
AWS
re:Invent
NOV. 28 – DEC. 2, 2022 | LAS VEGAS, NV

CMP316

Solving problems in TV broadcasting and production with HPC and ML

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Agenda

The challenge in broadcast environments

What latency is – and how much it matters – in different contexts

The Elastic Fabric Adapter (EFA) and why we needed to invent it

The emergence of AWS Cloud Digital Interface (CDI)

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Audience participation

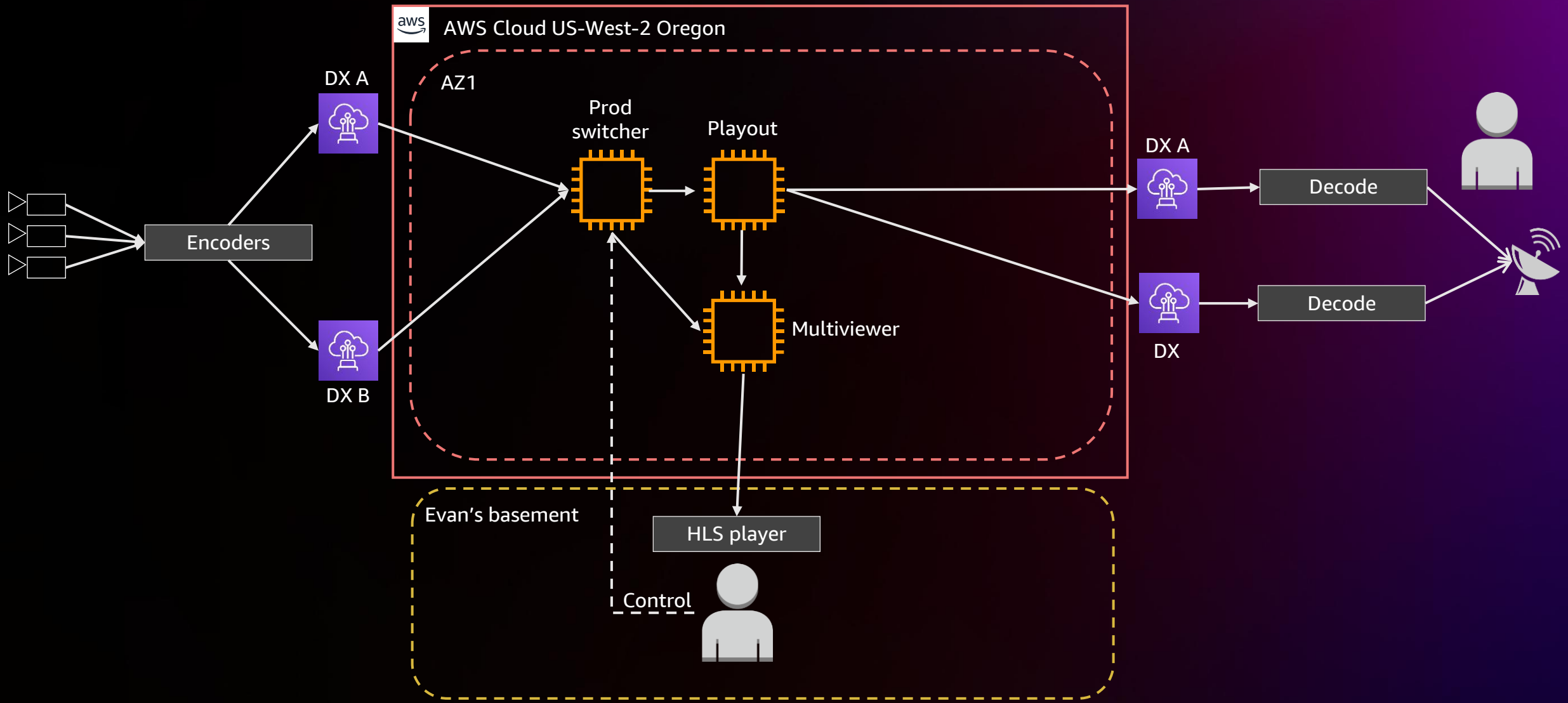
This isn’t a slide show

Pictures help (they tell a thousand words), but **questions from you** will help to shape the discussion today

Please interrupt us a lot ☺

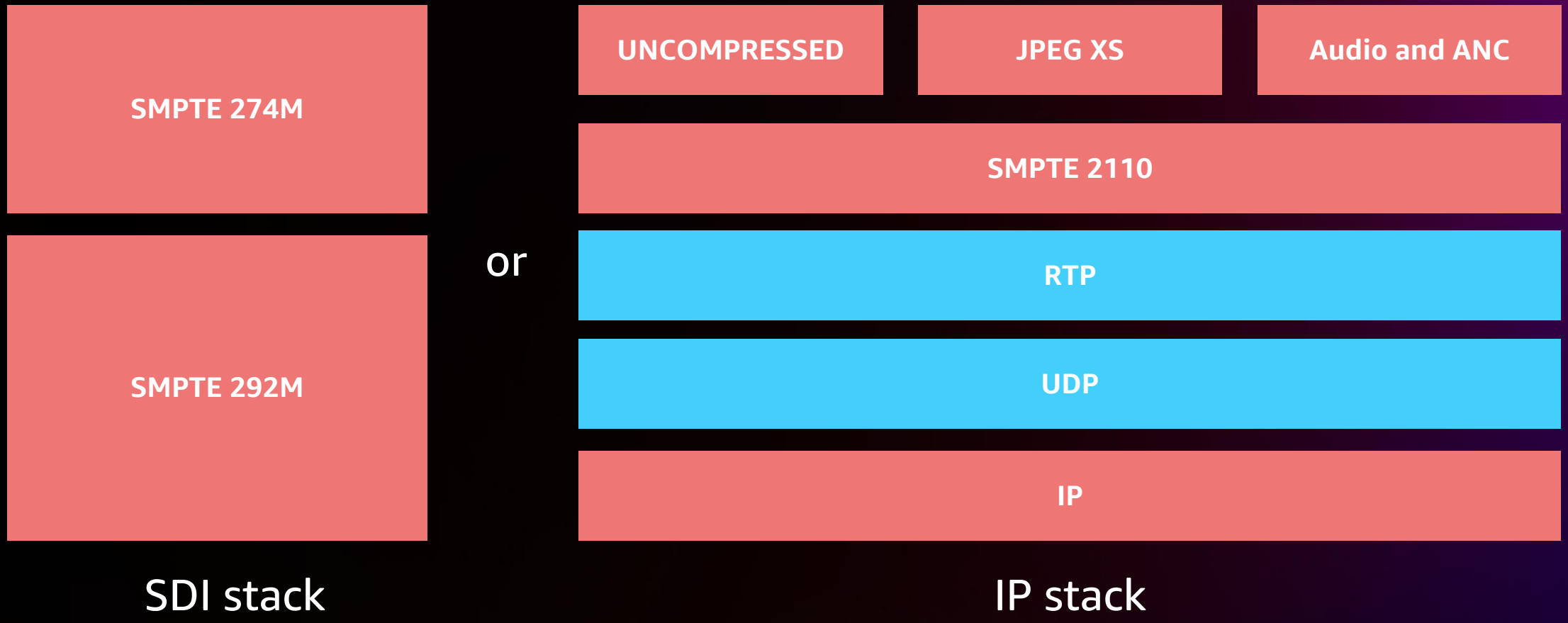
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Remote live production and playout



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A little backstory



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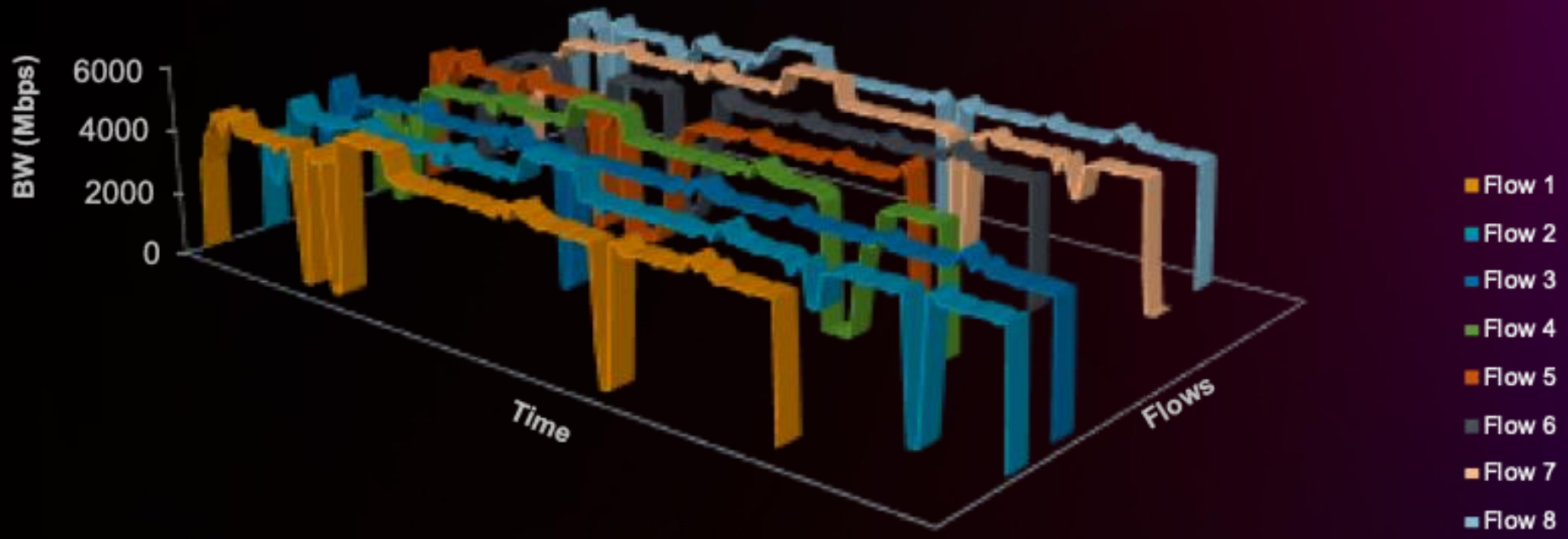
Requirements for uncompressed video



- Move **uncompressed** media in the cloud, **reliably**
- Expected latency – **less than a frame**
- Must function reliably up to 4Kp60

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UDP in the cloud



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Meanwhile in HPC and machine learning

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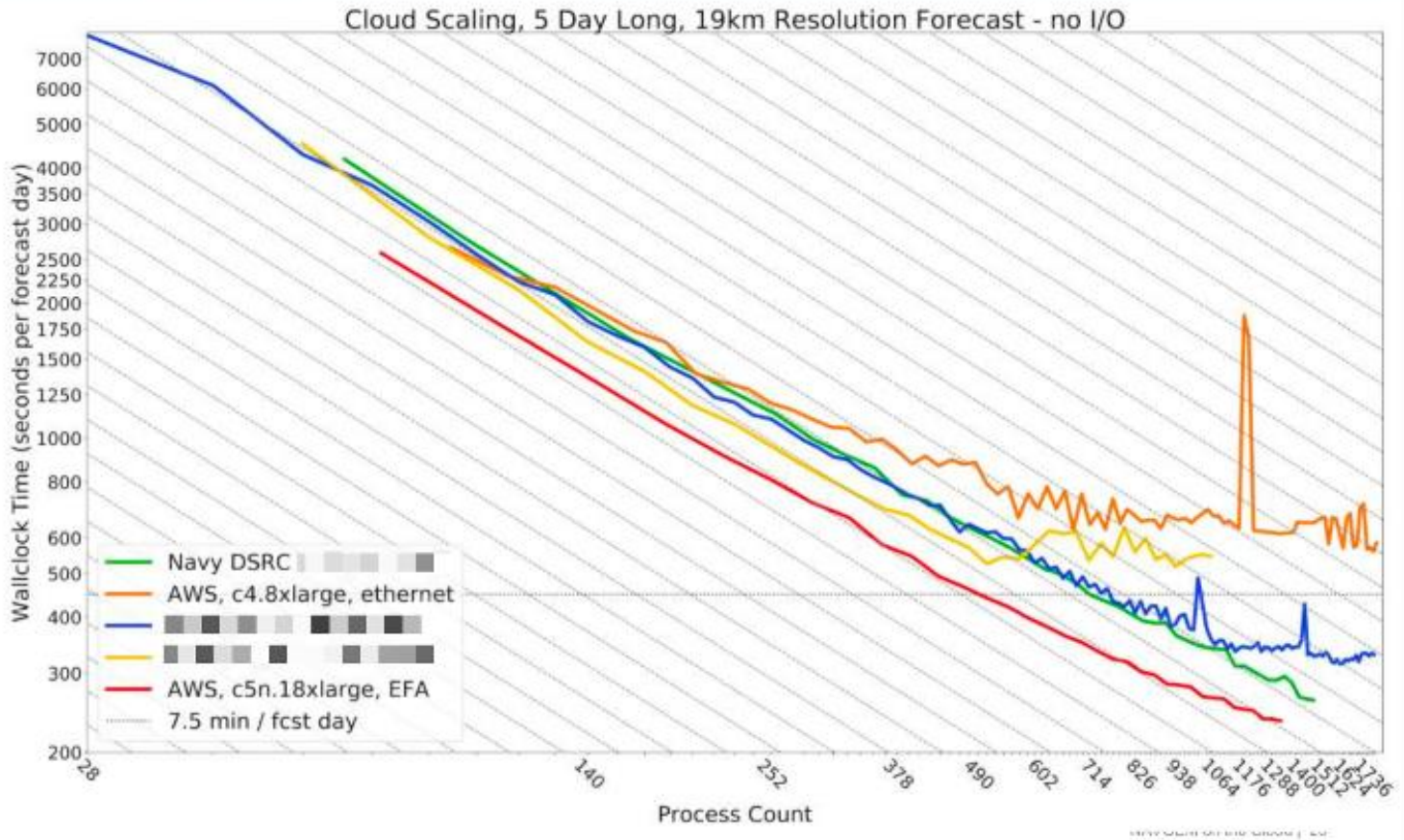
Weather simulation is very hard to scale

U.S. NAVAL RESEARCH LABORATORY

High Resolution Forecast: Performance - Comparison

Performance Improvements:
C5n with EFA on AWS EC2

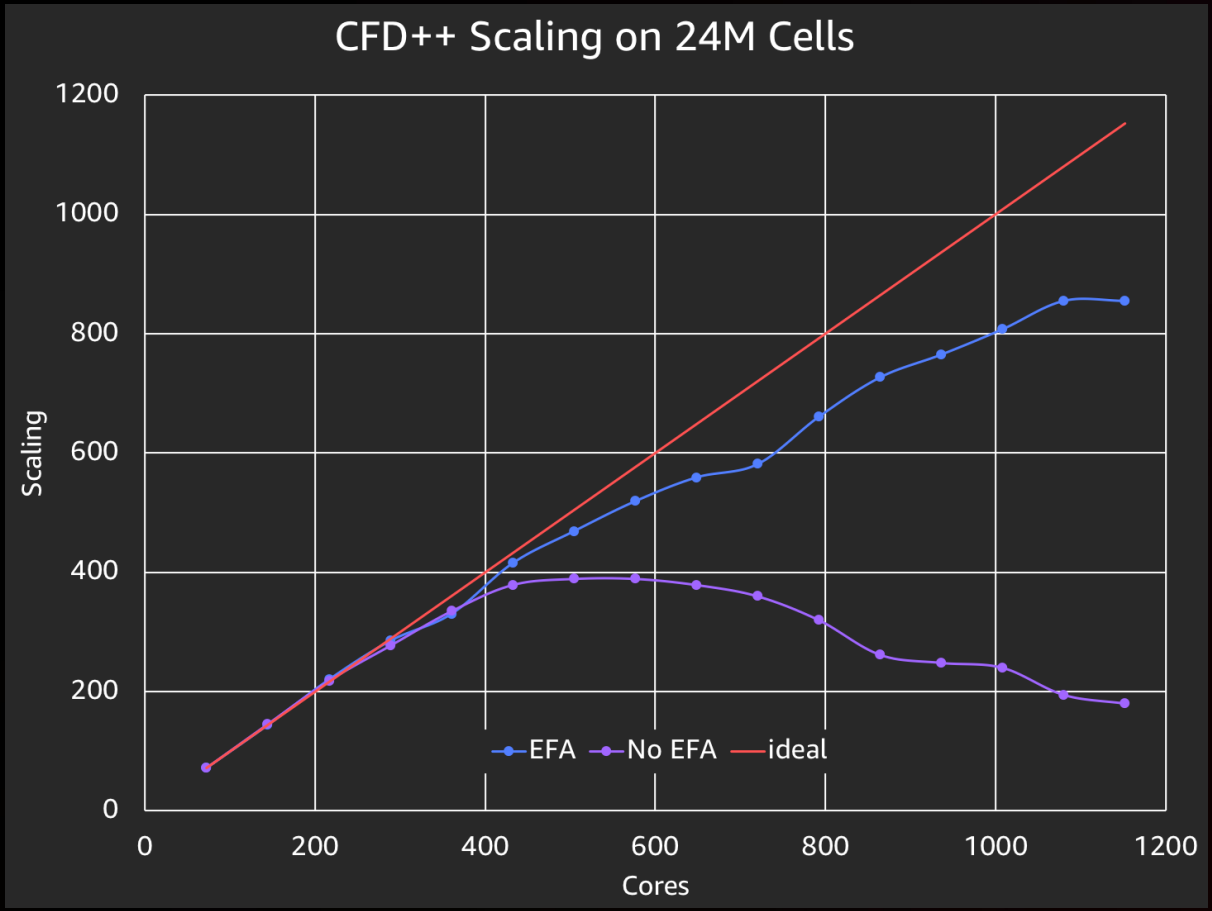
- At the highest core counts:
  - 107% faster than [redacted]
  - 43% faster than [redacted]
  - 160% faster than previous AWS
  - 25% faster than Navy DSRC
- Min size estimated to meet 7.5 min:
  - 33% faster than [redacted]
  - 23% faster than Navy DSRC
- Min size forecast cost estimate:
  - [redacted] $82.97
  - C5n with EFA: $44.02

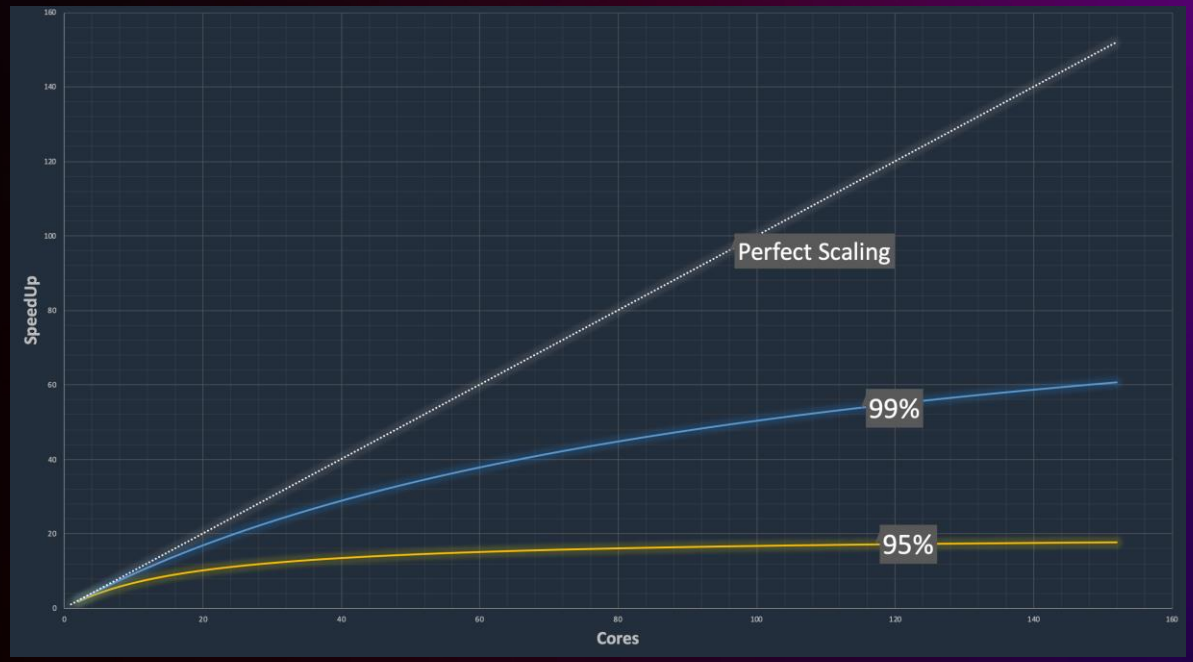


U.S. Naval Research Laboratory

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Scaling is nontrivial (it's the law)

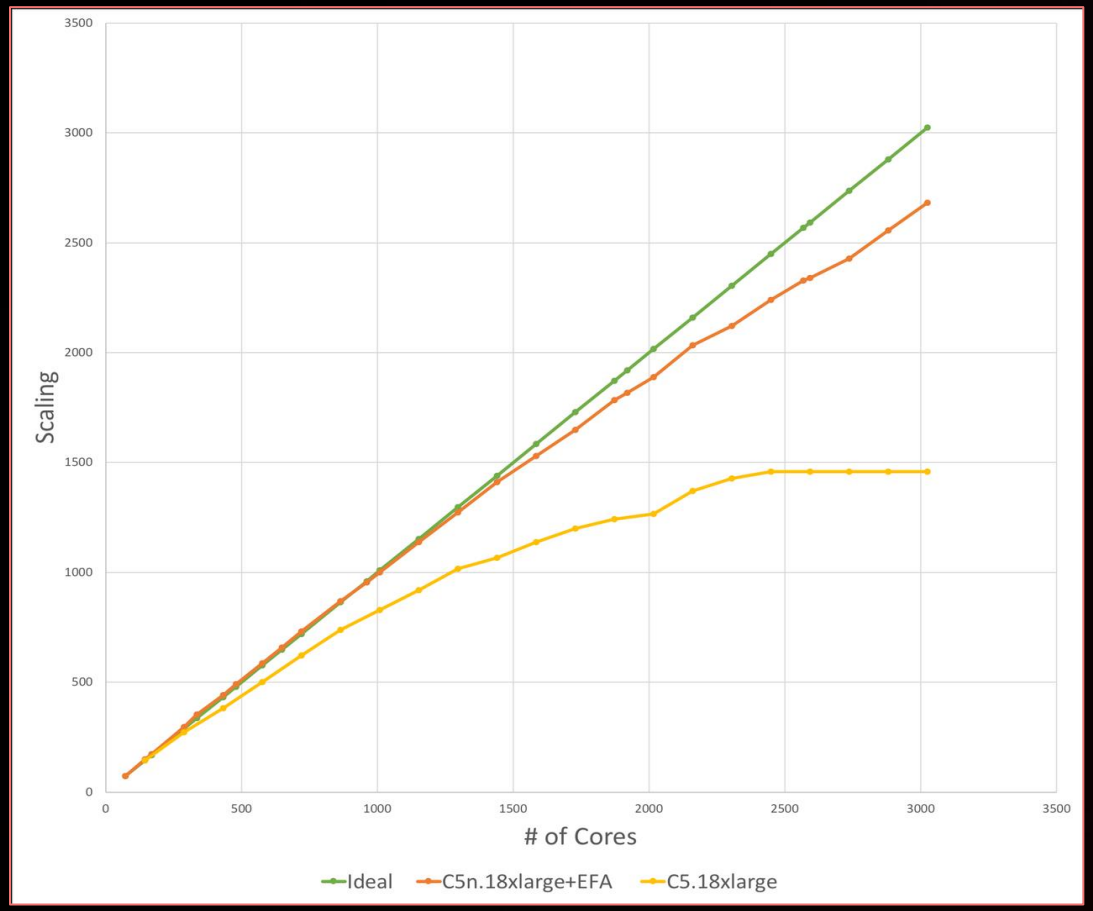


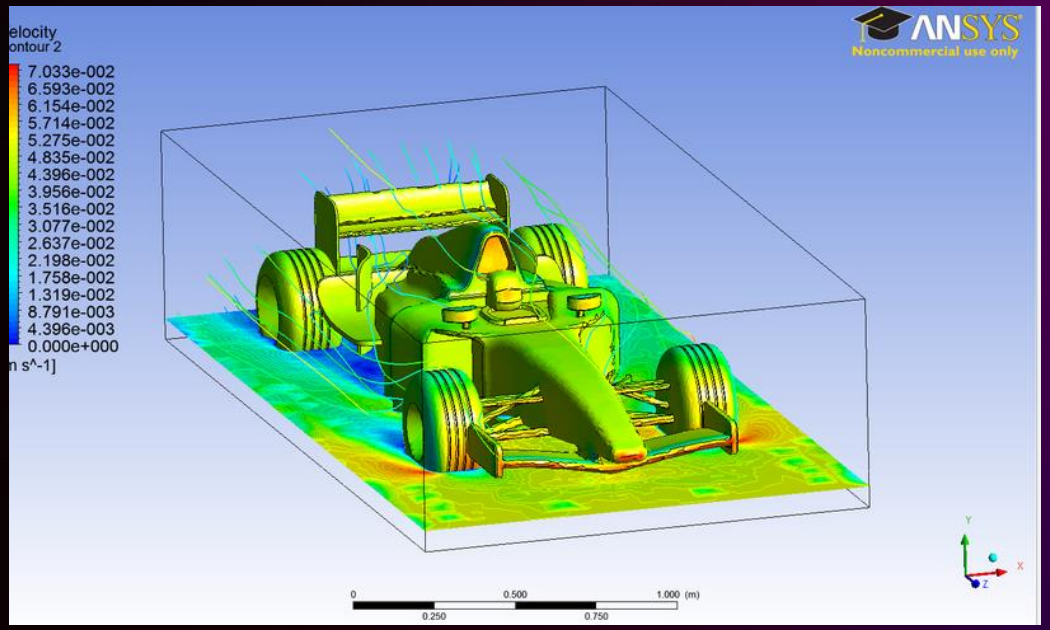


Amdahl's law (above) shows us how hard it is to scale an application even close to linearly

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Serious applications





External flow over a Formula 1 race car (140M cell mesh)

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Elastic Fabric Adapter (EFA)

- A interface for Amazon EC2 instances that enables HPC applications requiring high levels of inter-node comms to scale massively
- Custom-built **OS-bypass hardware** leveraging AWS Nitro System
- Plays an analogous role to InfiniBand but uses its own swarm-delivery Scalable Reliable Datagram (**SRD**)
- Presented as a **`libfabric` provider** for use by **MPIs** and machine learning codes using NVIDIA's **NCCL**
- Scales to thousands of CPUs or GPUs
- Application performance of on-premises HPC clusters with the on-demand elasticity and flexibility of the AWS cloud



Blog: Why we built EFA for HPC

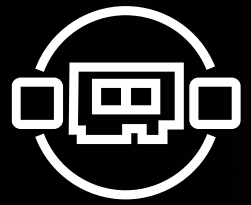
Paper: SRD at IEEE Explore



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Elastic Fabric Adapter

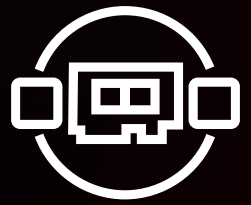


OS bypass

GPUdirect and RDMA

Libfabric interface supports wide array of MPIs and NCCL

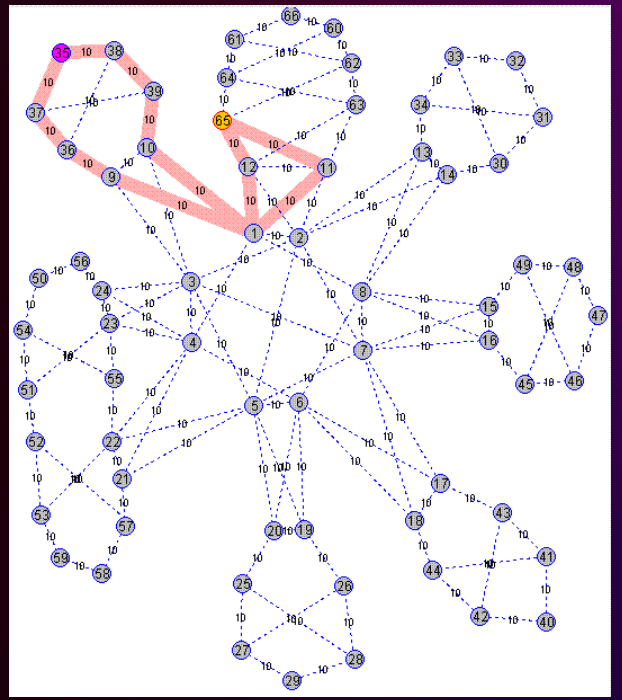
Scalable Reliable Datagram



ECMP-enabled swarm-like delivery

Cloud-scale congestion control

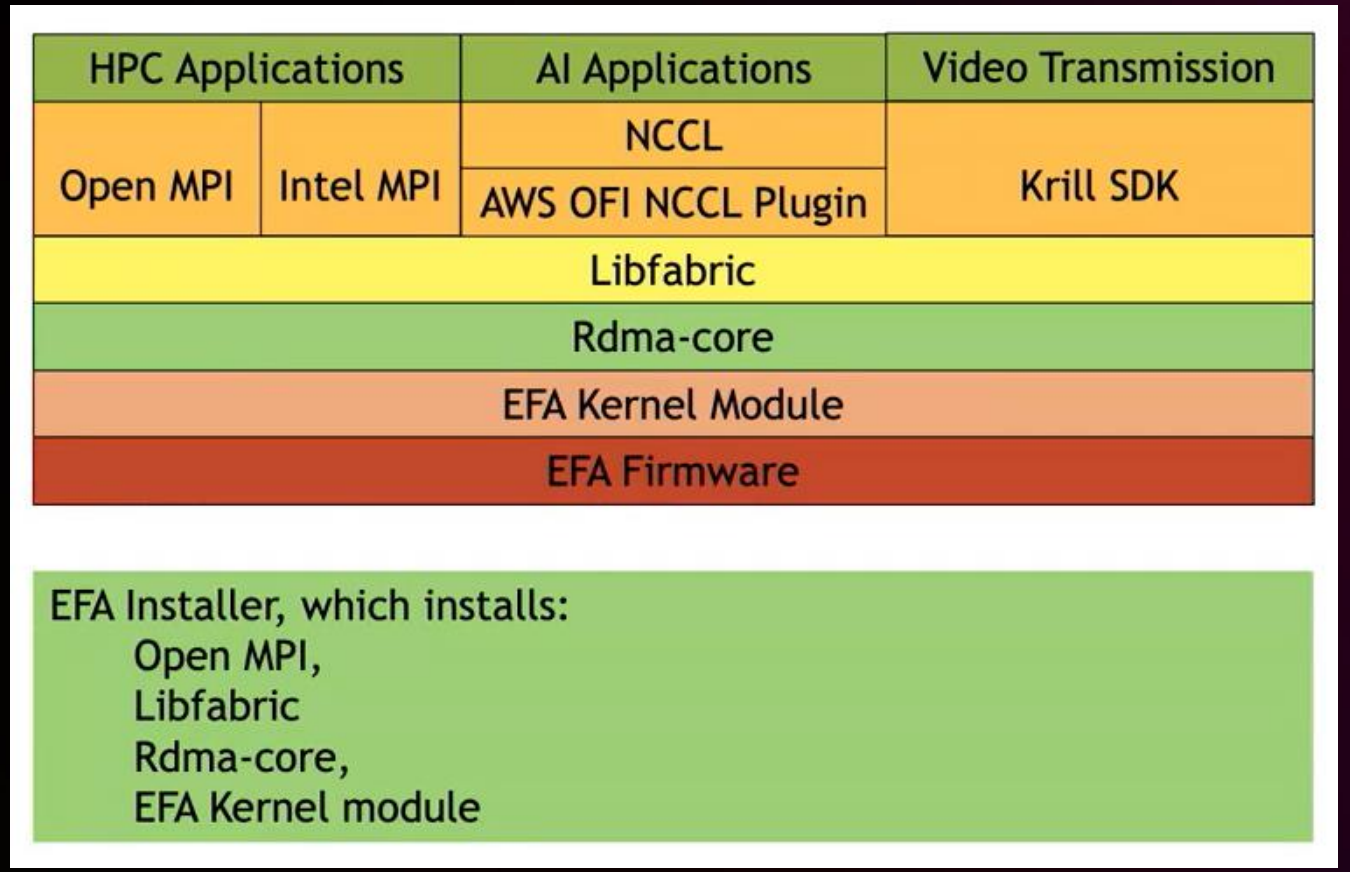
Fast recovery from packet loss or link failure



Thanks to Wikipedia and Peter Ashwood-Smith for the snappy animated GIF explaining ECMP

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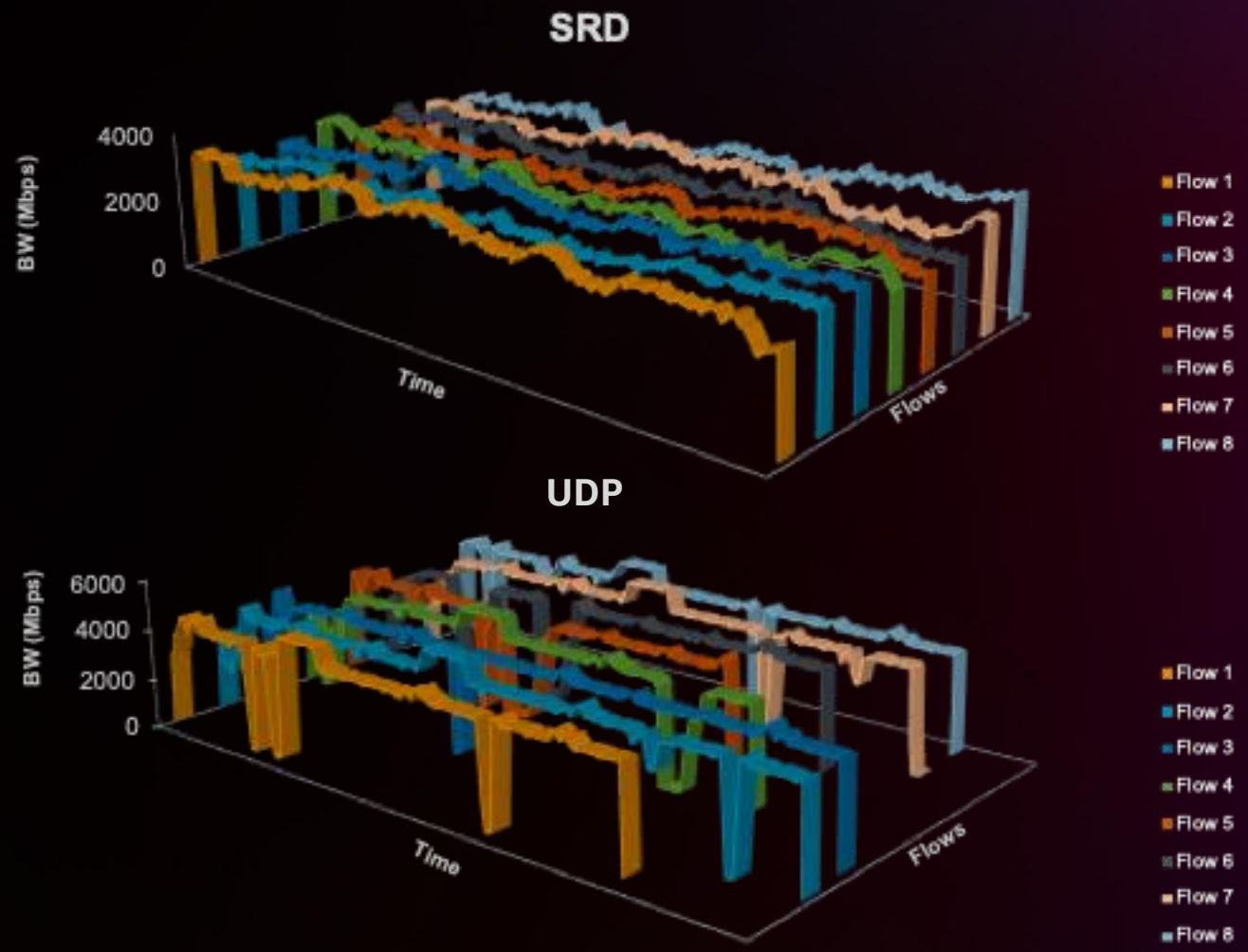


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Back to broadcast

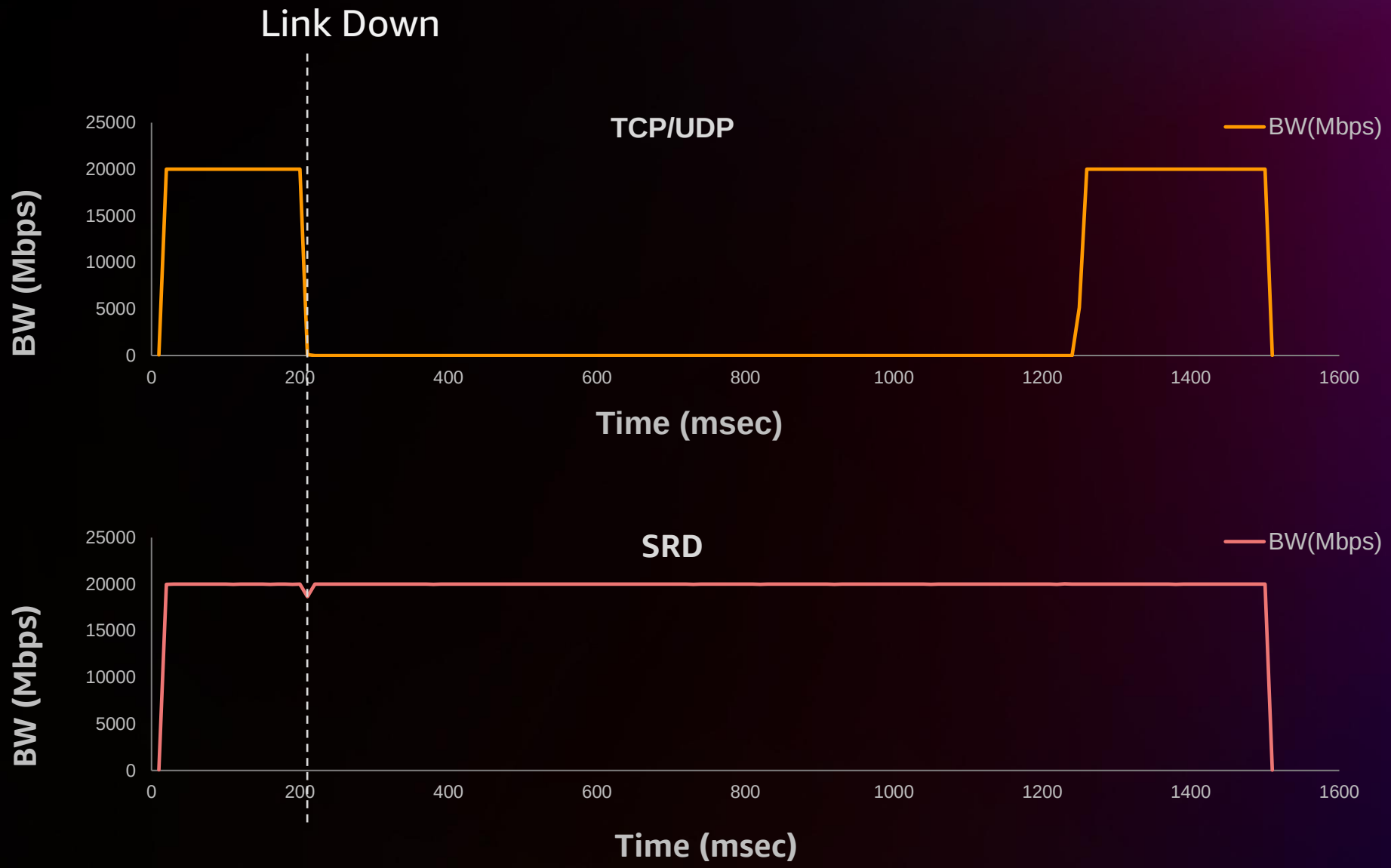
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SRD vs. UDP



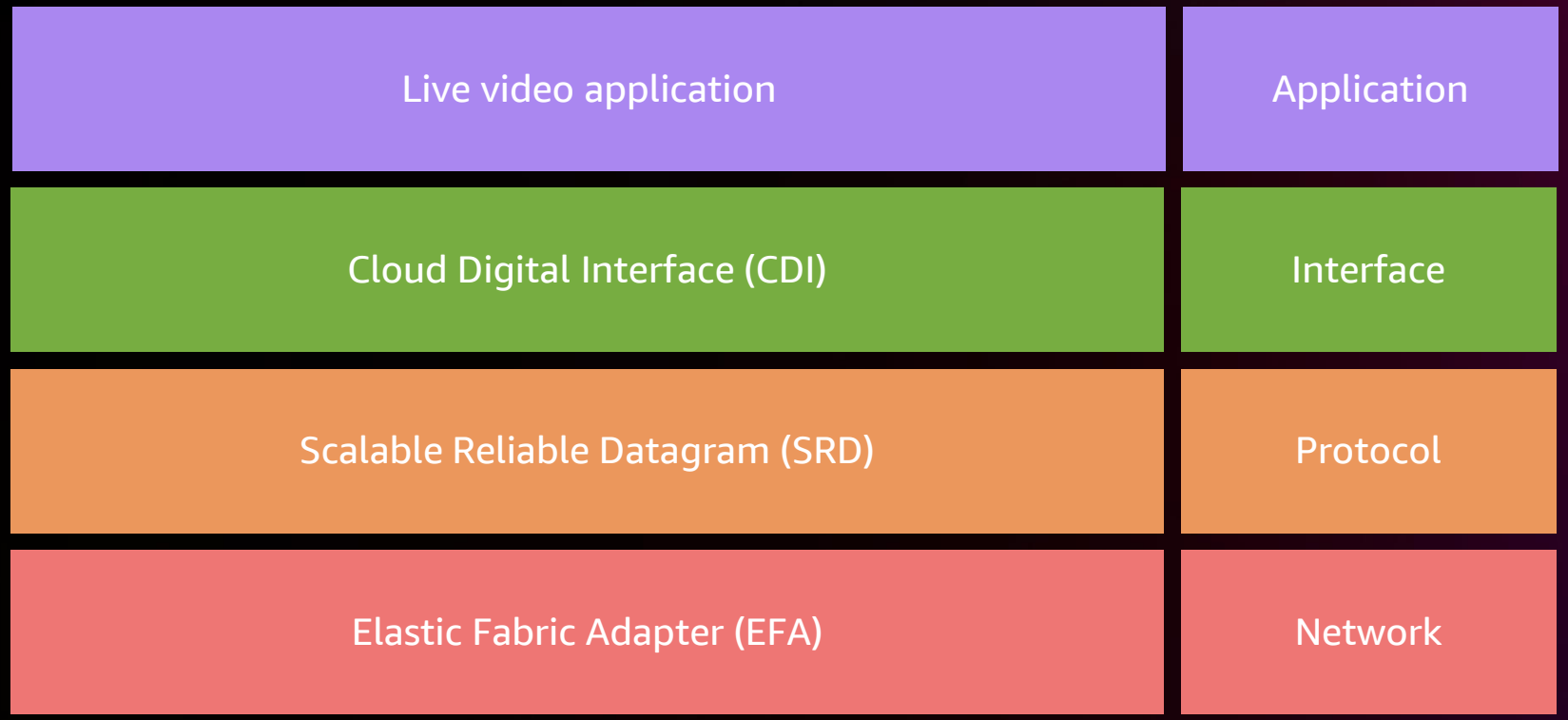
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How CDI works – Fault tolerance



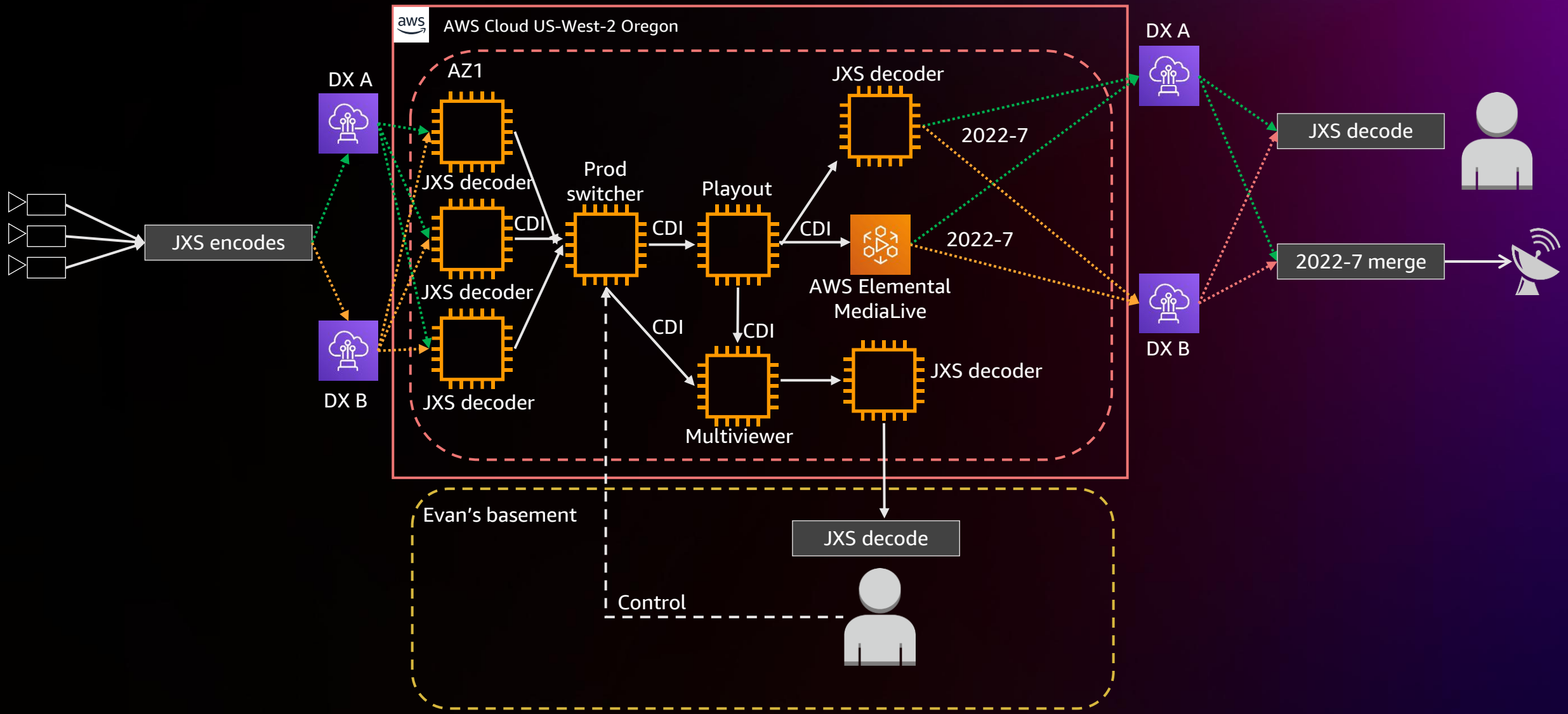
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How AWS CDI works – The technology stack



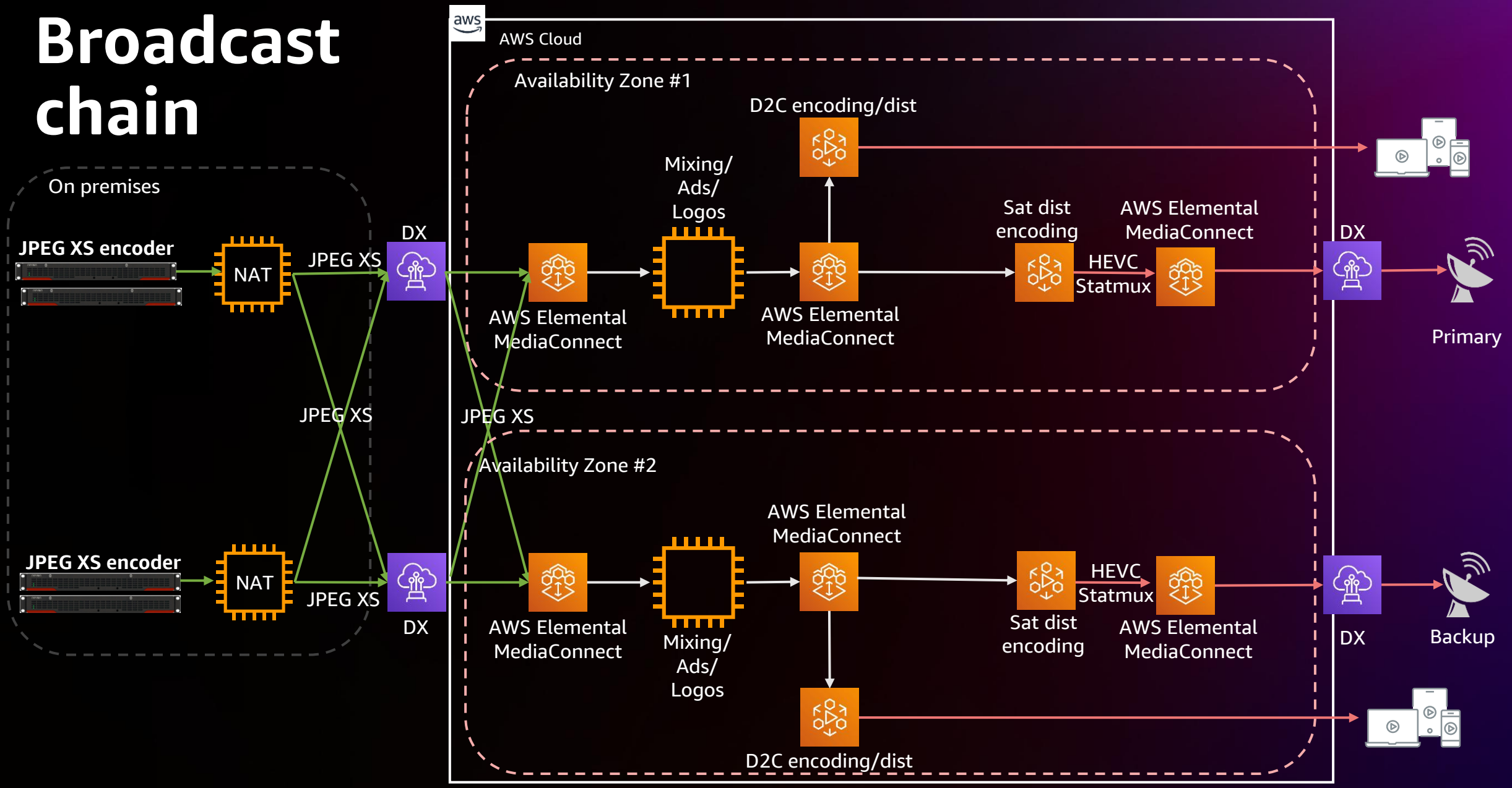
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Live production with CDI



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Broadcast chain



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Introducing the AWS CDI SDK



AWS CDI technology is available with an **SDK** in both **Windows and Linux** versions



SDK is available as an **open-source project released under the 2-clause BSD license**, customers only pay for EFA-enabled Amazon EC2 instance usage



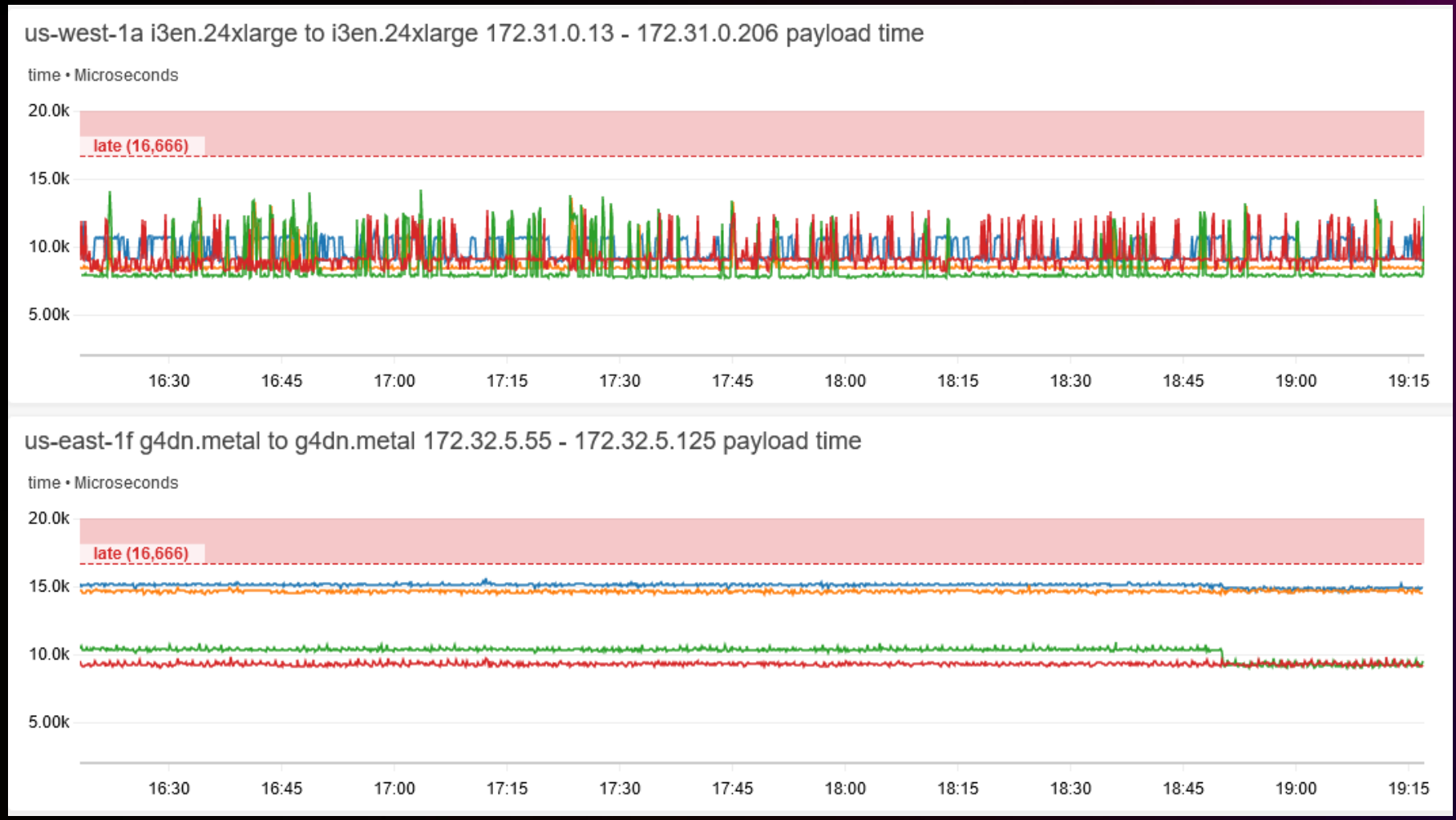
SDK is for **Intra-Availability Zone** transmission and is optimized for Amazon EC2 **Placement Groups**



For **increased** inter-vendor **interop** the SDK includes a schema-based audio visual management (AVM) layer

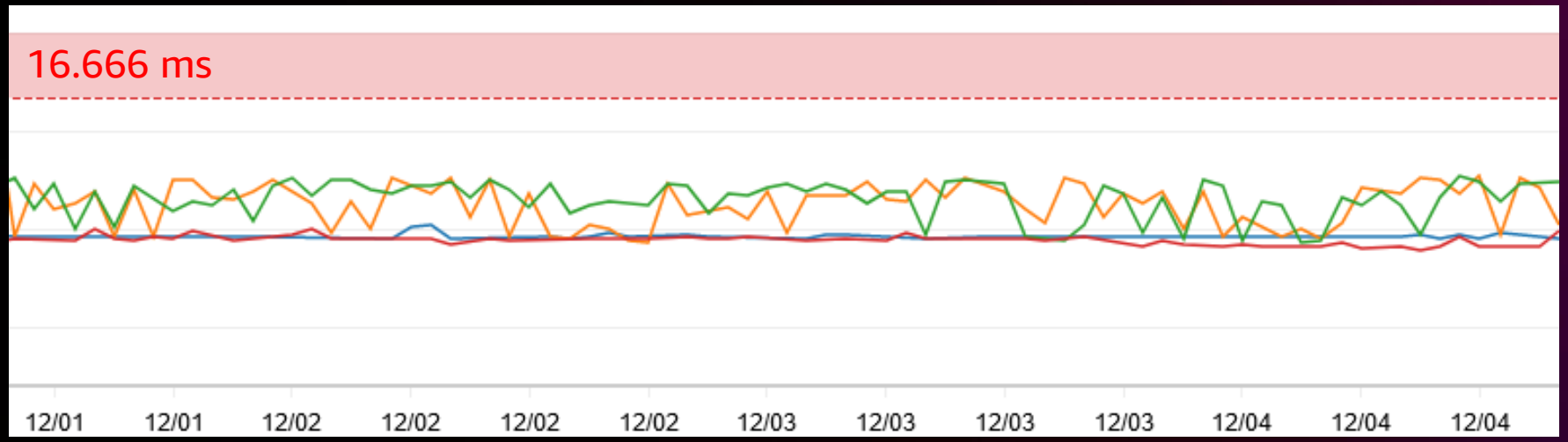
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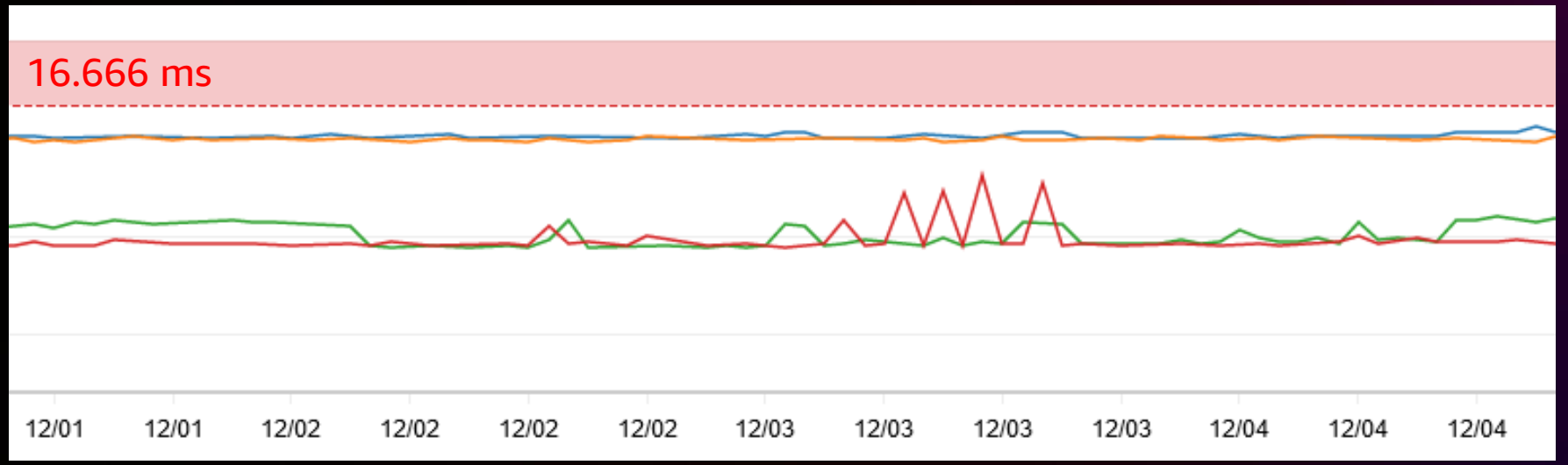
SRD – Reliable sub-frame latency (4k video flows)



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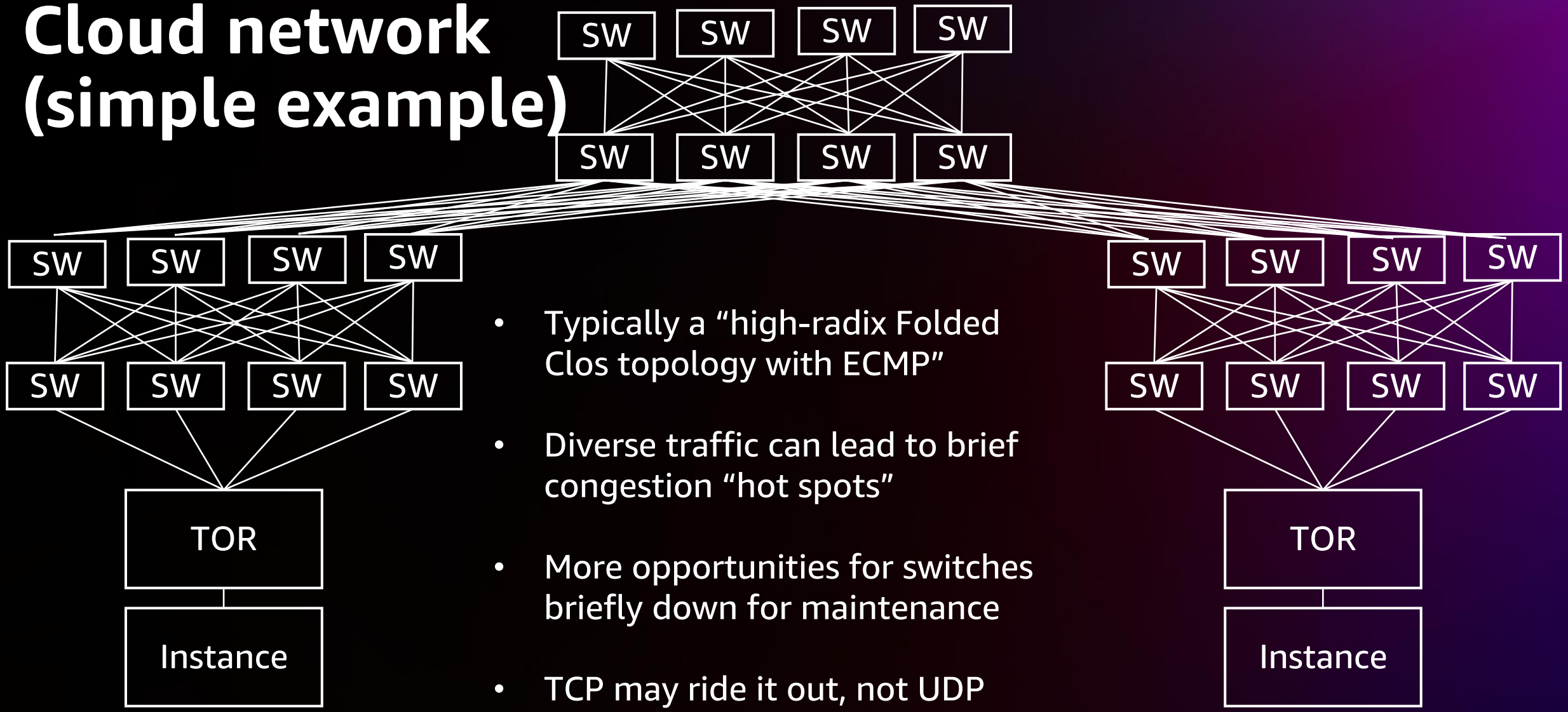
SRD – Sub-frame latency over 4 days (4k video flows)





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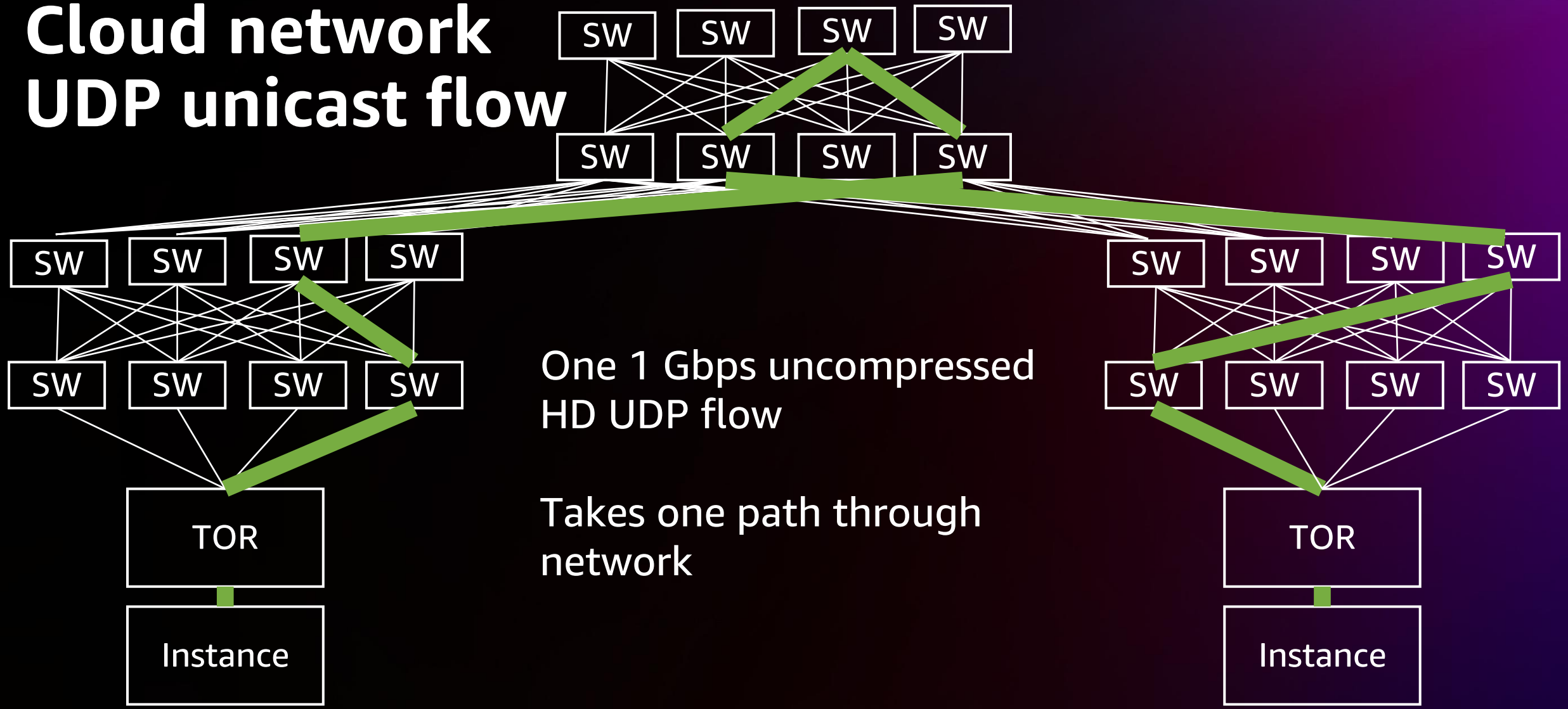
Cloud network (simple example)



- Typically a “high-radix Folded Clos topology with ECMP”
- Diverse traffic can lead to brief congestion “hot spots”
- More opportunities for switches briefly down for maintenance
- TCP may ride it out, not UDP

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Cloud network UDP unicast flow

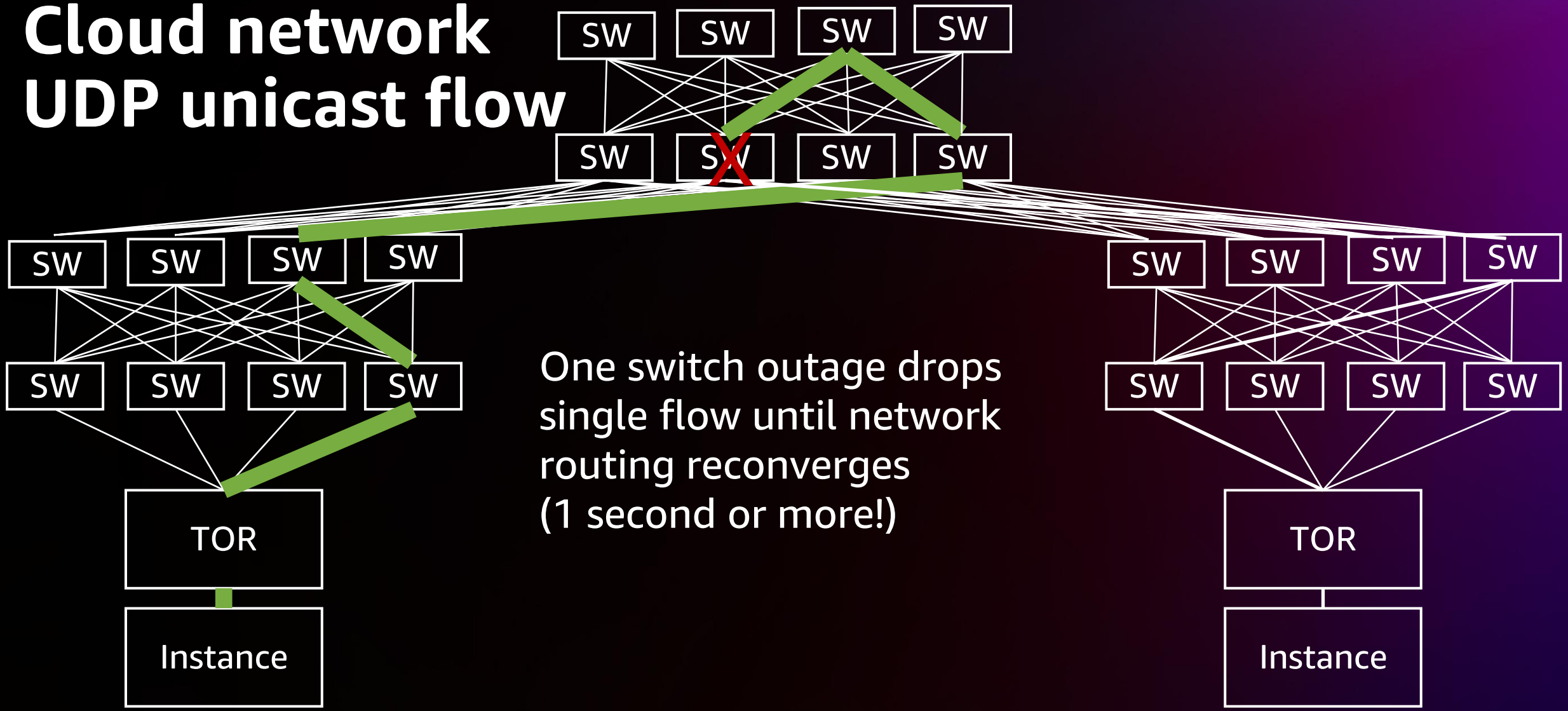


One 1 Gbps uncompressed HD UDP flow

Takes one path through network

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Cloud network UDP unicast flow



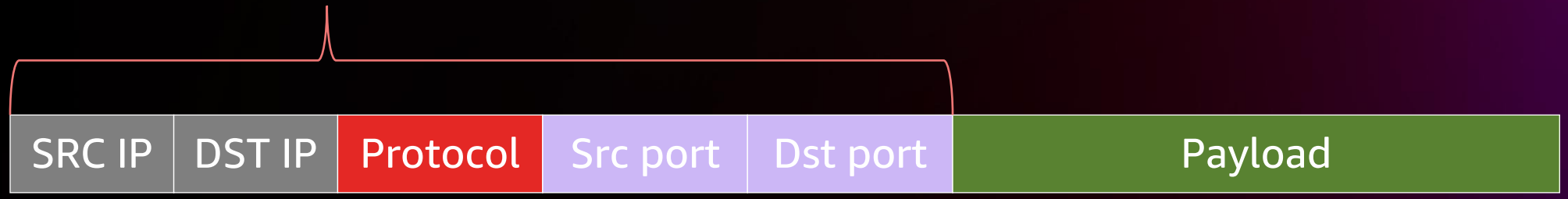
One switch outage drops single flow until network routing reconverges (1 second or more!)

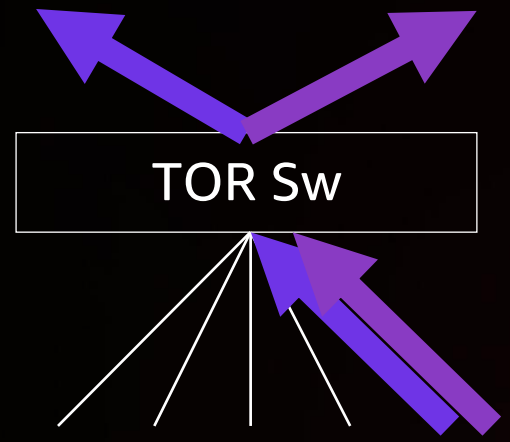
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What is ECMP?

Equal-cost multi-path routing

Assigns flows to leave switch via port determined by 5-tuple hash





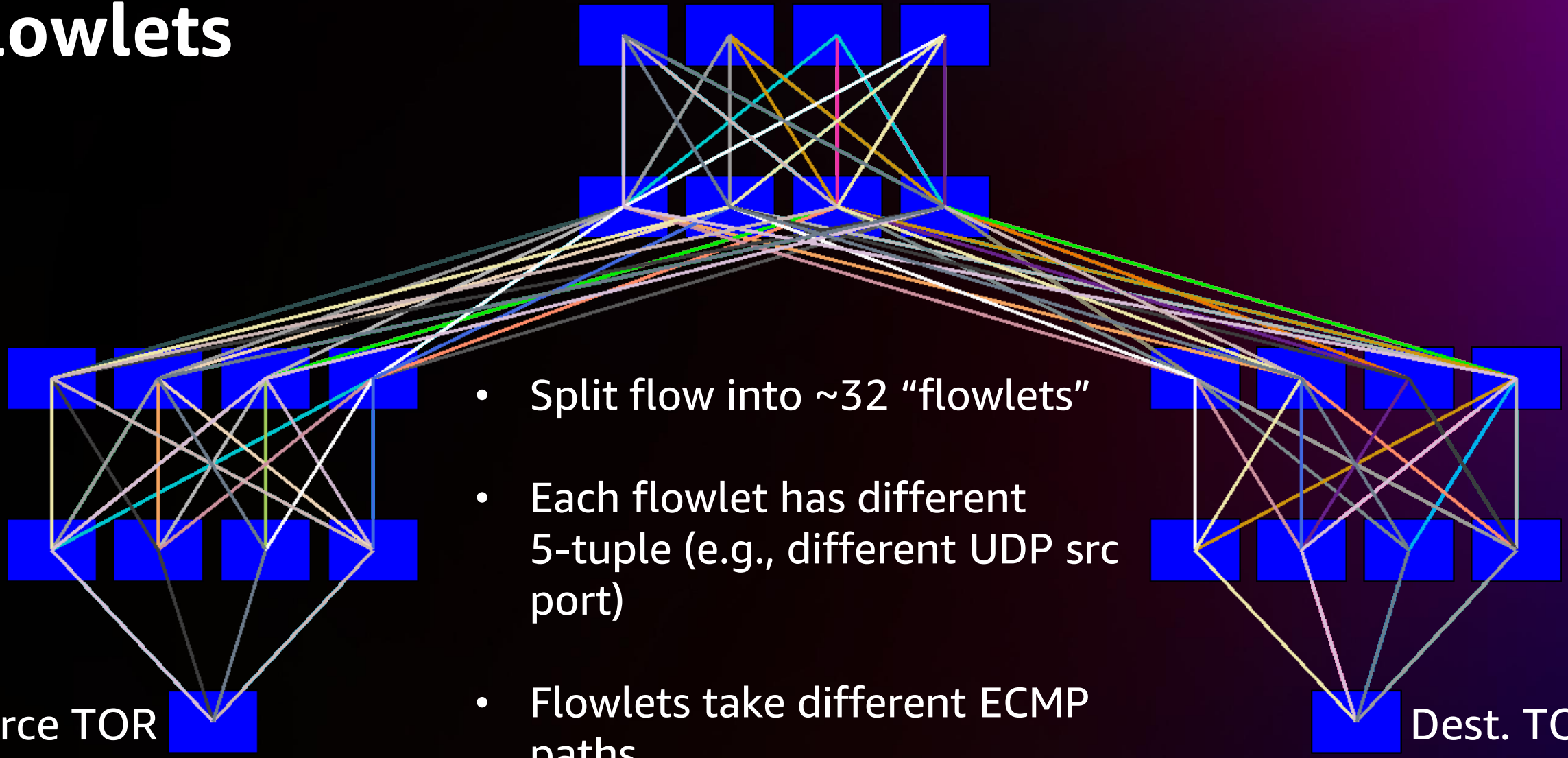
10.0.0.3|10.1.0.5|UDP|2000|2000

10.0.0.3|10.1.0.6|UDP|2000|2000

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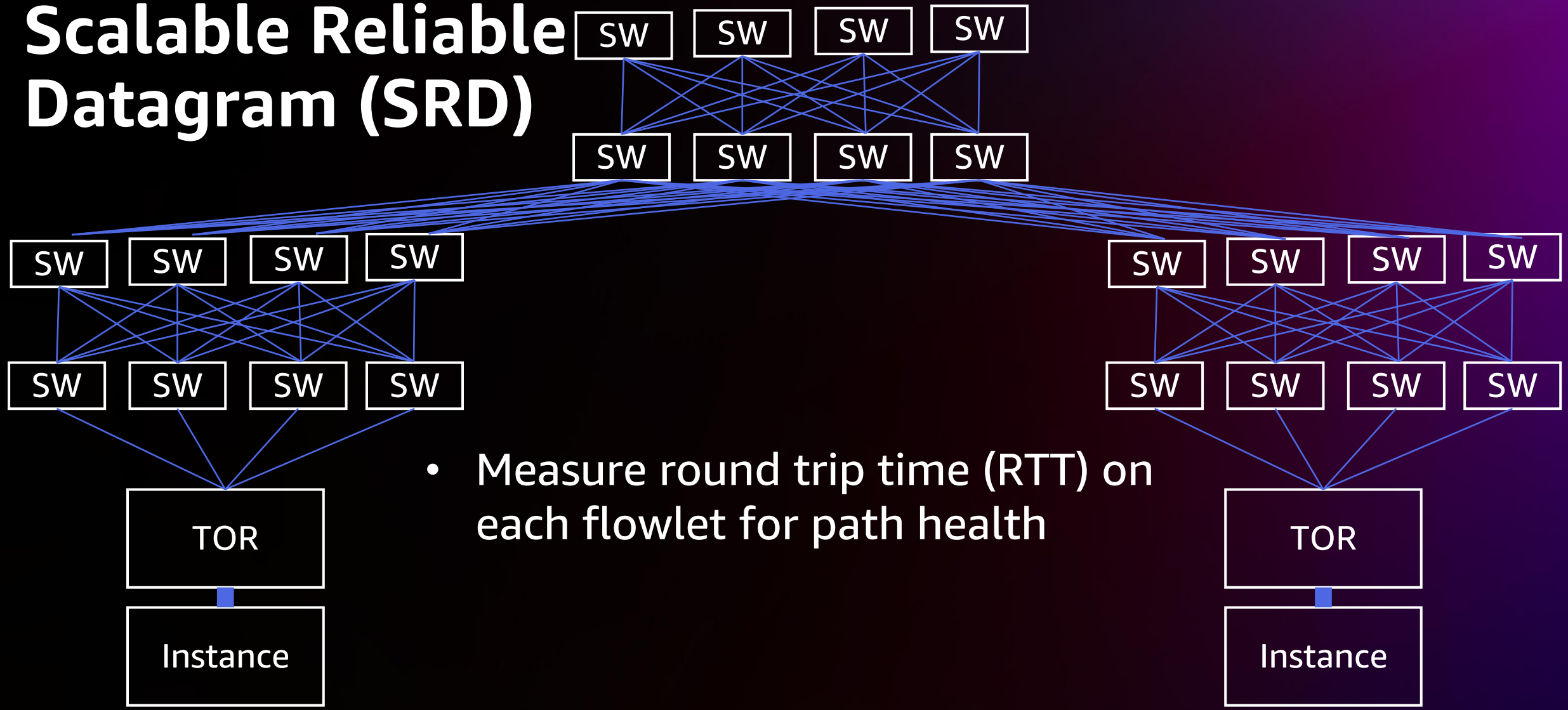
Scalable Reliable Datagram (SRD) protocol – Flowlets



- Split flow into ~32 “flowlets”
- Each flowlet has different 5-tuple (e.g., different UDP src port)
- Flowlets take different ECMP paths

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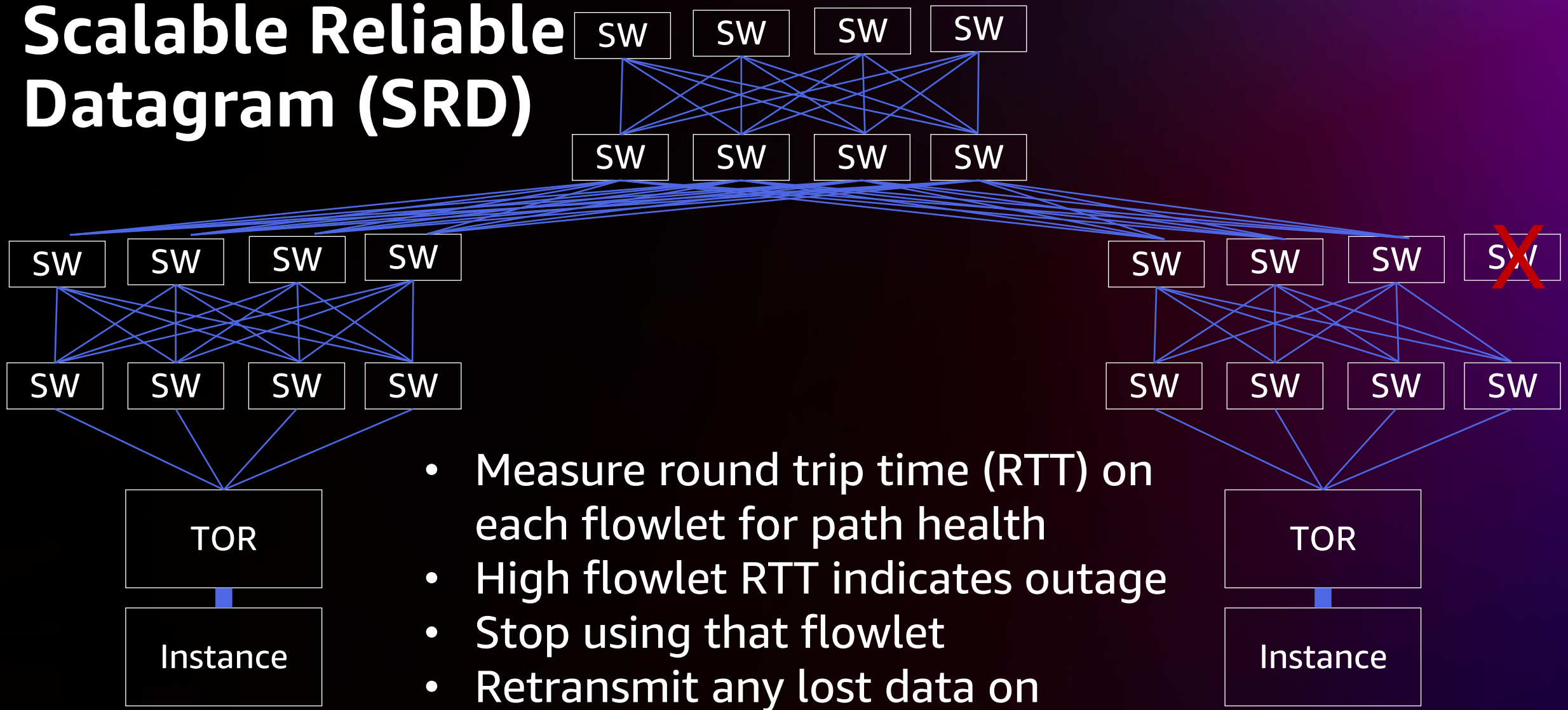
Scalable Reliable Datagram (SRD)



- Measure round trip time (RTT) on each flowlet for path health

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Scalable Reliable Datagram (SRD)



- Measure round trip time (RTT) on each flowlet for path health
- High flowlet RTT indicates outage
- Stop using that flowlet
- Retransmit any lost data on another flowlet

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Getting started

- GitHub repository
  https://github.com/aws/aws-cdi-sdk

- AWS website
  http://aws.amazon.com/media-services/resources/cdi/

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In 2020, EFA scaled itself up

C5n

Intel Skylake

36 Cores /
72 vCPUs

100 Gbps EFA

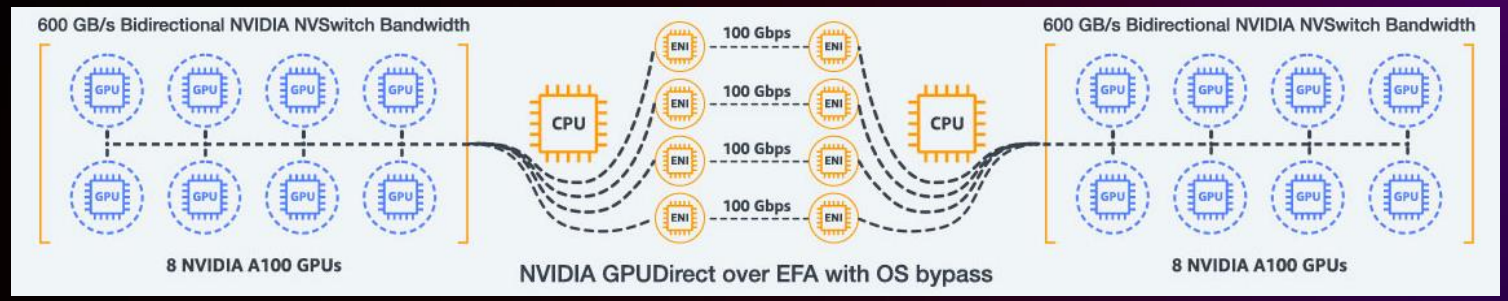
P4d

Intel Cascade Lake

48 Cores /
96 vCPUs

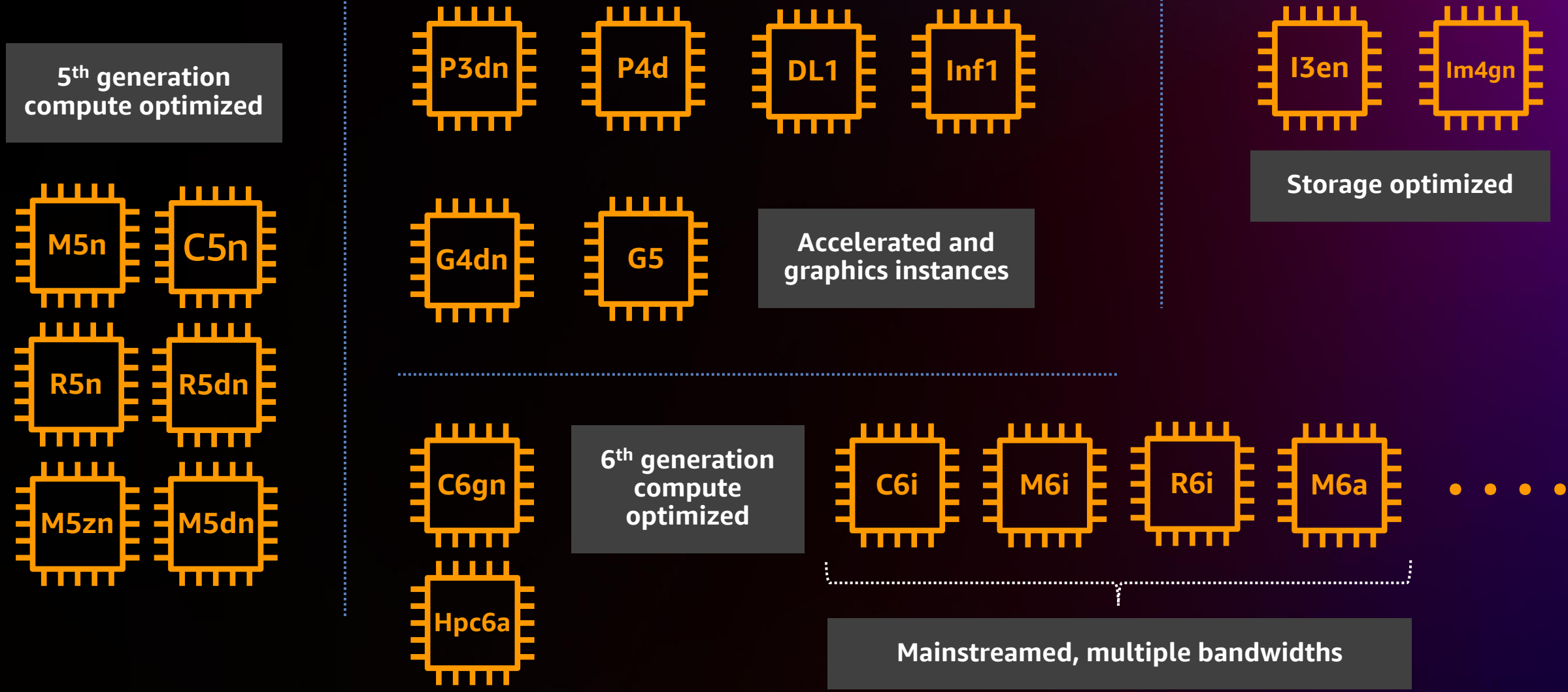
NVIDIA A100 Tensor Core GPUs

400 Gbps EFA



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EFA instances



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Thank you!

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