**DataCenter Middleboxes: Enabling Commodity Packet Processing Through Operating Systems Abstractions**

Tudor Marian, Hakim Weatherspoon, Ken Birman

---

**Ubiquitous Datacenters**

Network of Globally Distributed Commodity Datacenters

- Datacenters interconnected via fiber
- Long Fat Networks (LFN) or \( \lambda \) — networks
- Middleboxes — packet processing network appliances (aka gateways)
  - Increase functionality, performance, and reliability of LFN
  - E.g. DPI, IDS, PEP, protocol accelerators, overlay routers, multimedia servers, security appliances, and network monitors, etc.

---

**Commodity Middleboxes**

High Performance Middleboxes from Commodity Components

- Cooperative or transparent to applications
- Scalable
- Tandem solution — two operational modes
- Deduplication — decreases bytes transferred over WAN
- Exploit temporal similarity of packets
- FEC — introduce proactive repair packets to mask IP packet loss
- Aggregation increases performance (lowers recovery latency)
- Split — increase amount of in-flight data by splitting TCP connection

---

**Middleboxes Providing Both Consistency and Performance**

Mirroring and the speed of light dilemma

Use network level redundancy and exposure

- Reduces probability data lost due to network failure

---

**Enterprise Continuity: Network Sync**

Network Sync increases data reliability
- Data loss can still occur
- When primary fails...
- Network partitions, mirror failure (disk, power)

- Emulab setup, FEC(r,c)=(8,3)

- High throughput
- Under high latency & loss
- Zero data loss (network sync)

---

**Featherweight Pipes (FwP)**

High Performance Middleboxes in User-space

- Streamlined communication channel
  - Fast (uncluttered) path from the NIC into user-space
  - Take advantage of multiple cores
  - Thin system call interface
  - Reduce system calls & context switches
  - Reduce copies between domains
  - Cache aware — minimize misses and cache coherency
  - Proactive resource allocation

- Emulab setup, FEC(r,c)=(8,3)

---

**Solution fit for the datacenter**

- Using commodity machines
- Fully transparent & readily deployable
- Aggregated data rates are high
- Commodity OS option — build middlebox at low level
- No proper prior mainstream user-space driver support
- As a runtime loadable kernel module / extension
- Large volumes of transient data (10 GB every 8 seconds)

---

**Fundamental issues with Middlebox Design**

- No proper prior mainstream user-space driver support