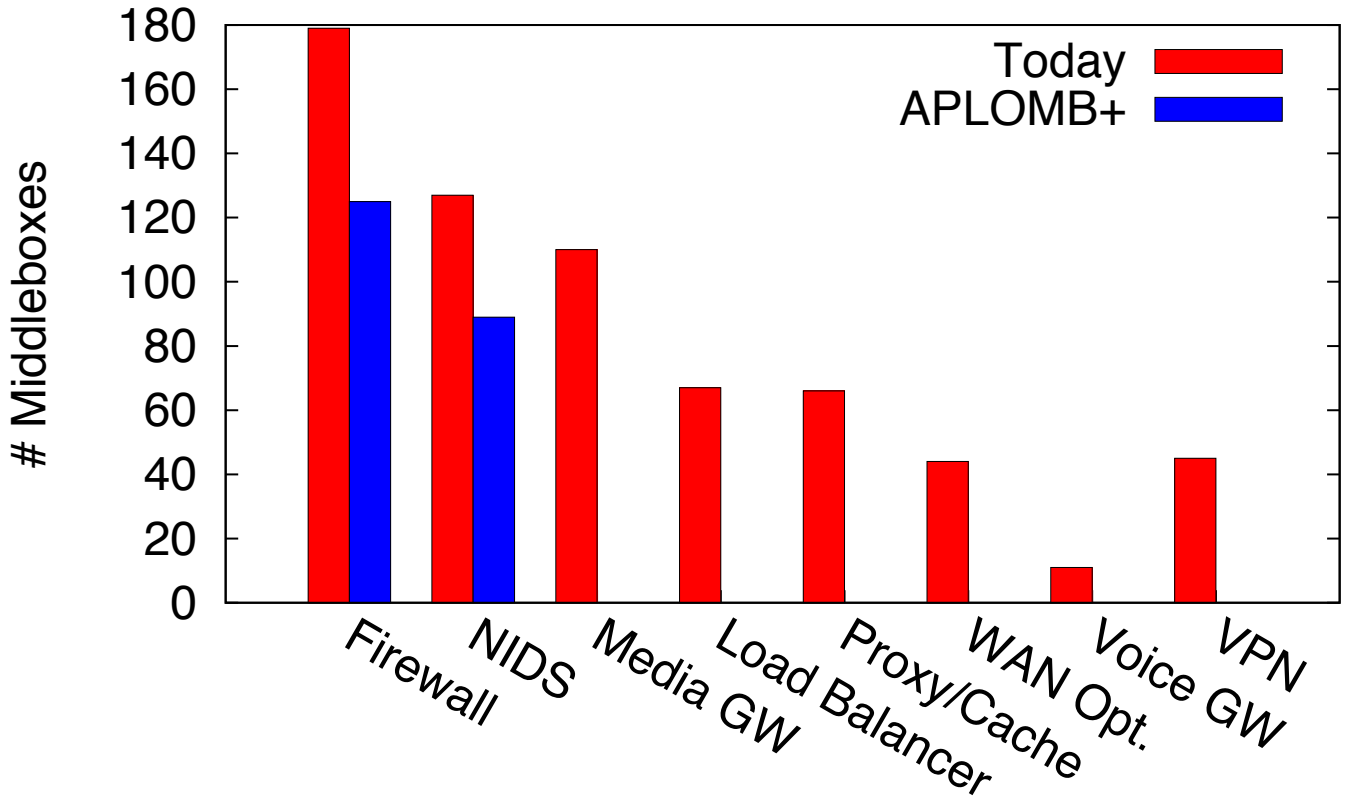

Figure 14: Number of middleboxes in the enterprise with and without APLOMB+. The enterprise has an atypical number of 'internal' firewalls and NIDS.

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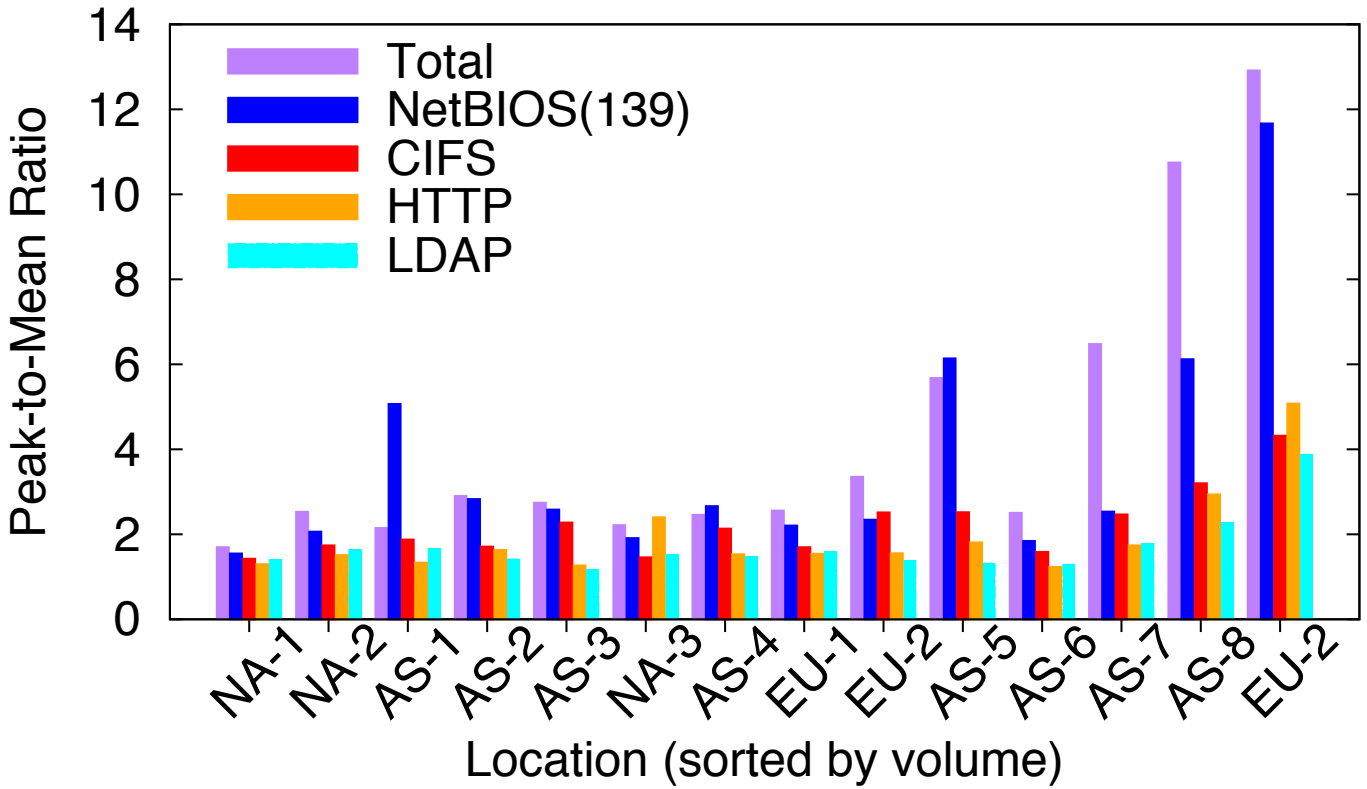

Figure 15: Ratio of peak traffic volume to average traffic volume, divided by protocol.

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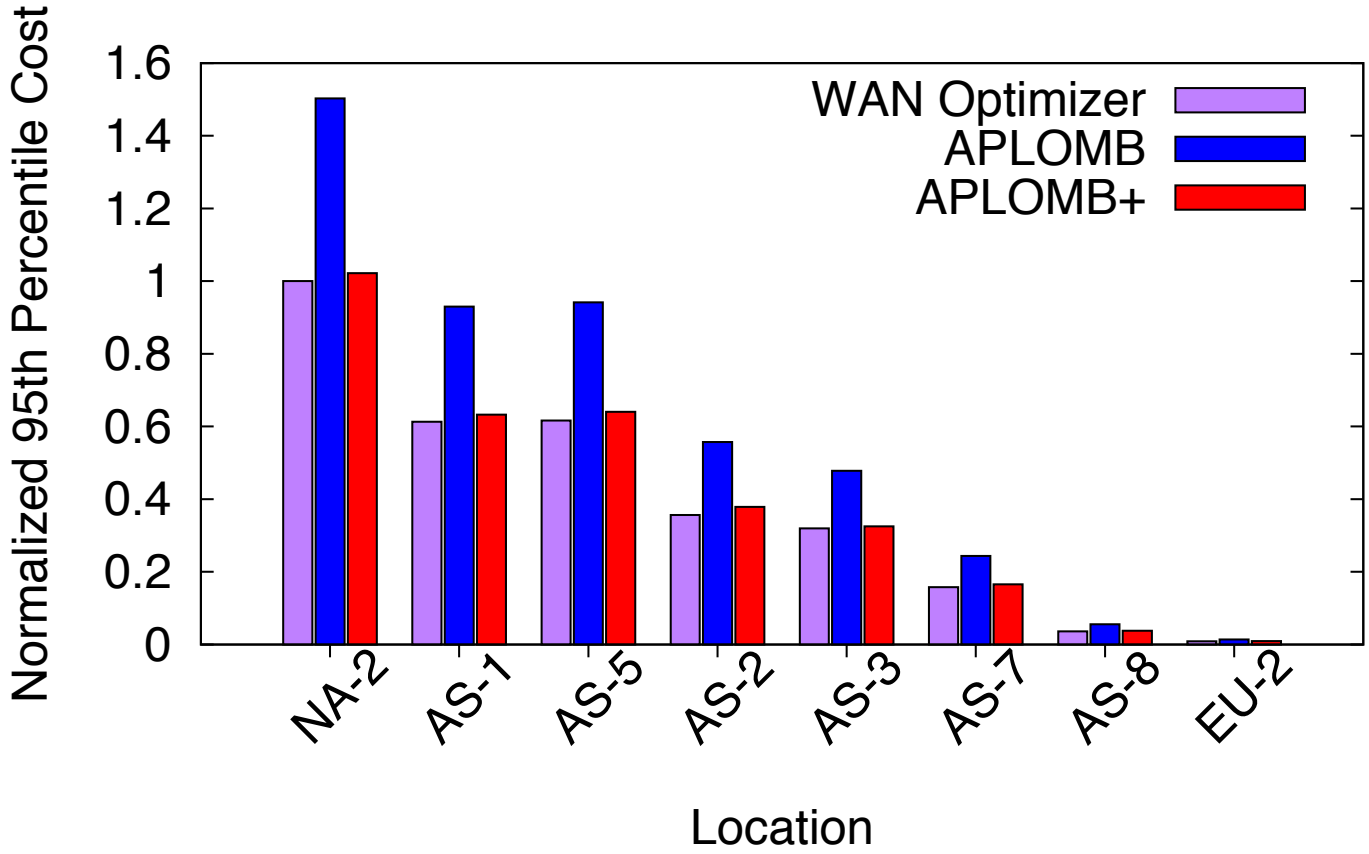

Figure 16: 95^{th} percentile bandwidth without APLOMB, with APLOMB, and with APLOMB+.

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Outsourcing Middleboxes to Cloud

Pricing Model	Total Cost	$/GB	$/Mbps
Standard EC2	30003.20	0.0586	17.58
Amazon DirectConnect	11882.50	0.0232	6.96
Wholesale Bandwidth	6826.70	0.0133	4.00

Table 3: Cost comparison of different cloud bandwidth pricing models given an enterprise with a monthly transfer volume of 500TB (an overestimate as compared to the very large enterprise in our study); assumes conversion rate of 1Mbps of sustained transfer equals 300GB over the course of a month.

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Questions?