iCAN (instant Congestion Assessment Network) for Data Plane Traffic Engineering

(*draft-liu-ican-00*)

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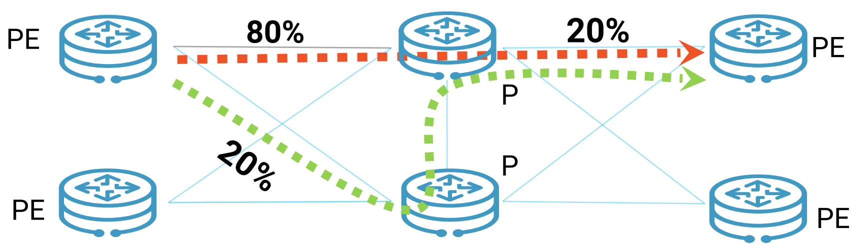
Contents

- Targeted Challenges (mostly for Metro Network)
- iCAN Architecture and Technologies
- Use Cases and Scenarios

Challenge-1: Low Network Utilization due to Unbalanced Traffic

Impacts to the operators

Unbalanced load



Low network throughput

- The average bandwidth utilization of the most operators' network is approximately 30%.

Bad user's experience

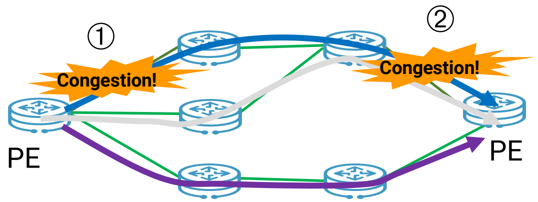
- Unnecessary congestion leads to more packet loss and more delays

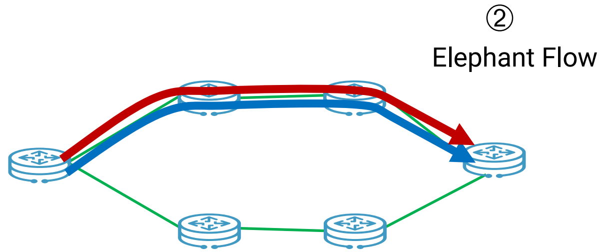
Why current technologies cannot handle it

Device-level Load Balance (e.g. ECMP)

1. Not consider congestion status of local links
2. Not consider congestion status of E2E paths

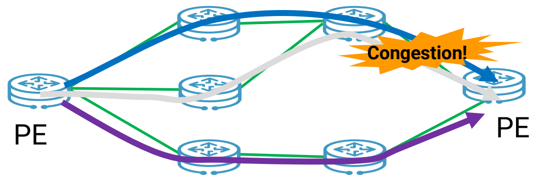
3. Not consider flow's bandwidth





Network-level Load Balance (e.g. UCMP)

Configure the sharing ratio of 3 path to be 1:3:5.

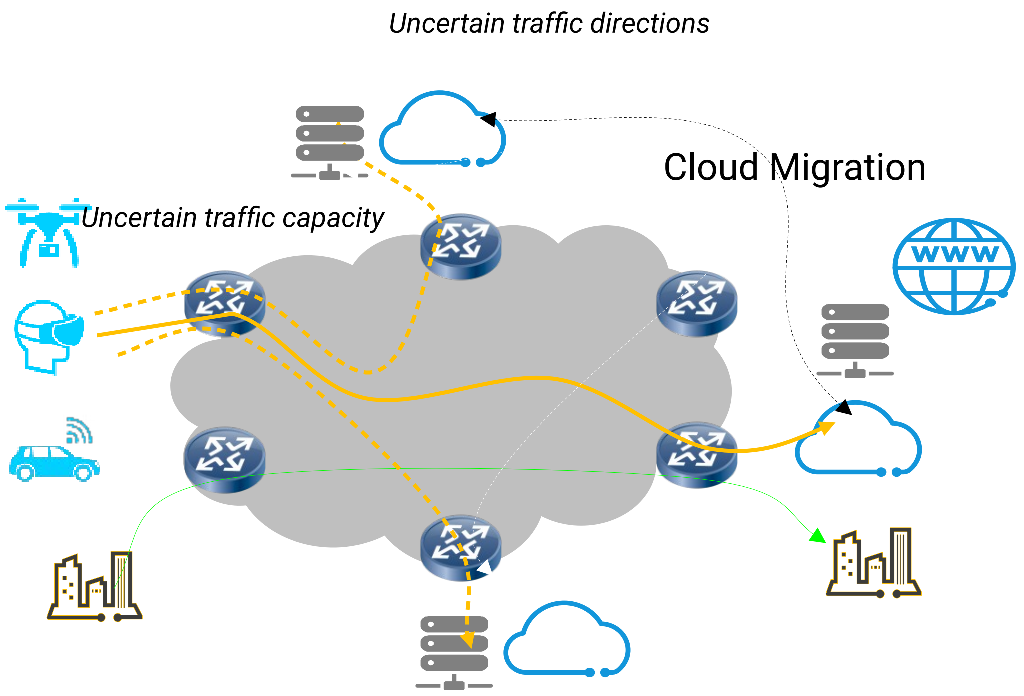


The actual execution result of the device is not 1:3:5.

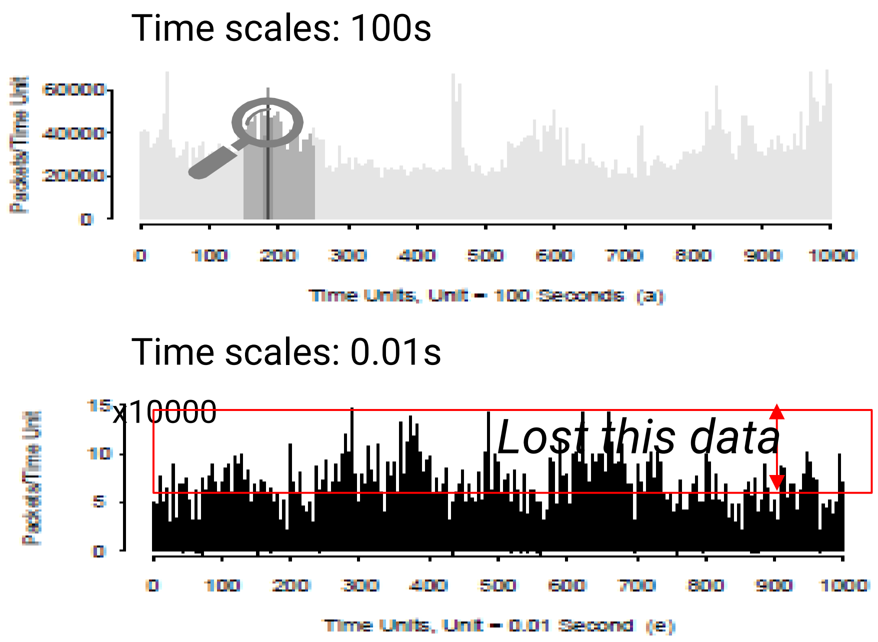
Lack of data plane mechanisms to ensure the real sharing ratio between multiple paths

Challenge-2: traditional traffic planning might fail due to highly dynamic change

Traffic changes are becoming unpredictable



Traditional techniques is unable to detect microburst traffic



https://www.google.com/search?q=On+the+Self-Similar+Nature+of+Ethernet+Traffic&rlz=1C1GCEU_zh-CNMY821MY821&oq=On+the+Self-Similar+Nature+of+Ethernet+Traffic&aqs=chrome..69i57.599j0j4&sourceid=chrome&ie=UTF-8

New technology is needed to adapt the traffic in real-time

Proposed Solution: iCAN (instant Congestion Assessment Network)

SDN Controller

Multi-path Calculation

Centralized: Minute-level Closed Control Loop

Distributed: Millisecond-level Closed Control Loop

Ingress Router

Key Technologies

- Path Quality Assessment
- Flow Recognition and Statistics
- Flow Path Switching

Network-level algorithms for

- Planning and delivering multiple paths to devices
- Indicate the flows that would be aggregated to the paths between a pair of Ingress/Egress nodes

Data plane algorithms for

- Measuring the congestion status of the delivered multiple paths simultaneously
- Recognizing TopN large flows passing through a path

And finally

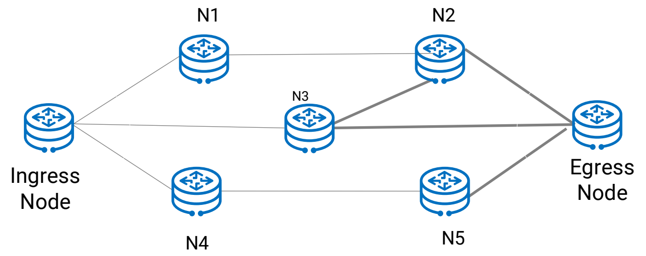
- Autonomic adjustment of (most largest) flows' paths to adapt the traffic changes

Egress Router

Key Technologies

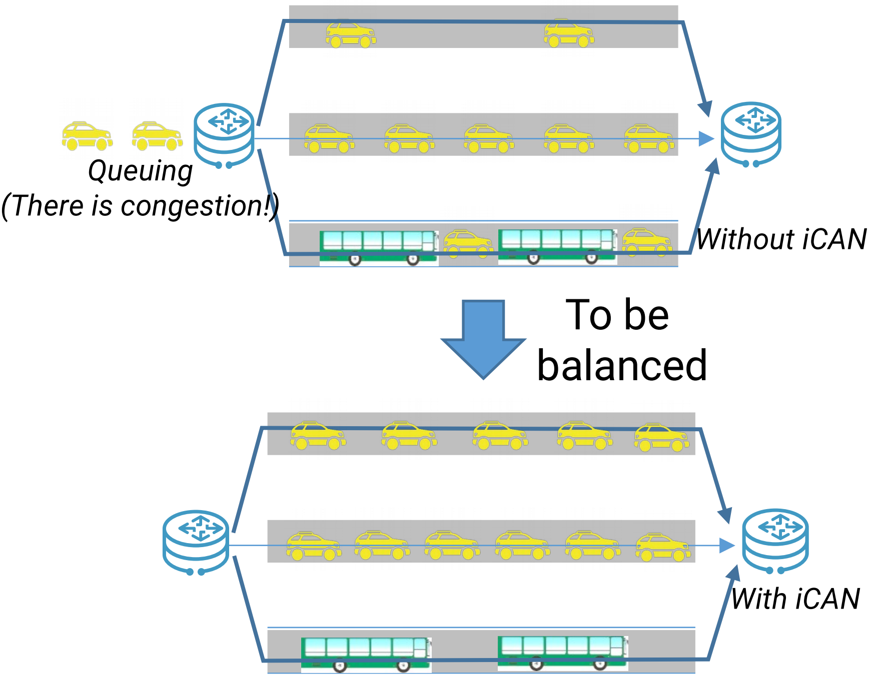
- Path Quality Assessment
- Flow count for each path

Intermediate Node do not need to support iCAN.



Use Cases of iCAN

UC-1: Network Load Balancing (for real!)

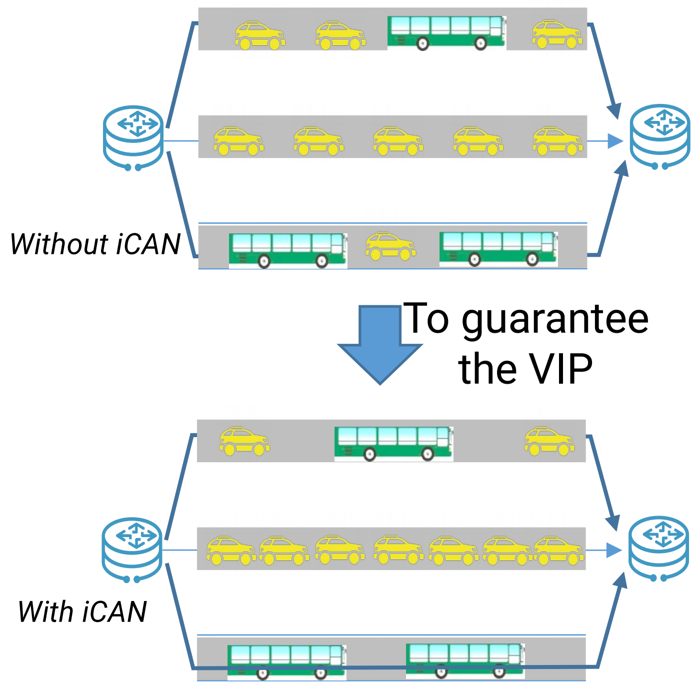


- No congestion (and probably no packet loss)
- Higher network throughput

✓ **For load balancing use case, we've developed a commercial hardware router based prototype, using SRv6 as the data plane.**

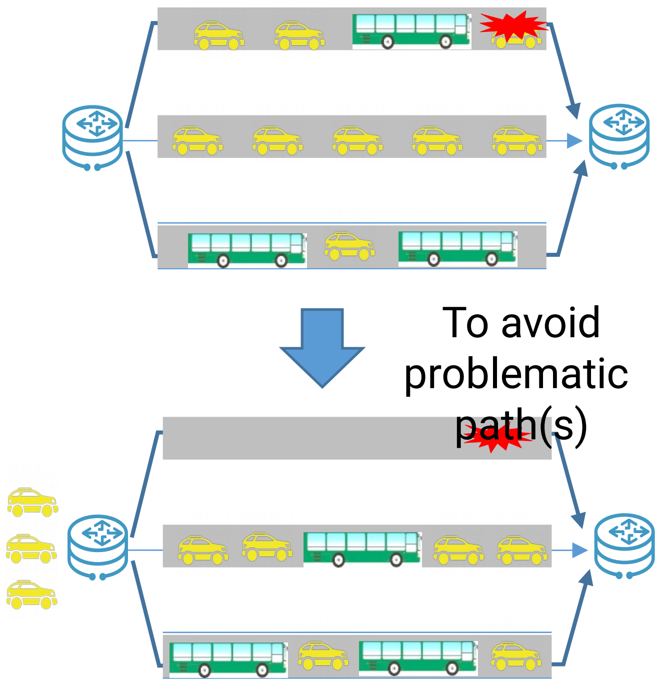
✓ **30% network throughput increment, according to the test in our lab.**

UC-2: SLA Assurance



- No potential SLA deterioration of high-priority services

UC-3: High Availability

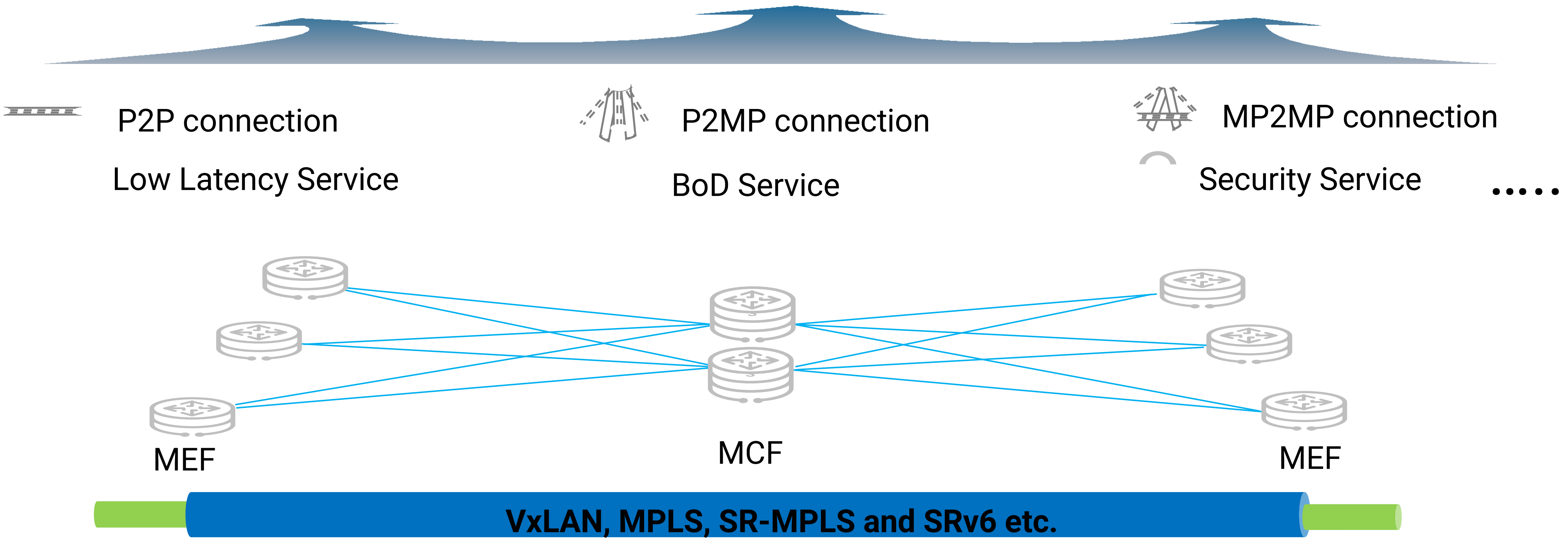


iCAN naturally supports BFD-alike functions, and can even do better:

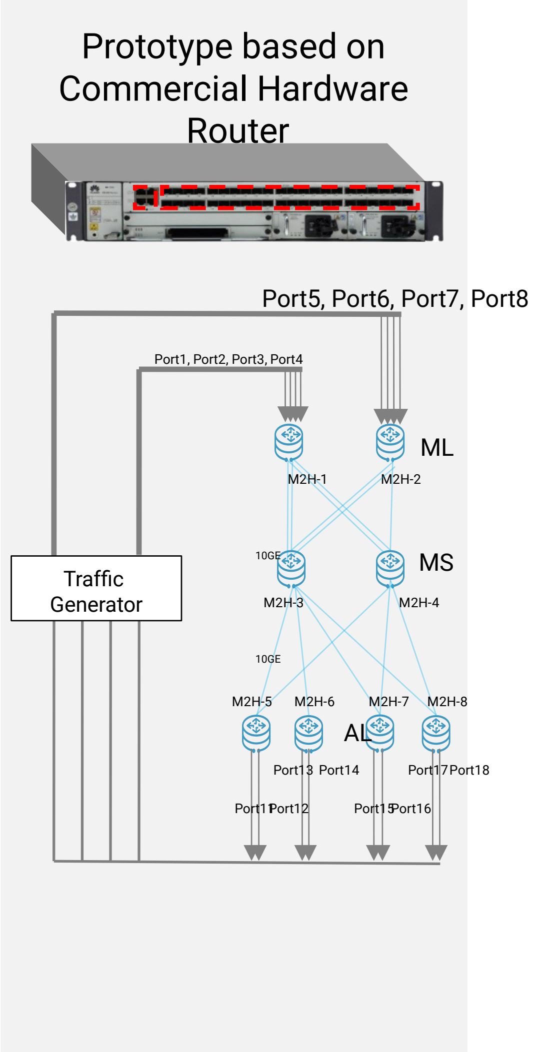
- No need for complex configurations
- Faster link failure detection
- Not only detecting path on/off, but also path quality deterioration
- Can distinguish individual paths in multi paths

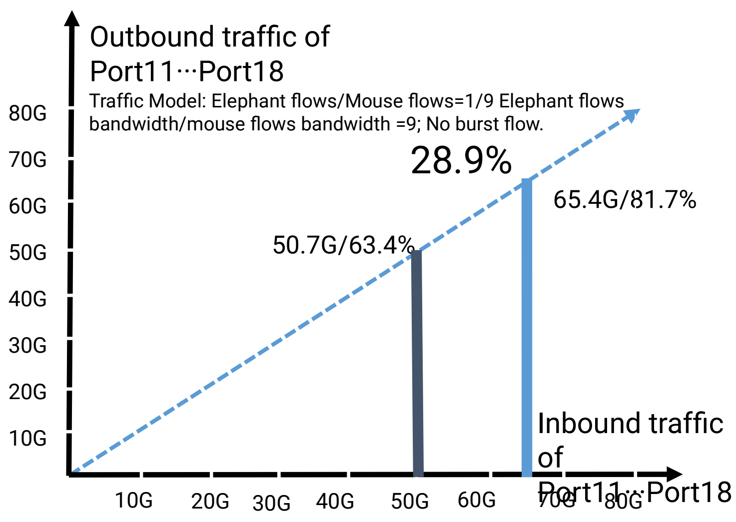
Deployment Scenarios: agnostic to underlay technologies/services

iCAN supports VxLAN, MPLS, SR-MPLS and SRv6 etc.

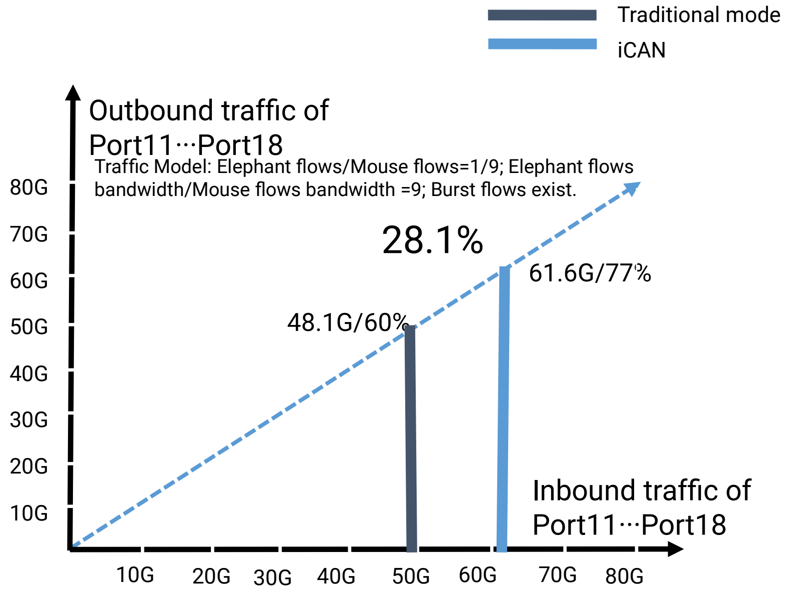


Test Result: Network throughput is increased by around 30%





Network without sudden bursts



Network with bursts

- Physical capacity of the test bed is 80Gbps
- Without iCAN, it started to drop packets at 48-50Gbps
- With iCAN, it started to drop packets at 61-65Gbps, about **30% throughput increment**
- iCAN could work effectively under both burst/non-burst situations

Comments are appreciated very much!

Thank you!

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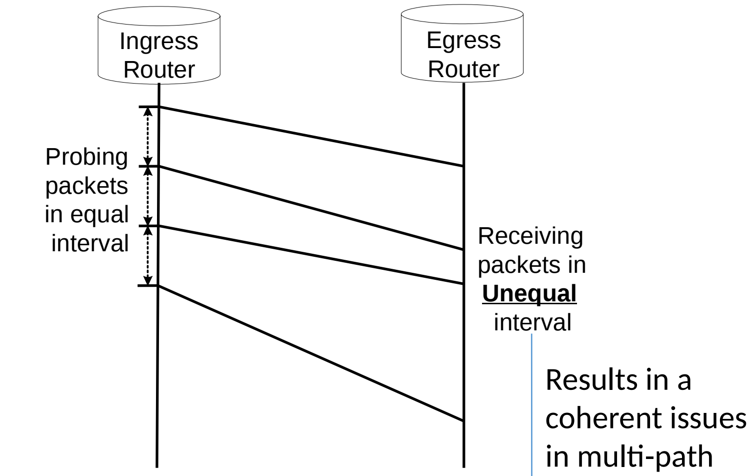
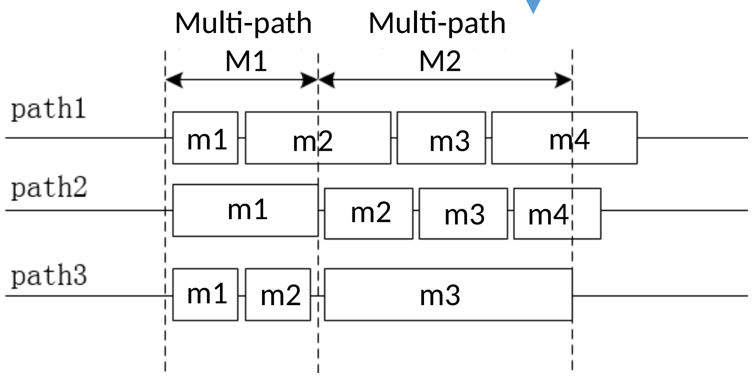
Backup Slides
for technical details of iCAN

Path Quality Assessment 1/2: *coherent multi-path measurement*

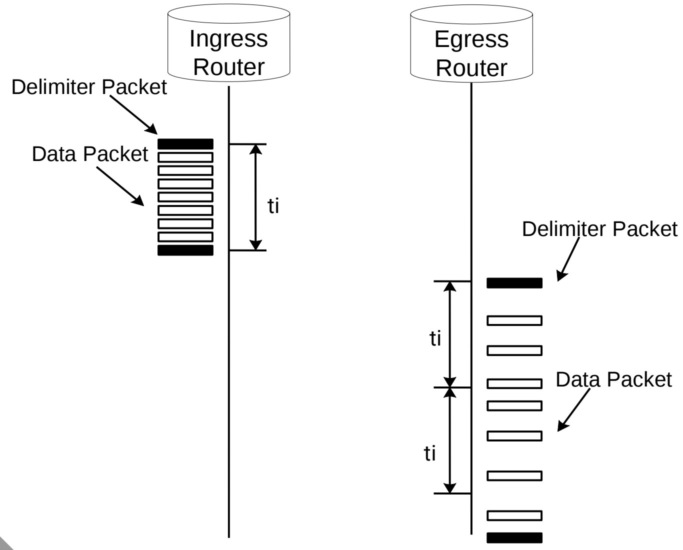
Problem



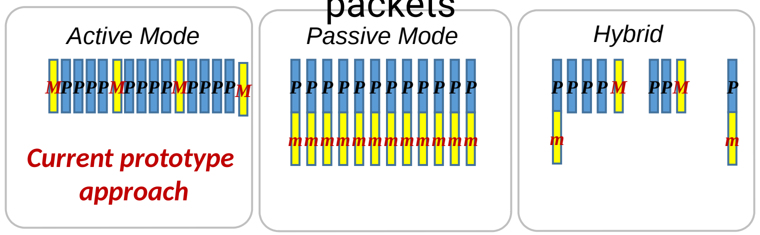


- On each path, the egress router would feedback the measurement results (m1, m2…) according to its own real interval.
- The ingress router would have to wait until the last m1/m2/m3 of the latest path come back.

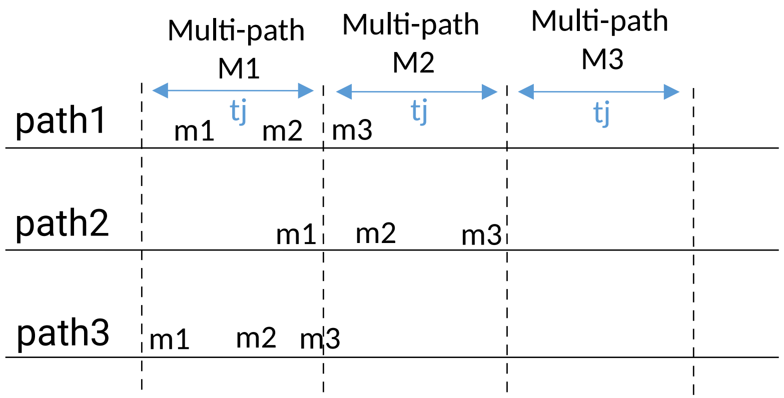
Solution



Methods of conveying delimiter packets

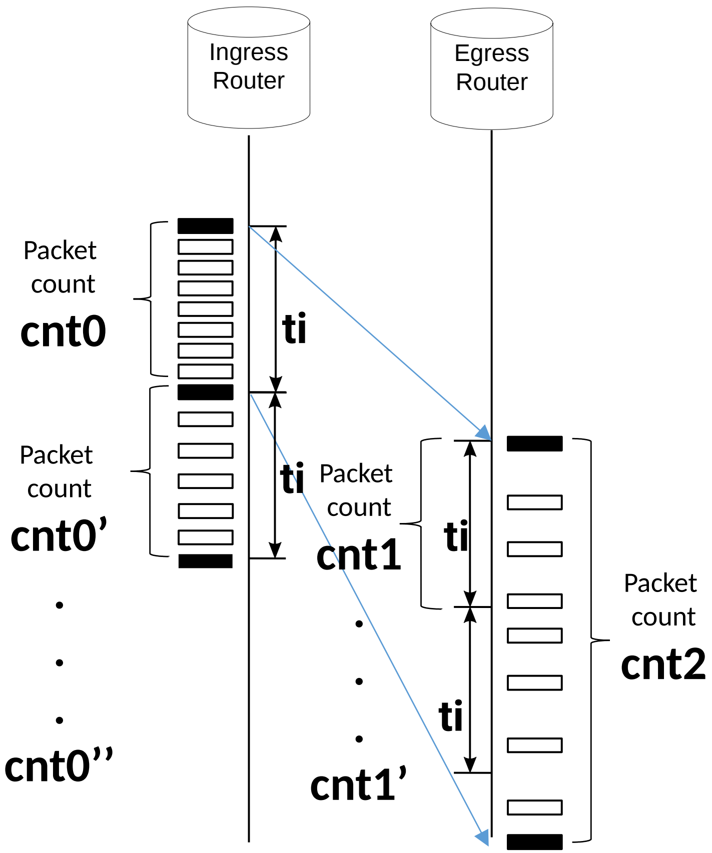


- The active probing packet acts as the delimiter packet among normal data packets. (In current prototype, the probing packet would be sent every 3.3ms, e.g. ti=3.3ms)
- Regardless of the shifting of the probing packets, the egress router would return the measurement result to the ingress router every ti internal.



- The ingress router would assess each path's congestion status every tj interval (In current prototype, tj=10ms)
- Tj should be larger enough than ti, so that every tj interval, the ingress would get at least one measurement result of each path.

Path Quality Assessment 2/2: *Path congestion calculation*



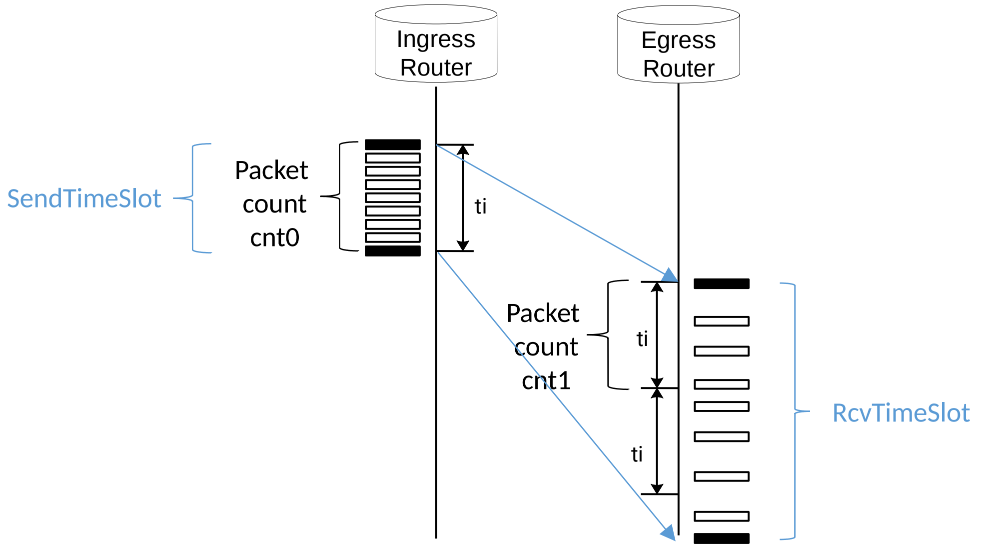
The Egress router read the cnt1 every ti interval, and send the result to the ingress; the Ingress gathers the results, and do calculation in everty ti*N interval. (e.g., ti=3.3ms, N=3)

- **TxRate** = (cnt0+cnt0’+cnt0’’…) / ti*N
- **RxRate** = (cnt1+cnt1’+cnt1’’…) / ti*N

PathCongestion = **RxRate** / **TxRate**

- The smallest one is the “worst” path; while the biggest one is the “best” path.
- If cnt<cnt0, it means there is packet loss happening, then the PathCongestion needs to be adjusted.

Flow path switching 1/2: basic method



$$\text{AftrSwitch\_PathCon} = \frac{(cnt1+cnt1'+cnt1''\ldots+ dRx+ dTx) / (ti*N + CurPathJitter)}{(cnt0+cnt0'+cnt0''\ldots + dRx + dTx\ ) \ / (ti*N)}$$

Other parameters:

- **CurPathJitter** = RcvTimeSlot-SendTimeSlot
- **dRx**: the count of flow(s) which is(are) planned to be switched into the current path
- **dTx**: the count of flow(s) which is(are) planned to be switched out of the current path

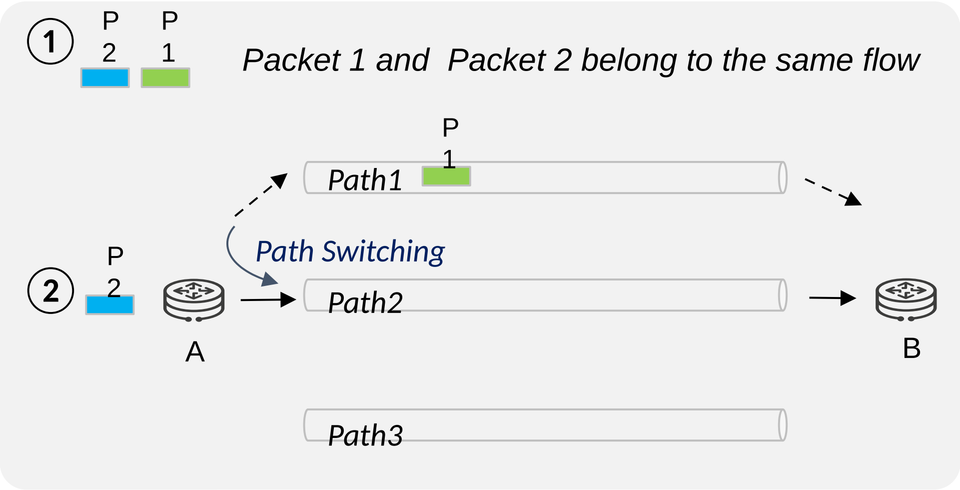
Basic Rules:

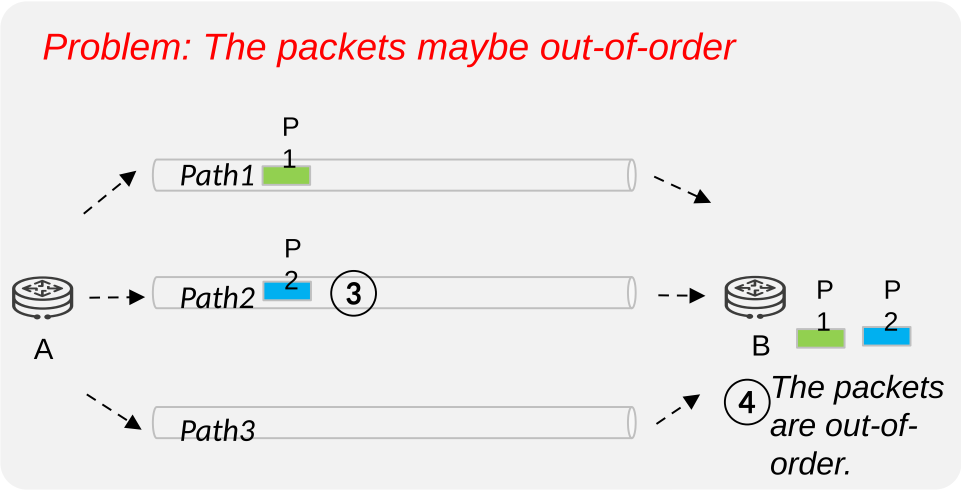
- Choose a flow in the “worst path”, and intend to switch it to the “best path”.
- Estimates the path congestion of each path, after the switching, according to the formula above. If the path congestion is more averaged than before, then the flow is considered a valid choice.
- Do the real path switch.
- Iterate above steps.

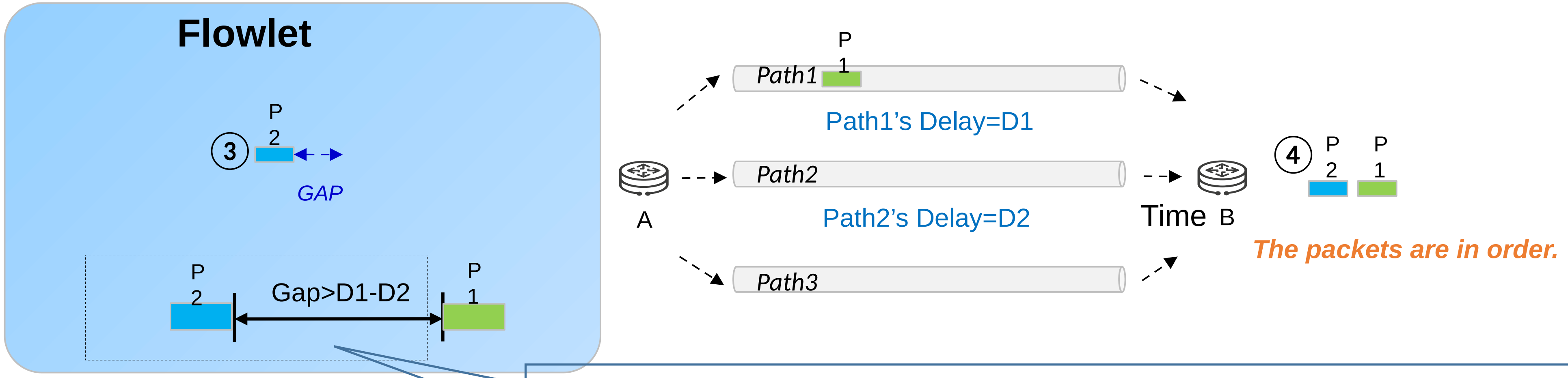
To avoid the flow switch oscillation, the flow that be switched would not be allowed to be switched again within a certain time slot (e.g. 5min).

Flow path switching 2/2 : packet order assurance

Flowlet-based Scheduling ensure no packet ordering/loss issue during path switching

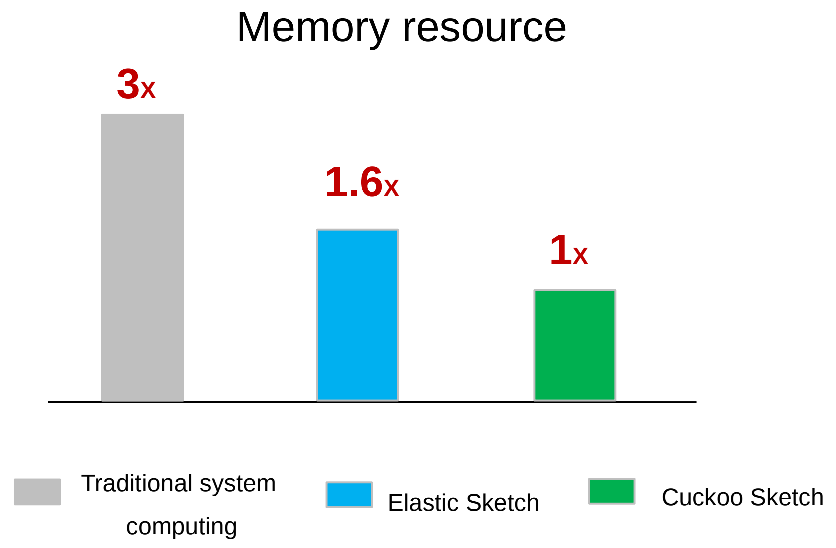






Allocating P2 a high-priority queue in the router, to avoid queuing time; and finding P2 a proper queue which has a queuing time larger than the gap time.

Flow statistics within router



The CAIDA Anonymized Internet Traces (177K streams, 2M packets, maximum stream 16K packets)		
Algorithm	**Accuracy**	**Memory resource**
Traditional system computing	100%	~1MB
Elastic Sketch (SIGCOMM 2018)	≥99%	600KB
Cuckoo Sketch	≥99%	385KB

Enhanced Cuckoo Sketch Algorithm