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R&D Document

Azure Global Infrastructure

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1. Introduction

Microsoft Azure is a leading cloud computing platform that delivers a wide range of services through a globally distributed infrastructure. Its architecture is designed to ensure high availability, low latency, regulatory compliance, and resilience for mission-critical applications. This document provides a comprehensive overview of Azure's global infrastructure, focusing on **Geographies**, **Regions**, **Availability Zones**, **Data Centers**, and emerging components like **Edge Zones**. It explores their roles, characteristics, and practical applications, supported by examples, reference tables, and best practices to guide effective cloud deployment strategies.

2. Azure Geographies

2.1 Definition

An Azure **Geography** is a discrete market area encompassing one or more Azure Regions, defined by geopolitical boundaries to ensure data residency, sovereignty, and compliance with local regulations.

2.2 Purpose

- **Data Residency:** Keeps data within a specific geographic boundary to meet legal and regulatory requirements (e.g., GDPR in Europe).
- **Resilience:** Ensures redundancy by including multiple Regions within a Geography for disaster recovery.
- **Compliance:** Aligns with regional standards like HIPAA (USA), ISO 27001, or China's Cybersecurity Law.

2.3 Examples

- **United States:** Includes Regions like East US, West US, Central US, and US Gov Virginia.
- **Europe:** Includes North Europe (Ireland), West Europe (Netherlands), Germany North, and France Central.
- **Asia Pacific:** Includes Southeast Asia (Singapore), East Asia (Hong Kong), Japan East, and India Central.
- **Special Geographies:** Azure Government (USA), Azure China (operated by 21Vianet), and Germany (isolated for strict data sovereignty).

2.4 Data Residency and Compliance

- Azure provides tools like **Azure Policy** and **Compliance Manager** to enforce data residency.
- Certain Geographies (e.g., Germany, China) offer isolated environments to meet stringent sovereignty requirements.
- Example: A European company can deploy services in the Europe Geography to ensure GDPR-compliant data storage.

3. Azure Regions

3.1 Definition

An Azure **Region** is a set of data centers within a specific geographic location, connected through a low-latency, high-bandwidth network. Each Region is designed to support a wide range of Azure services.

3.2 Characteristics

- **Global Presence:** Azure operates over **60 Regions** worldwide, with plans for continuous expansion.
- **Service Availability:** Not all services (e.g., Azure AI, specialized VMs) are available in every Region. The **Azure Region Explorer** tool helps identify service availability.
- **Isolation:** Regions are physically separated to mitigate risks like natural disasters or power outages.
- **Sovereignty Options:** Specialised Regions (e.g., US DoD Central, Azure China) cater to government or regulated industries.

3.3 Region Pairs

Each Region is paired with another within the same Geography for disaster recovery and data replication.

- **Characteristics:**
 - Minimum physical distance of 300 miles to avoid shared risks.
 - Synchronised data replication (e.g., Azure SQL Database Geo-Replication).
 - Sequential updates to ensure one Region remains operational during maintenance.
- **Examples:**
 - East US (Virginia) ↔ West US (California)
 - North Europe (Ireland) ↔ West Europe (Netherlands)
 - Southeast Asia (Singapore) ↔ East Asia (Hong Kong)

3.4 Examples

Region Name	Location	Paired Region
East US	Virginia, USA	West US
West Europe	Netherlands	North Europe
Southeast Asia	Singapore	East Asia
Japan East	Tokyo, Japan	Japan West
Brazil South	São Paulo, Brazil	South Central US

4. Availability Zones

4.1 Definition

Availability Zones are physically separate locations within an Azure Region, each with independent power, cooling, and networking infrastructure to enhance fault tolerance.

4.2 Purpose

- **High Availability:** Protects applications from data center failures by distributing workloads across zones.
- **SLA Guarantees:** Offers up to **99.99% uptime** for services deployed across multiple zones (e.g., Virtual Machines, Azure Kubernetes Service).
- **Low Latency:** Zones are close enough to ensure minimal latency between them (typically <2ms).

4.3 Components

- **Minimum Zones:** Most Regions with Availability Zone support have **at least three zones** (e.g., Zone 1, Zone 2, Zone 3).
- **Supported Services:** Includes VMs, managed disks, load balancers, and databases like Azure Cosmos DB.
- **Zonal vs. Zone-Redundant Services:**
 - **Zonal:** Pinned to a specific zone (e.g., a VM in Zone 1).
 - **Zone-Redundant:** Automatically distributed across zones (e.g., zone-redundant storage).

4.4 Practical Example

- **Scenario:** A company deploys a web application in **East US 2**, which supports Availability Zones.
- **Architecture:**
 - VM 1 in Zone 1, VM 2 in Zone 2, VM 3 in Zone 3.
 - Azure Load Balancer distributes traffic across all zones.
 - Azure SQL Database configured for zone-redundant replication.
- **Outcome:** If Zone 1 fails due to a power outage, Zones 2 and 3 continue serving traffic, ensuring minimal downtime.

5. Azure Data Centers

5.1 Definition

Azure Data Centers are the physical facilities housing servers, storage, networking equipment, and other infrastructure components that power Azure services.

5.2 Design and Security

- **Physical Security:** 24/7 monitoring, biometric access, and multi-layer security protocols.
- **Redundancy:** Multiple power sources, backup generators, and cooling systems to ensure uptime.
- **Compliance:** Certified for standards like ISO 27001, SOC 1/2/3, PCI DSS, and GDPR.
- **Modular Design:** Uses containerised or prefabricated units for rapid deployment and scalability.

5.3 Global Network Backbone

- Microsoft's global network connects data centers via a private fiber-optic backbone spanning over 165,000 miles.
- **Benefits:**
 - Low-latency connectivity between Regions and Availability Zones.
 - Dedicated bandwidth for services like Azure ExpressRoute.
 - Resilience against internet disruptions through redundant paths.

6. Azure Edge Zones

6.1 Definition

Azure Edge Zones extend Azure's infrastructure to the network edge, bringing compute, storage, and services closer to end-users or devices for ultra-low-latency application

6.2 Use Cases

- **Public Edge Zones:** Deployed in metropolitan areas for applications like gaming or AR/VR (e.g., Los Angeles, New York).
- **Private Edge Zones:** On-premises edge solutions for enterprises using Azure Stack Edge.
- **5G Integration:** Partners with telecom providers (e.g., AT&T) to deliver edge services over 5G networks.
- **Example:** A retailer uses Edge Zones to process real-time IoT data from in-store sensors, reducing latency for inventory management.

7. Summary Table

Component	Description	Scope
Geography	Discrete market area for data residency and compliance	Multiple Regions
Region	Group of data centers in a specific location	Multiple Availability Zones
Availability Zone	Physically separate location within a Region	Single Region
Data Center	Physical facility housing Azure infrastructure	Part of a Region/Zone
Edge Zone	Edge compute location for low-latency applications	Metropolitan or on-premises

8. Benefits of Azure's Global Infrastructure

- **High Availability:** Region Pairs and Availability Zones ensure uptime and disaster recovery.
- **Low Latency:** Global distribution and Edge Zones minimise delays for end-users.
- **Compliance:** Geographies align with regional data protection laws (e.g., GDPR, CCPA).
- **Scalability:** Modular data centers and global network support rapid expansion.
- **Resilience:** Redundant infrastructure mitigates risks from failures or natural disasters.

9. Recent Updates in Azure Infrastructure

As of June 2025, Microsoft continues to expand its Azure infrastructure:

- **New Regions:** Announced first cloud regions in Belgium, Austria, Greece, and Denmark, focusing on digital transformation and sustainability.
- **Availability Zones:** General availability of Availability Zones in Norway East and China North 3, enhancing resiliency.
- **AI Investments:** \$2.9 billion investment in Japan to double AI and cloud capacity, and \$2.1 billion in Spain for AI-focused data centers.
- **Sustainability:** New sustainable data center in Arizona and a carbon-neutral region in New Zealand.
- **Capacity Expansion:** Microsoft plans to quadruple investments in AI and cloud infrastructure in Spain by 2025 and double server capacity globally.

10. Real-World Applications

- **E-Commerce:** An e-commerce platform leverages East US and West US Regions with Availability Zones to ensure uptime during peak traffic (e.g., Black Friday).
- **Financial Services:** A bank uses Region Pairs (e.g., Canada Central and East) for disaster recovery, replicating critical financial data to comply with regulations.
- **Healthcare:** A hospital deploys HIPAA-compliant services in US Regions to store patient data securely while using Zone-Redundant Storage for resiliency.
- **AI Workloads:** A tech company uses Malaysia's new Region to deploy low-latency AI models, benefiting from proximity to Asia Pacific users.
- **Government:** Azure Government Regions support US federal agencies with stringent compliance and isolated infrastructure.

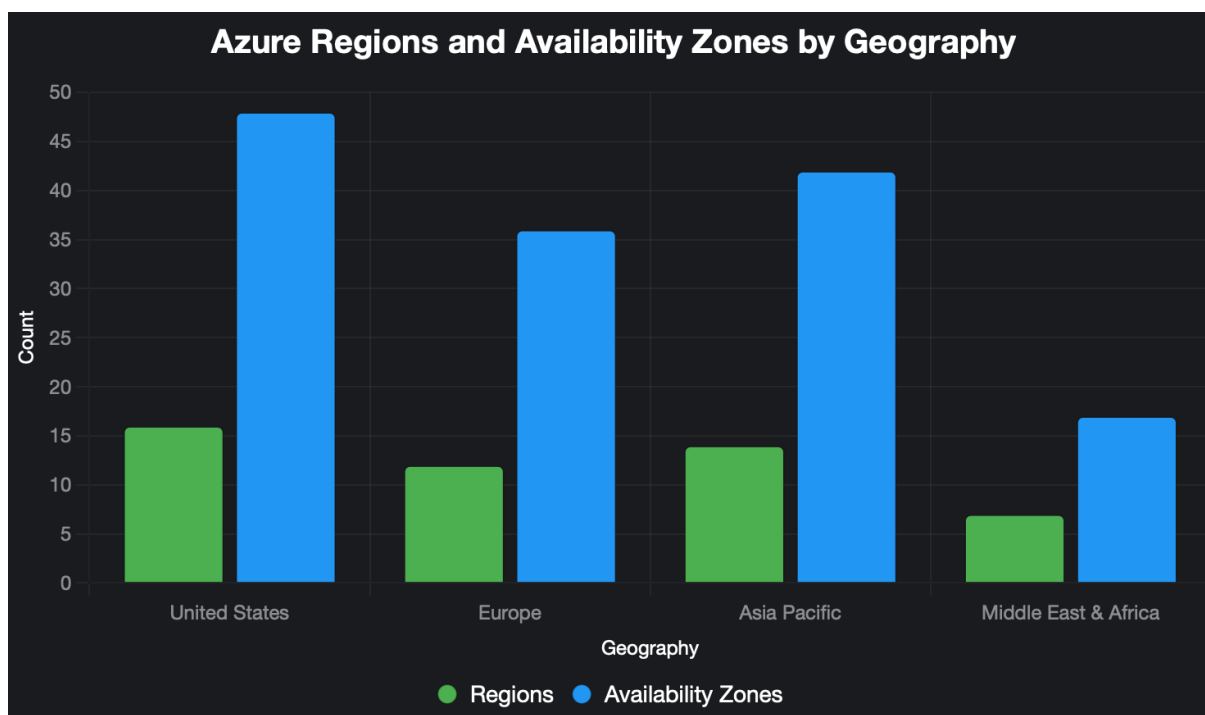
11. Best Practices

- **Choose Regions Strategically:** Select Regions based on latency, compliance, and service availability. Use tools like Azure's Products by Region page.
- **Leverage Availability Zones:** Deploy mission-critical applications across multiple zones to achieve 99.99% uptime and fault tolerance.
- **Use Region Pairs:** Configure geo-redundant storage and backups across paired Regions for disaster recovery.
- **Optimise Costs:** Compare pricing across Regions using tools like Azure Price Calculator to minimise expenses.
- **Monitor Infrastructure:** Use Azure Monitor and Holori to visualise resource distribution and identify underutilised assets.

- **Plan for Sustainability:** Prioritise Regions with renewable energy (e.g., New Zealand, Arizona) to align with environmental goals.
- **Secure Data Transfers:** Ensure encrypted connections for inter-Region data replication to comply with security standards.

12. Visualising Azure Infrastructure

To illustrate the distribution of Azure Regions and Availability Zones, the following chart compares the number of Regions and Availability Zones across key Geographies. (Confirm with your supervisor if a visual chart is desired.)



This chart highlights Azure’s extensive infrastructure, with the US and Europe leading in Regions and Availability Zones, reflecting high demand and compliance needs.

13. Conclusion

Azure’s global infrastructure, comprising Geographies, Regions, Availability Zones, and Data Centers, is engineered for scalability, resiliency, and compliance. With over 64 Regions, 126 Availability Zones, and ongoing expansions, Azure offers unmatched flexibility to deploy applications globally while meeting data sovereignty and performance requirements. By leveraging Region Pairs, Availability Zones, and sustainable data centers, organisations can build robust, low-latency, and environmentally responsible solutions. This document provides

a foundation for understanding and utilising Azure's infrastructure to design future-proof cloud architectures.

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