The bridge to possible

The New, Encrypted Protocol Stack & How to deal with it

Adding Real Value to Networks

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In memory of and based on the brilliant work of Mark Gallagher

(14/09/1966-17/09/2021)

Agenda

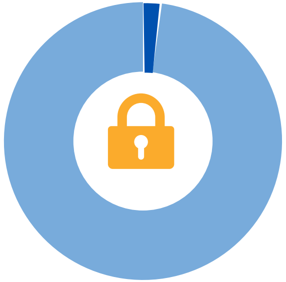
- The New Internet
- Toolbox
- Use cases

Sessio

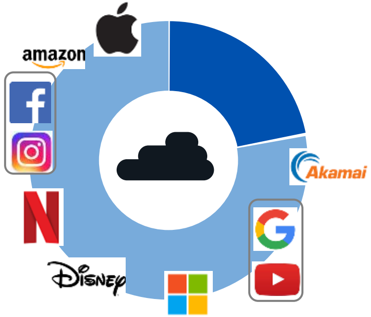
The New Internet

The Internet Reality – circa 2020 – Major US Carrier

>90% of
Volume: encrypted

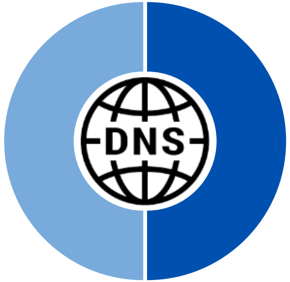


>70% of
Volume: to Cloud

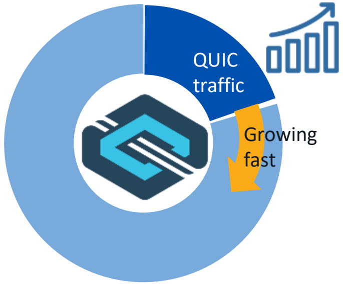


10 Cloud sites
“Elephant destinations”
not “Elephant flows”

~50% of Flows:
DNS



>20% of Traffic:
QUIC



Many small flows
Micro-sessions

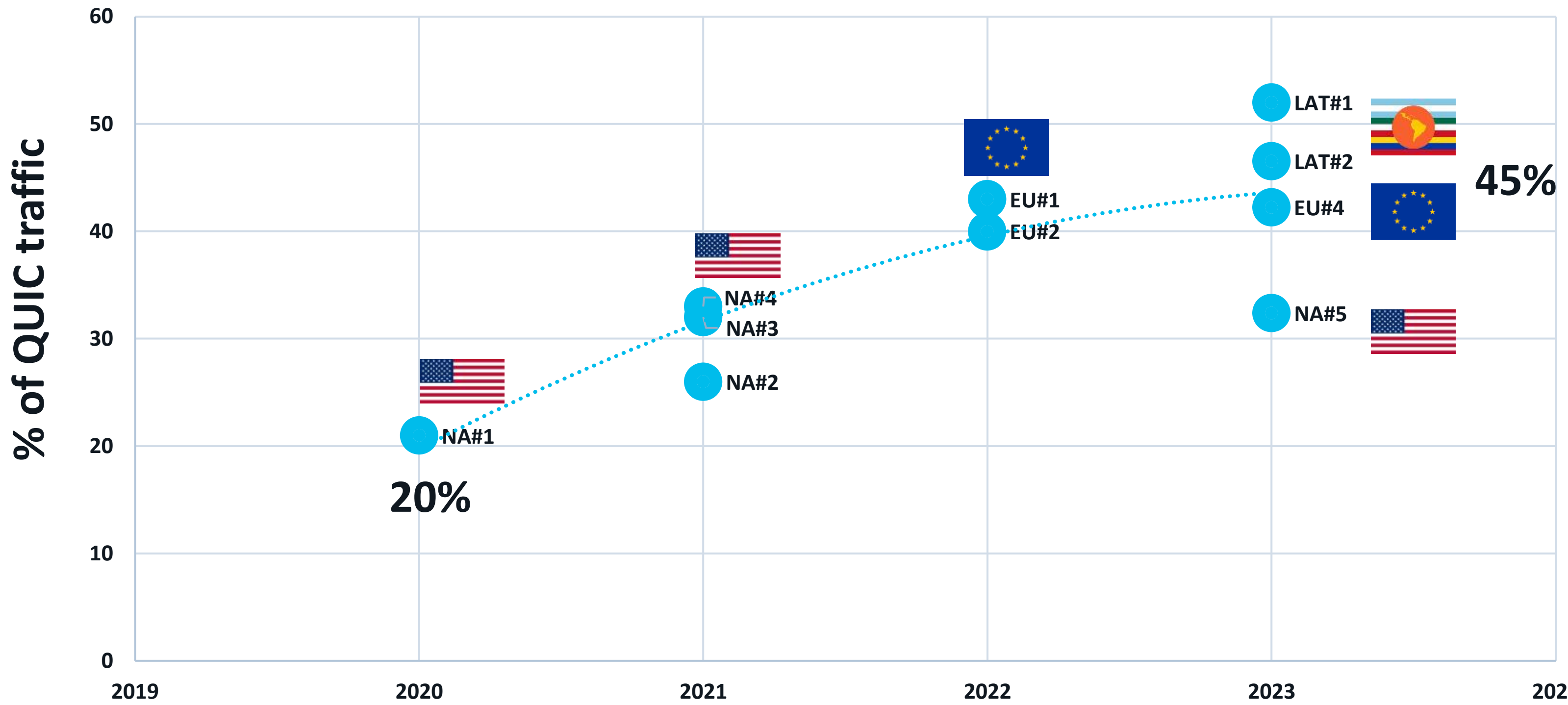
- Destination: all-encrypted world
- Cloud: concentrating the Internet

- Content: DNS is the load-balancer
- QUIC: Future Protocol of choice

QUIC is growing across the world

various snapshots

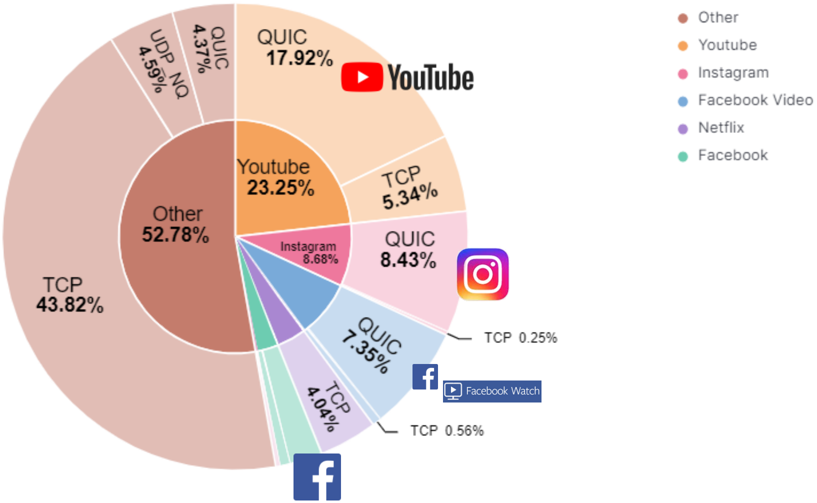
QUIC traffic evolution data 2020-2023



Network Traffic by Volume and Flows

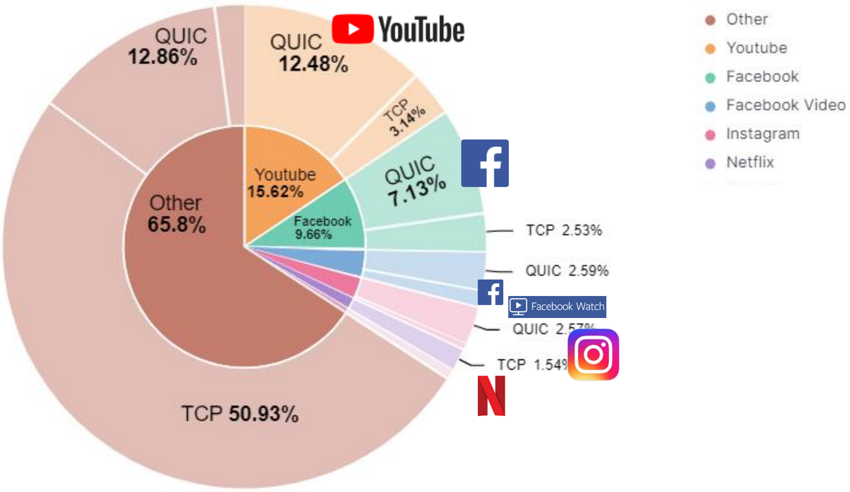
Overall Volume by Apps

Big 5 is 48% of traffic
QUIC is 40% of traffic
“other traffic” still largely TCP, QUIC now visible (4.3%).



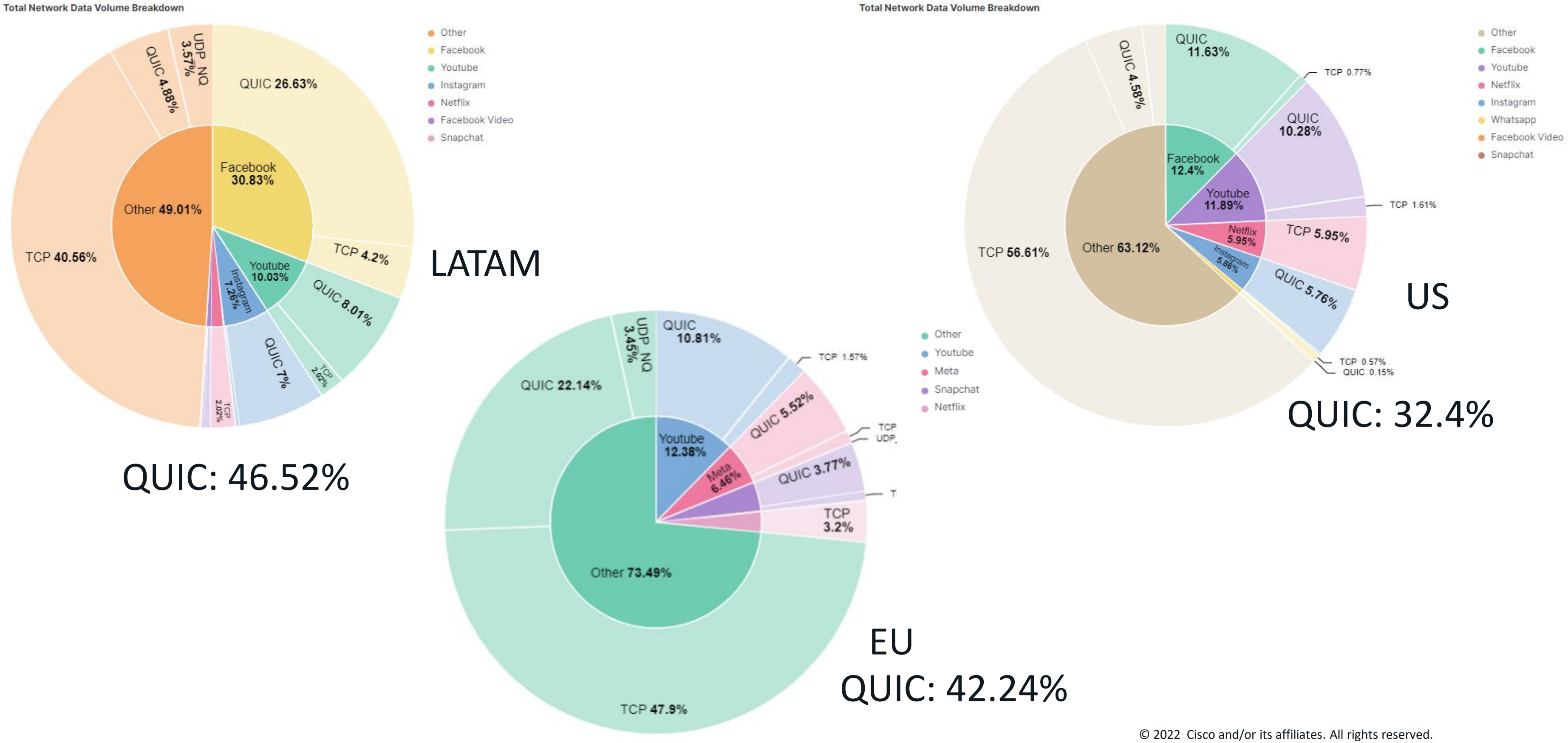
Total Flows by Apps

Lots of TCP sessions (likely IOT related, transactional related)
Big 5 QUIC sessions are very targetted and high efficiency
(video related behaviour)



*source EU Operator 2022

The pattern persists worldwide into 2023



LATAM

QUIC: 46.52%

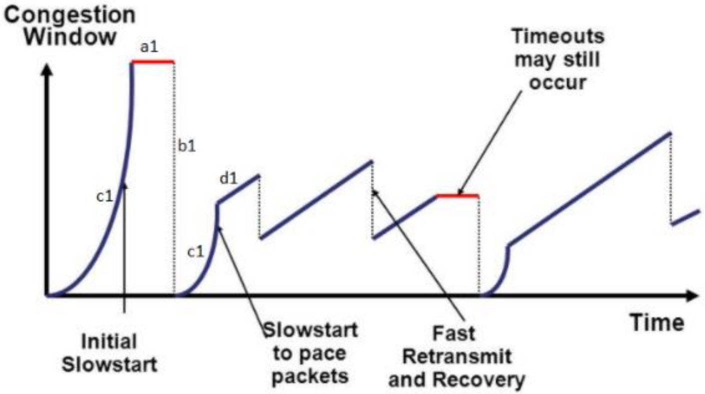
EU

QUIC: 42.24%

US

QUIC: 32.4%

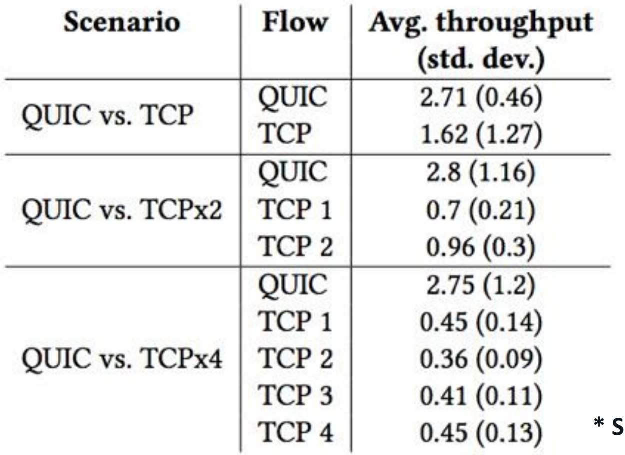
The old network design assumptions are challenged



TCP goal is network fairness

Today IP Networks are architected with TCP behaviour as implicit assumption

So when packets are dropped TCP will take care of it at a higher layer



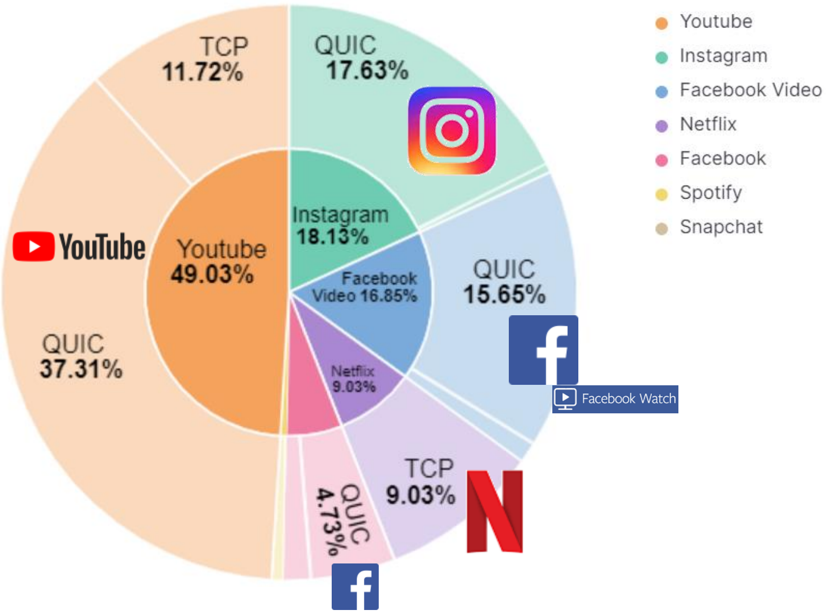
Scenario	Flow	Avg. throughput (std. dev.)
QUIC vs. TCP	QUIC	2.71 (0.46)
	TCP	1.62 (1.27)
QUIC vs. TCPx2	QUIC	2.8 (1.16)
	TCP 1	0.7 (0.21)
	TCP 2	0.96 (0.3)
QUIC vs. TCPx4	QUIC	2.75 (1.2)
	TCP 1	0.45 (0.14)
	TCP 2	0.36 (0.09)
	TCP 3	0.41 (0.11)
	TCP 4	0.45 (0.13)

* Source : APNIC

QUIC goal is “MY App” performance

Where are the IP Network Design assumptions wrt QUIC ?

Top 5 Apps – QUIC is dominant
80/20 rule now



April 10 2022

An application driven global transition

HTTP/3 Stack = UDP+QUIC+TLS

Old App Stack

- HTTP/1.1/2
- TLS
- TCP
- IP

New App Stack

QUIC – RFC 9000
HTTP/3 – RFC9114

- HTTP/3
- QUIC + TLS1.3
- UDP
- IP

- *Improved Security*
- *Multi-session*
- *Improved QoE*
- *APP friendly design*

+

DoH

DoT – RFC7858
DoH – RFC8484

Application Controlled DNS
DNS Traffic not observable

Google & CloudFlare serve 50% of global DNS requests
Both support DoH
All major OSs & Browsers support DoH
(Firefox Defaults for US to CloudFlare)

+

eSNI / ECH

RFC8744

Target Domain is opaque / unobservable

TikTok Uber

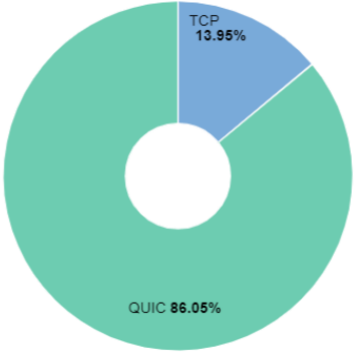
Large Scale Adoption

DPI Ineffective

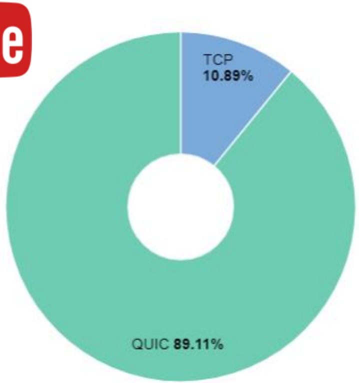
including alternative hints e.g. DNS or SNI analysis

Packet Inspection needs different approach

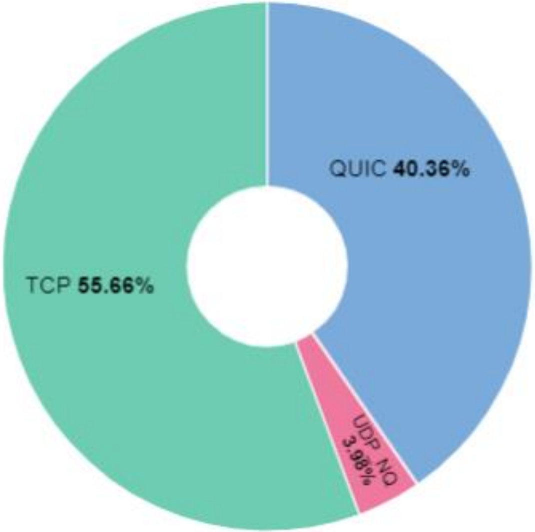
QUIC : 86%



QUIC : 90%



Overall Volume



TCP : 55%

QUIC : 40%

*source: Live Traffic USA Operator ; dd. May 2023

QUIC/H3/DoH stack is in business

fastly
CLOUDFLARE
Akamai
android
Google
Microsoft
aws
Uber
YouTube

Content Delivery Security Privacy Loadbalancing App Infrastructure App Experience

Dealing with the new reality: Toolbox & Use Cases

Customers are looking for solutions

Example Use Cases Asked

Manage video downloads vs video streaming, downloads being the priority

DPI won’t work anymore in QUIC

Recognise type of flow and act accordingly

Manage Snap video vs Snap apps

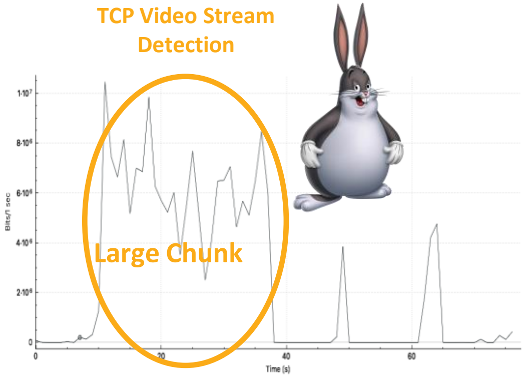
Same problem

Account for encrypted traffic in terms of source/destination

More generically: Identify and manage QUIC flows; mitigate impact on Radio; optimise against industry metrics; future-proof network smarts

App (e.g. Video) Behavior varies by protocol and use case

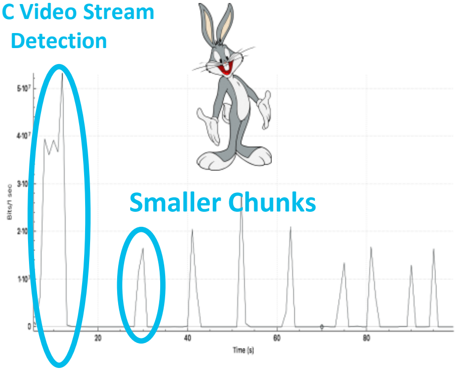
TCP Video Stream Detection



Large Chunk

TCP based ABR video players prefer **larger, sustained downloads** due to high cost of establishing the TCP session and reducing time spent in TCP slow start.
Often use HTTP/2 connection. (DASH/HLS) to fix HOL.

QUIC Video Stream Detection

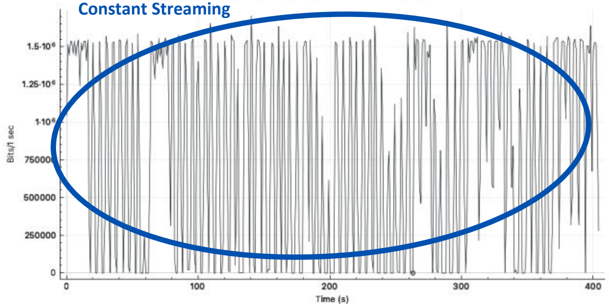


Smaller Chunks

QUIC based ABR video players prefer requesting **video in smaller chunks**.

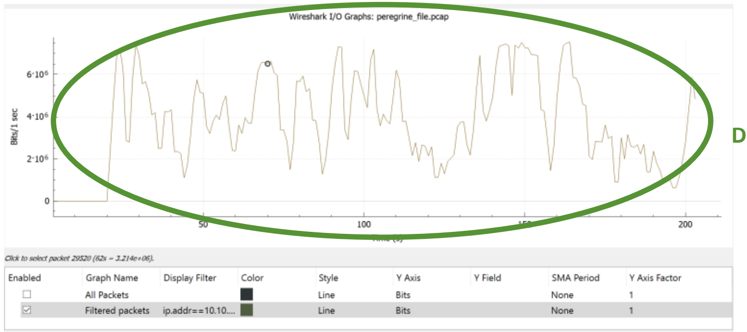
Multiple QUIC Streams in many cases to (different) servers

UDP Video Live Stream Detection



Constant Streaming

UDP based video players are extremely reliant on consistent network performance. Small buffer, sustained T'put
Applications: YouTube Live, WebEx, Microsoft Teams, Zoom



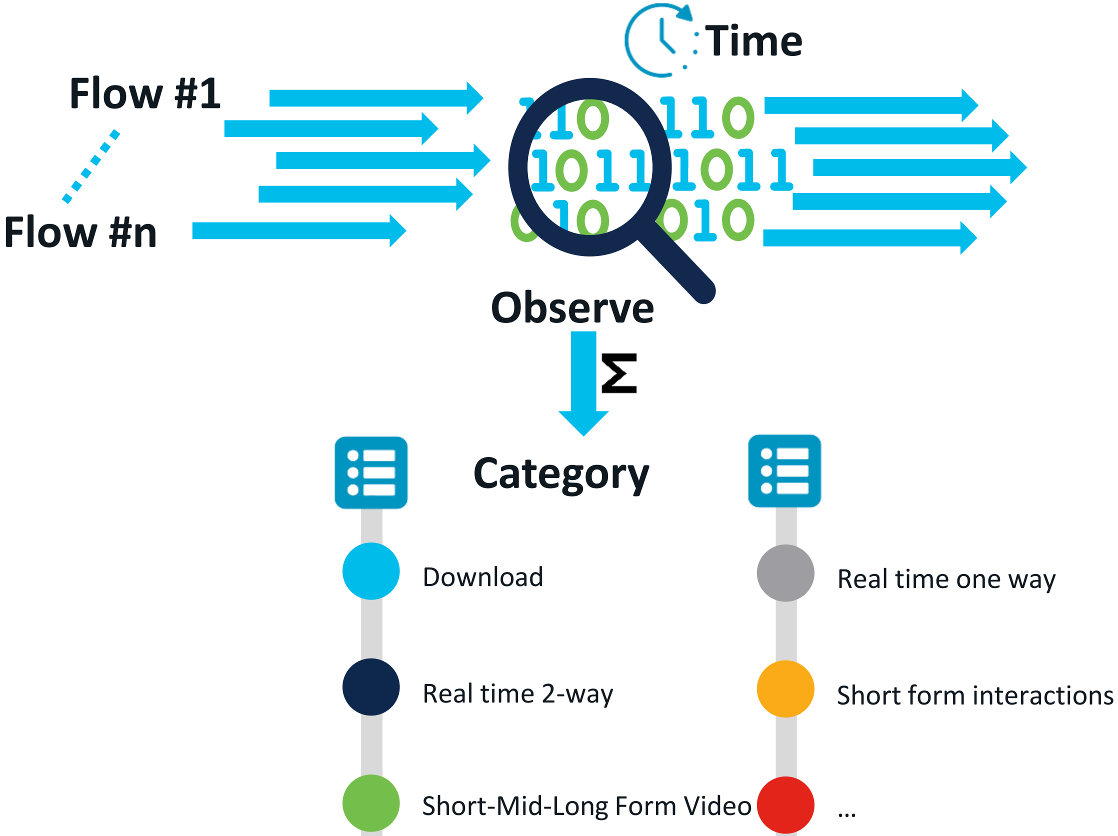
Click to select packet 29520 (62s = 3.214e+06).

Enabled	Graph Name	Display Filter	Color	Style	Y Axis	Y Field	SMA Period	Y Axis Factor
□	All Packets		■	Line	Bits		None	1
☑	Filtered packets	ip.addr==10.10....	■	Line	Bits		None	1

Download Stream Detection

Time Domain Flow recognition

- Observe all flows
- Profile per flow (Time domain matched)
- The resulting profile will allow to distinguish the nature of the flow
  - Content Download
  - (x-Form) Streaming content
  - Real time 2 way communication
  - Video/non-video
  - Short lived flows



Flow #1

Flow #n

Time

Observe

Σ

Category

● Download

● Real time 2-way

● Short-Mid-Long Form Video

● Real time one way

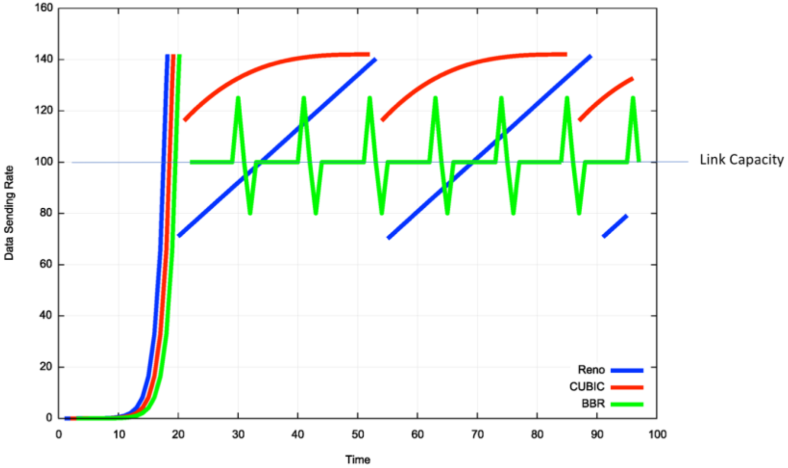
● Short form interactions

● …

Inferring congestion

- Different congestion algo’s have different behaviour
- Time-domain observation + anomaly detection -> congestion inference

Reno vs CUBIC vs BBR behaviour*

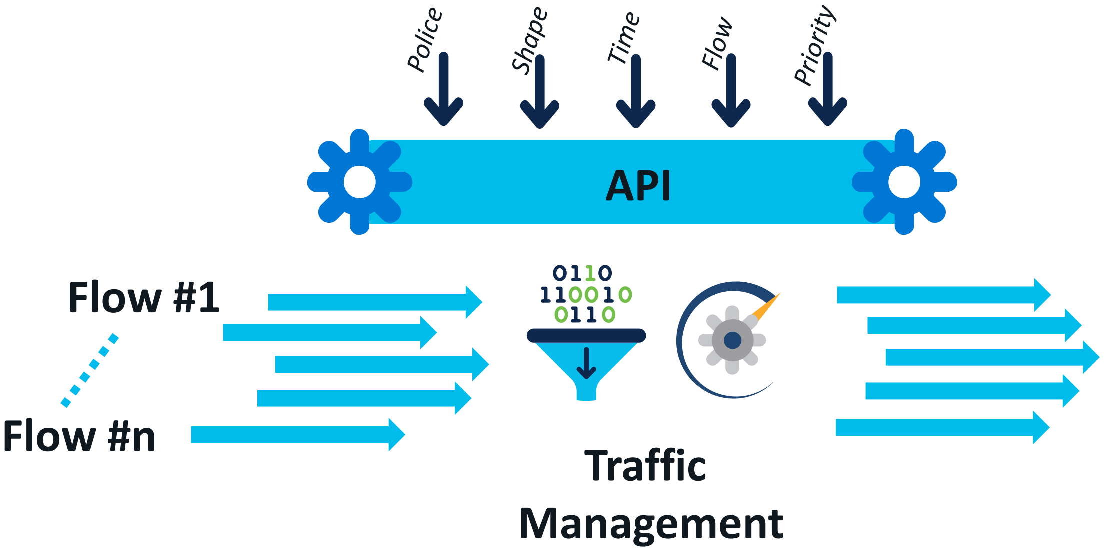


- Assessment of various flows in parallel
- Understand Protocol behaviour: congested or not
- This serves as input for Policy Application

* https://blog.apnic.net/2017/05/09/bbr-new-kid-tcp-block/

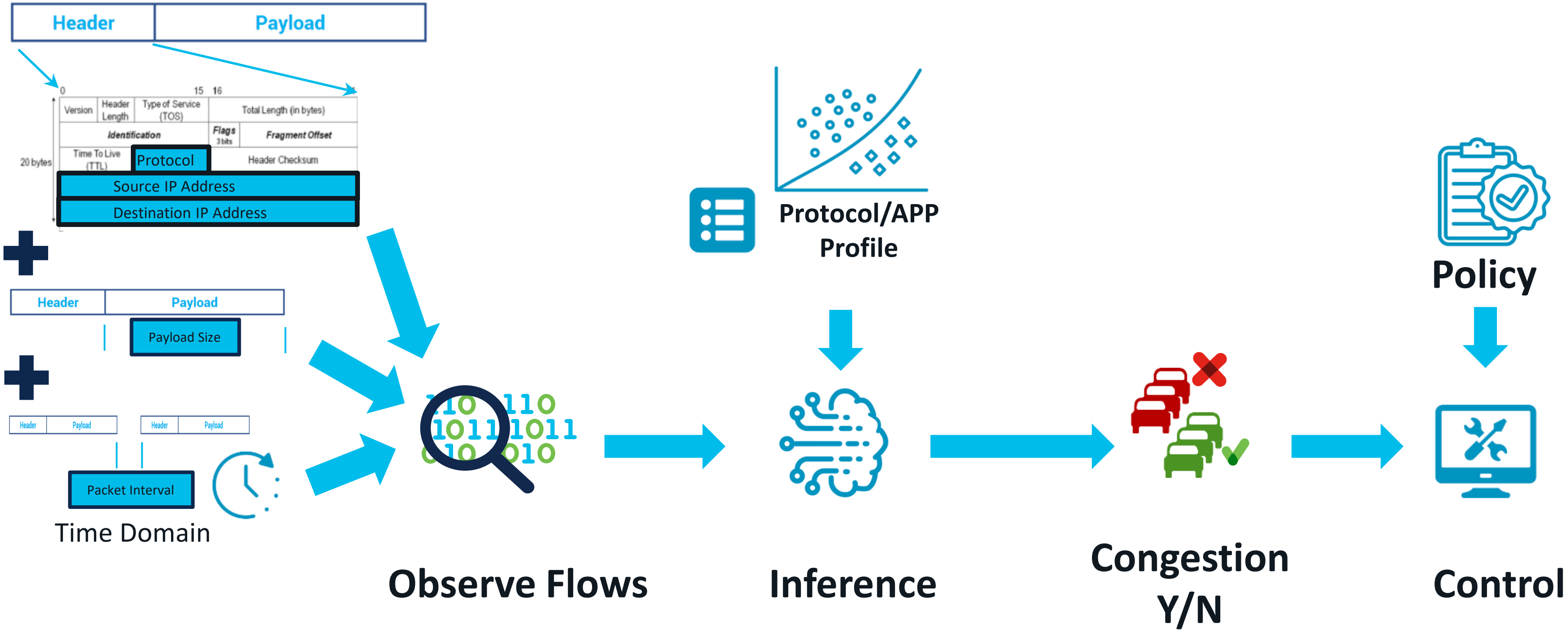
Programmable Traffic Management

- Traffic can be controlled in various ways.
  - Buffer
  - Discard
  - Flow control
  - …
- It’s also possible to pre-compile a traffic management action based on these parameters, for constant enforcement (eg. Elephant flow management)



Overall Toolbox

Basis for building use cases



Use Case : Monitoring and analytics

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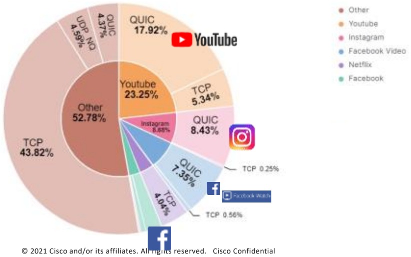

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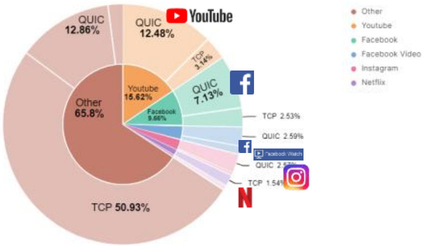
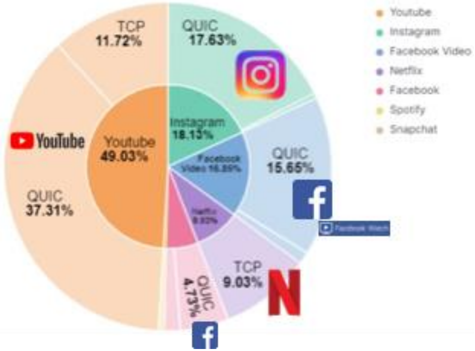
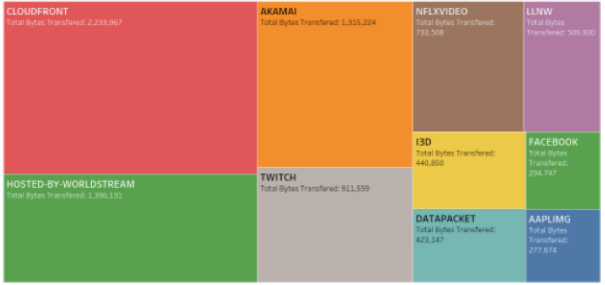


- Monitor all flows
- Infer information for Source (DNS, SNI/eSNI), CDN (ECH), Flow Type (Time domain behaviour)
- ELK (elastic Search, Logstash, Kibana) analytics engine
- Extensible to enriched CDR production



Data Volume Distribution by Hostname



CDN

Hosting

Gaming

Video Streaming

Profile aligned with Fixed Broadband traffic (browser traffic)

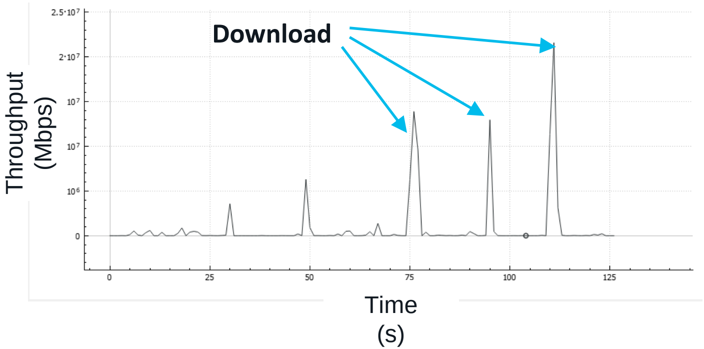
QUIC : 41%

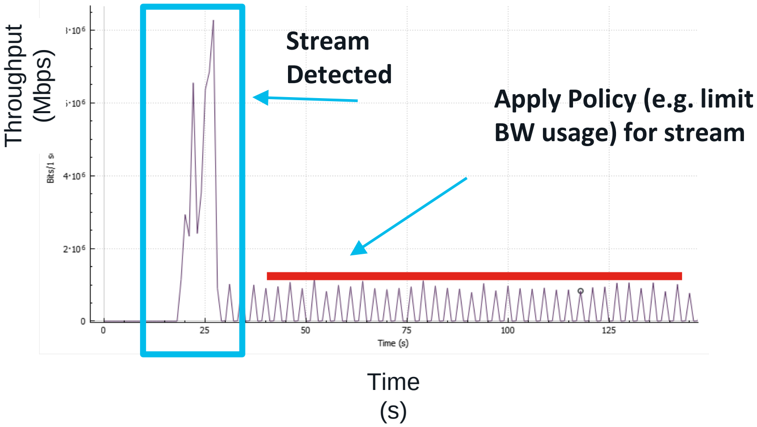
TCP: 53%

UDP (other): 6%

Custom Policy Enforcement

e.g. Differentiate between ”download” and “streaming” (within same app)


Download


Stream Detected

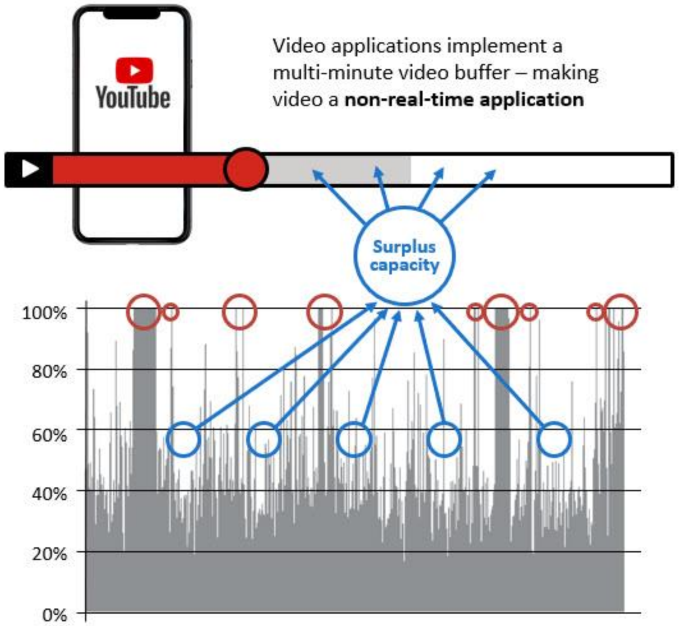
Apply Policy (e.g. limit BW usage) for stream

- Same Source/Destination Address
- Differentiate between download versus streaming *on the same SA/DA*
- ***Apply Policy per flow type, e.g.***
  - ***Download Policy: no action***
  - ***Streaming Policy: Limit to set BW profile (police/buffer/…)***

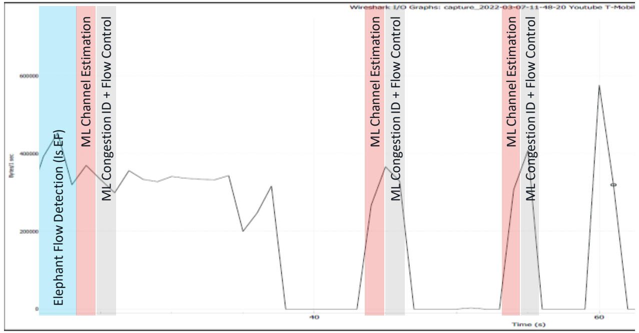
Time Domain shaping

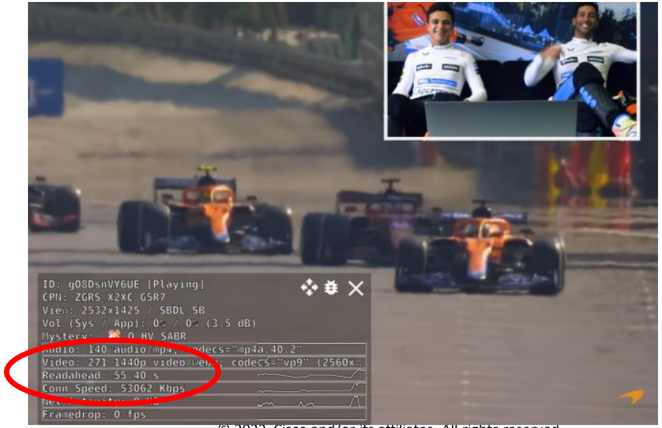
User Experience optimization under congestion

Congestion inference determines which links are congested and which flows are impacted
Elephant Flow Detection identifies which (QUIC or not) Flows can be managed.
Then Machine Learning determines if that Flow is being delivered during congestion (red circle) and require Flow Control or not (blue circle)


Video applications implement a multi-minute video buffer – making video a **non-real-time application**

60 seconds of traffic on a single 4G cell

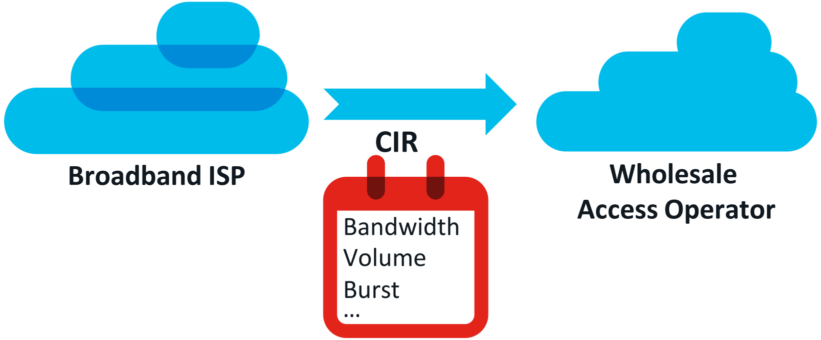



```
ID: gO8DsnVY6UE [Playing]
CPN: ZGRS X2XC G5R7
View: 2532x1425 / 5BDL 5B
Vol (Sys / App): 0% / 0% (3.5 dB)
Mystery: 0 HV SABR
Audio: 140 audio/mp4; codecs="mp4a.40.2"
Video: 271 1440p video/webm; codecs="vp9" (2560x…
Readahead: 55.40 s
Conn Speed: 53062 Kbps
Net Activity: 0 KB
Framedrop: 0 fps
```

Time domain shaping

User Experience Optimization within SLA Boundaries

Situation



Broadband ISP

CIR

Bandwidth
Volume
Burst
…

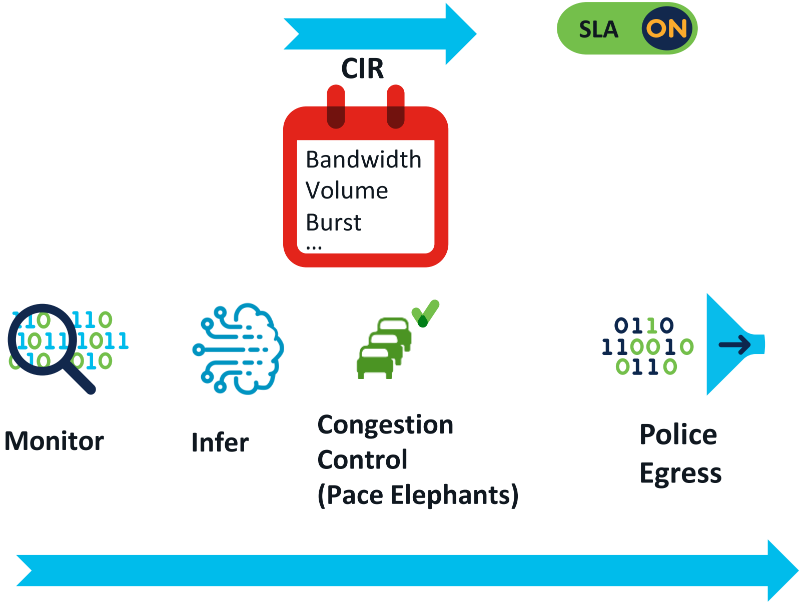
Wholesale
Access Operator

Conform to SLA results in predictable cost ✓

Violate SLA results in additional cost ✗

Indiscriminate Policing leads to bad user experience

Solution



SLA ON

CIR

Bandwidth
Volume
Burst
…

Monitor

Infer

Congestion
Control
(Pace Elephants)

Police
Egress

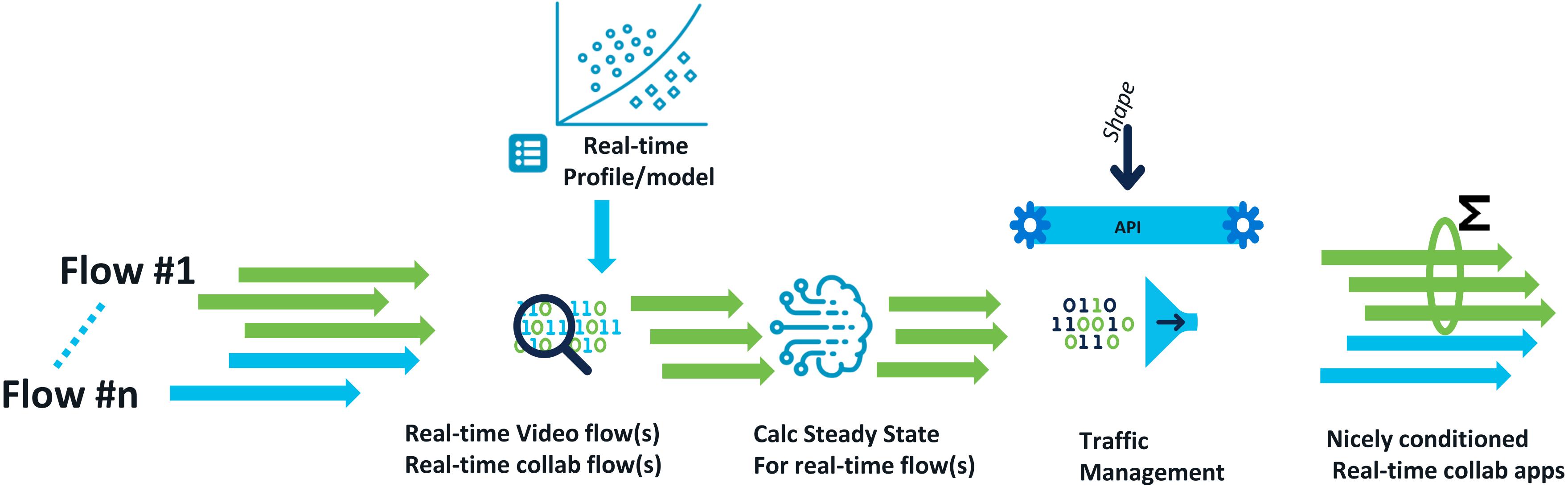
✓ ***Conform to SLA***

✓ ***Ensure QoE for every user***

✓ ***Fair use capability***

Use Case : Protecting Real-time Traffic

Observe traffic, detect videoconferencing stream, measure steady state Bandwith usage of video conf stream, shape traffic to (total-videoconf BW)



Flow #1

Flow #n

Real-time Profile/model

Real-time Video flow(s)
Real-time collab flow(s)

Calc Steady State
For real-time flow(s)

Traffic
Management

Nicely conditioned
Real-time collab apps

🟩 Real-time collab flow

🟦 Any other flow

Summary

- Traffic is encrypted, application controlled, and obfuscated
- H3/Quic/UDP/DOH stack is on the rise and here to stay
- Networks need an IP flow centric approach that scales

The bridge to possible

Thank you