

How Netflix directs 1/3rd of

Internet Traffic

Netflix

YouTube

Amazon
Prime

Facebook

iTunes

Hulu

Everything Else

QCon
San Francisco
Nov 16, 2015

Haley Tucker
Mohit Vora





House of Cards

@HouseofCards



+ Follow

This is Washington. There's always a leak. All 13 episodes will launch February 27.

RETWEETS

23,303

LIKES

16,314



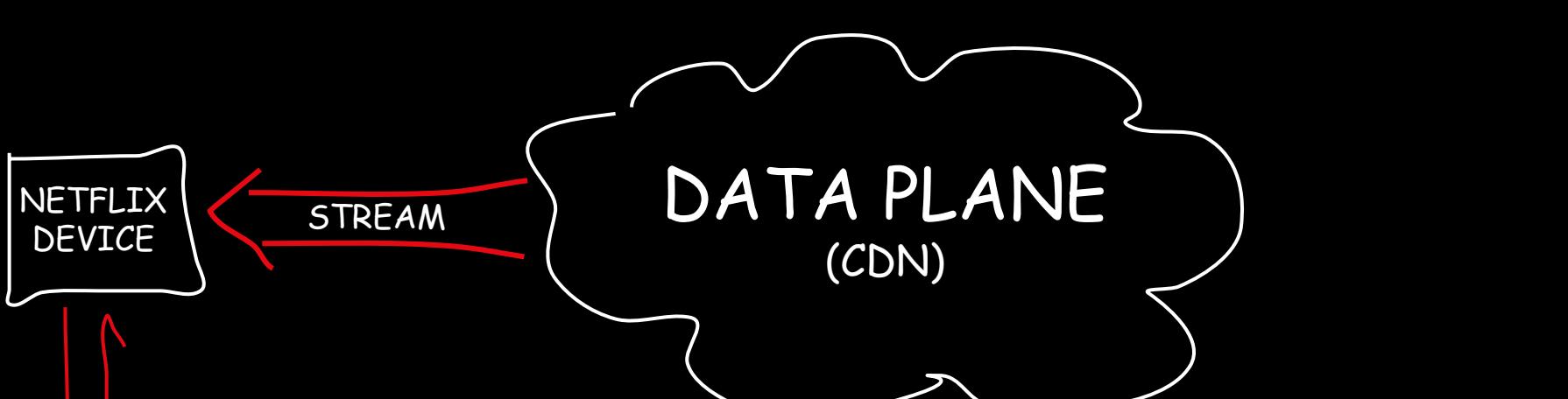
2:01 PM - 11 Feb 2015



...

Playback Overview





CONTROL PLANE

**CONGRATULATIONS
EMMY® AWARD WINNER**

NETFLIX ORIGINAL

ORANGE is the new **BLACK!**

Praise Norma! It's another Emmy win for Uzo Aduba.

▶ PLAY

+ MY LIST





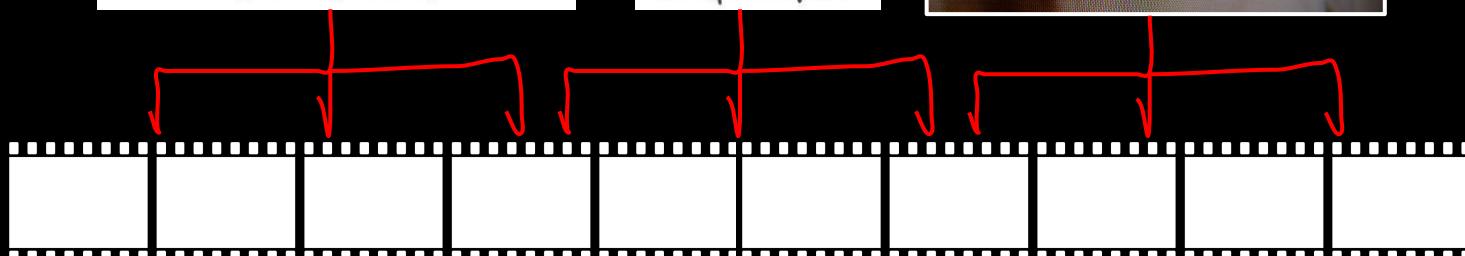
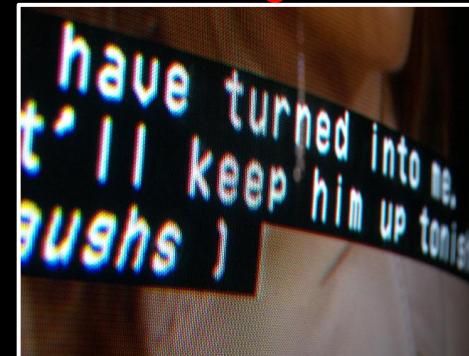
MADE IN ENGLAND



VIDEO

AUDIO

TEXT



STREAMS

How do we build a streaming “tape”?

Determine the preferred experience

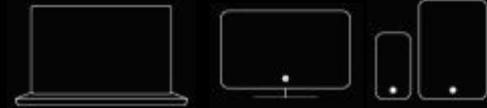
TITLE



COUNTRY



DEVICE



CUSTOMER



- | | |
|------------------------------------------|------------------------------------|
| <input type="radio"/> Dansk | <input type="radio"/> Norsk bokmål |
| <input type="radio"/> Deutsch | <input type="radio"/> Português |
| <input checked="" type="radio"/> English | <input type="radio"/> Suomi |
| <input type="radio"/> Español | <input type="radio"/> Svenska |
| <input type="radio"/> Français | <input type="radio"/> 日本語 |
| <input type="radio"/> Nederlands | |

NETWORK



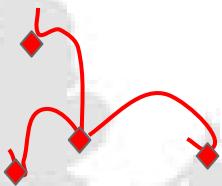
Broadband - wired or wifi
Cellular - Edge, 3G, LTE, ...

CONNECTIONS



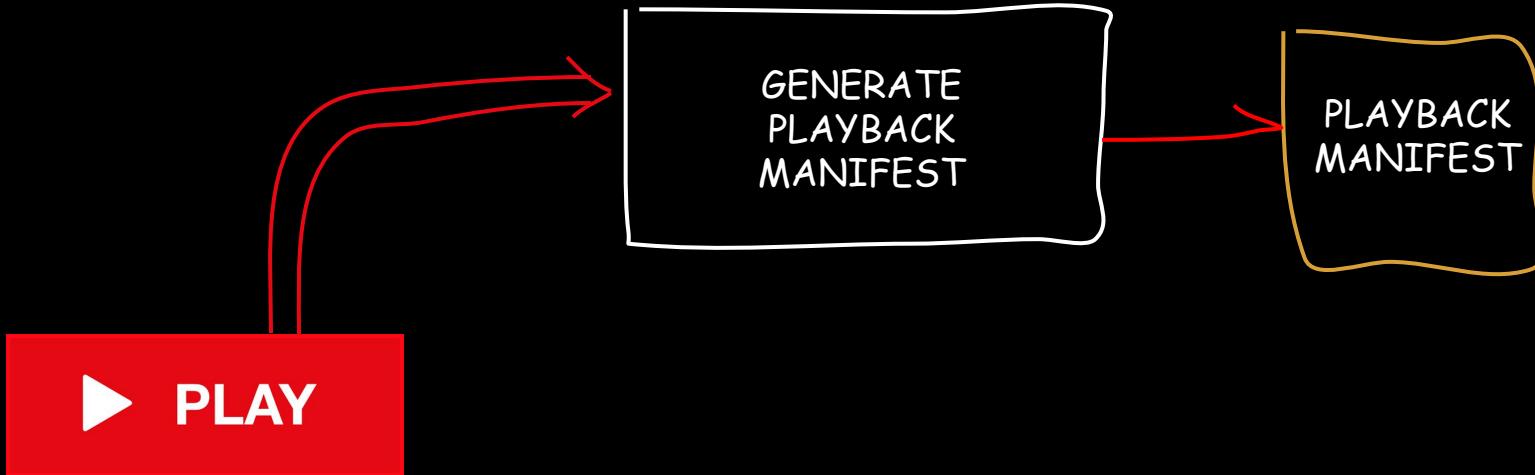
**That's exactly what I want
...now where can I get it?**

Point the device to appropriate locations



Steering

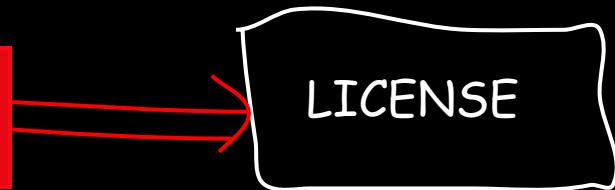
PLAYBACK MANIFEST





**Uh-oh, the
content is
encrypted!**

LICENSE



And...Action!

NETFLIX

57:04



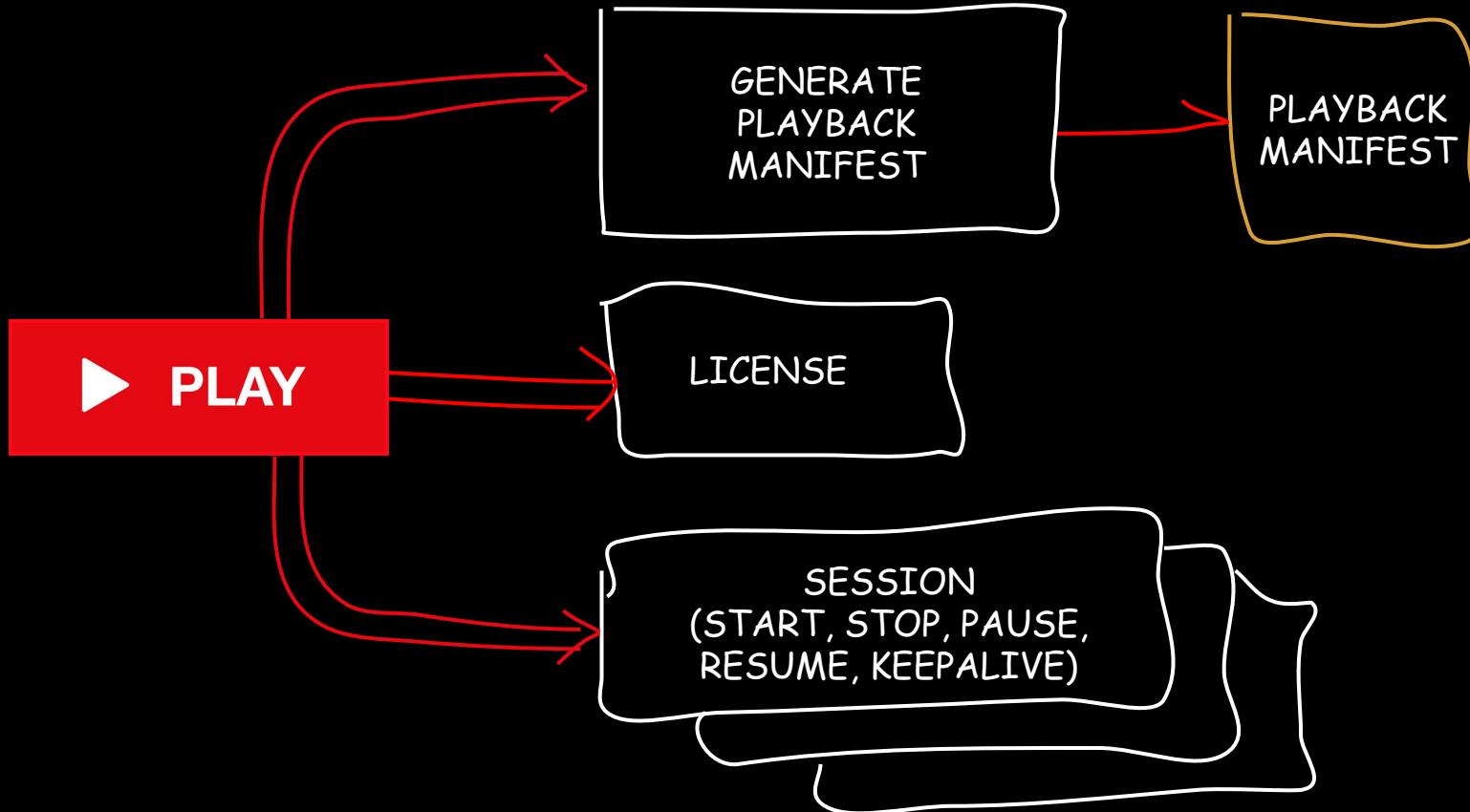
Orange Is the New Black Season 1: Ep. 6 WAC Pack

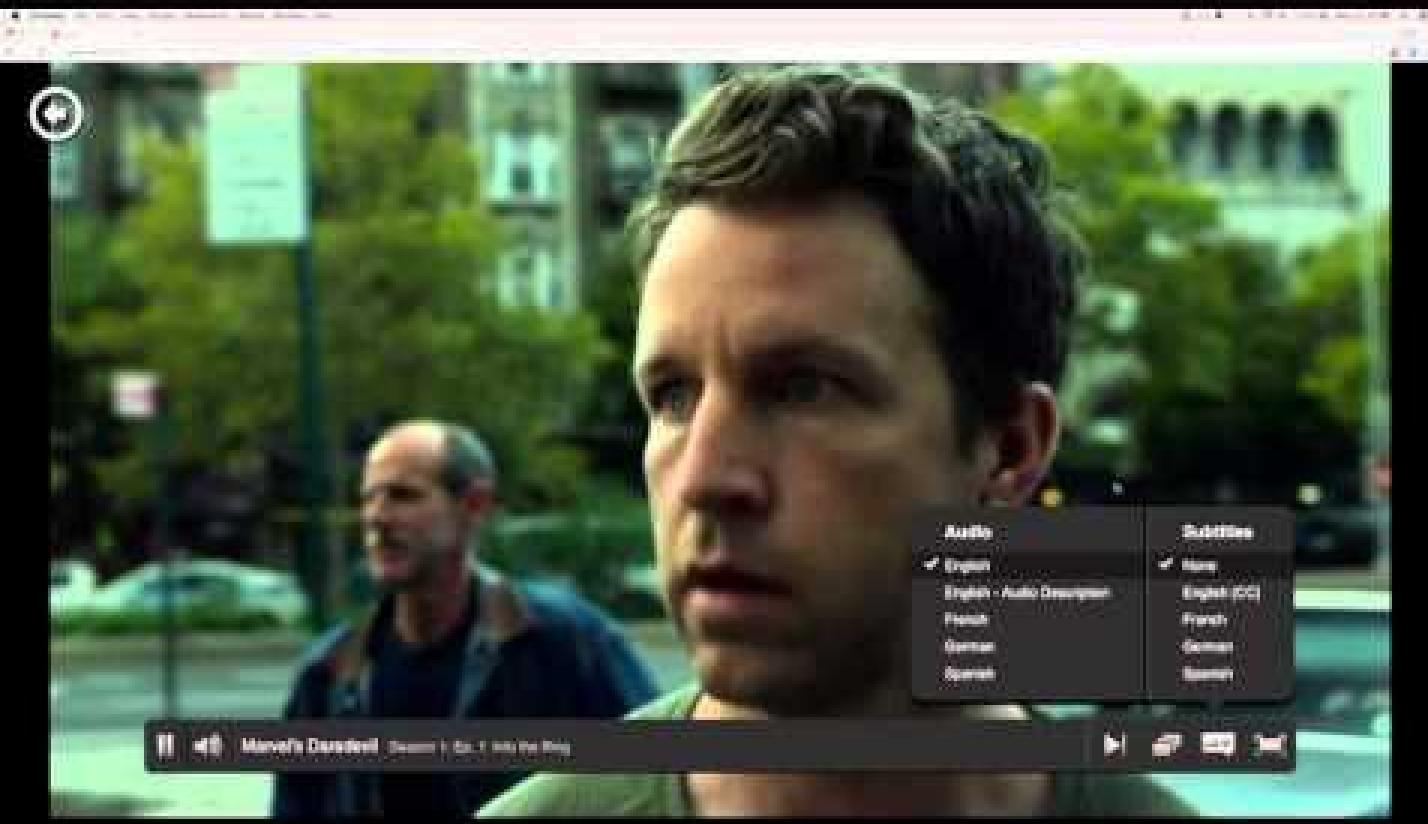


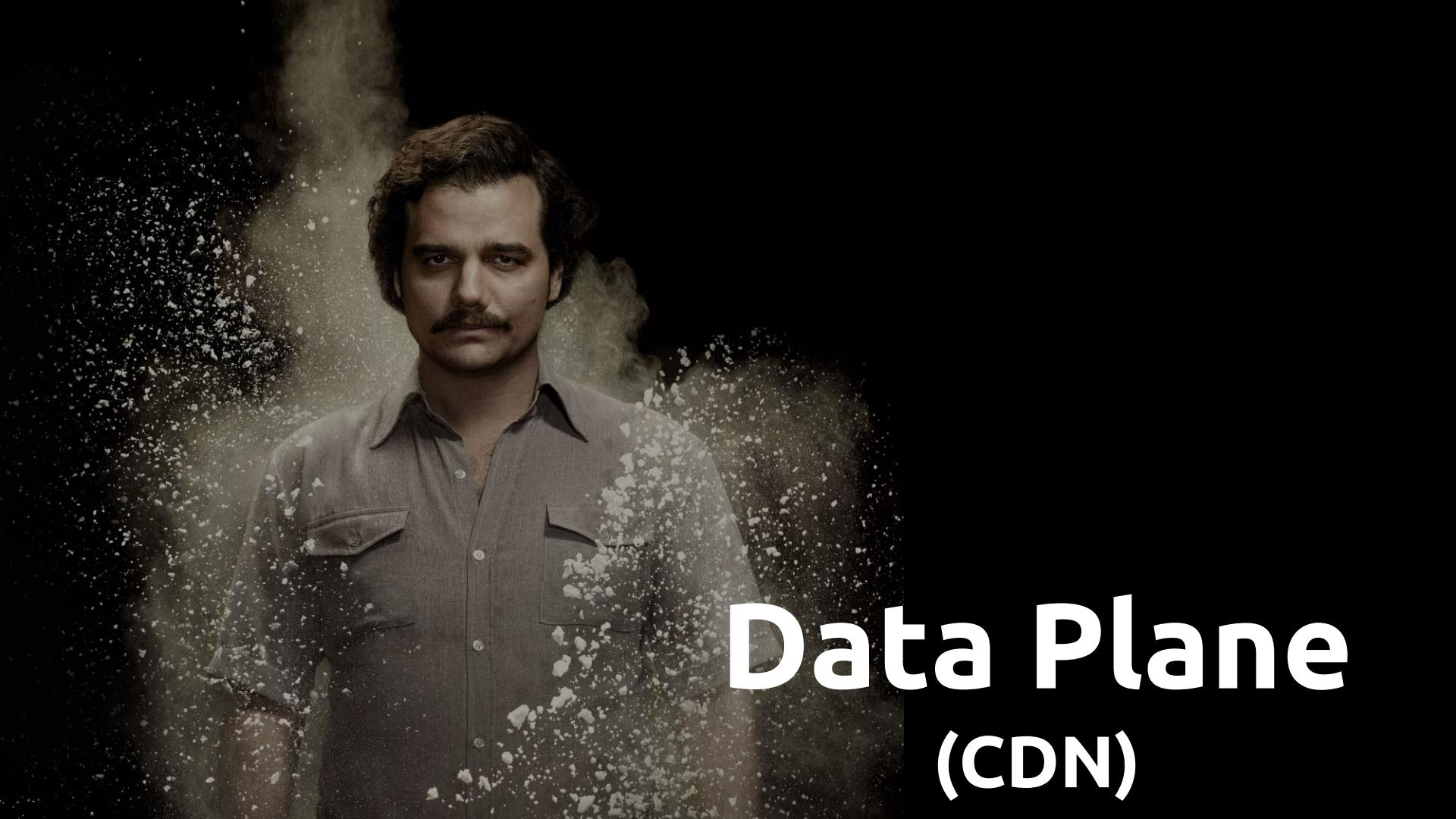
SESSION EVENTS



PLAYBACK LIFECYCLE







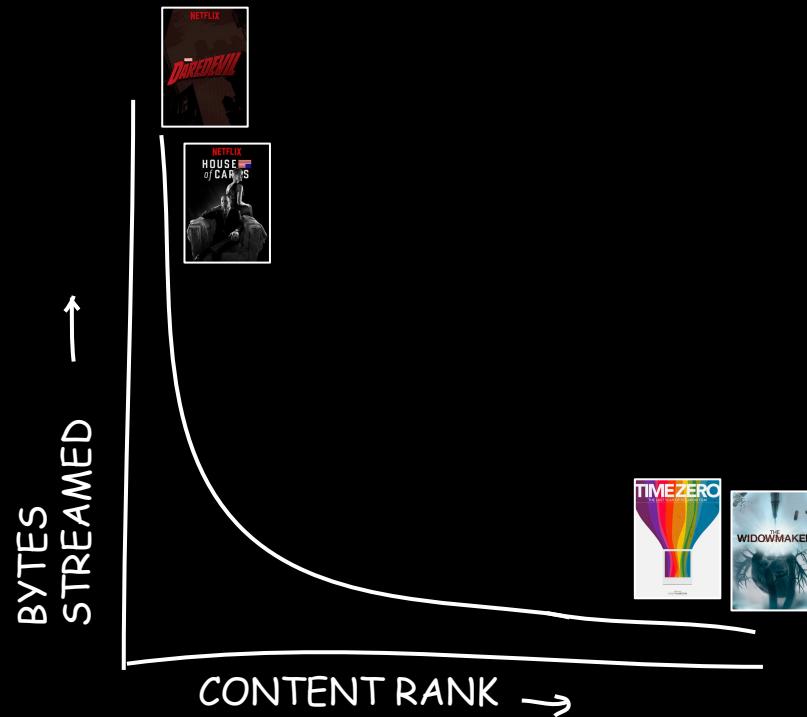
Data Plane (CDN)

What is a Content Delivery Network?

Open Connect

A NETFLIX ORIGINAL





PREDICTABLE VIEWING PATTERNS



FILLING WHEN YOU SLEEP



READ XOR WRITE





ADVENTURE... EXCITEMENT...

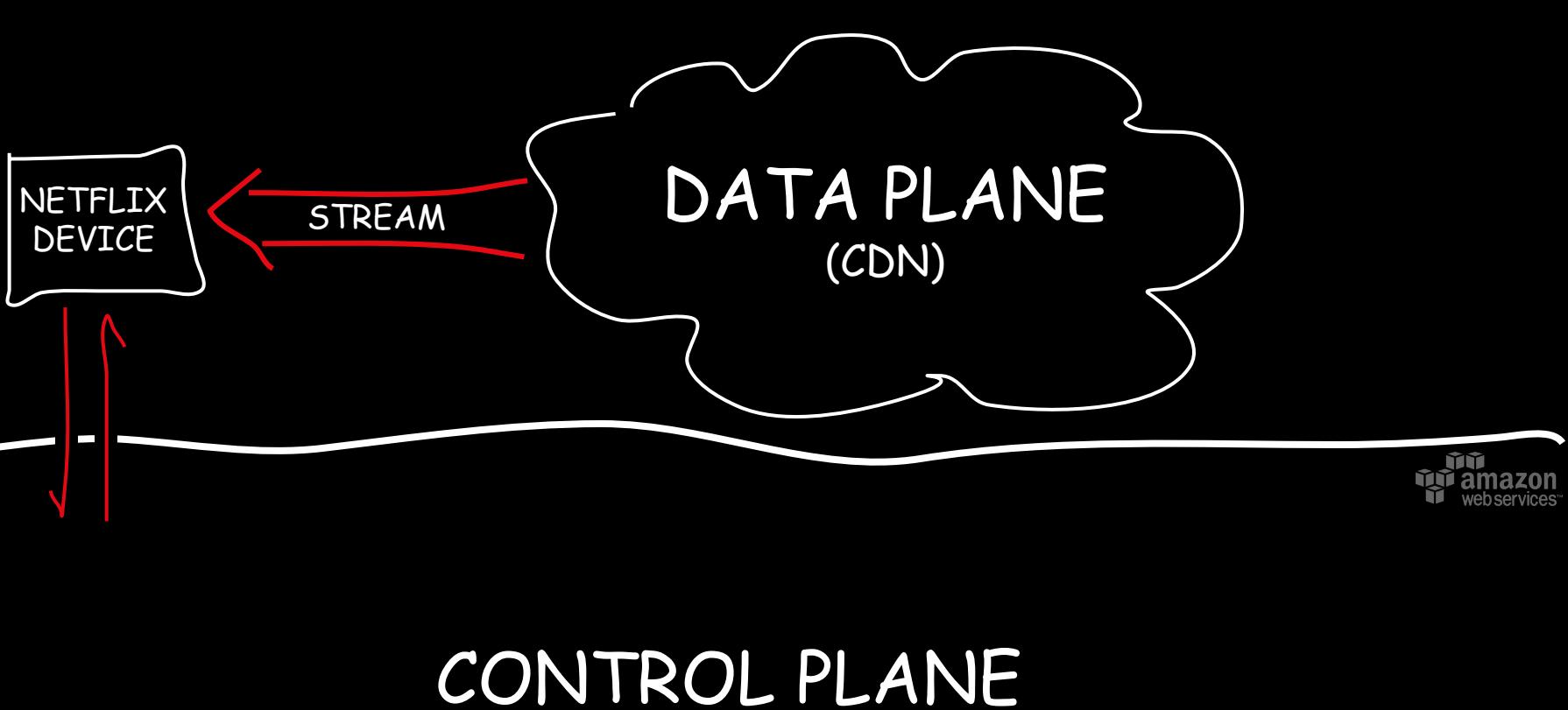


**A JEDI CRAVES NOT THESE
THINGS**





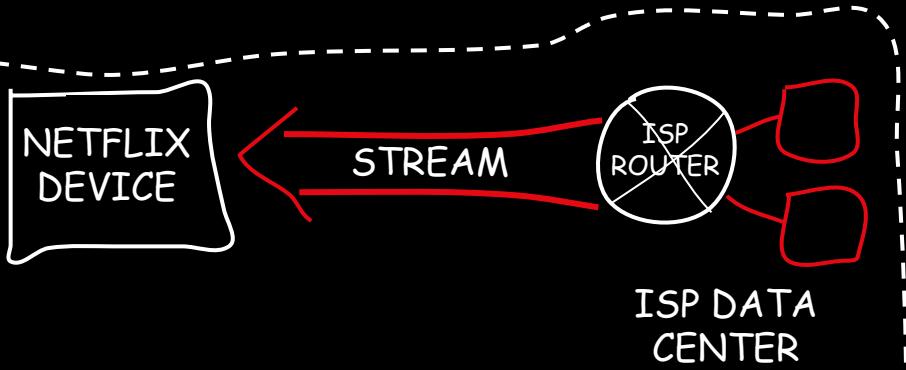
Content Delivery Mechanisms





STREAM

ISP DATA
CENTER

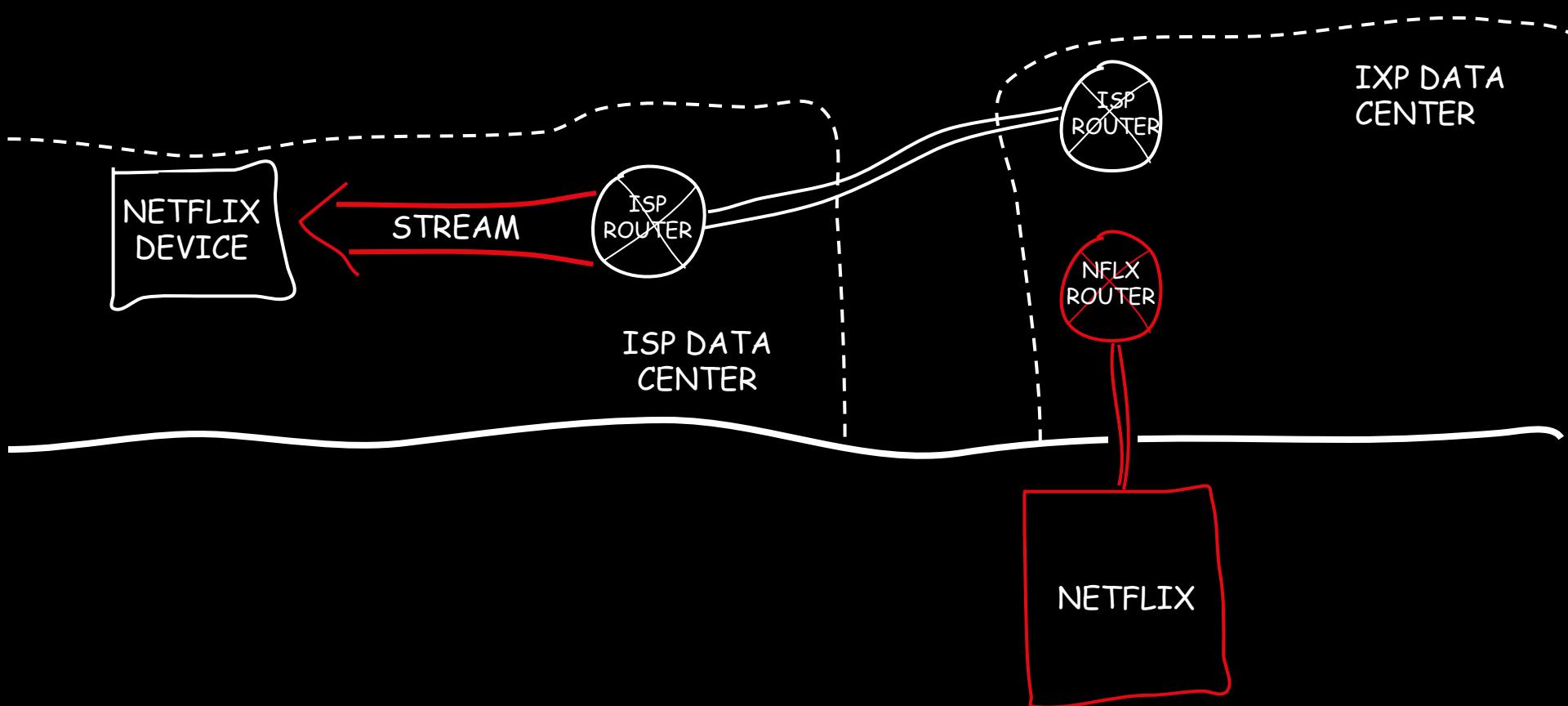


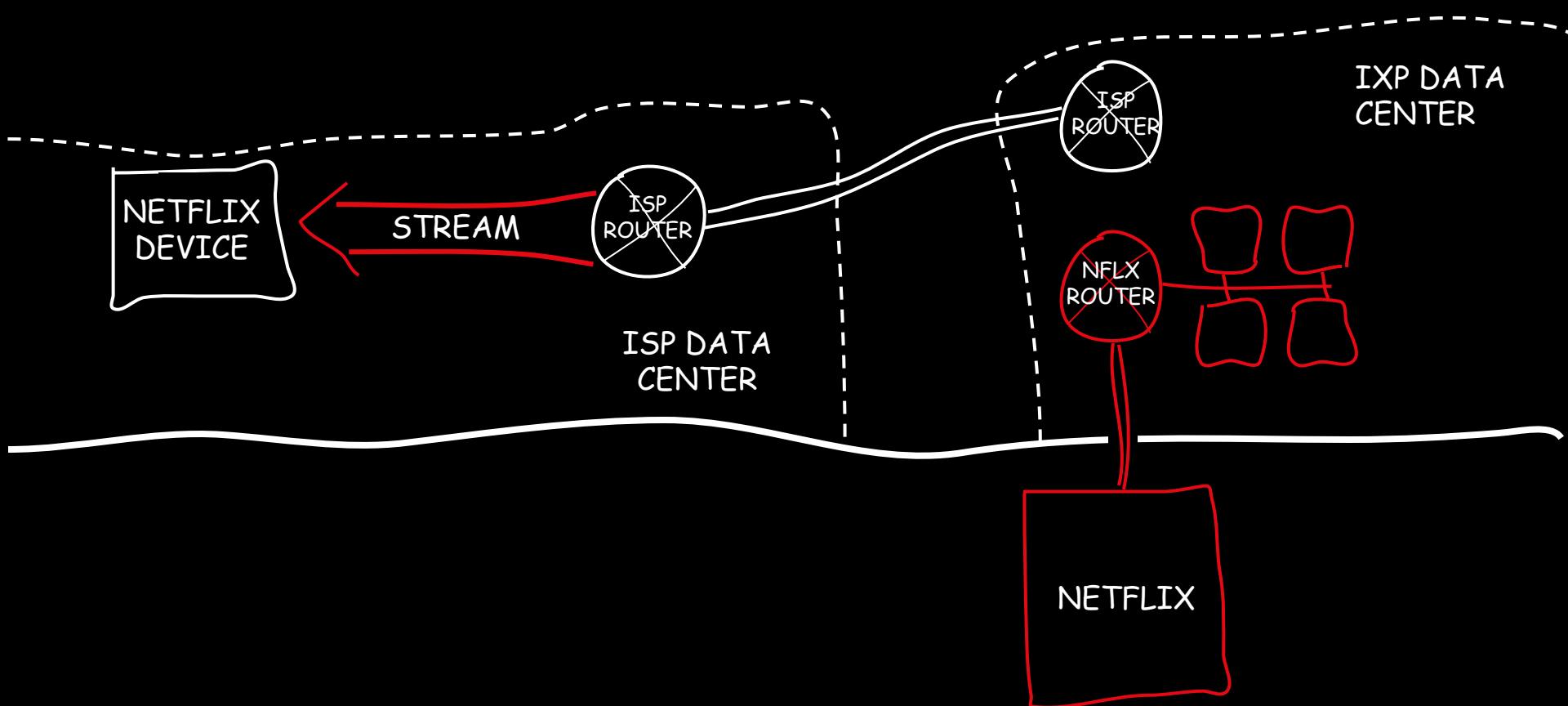
ISP CO-LOCATION

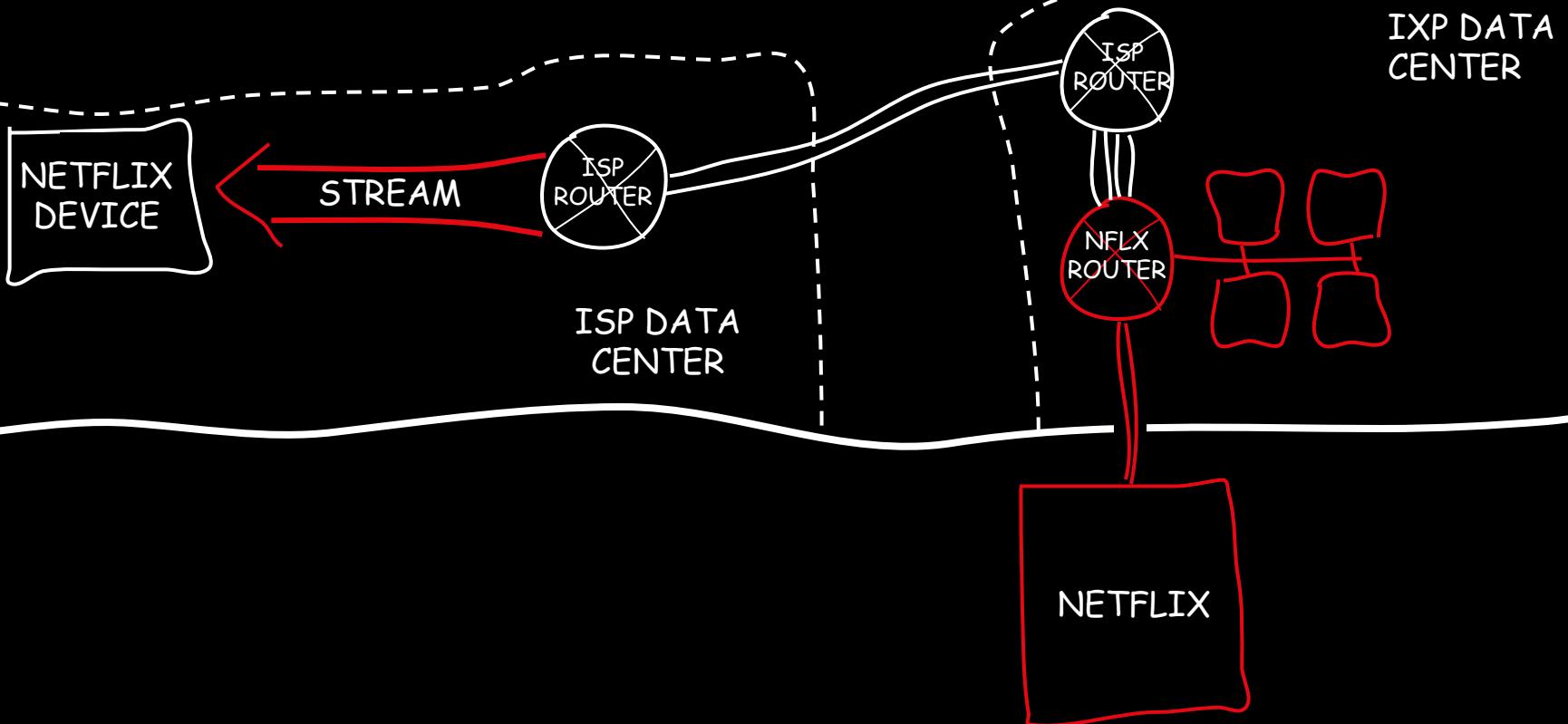


STREAM

ISP DATA
CENTER



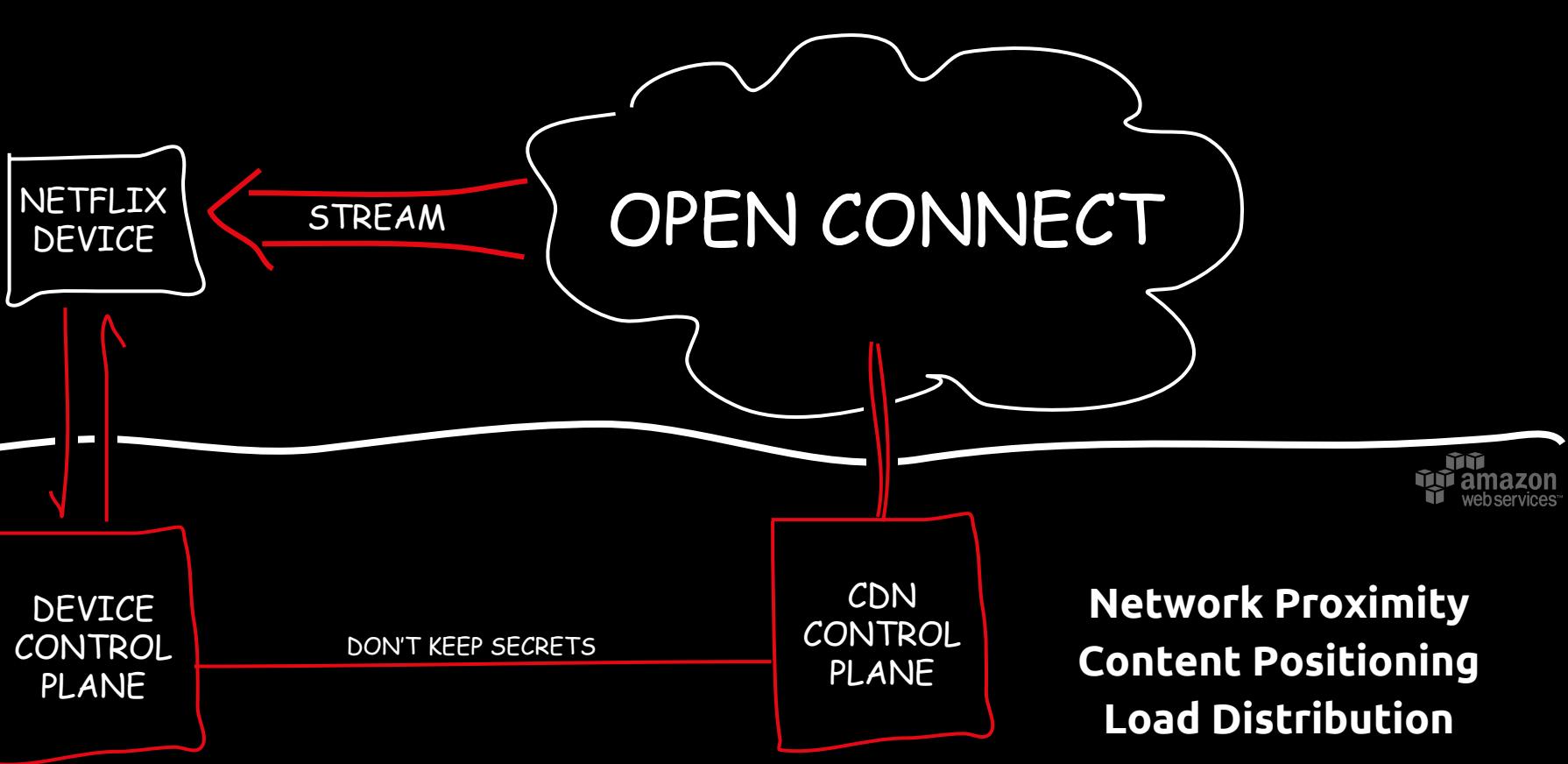




IXP INTERCONNECTION



Control Plane



Network Proximity

By Specification?

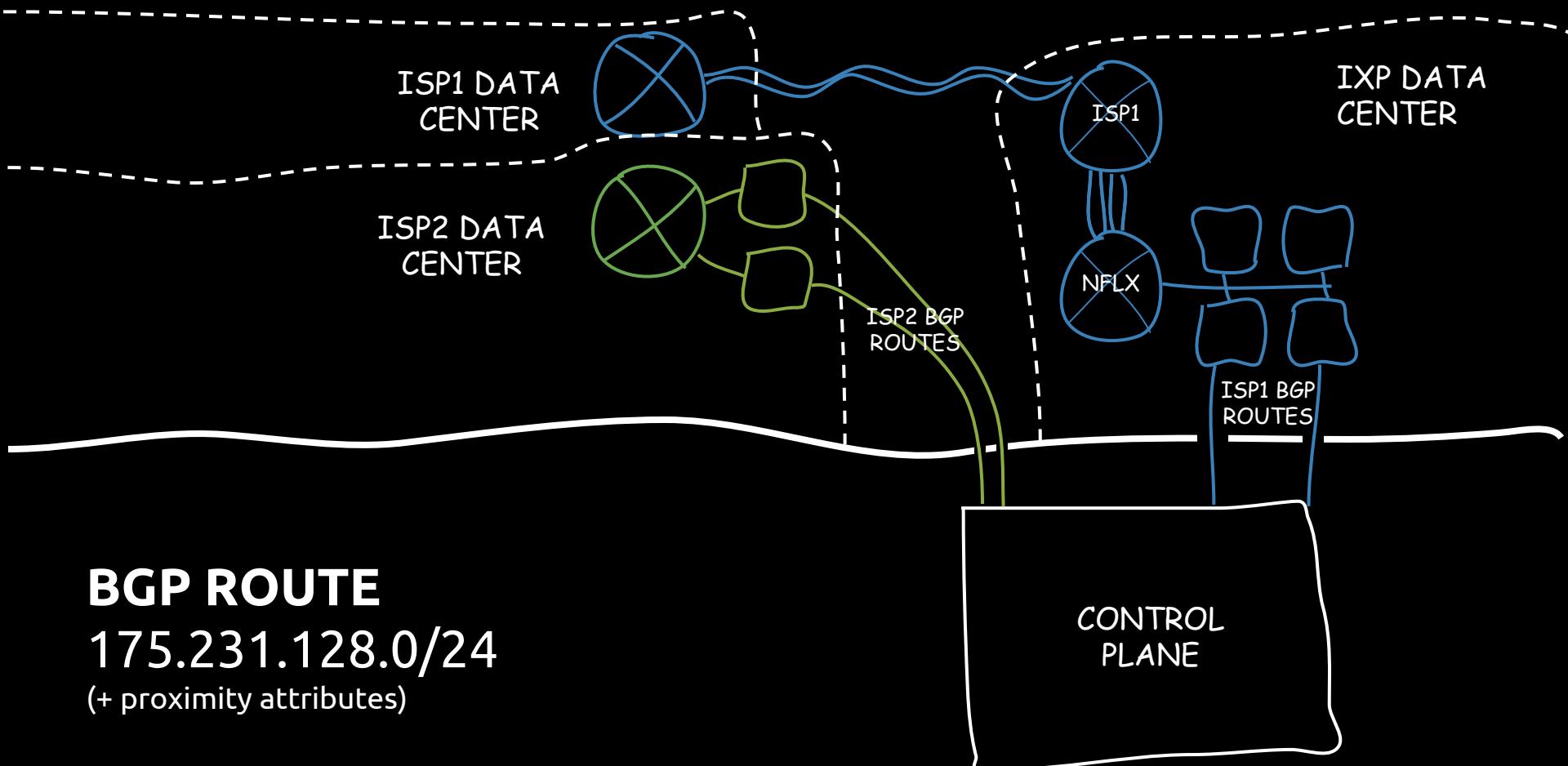
By Specification?
Doesn't scale

TAKEAWAY

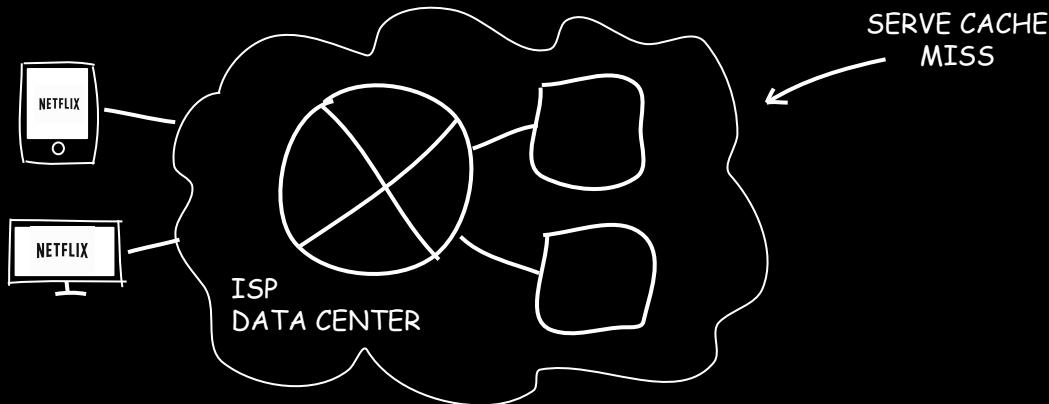
Use BGP

Border Gateway Protocol

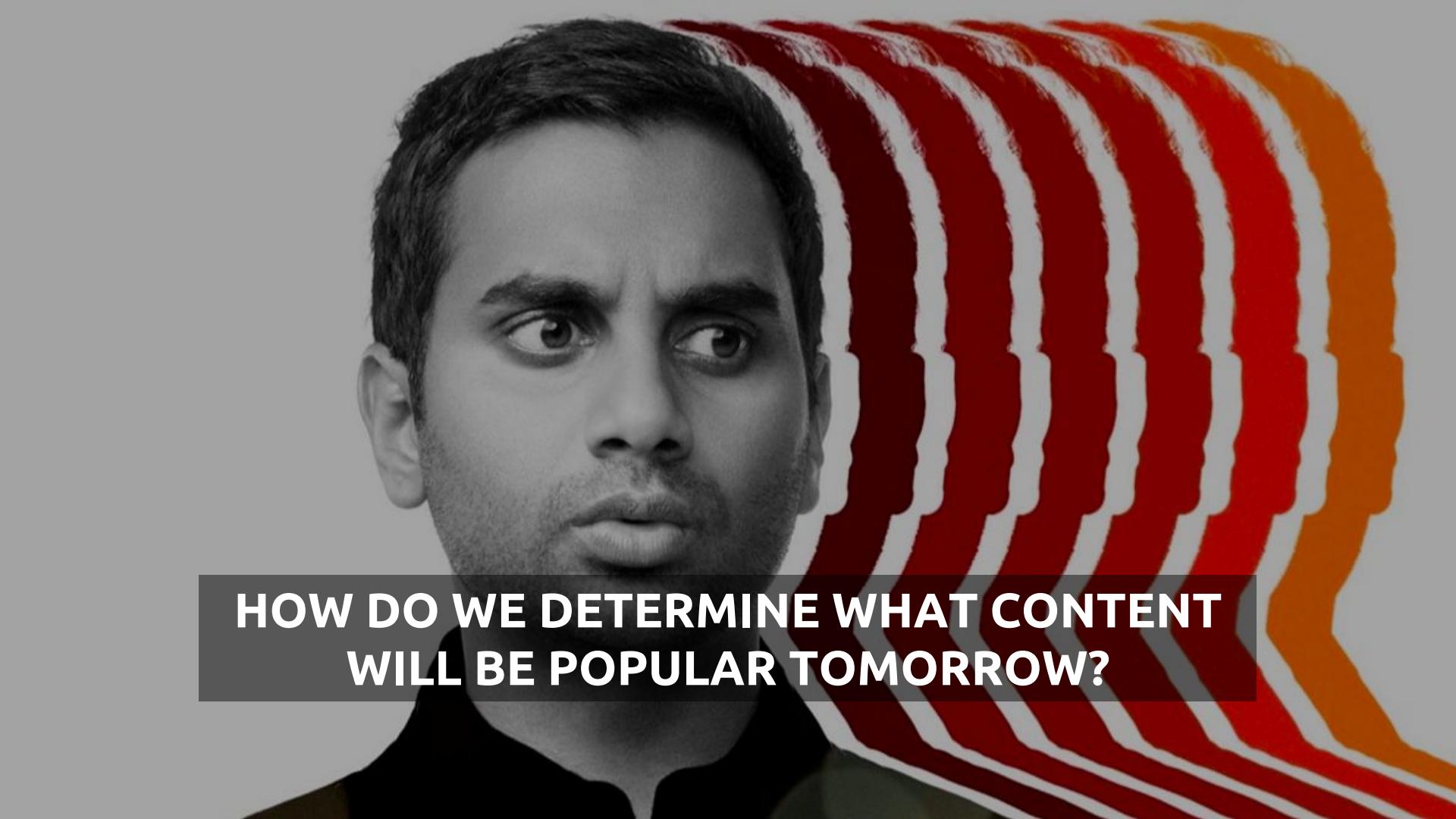
BGP ROUTE
175.231.128.0/24
(+ proximity attributes)



Content Positioning



LOCALIZE TRAFFIC



**HOW DO WE DETERMINE WHAT CONTENT
WILL BE POPULAR TOMORROW?**

Recently Added

Sort by

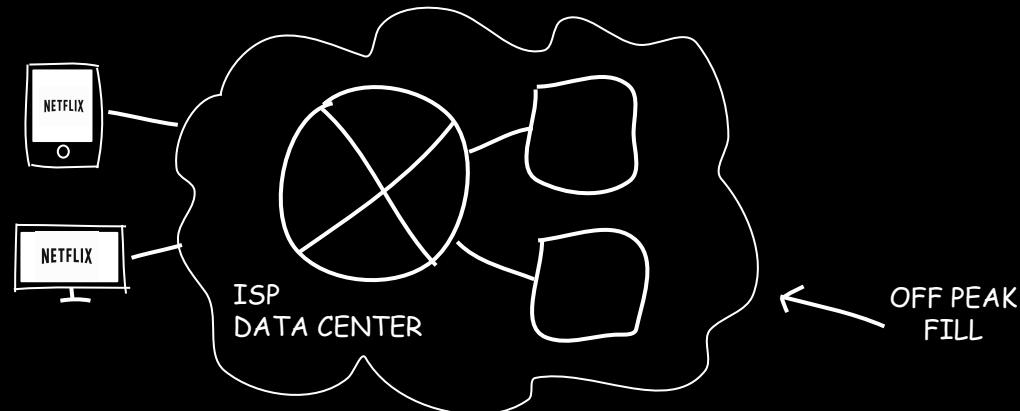
SUGGESTIONS FOR YOU ▾



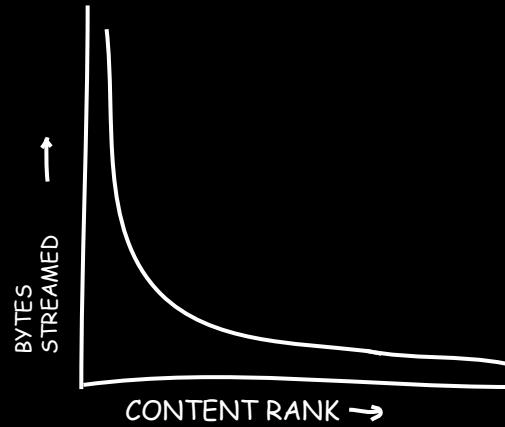
CHANGING CATALOG



EVOLVING MEMBER TASTES



MINIMIZE FILL CHURN



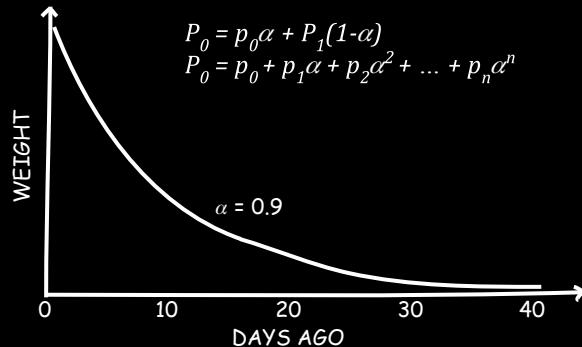
USE HISTORICAL DATA
bytesStreamed/bytesStored

A cartoon illustration of a brown horse's head and neck. The horse has a black mane, white blaze markings on its forehead and nose, and a pink tongue slightly out. It is wearing a grey hood or halter. The background is dark grey.

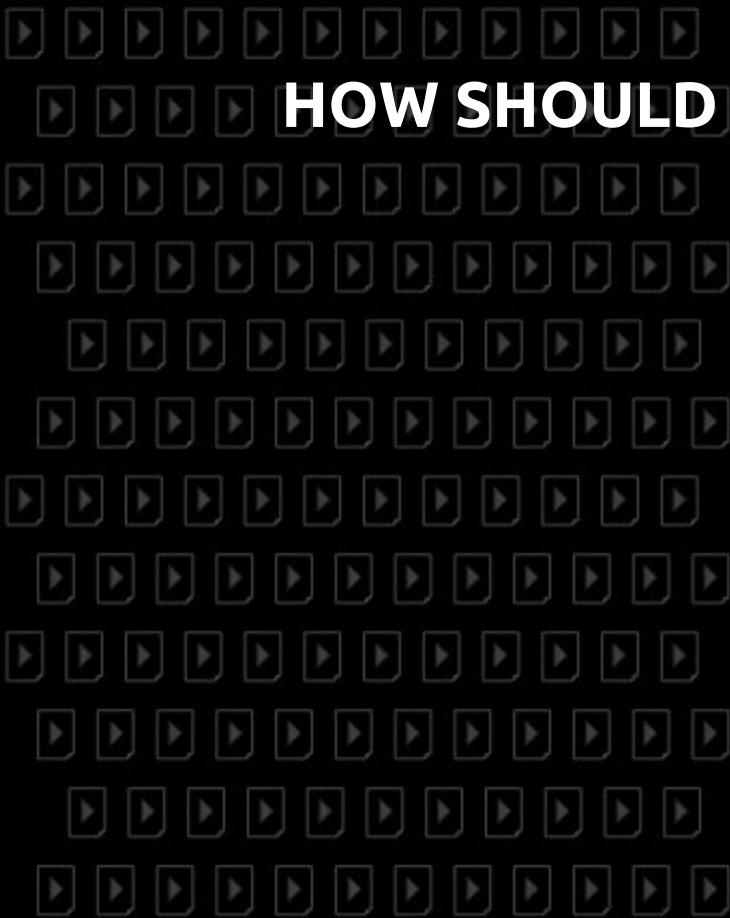
IS ONE DAY OF HISTORY ENOUGH?

TAKEAWAY

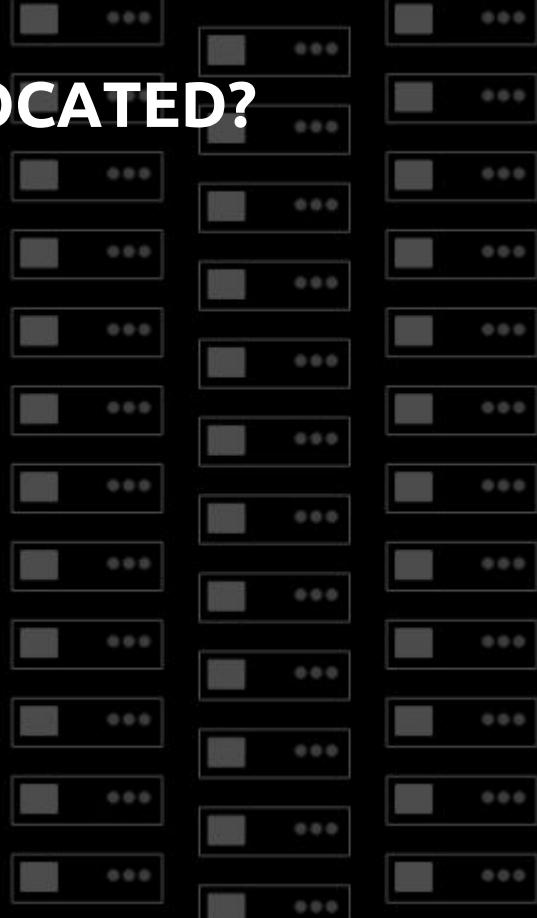
Weigh Recent Data Higher



EXPONENTIALLY WEIGHTED MOVING AVERAGE



HOW SHOULD CONTENT BE ALLOCATED?



HOW SHOULD CONTENT BE ALLOCATED?

The diagram illustrates the challenge of content distribution. On the left, a large number of small server icons (represented by rectangles with a play button) are arranged in a grid, labeled "MILLIONS OF FILES". A thick white arrow points from this side to the right. On the right, a smaller number of larger server icons (represented by rectangles with three dots) are also arranged in a grid, labeled "THOUSANDS OF SERVERS". This visual metaphor represents the need to efficiently map a vast number of individual file requests to a much smaller set of physical servers.

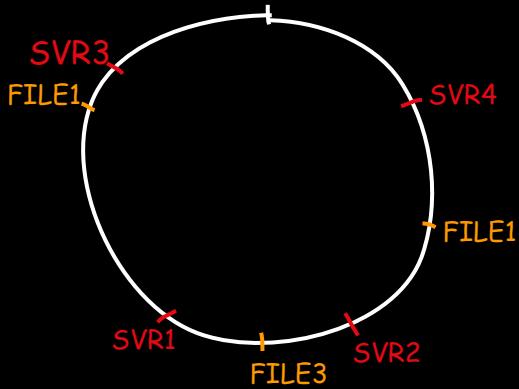
**MILLIONS
OF FILES**



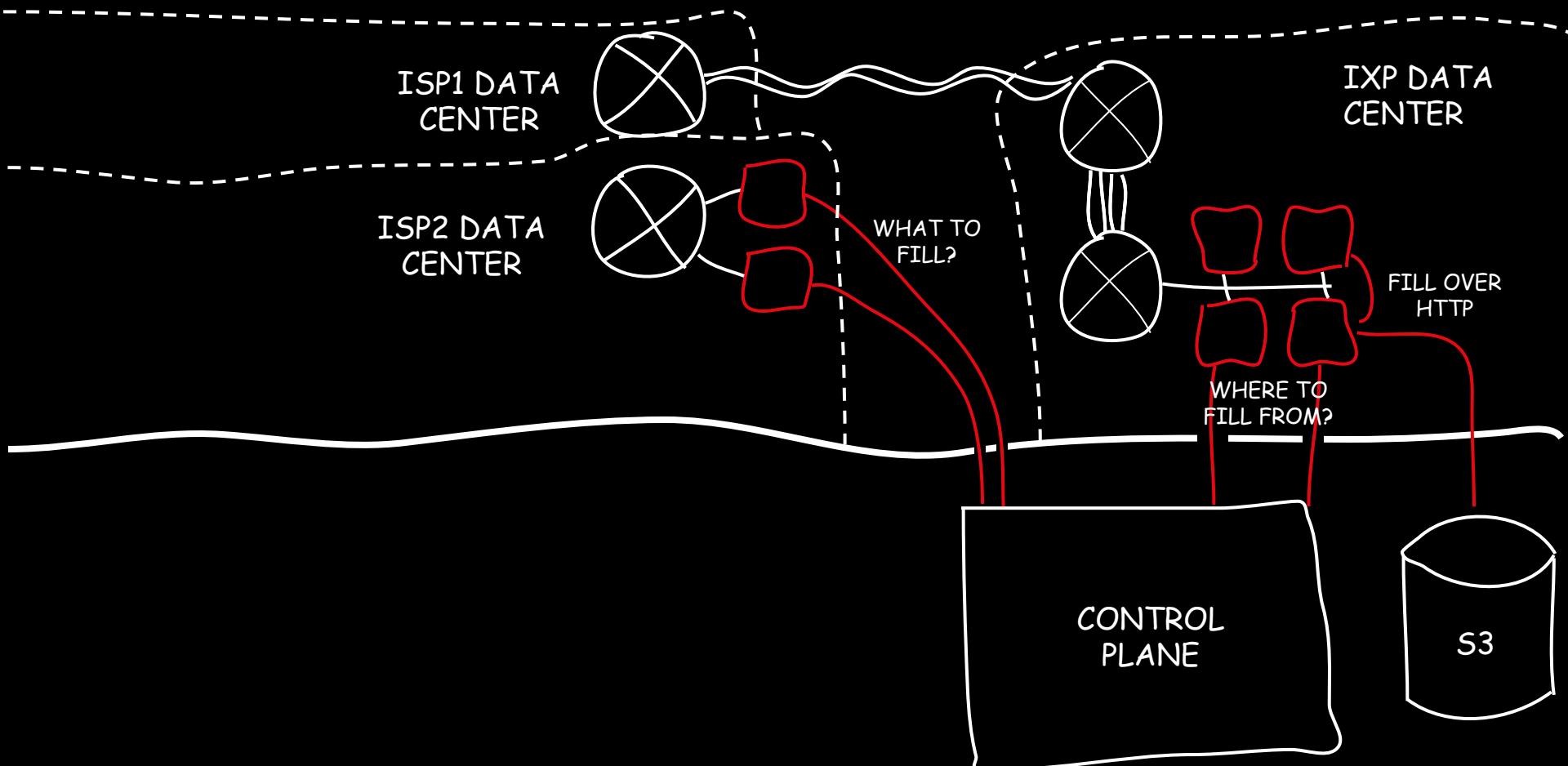
**THOUSANDS
OF SERVERS**

TAKEAWAY

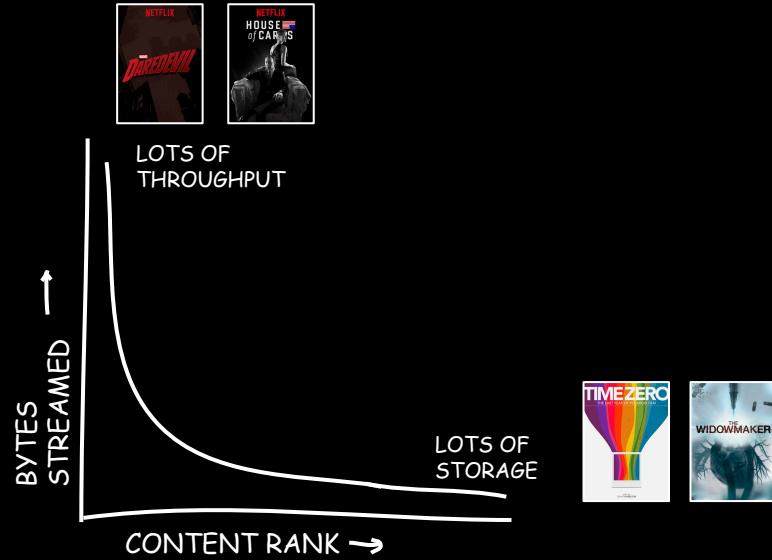
Consistent Hashing



**ALLOCATE MULTIPLE REPLICAS
RESILIENT TO CLUSTER CHANGES
REPEATABLE**



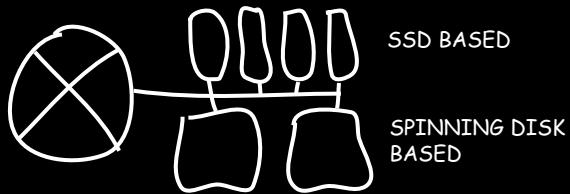
Load Distribution



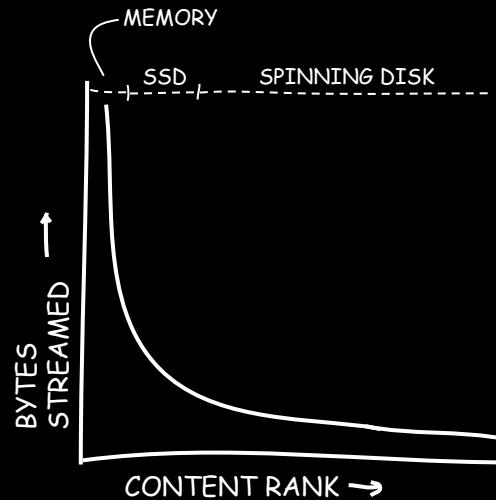
CONTENT WITH CONFLICTING CONSTRAINTS

TAKEAWAY

Tier Infrastructure

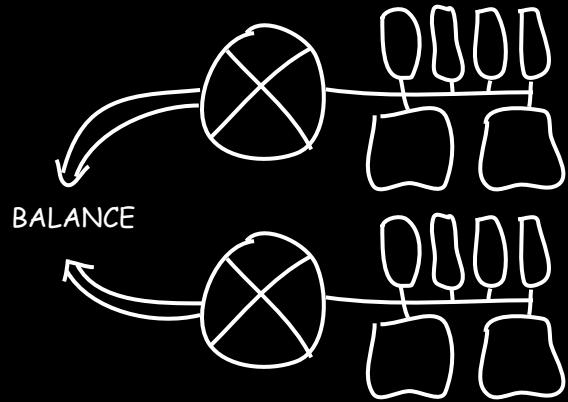


WITHIN CLUSTERS

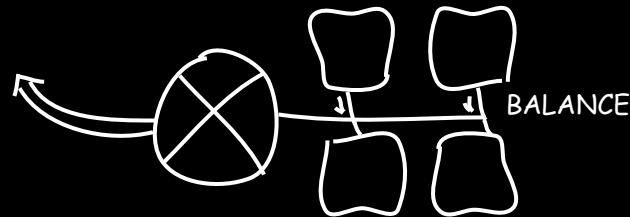


ON EACH SERVER

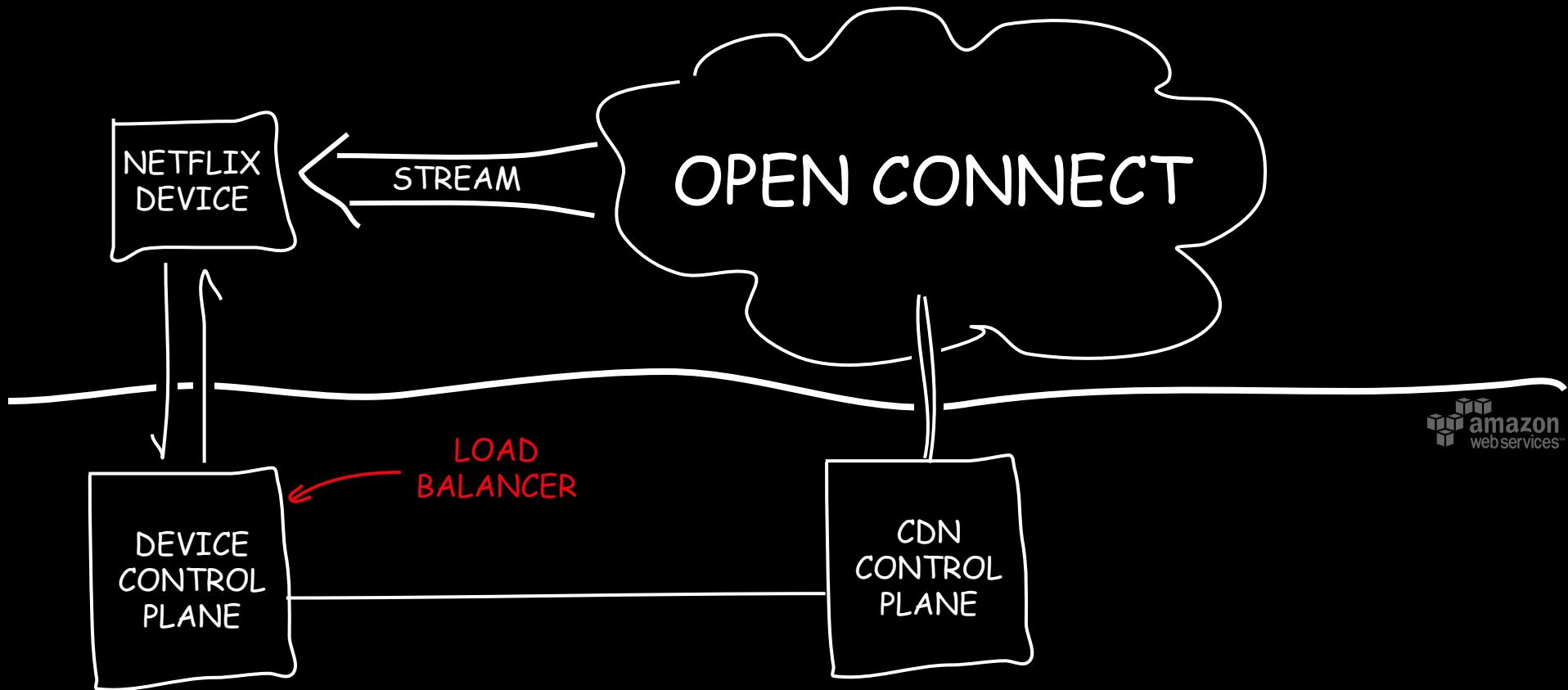
HOW DO WE BALANCE LOAD?



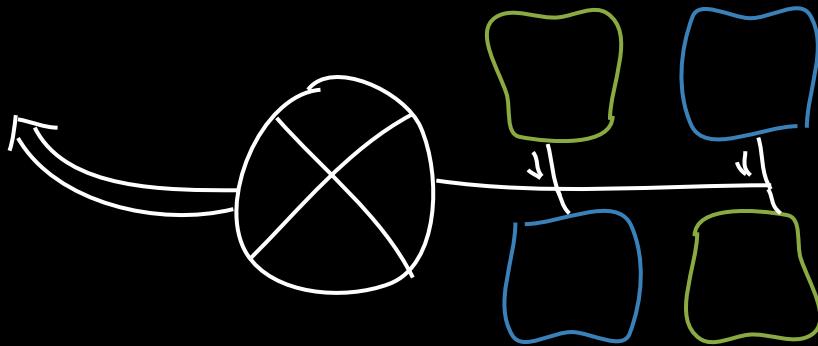
ACROSS EQUIDISTANT
CLUSTERS



ACROSS SERVERS
WITHIN CLUSTERS



HOW DO WE BALANCE LOAD?

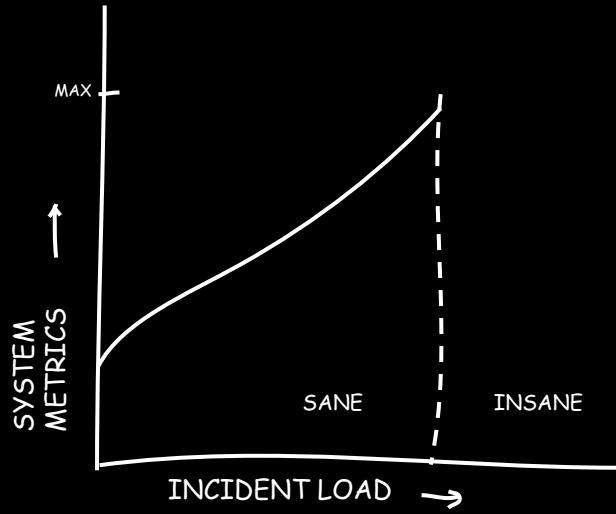


USING CONTENT DISTRIBUTION

**AND WHEN WE HAVE EQUALLY ATTRACTIVE
LOCATIONS TO SERVE FROM –**



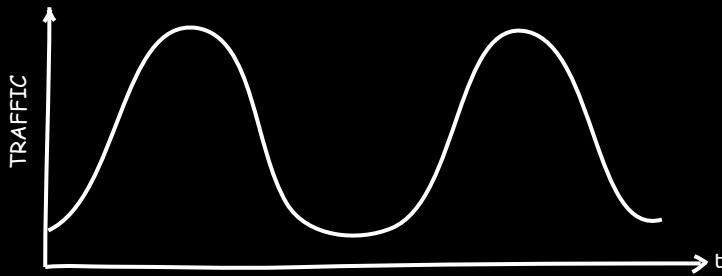
FLIP A COIN



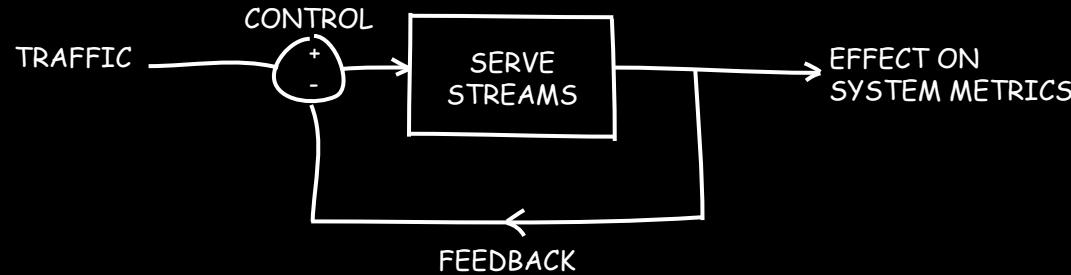
HOW DO WE LOAD SERVERS OPTIMALLY?



... AMIDST EVER CHANGING INTERNET WEATHER



... AND DAILY TRAFFIC EBBS AND FLOWS



WE INTRODUCE A FEEDBACK LOOP

TAKEAWAY | PID CONTROLLER

TAKEAWAY | PID CONTROLLER

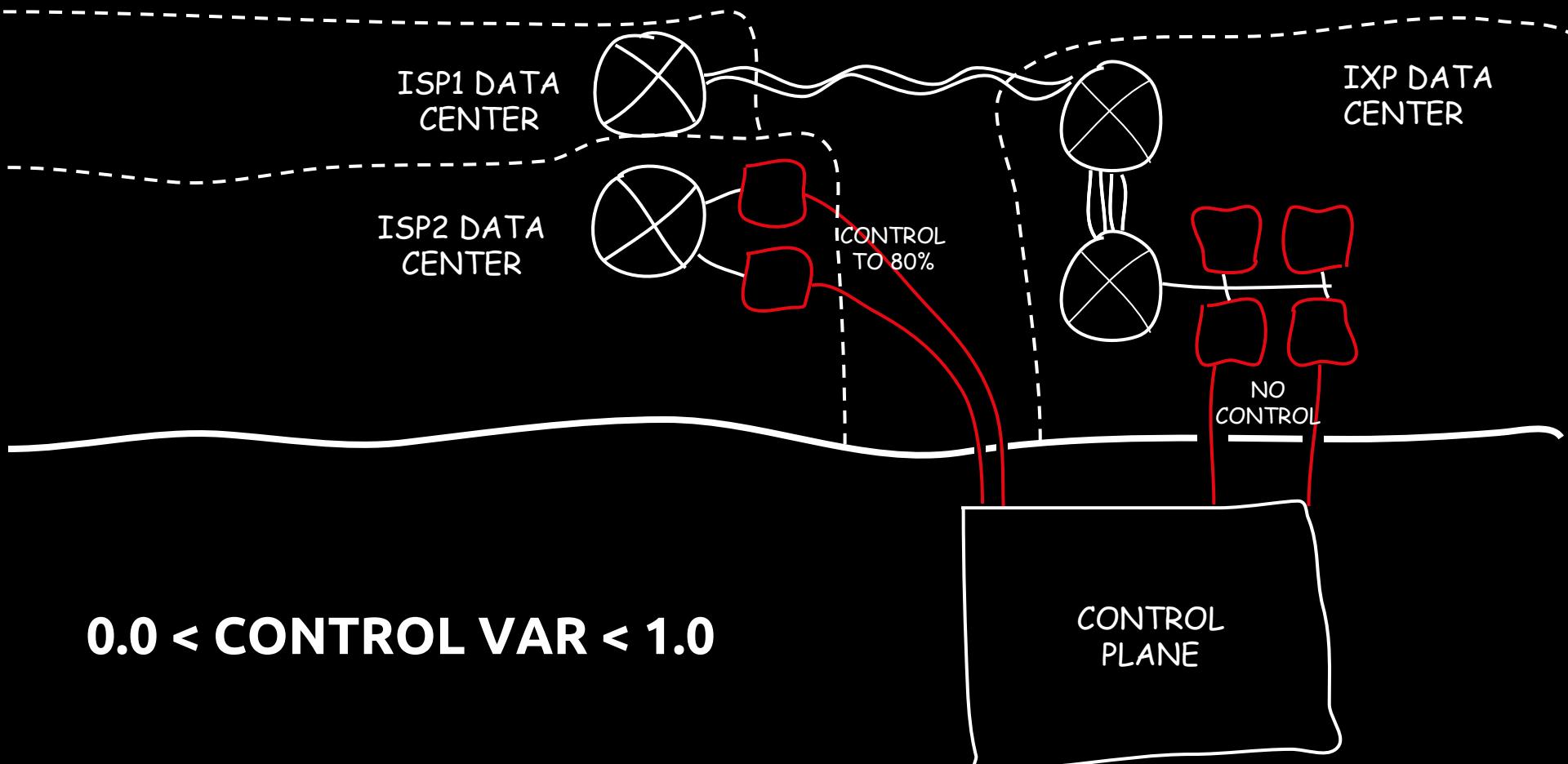
Process Variable	Current RPM
Set Point	Desired RPM
Control Variable	Input Voltage

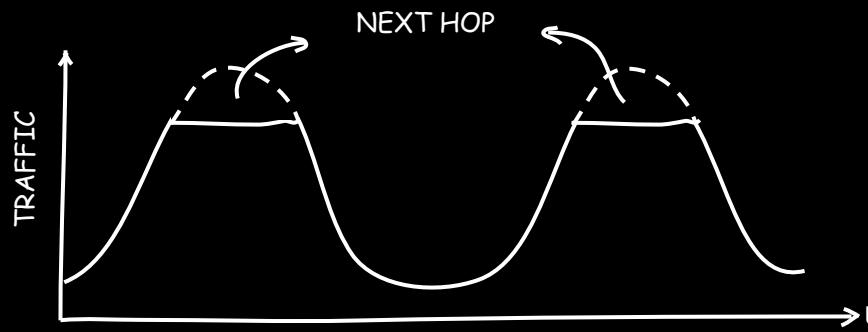
↑
DC MOTOR

TAKEAWAY | PID CONTROLLER

Process Variable	Current RPM	System Metrics
Set Point	Desired RPM	System Metrics Max
Control Variable	Input Voltage	Controlled Traffic

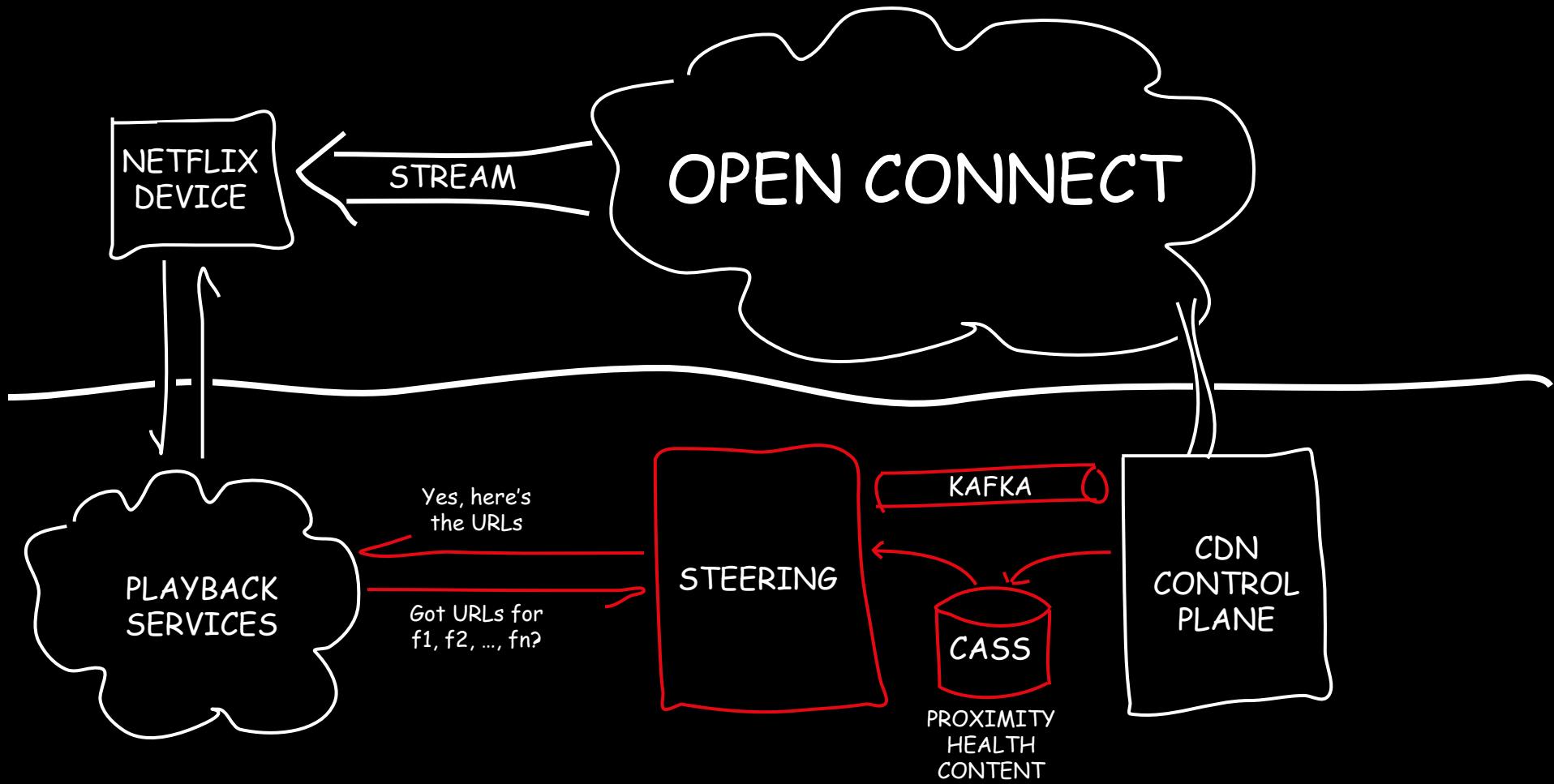
LOADING SERVERS





TRAFFIC SHIFTS TO NEXT HOP LOCATION

Steering

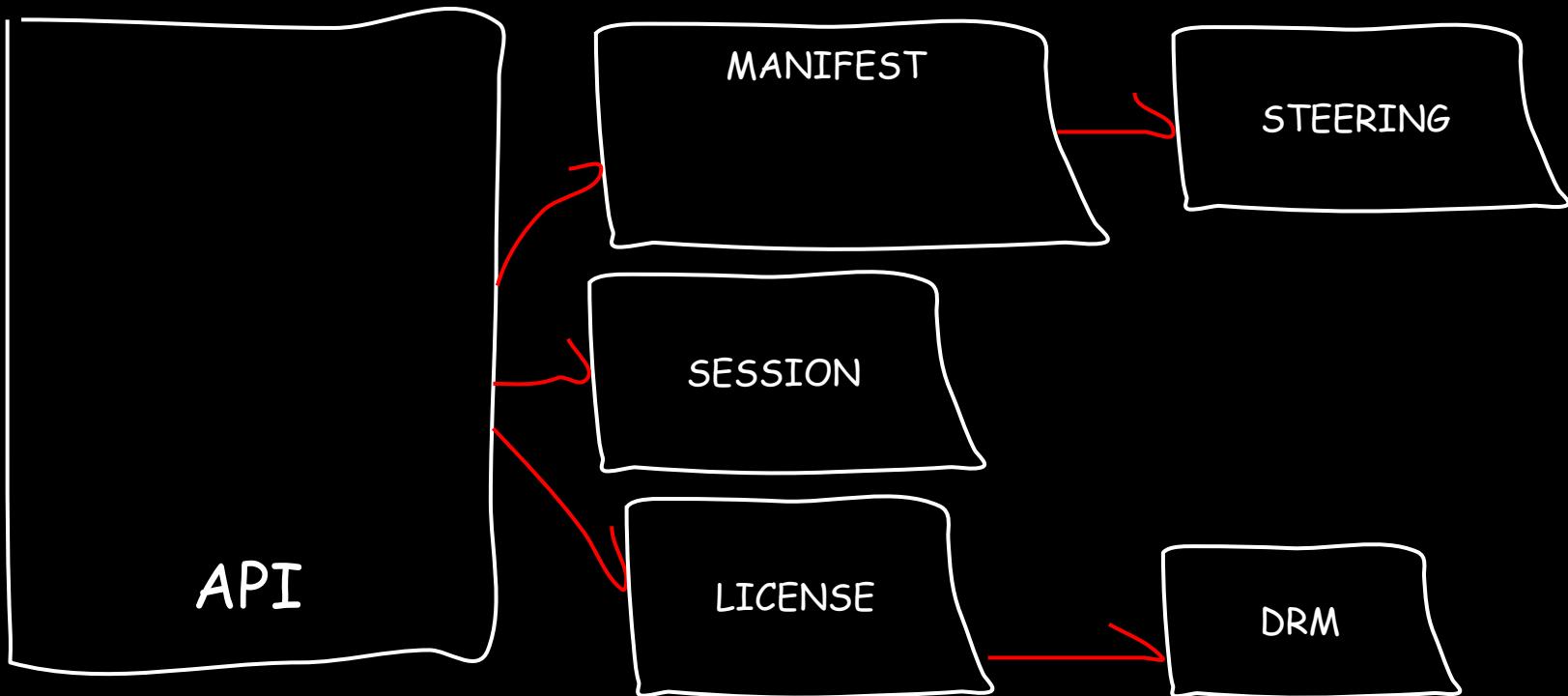


A photograph of four women of different ethnicities and styles standing close together. From left to right: a woman with short, spiky reddish-brown hair; a woman with dark skin and short black hair; a woman with blonde hair and bangs; and a woman with long dark hair wearing sunglasses. They are all looking directly at the camera with different expressions, from neutral to slightly surprised.

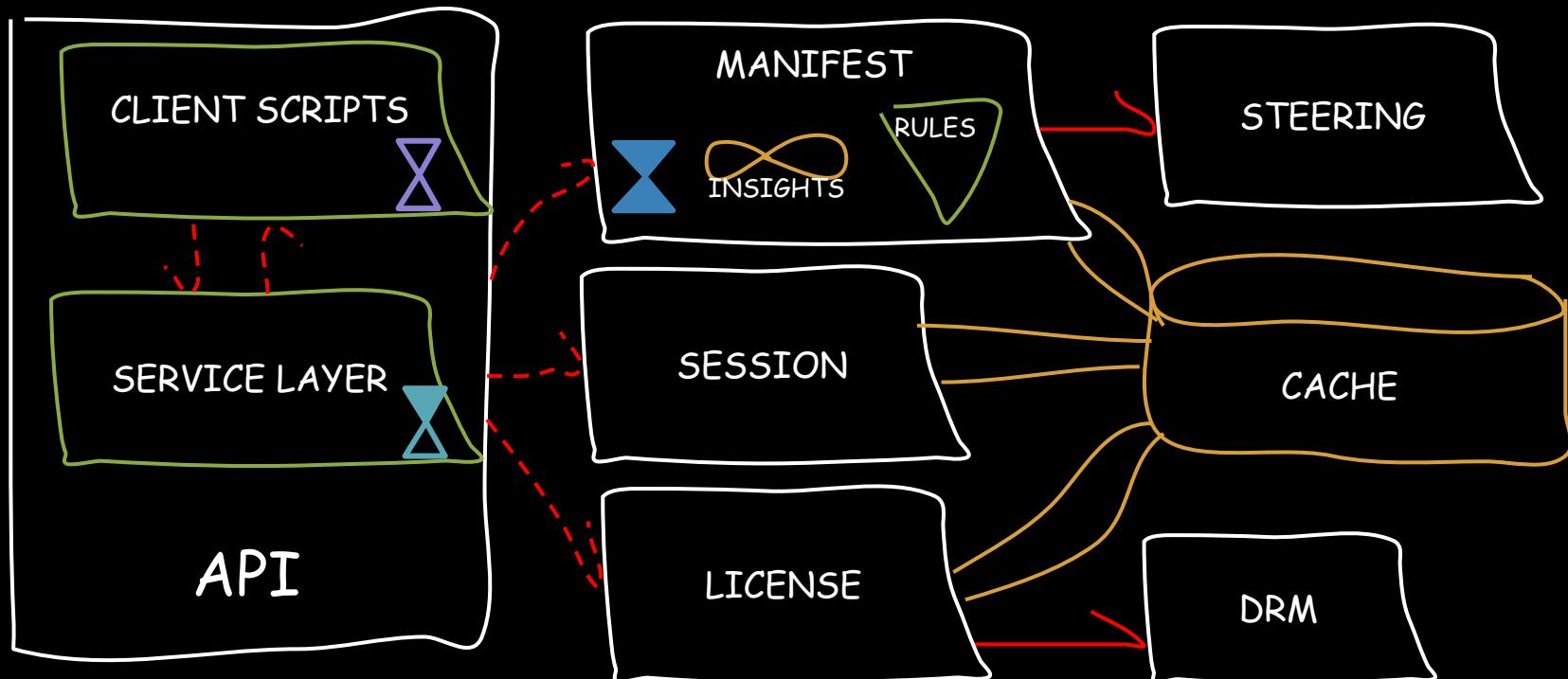
Architecture Evolution

5 CHALLENGES

How did we evolve from here...



...to here.



5 SOLUTIONS

CHALLENGE | High dimensionality

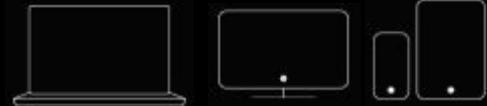
TITLE



COUNTRY



DEVICE



CUSTOMER



- | | |
|------------------------------------------|------------------------------------|
| <input type="radio"/> Dansk | <input type="radio"/> Norsk bokmål |
| <input type="radio"/> Deutsch | <input type="radio"/> Português |
| <input checked="" type="radio"/> English | <input type="radio"/> Suomi |
| <input type="radio"/> Español | <input type="radio"/> Svenska |
| <input type="radio"/> Français | <input type="radio"/> 日本語 |
| <input type="radio"/> Nederlands | |

NETWORK



Broadband - wired or wifi
Cellular - Edge, 3G, LTE, ...

CONNECTIONS

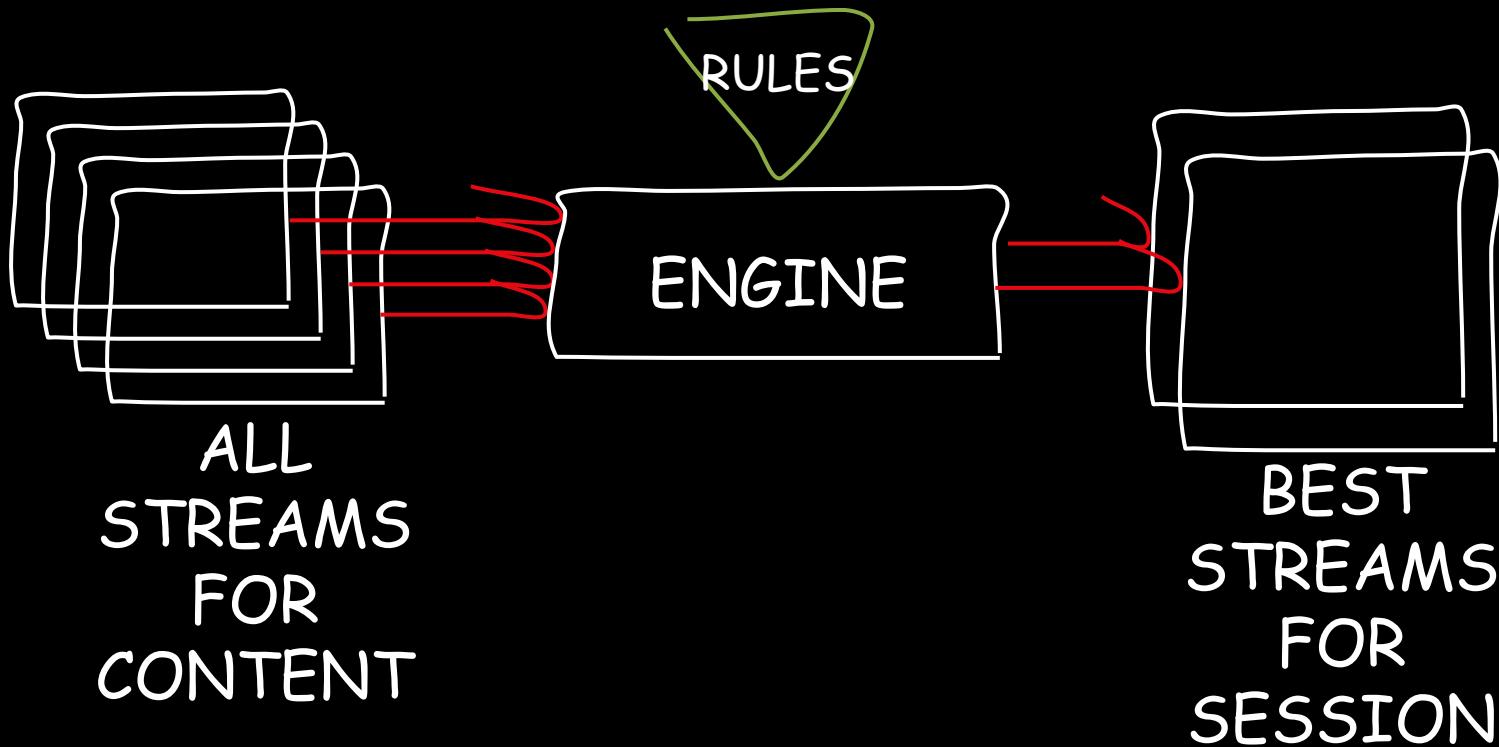




Loading

**How can we quickly alter the playback
experience in a targeted manner?**

USE CASE | Stream Filtering

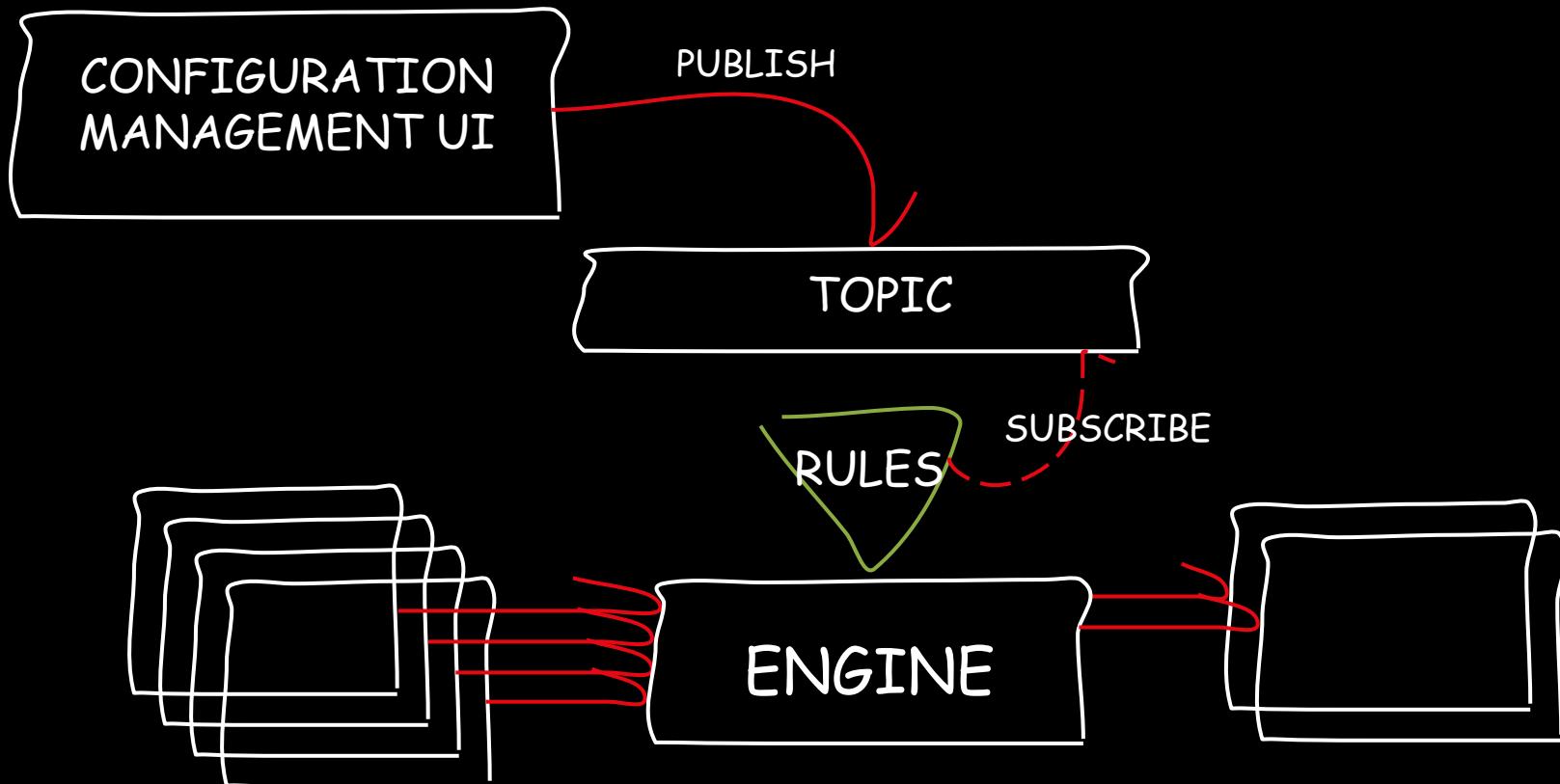


EXAMPLE RULES

```
<item identity="1.0.76">
    <description>Filter out video bitrates > 1050 for my device.</description>
    <dimension type="ESN">NFCDCH-MC-12345</dimension>
    <dimension type="DL_PROFILE_TYPE">VIDEO</dimension>
    <dimension type="DL_BITRATE" operation="GT">1050</dimension>
</item>

<item identity="1.0.75">
    <description>Filter out English audio description for my device.</description>
    <dimension type="ESN">NFCDCH-MC-12345</dimension>
    <dimension type="DL_PROFILE_TYPE">AUDIO</dimension>
    <dimension type="DL_AUDIO_TYPE">Assistive</dimension>
    <dimension type="DL_AUDIO_LANGUAGE">en</dimension>
</item>
```

UPDATING RULES

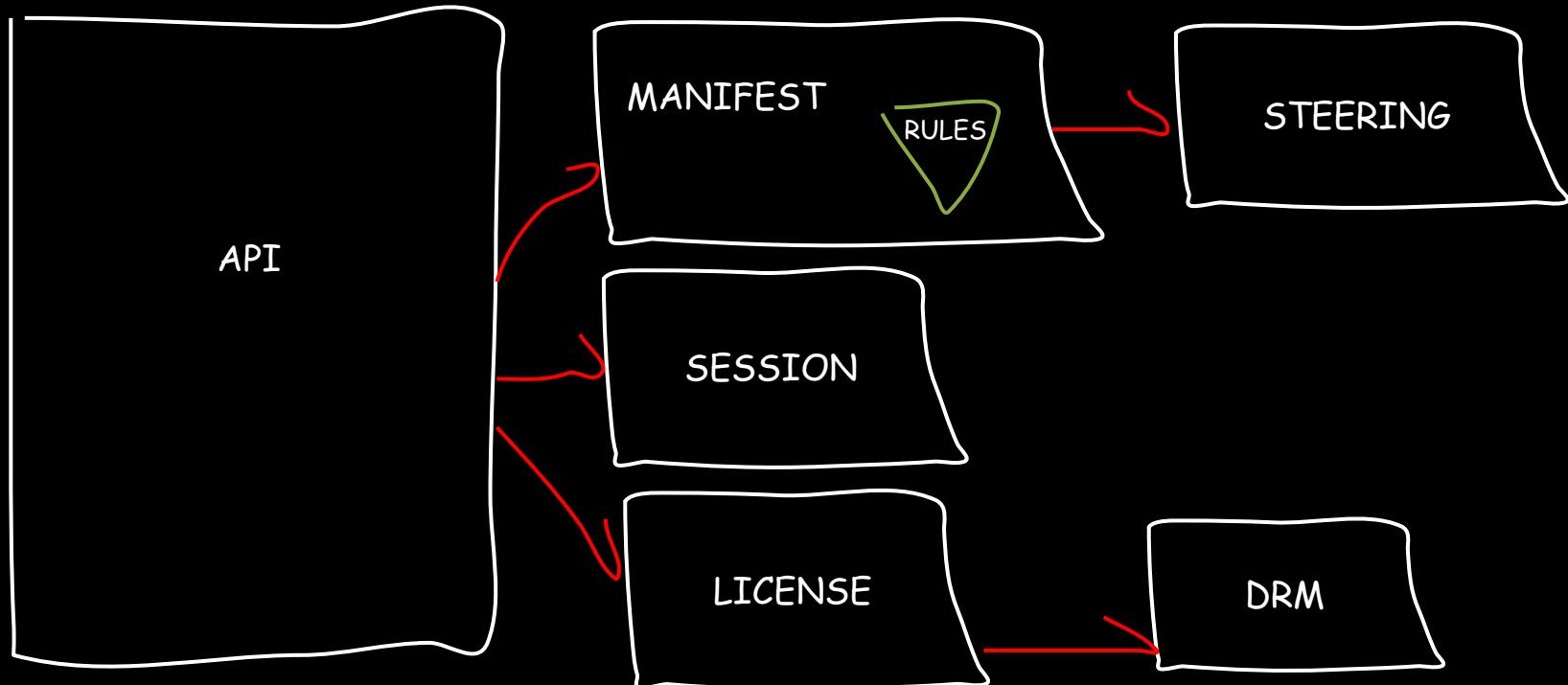






TAKEAWAY

Dynamic Business Rules



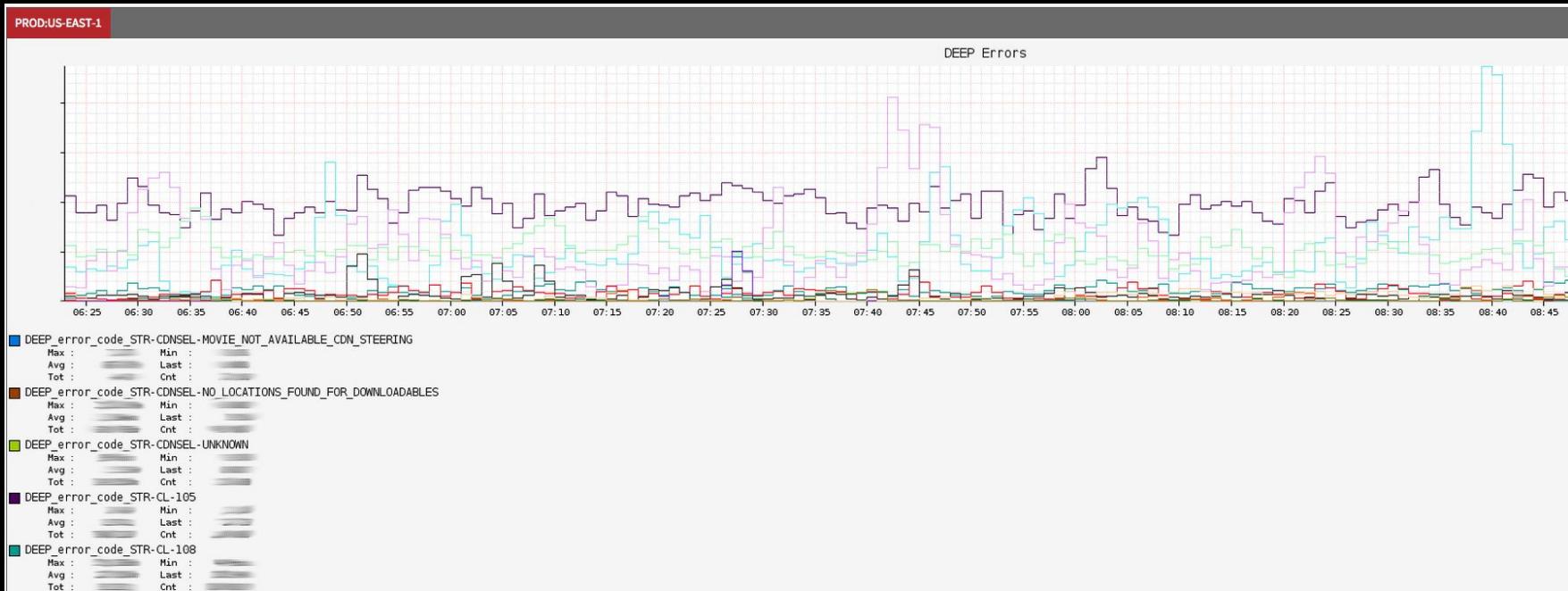
CHALLENGE

Pinpoint what is broken



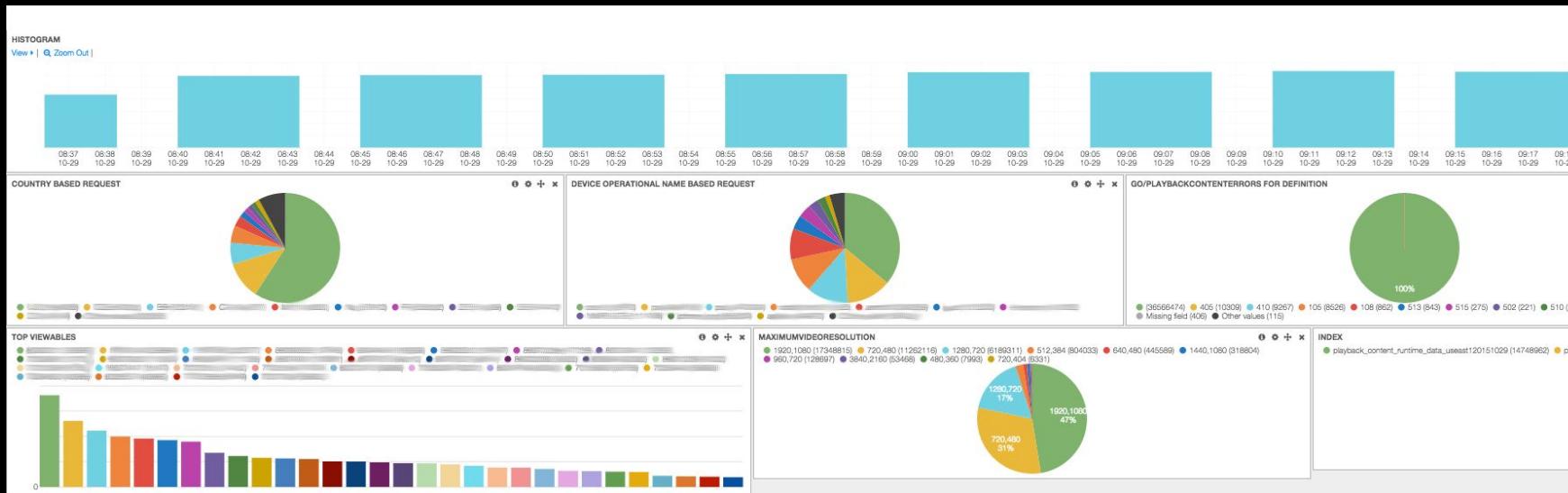
3:00 AM : Pager goes off

METRICS AND ALERTING



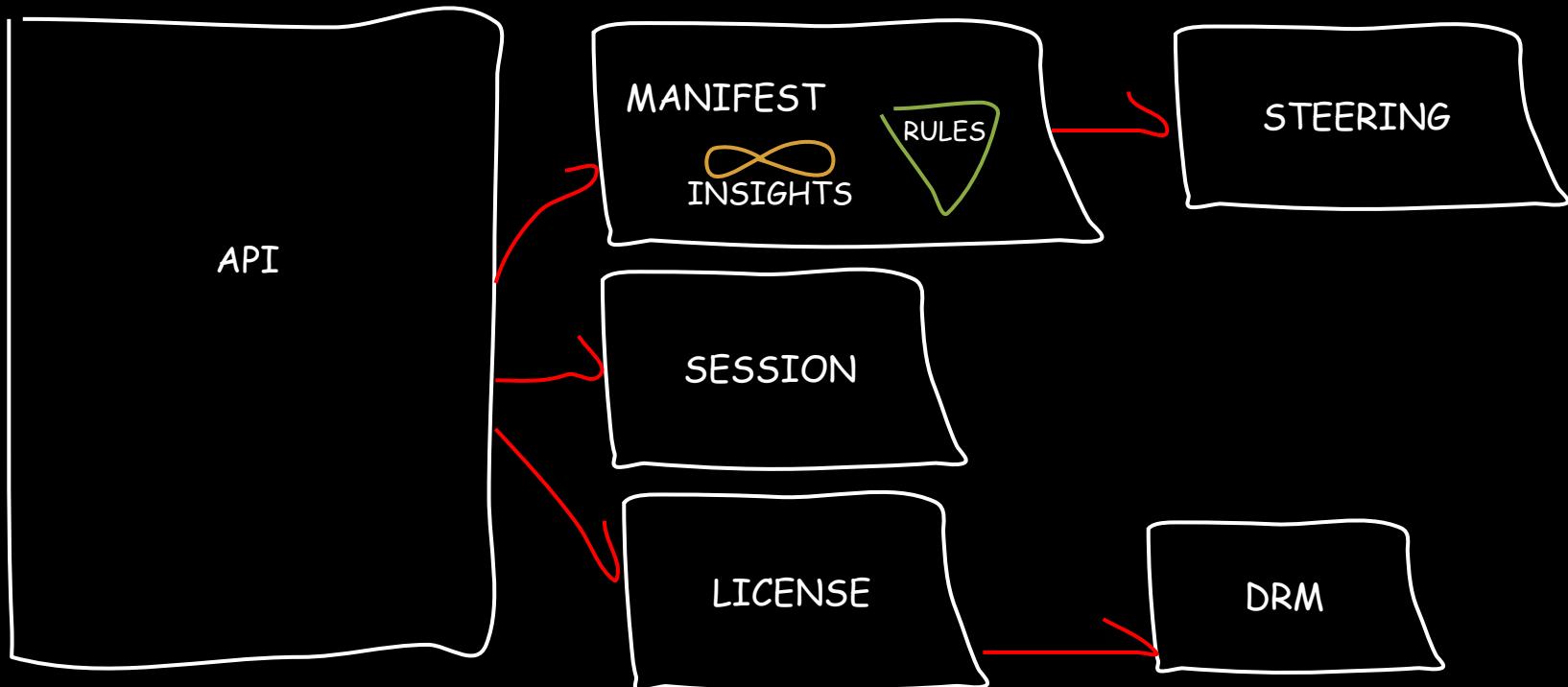
**OK...error code 105 is elevated. But
why?**

Indexed Logging



TAKEAWAY

Detailed Domain Insights



Continue Watching for Haley



Popular on Netflix



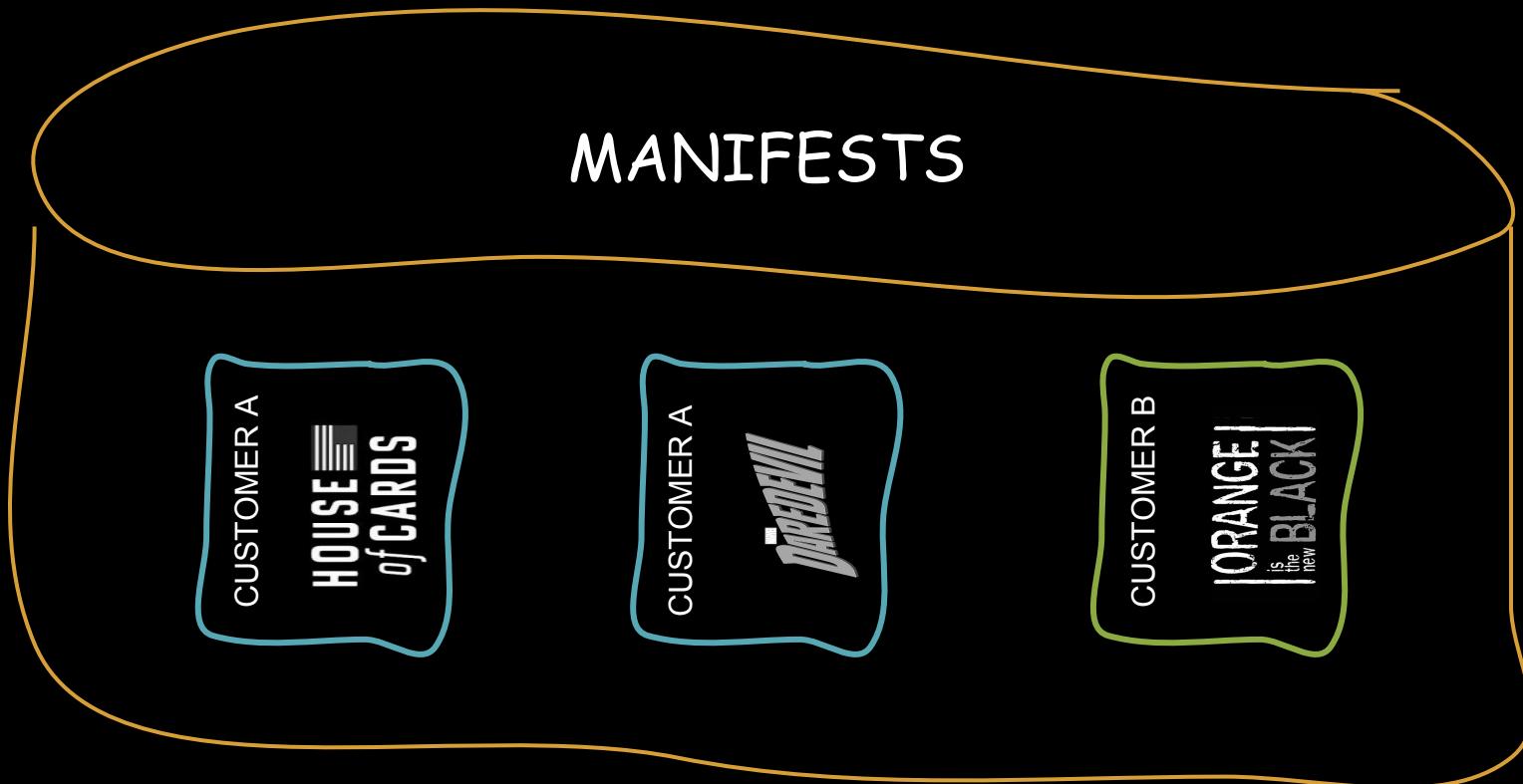
Trending Now



CHALLENGE | Large amount of state

**How can we enable faster UIs and
low-end devices?**

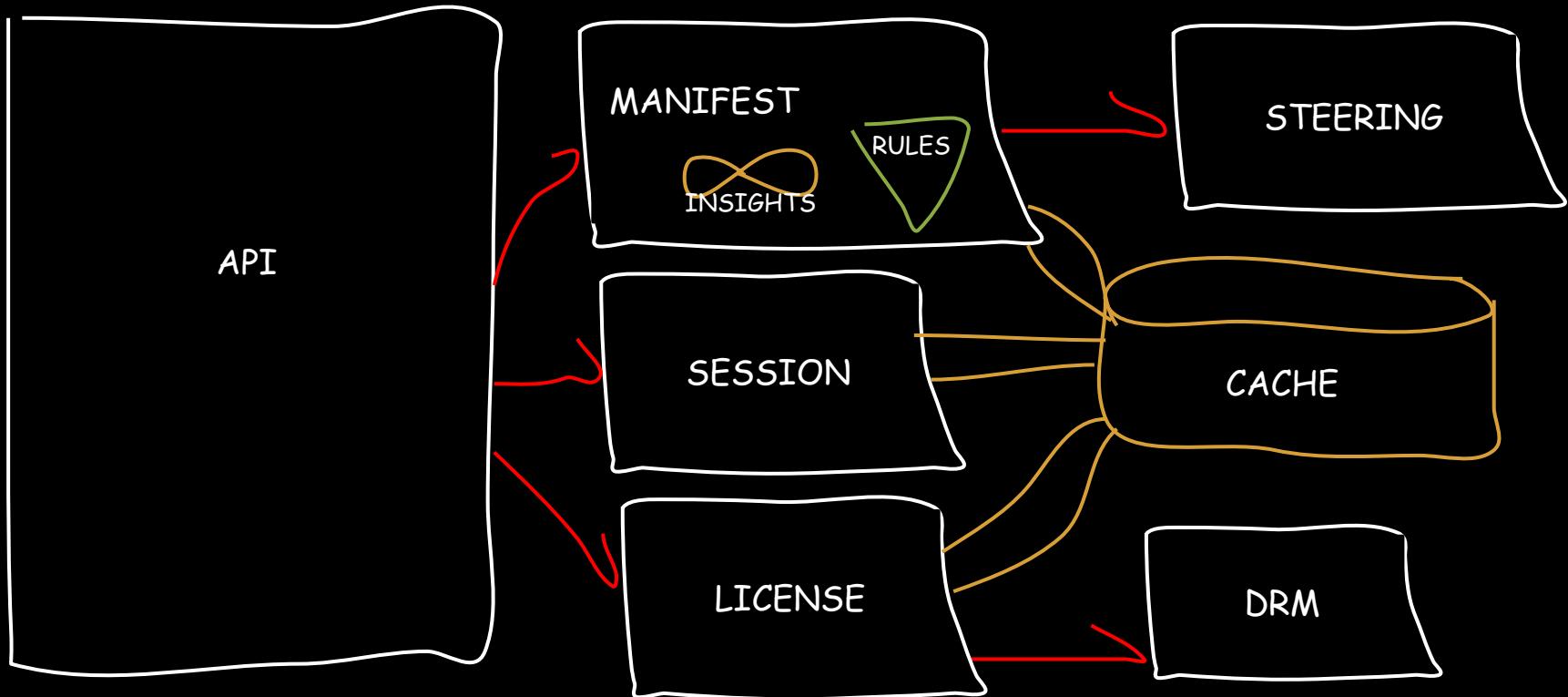
We introduced a server-side caching tier



Watch out for resiliency issues!!



TAKEAWAY | Reduce client state



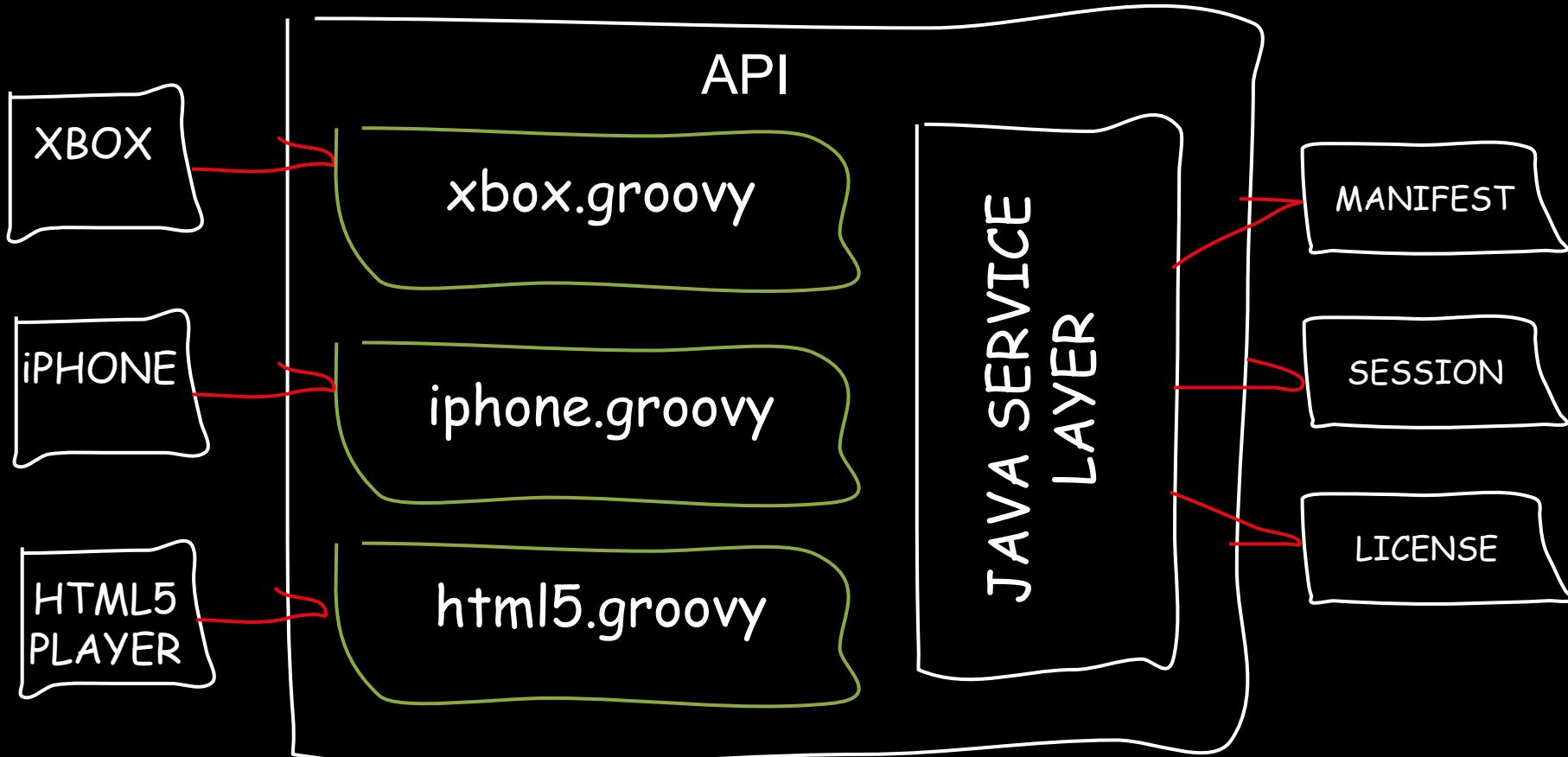
CHALLENGE | Managing device protocols



Square peg, round hole, CC BY-SA, Simon Law 2006, Flickr

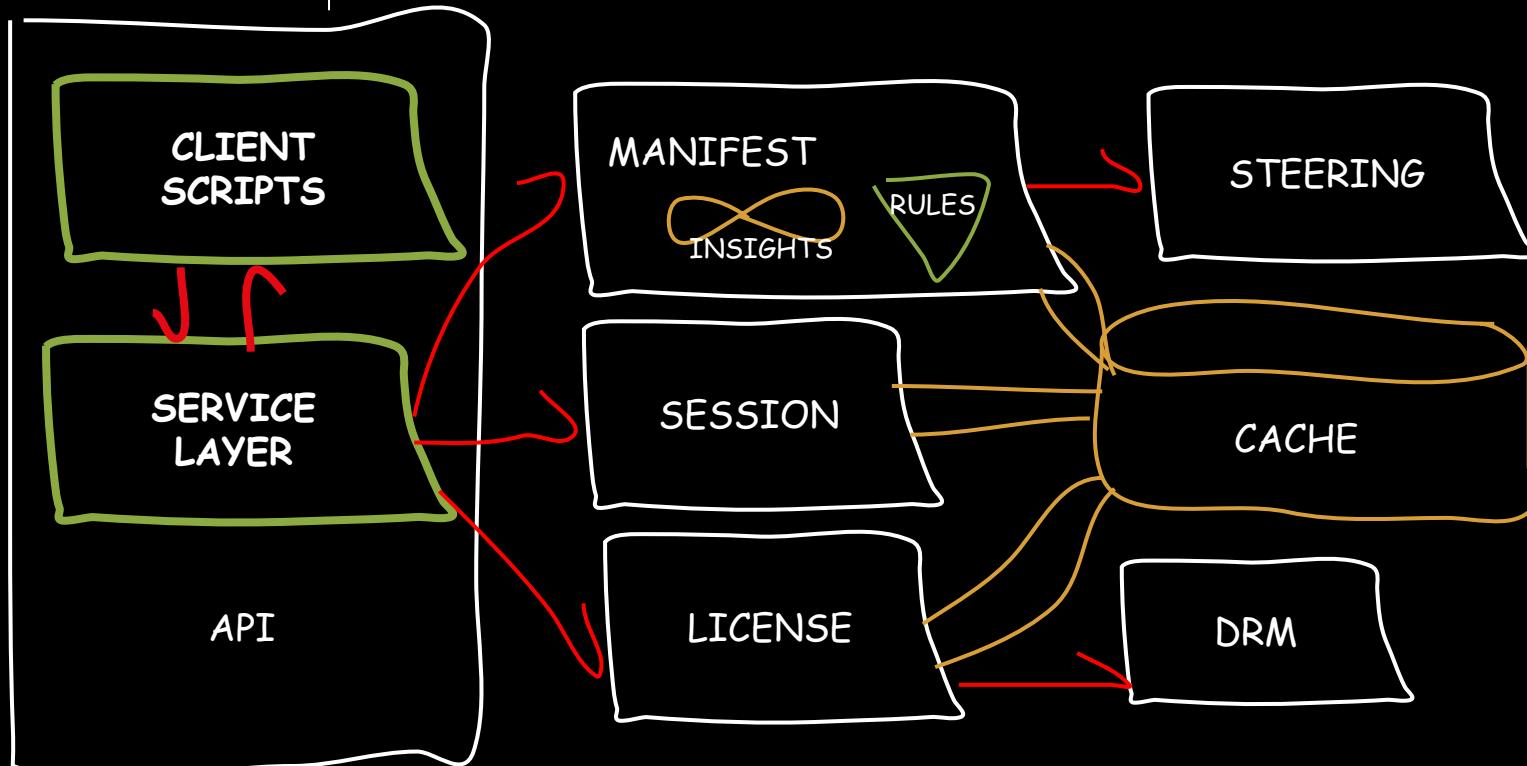
**Can we allow devices to define their
own protocols?**

DYNAMIC SCRIPTING PLATFORM



TAKEAWAY

Client-driven protocols



CHALLENGE | Enabling high-velocity innovation



How can we expose new data with the least amount of churn?

API



Stream'

- Bitrate
- Dynamic Data

Works
both
ways!

MANIFEST



Stream

- Bitrate
- Framerate
- Dynamic Data

This works from API:

- `stream.getBitrate()`
- `stream.getDynamicData().get("FRAME_RATE")`

CLIENT SCRIPT



Stream"

- Dynamic Data

Works
both
ways!

API



Stream'

- Bitrate
- Dynamic Data

Works
both
ways!

MANIFEST



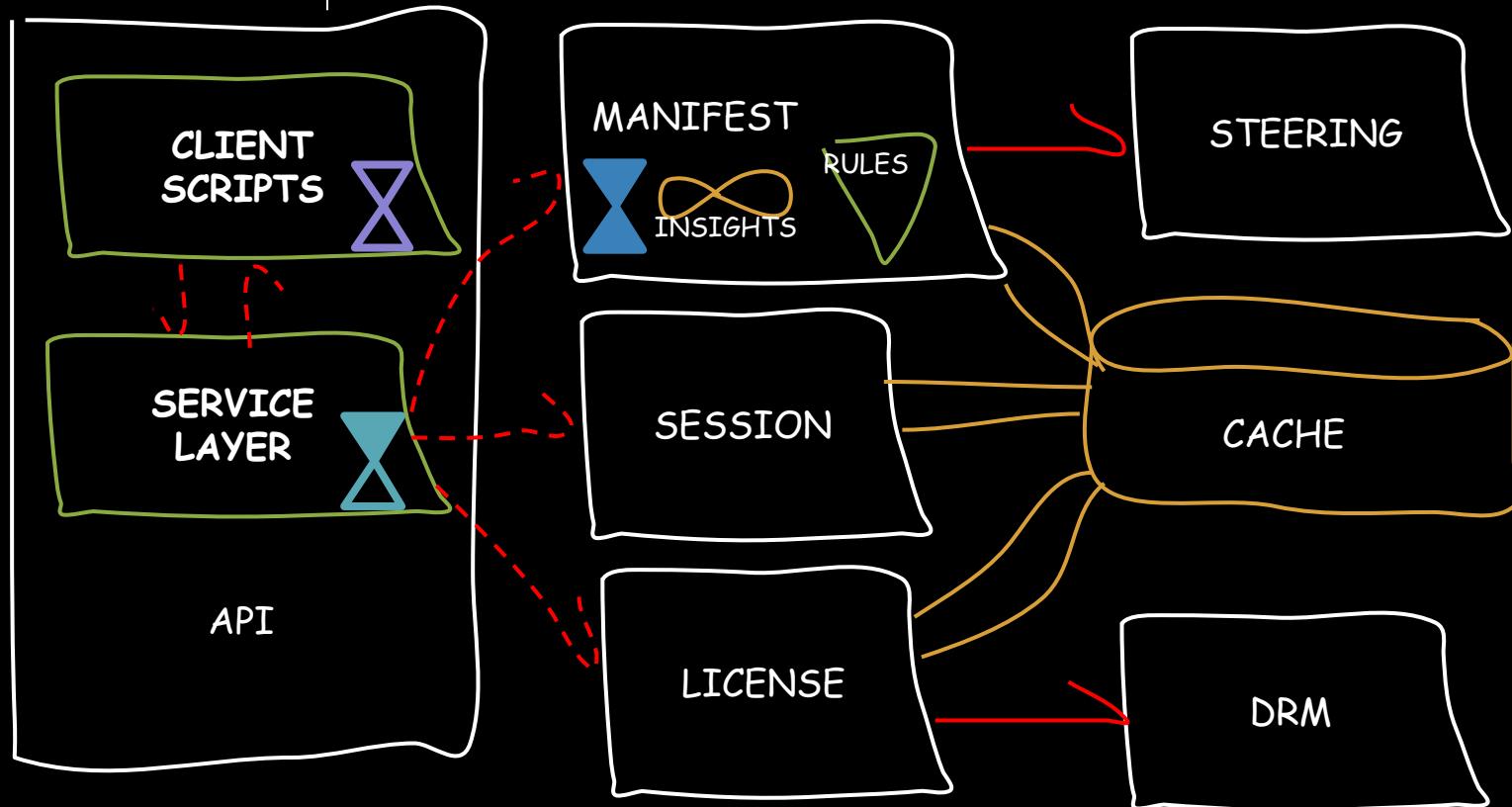
Stream

- Bitrate
- Framerate
- Dynamic Data

This works from CLIENT SCRIPT!

- `stream.getDynamicData().get("BIT_RATE")`
- `stream.getDynamicData().get("FRAME_RATE")`

TAKEAWAY | Data pass-thru



TAKEAWAYS

- BGP based proximity
- Tiered Infrastructure
- PID Controller
- EWMA for historical data
- Consistent Hashing
- Dynamic business rules
- Detailed domain insights
- Reduce client state
- Client-driven protocols
- Data pass-thru

TAKEAWAYS

- BGP based proximity
- Tiered Infrastructure
- PID Controller
- EWMA for historical data
- Consistent Hashing
- Dynamic business rules
- Detailed domain insights
- Reduce client state
- Client-driven protocols
- Data pass-thru

Haley Tucker Mohit Vora
@hwilson1204 @mohitvora

Questions?

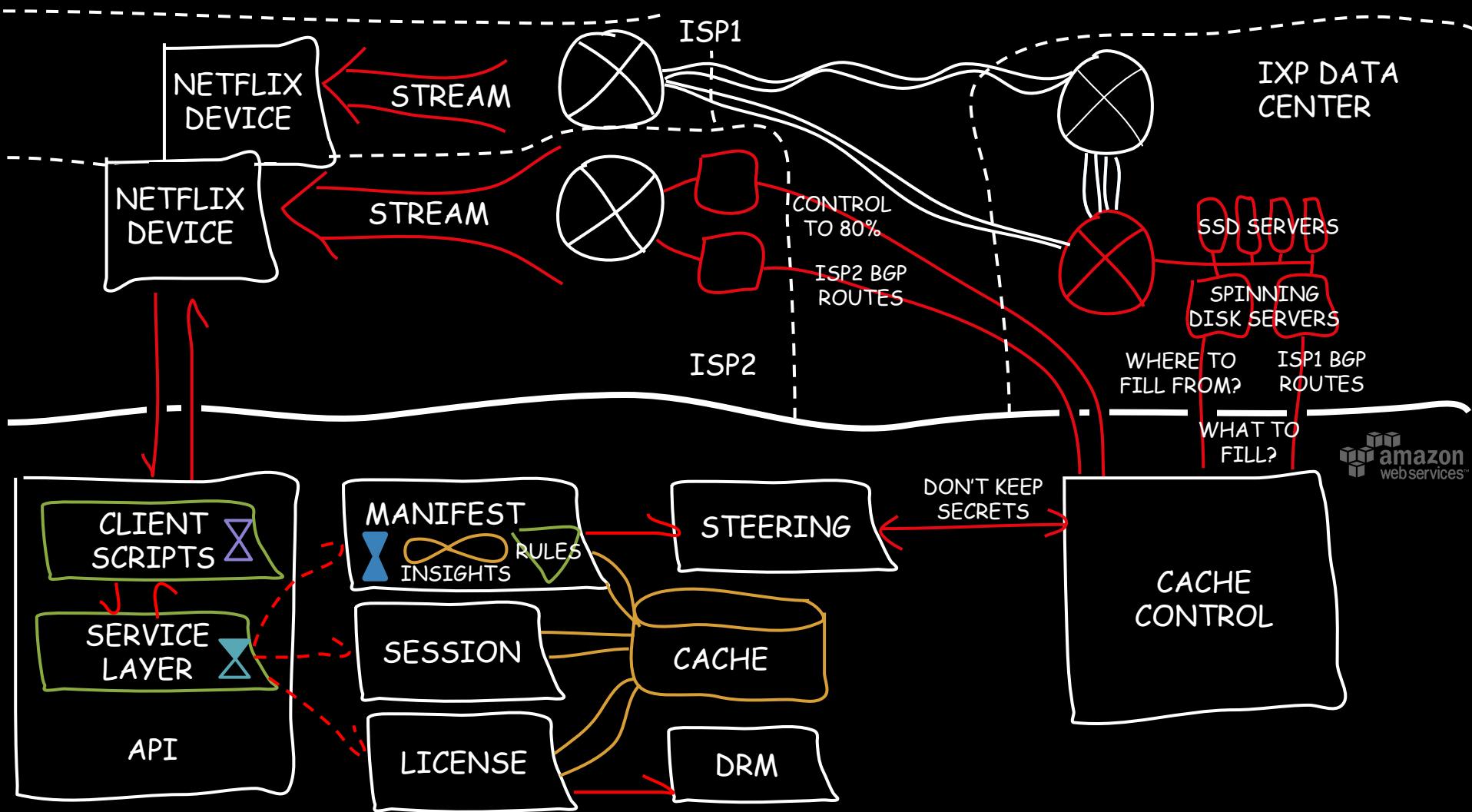


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- Image from <https://www.flickr.com/photos/thatguyfromcchs08/2300190277>, Image is dimmed, <https://creativecommons.org/licenses/by/2.0/>.
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