

AWS re:Invent

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FSI312

Nasdaq: Moving mission-critical, low-latency workloads to AWS

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Agenda

Who is Nasdaq?

Why move markets to the cloud?

Solution technical details

Lessons learned

Future direction

Nasdaq

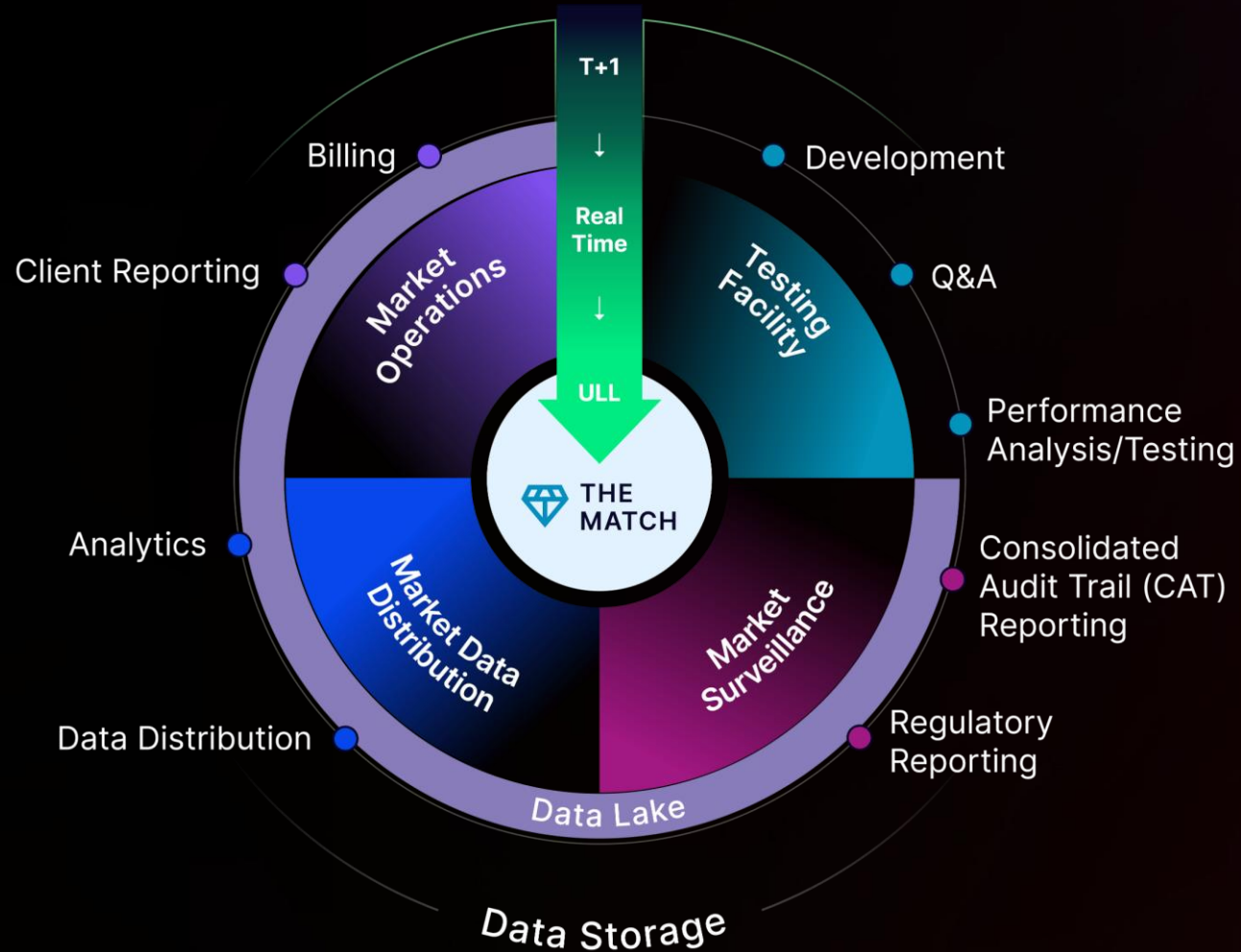
- First electronic exchange
- We operate **30+** exchanges for stocks, bonds, options, and derivatives in North America and the Nordics
- Home of technology: **73%** of all tech listings in the U.S. and the top **4** largest tech companies by market capitalization
- Technology provider to
 - Over **130** marketplaces globally
 - **2,200+** financial institutions
 - Over **6,000** corporates
- Listing venue for **4,150** public companies globally



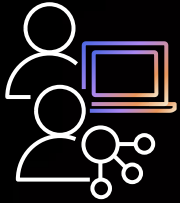
First mover and cloud pioneer since 2008



Systematic move to AWS



Our cloud ambitions



Prepare our customers for the next generation of capital markets

- Members
- Technology customers
- Partners



Accelerate capital market transformation by enabling our technology customers and their ecosystems to follow a blueprint



Leverage the cloud – and our footprint on AWS – as a hub for innovation

Why is it so hard to move markets to cloud technology?



Historical ingrained processes; native protocols and systems built up and used over several decades; mission-critical nature of these workloads, generally



Resiliency and 100% uptime expectation



Stringent regulation



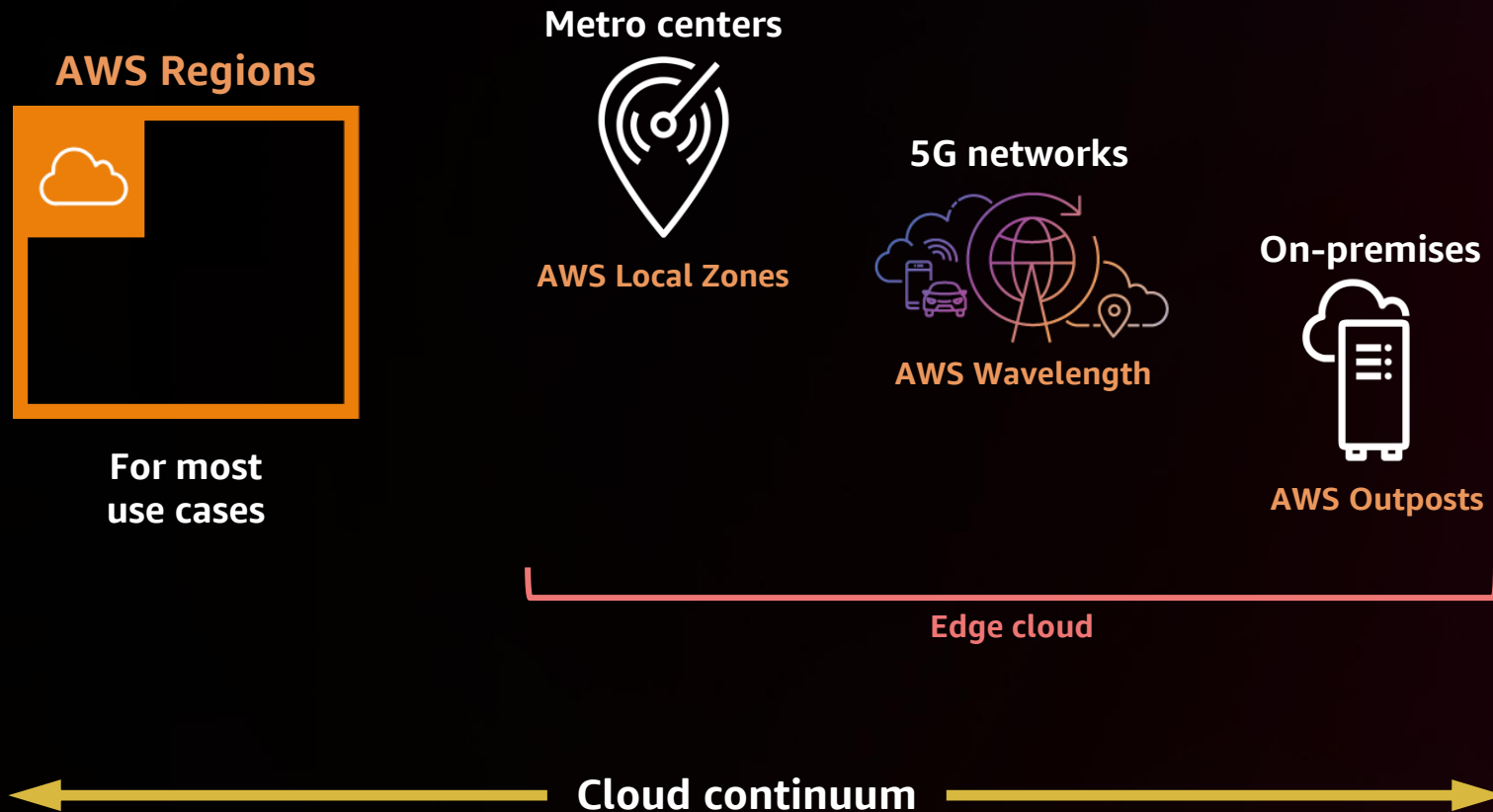
Ultra-low latency transactions and enormous volumes

The solution: Taking markets to the edge with AWS



Edge cloud infrastructure

DELIVERING CLOUD WHERE CUSTOMERS NEED IT



Infrastructure footprint

- Regions
- Local Zones
- AWS Wavelength
- Outposts

Edge cloud

- Moving cloud resources closer to customers
- Lower latency
- Proximity to clients
- Data residency
- Common operating model everywhere

AWS Outposts rack

EDGE CLOUD INFRASTRUCTURE

Industry-standard **42U rack**

Fully assembled, ready to be rolled into final position

Installed by AWS, simply plugged into power and network

Centralized redundant power conversion unit and DC distribution system for higher reliability, energy efficiency, easier serviceability

Redundant active components including top-of-rack switches



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AWS Outposts rack

EDGE CLOUD INFRASTRUCTURE

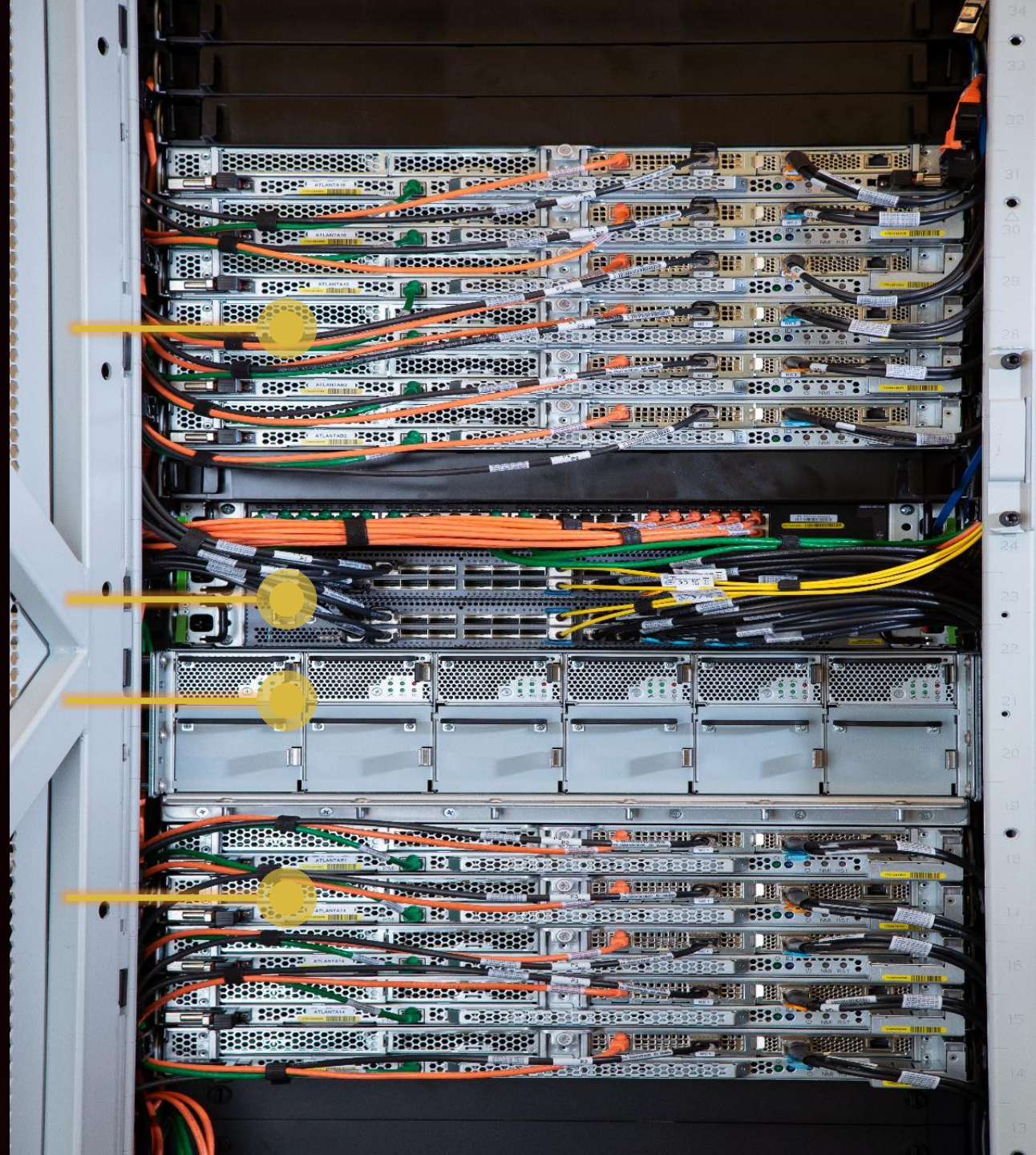
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Outposts rack security

EDGE CLOUD INFRASTRUCTURE

Enclosed rack with a lockable door

Built-in **tamper detection**

Data on Outposts rack is **encrypted**



Outposts rack security

EDGE CLOUD INFRASTRUCTURE

Enclosed rack with a lockable door

Built-in **tamper detection**

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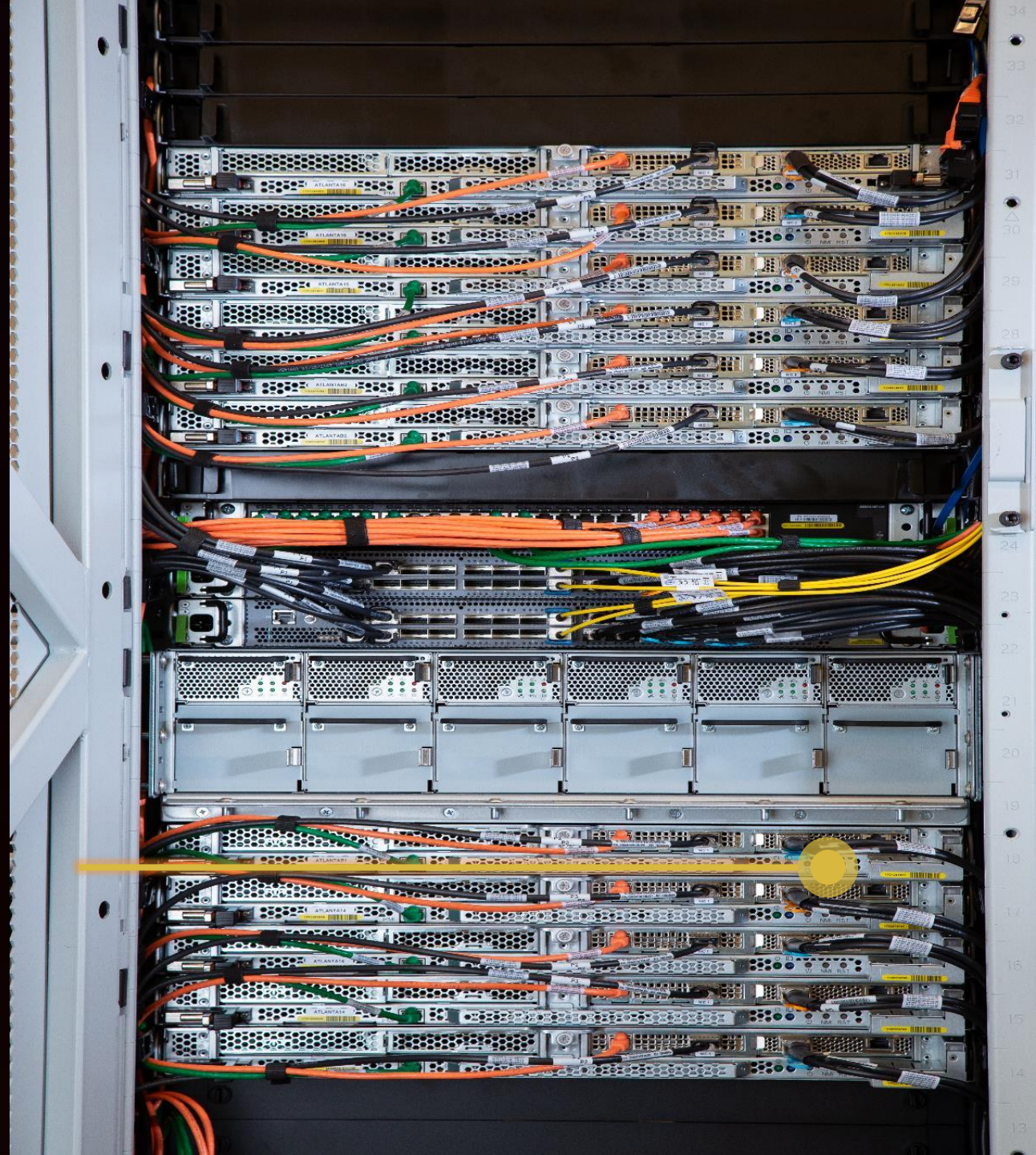
Removable and destroyable **hardware security key** on each server

Encrypted network connection to the AWS Region

Physical security of the Outposts rack location is the **customer's** responsibility

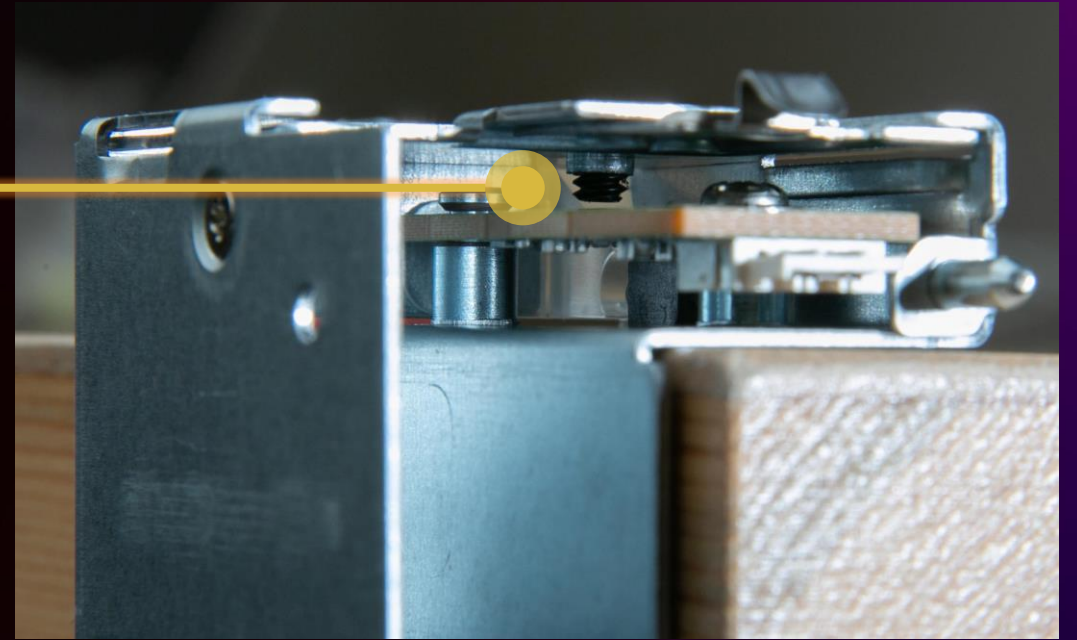
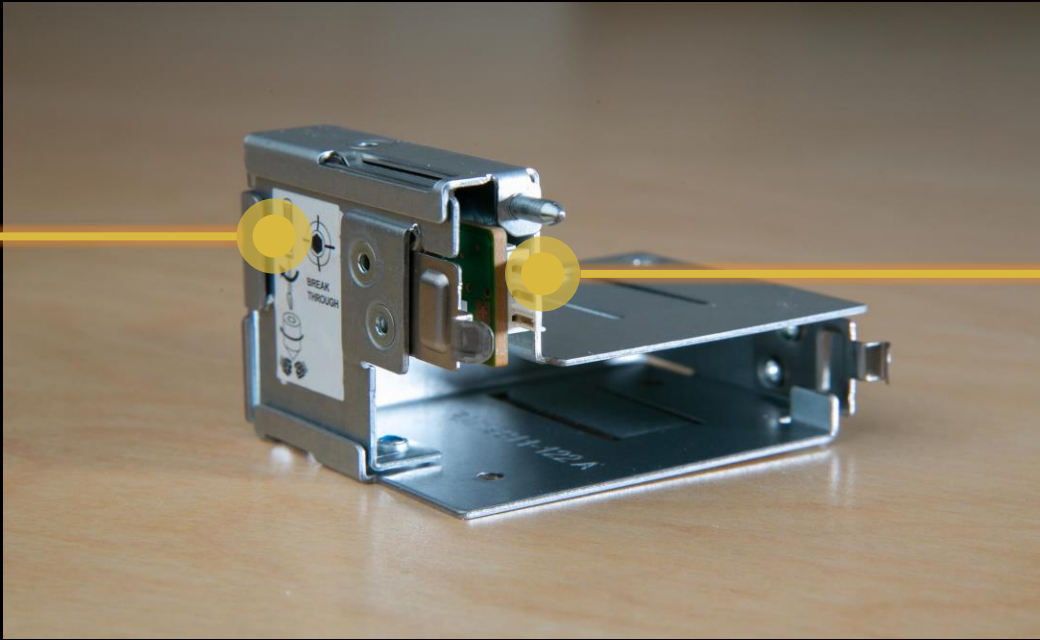


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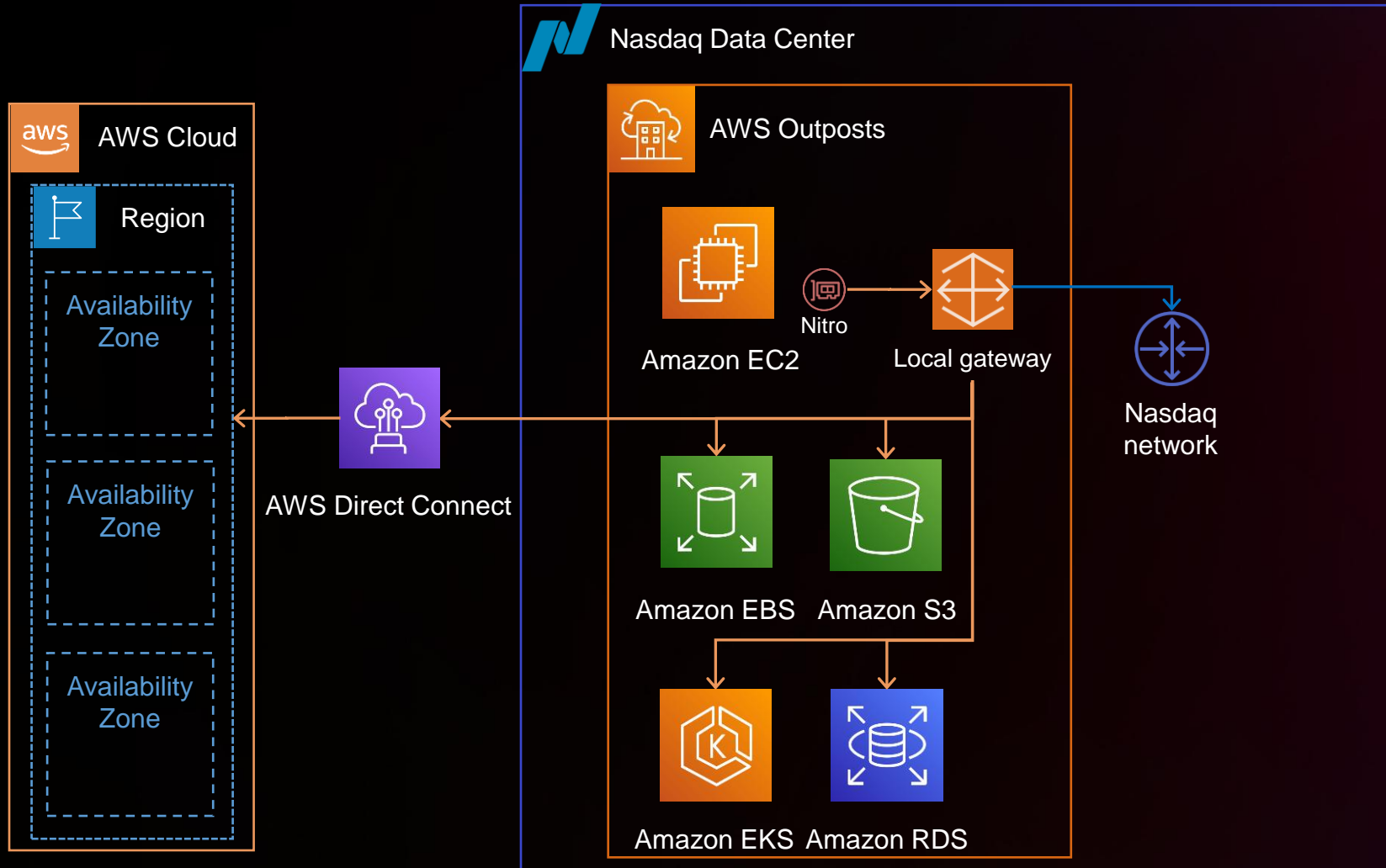
Hardware security key

EDGE CLOUD INFRASTRUCTURE



AWS Outposts

EDGE CLOUD INFRASTRUCTURE



“AWS Outposts is a family of fully managed solutions delivering AWS infrastructure and services to virtually any on-premises or edge location for a truly consistent hybrid experience”

AWS hardware

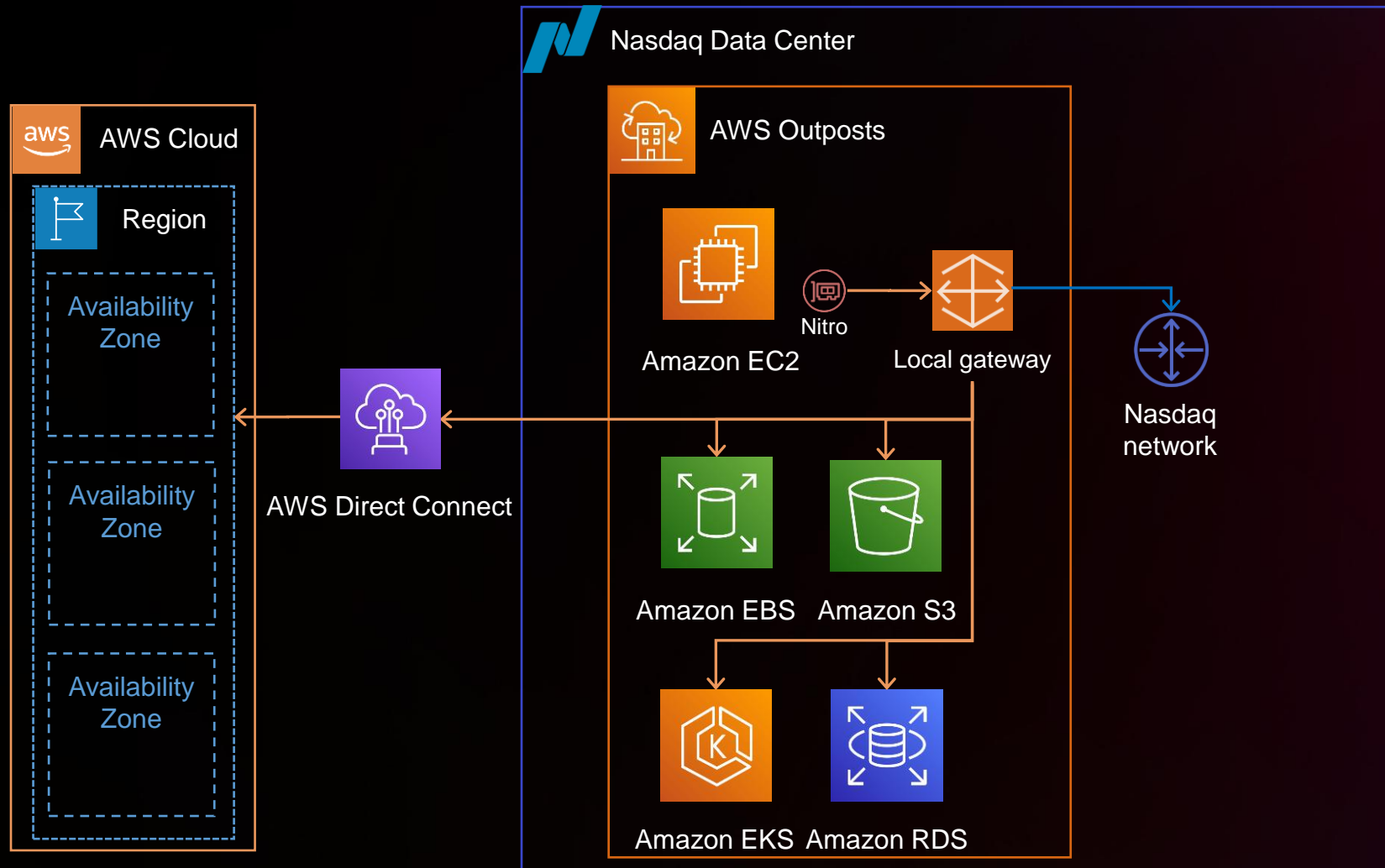
- Standard 42U rack
- Compute instances
- Storage
- Plus selected services

Cloud operating model

- API-driven operation
- Hardware as a service

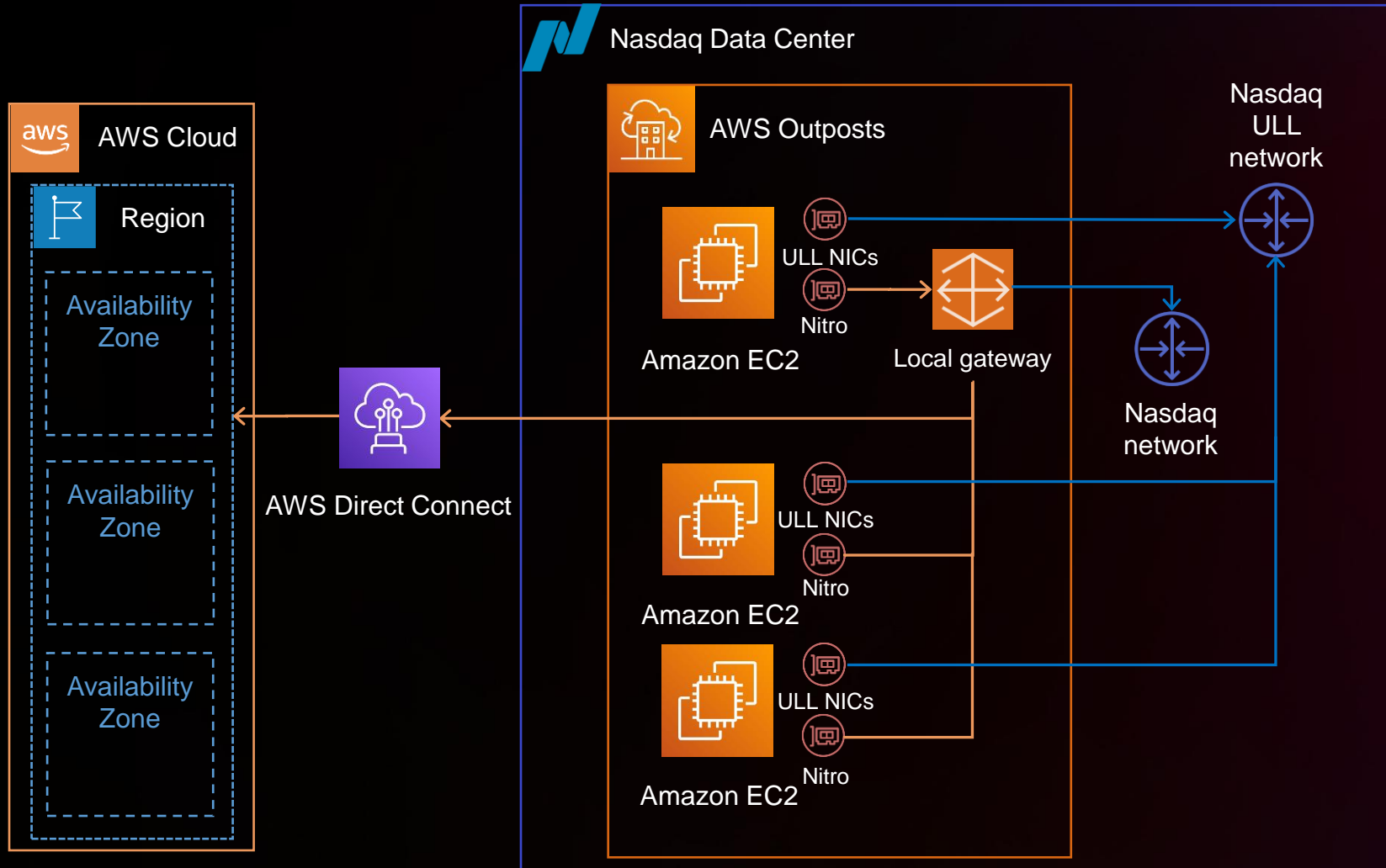
Ultra-low latency AWS Outposts

EDGE CLOUD INFRASTRUCTURE



Ultra-low latency AWS Outposts

EDGE CLOUD INFRASTRUCTURE



Bare metal compute

- No hypervisor

Bare metal network

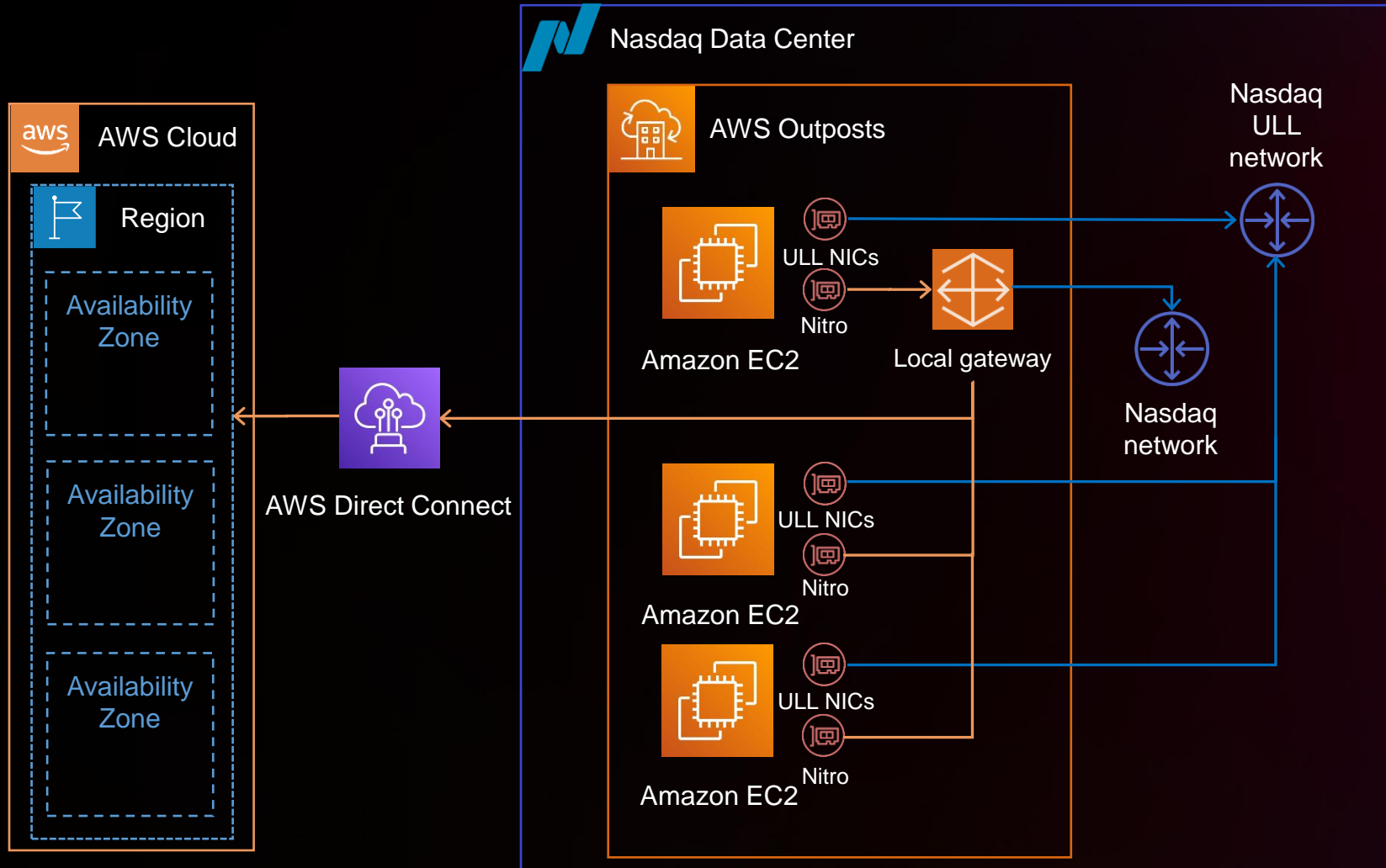
- Physically separate network
- ULL NICs
- Time source support
- Equal-distance cables

Facilitates

- Ultra-low latency
- L2 multicast
- Fairness
- Seamless access to existing ULL networks

Ultra-low latency AWS Outposts roadmap

EDGE CLOUD INFRASTRUCTURE



Roadmap

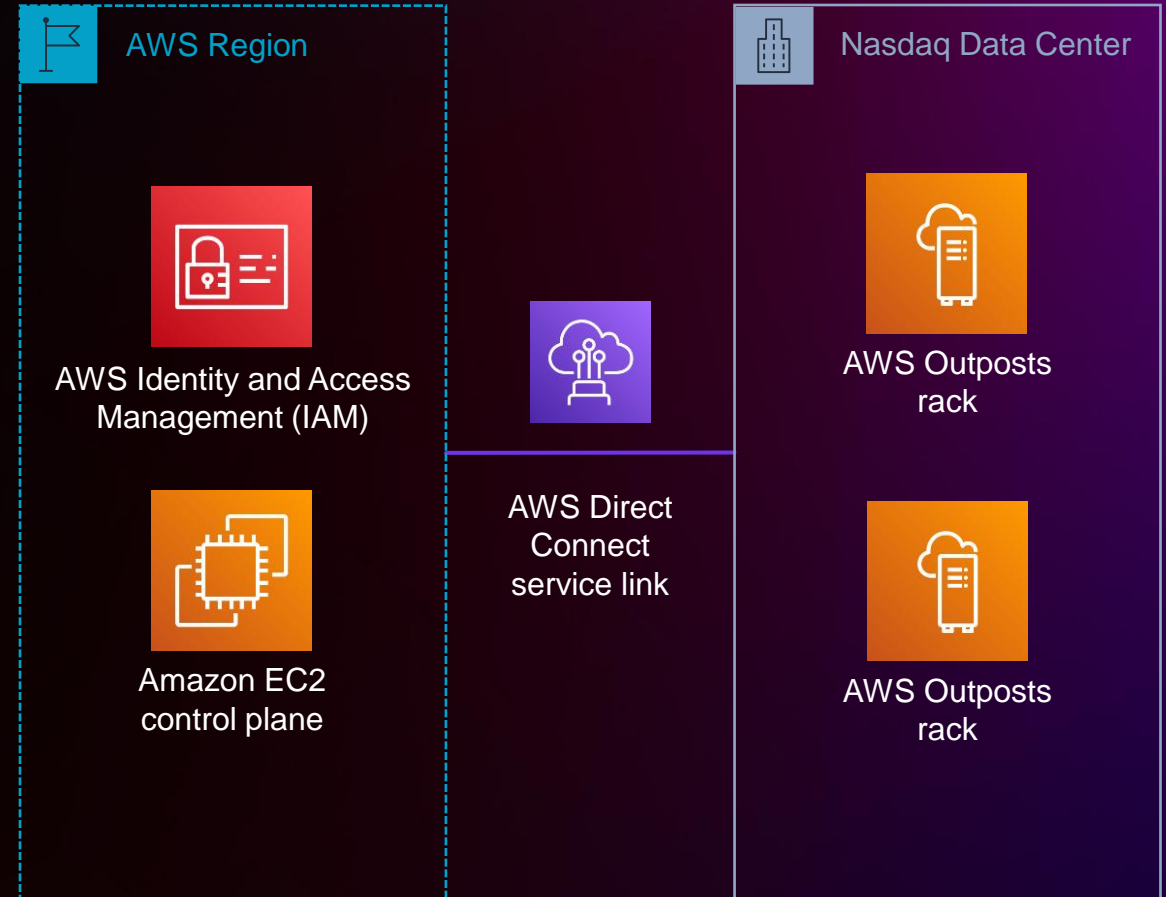
- Next-generation processors and NICs
- Enhanced power options
- Enhanced density
- Other component enhancements

Lessons learned: mission-critical workloads on AWS

- Architecture
- Operating model
- Collaboration

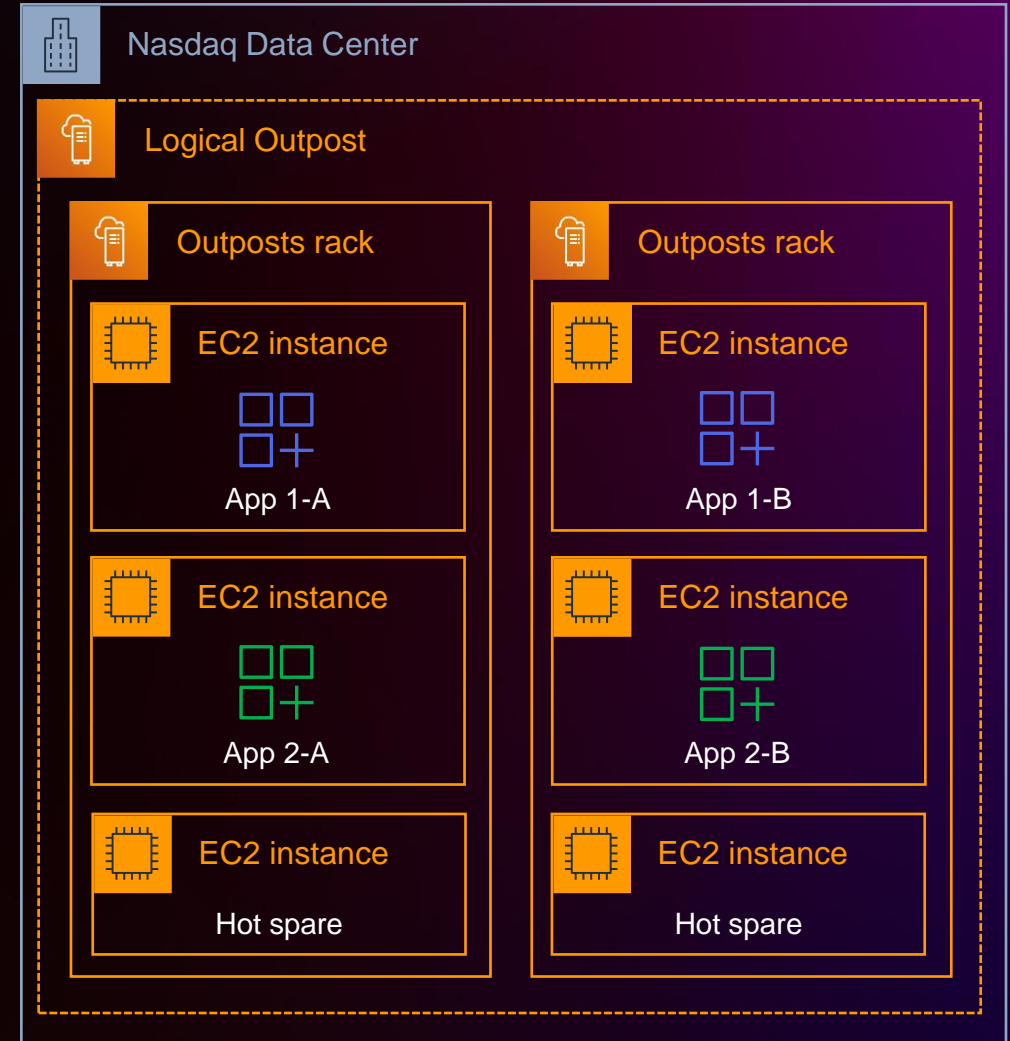
Architecture: Static stability

- No mutating control plane actions
- Disconnected operation
- Long-lived SSL certs
- Careful use of AWS services
 - Local gateway for break-glass access
 - Local boot in EC2 instances
 - Deep-dive on regional dependencies with service teams



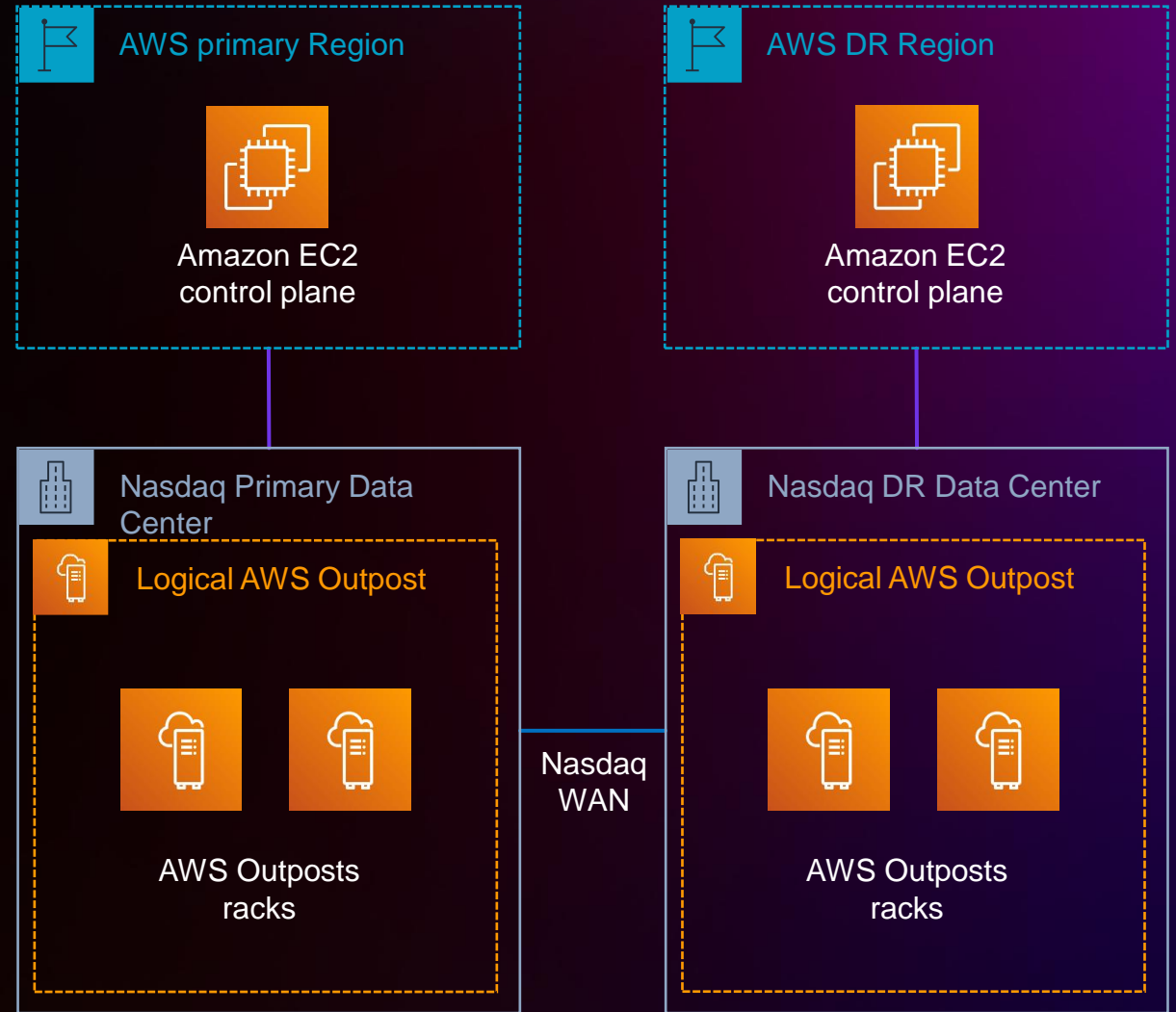
Architecture: Fault domains

- Hot spares in each rack
- Fault domain per rack in AWS Outposts
- Logical Outpost across multiple racks
- A/B pairs of every system component
- Components assigned across racks
- Adapting solution to public cloud



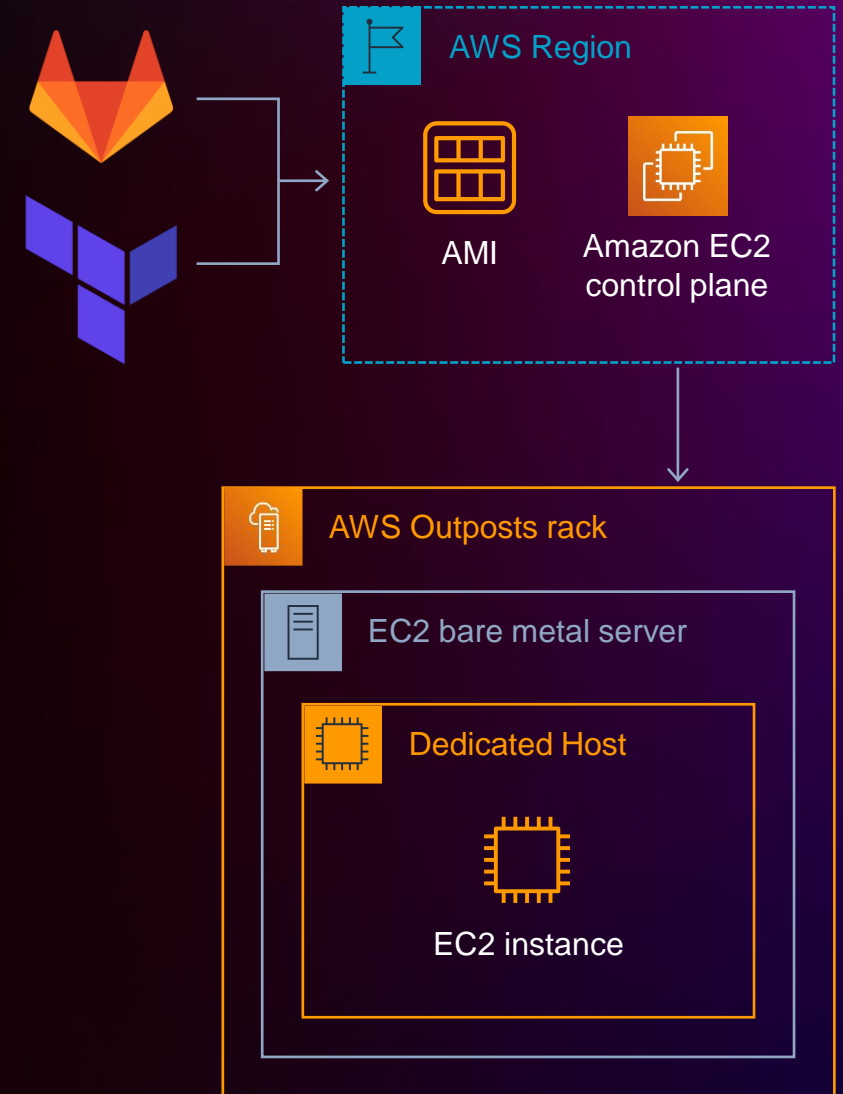
Architecture: Secondary site

- Separate data center for DR
- Separate AWS Outpost in DR
- Homed to a different AWS Region
- Owned by a different AWS account

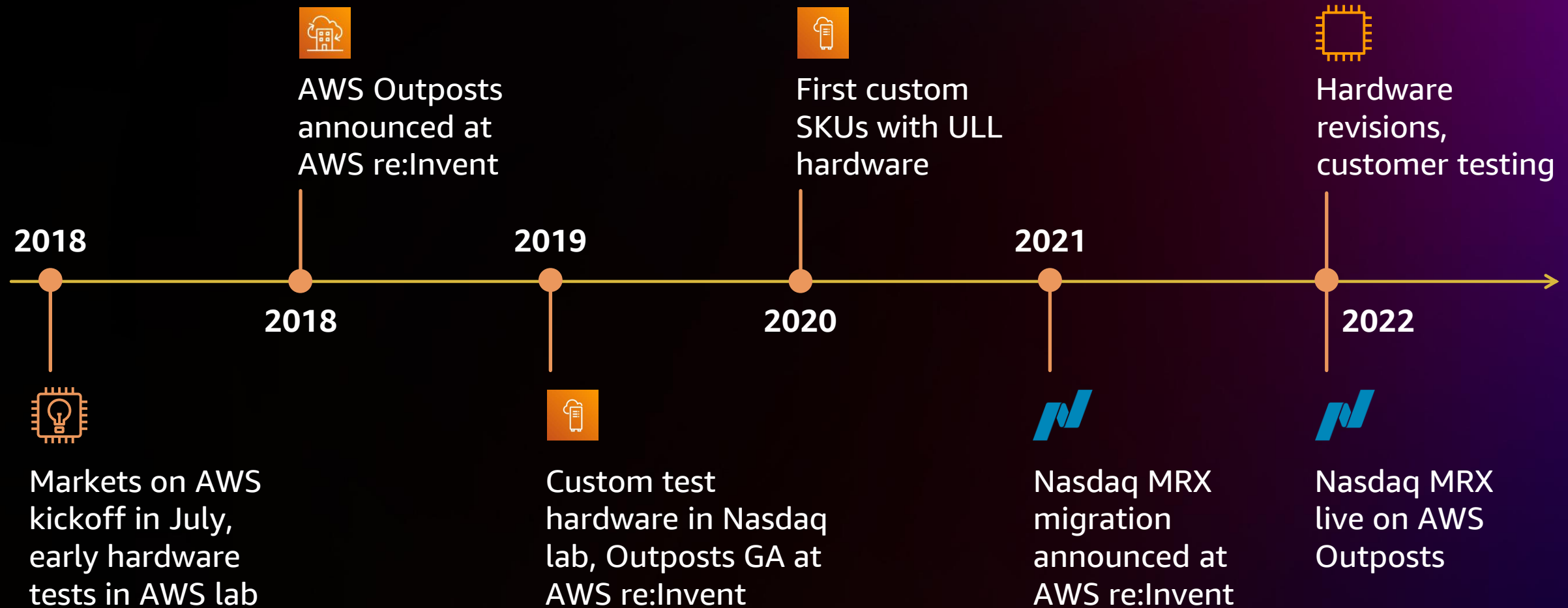


Operating model

- Rethinking operations for critical systems
- Transition PXE images to AMIs
- Automation with GitLab and Terraform
- Dedicated Hosts for deployment targeting
- Hardware lifecycle
- Test, test, test . . . and test some more
- Drills with AWS support for “game day” scenarios



Collaboration: Edge compute for capital markets



**The future:
We're just getting started**



The future: We're just getting started



- Tech roadmap for AWS Outposts
- Next market migration with next-gen Outpost platform
- Dynamic deployments
- More service integration
- Markets in AWS Outposts, Local Zones, Regions

The future: We're just getting started



- Deepen AWS collaboration for Nasdaq markets and global customers
- Colocation in the cloud
- NY11 ecosystem and PLZ
- Market Platforms customers globally

Thank you!



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