

AZ-220 Azure IoT Developer

Azure IoT Handbook

The following is a summary of the important parts to remember about Azure IoT. Use it when designing IoT systems in Azure and when learning for the exam.

Topic	Description																																						
IoT Hub Tiers	Free Basic Standard																																						
Tiers capabilities	<table><tr><th>Capability</th><th>Basic</th><th>Free / Standard</th></tr><tr><td>Device to cloud telemetry</td><td>Yes</td><td>Yes</td></tr><tr><td>Per-device identity</td><td>Yes</td><td>Yes</td></tr><tr><td>Message routing and enrichment</td><td>Yes</td><td>Yes</td></tr><tr><td>Event Grid integration</td><td>Yes</td><td>Yes</td></tr><tr><td>HTTP, AMQP, MQTT protocols</td><td>Yes</td><td>Yes</td></tr><tr><td>Device Provisioning Service (DPS)</td><td>Yes</td><td>Yes</td></tr><tr><td>Monitoring and diagnostics</td><td>Yes</td><td>Yes</td></tr><tr><td>Cloud-to-device messaging</td><td></td><td>Yes</td></tr><tr><td>Device & Module twins</td><td></td><td>Yes</td></tr><tr><td>Device management</td><td></td><td>Yes</td></tr><tr><td>IoT Edge</td><td></td><td>Yes</td></tr></table>			Capability	Basic	Free / Standard	Device to cloud telemetry	Yes	Yes	Per-device identity	Yes	Yes	Message routing and enrichment	Yes	Yes	Event Grid integration	Yes	Yes	HTTP, AMQP, MQTT protocols	Yes	Yes	Device Provisioning Service (DPS)	Yes	Yes	Monitoring and diagnostics	Yes	Yes	Cloud-to-device messaging		Yes	Device & Module twins		Yes	Device management		Yes	IoT Edge		Yes
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	B2, S2	16MB / minute	6,000,000 msgs / day		
	B3, S3	814MB / minute	300,000,000 msgs / day		
Message size	4 KB, 0.5KB in the Free tier				
Access policies					
	Policy		Use for...		
	iothubowner	IoT Hub admin, can do anything			
	service	Other services or apps connecting to IoT Hub to send messages to devices or get device notification			
	device	Devices connecting to IoT Hub			
Device authentication					
	Authentication Type		Description		
	Symmetric Key		A key (can be generated by IoT Hub) that the device should specify in order to connect		
	X.509 Self-Signed		Self-signed certificate		
	X.509 Signed		A certificate signed by a Certificate Authority (CA)		
Communication protocols					
			MQTT	AMQP	HTTPS
	Push notification		V	V	X
	Field gateway		X	V	X
	Low resource devices		V	X	V
	Standard ports		X	X	V
	Payload size		V	V	X
	Library compatibility		X	X	V
	Messaging method				
Cloud-to-device		Device twins	Direct method		
When to use?		Send notification to device	Configure device	Send command for immediate action	
Data flow		One-way	One-way	Two-way	

	If device is disconnected...	Message is retained for 48 hours	Device will be updated when connected	Invocation fails
	Targets	Single device	Single device or multiple using jobs	Single device or multiple using jobs
	Payload size	Up to 64KB	Up to 32KB	Up to 128KB
	Protocol	All protocols	MQTT, AMQP	MQTT, AMQP
DPS Allocation Policies	<ul style="list-style-type: none"> - Evenly weighted distribution (default) - Lowest latency - Static (manual) configuration - Custom (using Azure Functions) <p>Note: No built-in policy for geography distribution, use Custom policy for that</p>			
Disenroll and Deregister	<p>If you want to prevent device(s) to connect in the future, you should:</p> <ol style="list-style-type: none"> 1. Disenroll (disable) it from DPS 2. Deregister (remove) it from IoT Hub 			
Modules	A logical module inside the device. Has its own role, messages, consumers, twin etc.			
Automatic Device Management (Configuration)	<p>Contains:</p> <ol style="list-style-type: none"> 1. Target condition (what devices / modules should be configured) 2. Target content (the desired properties to configure) 3. Metrics (data about progress, success failures of the configuration) 			
Direct Methods	<ul style="list-style-type: none"> - Invoked on a device - Work with a request / response model - Device needs to be online and connected - Response is immediate - Available in the Standard tier 			
Jobs	<ul style="list-style-type: none"> - Schedule actions on devices - Can run device twins updates and direct methods - Offline devices will be updated once connected - Monitored - Scheduled using code - Progress can be queries from the portal - Available in the Standard tier 			
IoT Hub vs IoT Central				
	IoT Hub		IoT Central	
	Used by Azure experts		Used by IoT power users	

	Part of the Azure portal	Independent application
	Provides full control	Provides limited control
	Requires build and configuration from the ground up	Great for building solutions quickly
	Based on IoT Hub & DPS	
Device Templates	Contains:	
	Element	Description
	Model	Make and model of the device
	Cloud properties	Device metadata for use by solution developer. Not synchronized with the device
	Telemetry	Telemetry fields received from the device
	Commands	Commands that can be executed directly on the device
	Properties	Properties of the device, reported by the device. Can be defined as "writable".
	Views	Visualizations of device data
	Components	Logical container for additional properties, commands and telemetry
IoT Central Rules and Actions	<ul style="list-style-type: none"> - Rules: What to look for <ul style="list-style-type: none"> o Devices to monitor o Conditions for the alert - Actions: What to do when a condition is met <ul style="list-style-type: none"> o Send email o Trigger WebHook 	
Device Groups	<ul style="list-style-type: none"> - Group multiple devices based on pre-defined properties - Dynamic – devices get in and out of groups as properties change - Used for central management, viewing data and analytics 	
Troubleshooting devices	<p>Show rolling event of a device: <code>az iot central diagnostics monitor-events --app-id <app_id> --device-id <device-id></code></p> <p>Show status of a device: <code>az iot central device registration-info --app-id <app_id> --device-id <device-id></code></p> <p>Statuses are:</p> <ul style="list-style-type: none"> - Provisioned - Registered (not connected yet) - Blocked - Unapproved 	

	<ul style="list-style-type: none">- Unassociated <p>Validate messages from a device: az iot central diagnostics validate-messages --app-id <app_id> --device-id <device-id></p>																																
Jobs	<ul style="list-style-type: none">- Manages bulk of devices- Similar to Jobs in IoT Hub- Allow scheduling- Updates:<ul style="list-style-type: none">o Device propertieso Cloud propertieso Commands																																
Application Templates	<ul style="list-style-type: none">- Kickstart solution development- Includes:<ul style="list-style-type: none">o Dashboardso Device templateso Simulated deviceso Rules and jobso Rich documentation- Industry focused- Can be customized and exported																																
IoT Edge	<ul style="list-style-type: none">- Enables running analytics and custom business logic on the device instead of the cloud- Useful for:<ul style="list-style-type: none">o Responding faster to eventso Saving bandwidtho Decreasing load on server																																
Supported platforms	<div>IoT Edge v1.1:</div> <table><tr><th>Operating System</th><th>AMD64</th><th>ARM32v7</th><th>ARM64</th></tr><tr><td>Raspberry Pi OS Stretch</td><td></td><td>✓</td><td></td></tr><tr><td>Ubuntu Server 20.04</td><td>✓</td><td></td><td>✓</td></tr><tr><td>Ubuntu Server 18.04</td><td>✓</td><td></td><td>✓</td></tr><tr><td>Windows 10 Pro</td><td>✓</td><td></td><td></td></tr><tr><td>Windows 10 Enterprise</td><td>✓</td><td></td><td></td></tr><tr><td>Windows 10 IoT Enterprise</td><td>✓</td><td></td><td></td></tr><tr><td>Windows Server 2019</td><td>✓</td><td></td><td></td></tr></table>	Operating System	AMD64	ARM32v7	ARM64	Raspberry Pi OS Stretch		✓		Ubuntu Server 20.04	✓		✓	Ubuntu Server 18.04	✓		✓	Windows 10 Pro	✓			Windows 10 Enterprise	✓			Windows 10 IoT Enterprise	✓			Windows Server 2019	✓		
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	IoT Edge v1.2:							
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Components	<div>1. Modules – container running 3rd party services, custom code or Azure services (such as Stream Analytics)</div> <div>2. Runtime – manages the modules, maintains security, reports health, manages communication</div> <div>3. Cloud interface – monitors and manages devices</div>							
iotedge commands	<div>iotedge logs <module-name> – Displays logs of a specified module</div> <div>iotedge check – Runs self-diagnostics and reports the results</div> <div>iotedge config apply – Applies the configuration defined in the config.toml file and restarts the runtime</div> <div>iotedge restart <module-name> – Restarts the specified module</div>							
Deployments	<div>- Used to configure multiple devices based on condition</div> <div>- Defines:<div><div>Versions</div><div>Modules</div><div>Routes</div></div></div> <div>- Quite similar to configuration of regular (non-IoT Edge) devices</div>							
IoT Edge Gateway	Scenario when devices connect to another, IoT Edge, device functioning as a gateway, and it connects to IoT Hub and relays the messages from the other devices.							
Reasons for using gateway	<div>1. Processing at the edge</div> <div>2. Devices not connected</div> <div>3. Connection multiplexing</div> <div>4. Traffic smoothing</div> <div>5. Offline support</div>							
Types of gateway	<table><tr><th>Transparent</th><th>Translation</th></tr><tr><td><div><div>- Devices can connect to IoT Hub but choose not to</div><div>- Devices have identity in IoT Hub</div><div>- Gateway can manage up to 100 devices</div><div>- Use when gateway has better connectivity</div><div>- Configured using the portal</div></div></td><td><div><div>- Devices cannot connect to IoT Hub (no connection, protocol not supported etc.)</div><div>- No IoT Hub identity</div><div>- Gateway processes the data and sends to IoT Hub</div><div>- Requires custom code</div></div></td></tr></table>				Transparent	Translation	<div><div>- Devices can connect to IoT Hub but choose not to</div><div>- Devices have identity in IoT Hub</div><div>- Gateway can manage up to 100 devices</div><div>- Use when gateway has better connectivity</div><div>- Configured using the portal</div></div>	<div><div>- Devices cannot connect to IoT Hub (no connection, protocol not supported etc.)</div><div>- No IoT Hub identity</div><div>- Gateway processes the data and sends to IoT Hub</div><div>- Requires custom code</div></div>
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Translation gateway patterns and capabilities	Capability	Protocol Translation	Identity Translation
	IoT Hub device identities	Only the gateway	All devices
	Device twin	Only the gateway	All devices
	Direct methods and C2D messages	Only the gateway	All devices
	IoT Hub quotas	Apply to the gateway	Apply to all devices
Gateway hierarchy	Up to 5 levels		
Offline support	<ul style="list-style-type: none"> - Enabled by default - Retains messages for 7200 seconds (2 hours) - Retention can be configured 		
Digital Twins	<ul style="list-style-type: none"> - A platform for building device graphs - Graph = Relationship between devices 		
Models and twins	Models = A logical definition of a device Twin = An actual device connected to a model		
DTDL	Digital Twin Definition Language A JSON file defining the models and the relationships between them Contains: <ul style="list-style-type: none"> - Id of the model - Type of the model - Display name - Properties - Relationships - (Optional) properties and target of relationship 		
Stream Analytics	<ul style="list-style-type: none"> - Fully managed stream processing cloud service - Can handle million of events in a second - Can be set up on IoT Edge devices 		
Inputs	<ul style="list-style-type: none"> - Event Hub - IoT Hub - Storage Account 		
Query	<ul style="list-style-type: none"> - Using SQL-like query - Can be extended using C# & JavaScript user defined functions (see later) 		
Output	<ul style="list-style-type: none"> - Azure Function - Power BI - Storage services - Lots more... 		
User Defined Functions (UDF)	<ul style="list-style-type: none"> - JavaScript functions - JavaScript aggregates - C# functions - Azure Machine Learning 		
Query Syntax	SELECT temperature INTO		

	<pre> output FROM Input </pre>												
WITH	<p>Specifies a temporary named result set for use in a FROM clause.</p> <pre> WITH lowReadings AS (SELECT * FROM iothub WHERE temperature<40) SELECT temperature, entryTime INTO lowtempstorage FROM lowReadings </pre>												
TIMESTAMP BY	<p>Indicates which field holds the timestamp of the data.</p> <pre> SELECT temperature, UDF.CheckIfTemperatureIsHigh(temperature) INTO hightempstorage FROM iothub TIMESTAMP BY entryTime </pre>												
Windowing	<table> <tr> <th>Window type</th><th>Description and syntax</th></tr> <tr> <td>Tumbling</td><td>Fixed-size, non-overlapping GROUP BY TumblingWindow(second,10)</td></tr> <tr> <td>Hopping</td><td>Fixed-size, scheduled-overlapped GROUP BY HoppingWindow(second,10,5)</td></tr> <tr> <td>Sliding</td><td>Fixed-size, sliding, created dynamically based on events GROUP BY SlidingWindow(second,10)</td></tr> <tr> <td>Session</td><td>Variable-length window containing all events within the max duration and ends when a timeout occurs GROUP BY SessionWindow(second,2,10)</td></tr> <tr> <td>Snapshot</td><td>Groups all events with the same timestamp GROUP BY System.TimeStamp()</td></tr> </table>	Window type	Description and syntax	Tumbling	Fixed-size, non-overlapping GROUP BY TumblingWindow(second,10)	Hopping	Fixed-size, scheduled-overlapped GROUP BY HoppingWindow(second,10,5)	Sliding	Fixed-size, sliding, created dynamically based on events GROUP BY SlidingWindow(second,10)	Session	Variable-length window containing all events within the max duration and ends when a timeout occurs GROUP BY SessionWindow(second,2,10)	Snapshot	Groups all events with the same timestamp GROUP BY System.TimeStamp()
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Stream Analytics on IoT Edge	<p>Used for:</p> <ul style="list-style-type: none"> - Low-latency apps - Limited connectivity - Compliance 												

Limitations	<ul style="list-style-type: none"> - JavaScript UDF are not supported - Azure ML is not supported - Some advanced SQL operators are not supported 			
Time Series Insights	<ul style="list-style-type: none"> - Shows data across time 			
Storage	<ul style="list-style-type: none"> - Warm: For interactive analysis, immediate access, stores up to 30 days of data - Cold: Offline data, stores large amount of data, cheaper 			
Models	<ul style="list-style-type: none"> - Help contextualize data using predefined (computed) fields and hierarchies 			
Health Monitoring	<ul style="list-style-type: none"> - Done using two mechanisms: 			
	<table> <tr> <th>Logging</th><th>Metrics</th></tr> <tr> <td> <ul style="list-style-type: none"> - Log records about IoT Hub activities - Uses the Kusto query language - Data can be filtered and customized </td><td> <ul style="list-style-type: none"> - Shows data about various actions in IoT Hub - Displayed as chart over time - Can be customized </td></tr> </table>	Logging	Metrics	<ul style="list-style-type: none"> - Log records about IoT Hub activities - Uses the Kusto query language - Data can be filtered and customized
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Alerts	<ul style="list-style-type: none"> - Can be defined on Metrics and Logs - Trigger alerts - Alerts are sent to action groups - Can be email, SMS and more 			
Dashboards	<ul style="list-style-type: none"> - Log results and metrics can be pinned to dashboards - Can use existing or new, private or public dashboards 			
Kusto query example	<pre>AzureDiagnostics where ResourceProvider == "MICROSOFT.DEVICES" and ResourceType == "IOTHUBS" order by TimeGenerated desc project TimeGenerated, OperationName, metricName_s, total_d</pre>			
IoT Edge logs	Logs and metrics can be collected from IoT Edge device and sent to IoT Hub using the Microsoft Metrics Collector module			
Troubleshooting devices	<p>Run the following to troubleshoot devices:</p> <ul style="list-style-type: none"> - Connect to the device using RDP or SSH - Look at local logs - Make sure outbound traffic is not blocked by firewall - Check in IoT Hub's log analytics - Run direct method and twin command - Run <code>iotedge check</code> command in IoT Edge devices 			
High-availability and redundancy	<ul style="list-style-type: none"> - IoT Hub is not a cross-region service - If we need multi-region IoT endpoints – we need to deploy IoT Hub on every region and synchronize them - Failover is done either automatically in a case of region shutdown or manually 			

	<ul style="list-style-type: none">- IoT Hub can be down up to 26 hours in case of failover
IoT Security	<ul style="list-style-type: none">- Ensure security baseline:<ul style="list-style-type: none">○ Device-2-cloud communication is done only using secure protocols○ Access to devices is limited to minimum○ Validate messages arriving to the cloud○ Device is up-to-date and patched○ Use SDKs whenever possible○ Define access controls for IoT Hub○ Utilize logging and monitoring
Defender for IoT	<ul style="list-style-type: none">- Identifies vulnerabilities and threats in IoT environment- Enabled by default
Types of Defender for IoT	<ul style="list-style-type: none">- Agentless: Runs on the network, no impact on performance, can run on-premises or in the cloud- Micro-agent: Installed on the device, provides the best security

I Hope you enjoyed the course, and that it helped you become a Certified Azure IoT Developer. I'm sure you'll now be able to design secure, robust and reliable IoT systems in Azure, and that it made you a better developer and architect!

For any question or comment, contact me at:

memi@memilavi.com

Thanks,

Memi