AWS Infrastructure: Regions, Availability Zones & Backbone Network

Interview Preparation Guide with Real-World Examples

1. AWS Region - Geographic Data Centers

Definition: An AWS Region is a large geographic area containing multiple isolated data centers. Each region is completely independent and isolated from other regions.

Concrete Example: ap-south-1 (Mumbai Region)

- **Region Code:** ap-south-1
- **Location:** Mumbai metropolitan area, India
- **Coverage:** Entire Mumbai city and surrounding areas

Key Characteristics:

- **Isolation:** Regions are completely isolated from each other for fault tolerance
- **Latency:** Deploy in regions closest to your users for low latency
- **Compliance:** Meet data residency requirements (e.g., GDPR, Indian data laws)
- **Service Availability:** Not all AWS services available in all regions

2. Availability Zones (AZs) - Isolated Data Centers Within a Region

Definition: Availability Zones are physically separate data center facilities within the same region. Each AZ has independent power, cooling, networking, and security.

Mumbai Region AZ Mapping (Conceptual Example)

Important Note: AWS does not publicly disclose exact AZ locations for security reasons. The city mappings below are conceptual examples to understand geographic distribution.

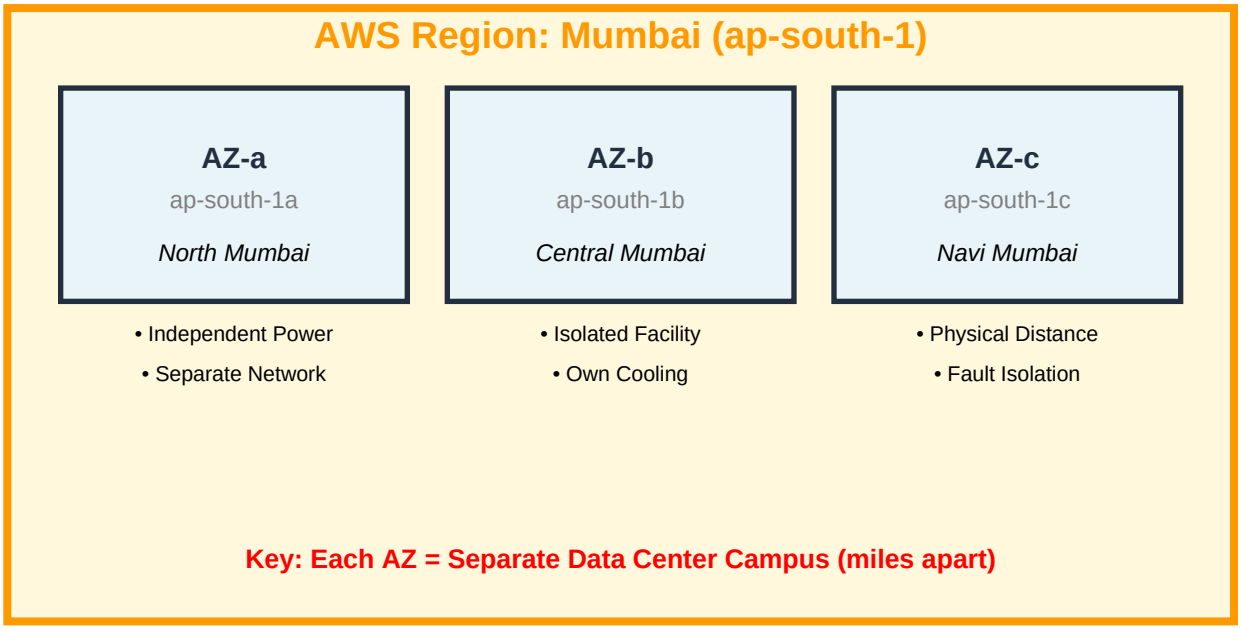
AZ Code	Conceptual Location	Characteristics
ap-south-1a	North Mumbai area	Independent power & networking
ap-south-1b	Central Mumbai area	Separate physical facility
ap-south-1c	Navi Mumbai/Outskirts	Isolated from other AZs

AZ Critical Features:

- **Physical Separation:** Each AZ is in a separate building/campus (miles apart)
- **Independent Infrastructure:** Own power supply, cooling systems, and network equipment

- **High Availability:** Deploy across multiple AZs to survive data center failures
- **Low Latency:** AZs within same region connected by high-speed private network

3. Architecture Diagram: Region with Multiple Availability Zones



4. AWS Backbone Network - Private High-Speed Connectivity

Definition: The AWS Backbone Network is a private, AWS-owned fiber-optic network that connects all AWS infrastructure globally. It does NOT use the public internet.

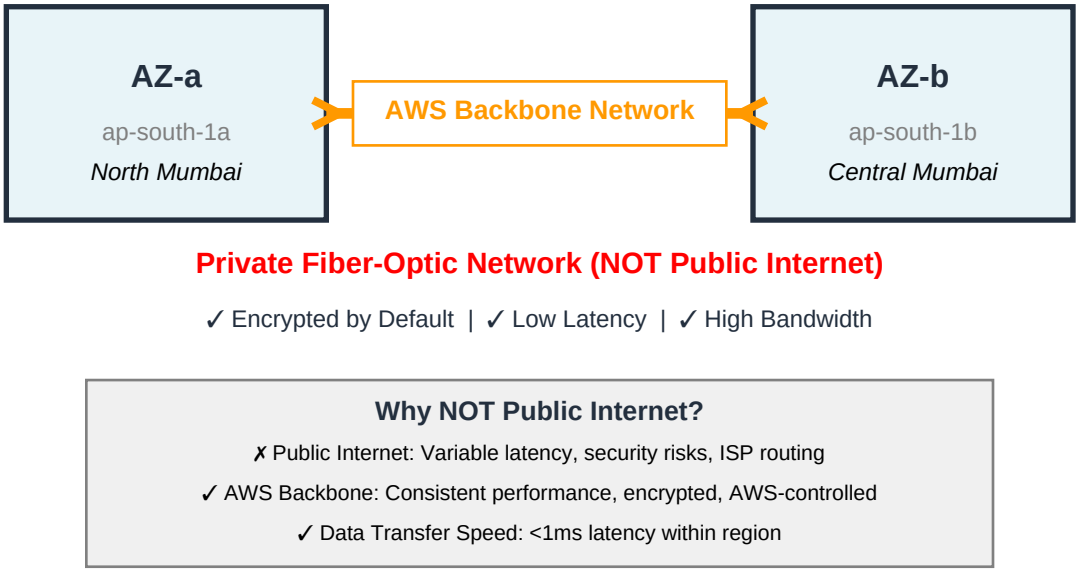
What It Connects:

- Availability Zones within the same region
- Different AWS Regions across continents
- AWS Edge Locations (CloudFront CDN points)
- AWS Direct Connect locations (private enterprise connections)

Key Benefits:

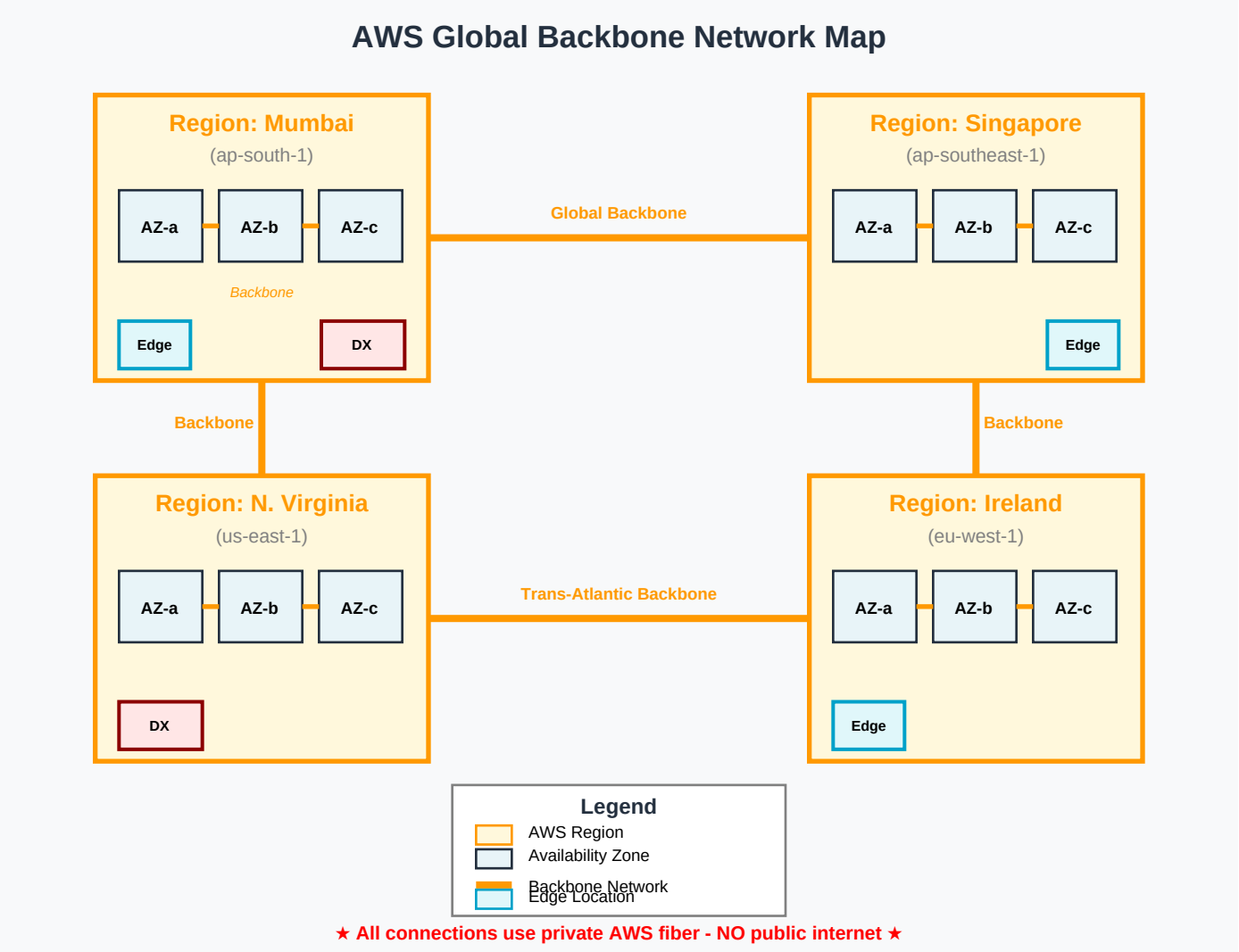
- **Low Latency:** Sub-millisecond latency between AZs in same region
- **High Bandwidth:** Terabits per second capacity for data transfer
- **Security:** Traffic encrypted by default, never touches public internet
- **Reliability:** Redundant paths with automatic failover
- **Predictable Performance:** No internet congestion or ISP routing issues

5. Architecture Diagram: AWS Backbone Network Connectivity



AWS Global Backbone Network Architecture

This diagram shows how the AWS Backbone Network connects multiple regions, edge locations, and enterprise connections globally using private fiber-optic infrastructure.



Key Components in the Backbone Network Map:

- **Regions:** Large boxes (Mumbai, Singapore, N. Virginia, Ireland) containing multiple AZs
- **Availability Zones:** Small boxes within regions - connected by low-latency backbone
- **Inter-Region Backbone:** Thick orange lines connecting regions across continents
- **Edge Locations:** CDN points of presence for CloudFront content delivery
- **Direct Connect (DX):** Dedicated private connections from enterprise data centers to AWS

6. How AWS Built Its Global Backbone Network

Does AWS Own Undersea Cables?

AWS does NOT lay its own undersea cables across oceans. Instead, AWS uses a **hybrid approach**:

- **Leases Dark Fiber:** AWS leases unused fiber-optic cables from telecom providers
- **Co-Investment in Cables:** AWS co-invests in undersea cable consortiums with other tech companies
- **Owns Regional Fiber:** AWS owns and operates fiber connections within metro areas and between nearby facilities
- **Installs Own Equipment:** AWS installs its proprietary networking equipment on leased fiber

Example Undersea Cable Investments:

Cable Name	Route	AWS Role	Capacity
MAREA	USA - Spain	Co-investor with Microsoft	200+ Tbps
JUPITER	USA - Japan	Co-investor consortium	60 Tbps
BtoBE	USA - Europe	Leased capacity	140 Tbps
SJC2	Asia-Pacific loop	Consortium member	144 Tbps

Why This Hybrid Model?

- **Cost-Effective:** Building undersea cables costs $200M-$500M per route
- **Shared Risk:** Co-investment spreads financial and operational risk
- **Faster Deployment:** Leveraging existing infrastructure speeds up global expansion
- **Control:** AWS still controls routing, security, and performance on the fiber

7. AWS Data Transfer Pricing & Cost Examples

AWS charges differently based on where data moves. Understanding these pricing tiers is critical for cost optimization in interviews and real-world architecture.

Data Transfer Pricing Tiers (Mumbai Region Example)

Transfer Type	Direction	Cost (USD per GB)	Example Use Case
Within Same AZ	Bidirectional	$0.00 (FREE)	EC2 to RDS in same AZ
Between AZs (Same Region)	IN/OUT	$0.01 per GB	EC2 (AZ-a) ↔ RDS (AZ-b)
Internet Download (Data IN)	From Internet → AWS	$0.00 (FREE)	Upload files to S3
Internet Upload (Data OUT)	AWS → Internet	$0.09 per GB (first 10 TB/month)	Website serving content from EC2/S3
Inter-Region (India → Singapore)	OUT	$0.086 per GB	Replication between Mumbai and Singapore
CloudFront to Origin	CloudFront → S3	$0.00 (FREE)	CDN pulling from S3
Direct Connect	Data OUT	$0.043 per GB	Enterprise data center to AWS via DX

Real-World Cost Calculation Example

Scenario: Healthcare company serving 10 TB of patient portal data per month from Mumbai region

Component	Data Transfer	Calculation	Monthly Cost
S3 Storage	Within AWS (FREE)	10 TB × $0.00	$0.00
EC2 to S3 (same AZ)	Within AZ (FREE)	2 TB × $0.00	$0.00
Multi-AZ RDS	Cross-AZ replication	500 GB × $0.01	$5.00
Internet Data OUT	First 10 TB to users	10 TB × $0.09 = 10,240 GB × $0.09	$921.60
CloudFront (Optional)	If using CDN	CDN pricing (lower than S3)	$~600-700
			$926.60

Cost Optimization Strategies (Interview Important!)

1. **Use CloudFront CDN:** Reduces data OUT charges by ~30-40% vs direct S3/EC2
2. **Keep Services in Same AZ:** FREE data transfer within AZ (but reduces HA)
3. **AWS PrivateLink:** Connect VPCs privately without internet data OUT charges
4. **S3 Transfer Acceleration:** Uses CloudFront edge - faster + cheaper for global uploads
5. **VPC Endpoints:** Access S3/DynamoDB from VPC without NAT Gateway data charges
6. **Direct Connect:** Cheaper than internet for high-volume enterprise transfers ($0.043 vs $0.09)

Internet Exchange Points & Peering

AWS also peers at major Internet Exchange Points (IXPs) to reduce costs and improve performance:

- **What is IXP?** Physical location where ISPs, CDNs, and cloud providers interconnect
- **AWS Presence:** AWS peers at 100+ IXPs globally (e.g., DE-CIX Frankfurt, AMS-IX Amsterdam)
- **Benefit:** Direct peering bypasses expensive transit providers, reducing latency and cost
- **Example:** AWS in Mumbai peers at Mumbai IXP to serve Indian ISP customers directly

Quick Reference: When Are You Charged?

✓ FREE	✗ CHARGED
• Data IN from internet	• Data OUT to internet ($0.09/GB)
• Within same AZ	• Between AZs ($0.01/GB)
• CloudFront to S3 origin	• Inter-region transfer ($0.086/GB)
• S3 to CloudFront	• NAT Gateway processing ($0.045/GB)
• VPC Endpoint (S3/DynamoDB)	• VPC Peering cross-region

8. Comparison: ISP Network vs AWS Backbone Network

Aspect	ISP/Public Internet	AWS Backbone Network
Ownership	Multiple ISPs & carriers	AWS-owned private network
Traffic Route	Through public internet hops	Direct private fiber connections
Latency	Variable (10-100+ ms)	Consistent (<1ms within region)
Security	Requires VPN/encryption	Encrypted by default
Bandwidth	Shared, can be congested	Dedicated high-capacity links
Reliability	Subject to ISP outages	Redundant paths with failover
Cost	ISP bandwidth charges	Included in AWS data transfer
Performance	Unpredictable routing	Optimized AWS-controlled paths

9. Interview Key Points to Remember

When explaining Regions:

- Use concrete examples (ap-south-1 = Mumbai)
- Emphasize isolation between regions for fault tolerance
- Mention data residency and compliance requirements

When explaining AZs:

- Stress physical separation (separate buildings, miles apart)
- Highlight independent infrastructure (power, cooling, networking)
- Note AWS doesn't disclose exact locations for security

When explaining Backbone:

- Clearly state it's NOT the public internet
- Emphasize private, encrypted, AWS-owned fiber network
- Mention low latency (<1ms within region) and high bandwidth
- Explain AWS uses leased fiber + co-invested undersea cables (hybrid model)

When discussing Pricing:

- Remember: Data IN is FREE, Data OUT to internet is charged ($0.09/GB)
- Same AZ transfers are FREE, cross-AZ costs $0.01/GB
- Suggest CloudFront for cost optimization (30-40% savings on data OUT)
- Mention VPC Endpoints for FREE S3/DynamoDB access from VPC
