Problems in DC's and why ICCRG/TCPM should care

What’s *new* in DCs

- High-speed access links and getting to comparable speeds to the DC core
- Operators considering multipath topologies attempting to provide full bisection bandwidth
- Very low latency, between racks its in 100s of us
- Low statmux
- Moving towards scale out designs with commodity switches
- High-burst tolerance AND low latency AND high-throughput
- Need ability to assign any service to any server to prevent resource fragmentation
- Workloads can migrate often and can require preserving connectivity

Multi-tenancy: Server/Network Virtualization

- 8-32 VMs per server depending on who you ask
- Unprecedented scale that's pushing all our protocol limits (ARMD is one such example)
- Don't trust the VM
  - Even if you do trust the VM image they don't deploy algorithms that are relevant for DC's they are all designed for the Internet
- Performance isolation is super hard
  - State-of-art-capacity sharing algorithm is ….. TCP
  - TCP operates on the wrong granularity

Examples of fundamental problems

- Cost of ToRs – deep vs shallow buffers
  - Say 200k servers/20 per ToR – 10k ToRs
  - 10k * $7000 savings = $70 million
- Burst tolerance and Incast
  - Reduce MinRTO
  - DCTCP aims to change sender congestion control
  - ICTCP which is based on a receiver window
- Performance isolation using TCP?
  - Trying to solve flow fairness

Performance Isolation in DCs

SEAWALL – CONGESTION CONTROLLED TUNNELS

What Do We Want To Achieve?

- Protect tenants from availability attacks
  – Internal DoS can wreak havoc
- Enforce tenant-specific quota
  – Customers purchase their weights, or admins can assign customers' weights
- Reduce network-performance interference among tenants
  – Elimination is more difficult

What Properties Do We Want?

- Traffic agnostic, lean service interface
  - Customers should be allowed to use any protocol, generate any traffic patterns
  - Have customers choose their network weights *only*
- Scalable
  - Support O(10^5) VMs, O(10^4) tenants, and O(10^3) deployment events per day
- Work-conserving (efficient)
  - Allow tenants to use residual capacity
  - Max-min fairness
- Require no change to network topology and devices
  - Avoid relying on mechanisms that require VM cooperation or special features in network devices

Why Existing Solutions Fall Short?

- TCP
  - Wrong granularity
  - Can’t enforce quota
  - Doesn’t meet customers’ needs for UDP
  - Cannot trust TCP traffic from VMs anyway
- Link-local QoS (queueing and rate limiting)
  - Not scalable, can be wasteful, and expensive
- Bandwidth reservation (RSVP, MPLS TE)
  - Overly conservative at low loads, or overly lenient at high loads
  - Enforce isolation even when congestion doesn’t exist

Why Existing Solutions Fall Short?

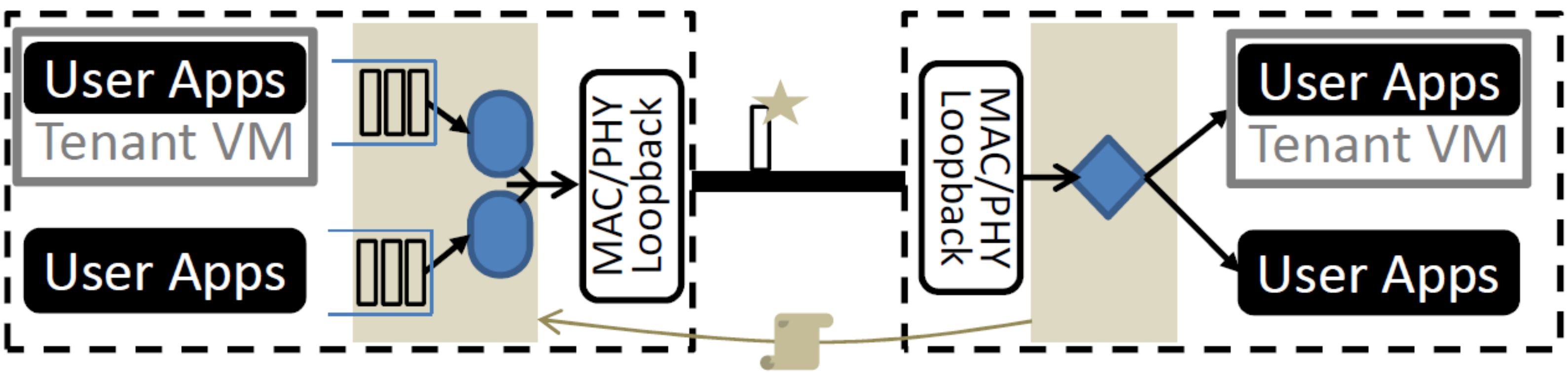
- VL2 (Oversubscription-free network)
  - Hose-model incompliant traffic (UDP) will happen
  - Can’t enforce quota
- DCTCP (Less-bursty TCP)
  - Avoids performance interference among different types of apps, but not among different tenants
  - Can’t enforce quota
- QCN (IEEE’s L2 congestion control)
  - Limited to a single L2 domain
  - Wrong granularity
  - Can’t enforce quota
  - Introduces network-device changes

Very Basic Seawall

- Use congestion-controlled edge-to-edge tunnels
  - All 5-tuple flows between a pair of sending entities (e.g., VMs) are bundled
  - Receiver periodically sends feedback to sender, notifying congestion (if any)
- Upon congestion, weight-proportionally rate limit tunnels
  - Each sending entity is given a weight
  - Guarantee bandwidth proportional to this weight at every bottleneck link that the entity uses
  - Weighted AIMD (additive-increase, multiplicative decrease)

Birds' Eye View

- Seawall introduces a shim layer to intercept packets



@sender: Adaptive rate throttles @receiver: Collect, send feedback

0 <------------- octets -------------> 4

Seawall Sndr. Shim Id	
Seawall Rcvr. Shim Id	
Traffic Sender Id	
Last Sequence Num. Rcvd.	
Bytes Received	
% bytes dropped	% bytes marked

Combining Feedback From Multiple Destinations

.**Begin**(weight W)
  { rc_l.Begin(W) $\forall$ links l used by sender } $\triangleright$ Initialize
.**TakeFeedback**(feedback f_{dest})
  { store feedback }
.**Periodically**()
{
proportion of traffic to d, $p_d = \frac{f_d.bytesRcvd}{\sum f_i.bytesRcvd}$
for all destinations d **do**
  for all links l on path to d **do**
    rc_l.TakeFeedback(f_d, p_d)
  end for
end for
$n_l \leftarrow$ count of dest with paths through link l
allowed rate to d, $r_d \leftarrow \min_l \left(\left(\beta p_d + \frac{1-\beta}{n_l} \right) rc_l.rate \right)$ $\forall$ links l in path to d
}

Why should IETF/IRTF care?

- These are real problems
  - Lots of innovative work happening so they will get solved one way or the other
- Design teams aren’t sufficient we need to understand the landscape better and experiment
- Hypervisor as a middlebox is clearly not ideal and wont scale
- Treat the DC problems as ***mainstream*** because SR-IOV will force these solutions into the OS
  - OR ISPs may move towards DC designs and ask for these
- Either way they will trickle to the Internet