The bridge to possible

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

## Adding Real Value to Networks

Bart Van de Velde (Sr. Director, Engineering, Networking CTO Office)
Andreas Enotiadis (MIG Sales CTO)

# 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

# The New Internet

# The Internet Reality – circa 2020 – Major US Carrier

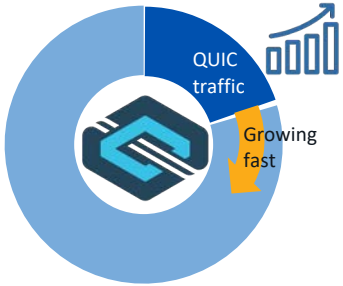
>90% of
Volume: encrypted

>70% of
Volume: to Cloud


10 Cloud sites
"Elephant destinations"
not "Elephant flows"

~50% of Flows:
DNS


>20% of Traffic:
QUIC



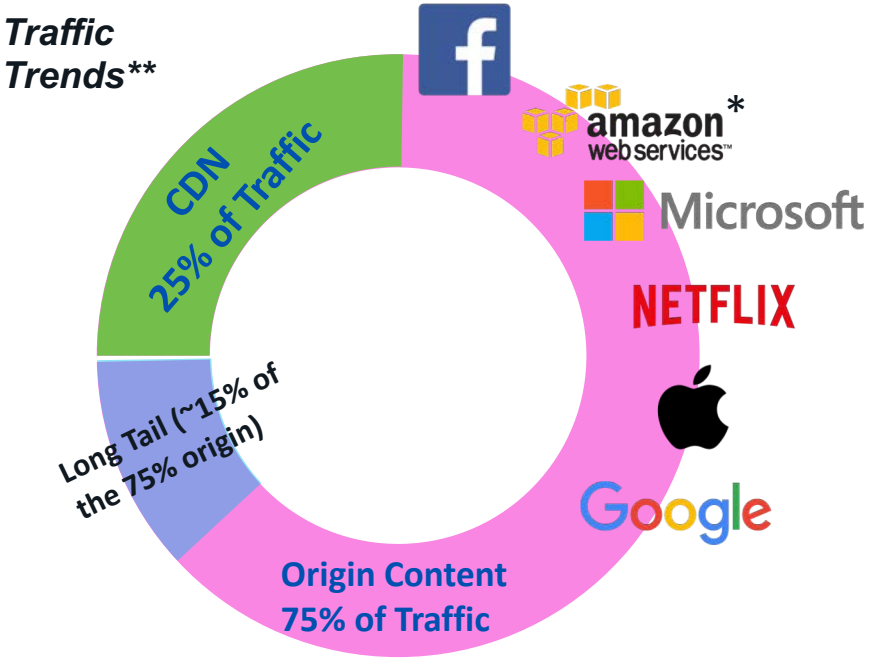

Many small flows
Micro-sessions

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

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

# The Internet is converging on a new normal

It’s not one Internet anymore




- **12 Cloud Domains = >80% of the Volume**
- **6 of 12 Cloud Origin Content Domains have their own CDNs and/or Secure DNS plans**
- **10 of 12 Cloud Domains Are implementing HTTP/3 + QUIC plans**

**Widespread Impact :**
Architecture, Network, Devices, Standards *and* Value-chain

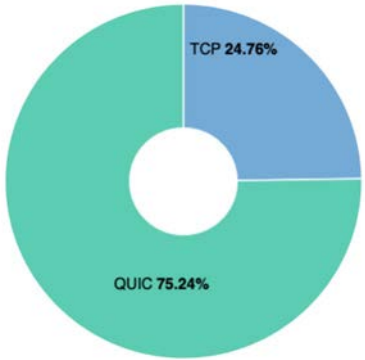
* Amazon own ~1% of public IPv4

**Consumer Traffic Analysis

# Fast forward 18 months - Tier-1 EU Mobile Carrier

YouTube

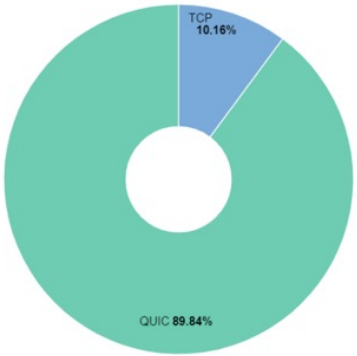
Volume




QUIC is “default”

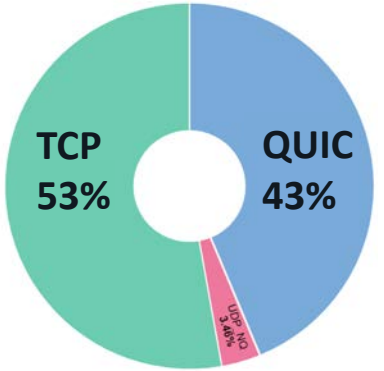
Meta

Volume




Meta is going full QUIC

Overall Volume

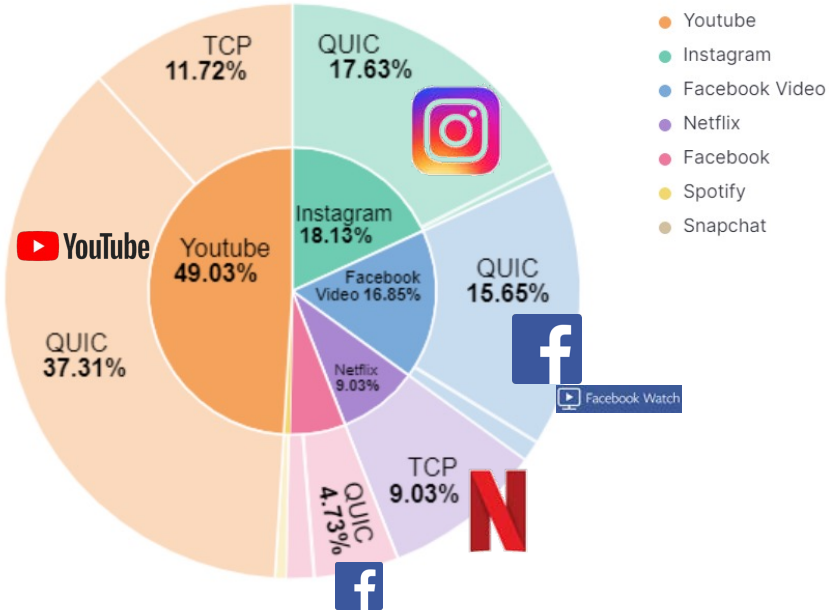



QUIC has doubled in 18 months

QUIC is 43% of total and rising

(snapshot 11/2/2022)

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

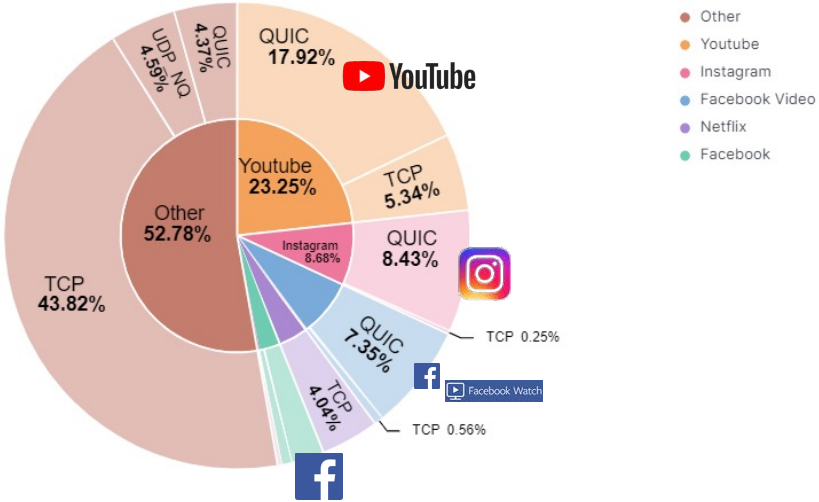



**April 10 2022**

# Network Traffic by Volume and Flows

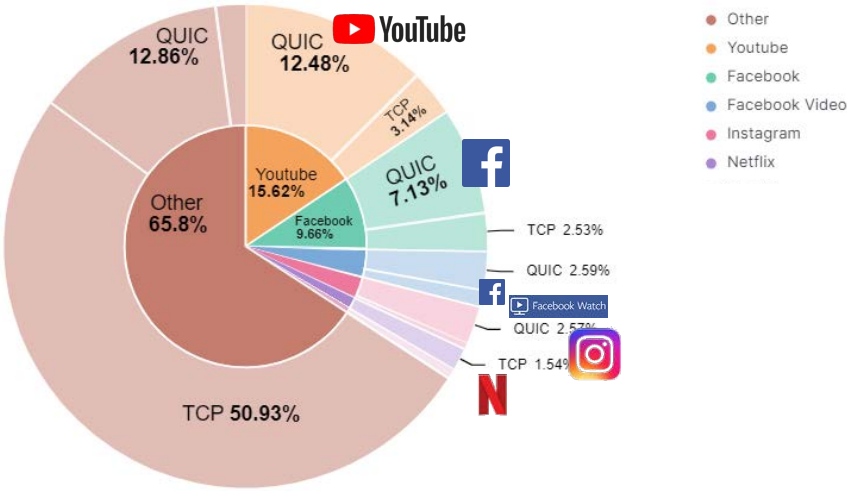
## Overall Volume by Apps

**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

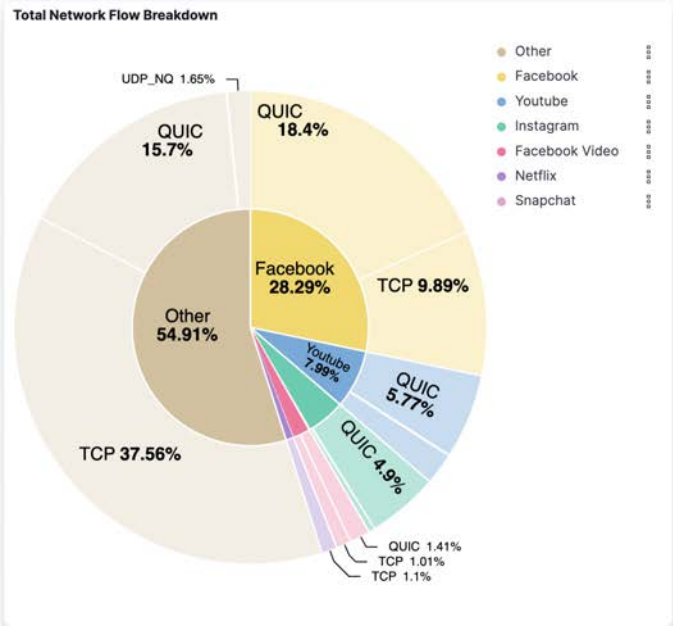
**Lots of TCP sessions (likely IOT related, transactional related)**
**Big 5 QUIC sessions are very targetted and high efficiency (video related behaviour)**

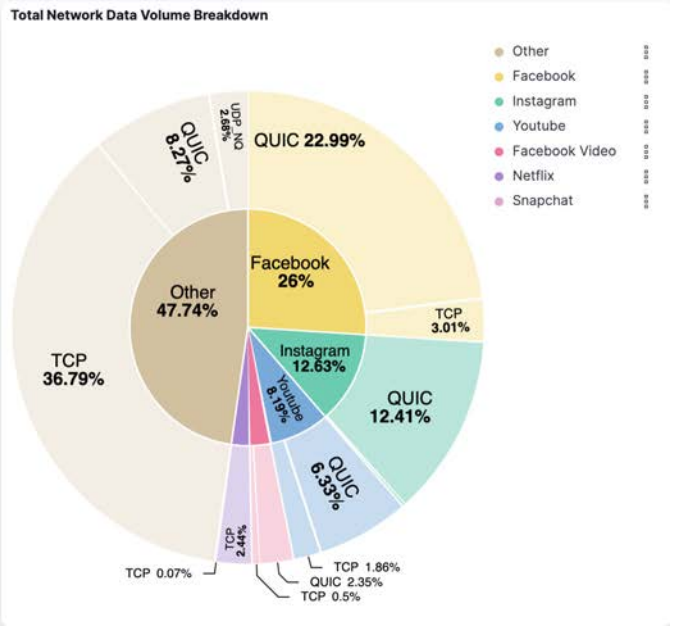


# LATAM Data

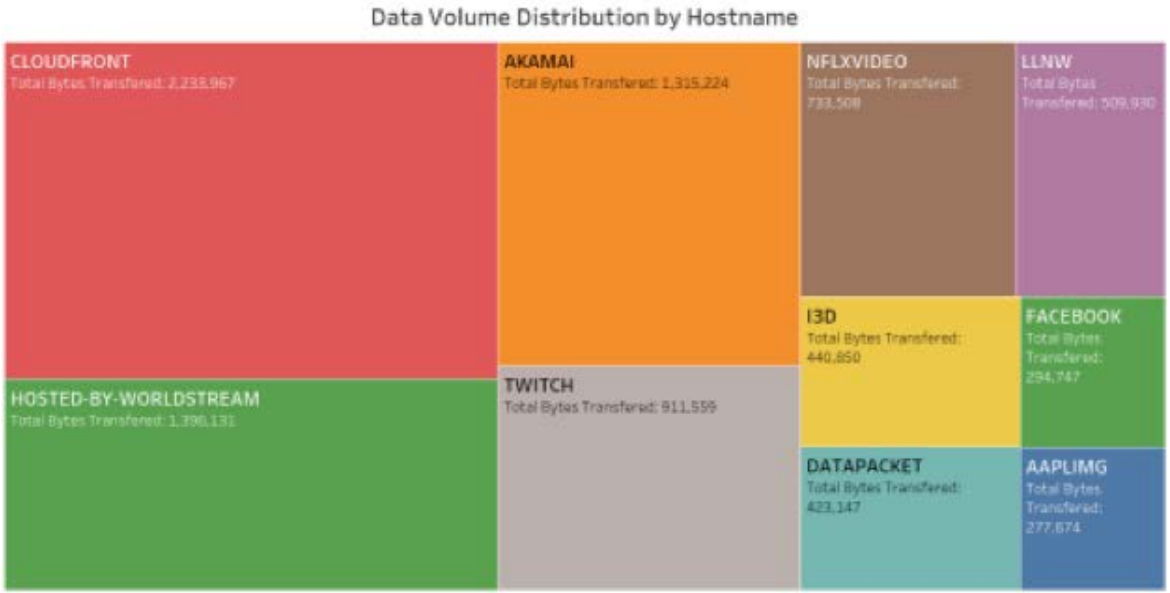
**Sessions** QUIC 46%
TCP 54%

**Volume:** QUIC 52%
TCP 48%



# Fixed Broadband: It’s not that different – May 2022
## if different sources




**CDN**

**Hosting**

**Gaming**

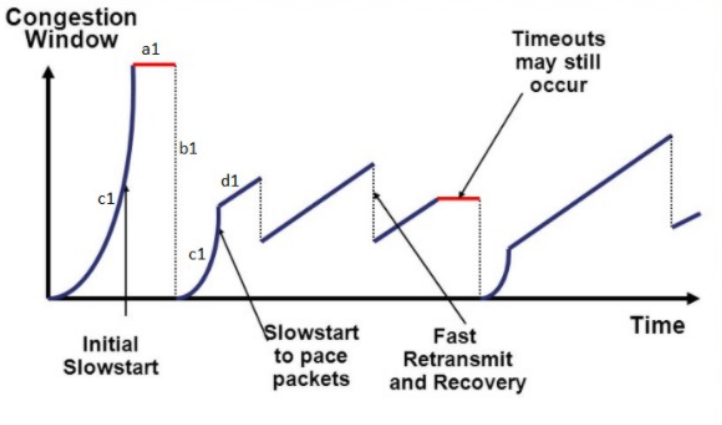
**Video Streaming**

**Profile aligned with Fixed Broadband traffic (browser driven traffic)**

**QUIC : 41%** **TCP: 53%** **UDP (other): 6%**

*source Tier 1 EU SP

# 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 ?***

# 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***

## DPI Ineffective

**including alternative hints e.g. DNS or SNI analysis**

**Large Scale Adoption**

# QUIC/H3/DoH stack is in business


**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

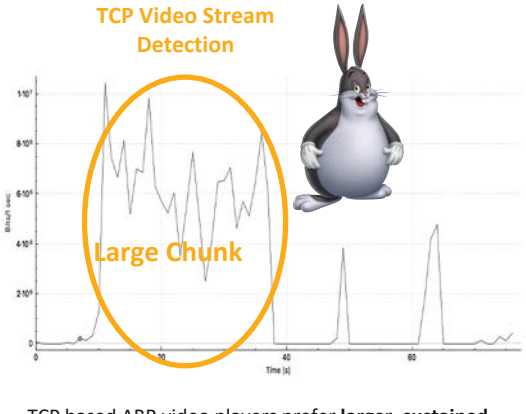
Same problem

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

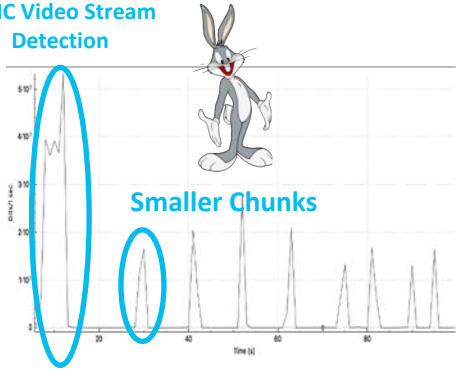
# App (e.g. Video) Behavior varies by protocol and use case

**TCP Video Stream Detection**




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.

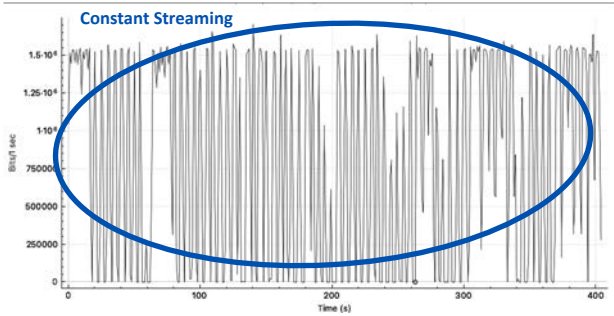
**QUIC Video Stream Detection**



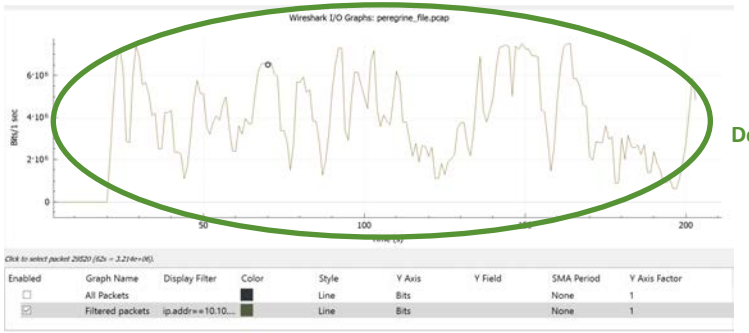

QUIC based ABR video players prefer requesting **video in smaller chunks**.

Multiple QUIC Streams in many cases to (different) servers

**UDP Video Live Stream Detection**




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




**Download Stream Detection**

Premium

NETFLIX

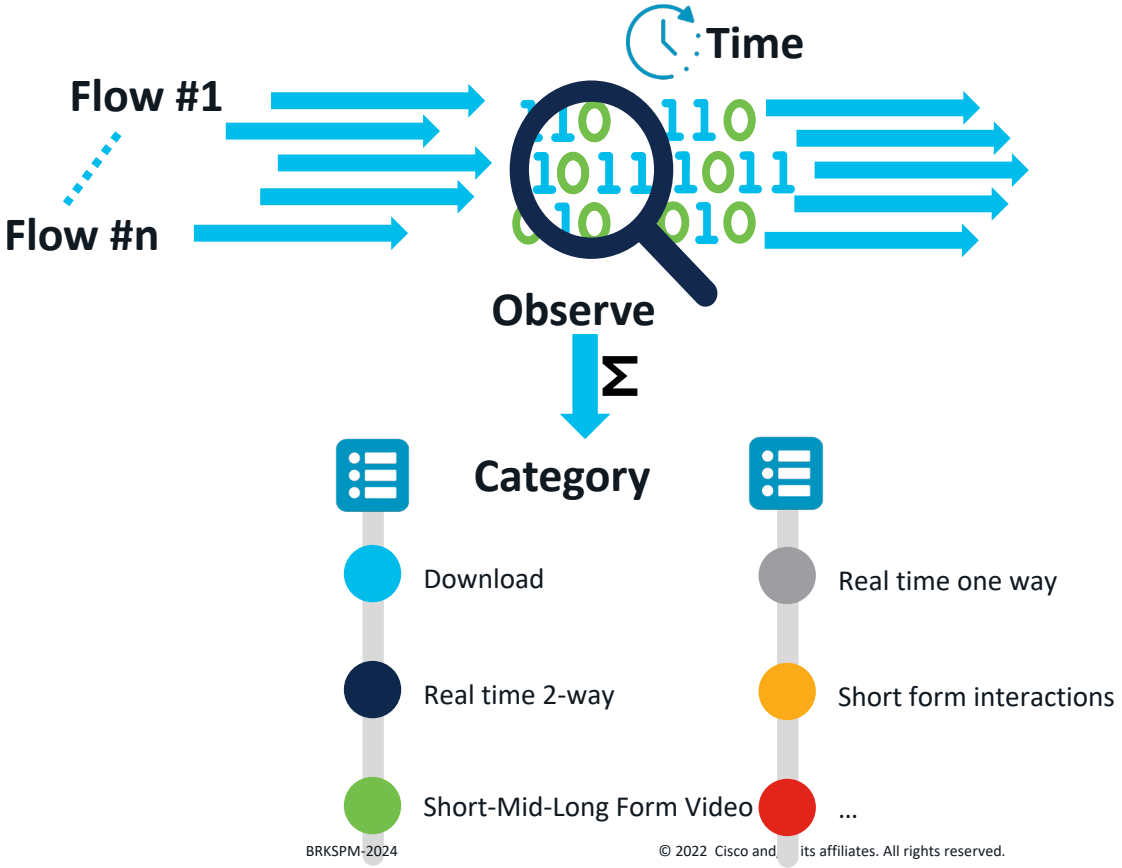
YouTube TV

webex by CISCO

zoom

# Time Domain Flow recognition

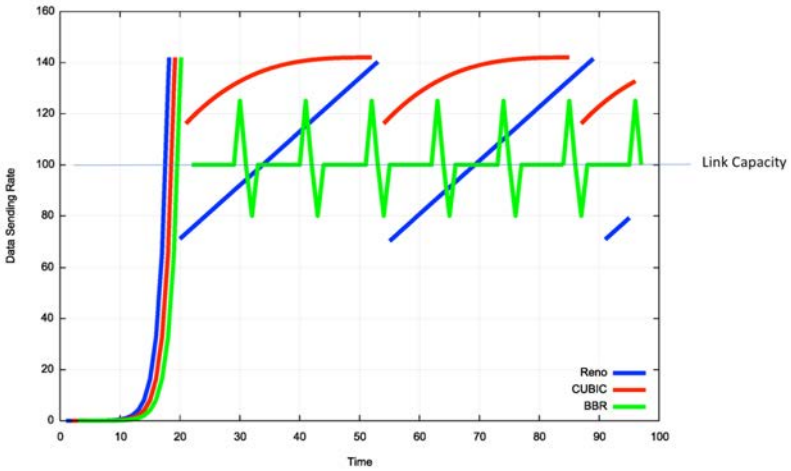
- Observe all flows
- Profile per flow (Time domain matched)
- The resulting profile will allow to distinguish the nature of the flow
  - Content Download
  - (x-Form) Streaming content
  - Real time 2 way communication
  - Video/non-video
  - Short lived flows



# Inferring congestion

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

Reno vs CUBIC vs BBR behaviour*

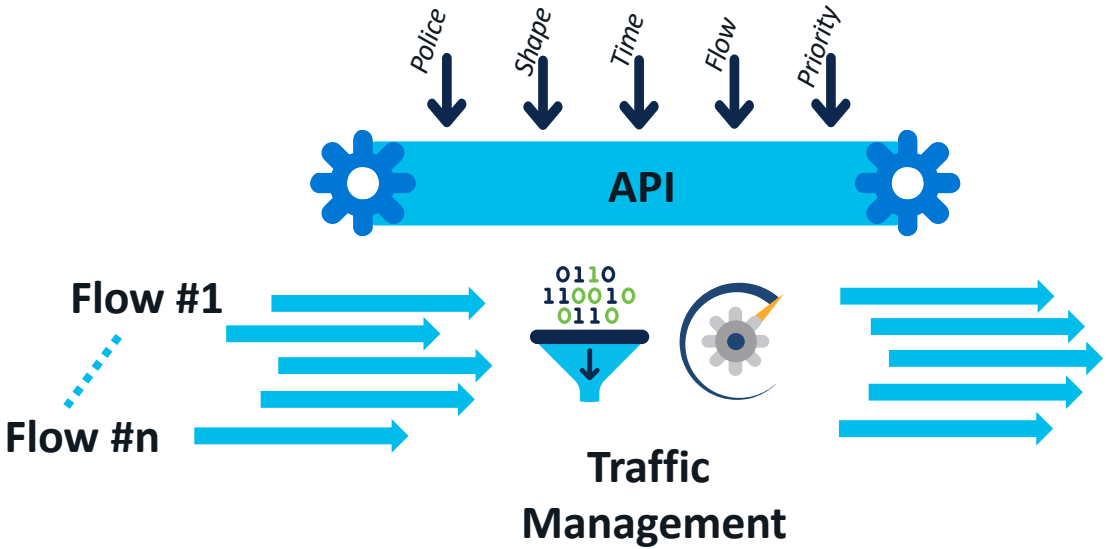



- Assessment of various flows in parallel
- Understand Protocol behaviour: congested or not
- This serves as input for Policy Application

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

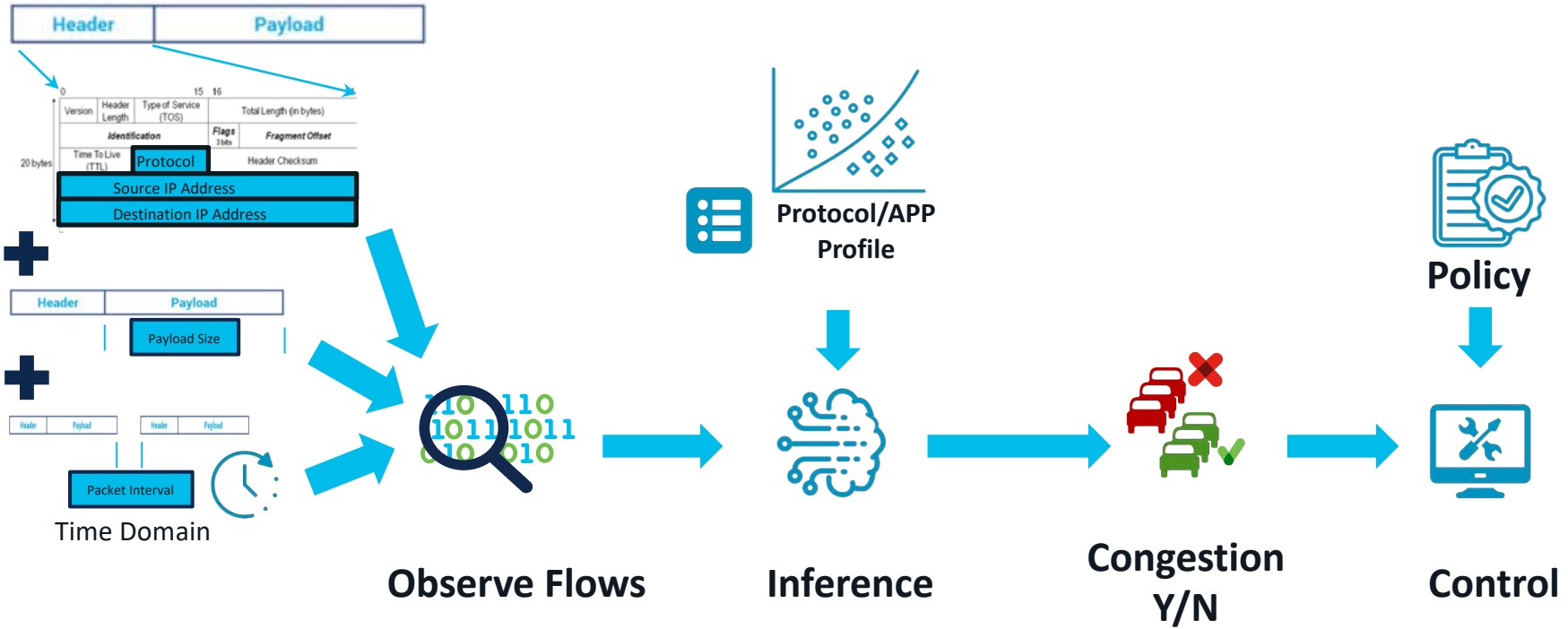
# Programmable Traffic Management

- 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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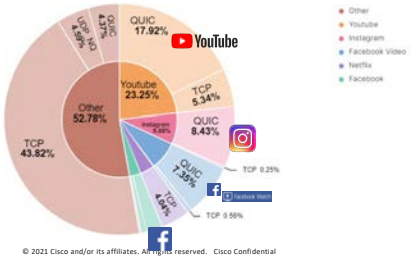




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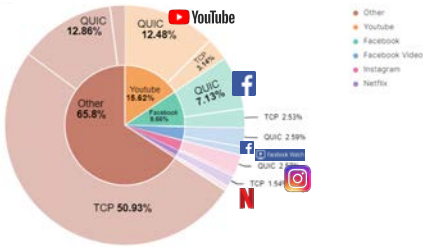


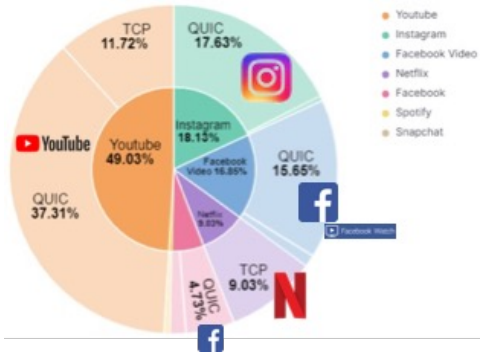


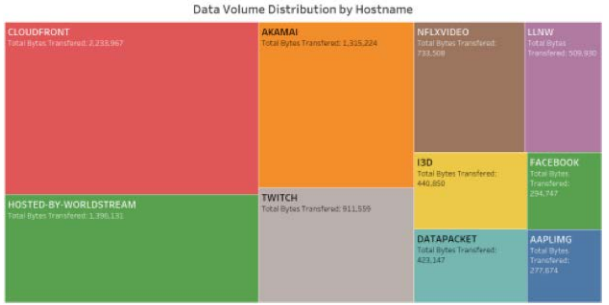


- Monitor all flows
- Infer information for Source (DNS, SNI/eSNI), CDN (ECH), Flow Type (Time domain behaviour)
- ELK (elastic Search, Logstash, Kibana) analytics engine
- Extensible to enriched CDR production

**CDN**

**Hosting**

**Gaming**

**Video Streaming**

**Profile aligned with Fixed Broadband traffic (browser driven traffic)**

**QUIC : 41%**

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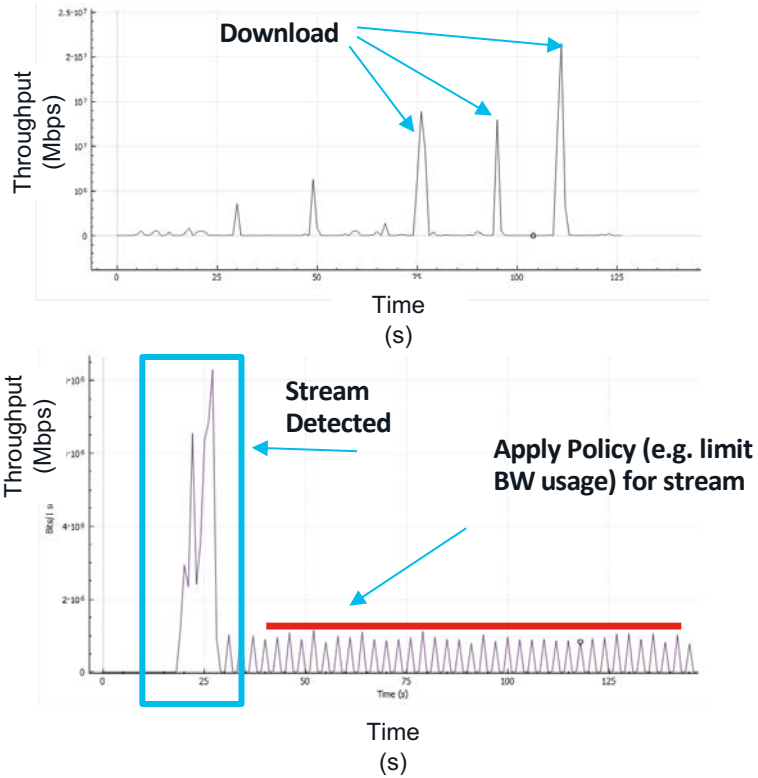
**UDP (other): 6%**

# Custom Policy Enforcement

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

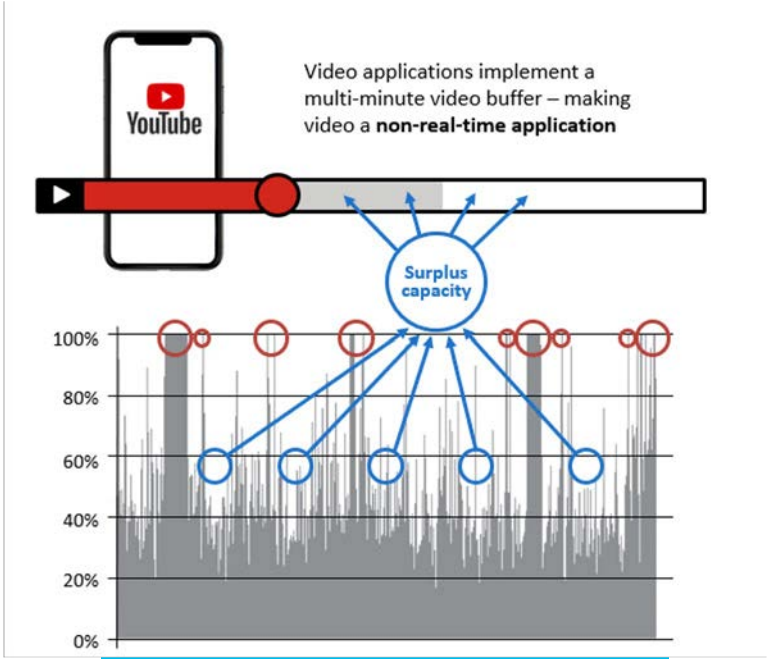



- Same Source/Destination Address
- Differentiate between download versus streaming *on the same SA/DA*
- ***Apply Policy per flow type, e.g.***
  - ***Download Policy: no action***
  - ***Streaming Policy: Limit to set BW profile (police/buffer/…)***

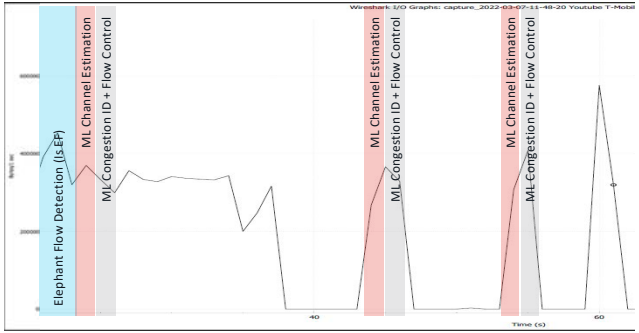
# Time Domain shaping

## User Experience optimisation 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)



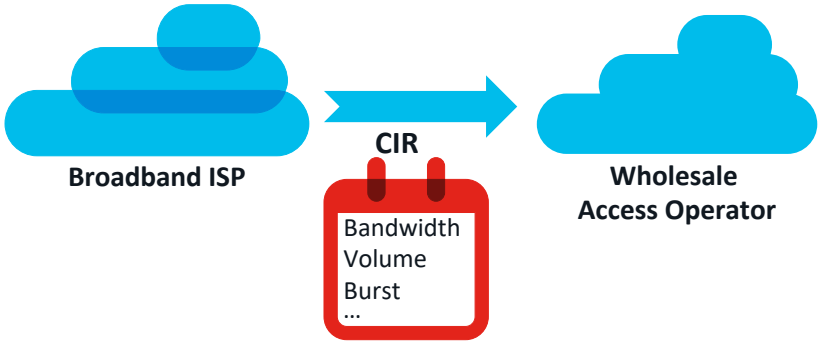

60 seconds of traffic on a single 4G cell




# Time domain shaping

## User Experience Optimization within SLA Boundaries

### Situation

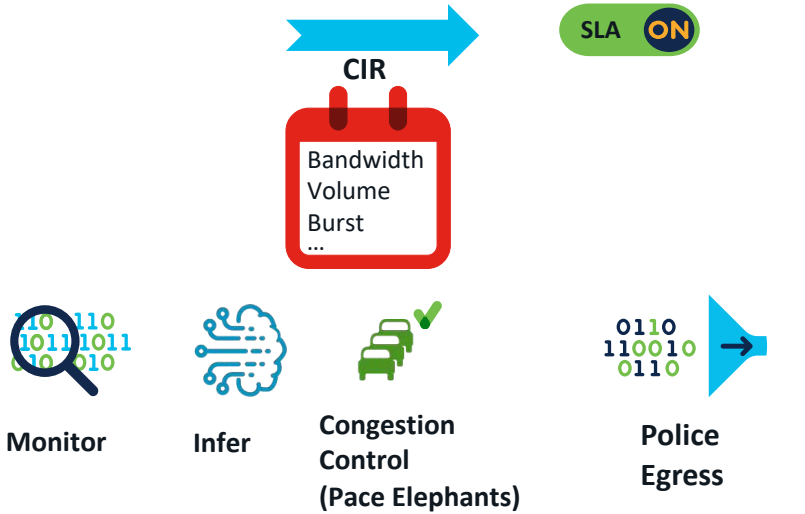



Conform to SLA results in predictable cost

Violate SLA results in additional cost

***Indiscriminate Policing leads to bad user experience***

### Solution



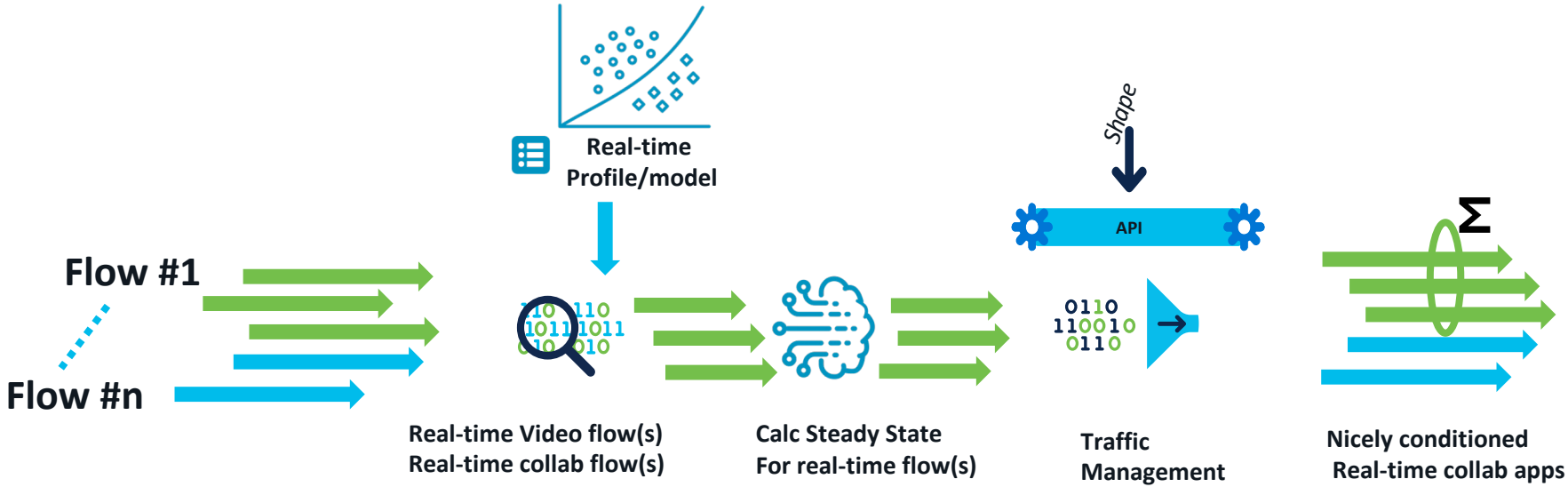

***Conform to SLA***

***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)



# 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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Thank you