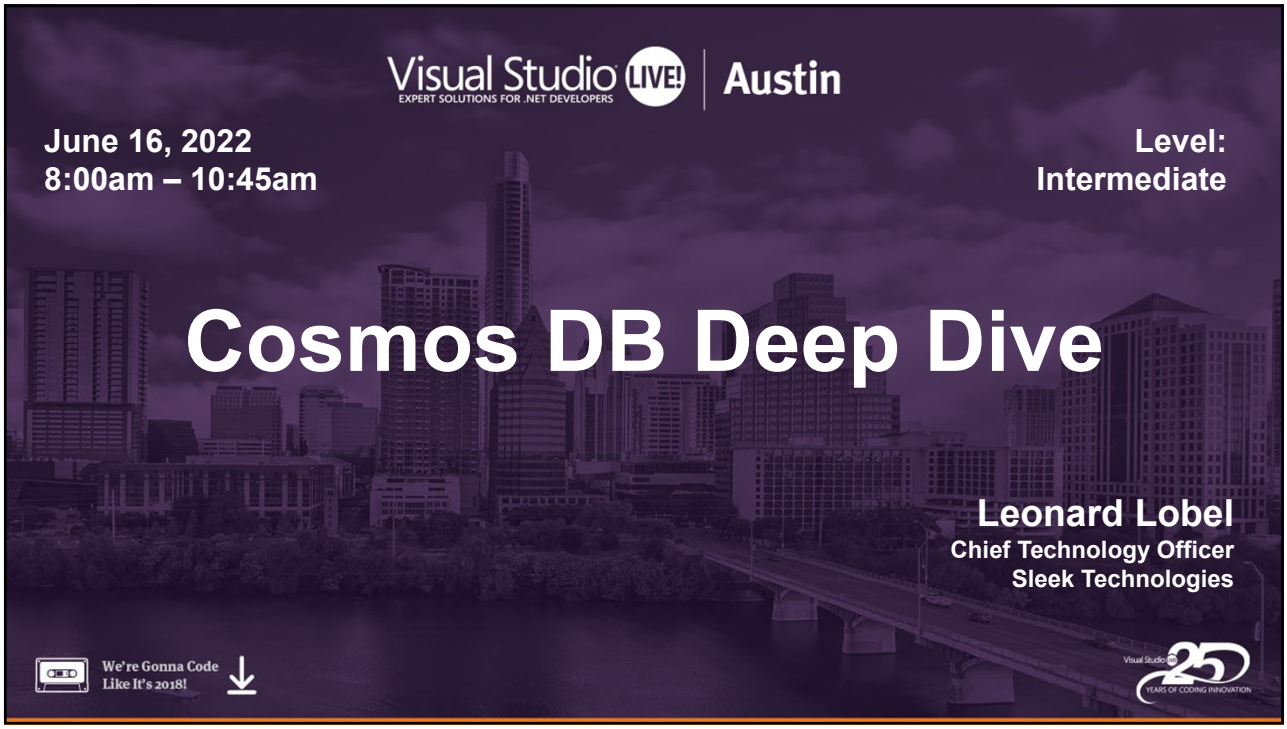

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Microsoft CERTIFIED AZURE COSMOS DB DEVELOPER SPECIALTY

Leonard Lobel

- CTO & Co-Founder
  - Sleek Technologies, Inc.
- Principal Consultant
  - Tallan, Inc.
- Microsoft MVP
  - Data Platform
- Trainer/Speaker/Author
- Programming since 1979

Contact

- Email: lenni.lobel@sleektech.com
- Blog: lennilobel.wordpress.com
- Twitter: @lennilobel

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(all lower case!)

Agenda

Part I

Introduction to
Azure Cosmos DB

- Overview
- Management
- Indexing
- Multiple APIs
- Migration
- Throughput
- Partitioning
- Global distribution

Part II

Building Event-driven Microservices
with the Cosmos DB Change Feed

- Replication
- Denormalization
- Notifications
- Materialized views
- Data movement

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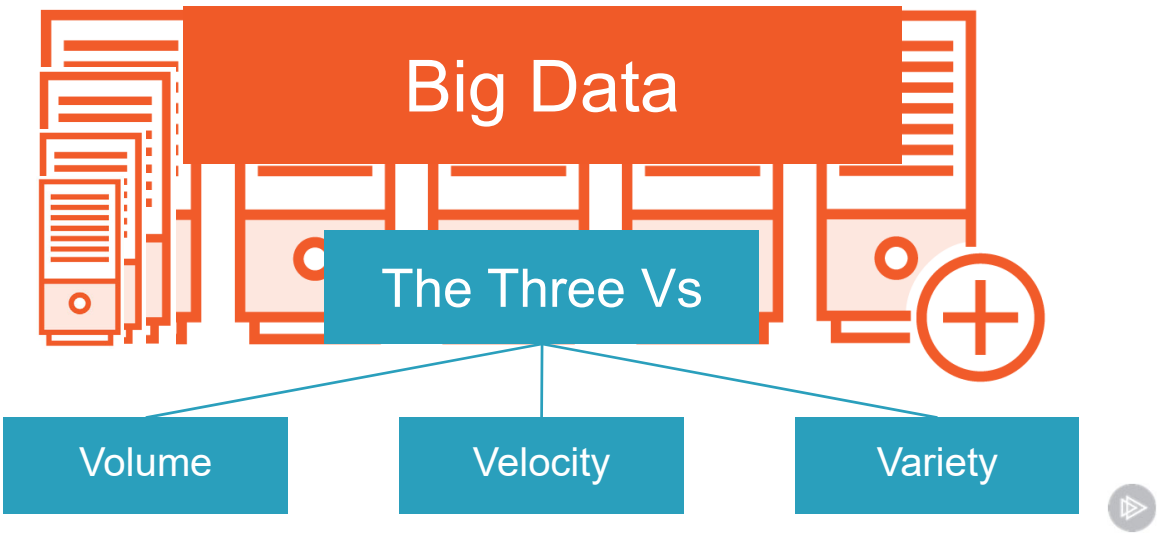
Introduction to Azure Cosmos DB

Introduction to Azure Cosmos DB

Overview

What is NoSQL?



What is a NoSQL database?

Distributed

Replicas ensure high availability and resilience

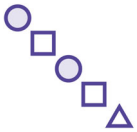
Scale-out

Horizontal partitioning for elastic storage and throughput

Schema-free

No enforced schema

No defined shape



What is Cosmos DB?

Massively scalable NoSQL database

Fully managed Azure PaaS

99.999% SLAs

Single-digit millisecond reads and writes

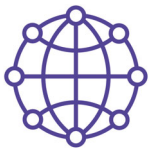
Automatic Horizontal Partitioning

Elastic scale for both storage and throughput

Global distribution

Point-and-click geo-replication

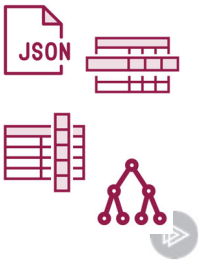
Multiple write regions



Multi-model / Multi-API

Not exclusively a document database

Also supports table, graph, and columnar



Getting Started

30-day Free Trial

http://azure.microsoft.com/try/cosmosdb

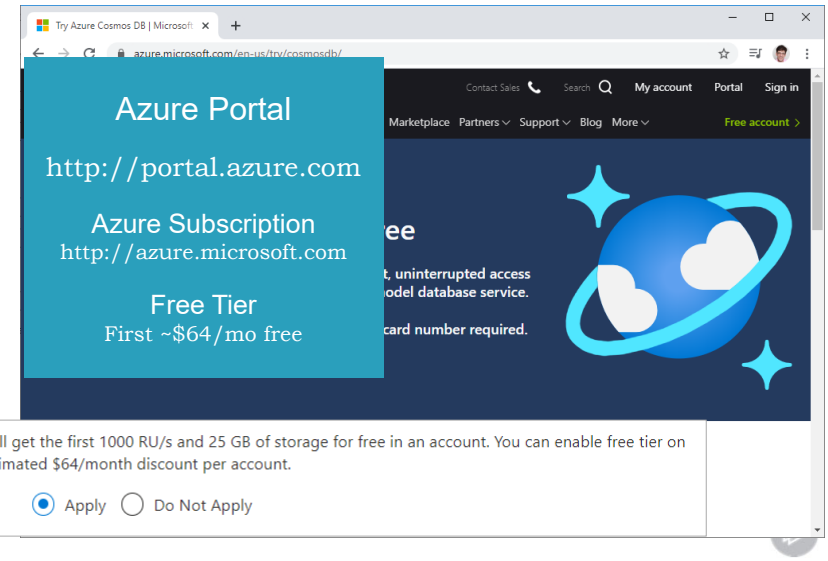
Microsoft Account
http://signup.live.com

Azure Portal

http://portal.azure.com

Azure Subscription
http://azure.microsoft.com

Free Tier
First ~$64/mo free



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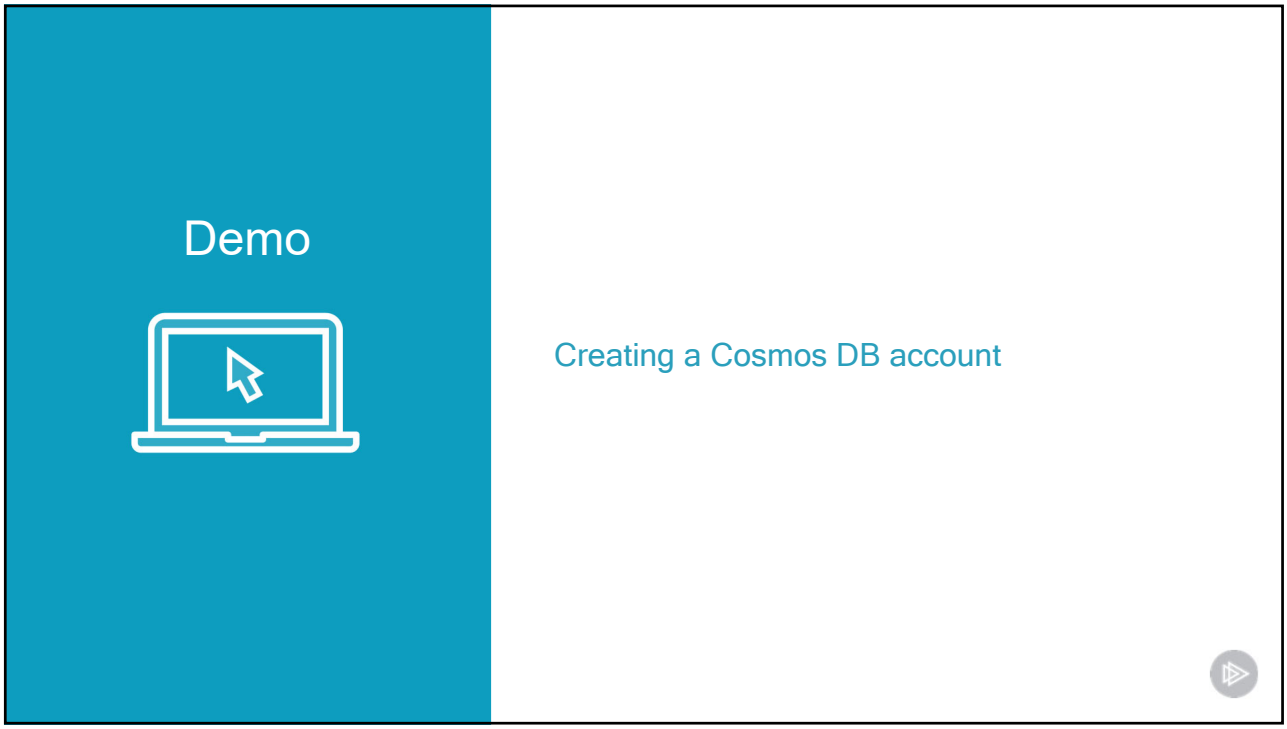
Local Emulator

http://aka.ms/cosmosdb-emulator

No internet connection required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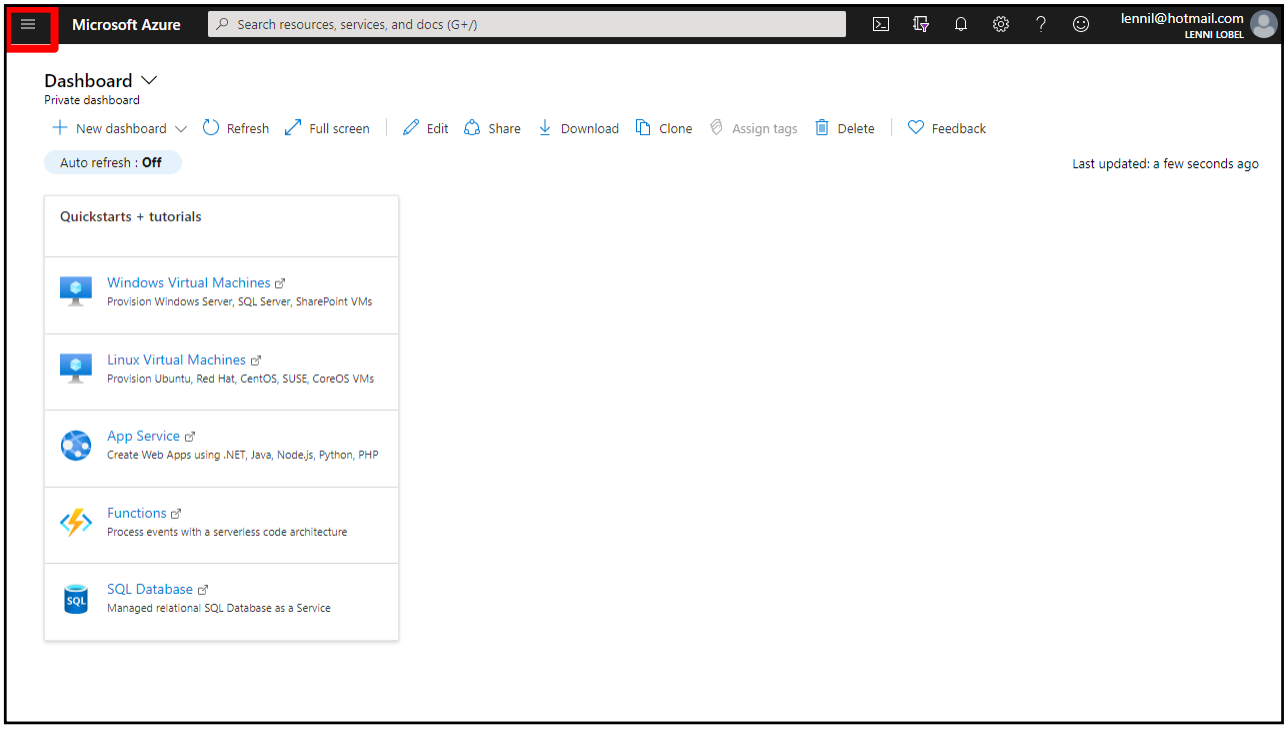
Creating a Cosmos DB account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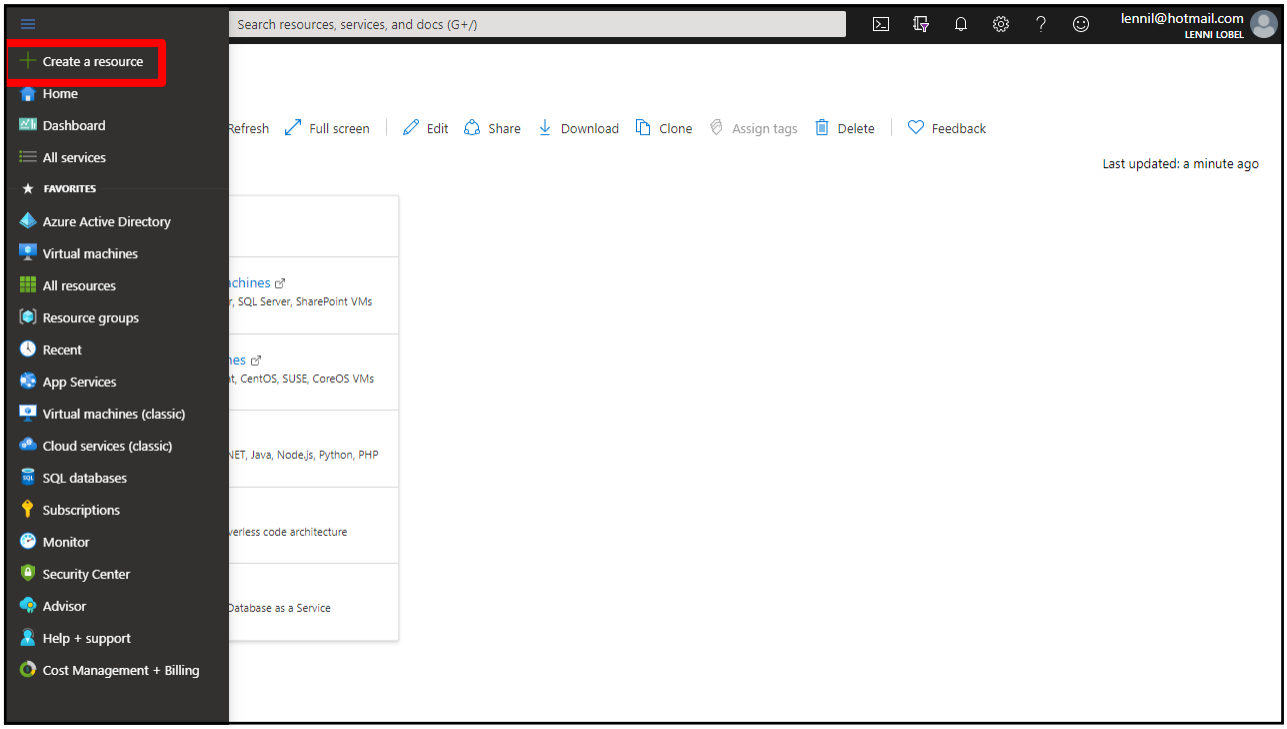
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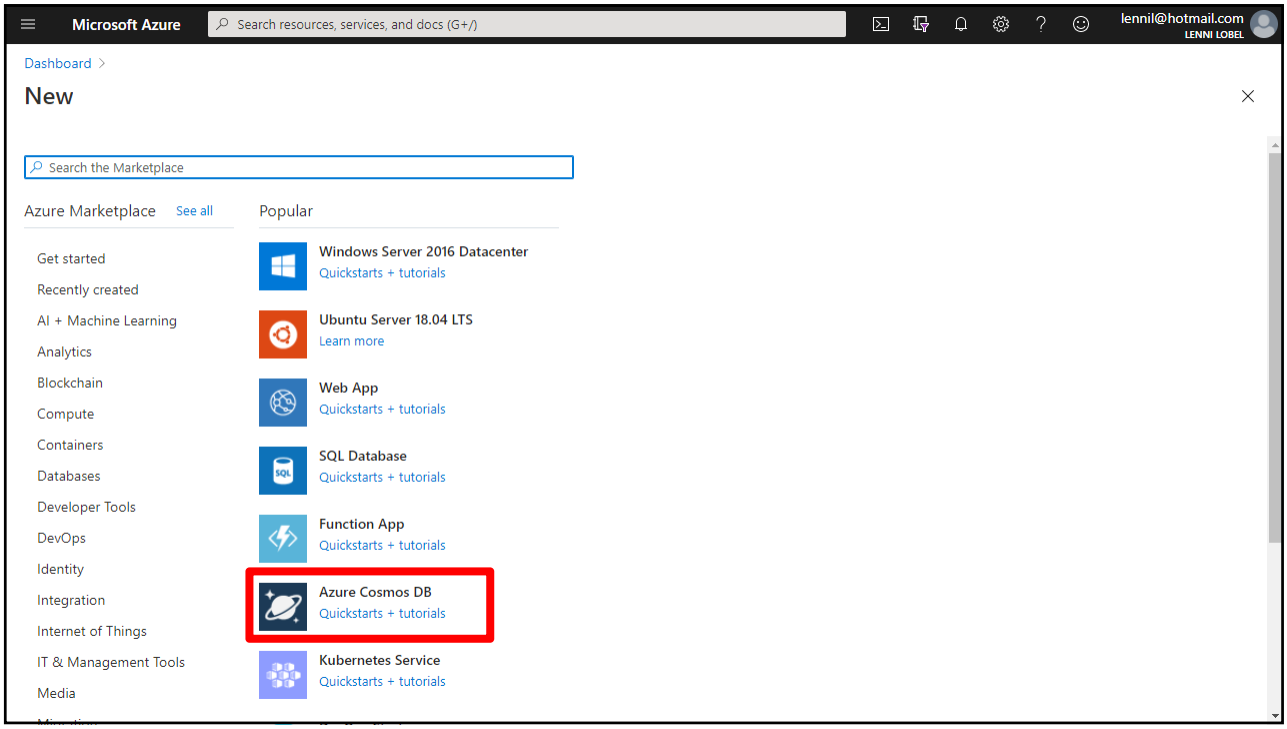
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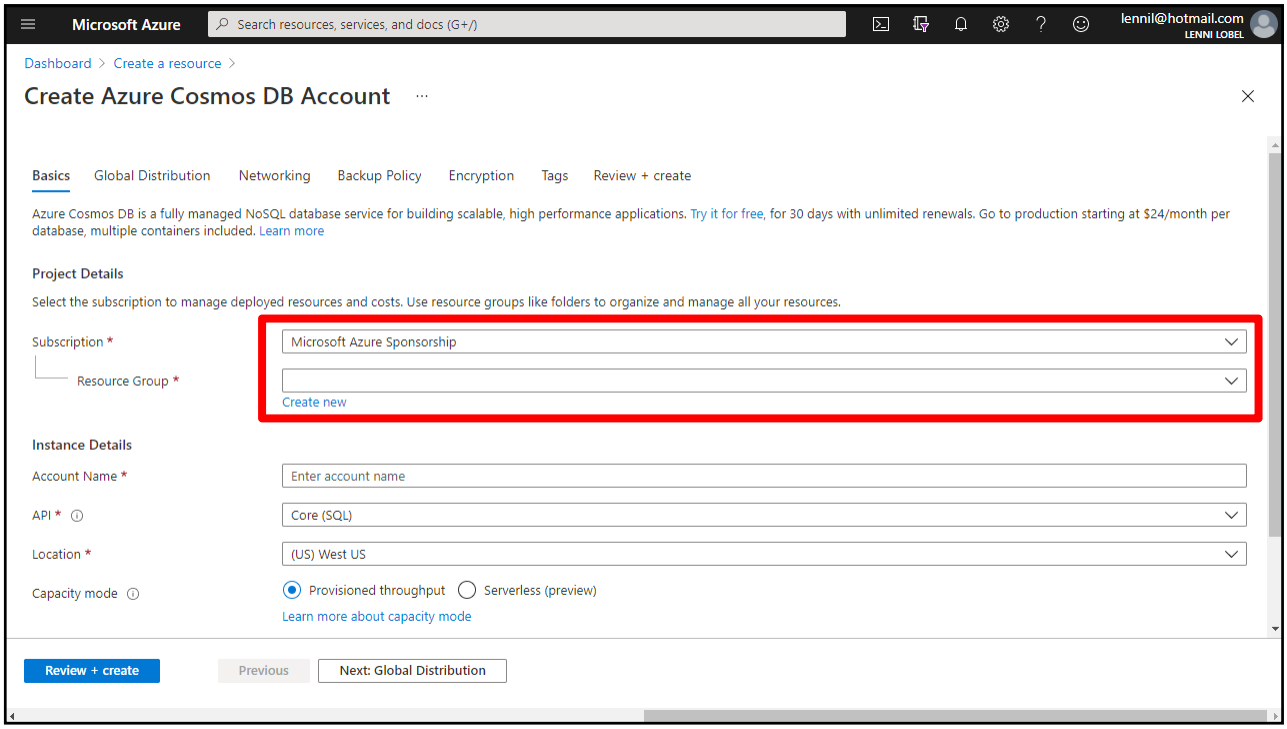
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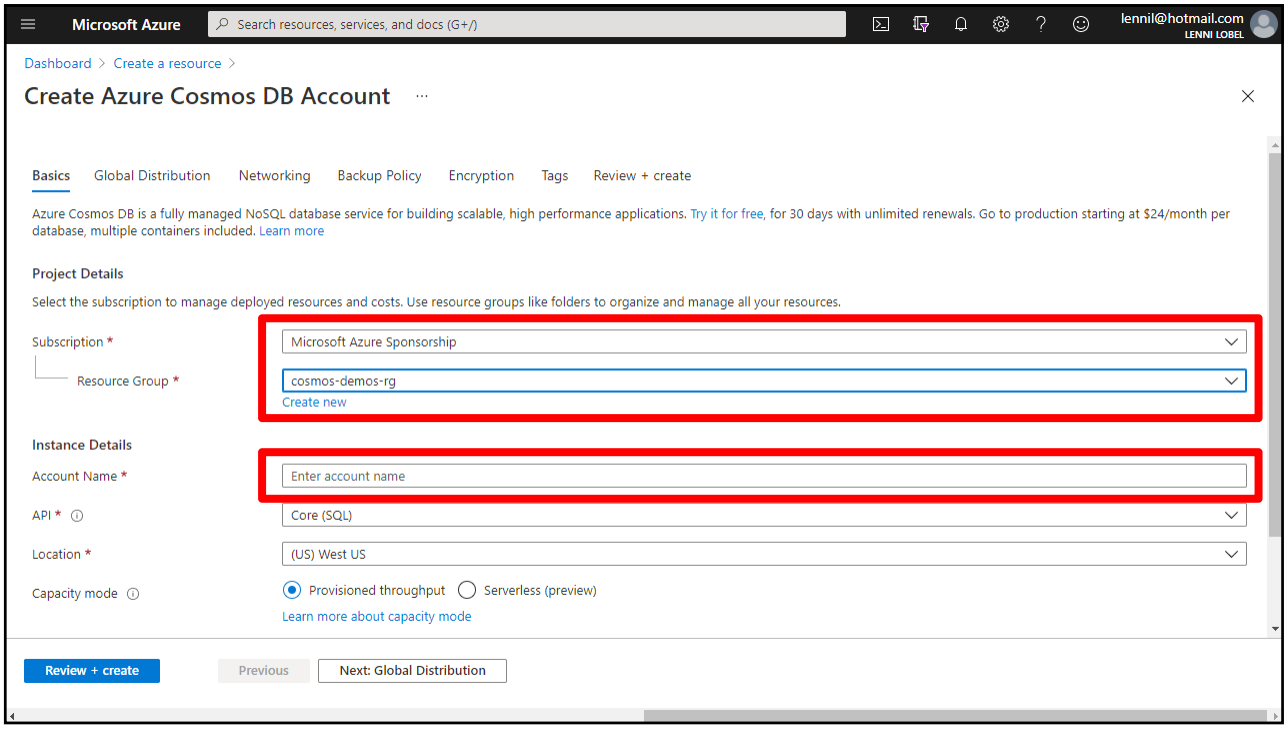
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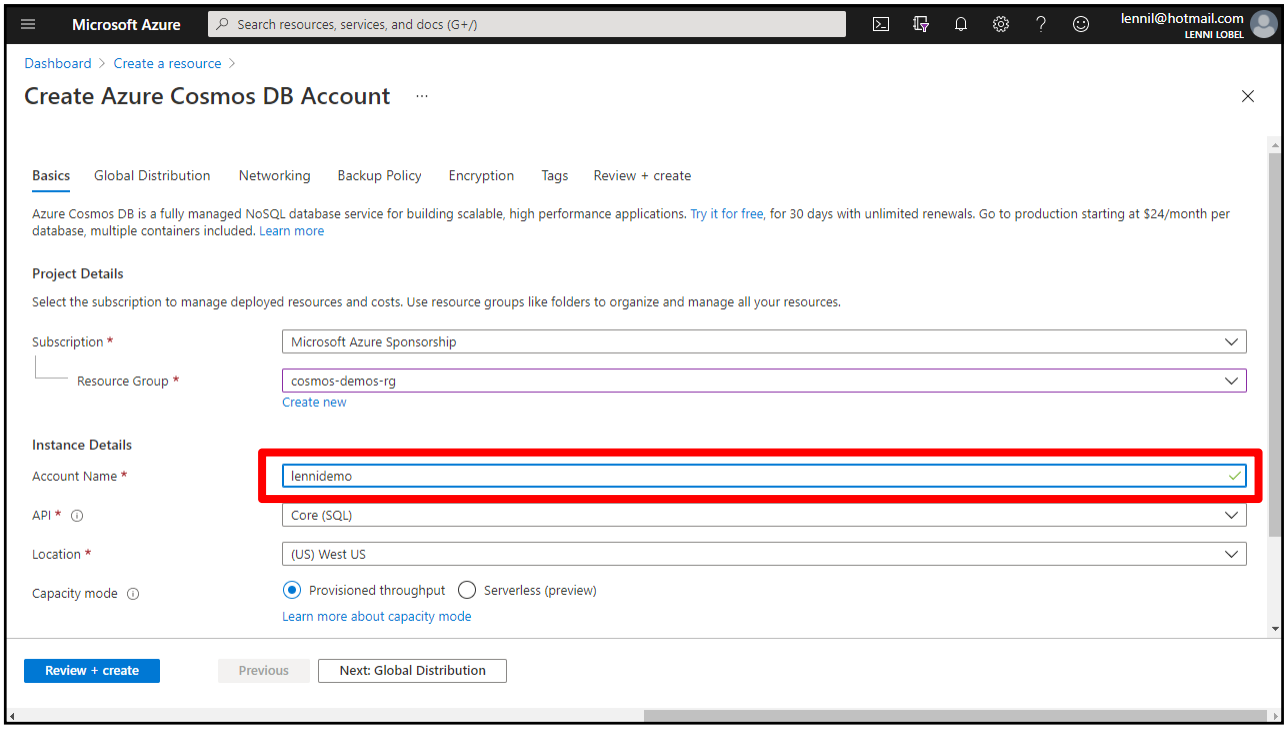
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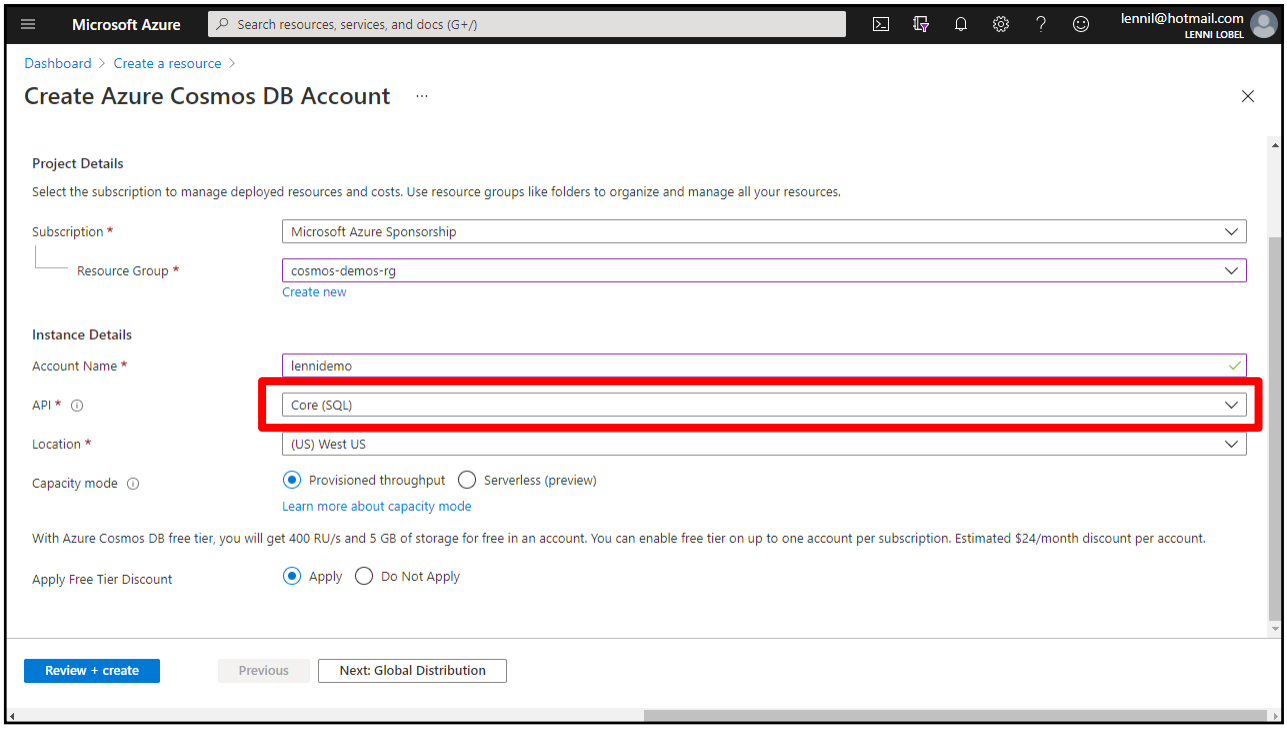
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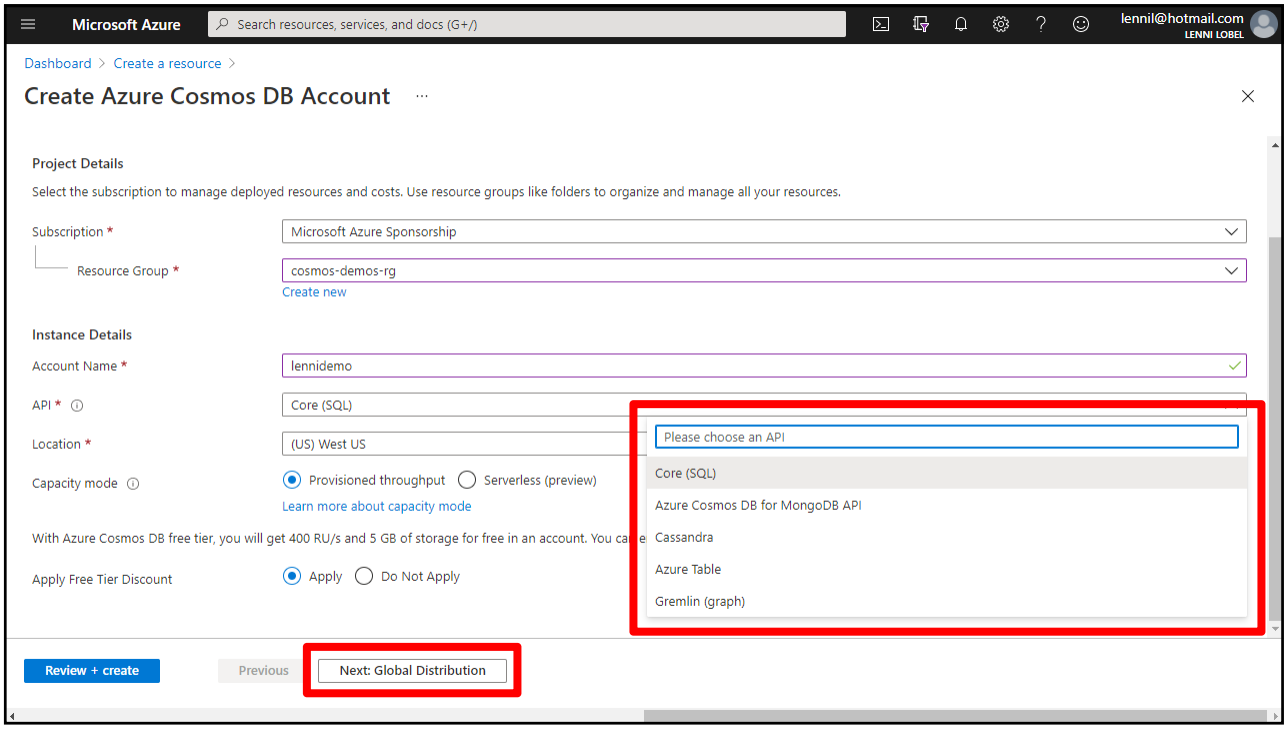
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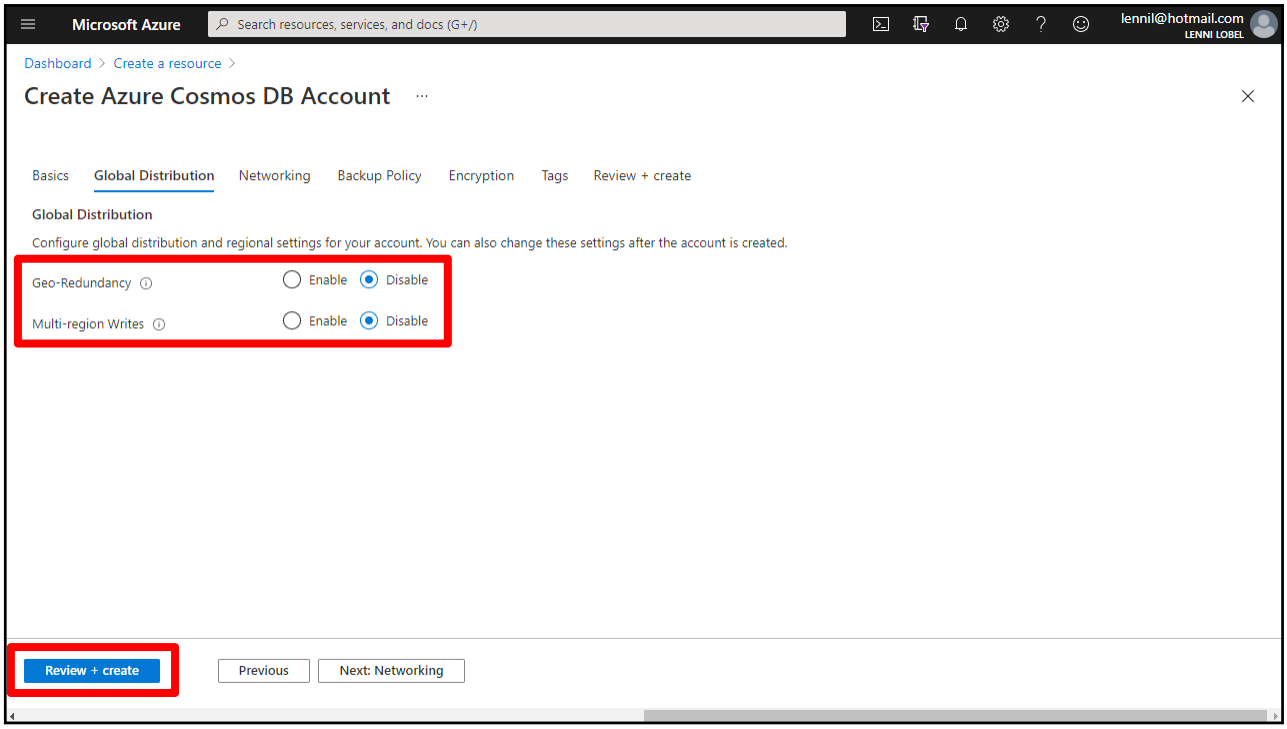
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Multi-region Writes
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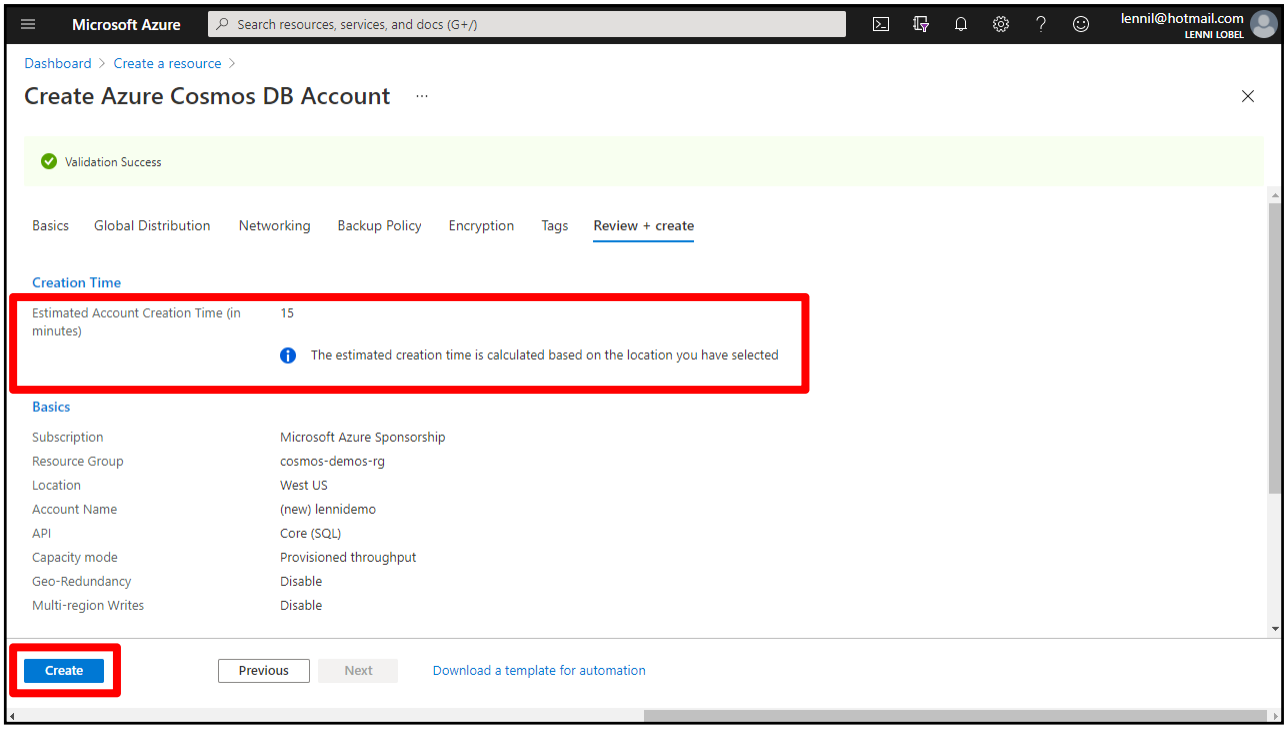
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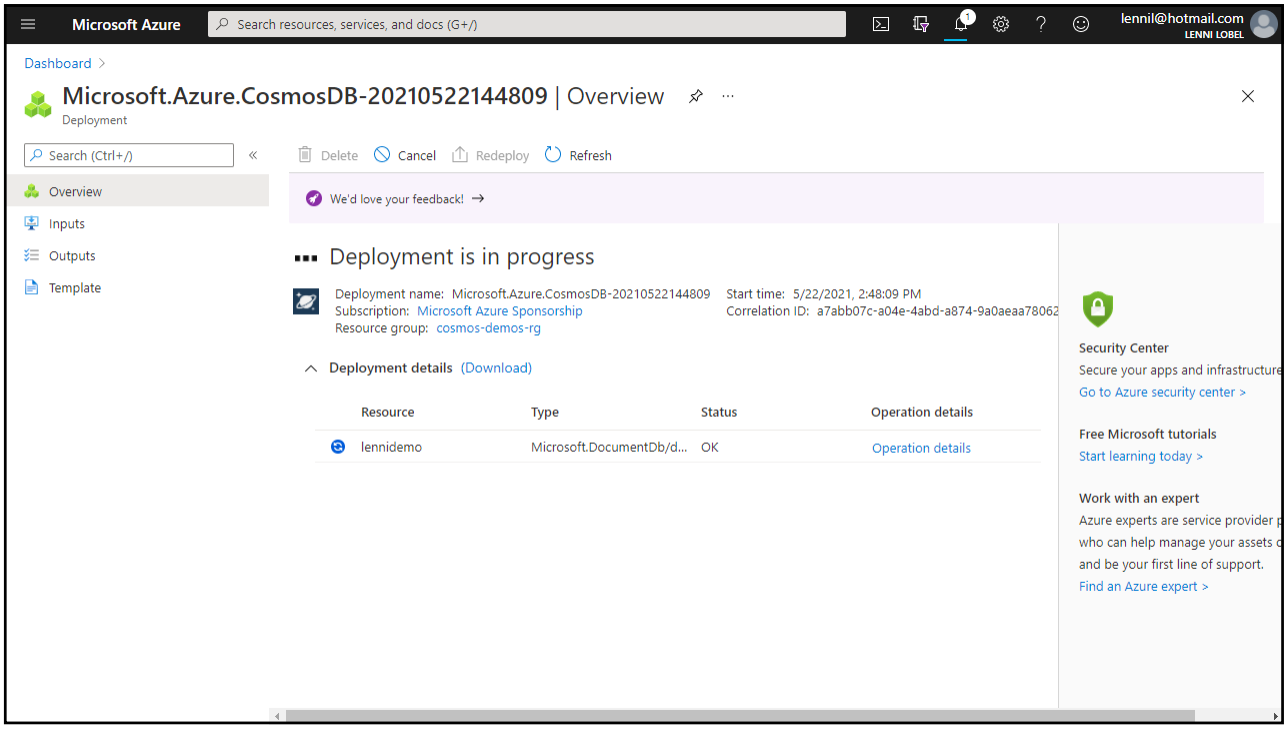
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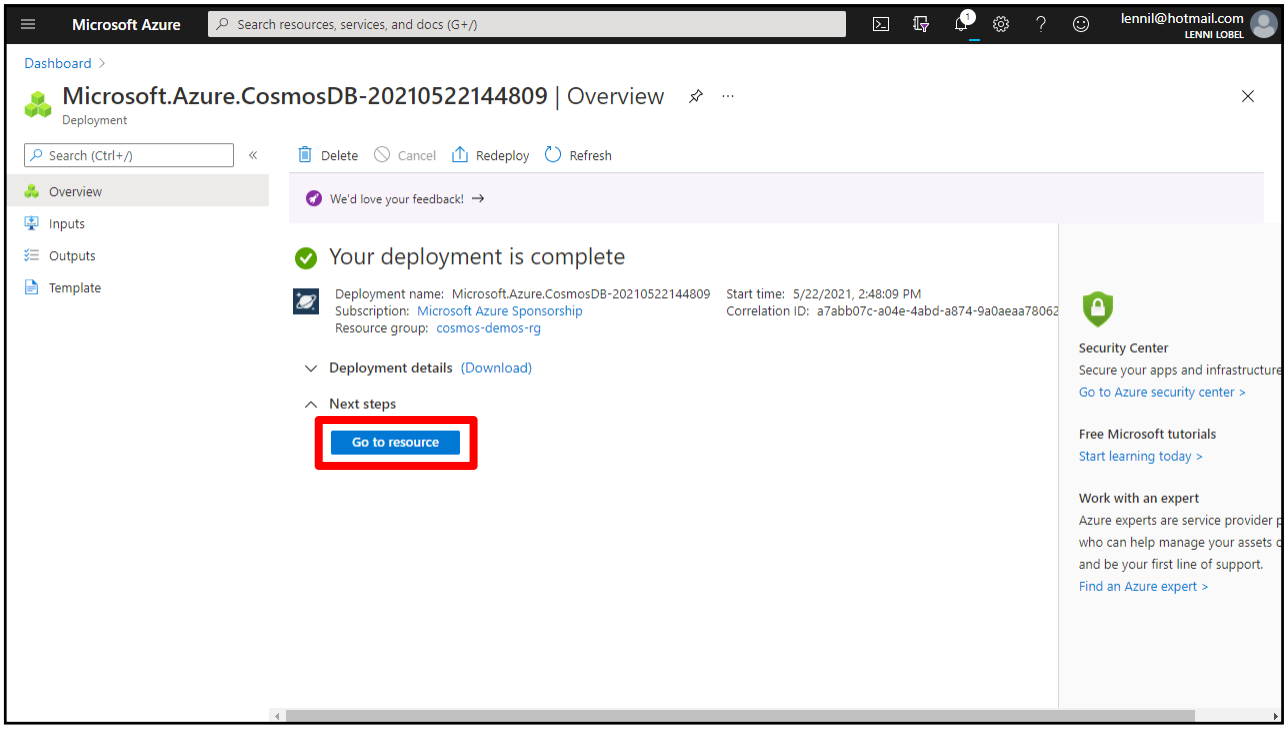
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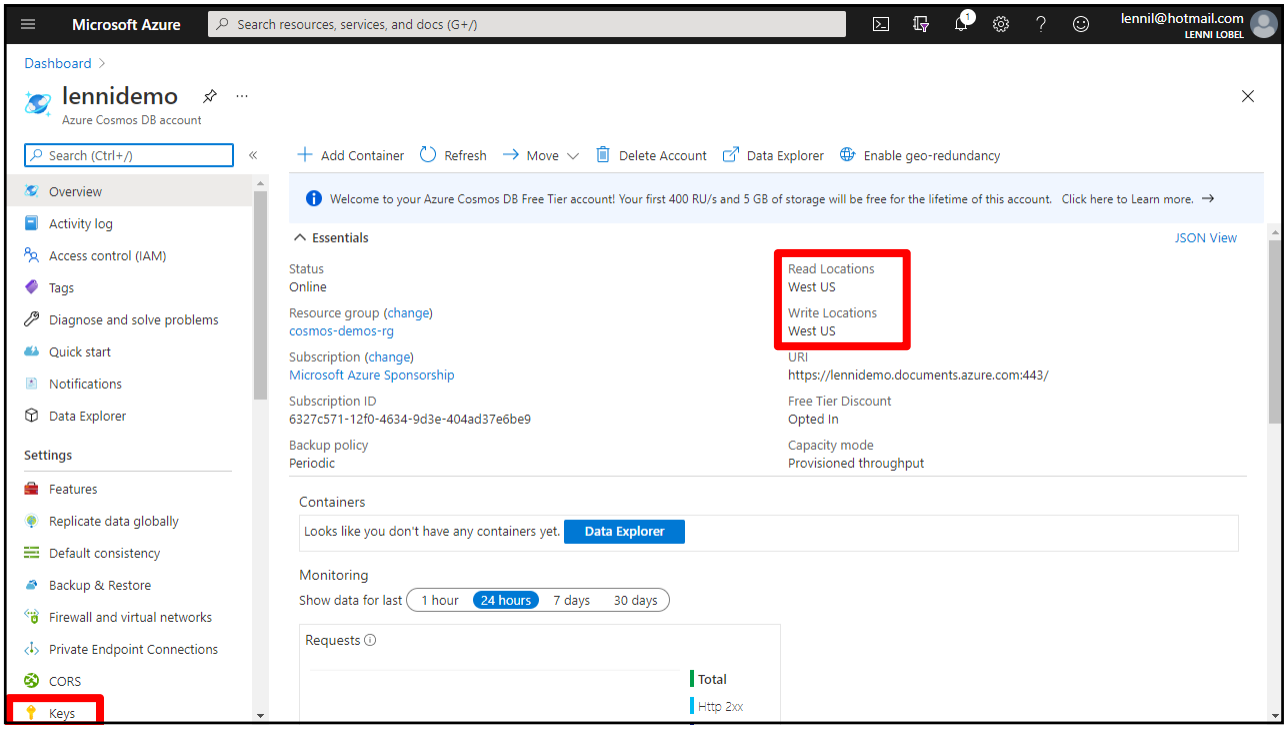
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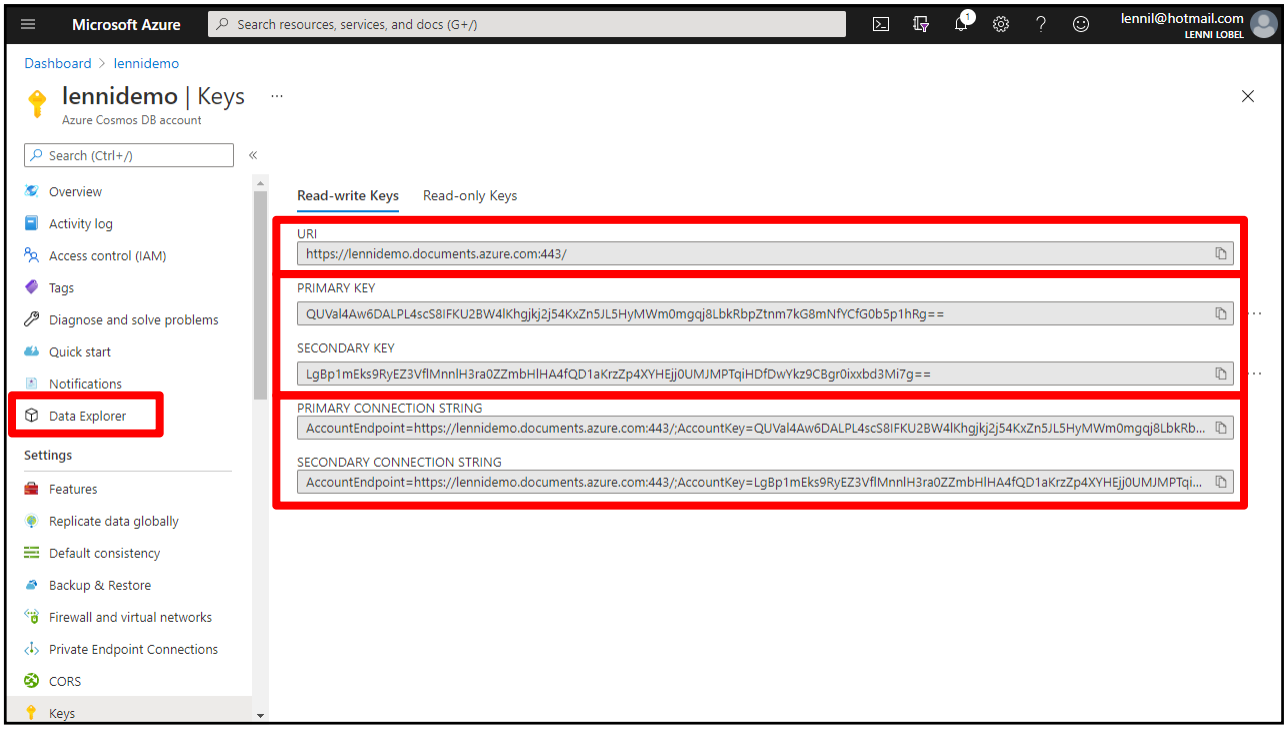
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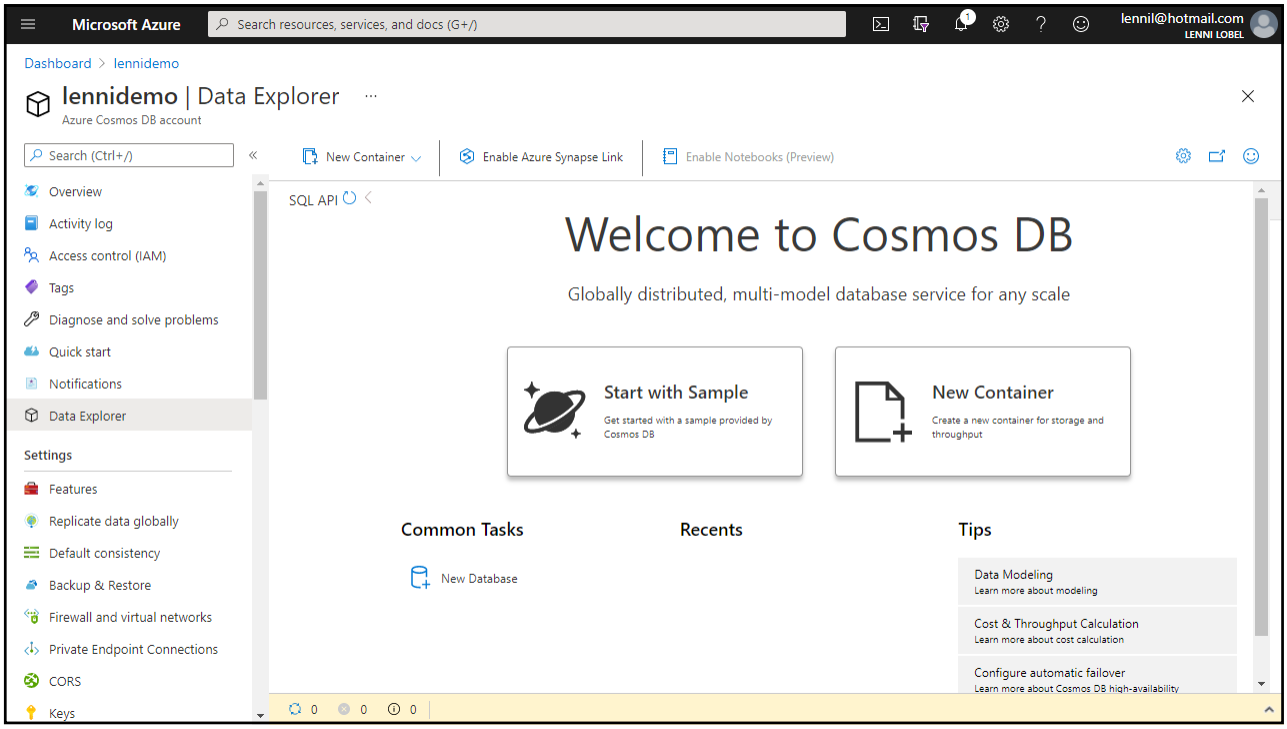
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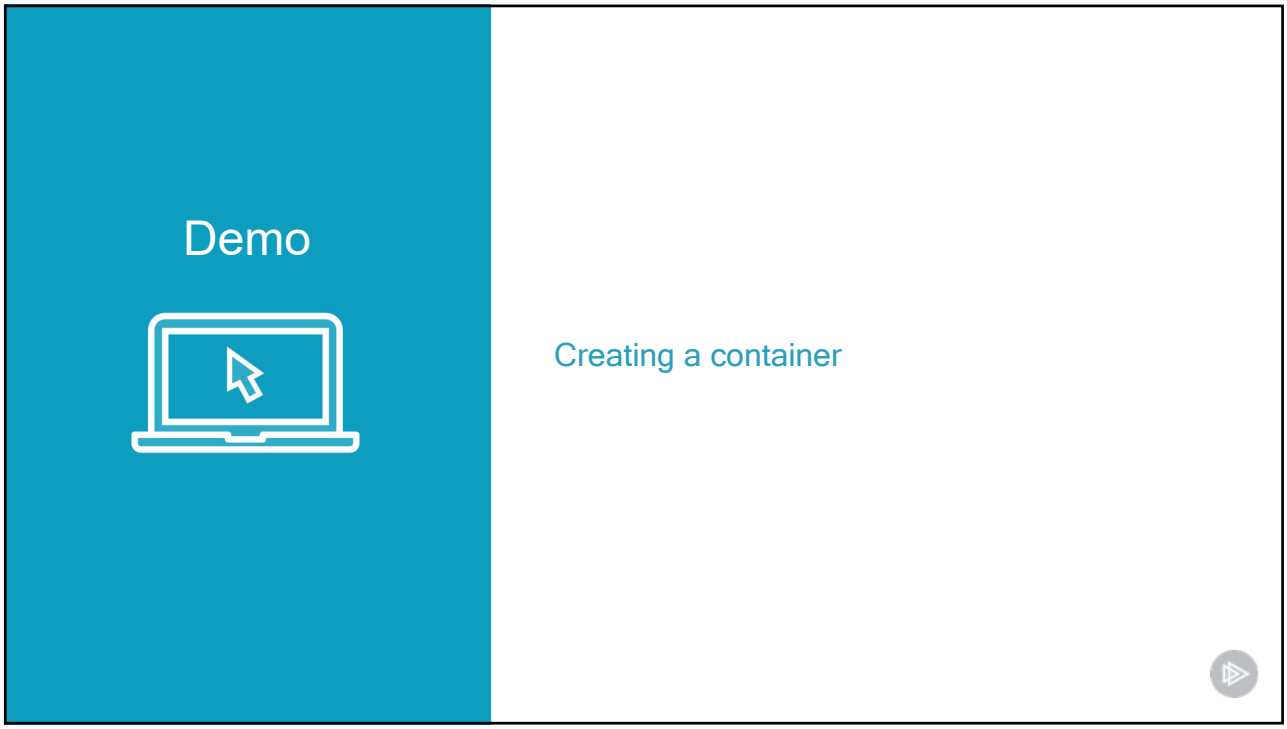
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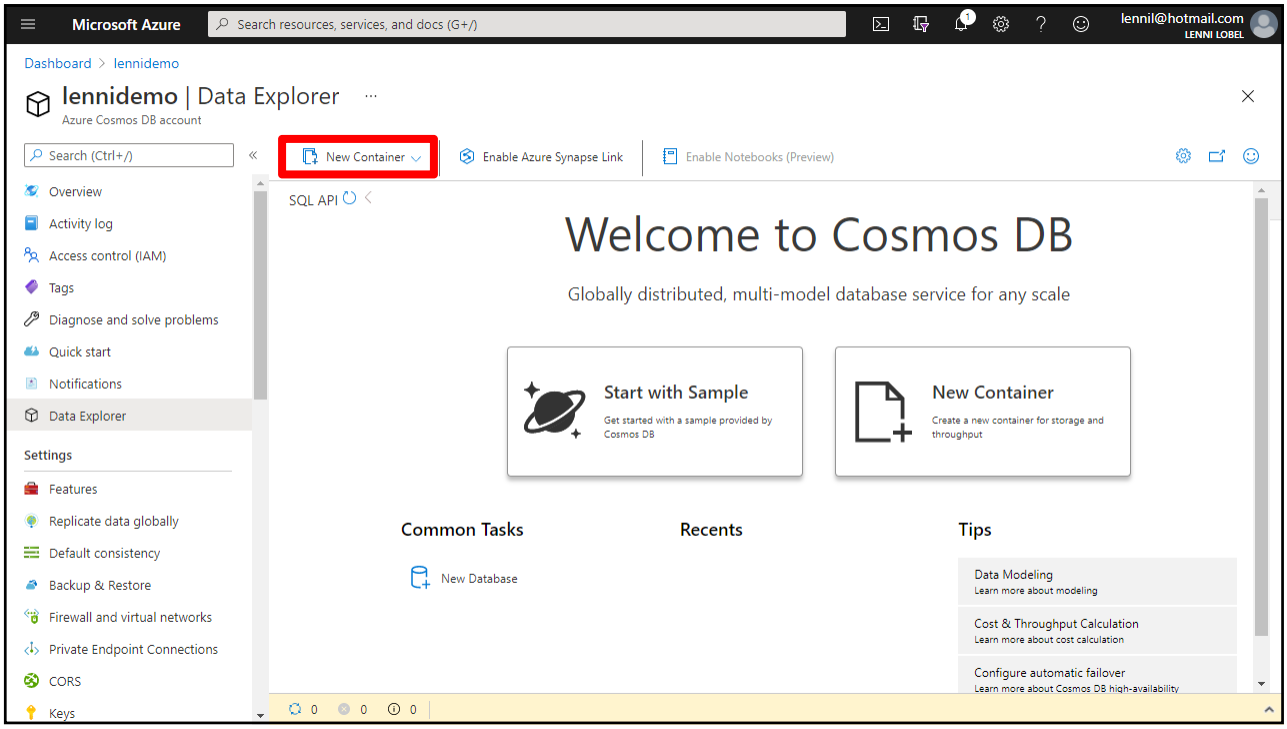
Creating a container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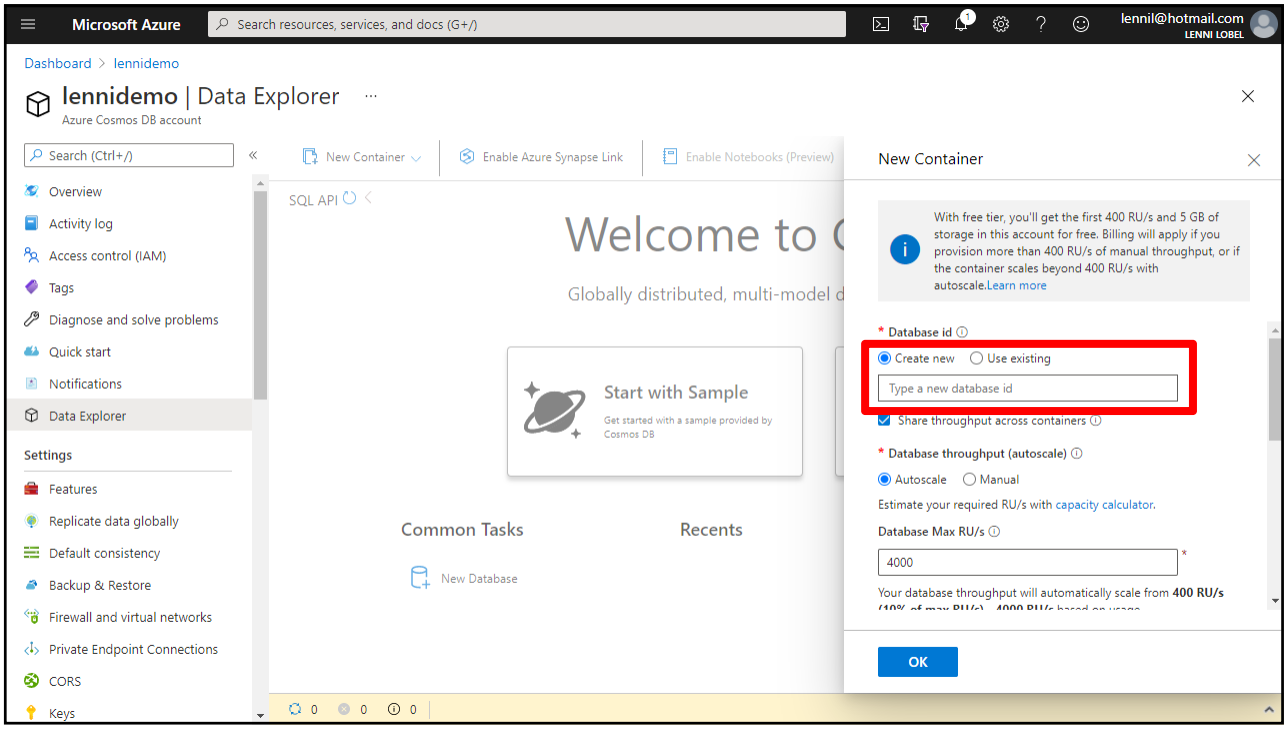
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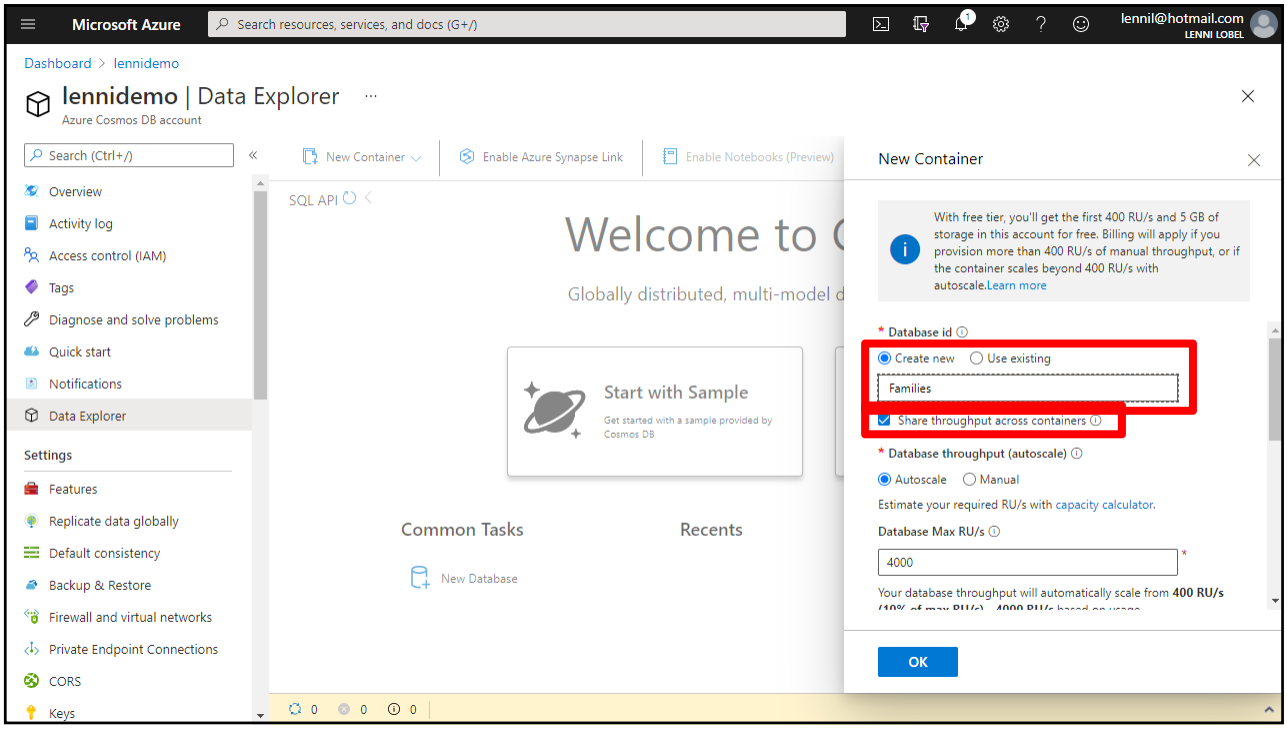
Create new
Use existing
Type a new database id
Share throughput across containers
* Database throughput (autoscale)
Autoscale
Manual
Estimate your required RU/s with capacity calculator.
Database Max RU/s
4000
Your database throughput will automatically scale from 400 RU/s
OK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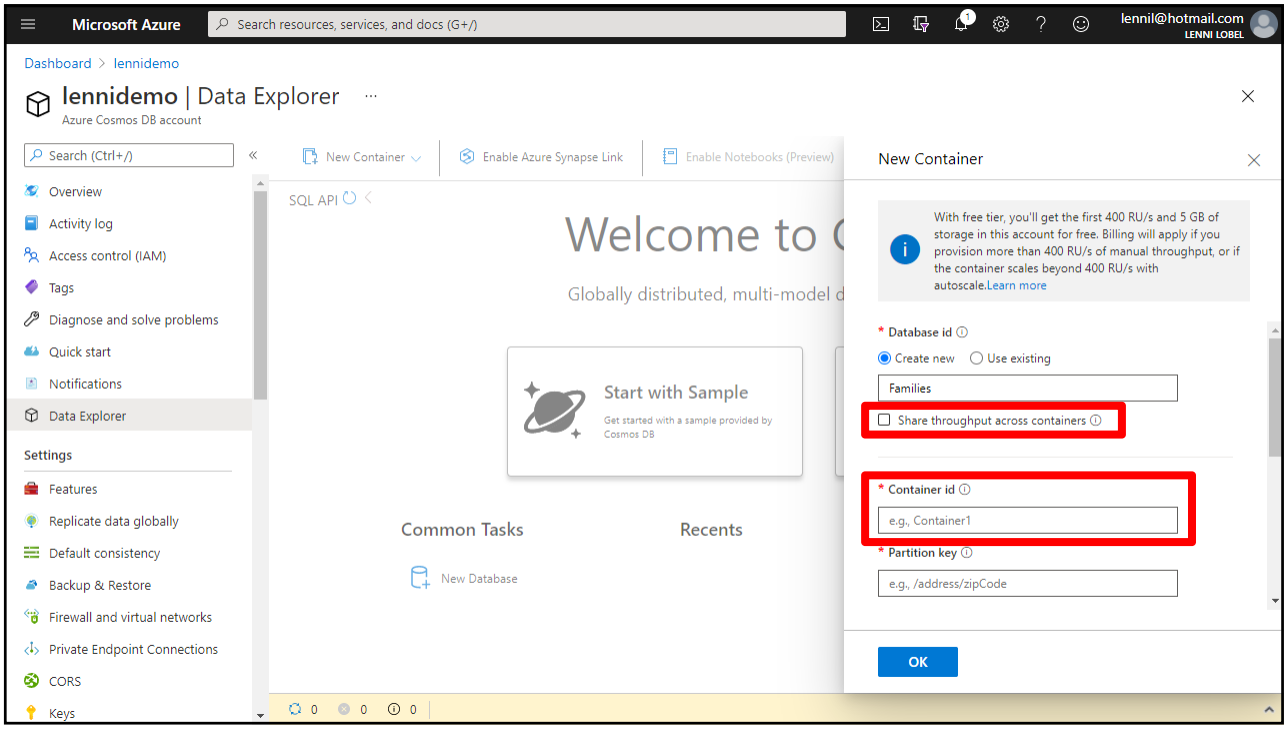
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Share throughput across containers
* Container id
e.g., Container1
* Partition key
e.g., /address/zipCode
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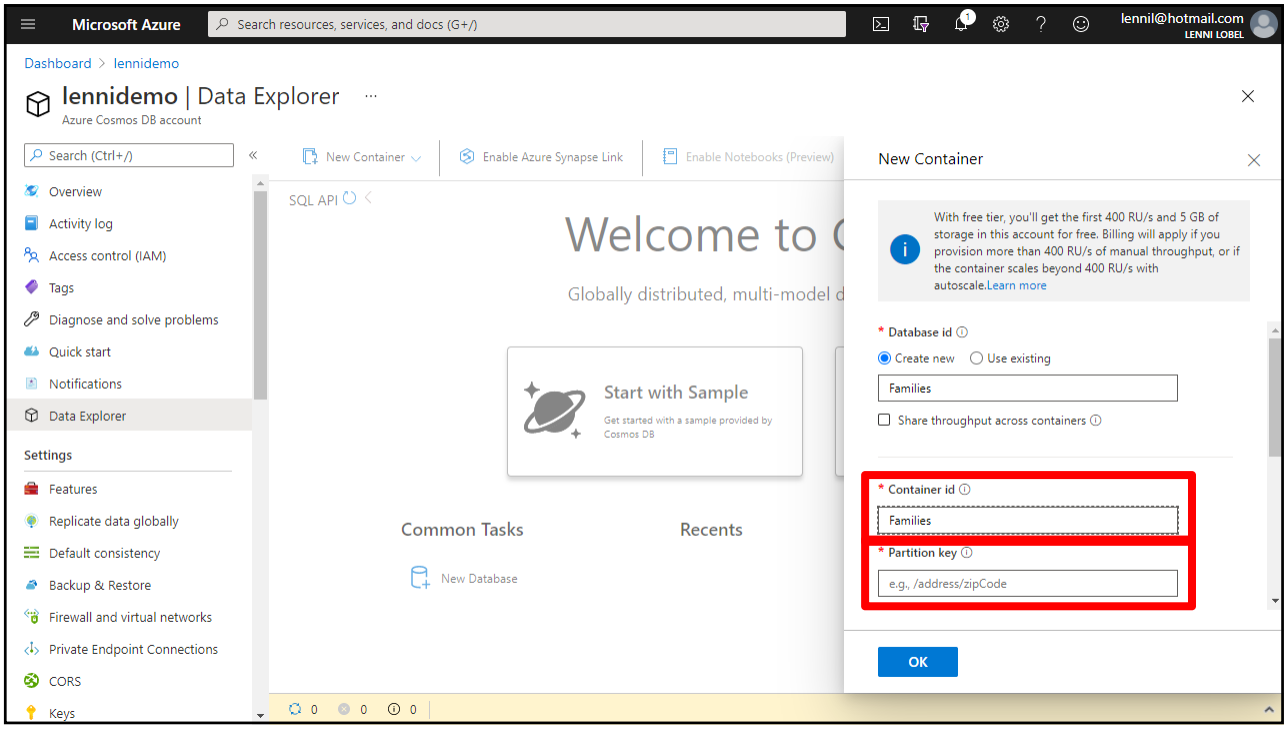
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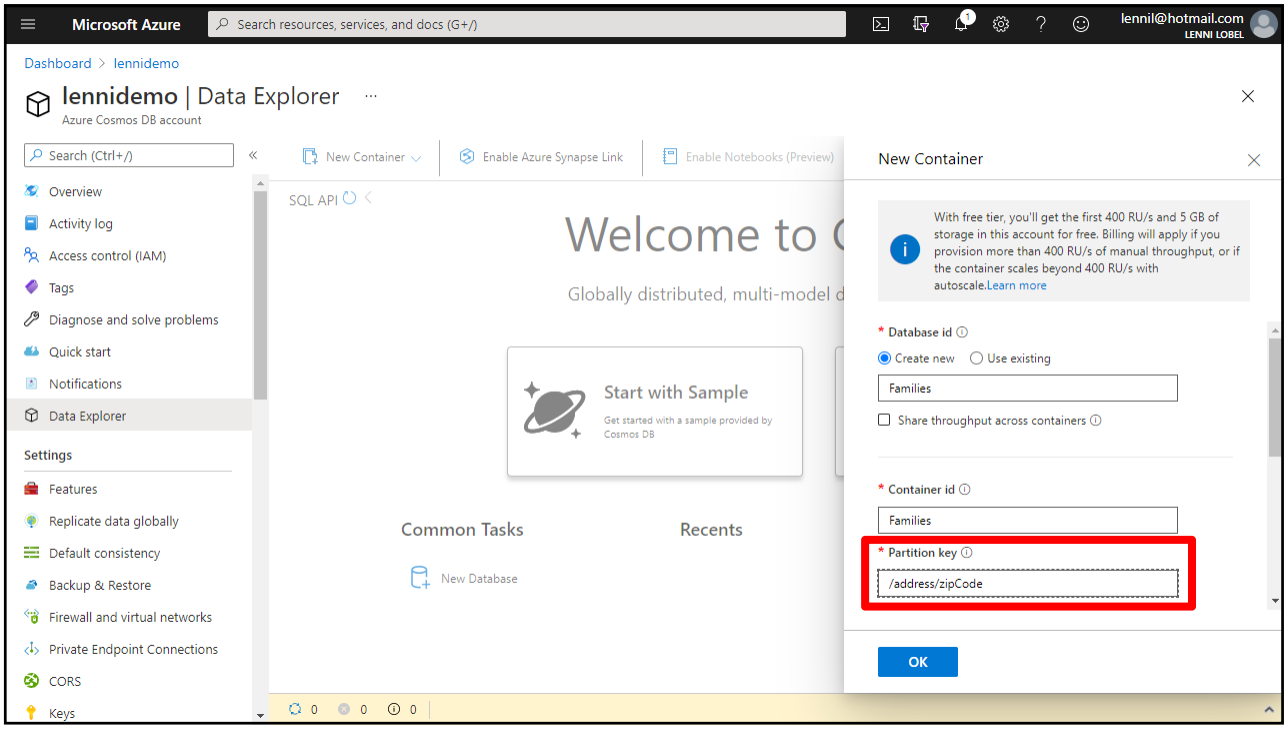
* Partition key
e.g., /address/zipCode
OK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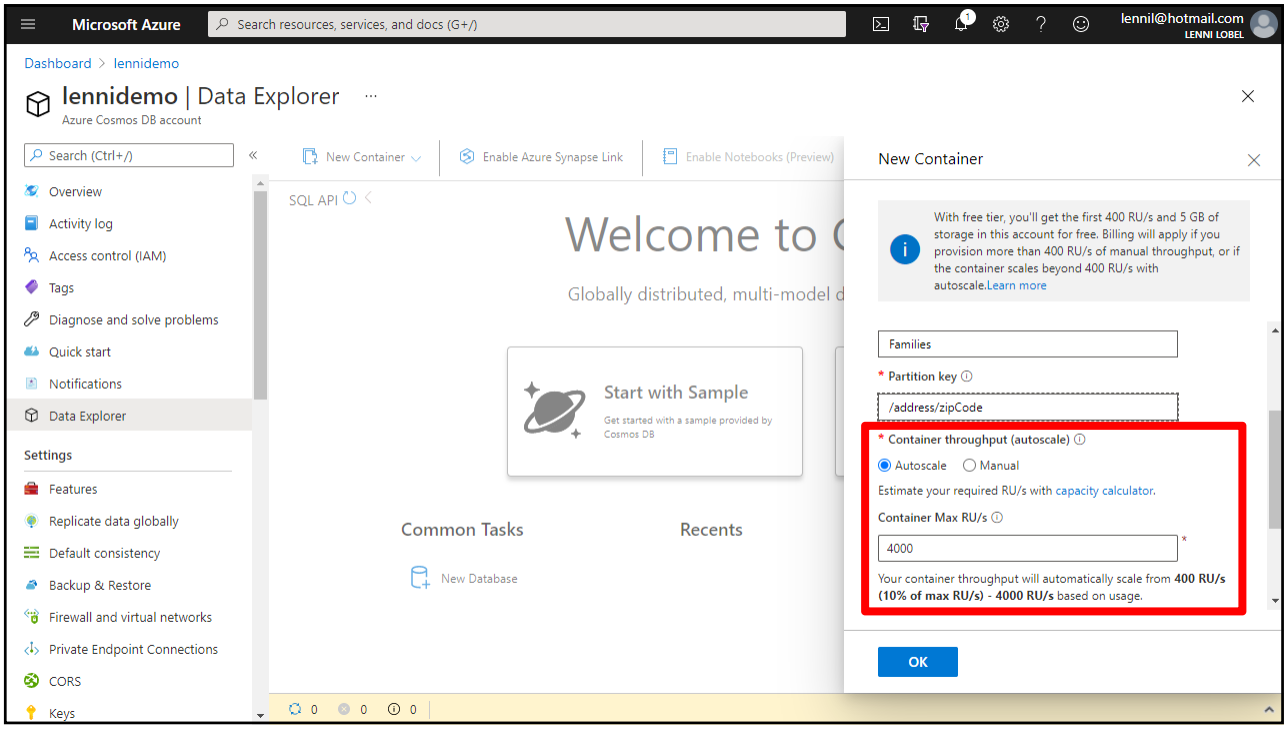
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Families
* Partition key
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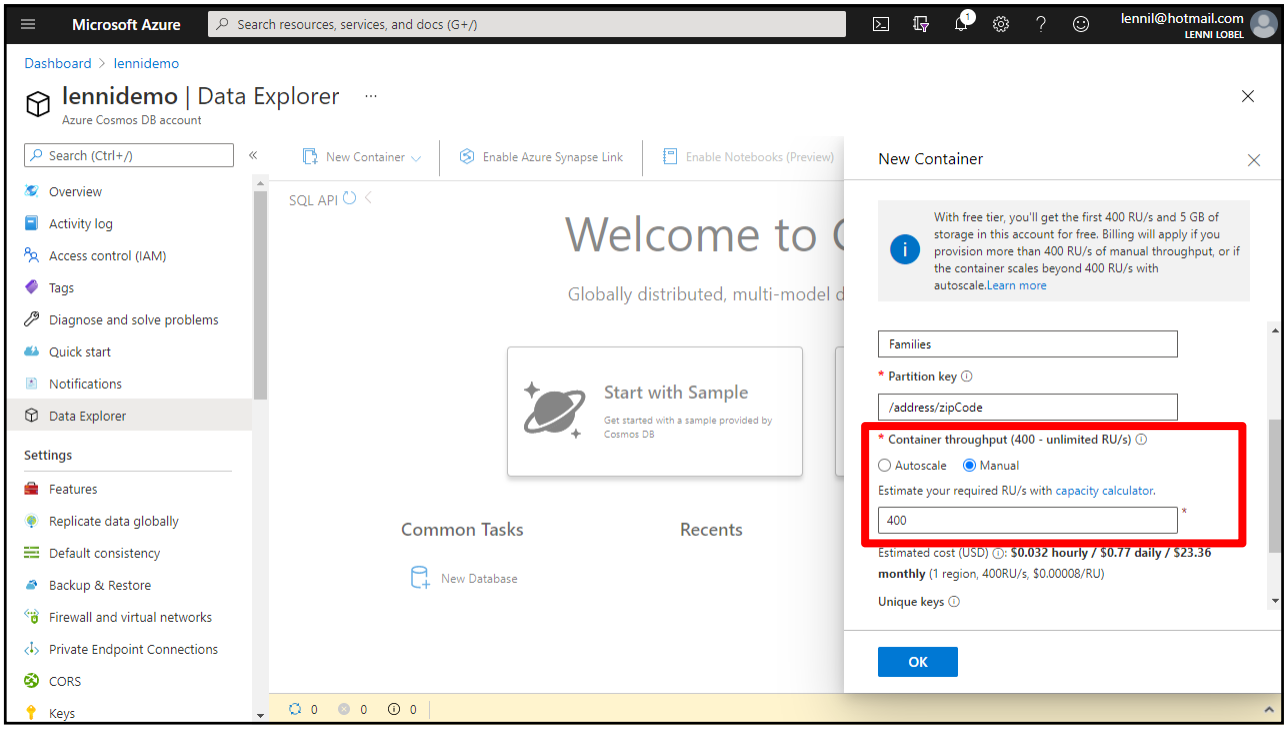
* Container throughput (autoscale)
Autoscale
Manual
Estimate your required RU/s with capacity calculator.
Container Max RU/s
4000
Your container throughput will automatically scale from 400 RU/s (10% of max RU/s) - 4000 RU/s based on usage.
OK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Families
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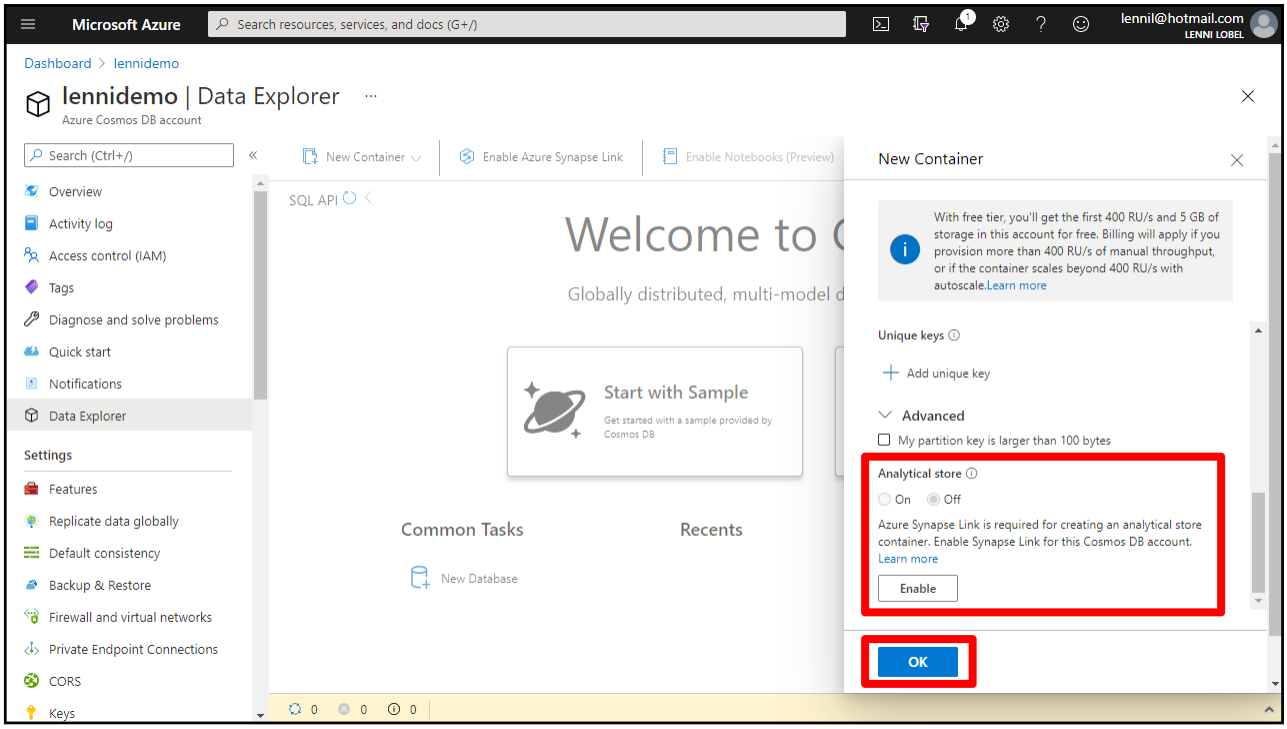
/address/zipCode
* Container throughput (400 - unlimited RU/s)
Autoscale
Manual
Estimate your required RU/s with capacity calculator.
400
Estimated cost (USD): $0.032 hourly / $0.77 daily / $23.36 monthly (1 region, 400RU/s, $0.00008/RU)
Unique keys
OK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Unique keys
Add unique key
Advanced
My partition key is larger than 100 bytes
Analytical store
On
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Azure Synapse Link is required for creating an analytical store container. Enable Synapse Link for this Cosmos DB account.
Learn more
Enable
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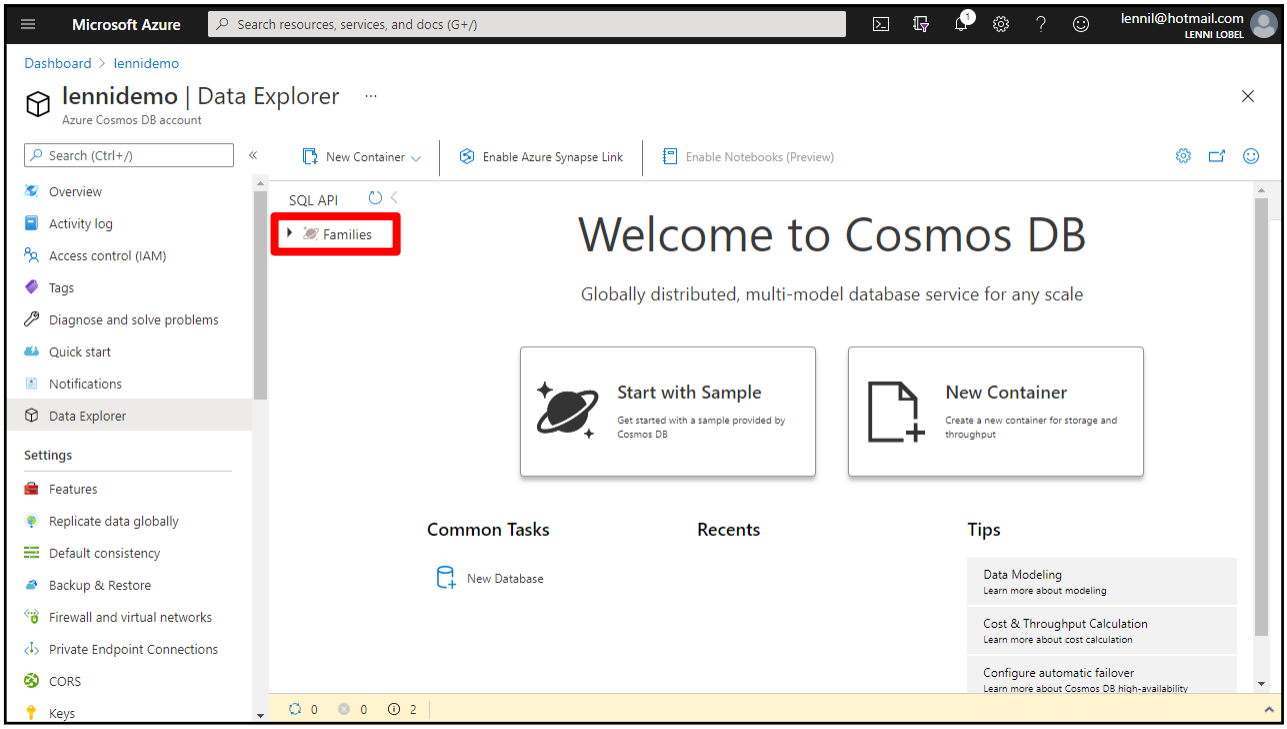
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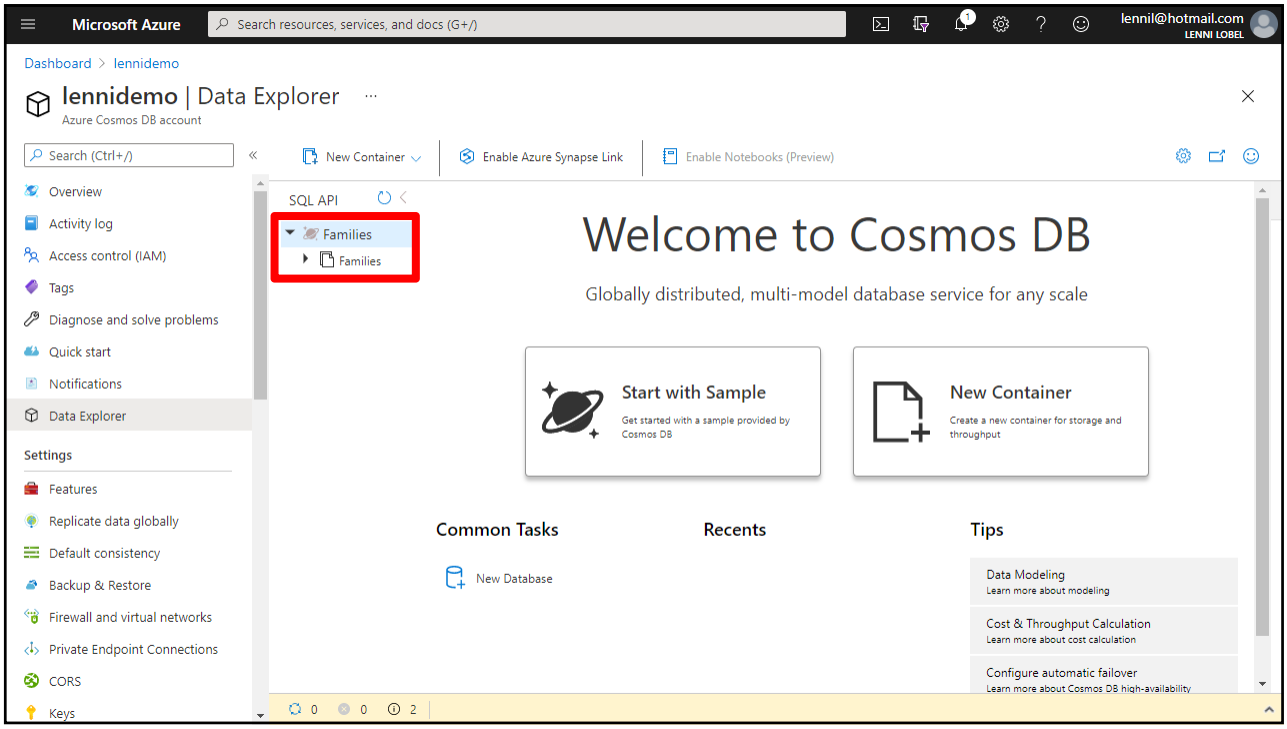
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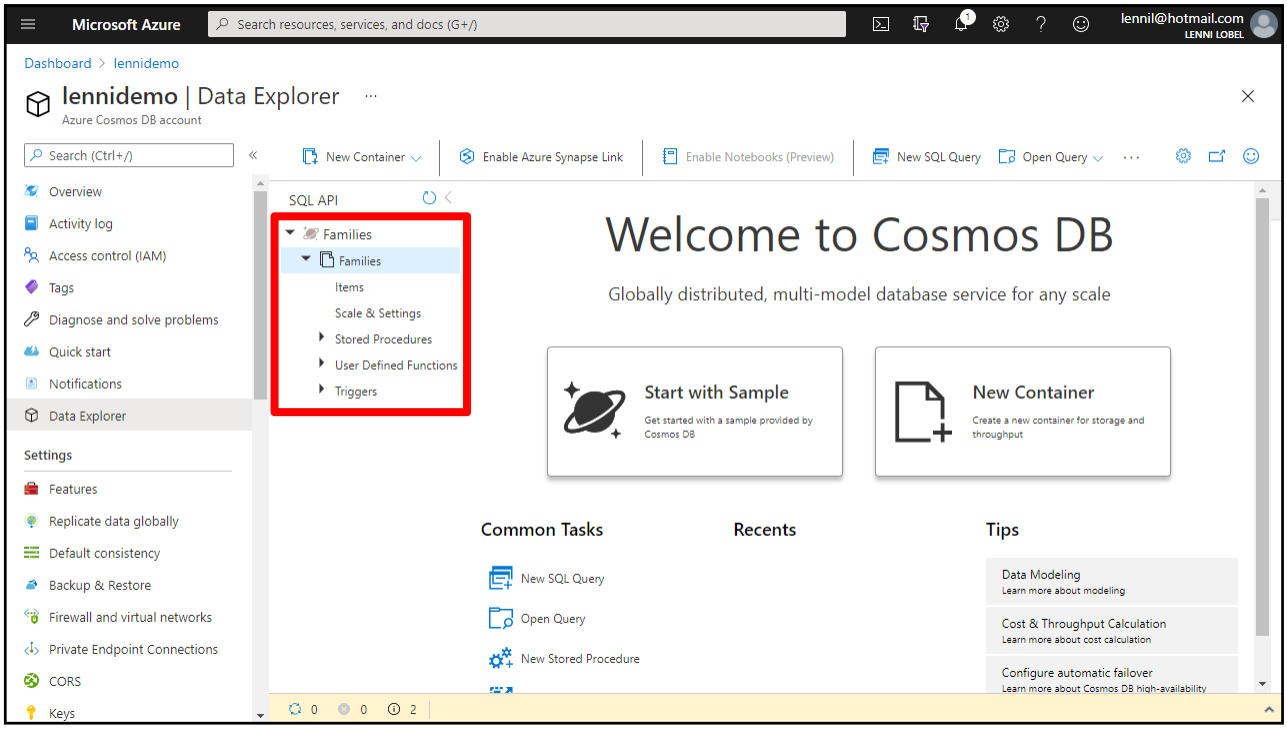
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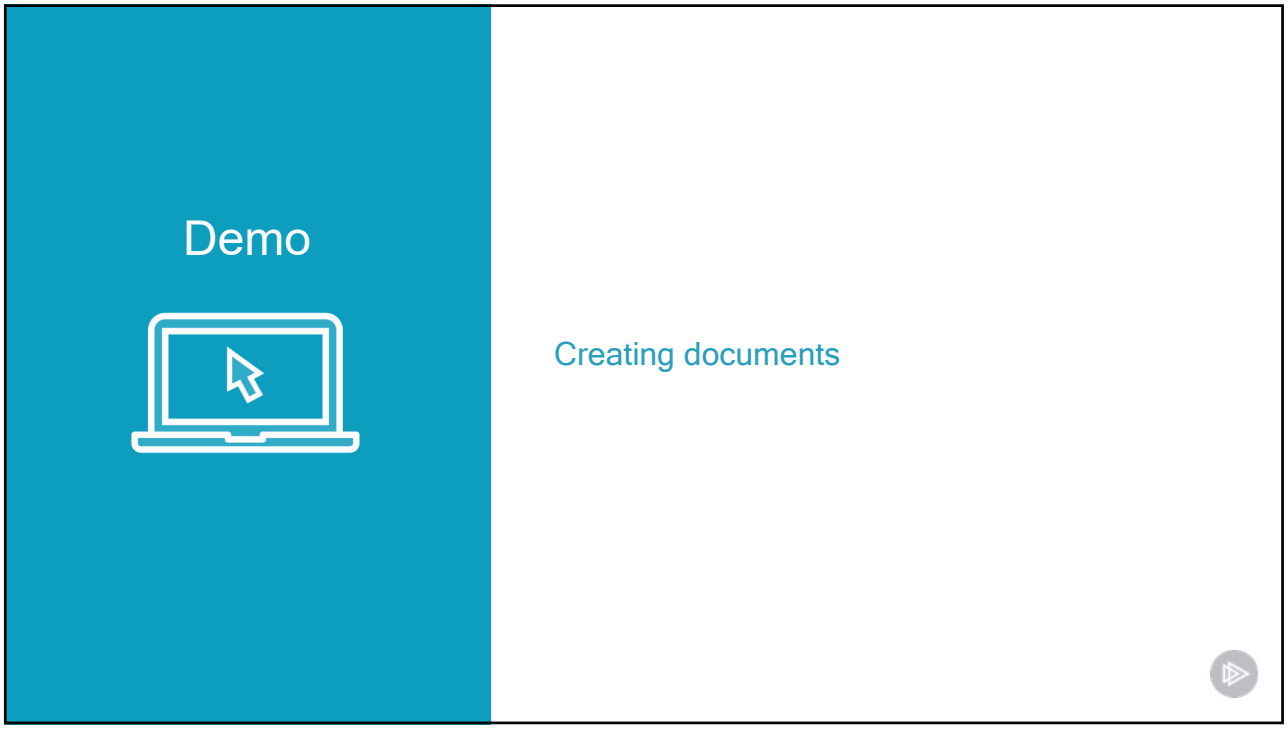
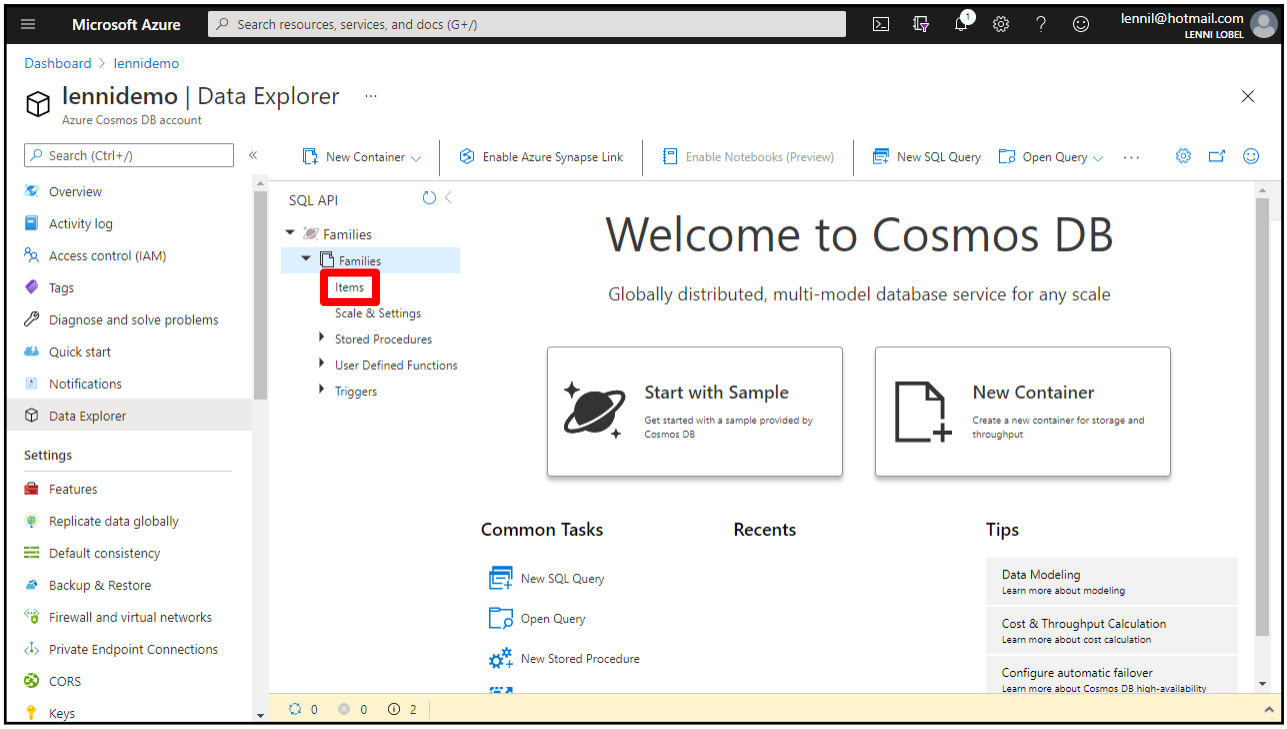

Demo
Creating documents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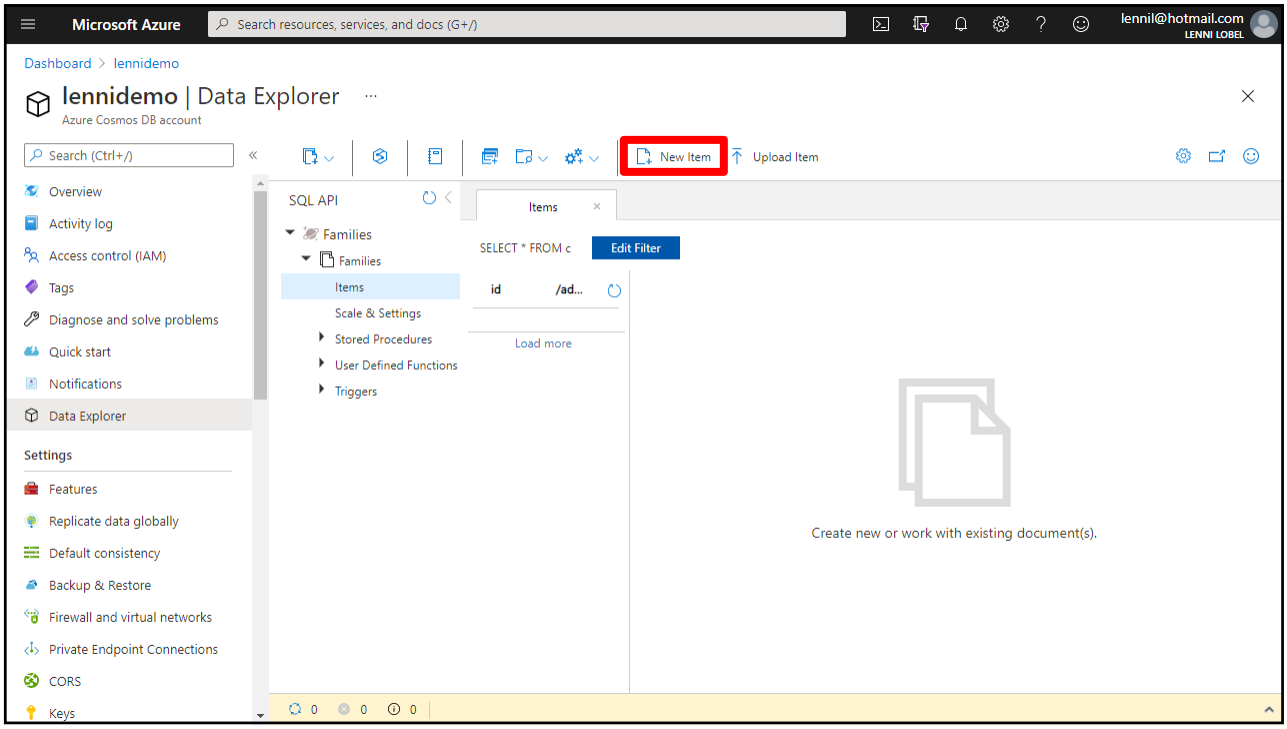
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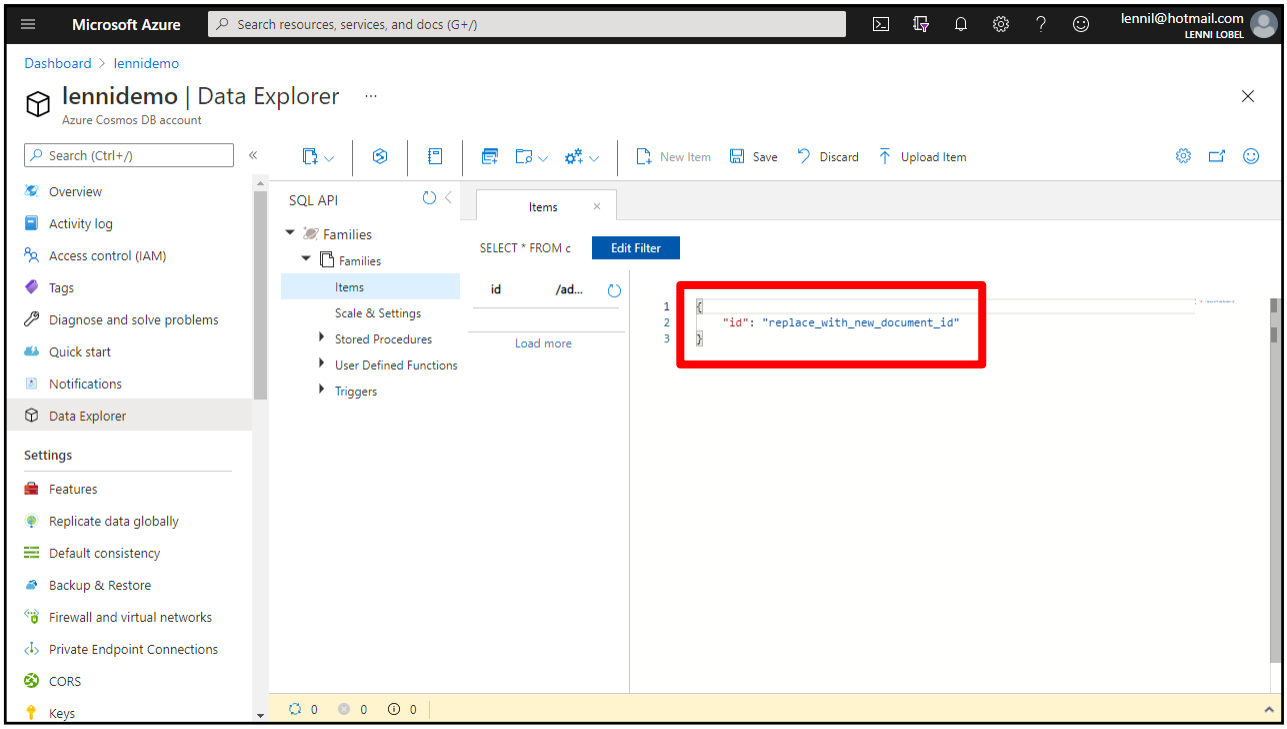
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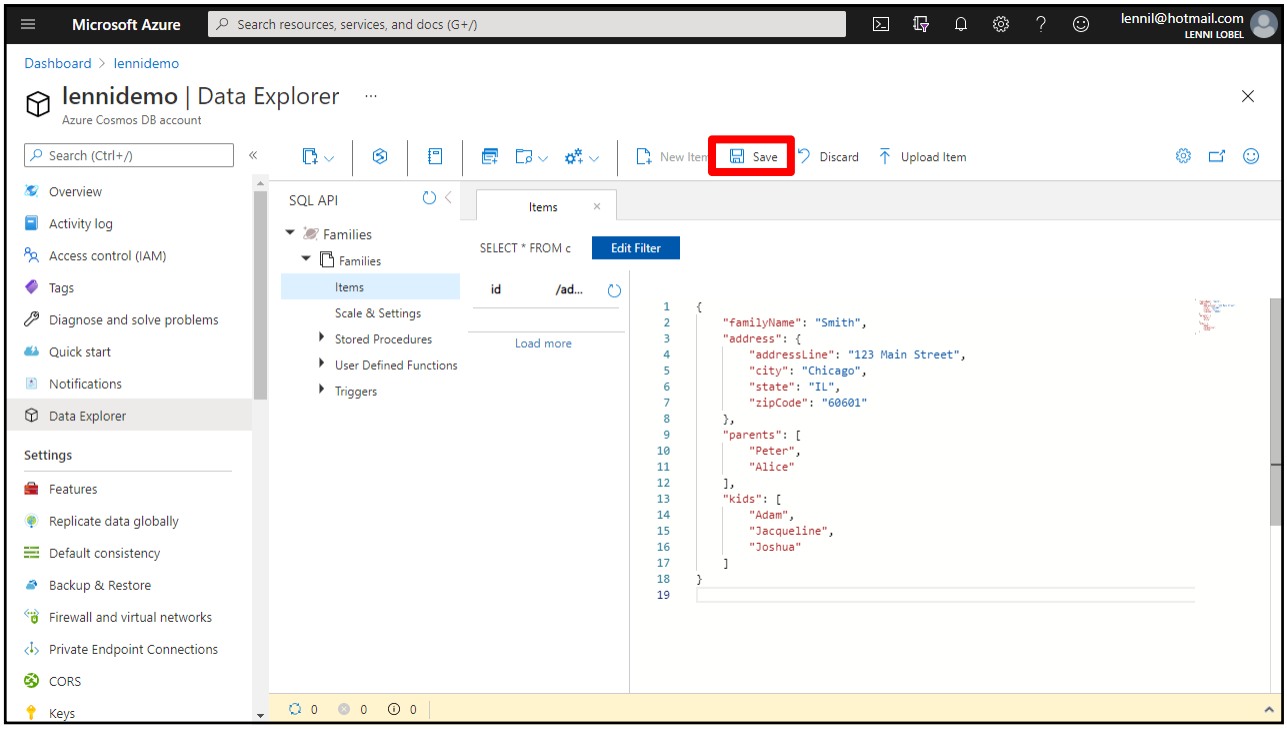
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"address": {
"addressLine": "123 Main Street",
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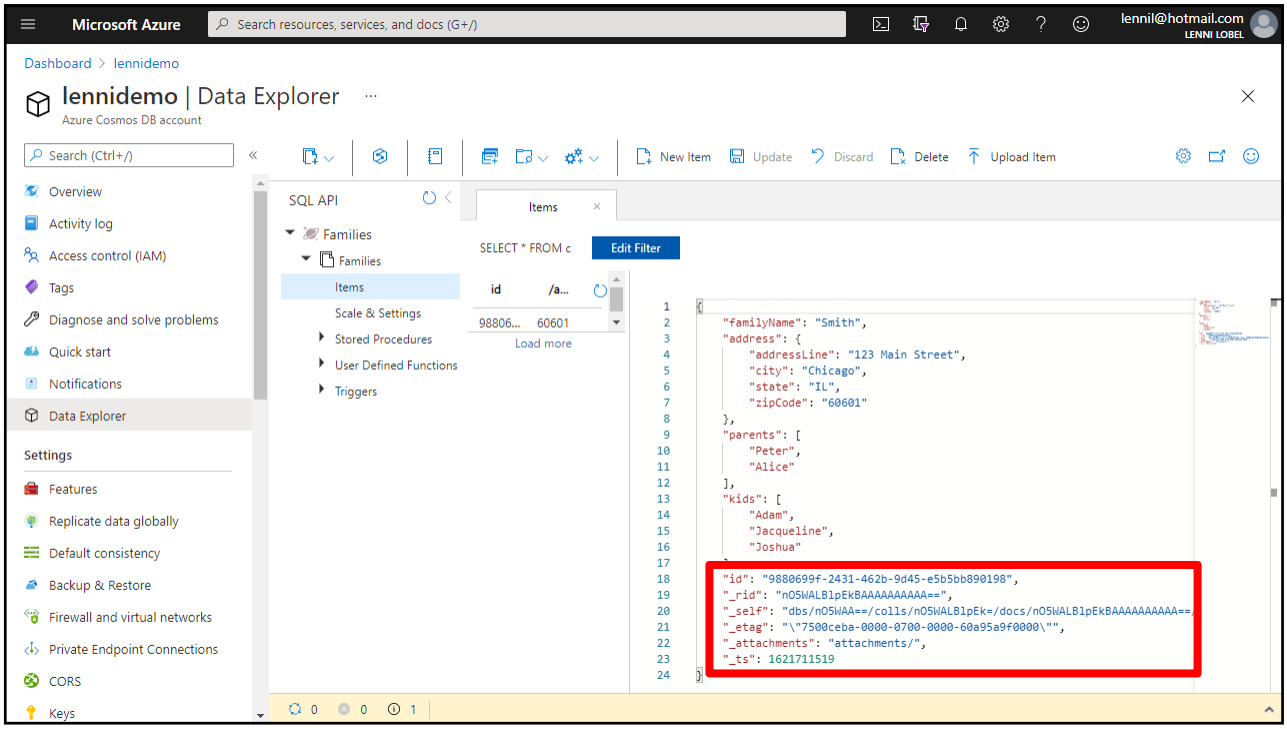
}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SQL API
Families
Items
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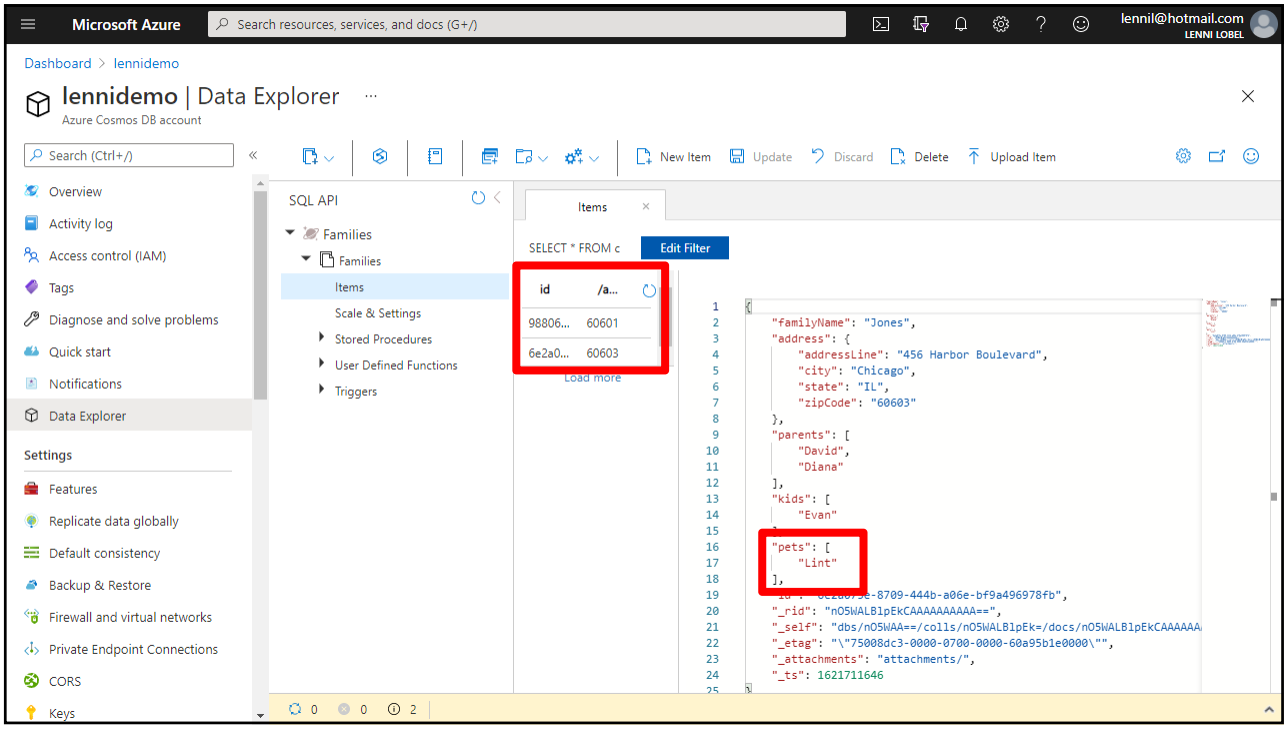
Stored Procedures
User Defined Functions
Triggers
SELECT * FROM c
Edit Filter
id
/a...
98806...
60601
Load more
{
"familyName": "Smith",
"address": {
"addressLine": "123 Main Street",
"city": "Chicago",
"state": "IL",
"zipCode": "60601"
},
"parents": [
"Peter",
"Alice"
],
"kids": [
"Adam",
"Jacqueline",
"Joshua"
],
"id": "9880699f-2431-462b-9d45-e5b5bb890198",
"_rid": "nO5WALBlpEkBAAAAAAAAAA==",
"_self": "dbs/nO5WAA==/colls/nO5WALBlpEk=/docs/nO5WALBlpEkBAAAAAAAAAA==/",
"_etag": "\"7500ceba-0000-0700-0000-60a95a9f0000\"",
"_attachments": "attachments/",
"_ts": 1621711519
}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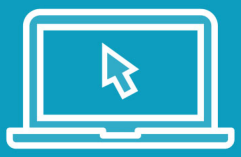
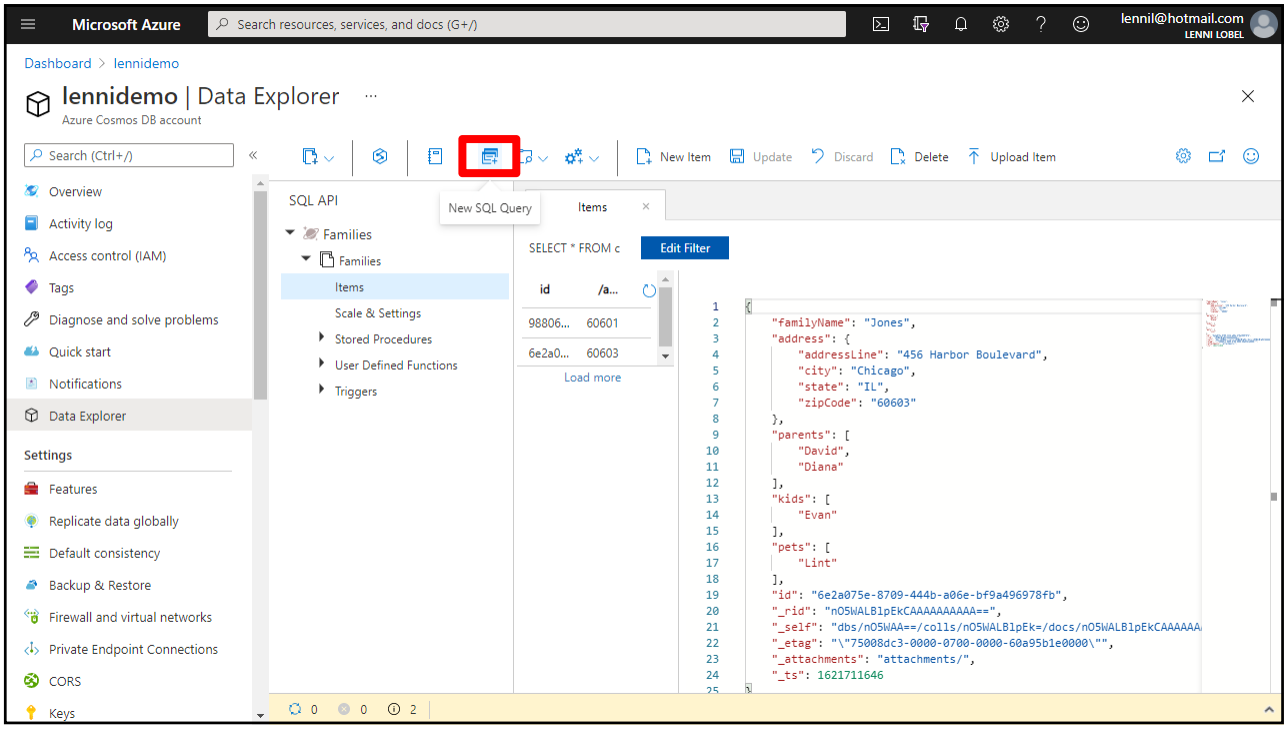
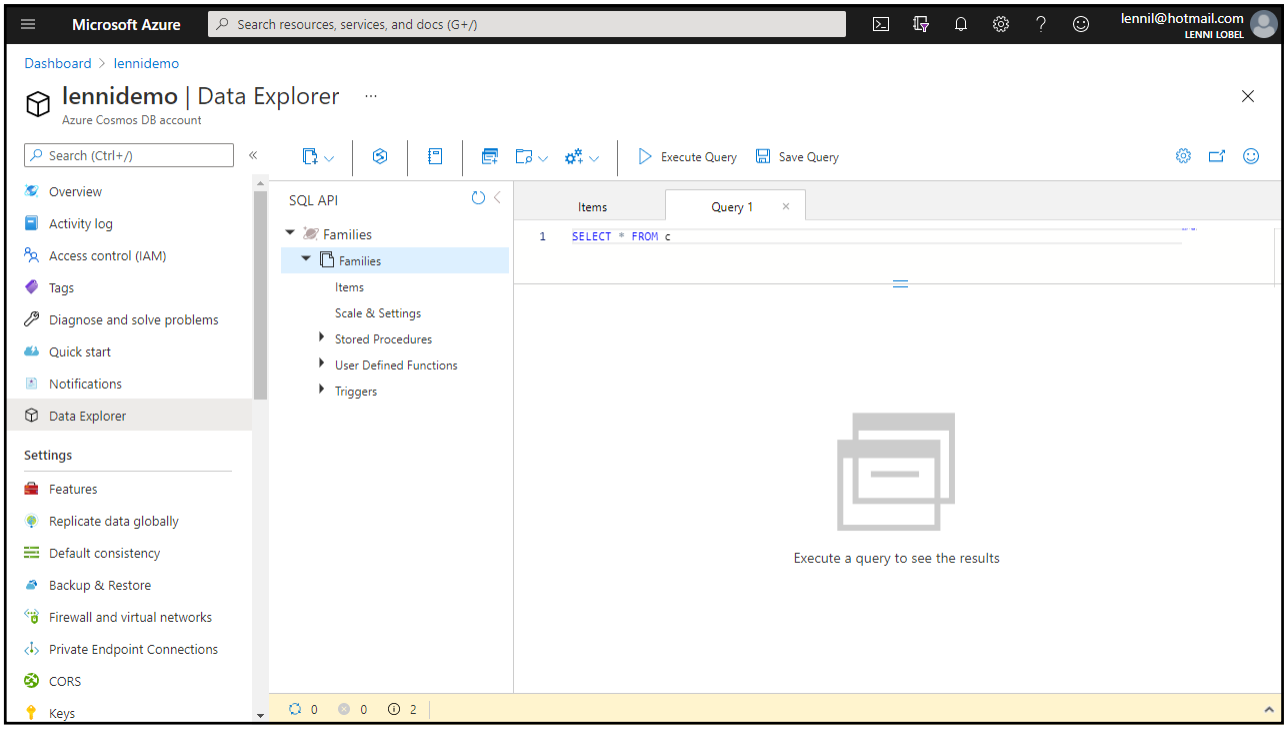
Triggers
SELECT * FROM c
Edit Filter
id
/a...
98806...
60601
6e2a0...
60603
Load more
{
"familyName": "Jones",
"address": {
"addressLine": "456 Harbor Boulevard",
"city": "Chicago",
"state": "IL",
"zipCode": "60603"
},
"parents": [
"David",
"Diana"
],
"kids": [
"Evan"
],
"pets": [
"Lint"
],
"_rid": "nO5WALBlpEkCAAAAAAAAAA==",
"_self": "dbs/nO5WAA==/colls/nO5WALBlpEk=/docs/nO5WALBlpEkCAAAAAA
"_etag": "\"75008dc3-0000-0700-0000-60a95b1e0000\"",
"_attachments": "attachments/",
"_ts": 1621711646
}

Demo



Querying documents

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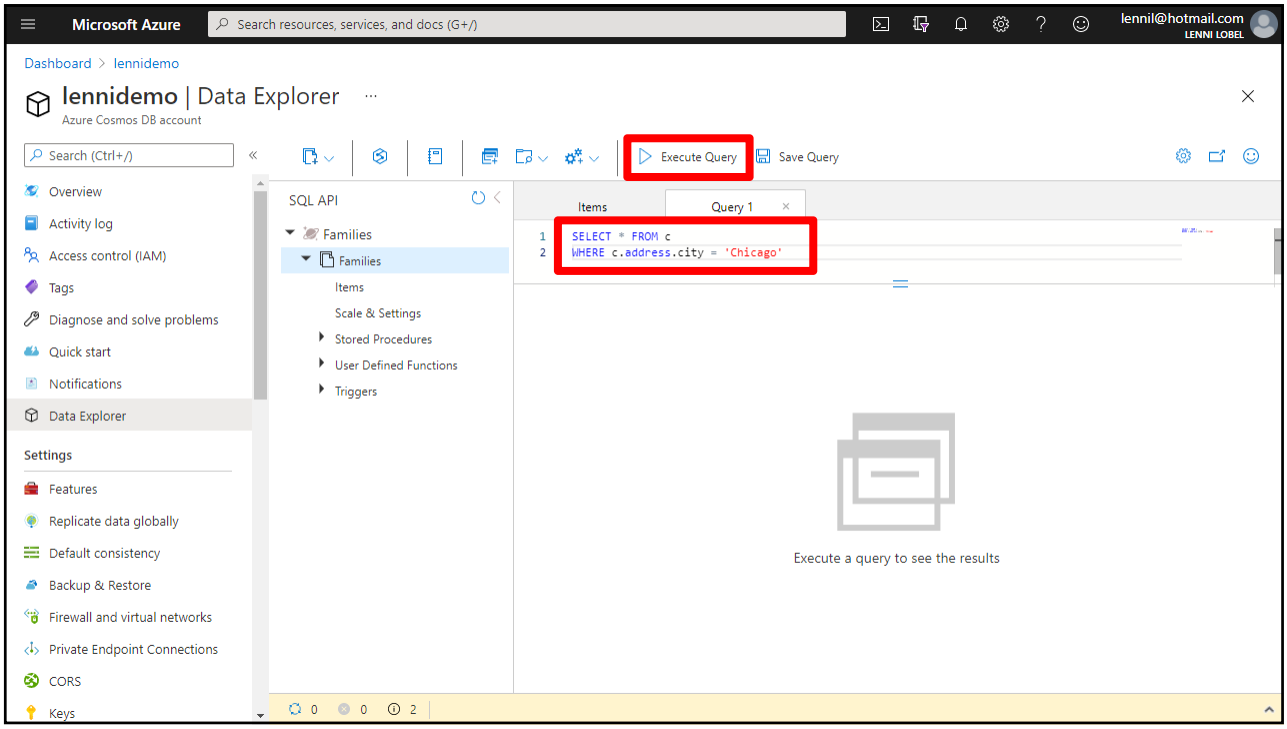
Query 1
1 SELECT * FROM c
Execute a query to see the results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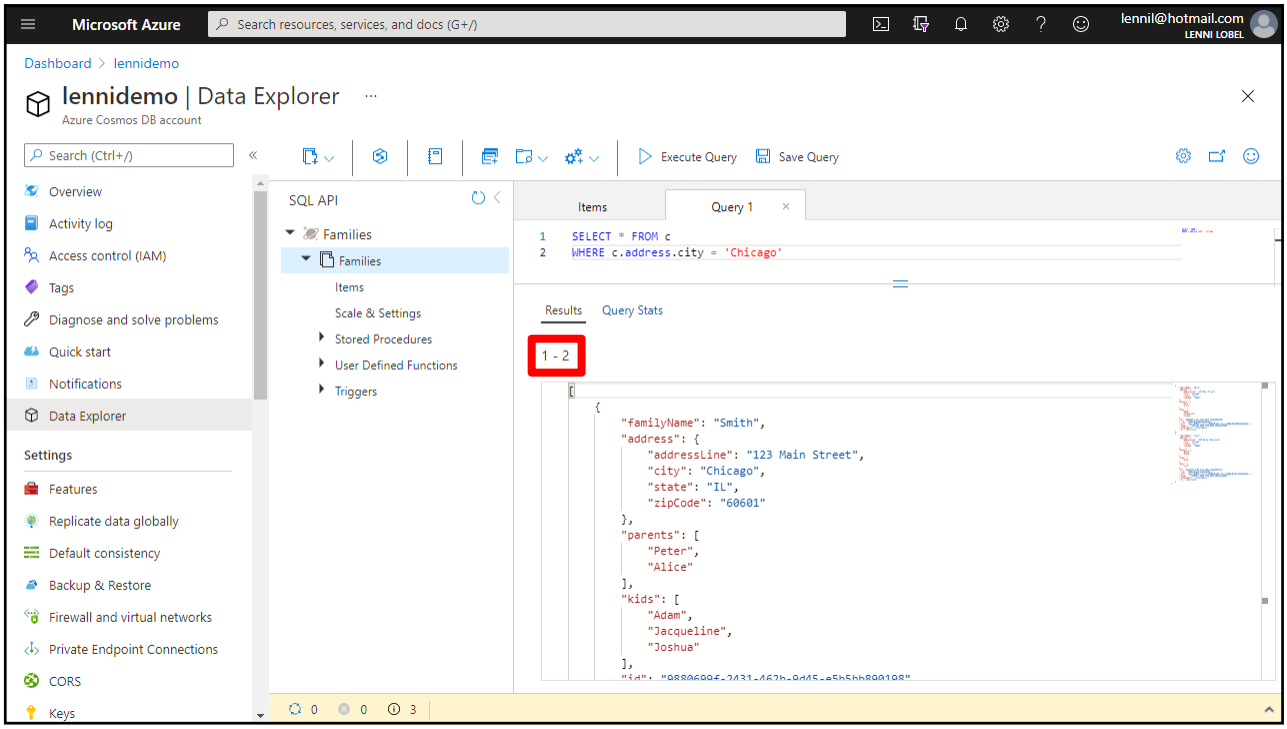
SQL API
Families
Items
Scale & Settings
Stored Procedures
User Defined Functions
Triggers
Items
Query 1
1 SELECT * FROM c
2 WHERE c.address.city = 'Chicago'
Execute a query to see the results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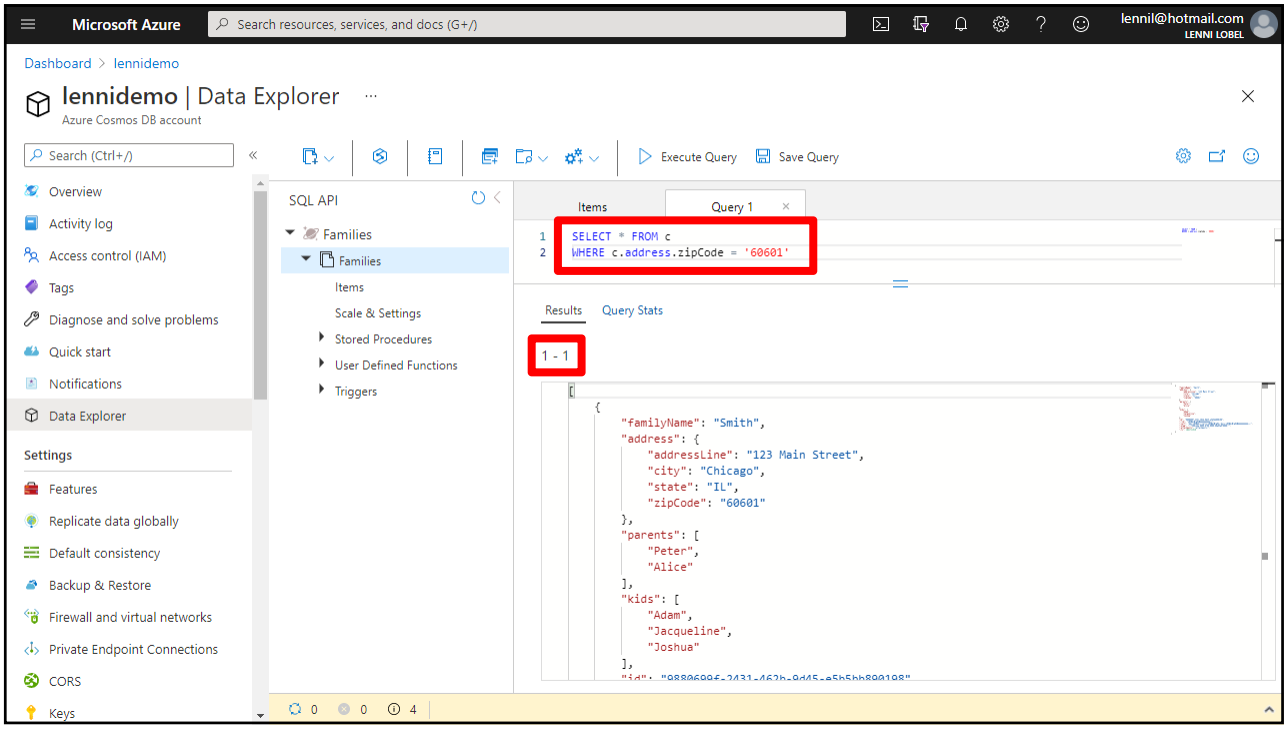
User Defined Functions
Triggers
Query 1
SELECT * FROM c
WHERE c.address.city = 'Chicago'
Results
Query Stats
1 - 2
{
"familyName": "Smith",
"address": {
"addressLine": "123 Main Street",
"city": "Chicago",
"state": "IL",
"zipCode": "60601"
},
"parents": [
"Peter",
"Alice"
],
"kids": [
"Adam",
"Jacqueline",
"Joshua"
],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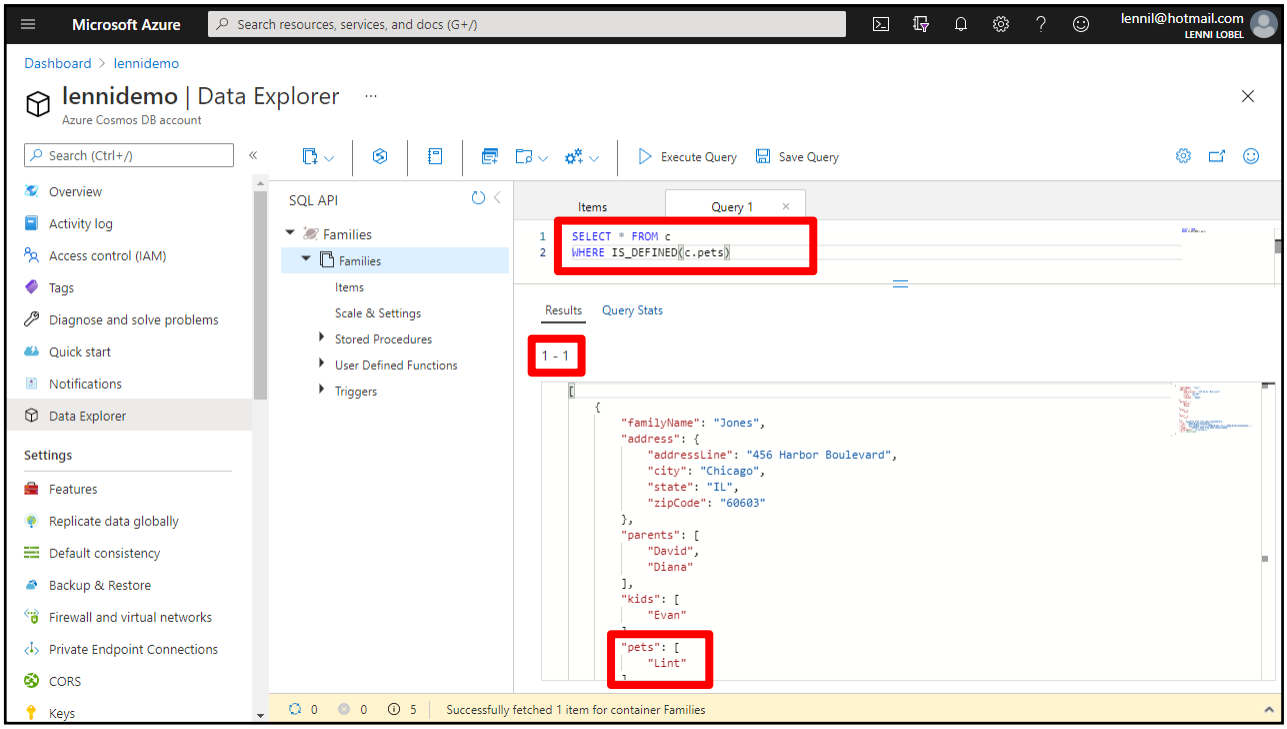
Triggers
Query 1
SELECT * FROM c
WHERE c.address.zipCode = '60601'
Results
Query Stats
1 - 1
{
"familyName": "Smith",
"address": {
"addressLine": "123 Main Street",
"city": "Chicago",
"state": "IL",
"zipCode": "60601"
},
"parents": [
"Peter",
"Alice"
],
"kids": [
"Adam",
"Jacqueline",
"Joshua"
],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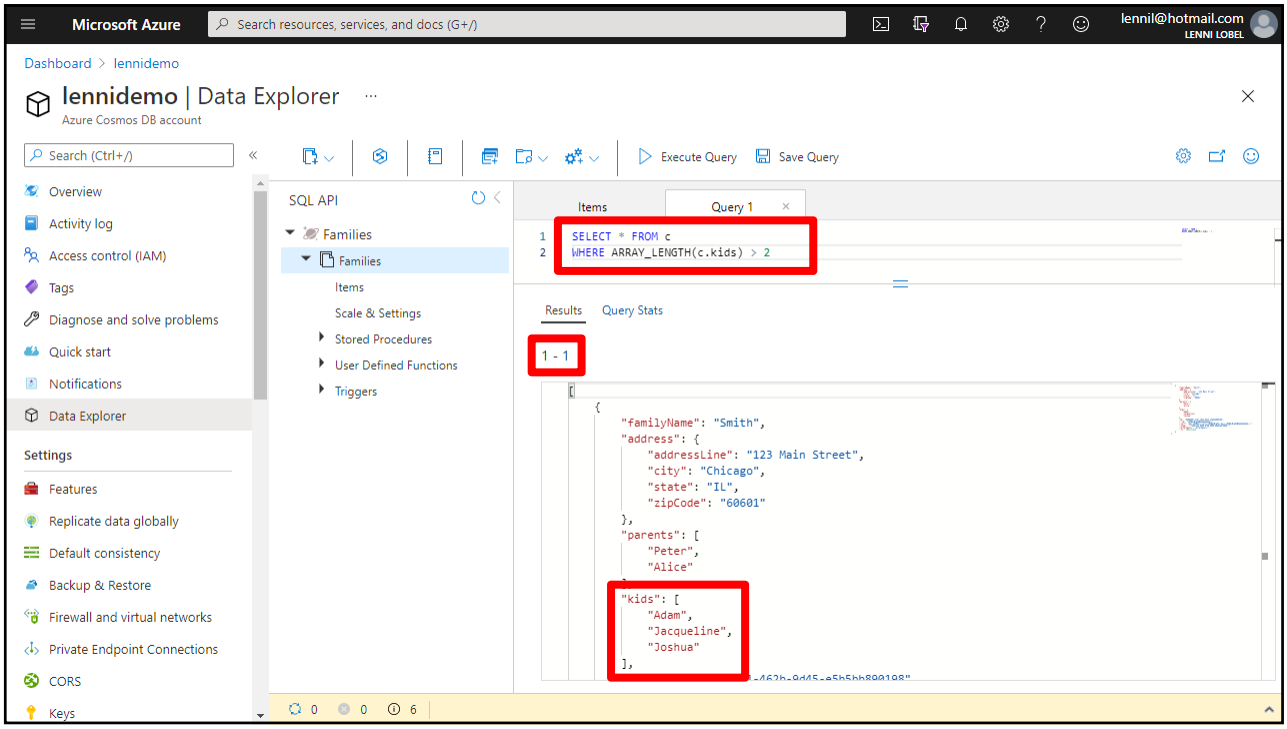
Triggers
Query 1
SELECT * FROM c
WHERE IS_DEFINED(c.pets)
Results
Query Stats
1 - 1
"familyName": "Jones",
"address": {
"addressLine": "456 Harbor Boulevard",
"city": "Chicago",
"state": "IL",
"zipCode": "60603"
},
"parents": [
"David",
"Diana"
],
"kids": [
"Evan"
],
"pets": [
"Lint"
Successfully fetched 1 item for container Families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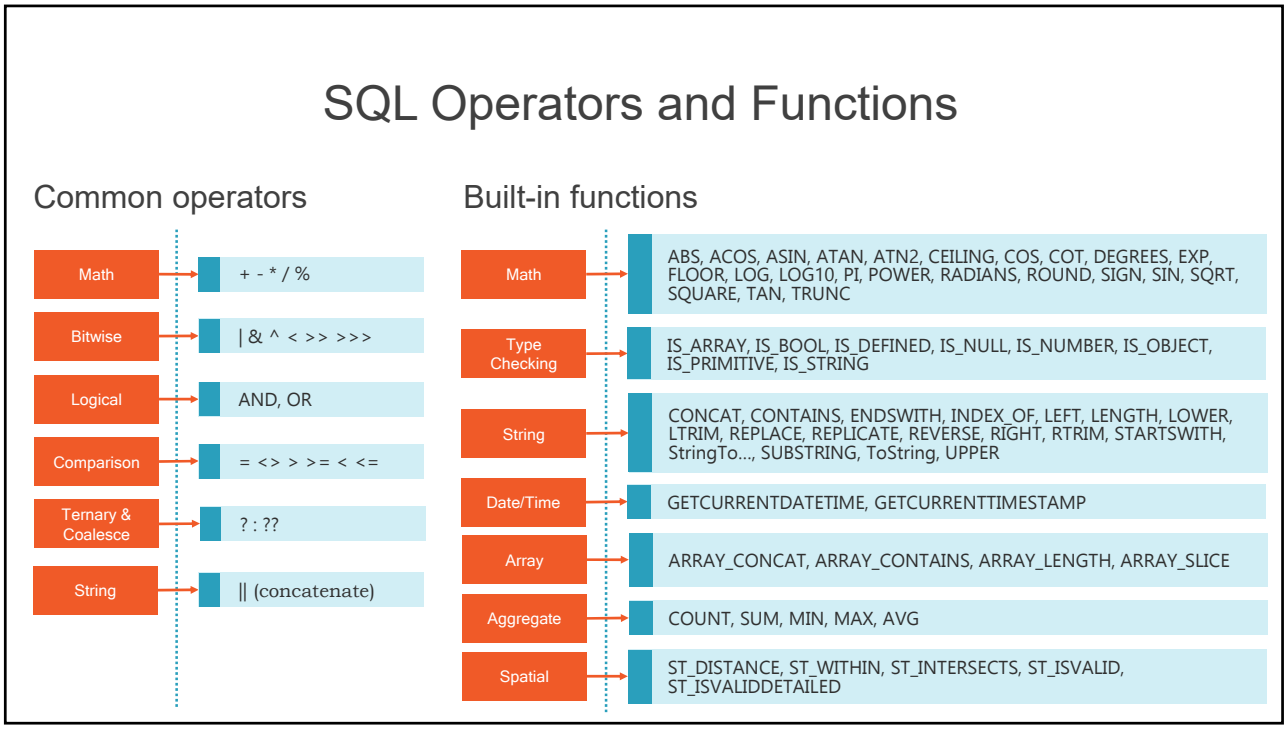
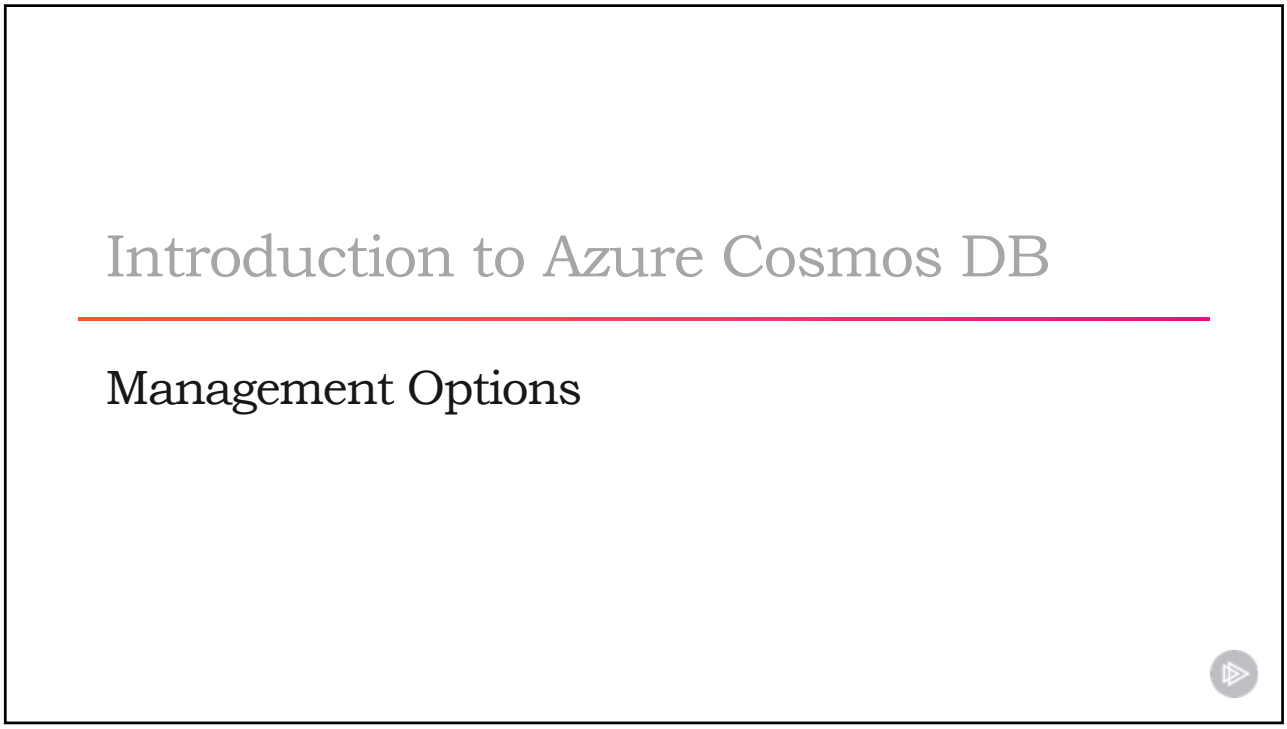
Triggers
Query 1
SELECT * FROM c
WHERE ARRAY_LENGTH(c.kids) > 2
Results
Query Stats
1 - 1
"familyName": "Smith",
"address": {
"addressLine": "123 Main Street",
"city": "Chicago",
"state": "IL",
"zipCode": "60601"
},
"parents": [
"Peter",
"Alice"
"kids": [
"Adam",
"Jacqueline",
"Joshua"
],


SQL Operators and Functions
Common operators
Math
+ - * / %
Bitwise
| & ^ < >> >>>
Logical
AND, OR
Comparison
= <> > >= < <=
Ternary & Coalesce
? : ??
String
|| (concatenate)
Built-in functions
Math
ABS, ACOS, ASIN, ATAN, ATN2, CEILING, COS, COT, DEGREES, EXP, FLOOR, LOG, LOG10, PI, POWER, RADIANS, ROUND, SIGN, SIN, SQRT, SQUARE, TAN, TRUNC
Type Checking
IS_ARRAY, IS_BOOL, IS_DEFINED, IS_NULL, IS_NUMBER, IS_OBJECT, IS_PRIMITIVE, IS_STRING
String
CONCAT, CONTAINS, ENDSWITH, INDEX_OF, LEFT, LENGTH, LOWER, LTRIM, REPLACE, REPLICATE, REVERSE, RIGHT, RTRIM, STARTSWITH, StringTo..., SUBSTRING, ToString, UPPER
Date/Time
GETCURRENTDATETIME, GETCURRENTTIMESTAMP
Array
ARRAY_CONCAT, ARRAY_CONTAINS, ARRAY_LENGTH, ARRAY_SLICE
Aggregate
COUNT, SUM, MIN, MAX, AVG
Spatial
ST_DISTANCE, ST_WITHIN, ST_INTERSECTS, ST_ISVALID, ST_ISVALIDDETAILED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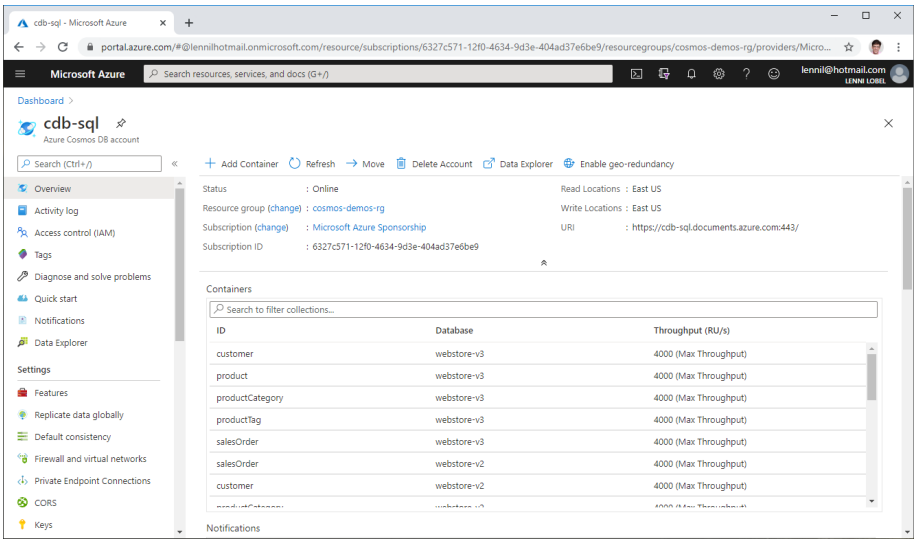
Management Options

Management Options

Azure Portal

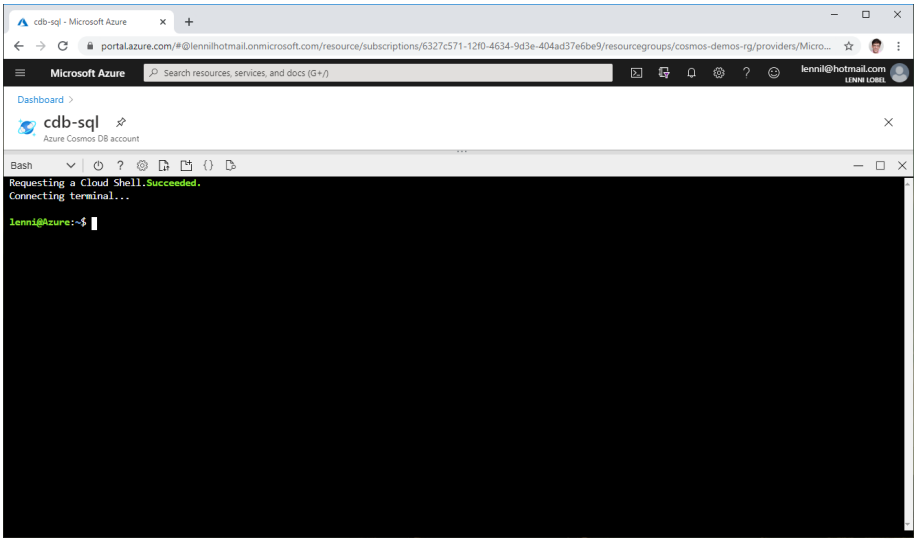
Azure CLI



Management Options

Azure Portal

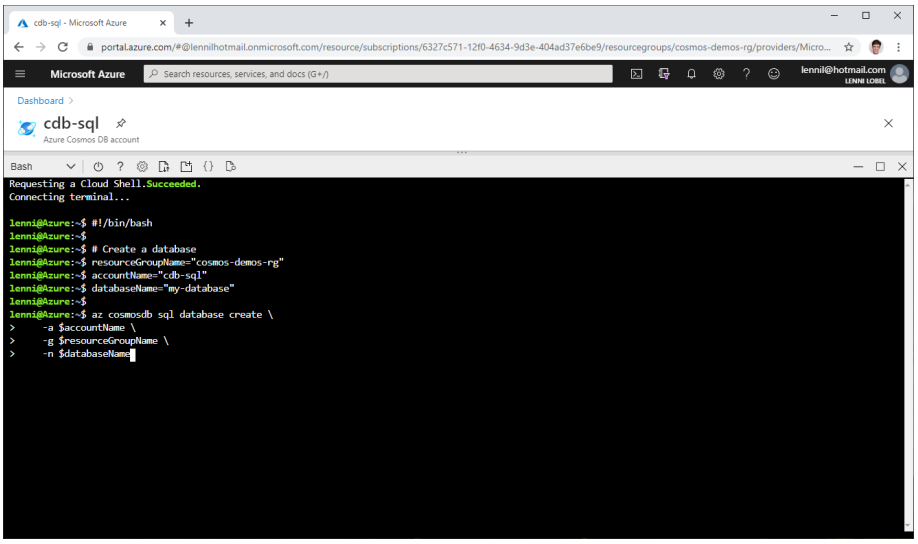
Azure CLI



Management Options

Azure Portal

Azure CLI

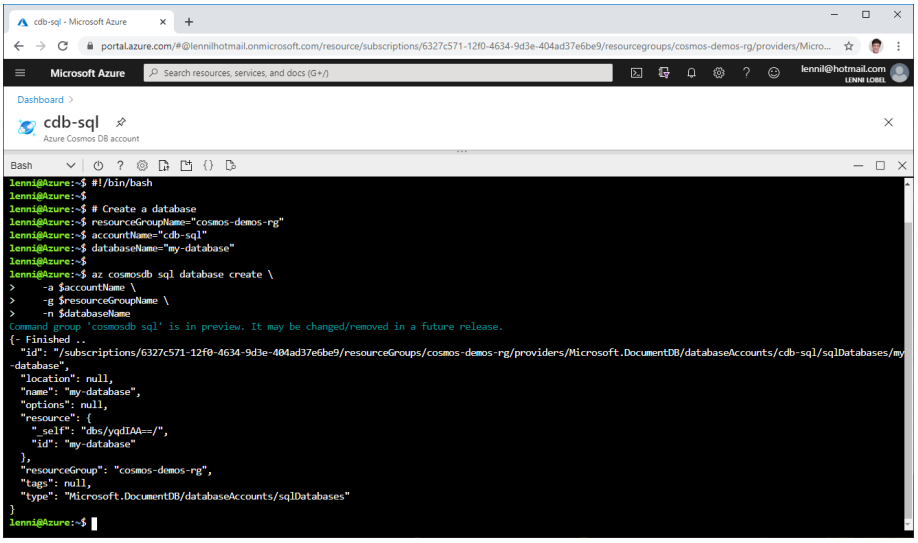


Management Options

Azure Portal

Azure CLI

PowerShell

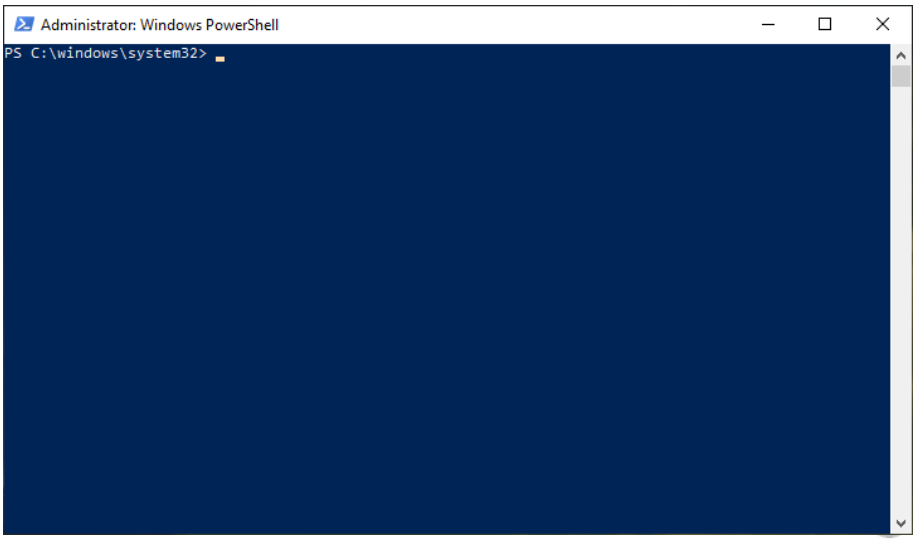


Management Options

Azure Portal

Azure CLI

PowerShell

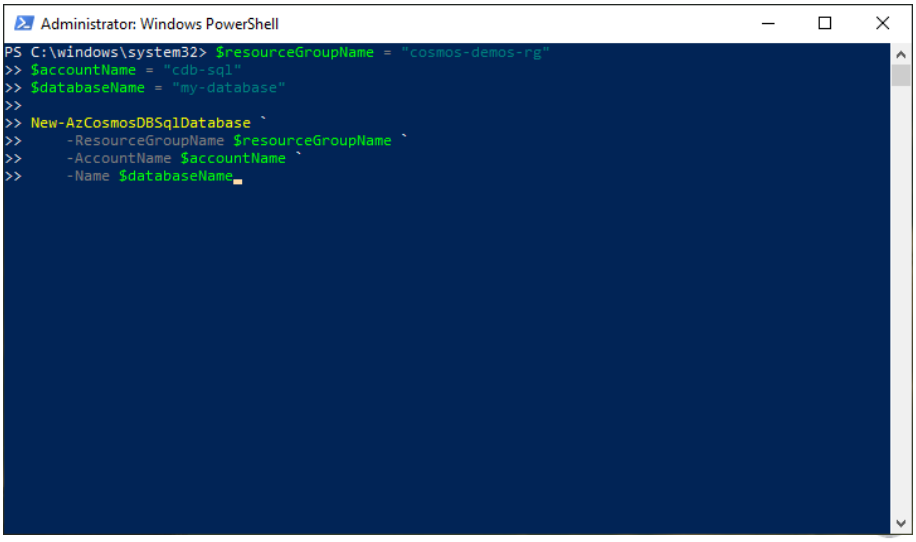


Management Options

Azure Portal

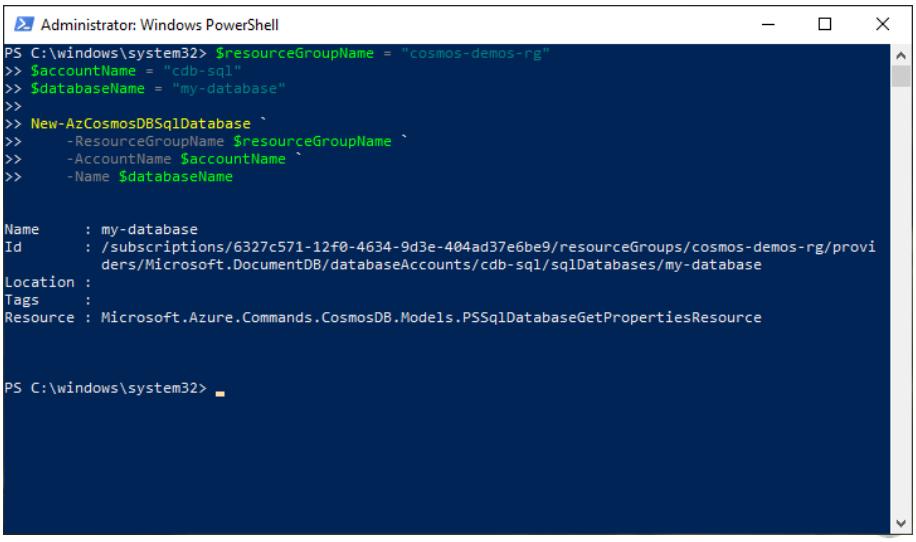
Azure CLI

PowerShell



Management Options

- Azure Portal
- Azure CLI
- PowerShell
- ARM Templates



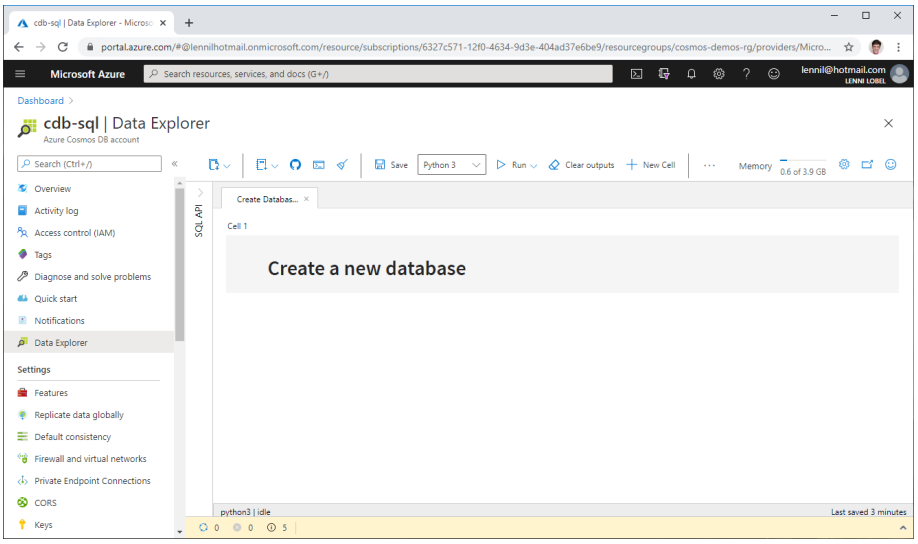
Management Options

- Azure Portal
- Azure CLI
- PowerShell
- ARM Templates

```
{
  "type": "Microsoft.DocumentDB/databaseAccounts",
  "apiVersion": "2015-04-08",
  "name": "[variables('accountName')]",
  "location": "[resourceGroup().location]",
  "tags": {},
  "kind": "GlobalDocumentDB",
  "properties": {
    "consistencyPolicy": {
      "defaultConsistencyLevel": "Eventual",
      "maxStalenessPrefix": 1,
      "maxIntervalInSeconds": 5
    },
    "locations": [
      {
        "locationName": "West Europe",
        "failoverPriority": 0
      },
      {
        "locationName": "East US 2",
        "failoverPriority": 1
      }
    ],
    "databaseAccountOfferType": "Standard",
    "enableAutomaticFailover": true,
    "enableMultipleWriteLocations": true
  }
}
```

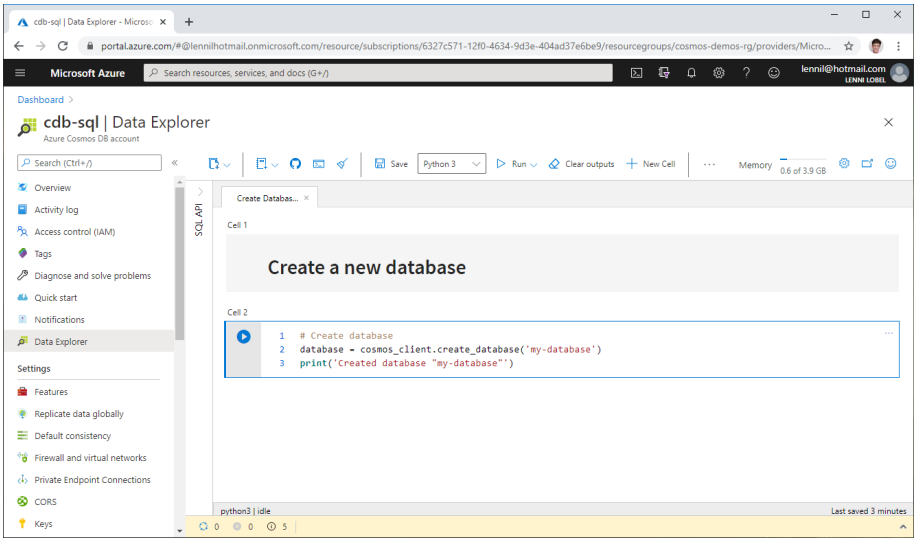
Management Options

- Azure Portal
- Azure CLI
- PowerShell
- ARM Templates
- Notebooks



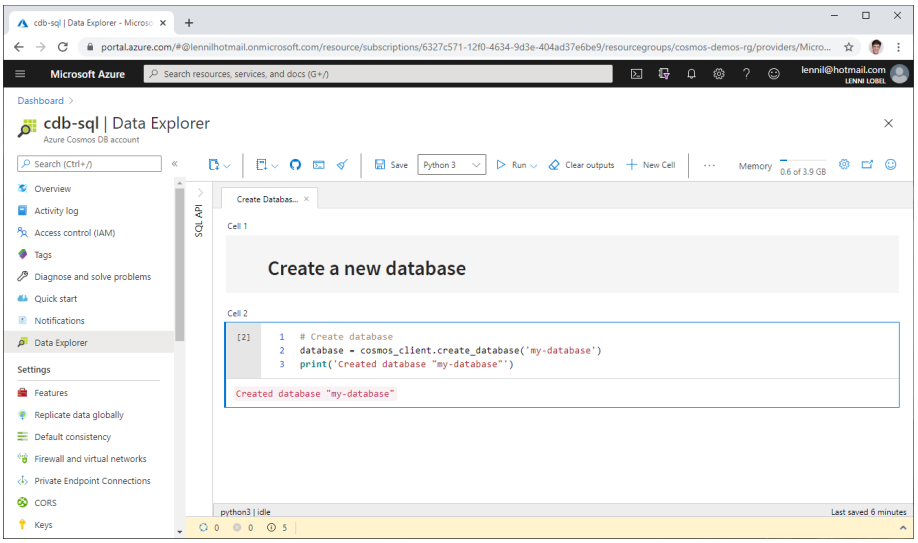
Management Options

- Azure Portal
- Azure CLI
- PowerShell
- ARM Templates
- Notebooks



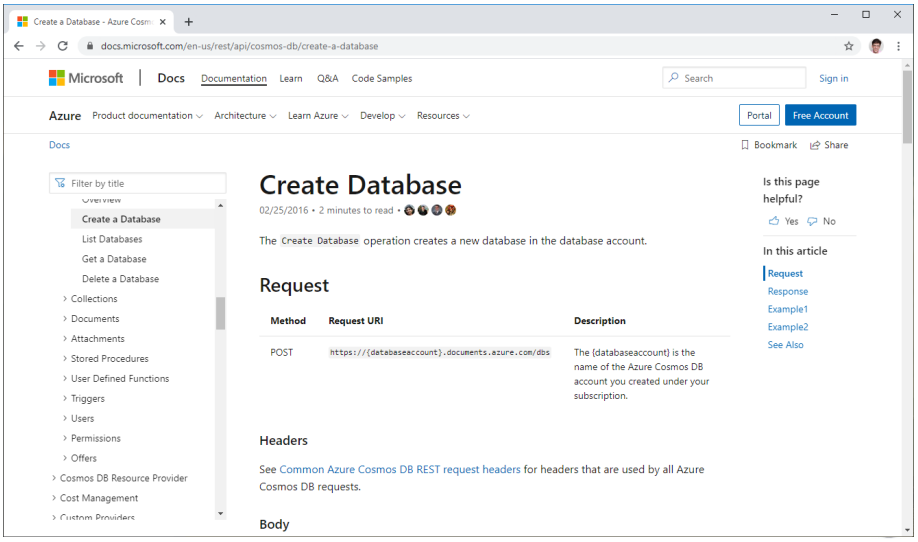
Management Options

- Azure Portal
- Azure CLI
- PowerShell
- ARM Templates
- Notebooks
- REST API



Management Options

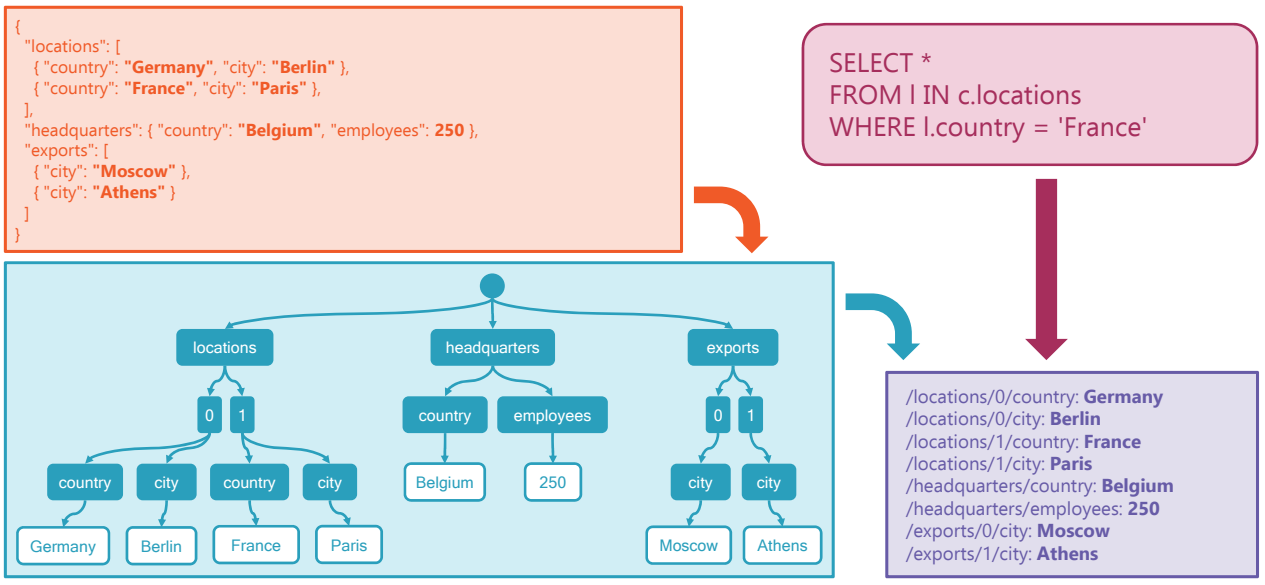
- Azure Portal
- Azure CLI
- PowerShell
- ARM Templates
- Notebooks
- REST API

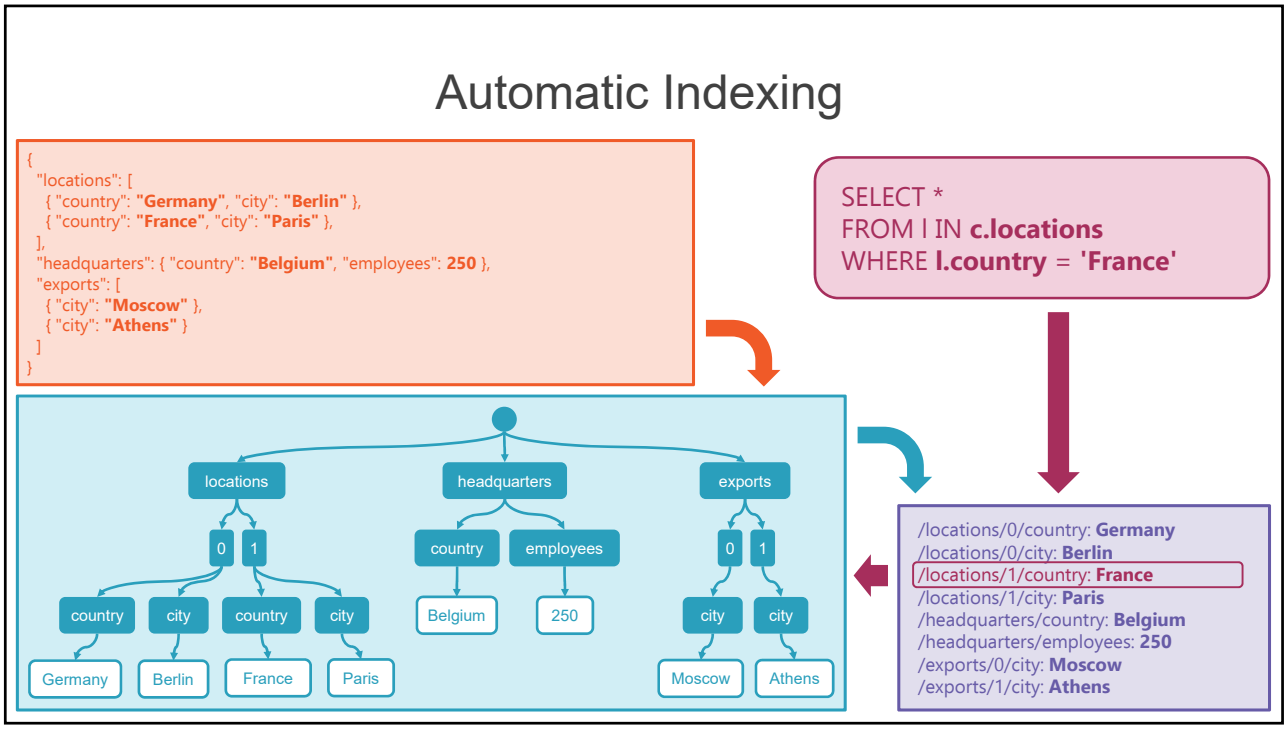


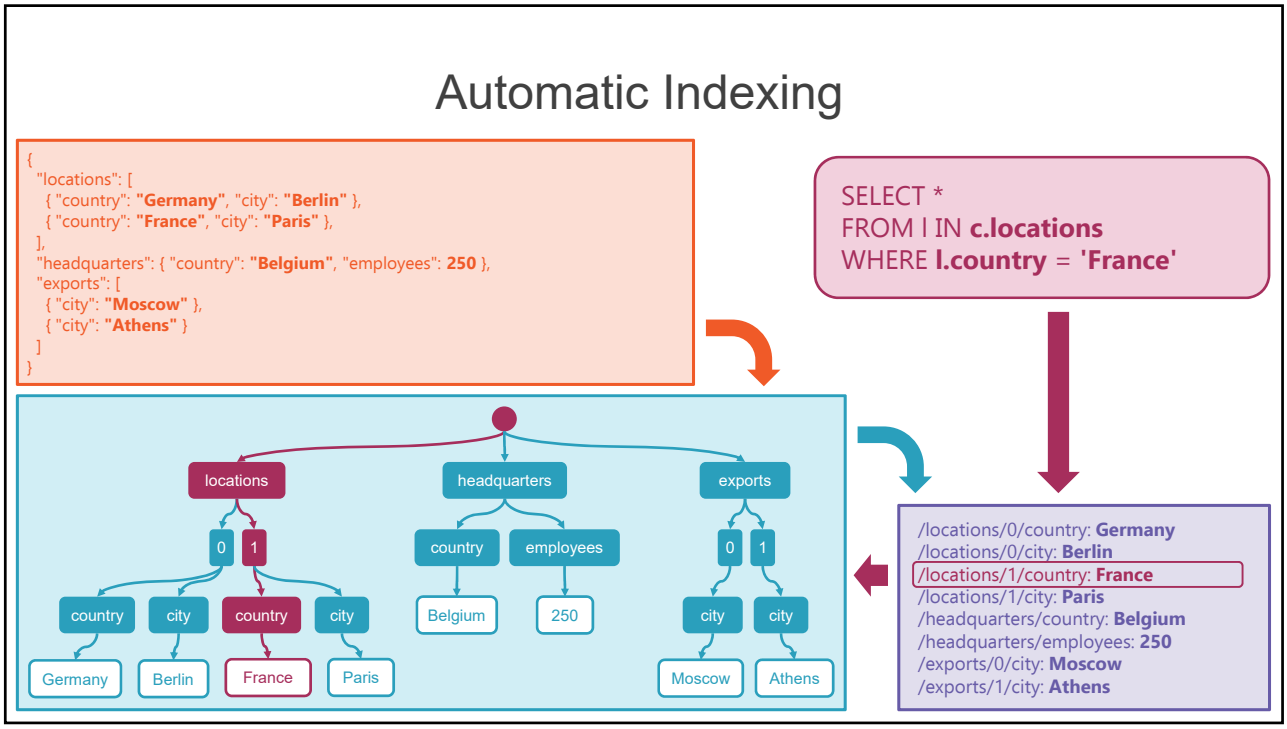
Introduction to Azure Cosmos DB

Automatic Indexing

Automatic Indexing



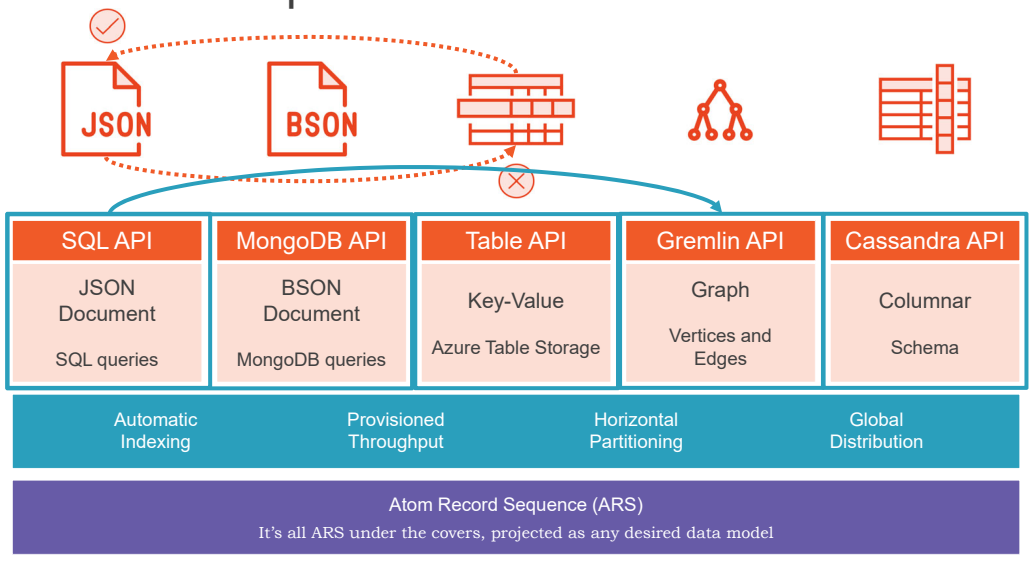

Automatic Indexing
{
"locations": [
{ "country": "Germany", "city": "Berlin" },
{ "country": "France", "city": "Paris" },
],
"headquarters": { "country": "Belgium", "employees": 250 },
"exports": [
{ "city": "Moscow" },
{ "city": "Athens" }
]
}
SELECT *
FROM l IN c.locations
WHERE l.country = 'France'
locations
headquarters
exports
0
1
country
city
country
city
country
employees
0
1
Germany
Berlin
France
Paris
Belgium
250
city
city
Moscow
Athens
/locations/0/country: Germany
/locations/0/city: Berlin
/locations/1/country: France
/locations/1/city: Paris
/headquarters/country: Belgium
/headquarters/employees: 250
/exports/0/city: Moscow
/exports/1/city: Athens


Automatic Indexing
{
"locations": [
{ "country": "Germany", "city": "Berlin" },
{ "country": "France", "city": "Paris" },
],
"headquarters": { "country": "Belgium", "employees": 250 },
"exports": [
{ "city": "Moscow" },
{ "city": "Athens" }
]
}
SELECT *
FROM l IN c.locations
WHERE l.country = 'France'
locations
headquarters
exports
0
1
country
city
country
city
country
employees
0
1
Germany
Berlin
France
Paris
Belgium
250
city
city
Moscow
Athens
/locations/0/country: Germany
/locations/0/city: Berlin
/locations/1/country: France
/locations/1/city: Paris
/headquarters/country: Belgium
/headquarters/employees: 250
/exports/0/city: Moscow
/exports/1/city: Athens

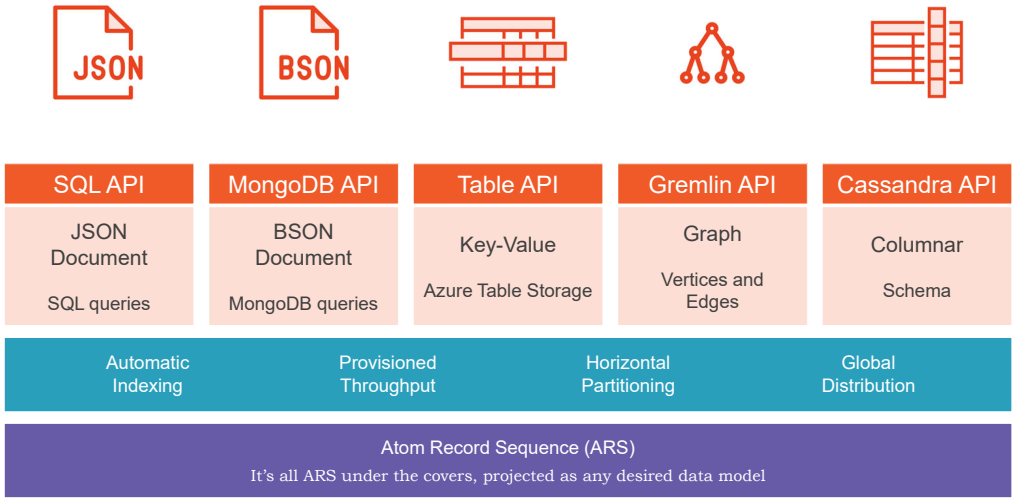
Introduction to Azure Cosmos DB

Multiple APIs and Data Models

Multiple APIs and Data Models



Multiple APIs and Data Models



Introduction to Azure Cosmos DB

Data Migration Options

Data Migration Options

Data Migration Tool

Open source desktop application, suitable for small-to-medium datasets

- Raw JSON files
- MongoDB
- SQL Server
- Raw CSV files
- Azure Table Storage
- Amazon DynamoDB
- HBase
- Cosmos DB

https://docs.microsoft.com/azure/cosmos-db/import-data
https://github.com/azure/azure-documentdb-datamigrationtool

Data Migration Options

Data Migration Tool

Open source desktop application, suitable for small-to-medium datasets

Azure Data Factory

ETL service for data integration, suitable for medium-to-large datasets

https://docs.microsoft.com/azure/data-factory

Data Migration Options

Data Migration Tool	Azure Data Factory	Spark connector
Open source desktop application, suitable for small-to-medium datasets	ETL service for data integration, suitable for medium-to-large datasets	Big data analytics using Apache Spark

https://docs.microsoft.com/azure/cosmos-db/spark-connector

Data Migration Options

Data Migration Tool	Azure Data Factory	Spark connector	Custom tool
Open source desktop application, suitable for small-to-medium datasets	ETL service for data integration, suitable for medium-to-large datasets	Big data analytics using Apache Spark	Support extremely large (10 TB+) datasets

https://docs.microsoft.com/en-us/azure/cosmos-db/migrate-cosmosdb-data

Data Migration Options

Data Migration Tool
Open source desktop application, suitable for small-to-medium datasets

Azure Data Factory
ETL service for data integration, suitable for medium-to-large datasets

Spark connector
Big data analytics using Apache Spark

Custom tool
Support extremely large (10 TB+) datasets

Online migrations
Change feed
Striim

https://docs.microsoft.com/en-us/azure/cosmos-db/change-feed
https://docs.microsoft.com/en-us/azure/cosmos-db/cosmosdb-sql-api-migrate-data-striim

Data Migration Options

Data Migration Tool
Open source desktop application, suitable for small-to-medium datasets

Azure Data Factory
ETL service for data integration, suitable for medium-to-large datasets

Spark connector
Big data analytics using Apache Spark

Custom tool
Support extremely large (10 TB+) datasets

Online migrations
Change feed
Striim

Stream Analytics
Aggregate, analyze, and transform fast streaming data

https://docs.microsoft.com/en-us/azure/stream-analytics/stream-analytics-documentdb-output

Data Migration Options

Data Migration Tool
Open source desktop application, suitable for small-to-medium datasets

Azure Data Factory
ETL service for data integration, suitable for medium-to-large datasets

Spark connector
Big data analytics using Apache Spark

Custom tool
Support extremely large (10 TB+) datasets

Online migrations
Change feed
Striim

Stream Analytics
Aggregate, analyze, and transform fast streaming data

Apache Kafka Connector
Import and export Kafka topics

https://docs.microsoft.com/en-us/azure/cosmos-db/sql/kafka-connector-sink

Introduction to Azure Cosmos DB

Throughput and Cost

Measuring Performance

Latency

How fast is the response for a given request?

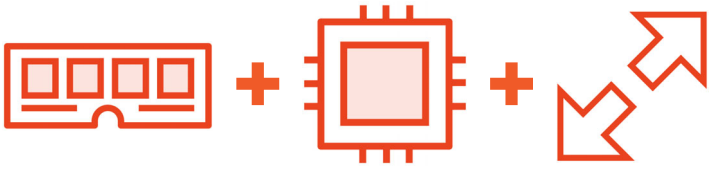
Throughput

How many requests can be served within a specific period of time?

Introducing Request Units

Throughput Currency

Blended measure of computational cost (memory, CPU, IOPs)



Introducing Request Units

Throughput Currency

Blended measure of computational cost (memory, CPU, IOPs)

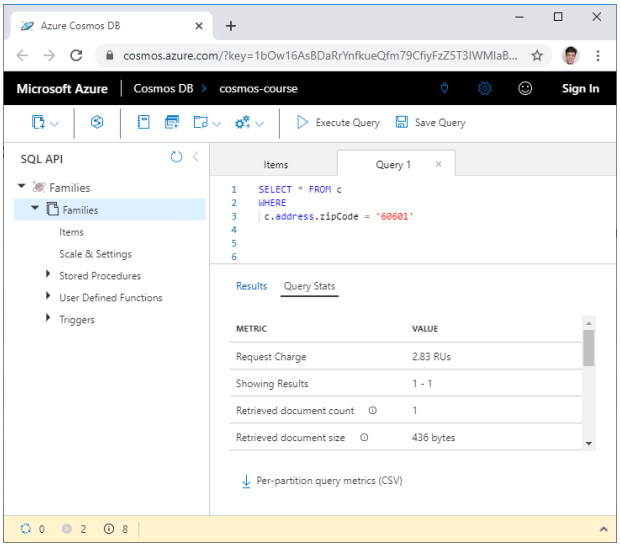
All Requests are Not Equal

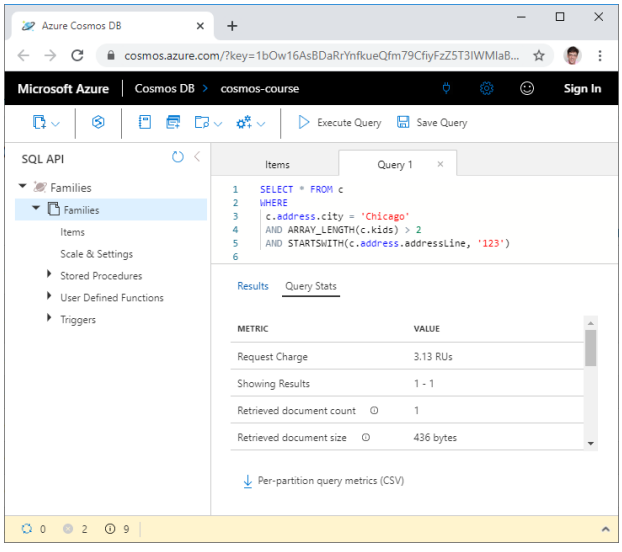
Every Cosmos DB response header shows the RU charge for the request

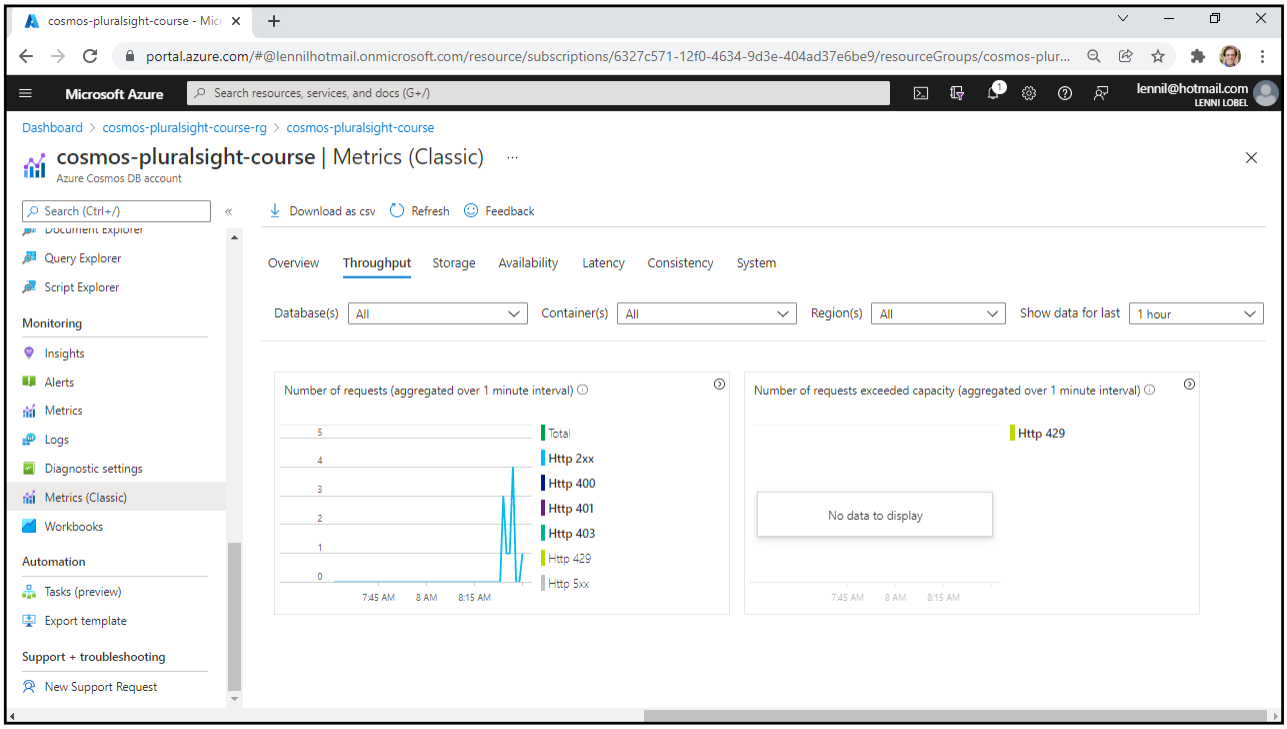
Request Units are Deterministic

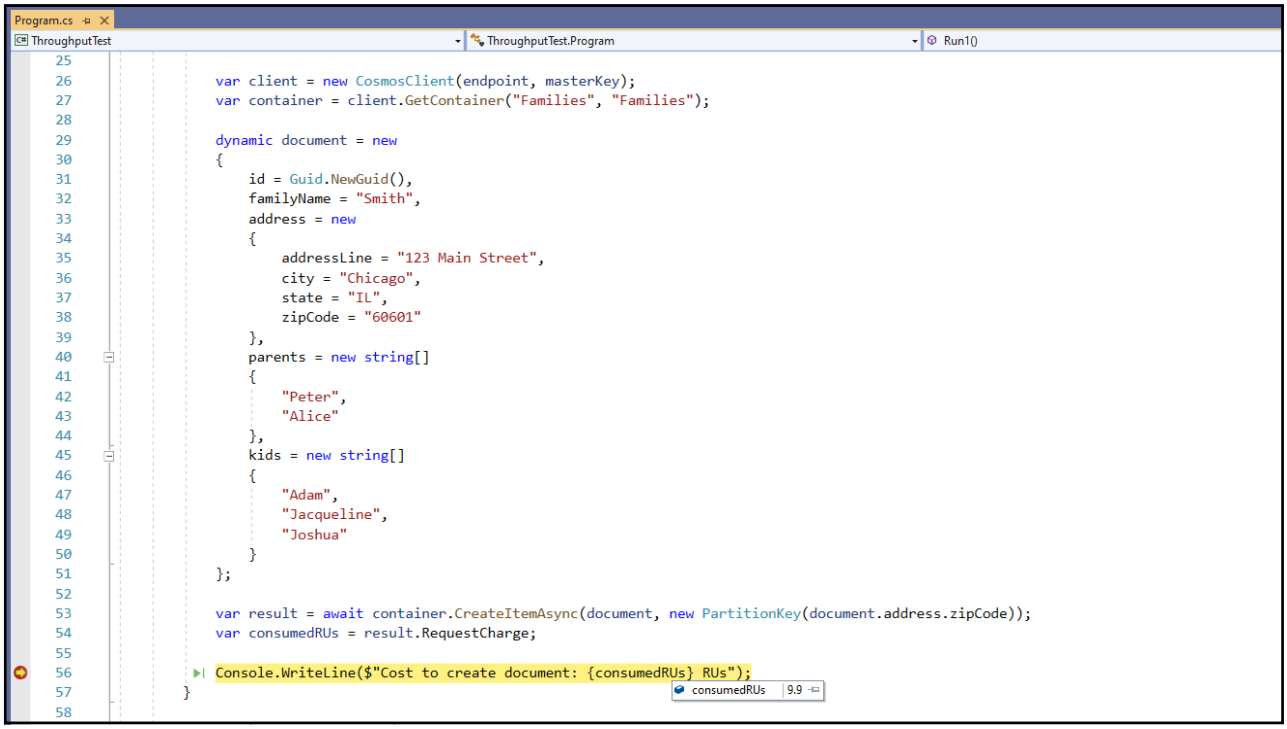
The same request will always require the same number of request units

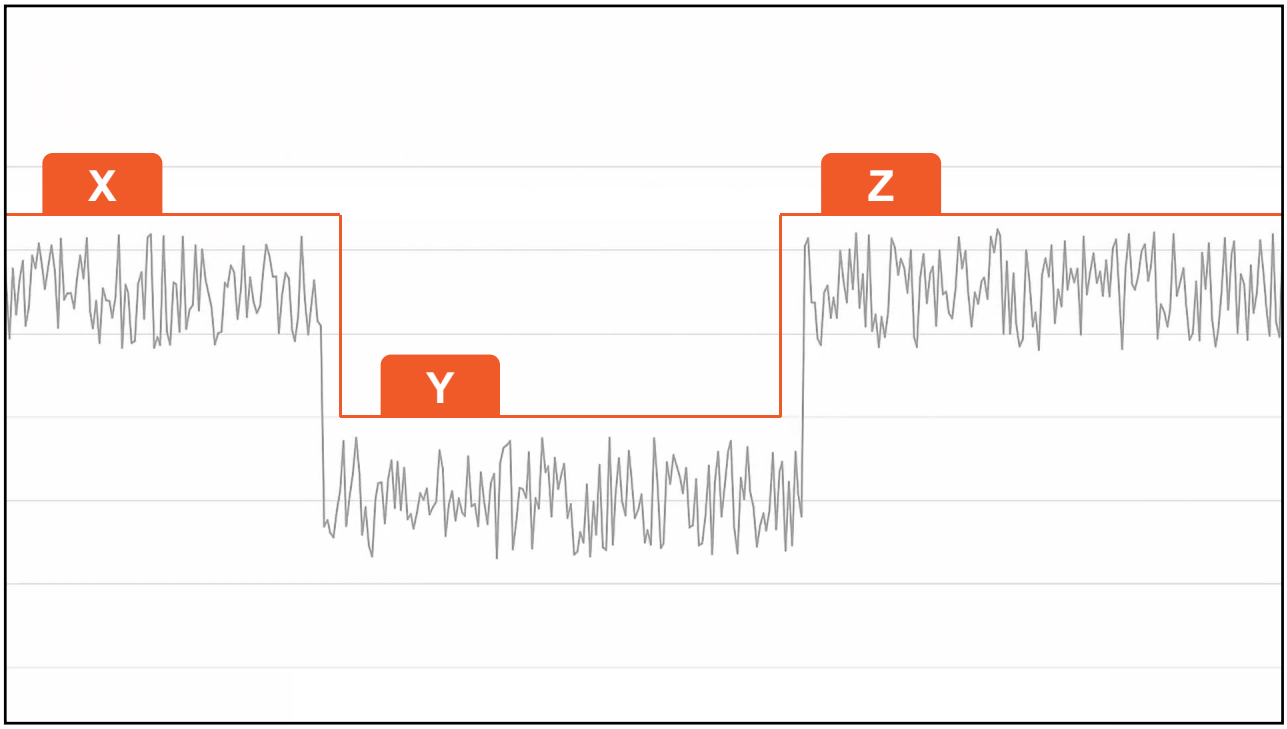
Monitoring Request Unit Consumption

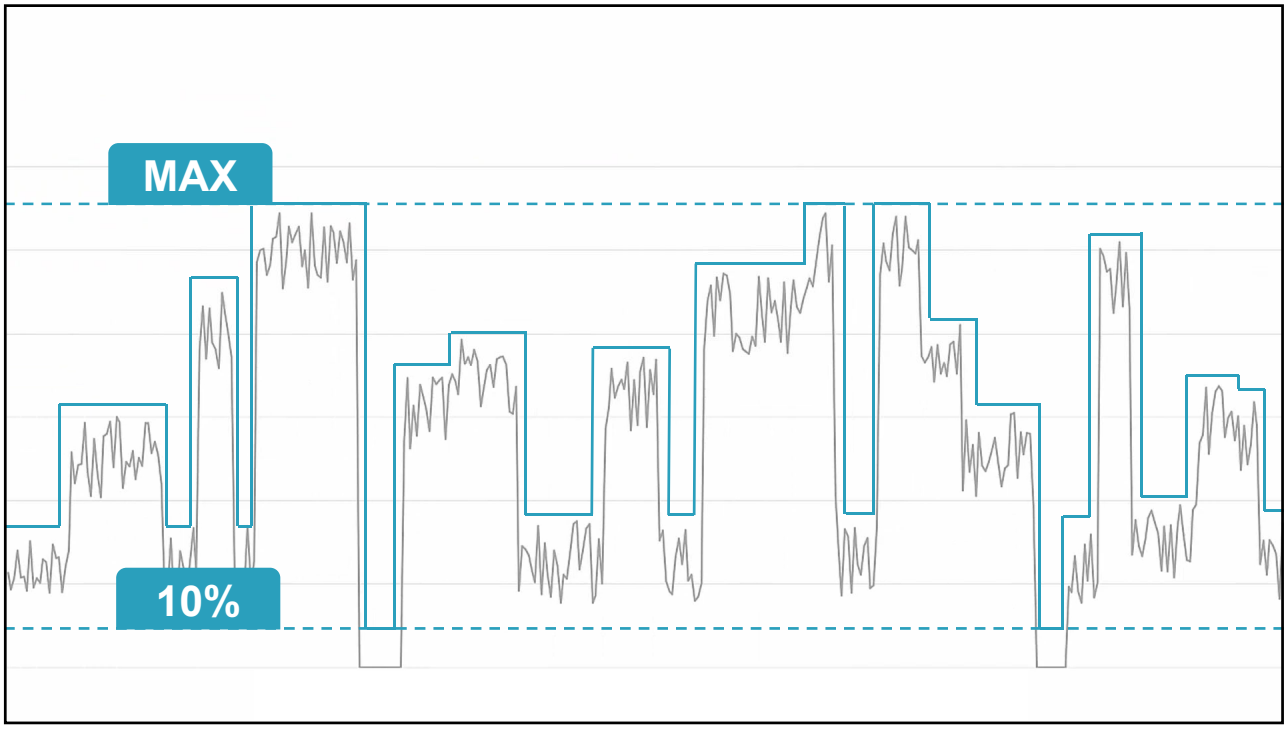


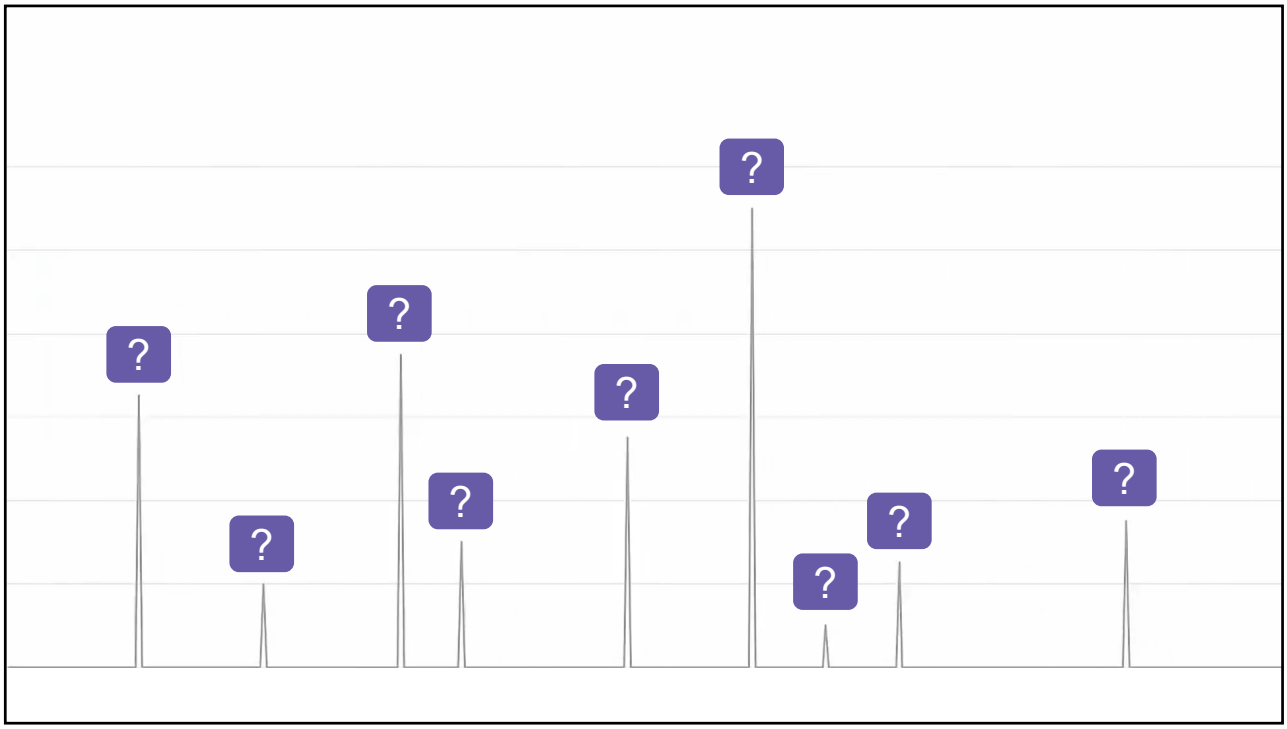



cosmos-pluralsight-course - Mic
portal.azure.com/#@lennilhotmail.onmicrosoft.com/resource/subscriptions/6327c571-12f0-4634-9d3e-404ad37e6be9/resourceGroups/cosmos-plur...
Microsoft Azure
Search resources, services, and docs (G+/)
lennil@hotmail.com
LENNI LOBEL
Dashboard > cosmos-pluralsight-course-rg > cosmos-pluralsight-course
cosmos-pluralsight-course | Metrics (Classic)
Azure Cosmos DB account
Search (Ctrl+/)
Download as csv
Refresh
Feedback
Query Explorer
Script Explorer
Monitoring
Insights
Alerts
Metrics
Logs
Diagnostic settings
Metrics (Classic)
Workbooks
Automation
Tasks (preview)
Export template
Support + troubleshooting
New Support Request
Overview
Throughput
Storage
Availability
Latency
Consistency
System
Database(s)
All
Container(s)
All
Region(s)
All
Show data for last
1 hour
Number of requests (aggregated over 1 minute interval)
Total
Http 2xx
Http 400
Http 401
Http 403
Http 429
Http 5xx
7:45 AM
8 AM
8:15 AM
Number of requests exceeded capacity (aggregated over 1 minute interval)
Http 429
No data to display


Program.cs
ThroughputTest
ThroughputTest.Program
Run10()
var client = new CosmosClient(endpoint, masterKey);
var container = client.GetContainer("Families", "Families");
dynamic document = new
{
id = Guid.NewGuid(),
familyName = "Smith",
address = new
{
addressLine = "123 Main Street",
city = "Chicago",
state = "IL",
zipCode = "60601"
},
parents = new string[]
{
"Peter",
"Alice"
},
kids = new string[]
{
"Adam",
"Jacqueline",
"Joshua"
}
};
var result = await container.CreateItemAsync(document, new PartitionKey(document.address.zipCode));
var consumedRUs = result.RequestCharge;
Console.WriteLine($"Cost to create document: {consumedRUs} RUs");
consumedRUs 9.9
}


X
Y
Z


MAX
10%



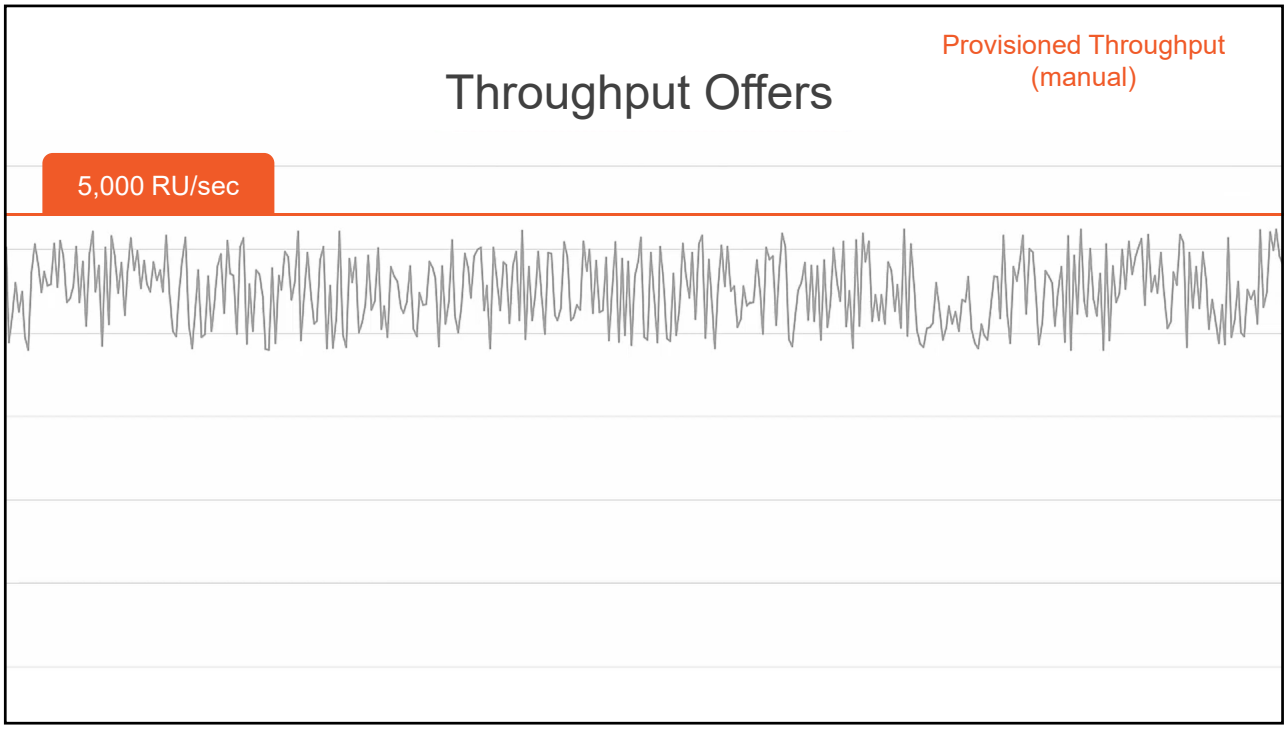
Throughput Offers

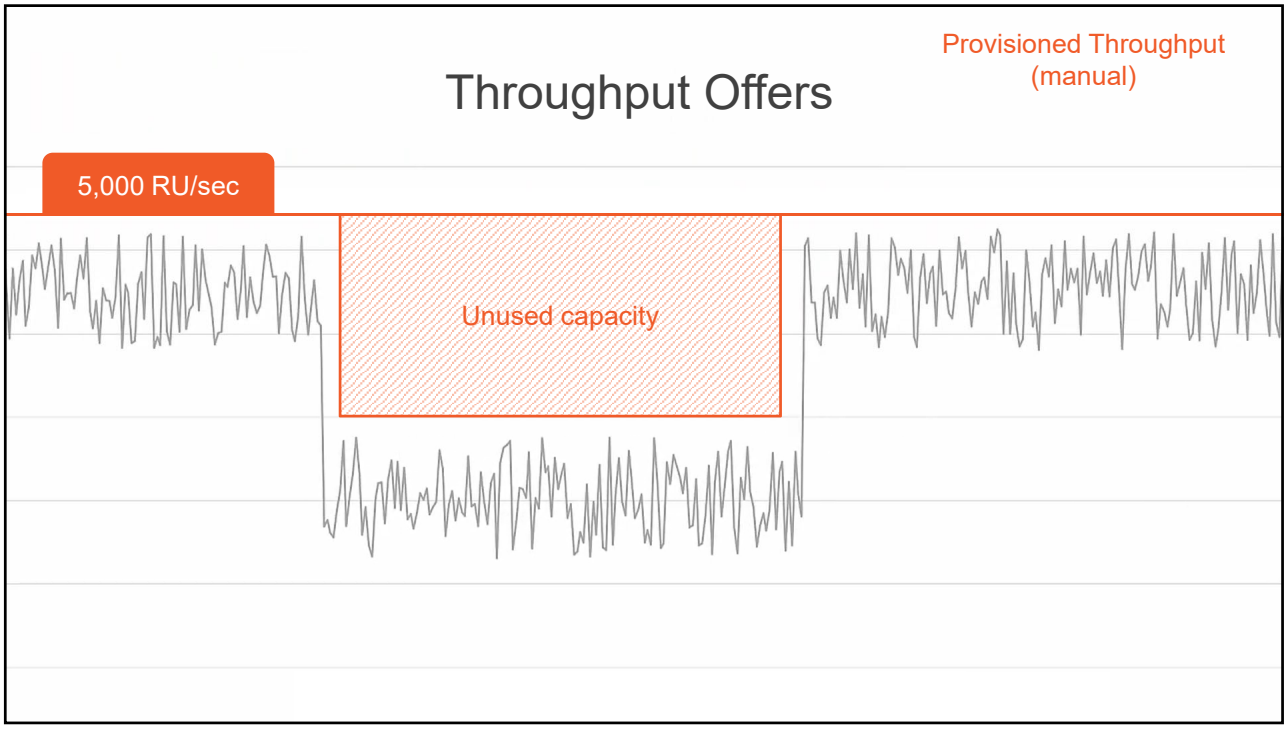
Provisioned throughput (manual)

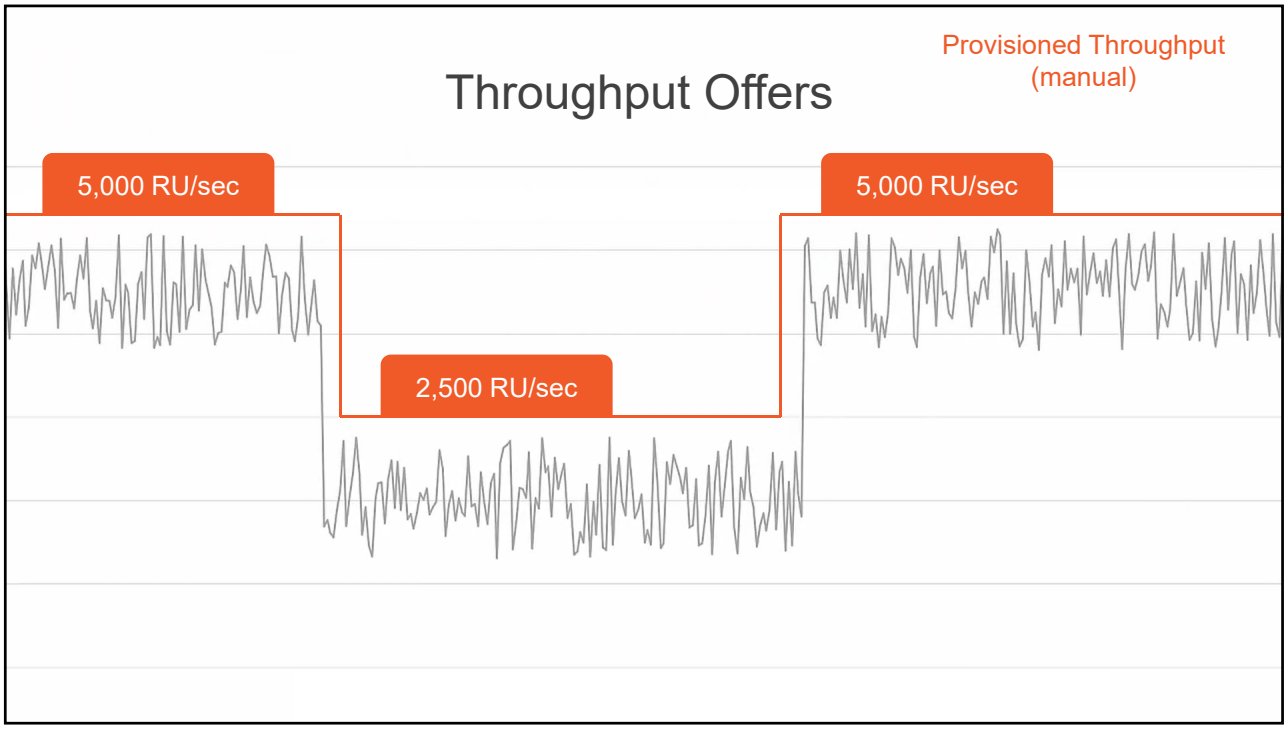
Reserve RU/sec

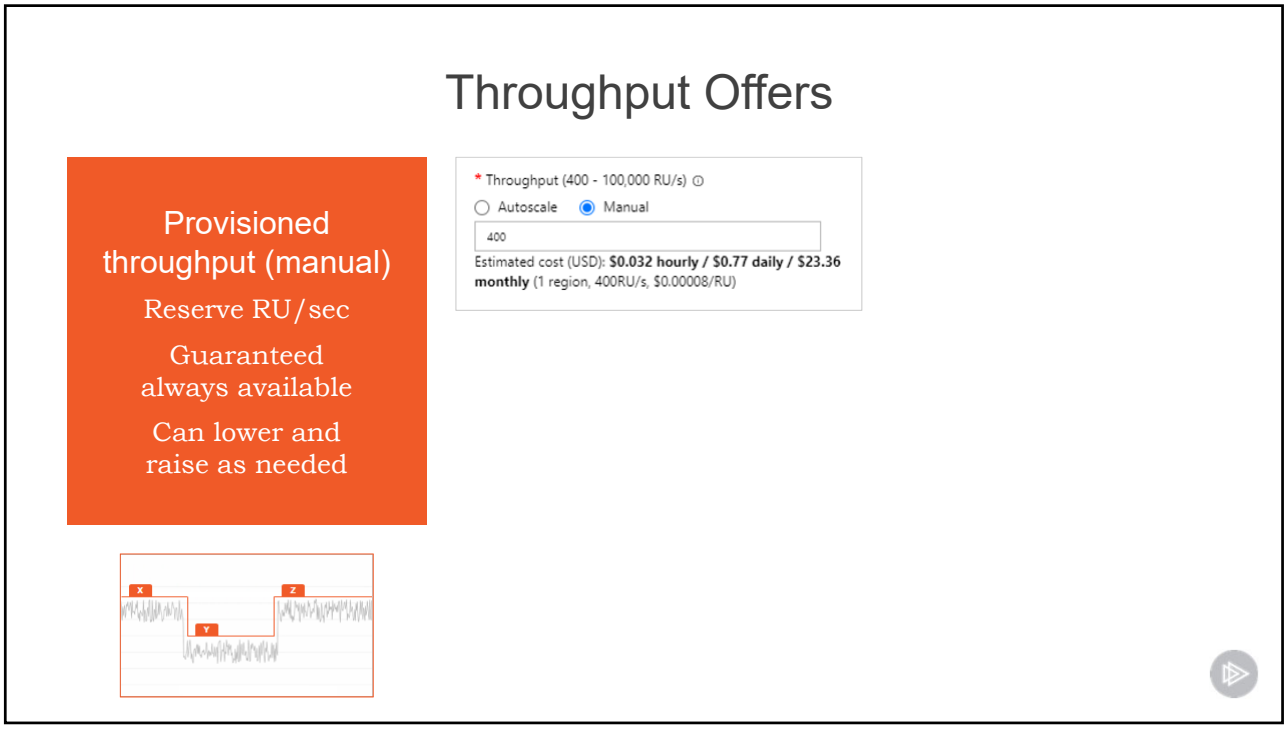
Guaranteed always available

Can lower and raise as needed


Throughput Offers
Provisioned Throughput (manual)
5,000 RU/sec


Throughput Offers
Provisioned Throughput (manual)
5,000 RU/sec
Unused capacity


Throughput Offers
Provisioned Throughput (manual)
5,000 RU/sec
2,500 RU/sec
5,000 RU/sec


Throughput Offers
Provisioned throughput (manual)
Reserve RU/sec
Guaranteed always available
Can lower and raise as needed
* Throughput (400 - 100,000 RU/s)
Autoscale
Manual
400
Estimated cost (USD): $0.032 hourly / $0.77 daily / $23.36 monthly (1 region, 400RU/s, $0.00008/RU)

Throughput Offers

Provisioned throughput (manual)

Reserve RU/sec

Guaranteed always available

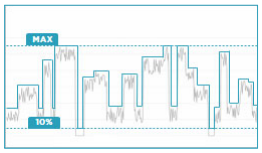
Can lower and raise as needed

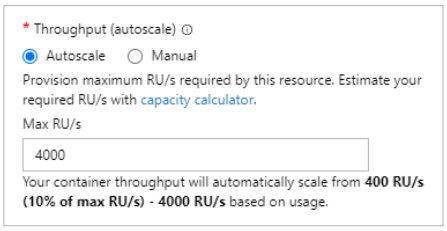
Provisioned throughput (autoscale)

Reserve max RU/sec

Scales up and down automatically

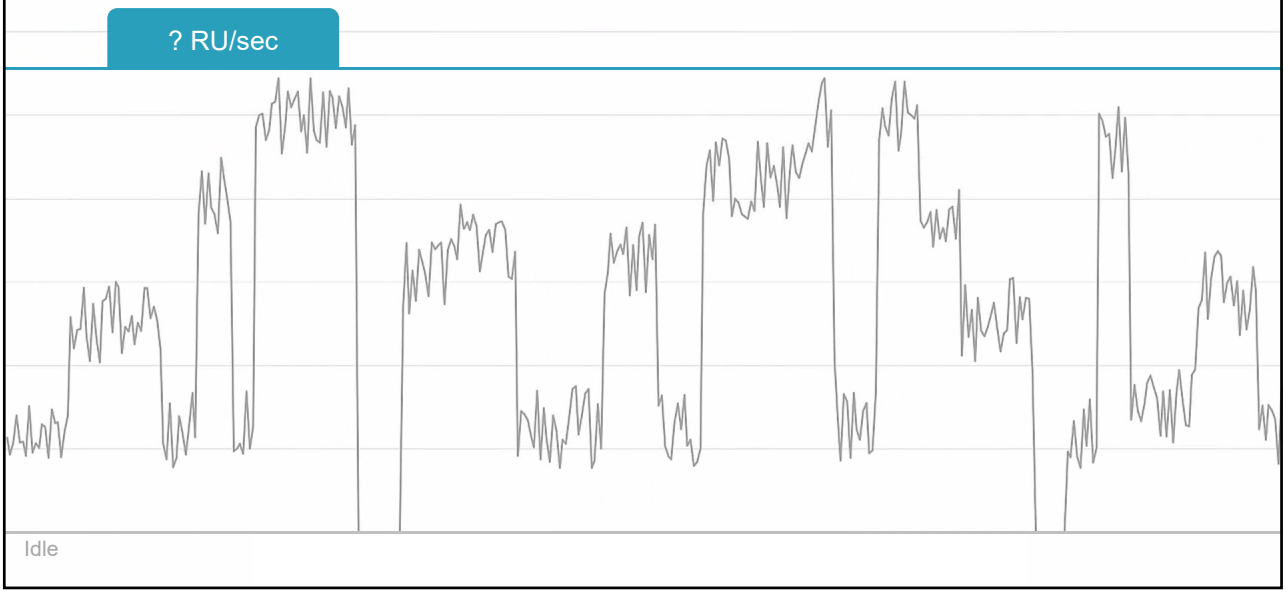
From max to 10% below

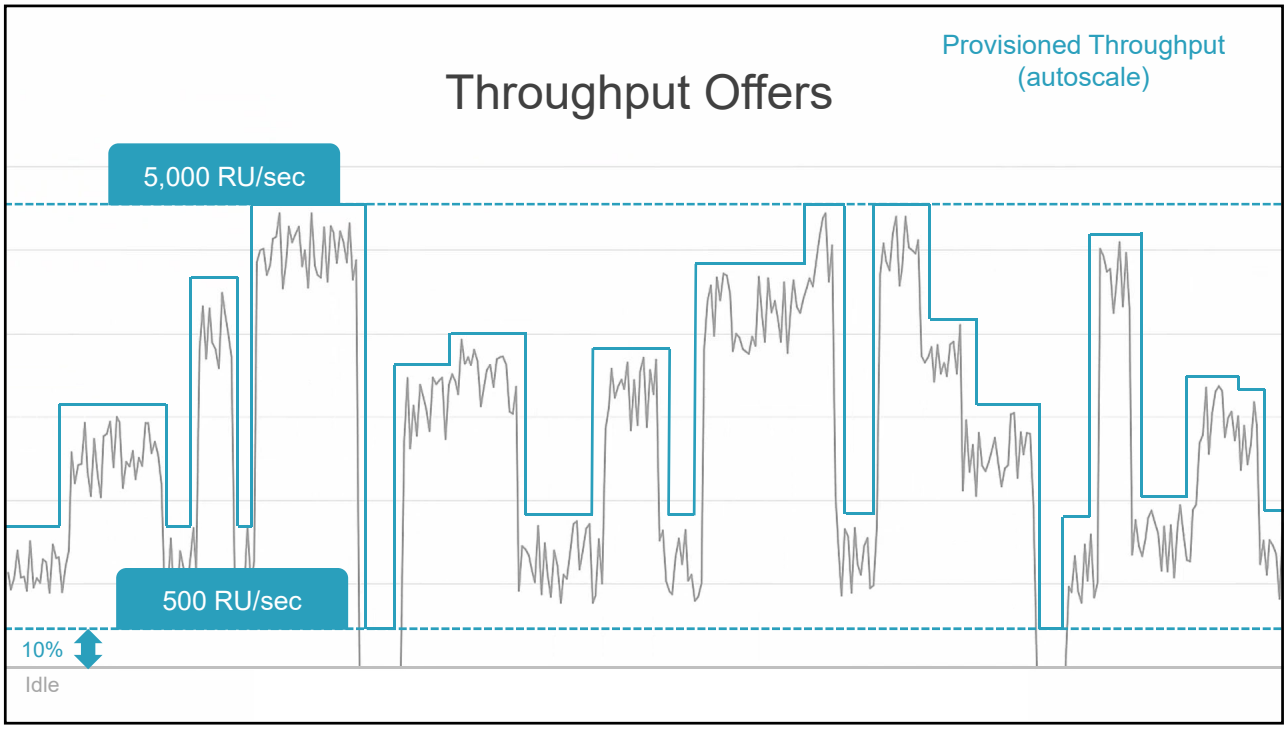


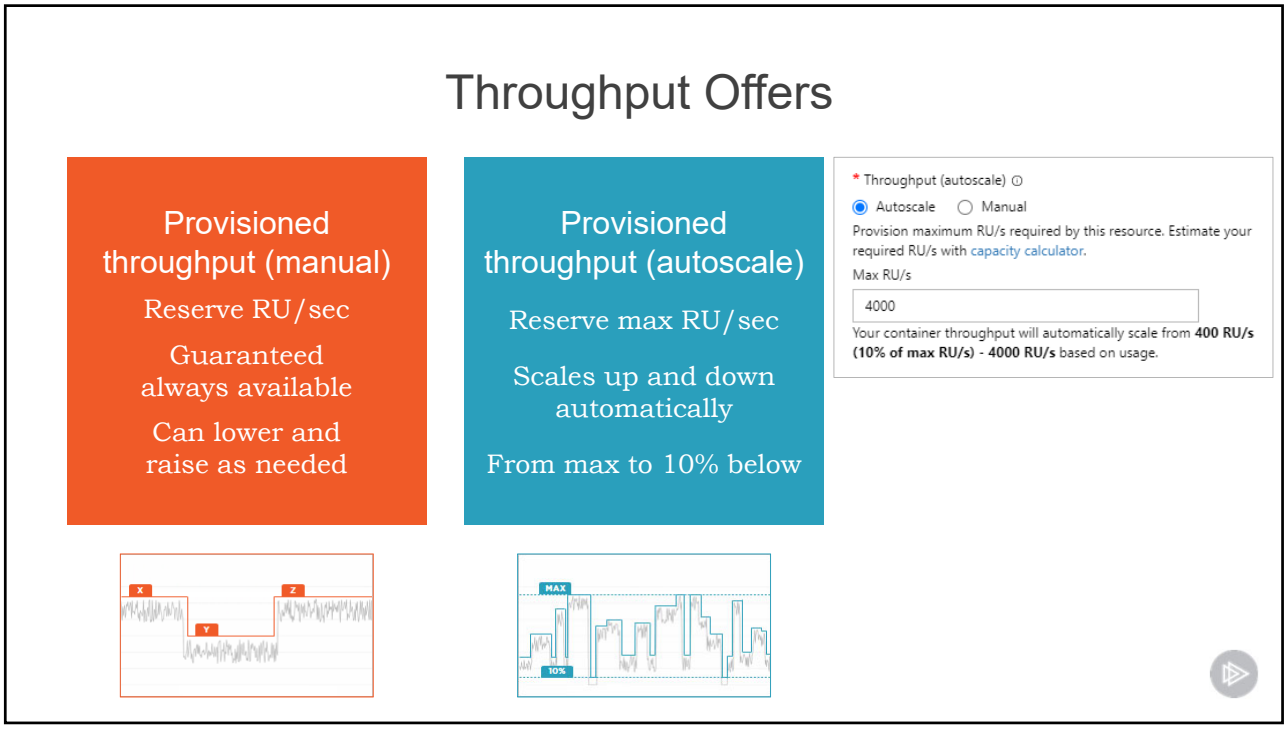


Throughput Offers

Provisioned Throughput (autoscale)




Throughput Offers
Provisioned Throughput (autoscale)
5,000 RU/sec
500 RU/sec
10%
Idle


Throughput Offers
Provisioned throughput (manual)
Reserve RU/sec
Guaranteed always available
Can lower and raise as needed
Provisioned throughput (autoscale)
Reserve max RU/sec
Scales up and down automatically
From max to 10% below
* Throughput (autoscale)
Autoscale
Manual
Provision maximum RU/s required by this resource. Estimate your required RU/s with capacity calculator.
Max RU/s
4000
Your container throughput will automatically scale from 400 RU/s (10% of max RU/s) - 4000 RU/s based on usage.
X
Y
Z
MAX
10%

Throughput Offers

Provisioned throughput (manual)

Reserve RU/sec

Guaranteed always available

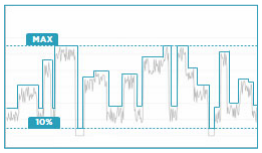
Can lower and raise as needed

Provisioned throughput (autoscale)

Reserve max RU/sec

Scales up and down automatically

From max to 10% below

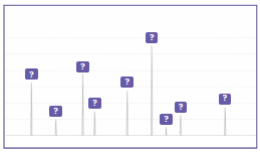


Serverless

Consumption model

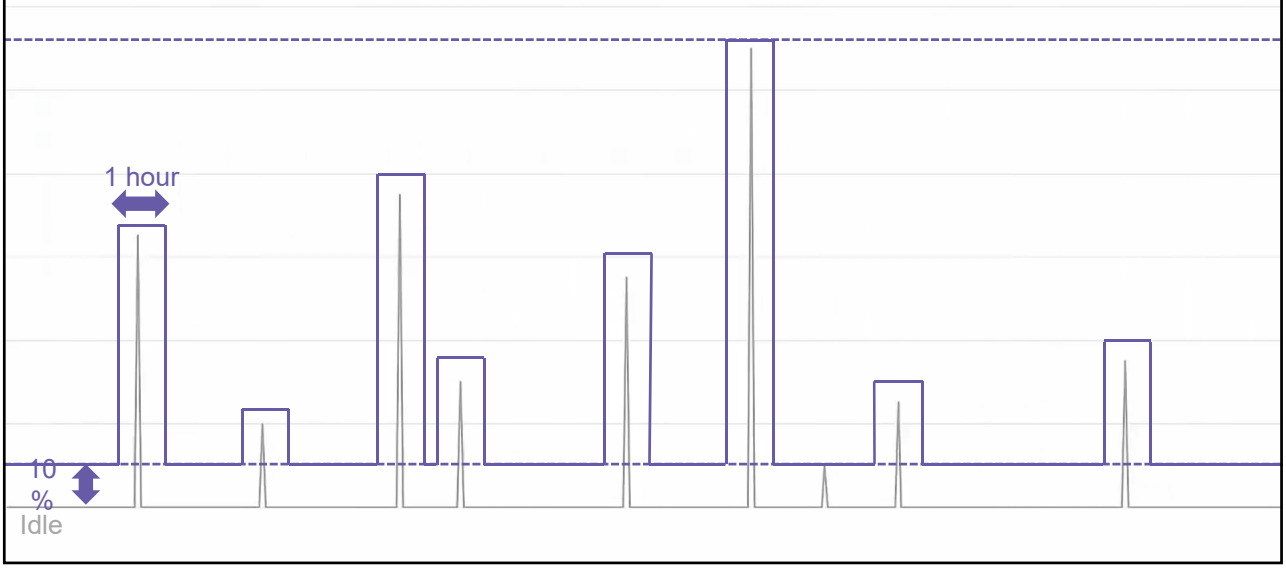
No provisioned throughput

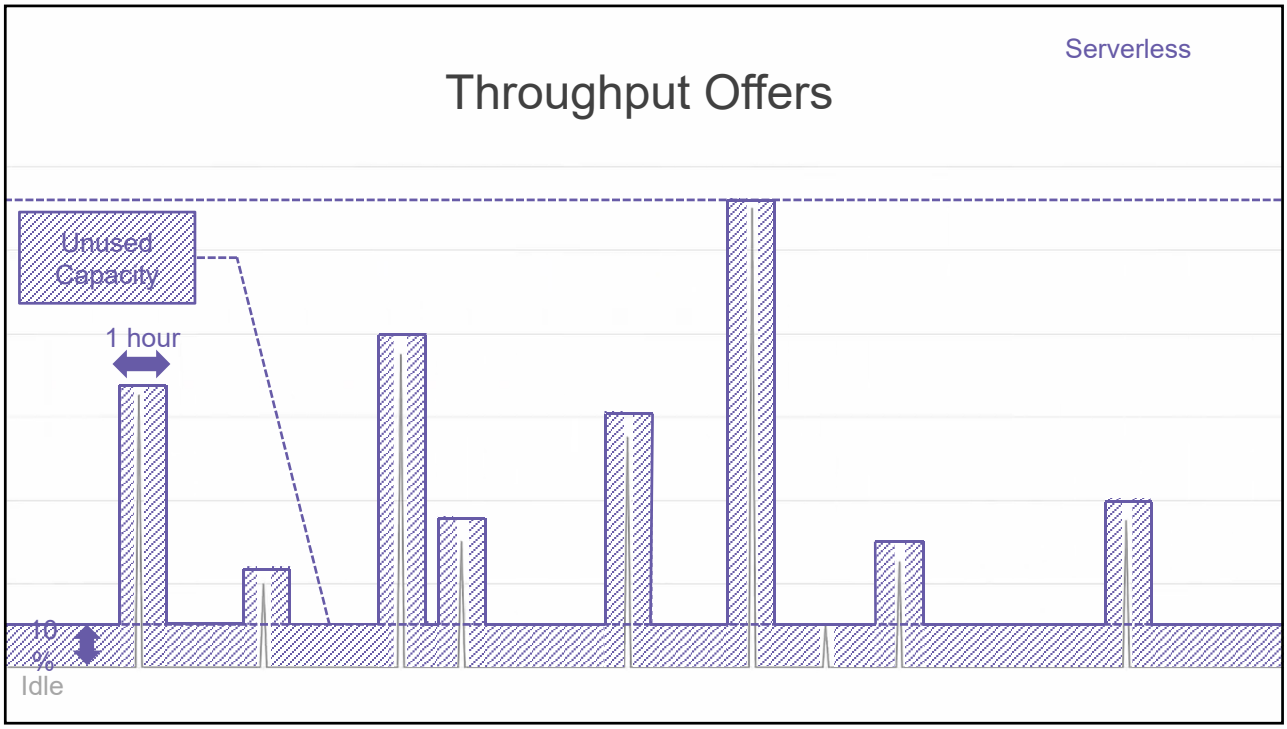
Pay only for the RUs that you use



Throughput Offers

Serverless




Serverless
Throughput Offers
Unused Capacity
1 hour
10 %
Idle


Serverless
Throughput Offers
5,000 RUs
3,000 RUs
2,900 RUs
2,500 RUs
1,700 RUs
1,500 RUs
1,400 RUs
1,300 RUs
1,000 RUs
Idle

Provisioning Container Throughput

Reserve request units per second (RU/s)

How many request *units* (not *requests*) per second are available to your application

Exceeding reserved throughput limits

Requests are "throttled" (HTTP 429)

```
HTTP/1.1 429 Too Many Requests
Content-Type: application/json
Server: Microsoft-HTTPAPI/2.0
Access-Control-Allow-Origin: https://cosmos.azure.com
Access-Control-Allow-Credentials: true
x-ms-retry-after-ms: 2853
lsn: 38069
x-ms-schemaversion: 1.8
x-ms-substatus: 3200
```

Exceeding Provisioned Throughput

```
100
101     try
102     {
103         await container.CreateItemAsync(docDef, new PartitionKey(docDef.pk));
104     }
105     catch (CosmosException ex) when (ex.StatusCode == HttpStatusCode.TooManyRequests) // 429
106     {
107         Console.WriteLine("Can't create document; request was throttled");
108     }
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
```

QuickWatch

Expression: $exception

Reevaluate | Add Watch

Value:

Name	Value	Type
$exception	{"Response status code does not ...	Microsof...
ActivityId	"4d1702db-2c82-4730-9e1e...	string
Data	{System.Collections.ListDictionar...	System.C...
HResult	-2146233088	int
HelpLink	null	string
InnerExcept...	null	System.E...
Message	"Response status code does...	string
RequestCh...	0.38	double
ResponseB...	null	string
Source	"Microsoft.Azure.Cosmos.C...	string
StackTrace	" at Microsoft.Azure.Cosm...	string
StatusCode	TooManyRequests	System....
SubStatusC...	3200	int

Close | Help

Exception Thrown

Microsoft.Azure.Cosmos.CosmosException: 'Response status code does not indicate success: 429 Substatus: 3200 Reason: ().'

View Details | Copy Details | Start Live Share session...

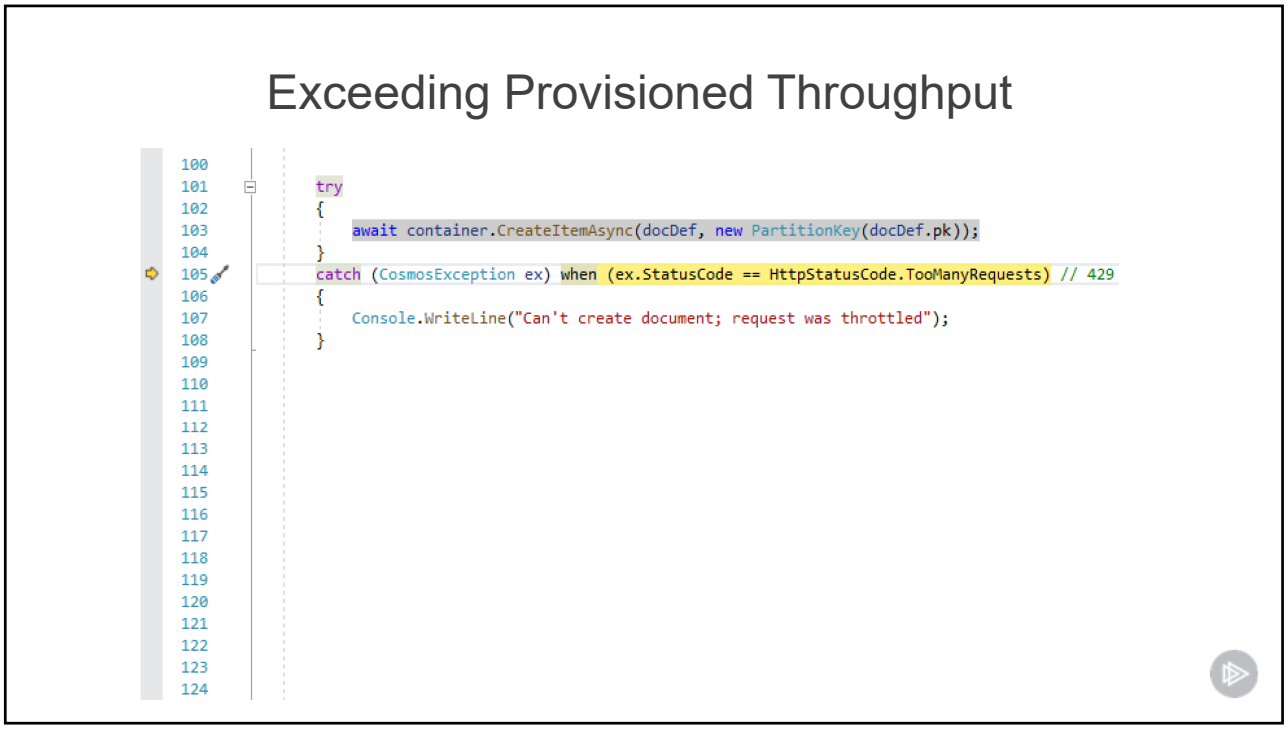
Exception Settings

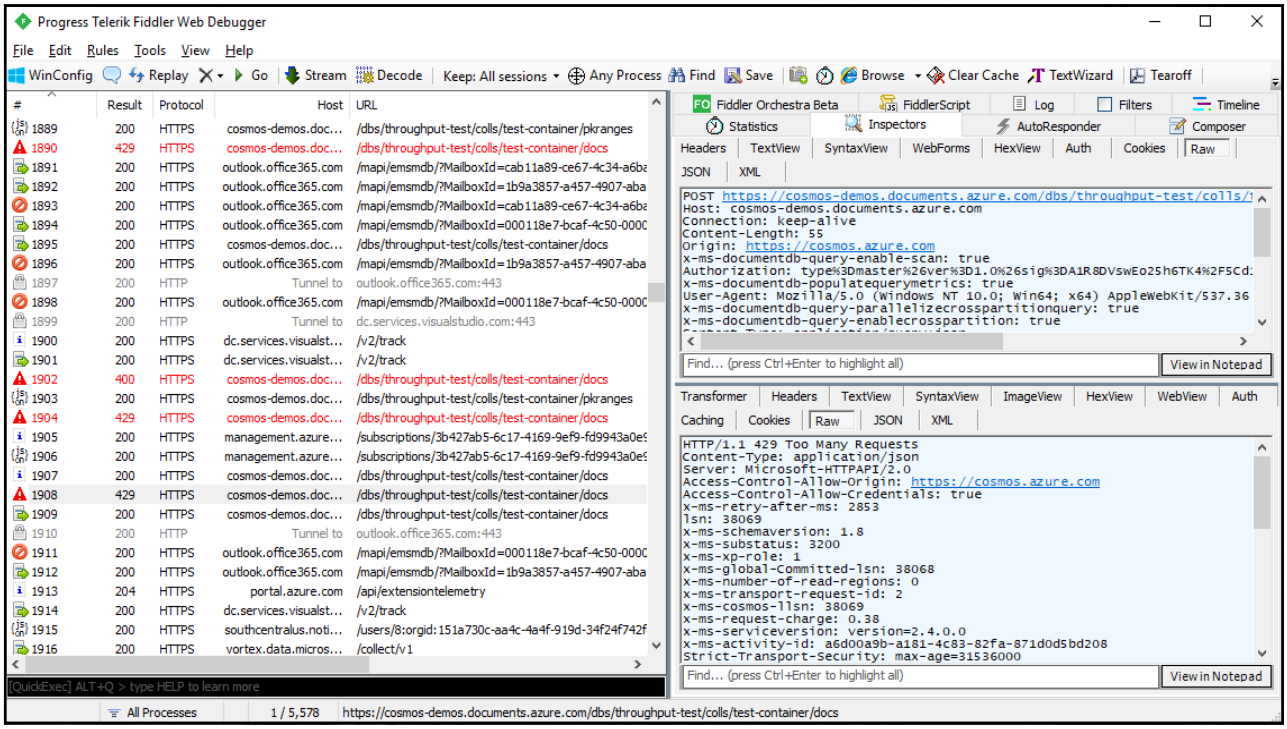
- [x] Break when this exception type is thrown

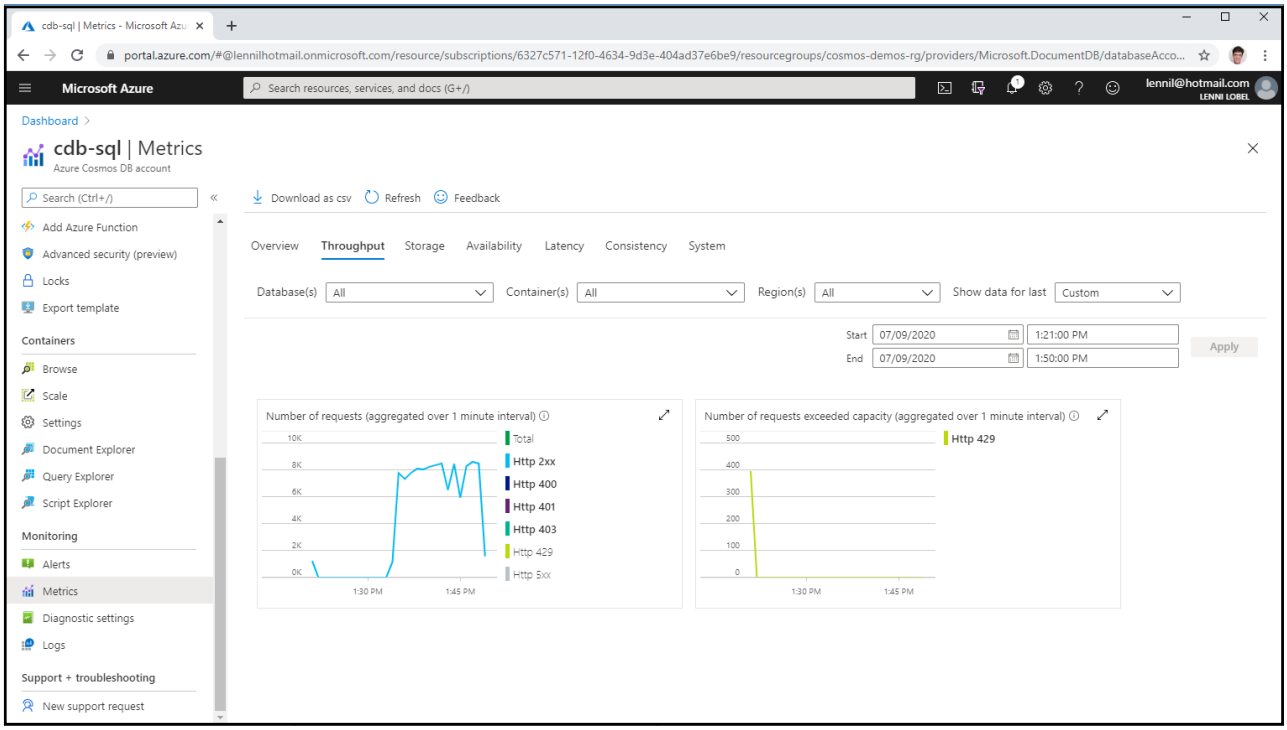
Except when thrown from:

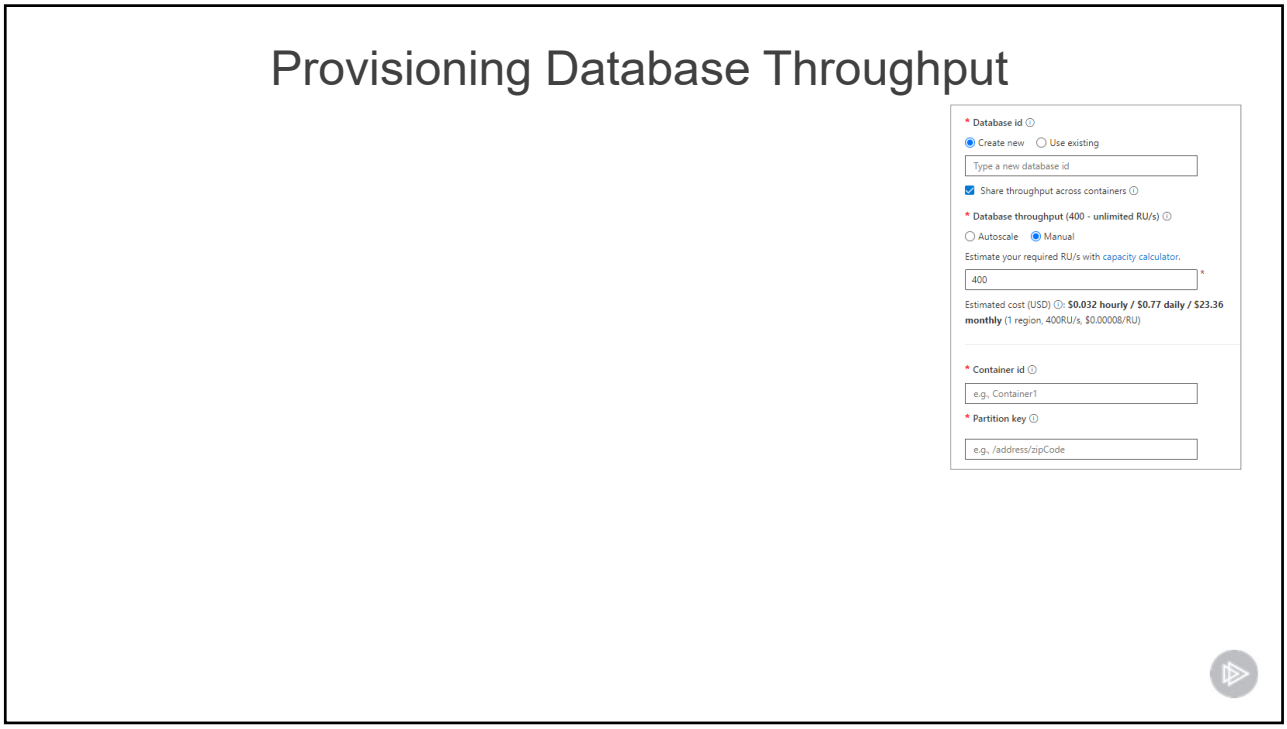
- [ ] ThroughputTest.dll

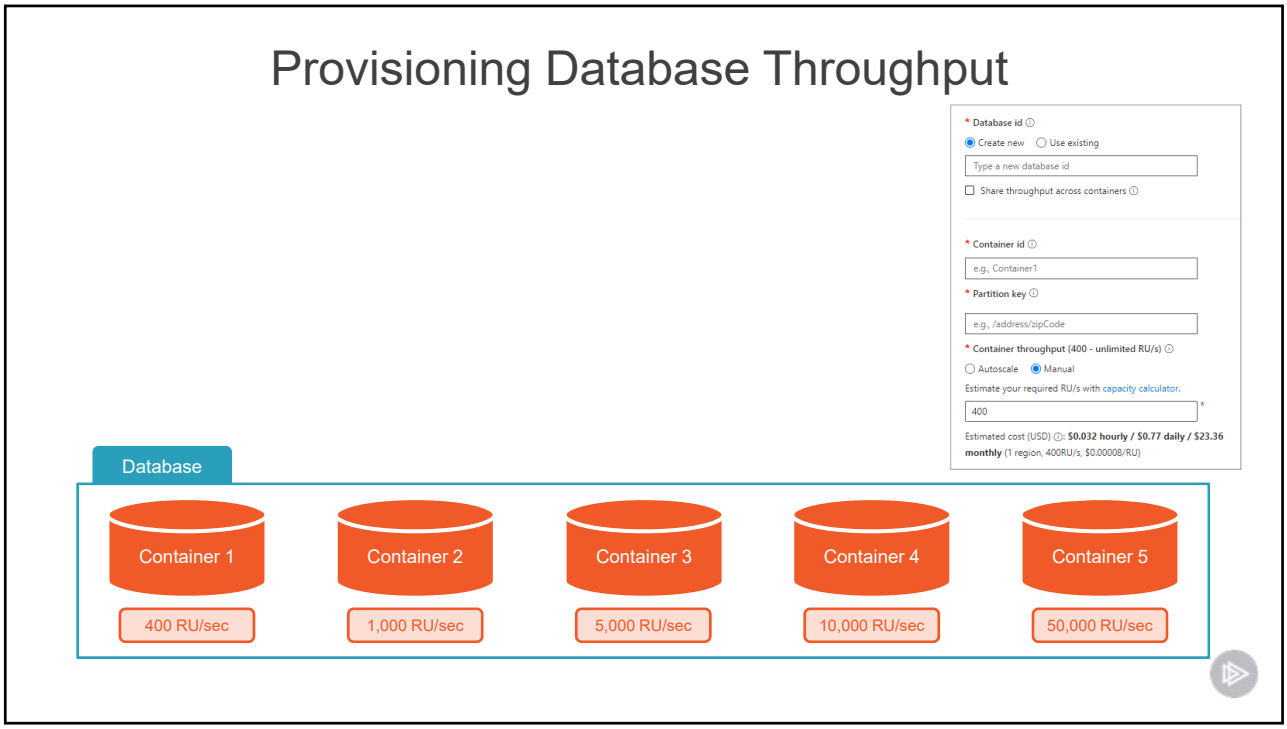
Open Exception Settings | Edit Conditions


Exceeding Provisioned Throughput
100
101 try
102 {
103 await container.CreateItemAsync(docDef, new PartitionKey(docDef.pk));
104 }
105 catch (CosmosException ex) when (ex.StatusCode == HttpStatusCode.TooManyRequests) // 429
106 {
107 Console.WriteLine("Can't create document; request was throttled");
108 }
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124


Progress Telerik Fiddler Web Debugger
File Edit Rules Tools View Help
WinConfig Replay Go Stream Decode Keep: All sessions Any Process Find Save Browse Clear Cache TextWizard Tearoff
Result Protocol Host URL
1889 200 HTTPS cosmos-demos.doc... /dbs/throughput-test/colls/test-container/pkranges
1890 429 HTTPS cosmos-demos.doc... /dbs/throughput-test/colls/test-container/docs
1891 200 HTTPS outlook.office365.com /mapi/emsmdb/?MailboxId=cab11a89-ce67-4c34-a6ba
1892 200 HTTPS outlook.office365.com /mapi/emsmdb/?MailboxId=1b9a3857-a457-4907-aba
1893 200 HTTPS outlook.office365.com /mapi/emsmdb/?MailboxId=cab11a89-ce67-4c34-a6ba
1894 200 HTTPS outlook.office365.com /mapi/emsmdb/?MailboxId=000118e7-bcaf-4c50-0000
1895 200 HTTPS cosmos-demos.doc... /dbs/throughput-test/colls/test-container/docs
1896 200 HTTPS outlook.office365.com /mapi/emsmdb/?MailboxId=1b9a3857-a457-4907-aba
1897 200 HTTP Tunnel to outlook.office365.com:443
1898 200 HTTPS outlook.office365.com /mapi/emsmdb/?MailboxId=000118e7-bcaf-4c50-0000
1899 200 HTTP Tunnel to dc.services.visualstudio.com:443
1900 200 HTTPS dc.services.visualst... /v2/track
1901 200 HTTPS dc.services.visualst... /v2/track
1902 400 HTTPS cosmos-demos.doc... /dbs/throughput-test/colls/test-container/docs
1903 200 HTTPS cosmos-demos.doc... /dbs/throughput-test/colls/test-container/pkranges
1904 429 HTTPS cosmos-demos.doc... /dbs/throughput-test/colls/test-container/docs
1905 200 HTTPS management.azure... /subscriptions/3b427ab5-6c17-4169-9ef9-fd9943a0e5
1906 200 HTTPS management.azure... /subscriptions/3b427ab5-6c17-4169-9ef9-fd9943a0e5
1907 200 HTTPS cosmos-demos.doc... /dbs/throughput-test/colls/test-container/docs
1908 429 HTTPS cosmos-demos.doc... /dbs/throughput-test/colls/test-container/docs
1909 200 HTTPS cosmos-demos.doc... /dbs/throughput-test/colls/test-container/docs
1910 200 HTTP Tunnel to outlook.office365.com:443
1911 200 HTTPS outlook.office365.com /mapi/emsmdb/?MailboxId=000118e7-bcaf-4c50-0000
1912 200 HTTPS outlook.office365.com /mapi/emsmdb/?MailboxId=1b9a3857-a457-4907-aba
1913 204 HTTPS portal.azure.com /api/extensiontelemetry
1914 200 HTTPS dc.services.visualst... /v2/track
1915 200 HTTPS southcentralus.noti... /users/8:orgid:151a730c-aa4c-4a4f-919d-34f24f742f
1916 200 HTTPS vortex.data.micros... /collect/v1
[QuickExec] ALT+Q > type HELP to learn more
All Processes 1 / 5,578 https://cosmos-demos.documents.azure.com/dbs/throughput-test/colls/test-container/docs
Fiddler Orchestra Beta FiddlerScript Log Filters Timeline
Statistics Inspectors AutoResponder Composer
Headers TextView SyntaxView WebForms HexView Auth Cookies Raw
JSON XML
POST https://cosmos-demos.documents.azure.com/dbs/throughput-test/colls/
Host: cosmos-demos.documents.azure.com
Connection: keep-alive
Content-Length: 55
Origin: https://cosmos.azure.com
x-ms-documentdb-query-enable-scan: true
Authorization: type%3Dmaster%26ver%3D1.0%26sig%3DA1R8DVswEo25h6TK4%2F5Cd
x-ms-documentdb-populatequerymetrics: true
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36
x-ms-documentdb-query-parallelizecrosspartitionquery: true
x-ms-documentdb-query-enablecrosspartition: true
Find... (press Ctrl+Enter to highlight all) View in Notepad
Transformer Headers TextView SyntaxView ImageView HexView WebView Auth
Caching Cookies Raw JSON XML
HTTP/1.1 429 Too Many Requests
Content-Type: application/json
Server: Microsoft-HTTPAPI/2.0
Access-Control-Allow-Origin: https://cosmos.azure.com
Access-Control-Allow-Credentials: true
x-ms-retry-after-ms: 2853
lsn: 38069
x-ms-schemaversion: 1.8
x-ms-substatus: 3200
x-ms-xp-role: 1
x-ms-global-Committed-lsn: 38068
x-ms-number-of-read-regions: 0
x-ms-transport-request-id: 2
x-ms-cosmos-llsn: 38069
x-ms-request-charge: 0.38
x-ms-serviceversion: version=2.4.0.0
x-ms-activity-id: a6d00a9b-a181-4c83-82fa-871d0d5bd208
Strict-Transport-Security: max-age=31536000
Find... (press Ctrl+Enter to highlight all) View in Notepad


cdb-sql | Metrics - Microsoft Azu
portal.azure.com/#@lennilhotmail.onmicrosoft.com/resource/subscriptions/6327c571-12f0-4634-9d3e-404ad37e6be9/resourcegroups/cosmos-demos-rg/providers/Microsoft.DocumentDB/databaseAcco...
Microsoft Azure
Search resources, services, and docs (G+/)
lennil@hotmail.com
LENNI LOBEL
Dashboard
cdb-sql | Metrics
Azure Cosmos DB account
Search (Ctrl+/)
Add Azure Function
Advanced security (preview)
Locks
Export template
Containers
Browse
Scale
Settings
Document Explorer
Query Explorer
Script Explorer
Monitoring
Alerts
Metrics
Diagnostic settings
Logs
Support + troubleshooting
New support request
Download as csv
Refresh
Feedback
Overview
Throughput
Storage
Availability
Latency
Consistency
System
Database(s)
All
Container(s)
All
Region(s)
All
Show data for last
Custom
Start
07/09/2020
1:21:00 PM
End
07/09/2020
1:50:00 PM
Apply
Number of requests (aggregated over 1 minute interval)
Total
Http 2xx
Http 400
Http 401
Http 403
Http 429
Http 5xx
Number of requests exceeded capacity (aggregated over 1 minute interval)
Http 429


Provisioning Database Throughput
* Database id
Create new
Use existing
Type a new database id
Share throughput across containers
* Database throughput (400 - unlimited RU/s)
Autoscale
Manual
Estimate your required RU/s with capacity calculator.
400
Estimated cost (USD): $0.032 hourly / $0.77 daily / $23.36 monthly (1 region, 400RU/s, $0.00008/RU)
* Container id
e.g., Container1
* Partition key
e.g., /address/zipCode


Provisioning Database Throughput
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400
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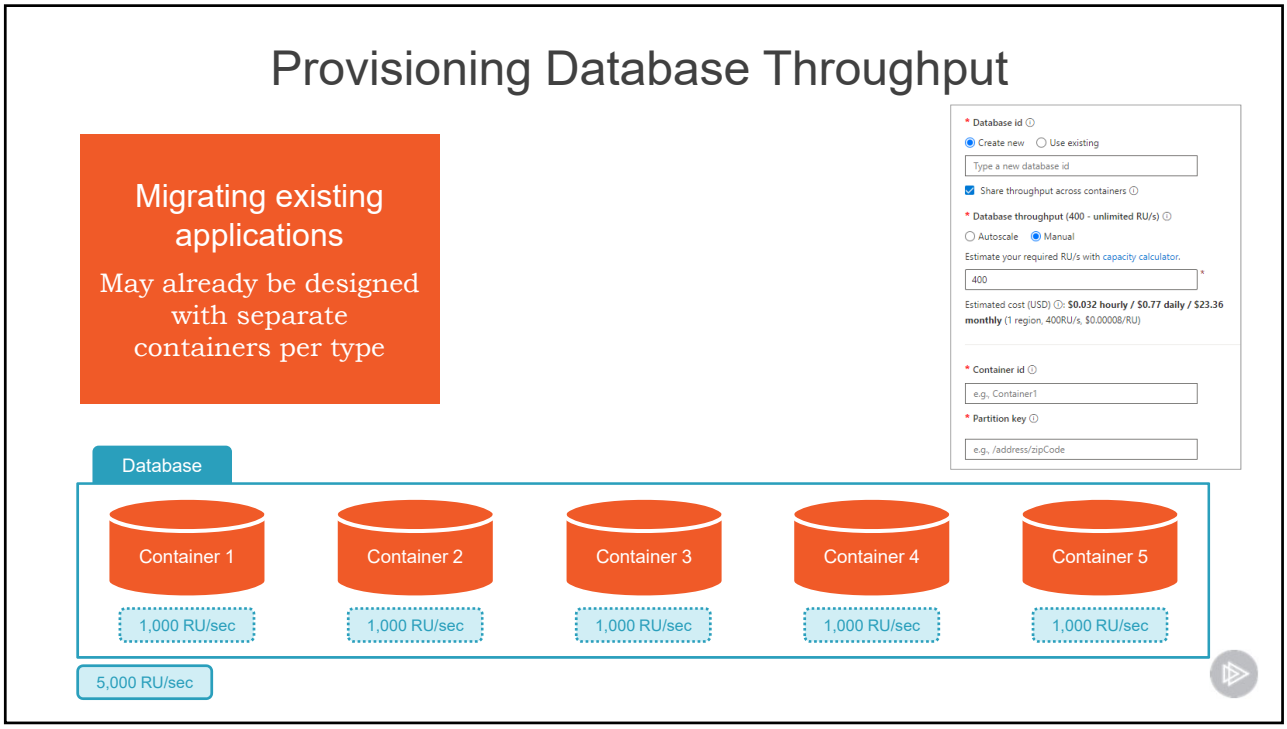
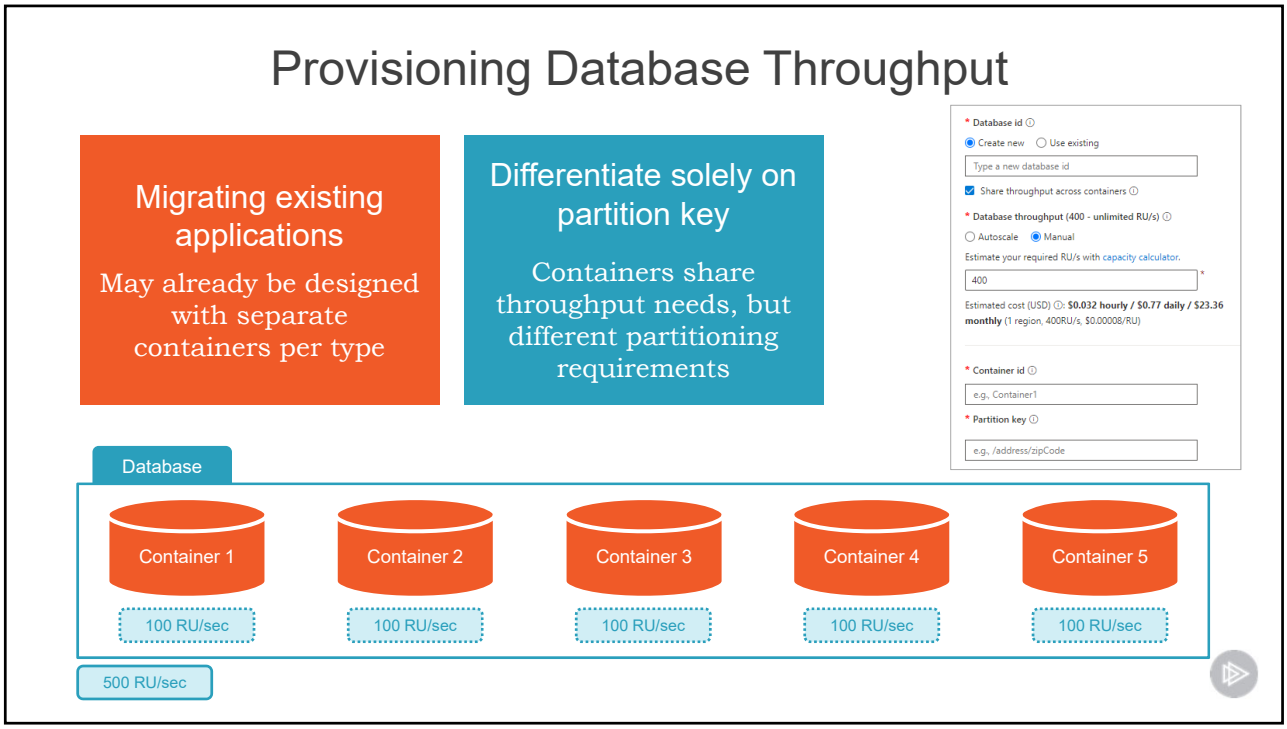
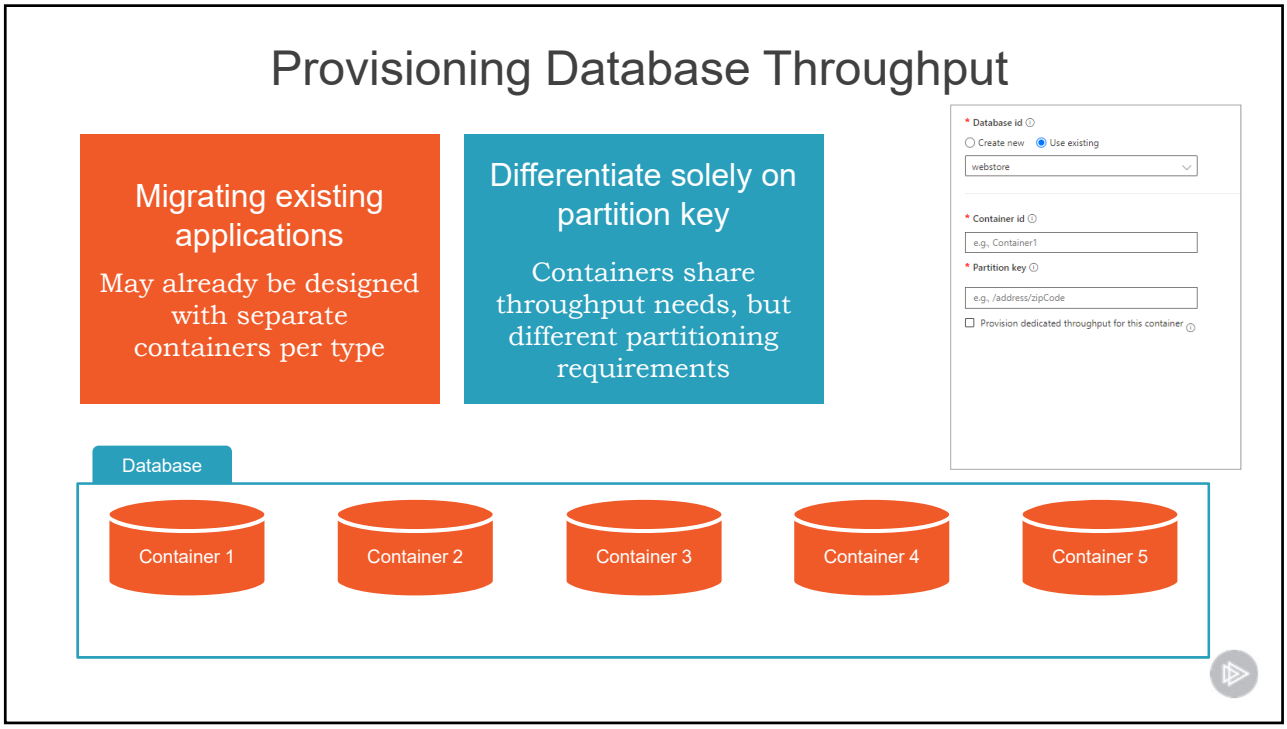
Database
Container 1
Container 2
Container 3
Container 4
Container 5
400 RU/sec
1,000 RU/sec
5,000 RU/sec
10,000 RU/sec
50,000 RU/sec


Provisioning Database Throughput
Migrating existing applications
May already be designed with separate containers per type
* Database id
Create new
Use existing
Type a new database id
Share throughput across containers
* Database throughput (400 - unlimited RU/s)
Autoscale
Manual
Estimate your required RU/s with capacity calculator.
400
Estimated cost (USD): $0.032 hourly / $0.77 daily / $23.36 monthly (1 region, 400RU/s, $0.00008/RU)
* Container id
e.g., Container1
* Partition key
e.g., /address/zipCode
Database
Container 1
Container 2
Container 3
Container 4
Container 5
1,000 RU/sec
1,000 RU/sec
1,000 RU/sec
1,000 RU/sec
1,000 RU/sec
5,000 RU/sec


Provisioning Database Throughput
Migrating existing applications
May already be designed with separate containers per type
Differentiate solely on partition key
Containers share throughput needs, but different partitioning requirements
* Database id
Create new
Use existing
Type a new database id
Share throughput across containers
* Database throughput (400 - unlimited RU/s)
Autoscale
Manual
Estimate your required RU/s with capacity calculator.
400
Estimated cost (USD): $0.032 hourly / $0.77 daily / $23.36 monthly (1 region, 400RU/s, $0.00008/RU)
* Container id
e.g., Container1
* Partition key
e.g., /address/zipCode
Database
Container 1
Container 2
Container 3
Container 4
Container 5
100 RU/sec
100 RU/sec
100 RU/sec
100 RU/sec
100 RU/sec
500 RU/sec


Provisioning Database Throughput
Migrating existing applications
May already be designed with separate containers per type
Differentiate solely on partition key
Containers share throughput needs, but different partitioning requirements
* Database id
Create new
Use existing
webstore
* Container id
e.g., Container1
* Partition key
e.g., /address/zipCode
Provision dedicated throughput for this container
Database
Container 1
Container 2
Container 3
Container 4
Container 5

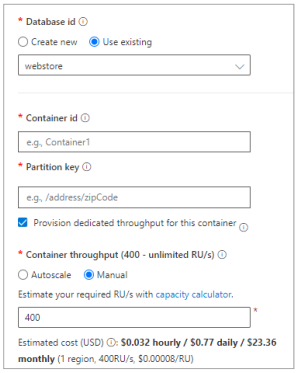
Provisioning Database Throughput

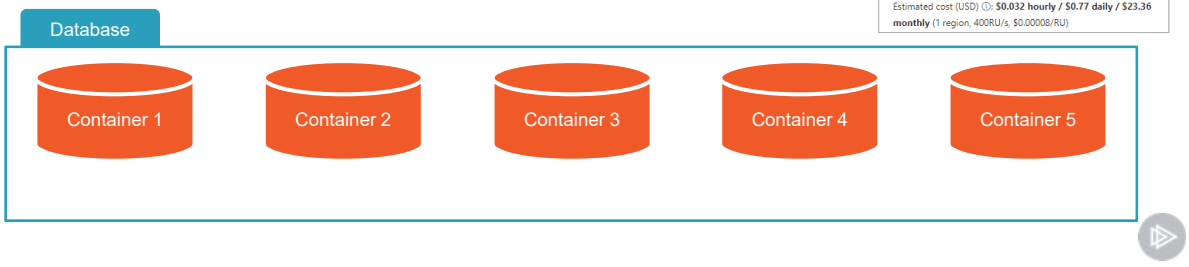
Migrating existing applications

May already be designed with separate containers per type

Differentiate solely on partition key

Containers share throughput needs, but different partitioning requirements





Provisioning Database Throughput

Migrating existing applications

May already be designed with separate containers per type

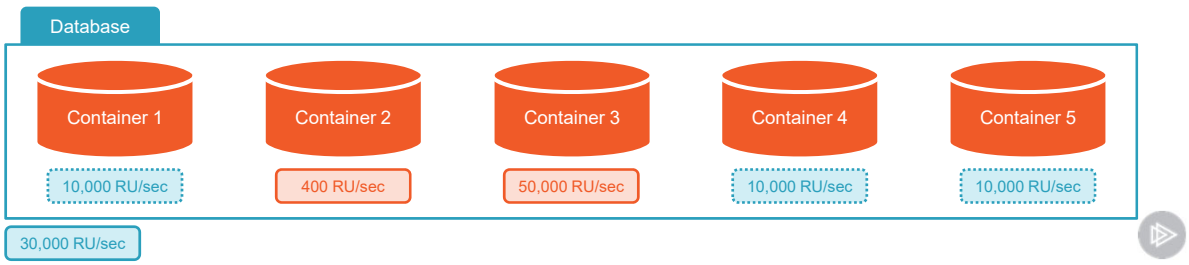
Differentiate solely on partition key

Containers share throughput needs, but different partitioning requirements

Mix and Match

Distribute database throughput across some containers

Provision other containers individually



Provisioning Database Throughput

Migrating existing applications

May already be designed with separate containers per type

Differentiate solely on partition key

Containers share throughput needs, but different partitioning requirements

Mix and Match

Distribute database throughput across some containers

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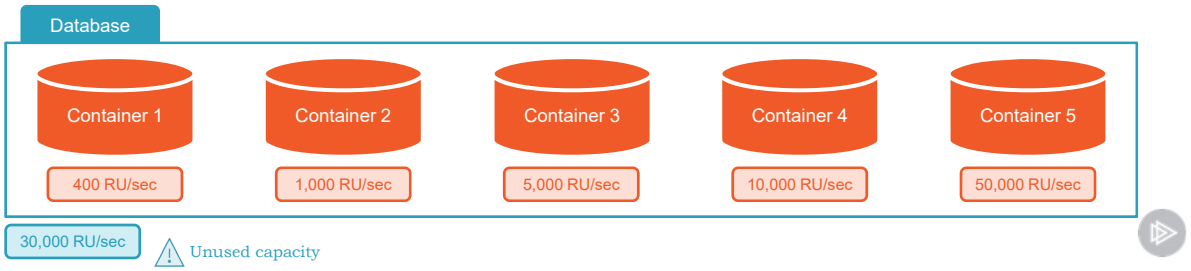


Whiteboarding the Cost

Baseline

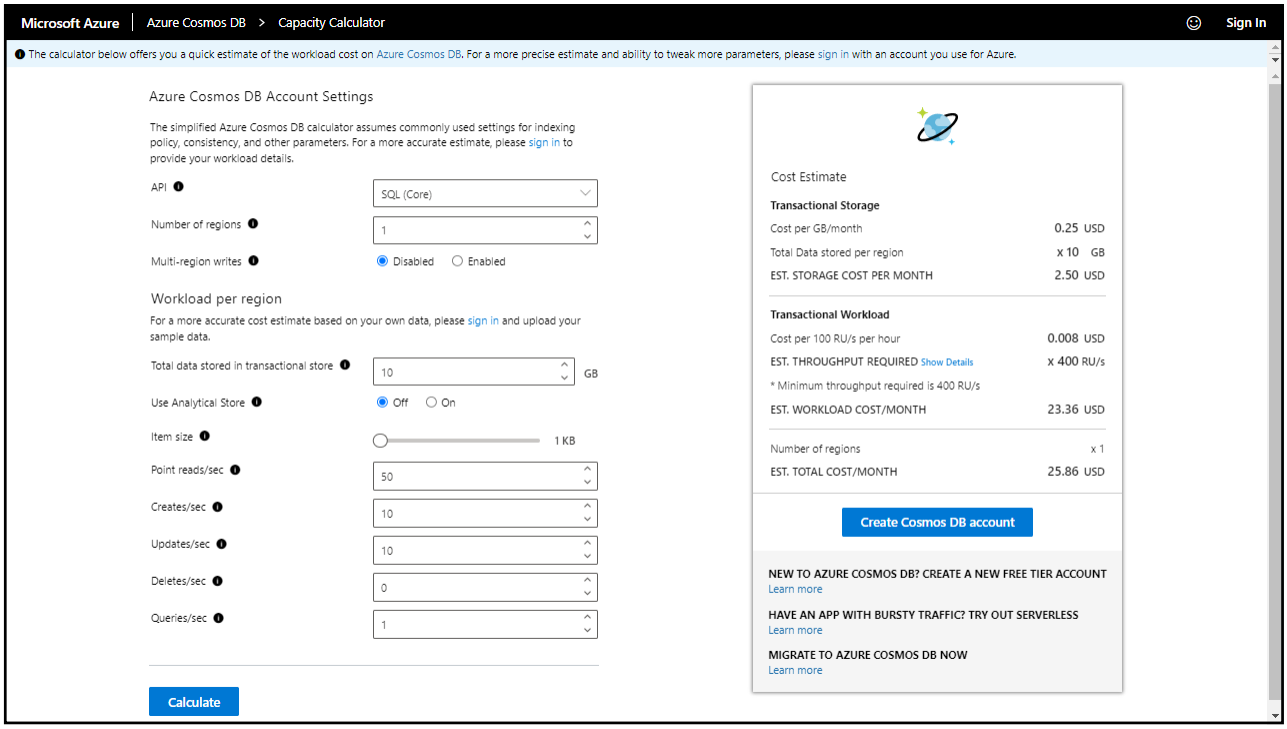
Read item	SQL Query	Write item
1 RU	~ 2.8 RUs	~ 10 RUs

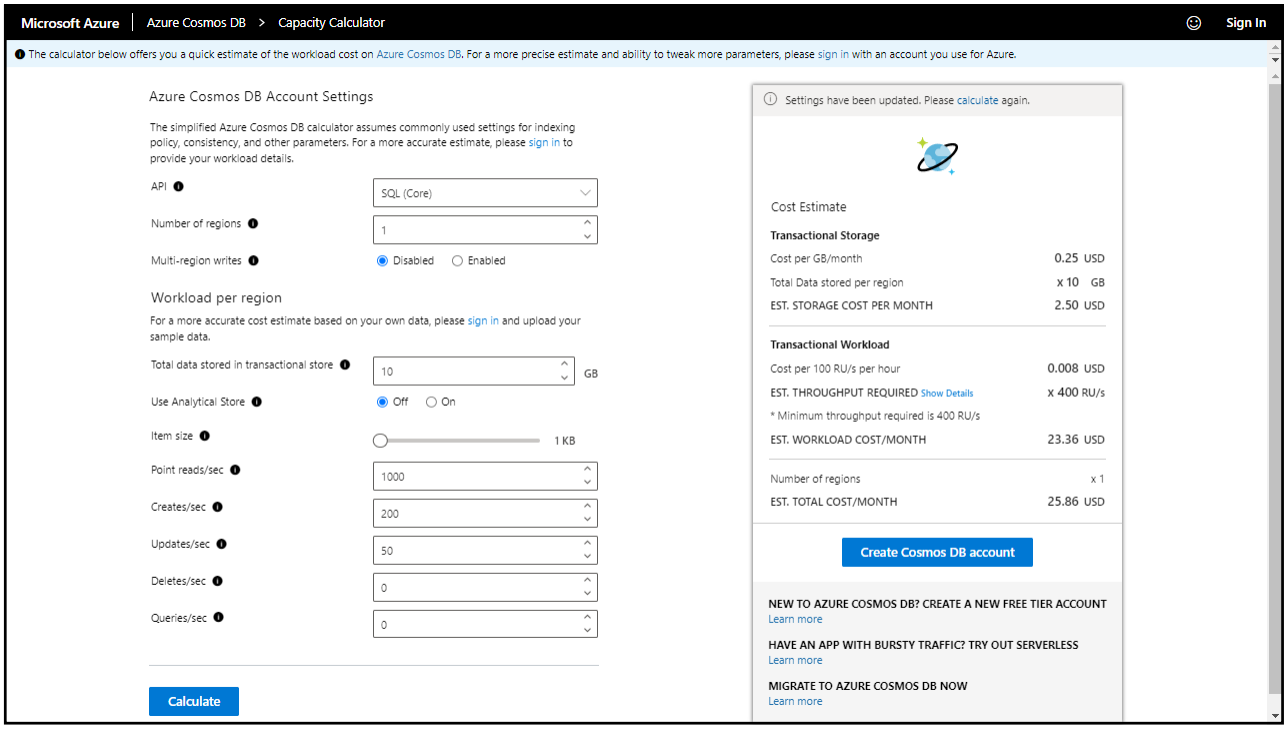
Application checklist

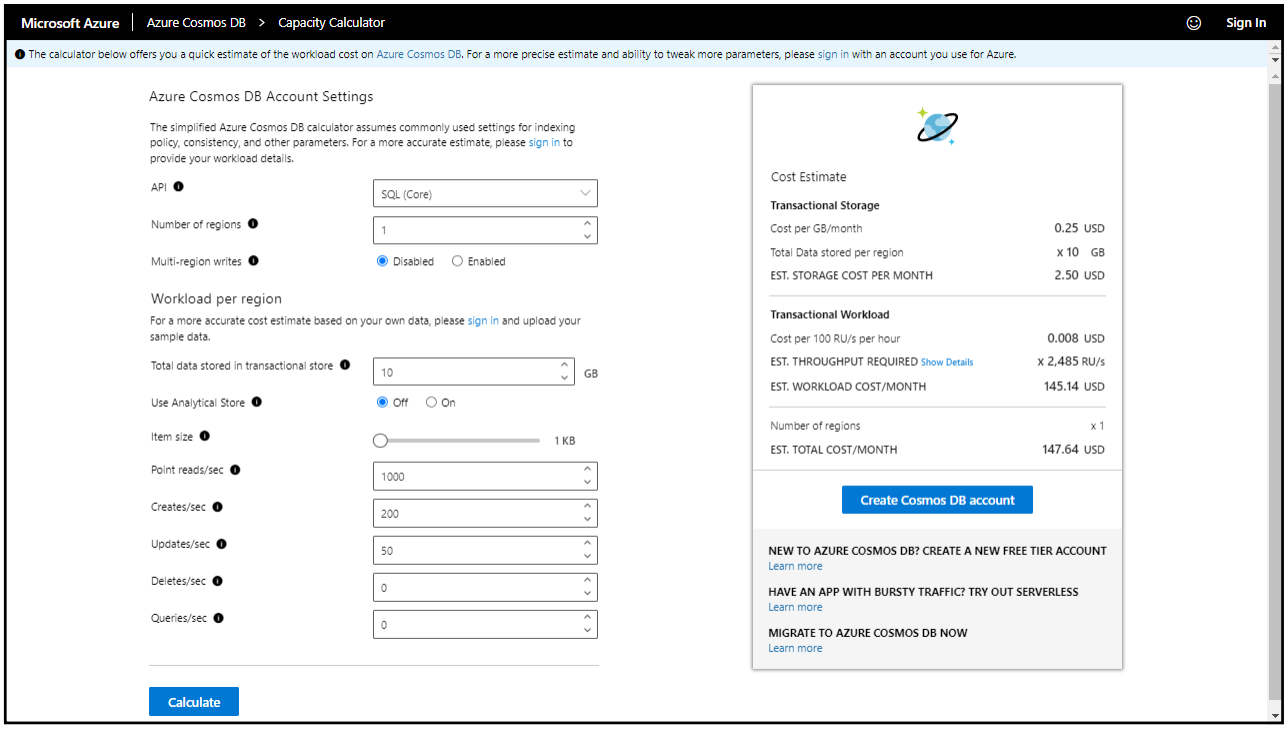
- What does a typical item look like?
- What are the typical queries that users will run?
- How many writes per second are required?
- How many queries per second are required?
- What is the acceptable consistency level?
- What is the indexing policy?

Using the Capacity Calculator

https://cosmos.azure.com/capacitycalculator




Microsoft Azure | Azure Cosmos DB > Capacity Calculator
Sign In
The calculator below offers you a quick estimate of the workload cost on Azure Cosmos DB. For a more precise estimate and ability to tweak more parameters, please sign in with an account you use for Azure.
Azure Cosmos DB Account Settings
The simplified Azure Cosmos DB calculator assumes commonly used settings for indexing policy, consistency, and other parameters. For a more accurate estimate, please sign in to provide your workload details.
API
SQL (Core)
Number of regions
1
Multi-region writes
Disabled
Enabled
Workload per region
For a more accurate cost estimate based on your own data, please sign in and upload your sample data.
Total data stored in transactional store
10
GB
Use Analytical Store
Off
On
Item size
1 KB
Point reads/sec
1000
Creates/sec
200
Updates/sec
50
Deletes/sec
0
Queries/sec
0
Calculate
Settings have been updated. Please calculate again.
Cost Estimate
Transactional Storage
Cost per GB/month
0.25 USD
Total Data stored per region
x 10 GB
EST. STORAGE COST PER MONTH
2.50 USD
Transactional Workload
Cost per 100 RU/s per hour
0.008 USD
EST. THROUGHPUT REQUIRED Show Details
x 400 RU/s
* Minimum throughput required is 400 RU/s
EST. WORKLOAD COST/MONTH
23.36 USD
Number of regions
x 1
EST. TOTAL COST/MONTH
25.86 USD
Create Cosmos DB account
NEW TO AZURE COSMOS DB? CREATE A NEW FREE TIER ACCOUNT
Learn more
HAVE AN APP WITH BURSTY TRAFFIC? TRY OUT SERVERLESS
Learn more
MIGRATE TO AZURE COSMOS DB NOW
Learn more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For a more accurate cost estimate based on your own data, please sign in and upload your sample data.
Total data stored in transactional store
10
GB
Use Analytical Store
Off
On
Item size
1 KB
Point reads/sec
1000
Creates/sec
200
Updates/sec
50
Deletes/sec
0
Queries/sec
0
Calculate
Cost Estimate
Transactional Storage
Cost per GB/month
0.25 USD
Total Data stored per region
x 10 GB
EST. STORAGE COST PER MONTH
2.50 USD
Transactional Workload
Cost per 100 RU/s per hour
0.008 USD
EST. THROUGHPUT REQUIRED Show Details
x 2,485 RU/s
EST. WORKLOAD COST/MONTH
145.14 USD
Number of regions
x 1
EST. TOTAL COST/MONTH
147.64 USD
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Learn more
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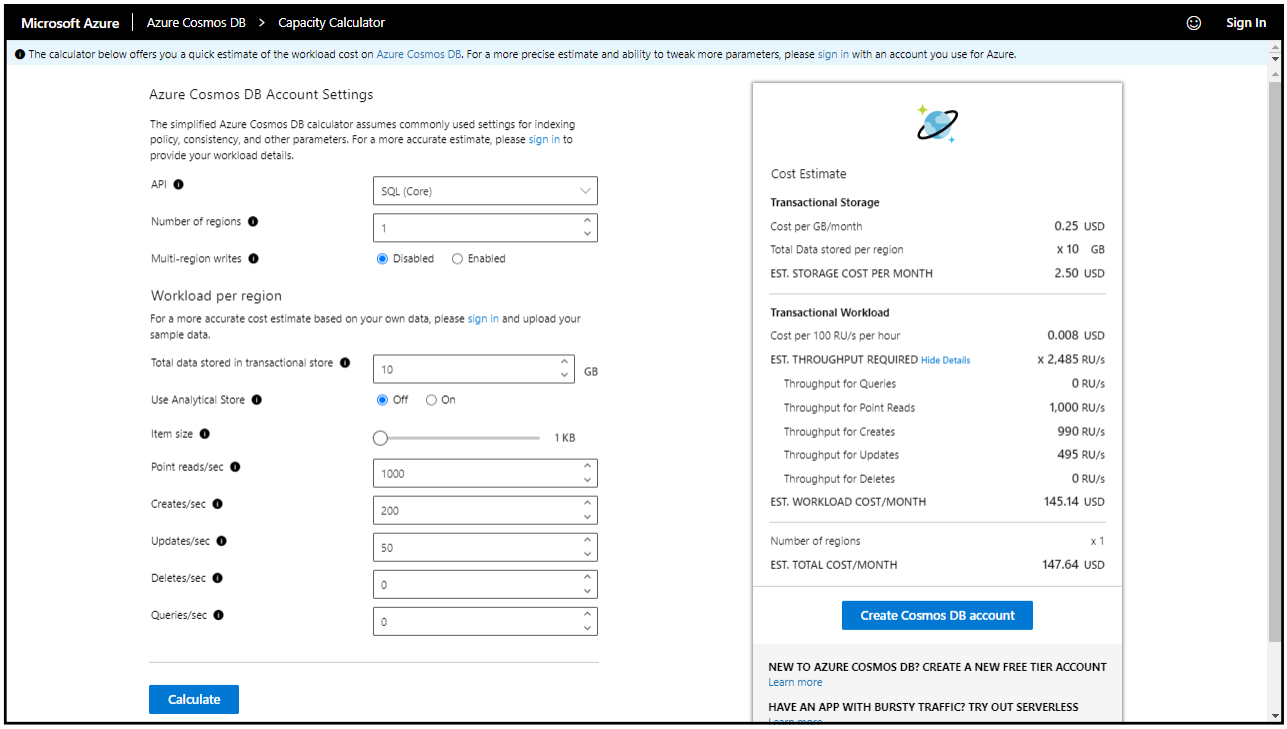


Pricing

Storage	Consumption-based SSD storage $0.25 for 1 GB per month per region	1 GB: $ 0.25 /month 10 GB: $ 2.50 /month
Provisioned throughput	Manual provisioned throughput $0.008/hr for 100 RU/sec per region Minimum 400 RU/sec	100 RU/s: $ 0.008 /hour, $ 0.192 /day, $ 5.856 /month 400 RU/s: $ 0.032 /hour, $ 0.768 /day, $ 23.424 /month
	Autoscale provisioned throughput $0.012/hr for 100 RU/sec per region Minimum 400 RU/sec	100 RU/s: $ 0.012 /hour, $ 0.288 /day, $ 8.784 /month 400 RU/s: $ 0.048 /hour, $ 1.152 /day, $ 35.136 /month
Serverless	Consumption-based per request $0.25 per 1 million RUs	1 M RUs: $ 0.25 /month 5 M RUs: $ 1.25 /month
More options	Reserved capacity, multi-master, analytic storage https://azure.microsoft.com/pricing/details/cosmos-db	

Introduction to Azure Cosmos DB

Horizontal Partitioning

Achieving Elastic Scale

What is Partitioning?

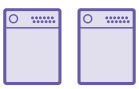
Massive scale-out within a container

Containers

Single logical resource composed of multiple physical partitions

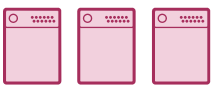
Partitions

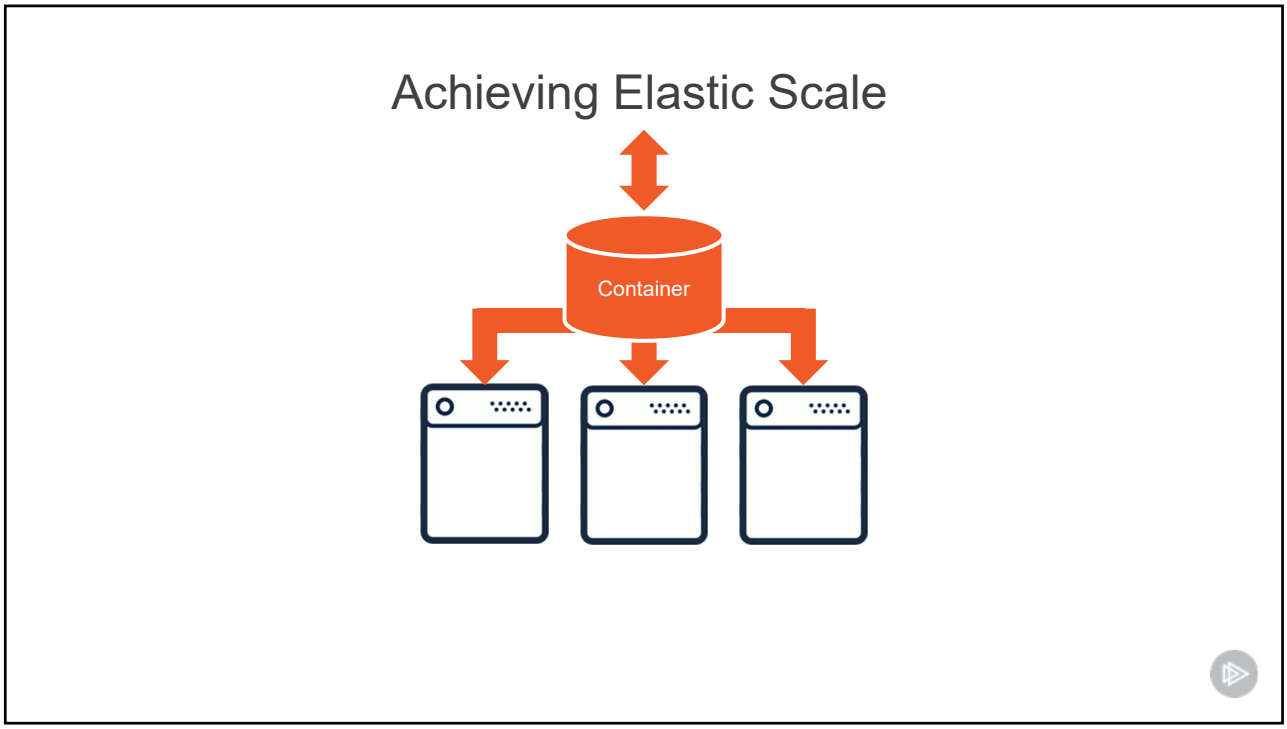
Physical fixed-capacity data buckets

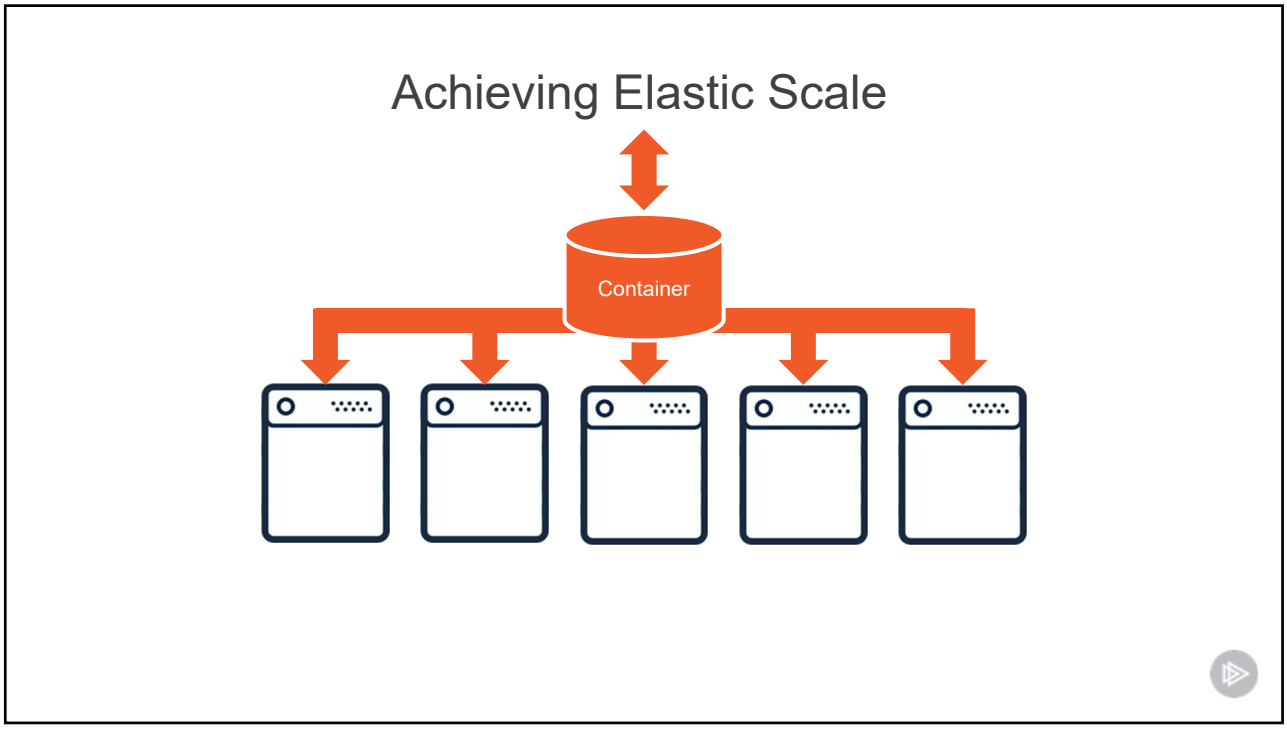


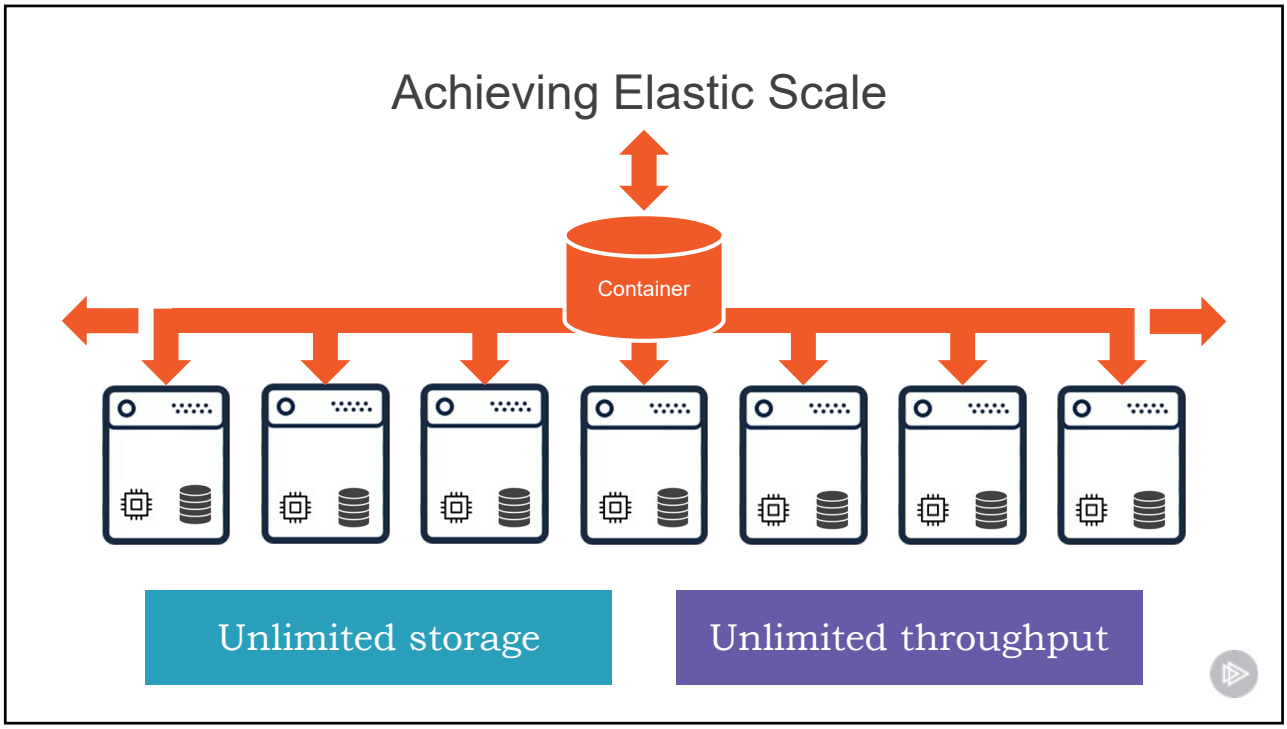
Automated Scale-Out

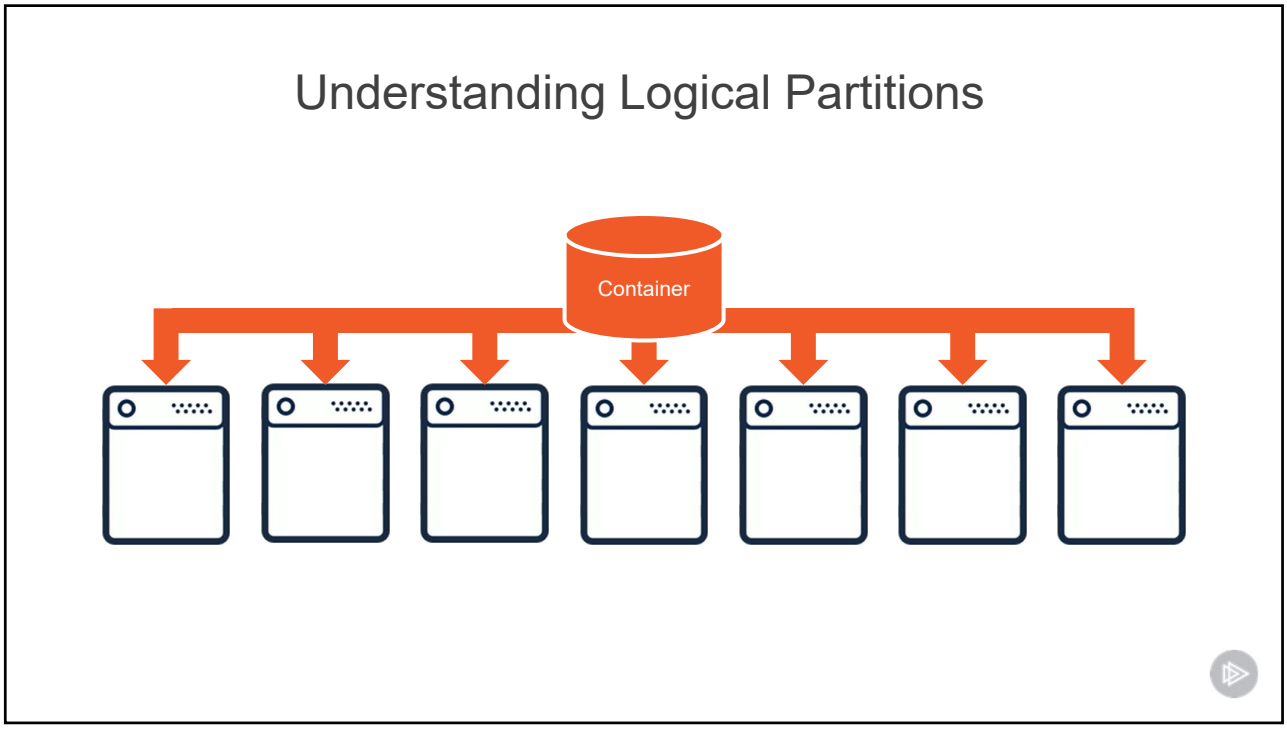
Cosmos DB transparently splits partitions to manage growth

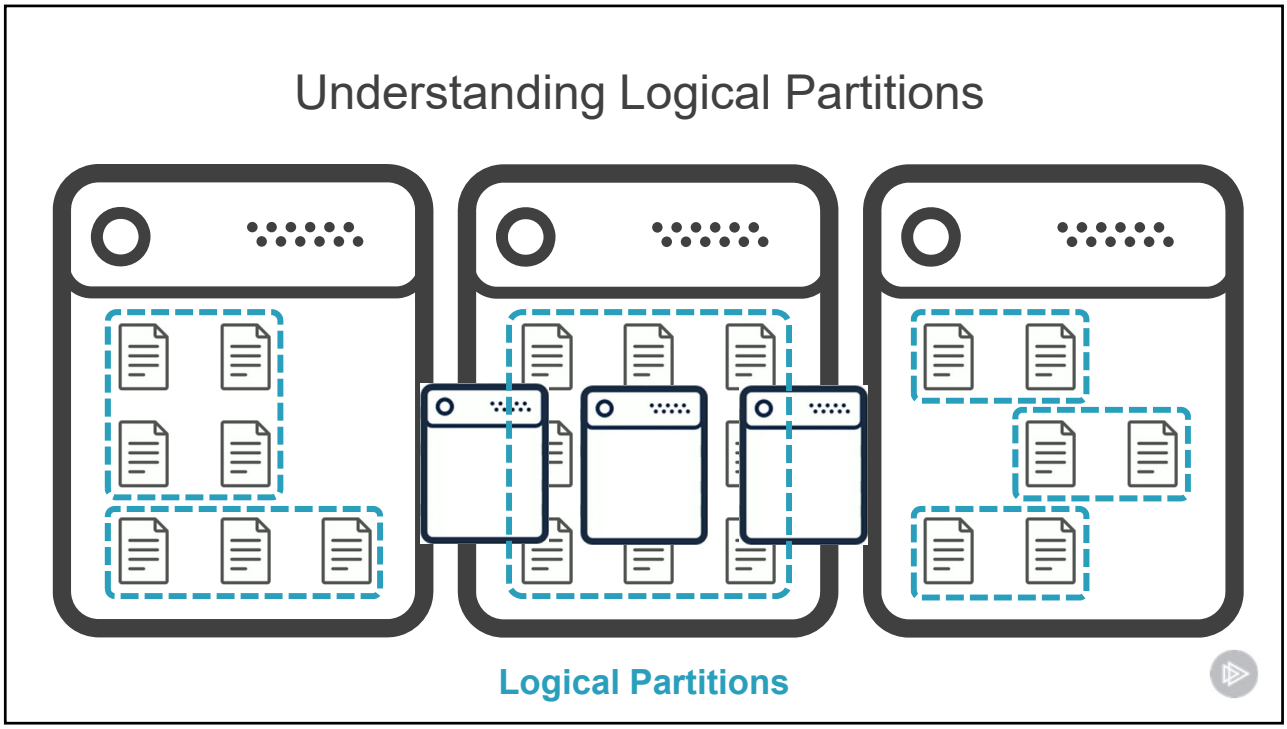


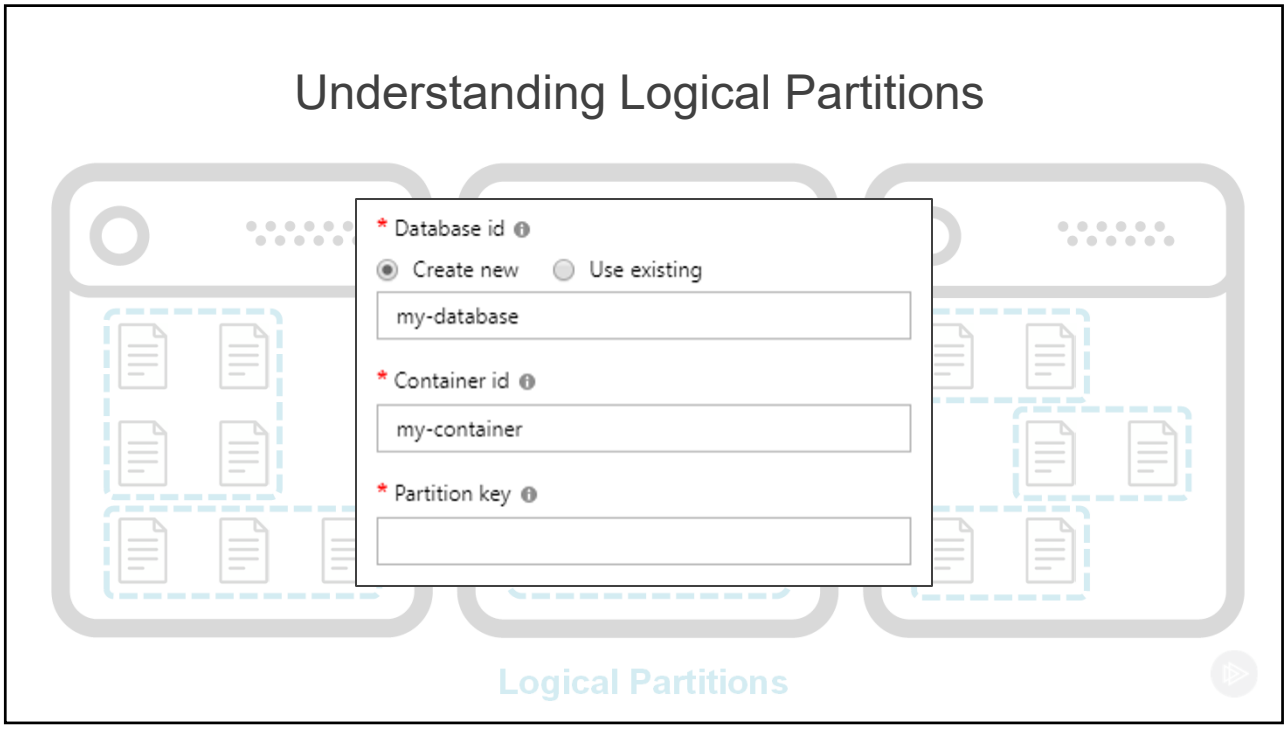

Achieving Elastic Scale
Container


Achieving Elastic Scale
Container

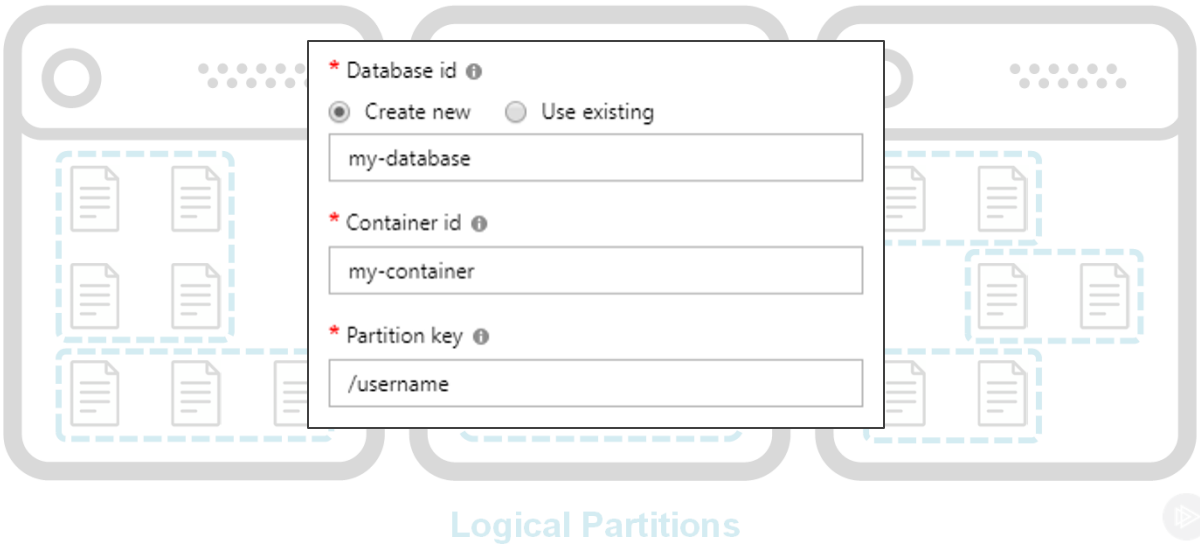

Achieving Elastic Scale
Container
Unlimited storage
Unlimited throughput


Understanding Logical Partitions
Container

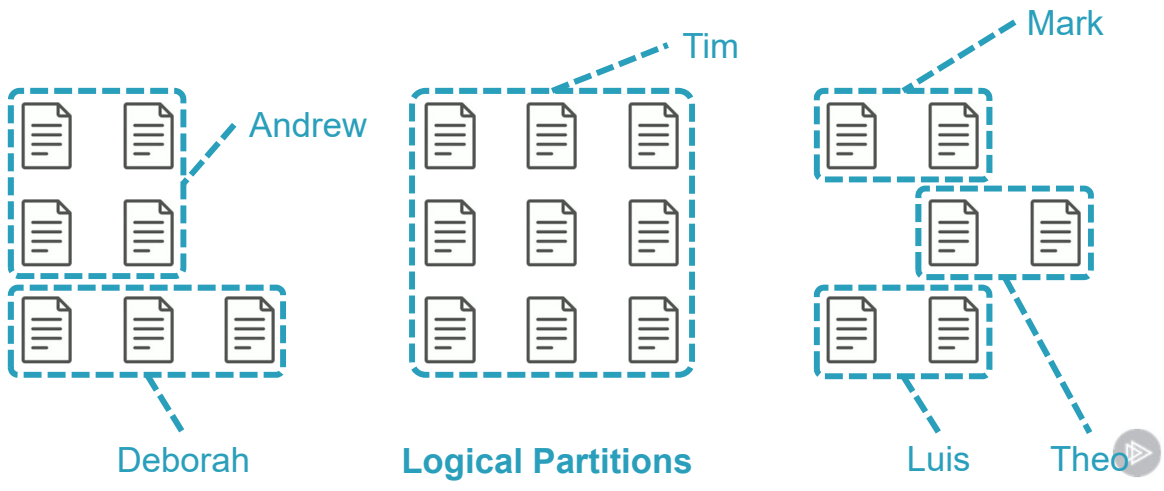

Understanding Logical Partitions
Logical Partitions


Understanding Logical Partitions
* Database id
Create new
Use existing
my-database
* Container id
my-container
* Partition key
Logical Partitions

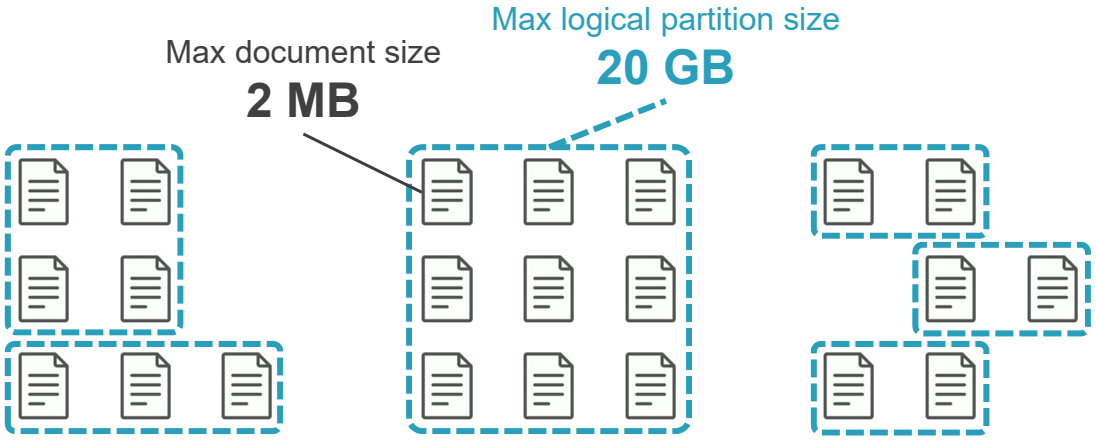
Understanding Logical Partitions



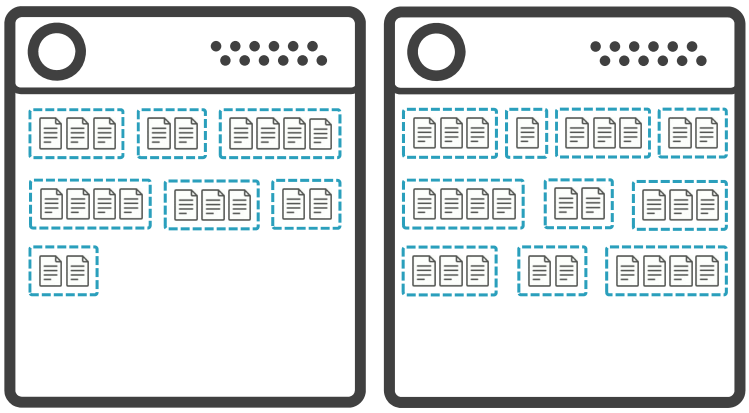
Understanding Logical Partitions

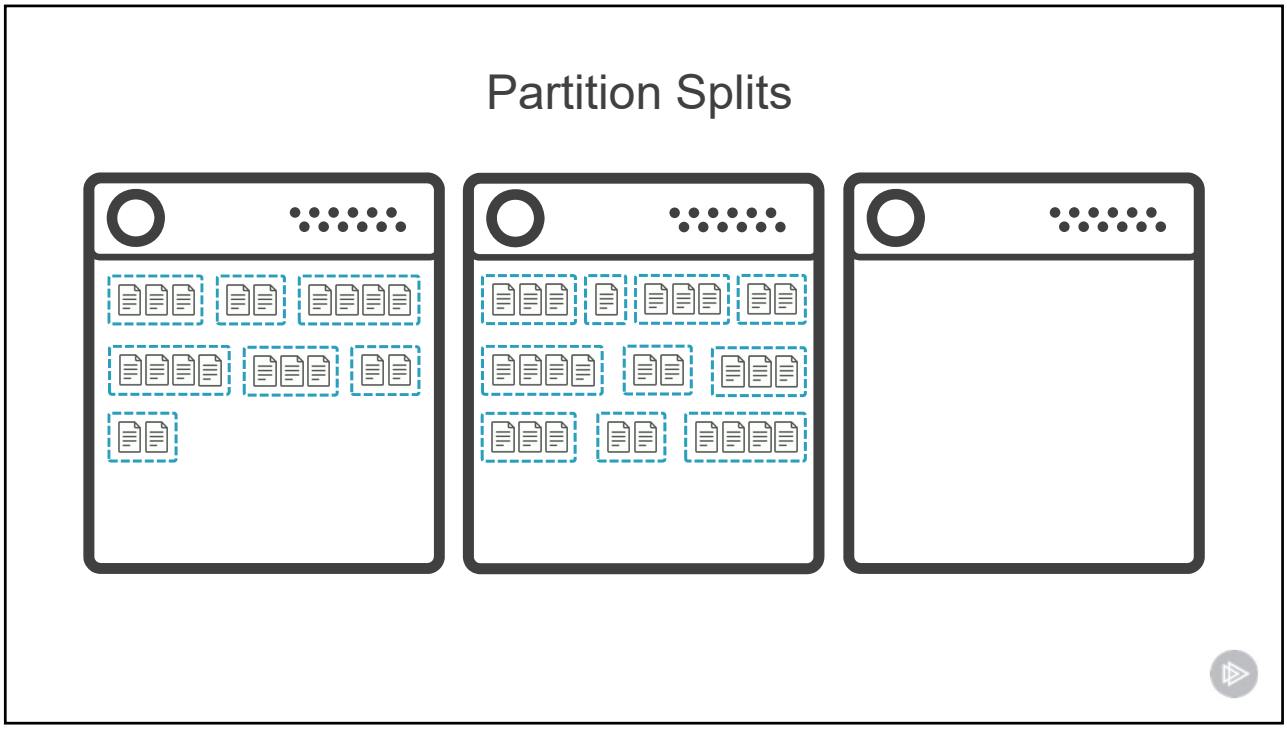


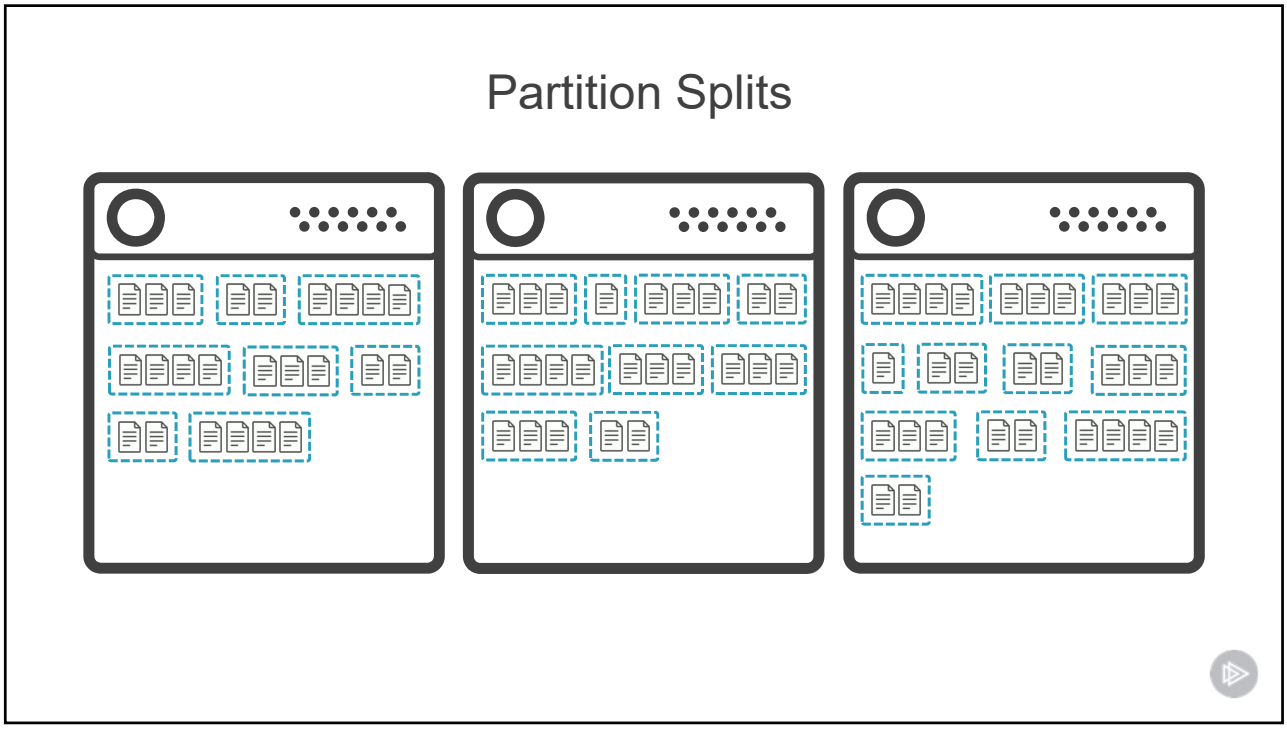
Understanding Logical Partitions

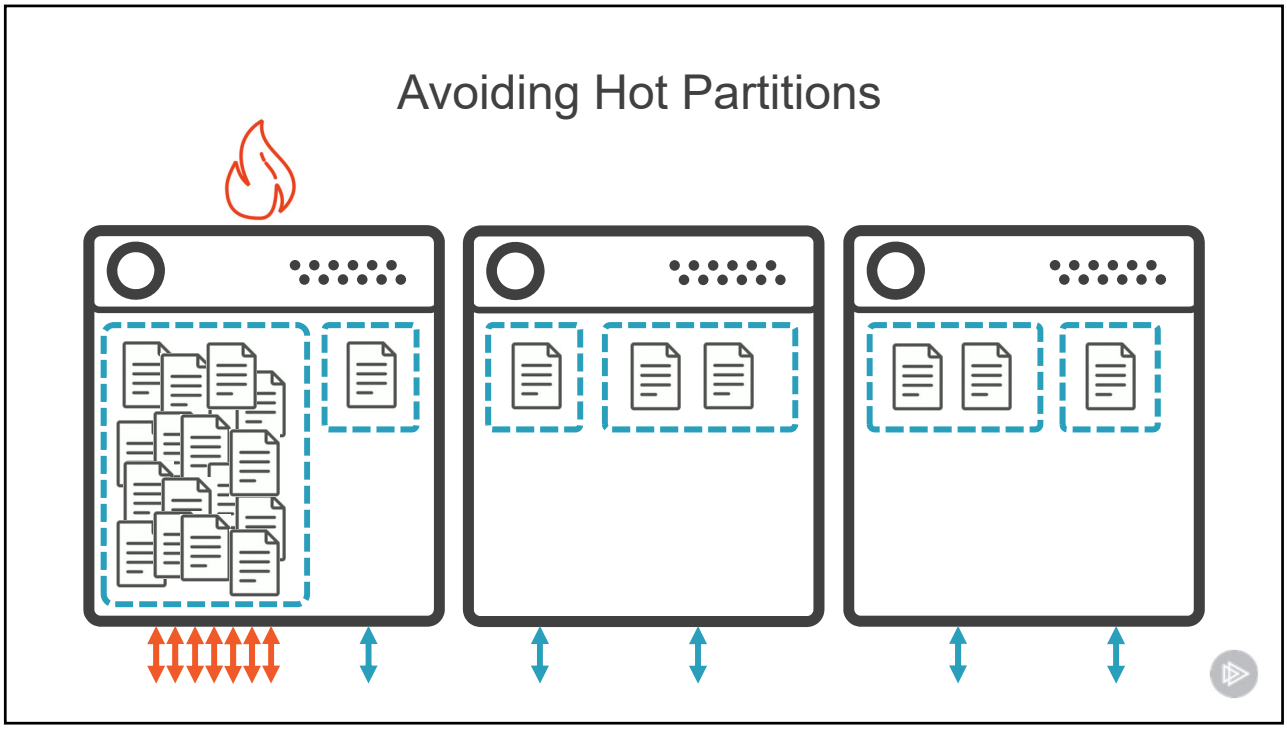


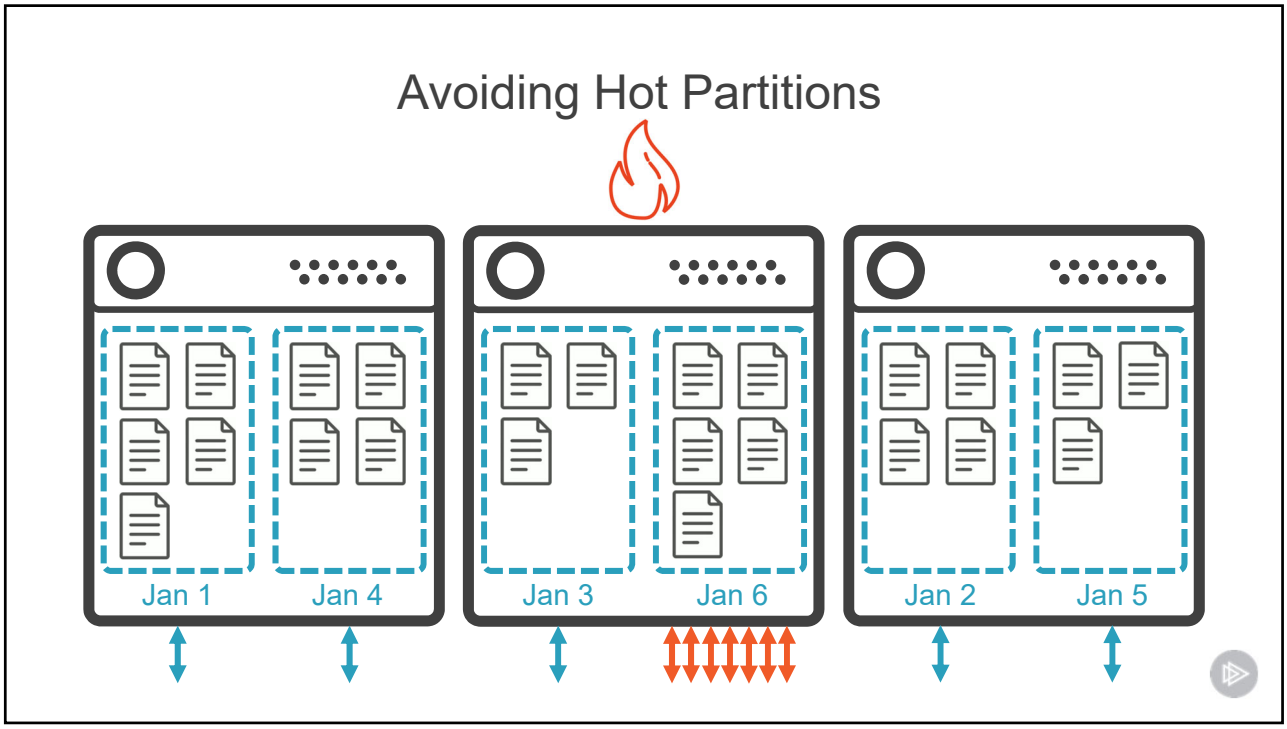
Partition Splits



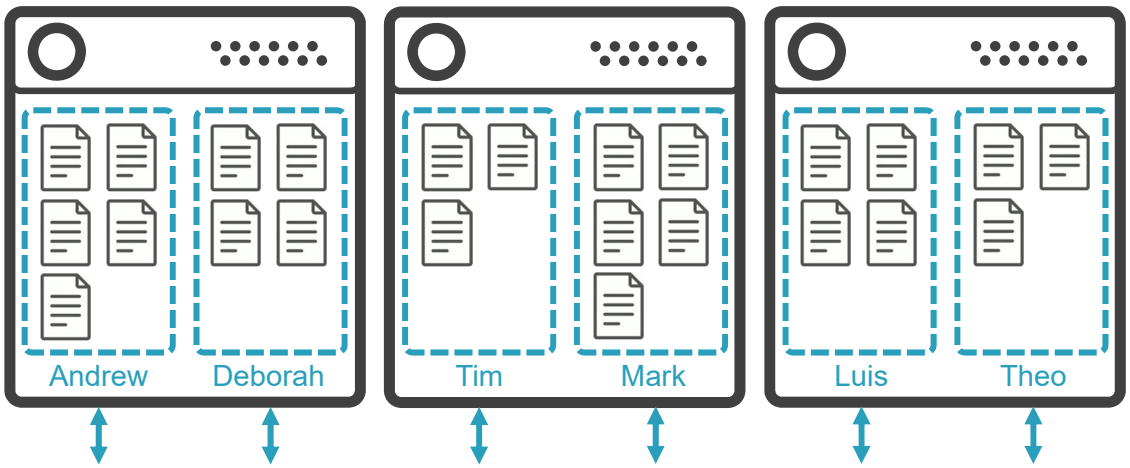

Partition Splits


Partition Splits

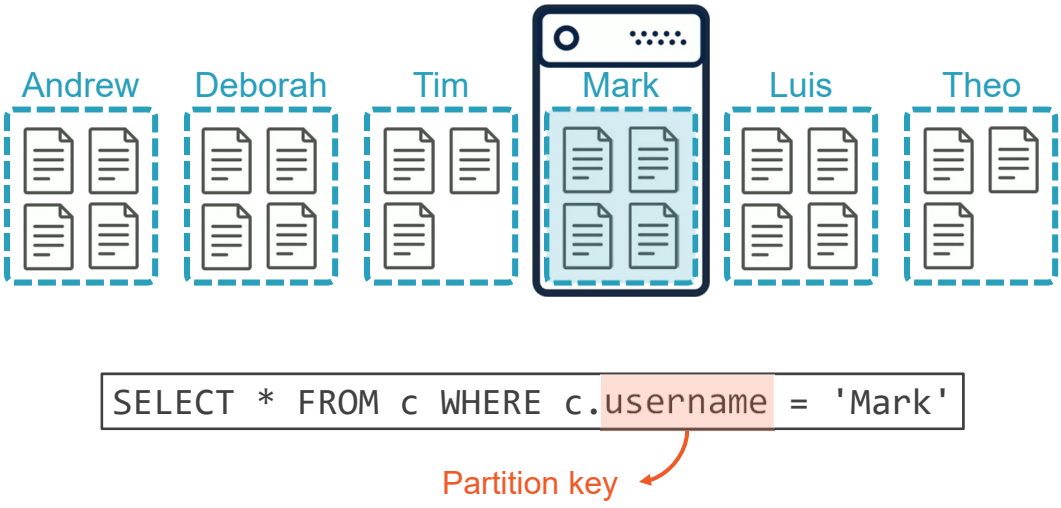

Avoiding Hot Partitions


Avoiding Hot Partitions
Jan 1
Jan 4
Jan 3
Jan 6
Jan 2
Jan 5

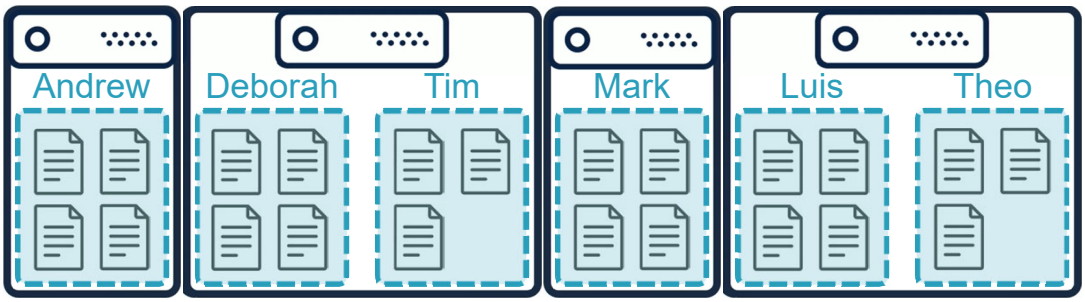
Avoiding Hot Partitions



Cross-partition Queries



Cross-partition Queries




```
SELECT * FROM c WHERE c.favoriteColor = 'Red'
```

?

Choosing the Right Partition Key

Based on common usage patterns

The right choice will deliver massive scale

Avoid performance bottlenecks

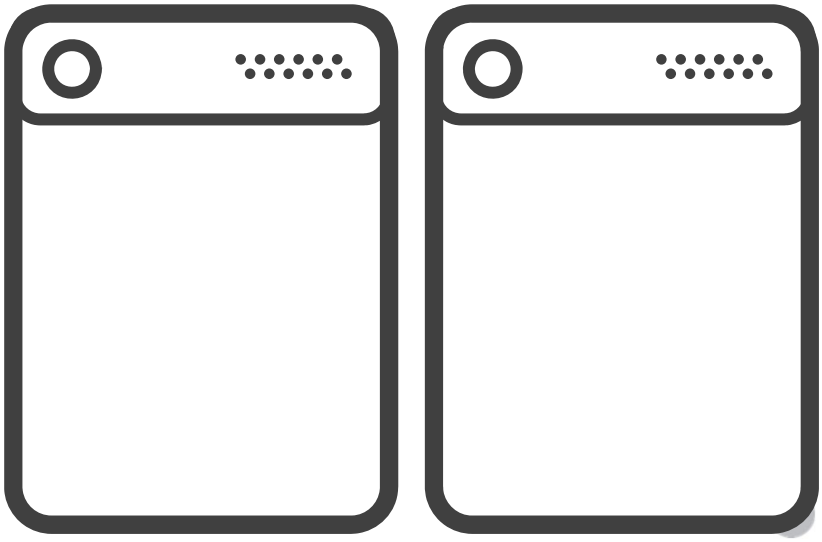
Ensure uniform distribution of both storage and throughput

Boundary for queries and transactions

Minimize cross-partition queries

Stored procedures with ACID guarantees

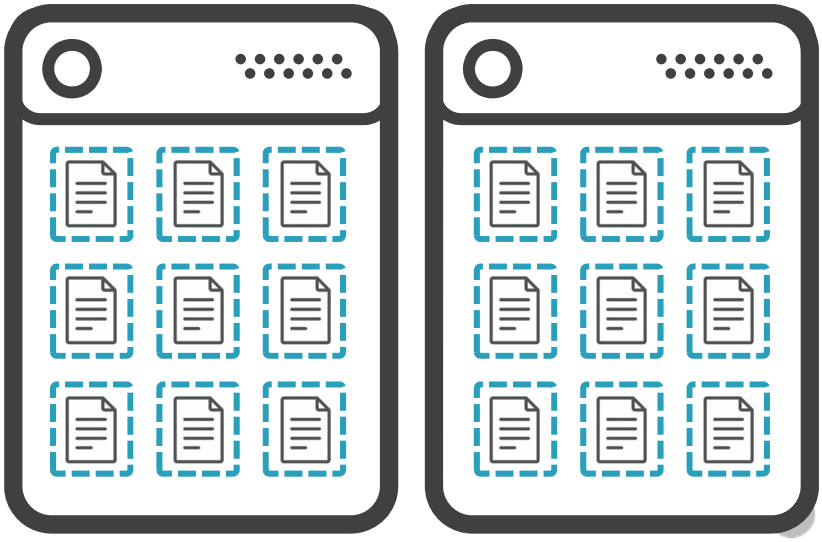
Common Partitioning Patterns



Common Partitioning Patterns

/id

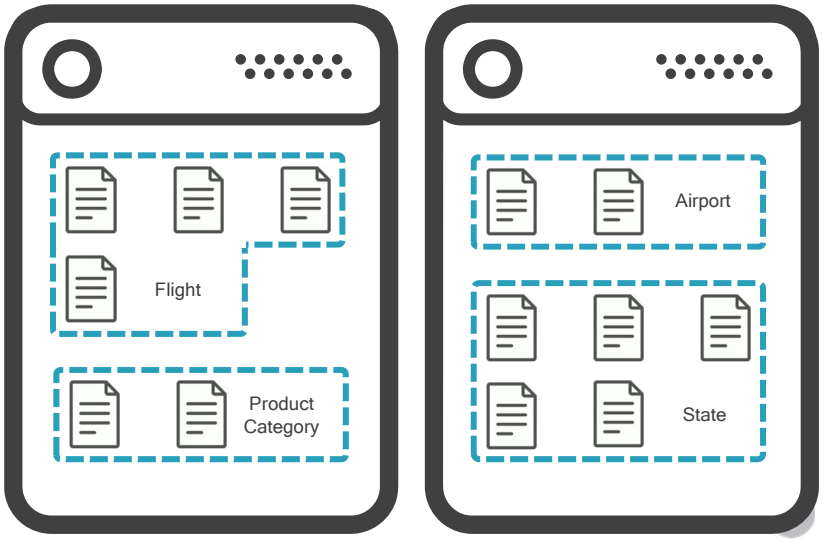
Single-documents



Common Partitioning Patterns

/id
Single-documents

/type
Small lookup lists

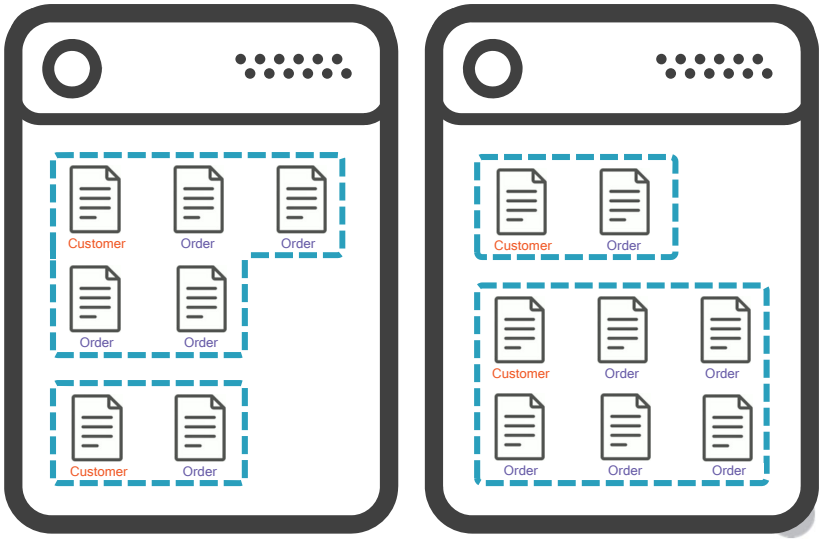


Common Partitioning Patterns

/id
Single-documents

/type
Small lookup lists

Other
Example: **/customerId**
Optimize for queries



Common Partitioning Patterns

/id

Single-documents

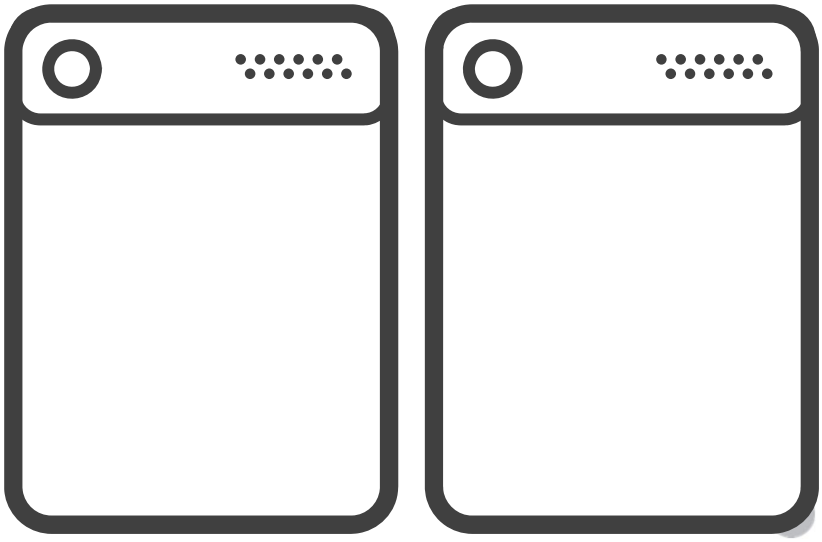
/type

Small lookup lists

Other

Example: /customerId

Optimize for queries



Changing the Partition Key

Partition keys are immutable

Can't change for the container

Can't change for the document

Always use the same property path

For example: /pk

Store a copy of the desired partition key

Always uniquely qualify the id property

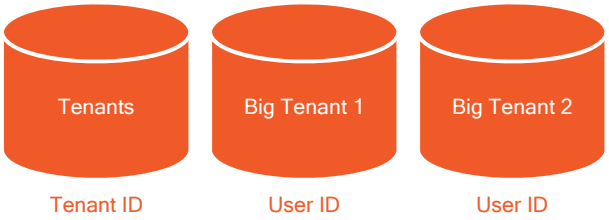
Can be a GUID, but doesn't have to be

Avoid collisions during migration

Partition Granularity

Synthetic Partition Keys

IoT: Device ID
Multitenant: Tenant ID



Partition Granularity

Synthetic Partition Keys

IoT: Device ID
Multitenant: Tenant ID

Device ID + Month
Tenant ID + User ID

Hierarchical Partition Keys

Aka “subpartitioning”

Up to 3 levels

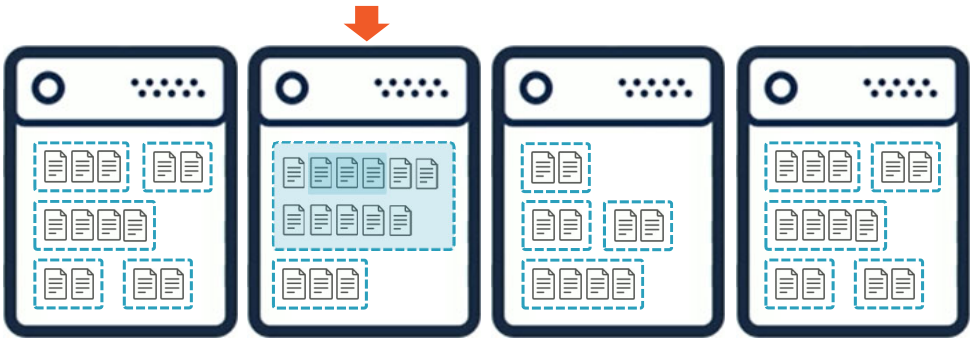
Leaf level limit = 20 GB
Parent level limit > 20 GB

Hierarchical Partition Keys

Currently in Private Preview

Signup:
https://aka.ms/cosmos-subpartitioning-signup

Hierarchical Partition Keys



Partition key: **Tenant ID**

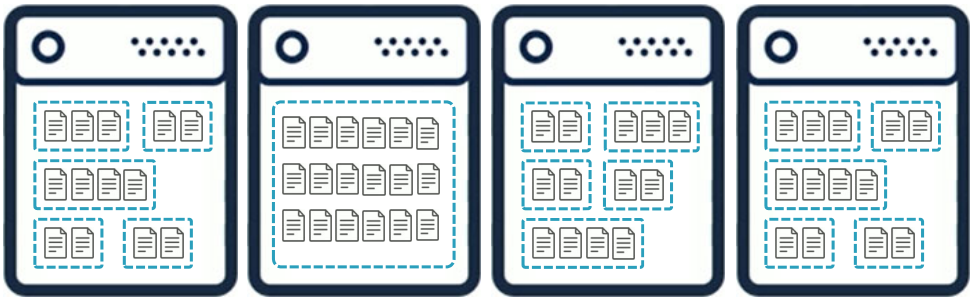
```
SELECT * FROM c WHERE c.tenantId = 'TenantX'
```

Single-partition

```
SELECT * FROM c WHERE c.tenantId = 'TenantX' AND c.userId = 'UserY'
```

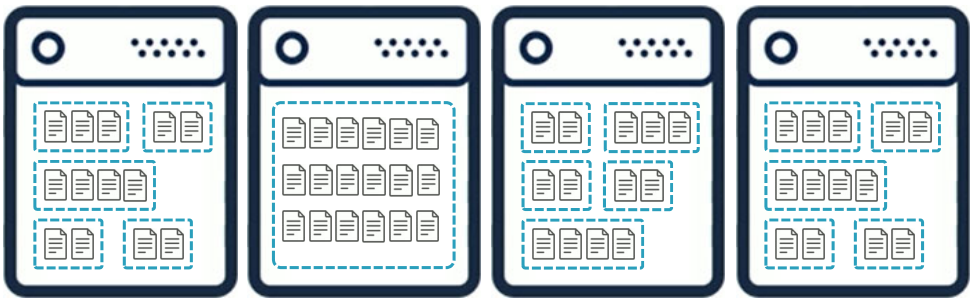
Single-partition

Hierarchical Partition Keys



Partition key: **Tenant ID**

Hierarchical Partition Keys



Synthetic partition key: **Tenant ID + User ID**

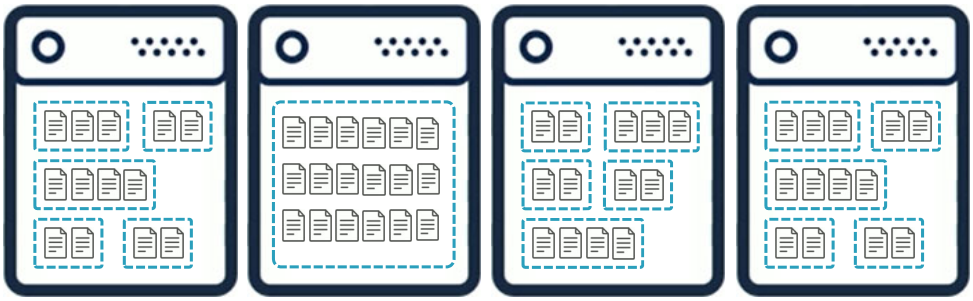
```
SELECT * FROM c WHERE c.tenantId = 'TenantX'
```

Cross-partition

```
SELECT * FROM c WHERE c.synthPk = 'TenantX_UserY'
```

Single-partition

Hierarchical Partition Keys

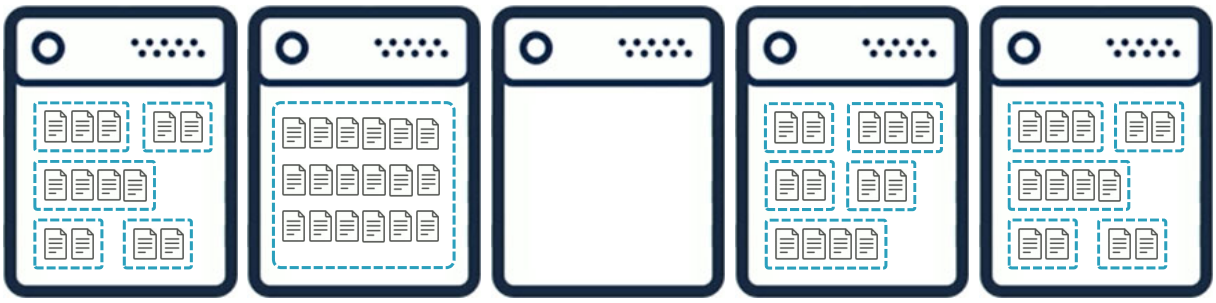


Hierarchical partition key: **Tenant ID / User ID**

Parent Level

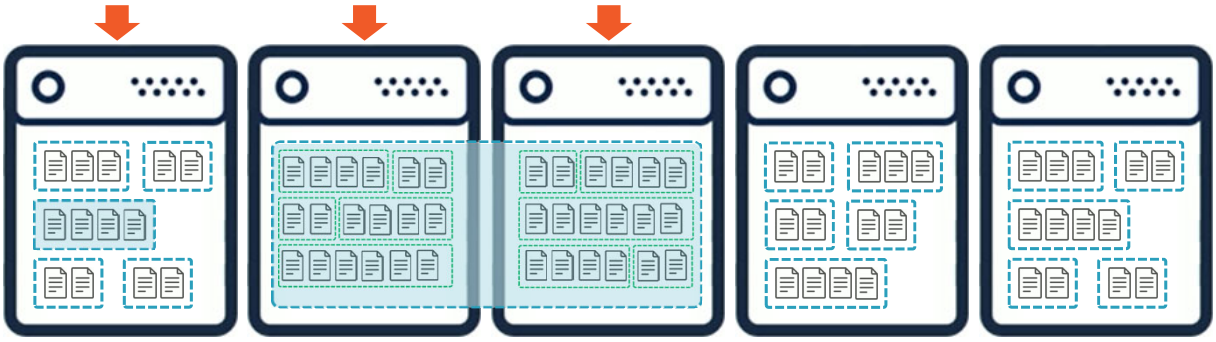
Leaf Level

Hierarchical Partition Keys



Hierarchical partition key: **Tenant ID / User ID**

Hierarchical Partition Keys

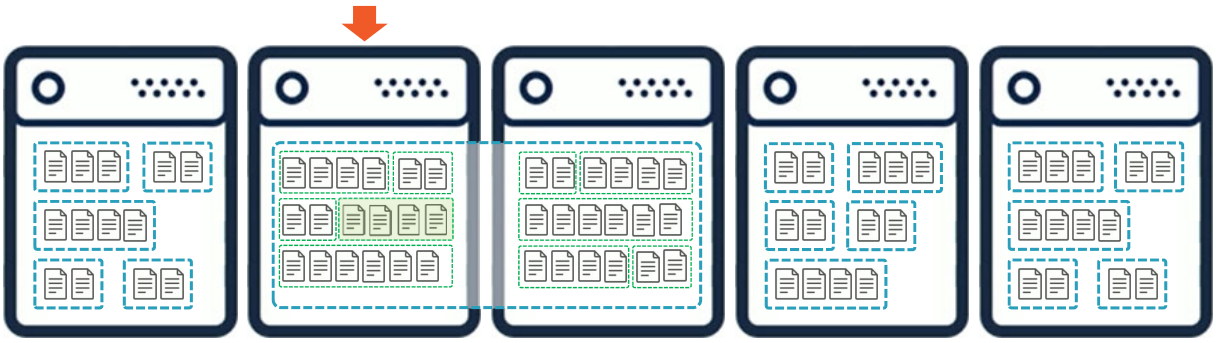


Hierarchical partition key: **Tenant ID / User ID**

```
SELECT * FROM c WHERE c.tenantId = 'TenantX'
```

Sub-partition

Hierarchical Partition Keys



Hierarchical partition key: **Tenant ID / User ID**

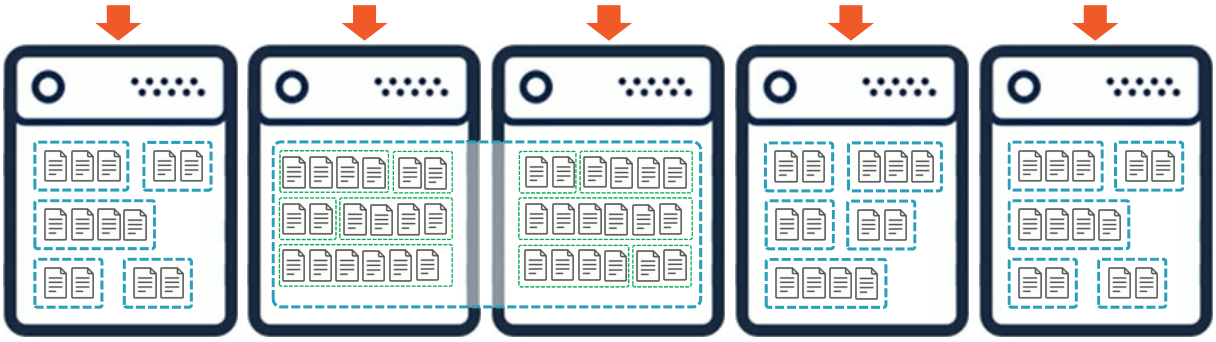
```
SELECT * FROM c WHERE c.tenantId = 'TenantX'
```

Sub-partition

```
SELECT * FROM c WHERE c.tenantId = 'TenantX' AND c.userId = 'UserY'
```

Single-partition

Hierarchical Partition Keys



Hierarchical partition key: **Tenant ID / User ID**

```
SELECT * FROM c WHERE c.tenantId = 'TenantX'
```
Sub-partition

```
SELECT * FROM c WHERE c.tenantId = 'TenantX' AND c.userId = 'UserY'
```
Single-partition

```
SELECT * FROM c WHERE c.userId = 'UserZ'
```
Cross-partition

Introduction to Azure Cosmos DB

Global Distribution

Replication – Why?

Performance

Multiple replicas within a region

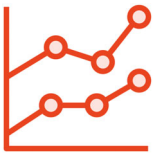
Ensures high availability

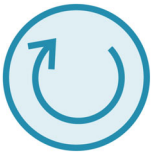
Across regions, brings data closer to the consumer

Business continuity

Replica failover within a region

Globally, in the event of major failure or natural disaster





Azure Data Centers

Enabling Global Distribution

Associate multiple regions with your Cosmos DB account

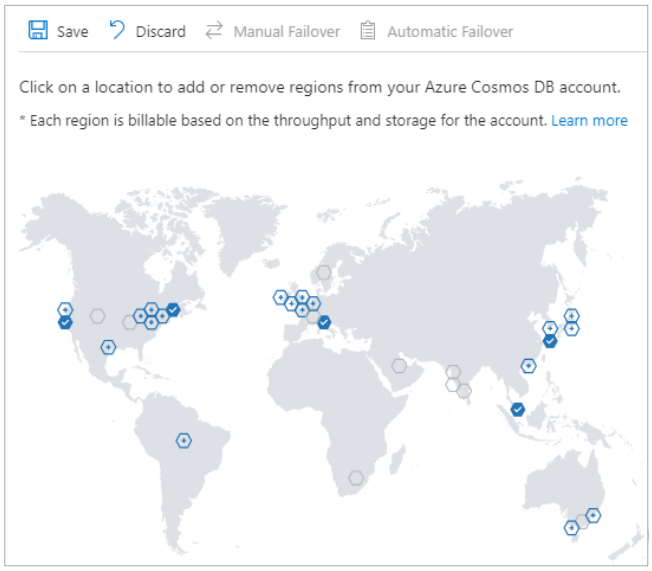
Limited to geo-fencing policies

Dynamically add and remove regions

Associate (and disassociate) regions with the click of a mouse

Multi-master

Enable writes across all regions, with automatic failover



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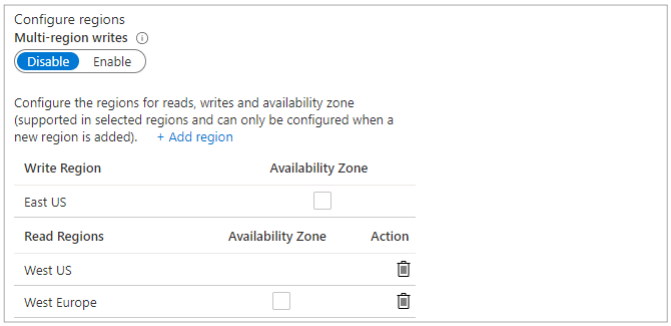

Enabling Global Distribution

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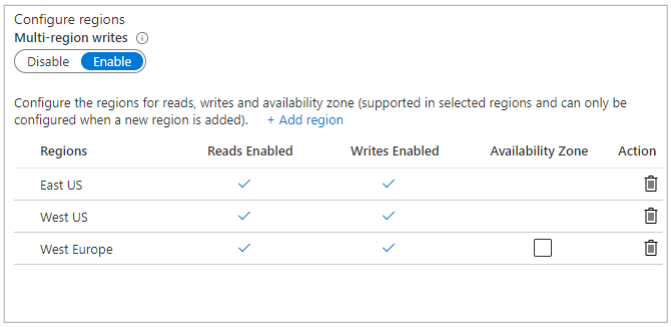
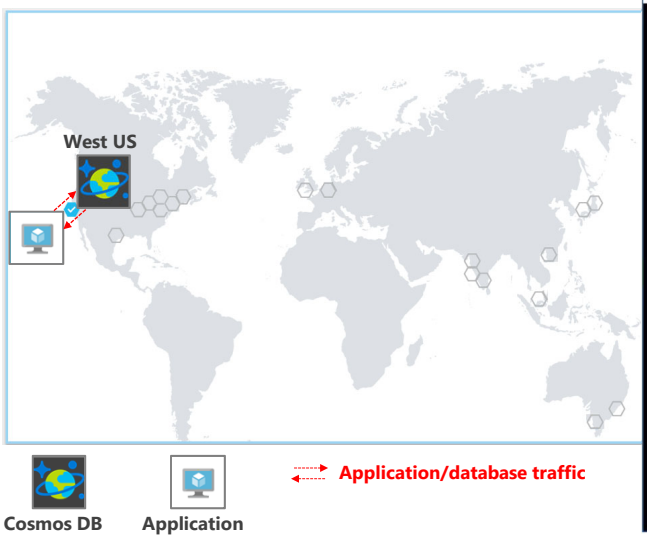
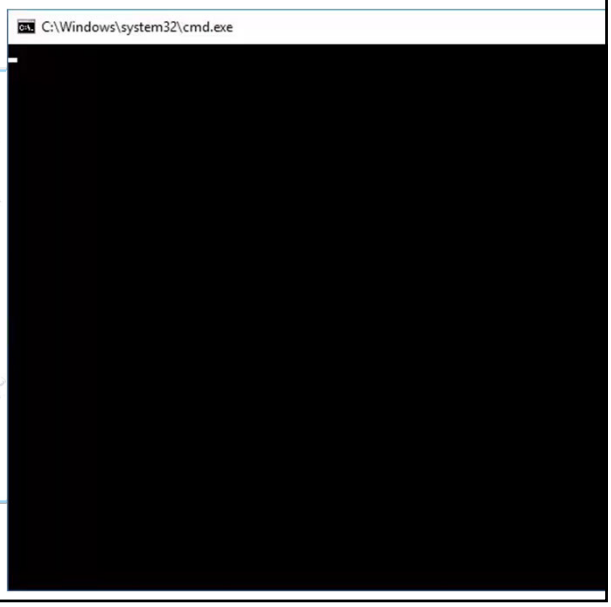
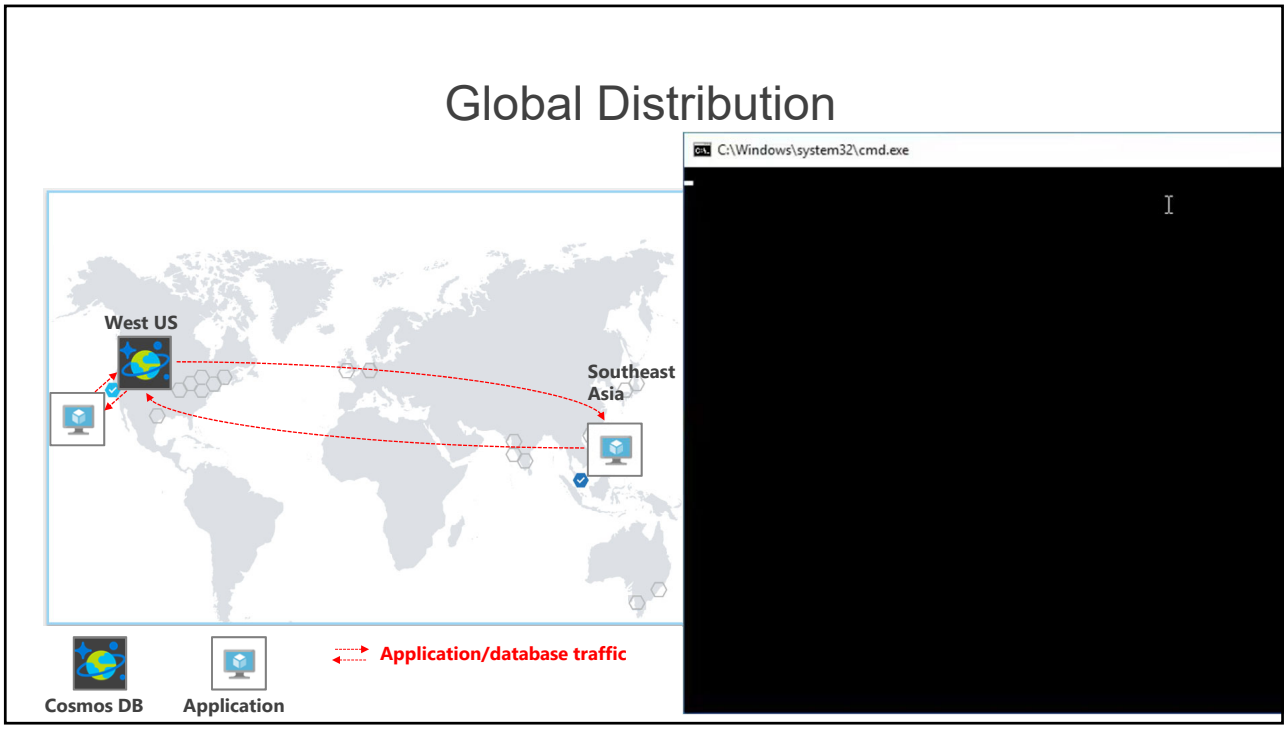
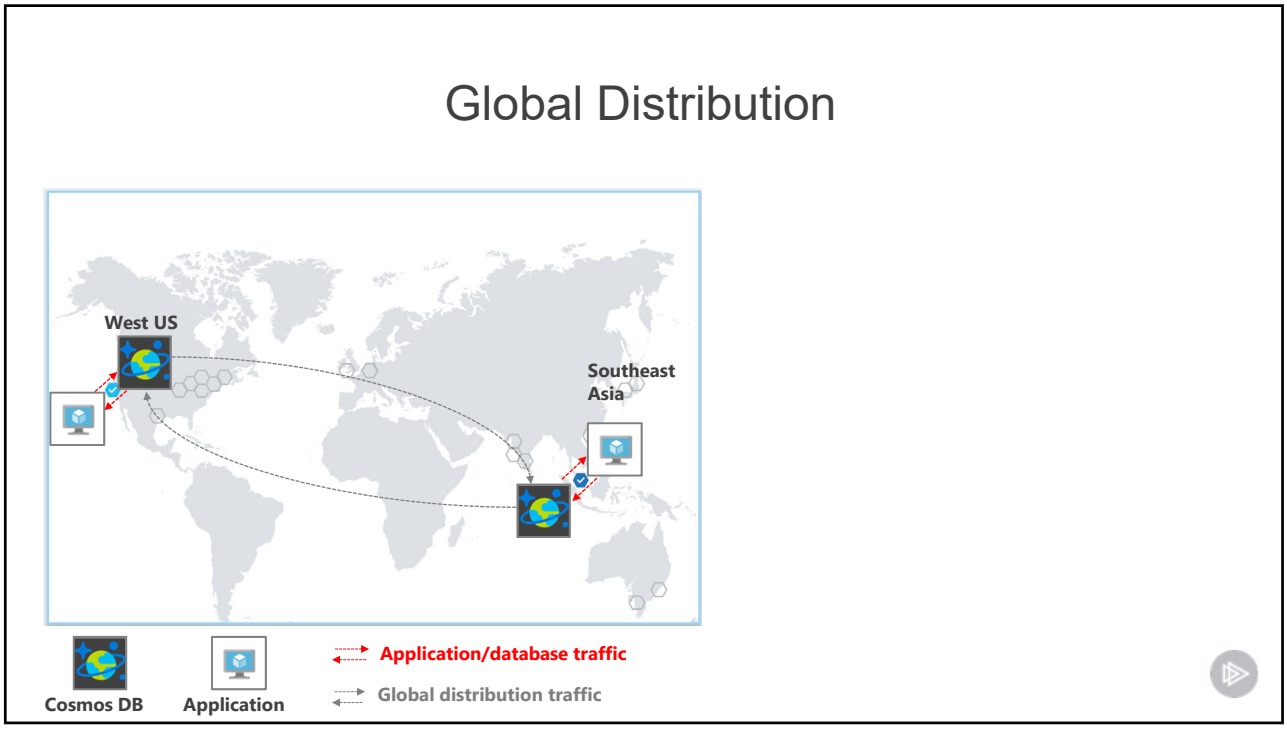


Global Distribution

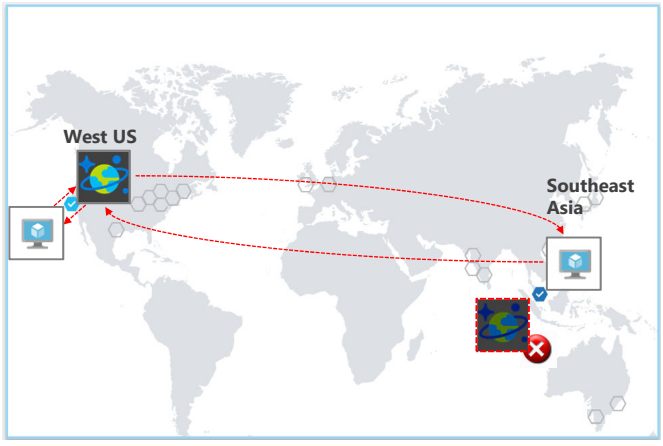





Global Distribution
C:\Windows\system32\cmd.exe
West US
Southeast Asia
Cosmos DB
Application
Application/database traffic


Global Distribution
West US
Southeast Asia
Cosmos DB
Application
Application/database traffic
Global distribution traffic

Global Distribution



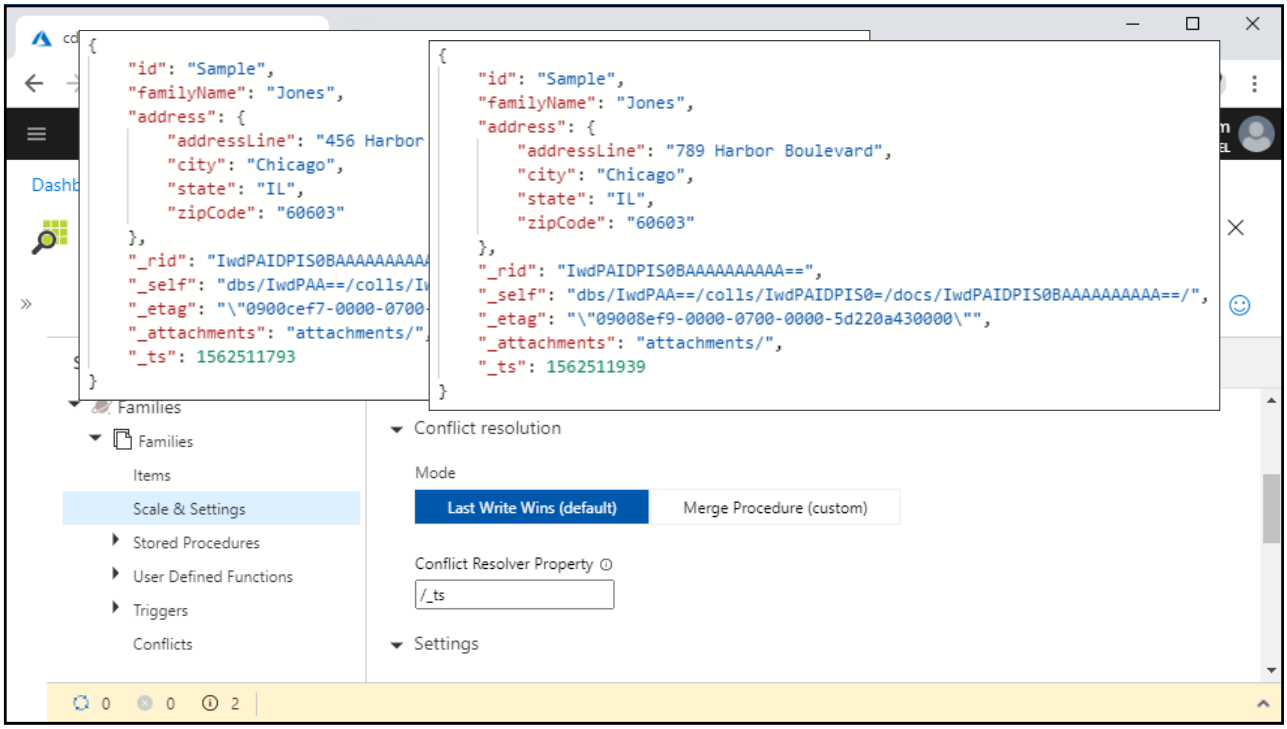
Multi-master Conflict Resolution

Every region is enabled for writes, inviting conflicts

Three options for conflict resolution

Last writer wins

Based on highest timestamp value in _ts



Multi-master Conflict Resolution

Every region is enabled for writes

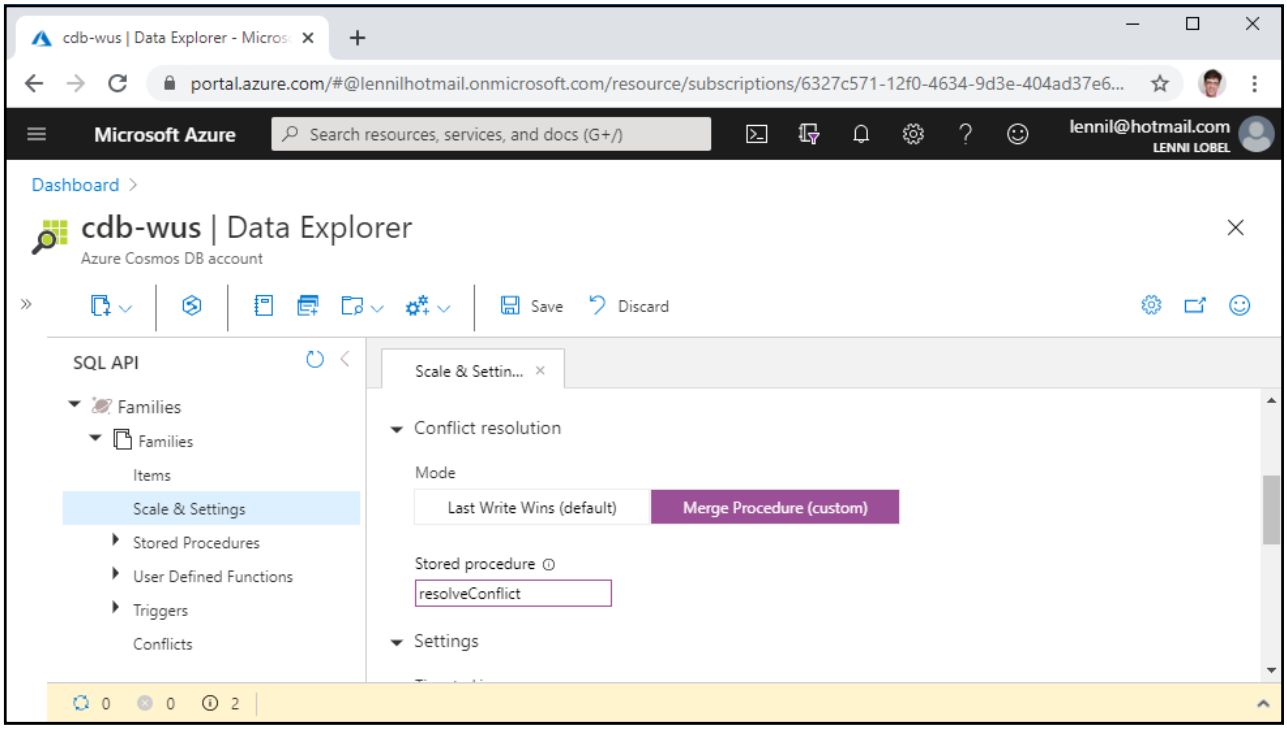
Three options for conflict resolution

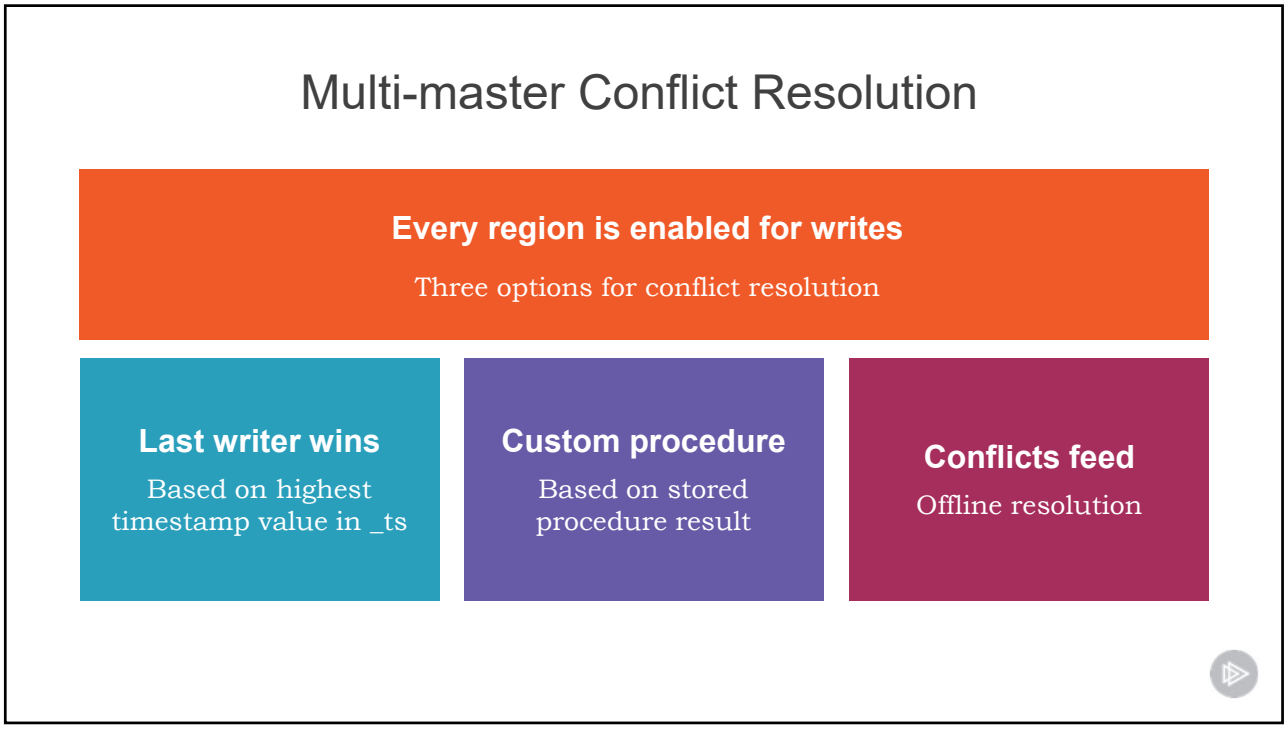
Last writer wins

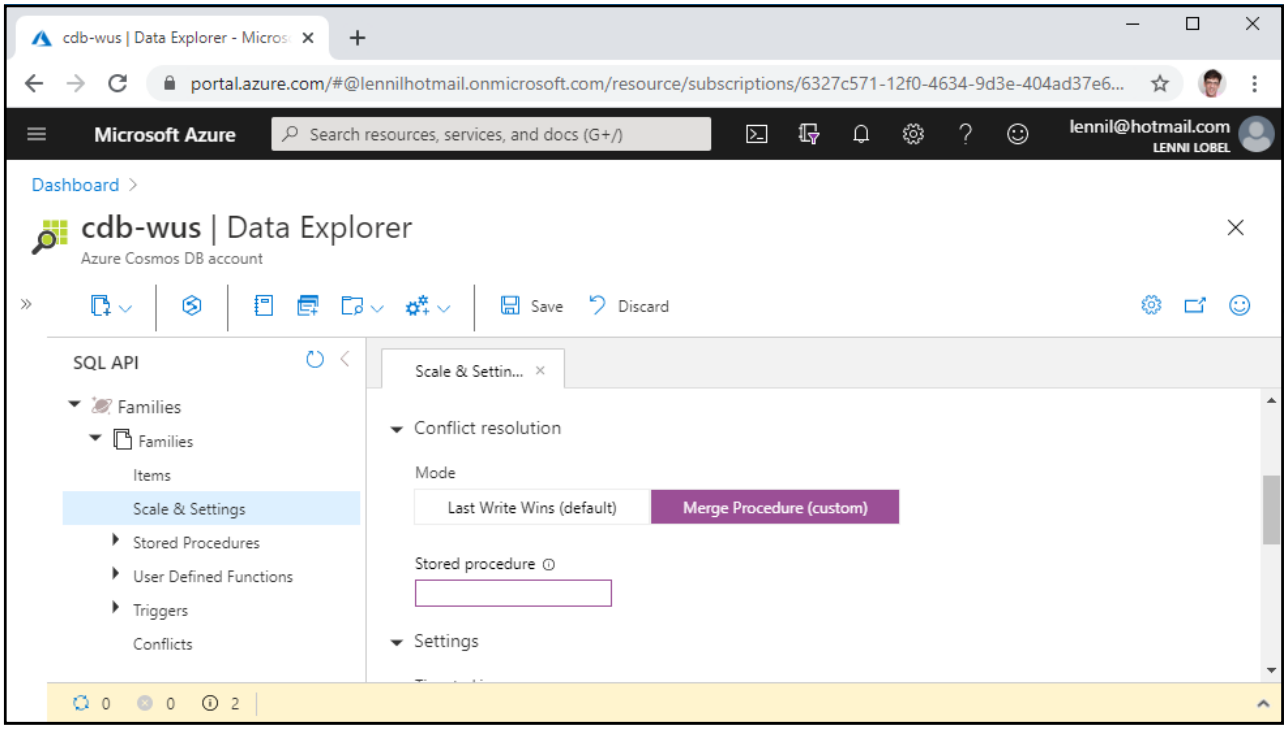
Based on highest timestamp value in _ts

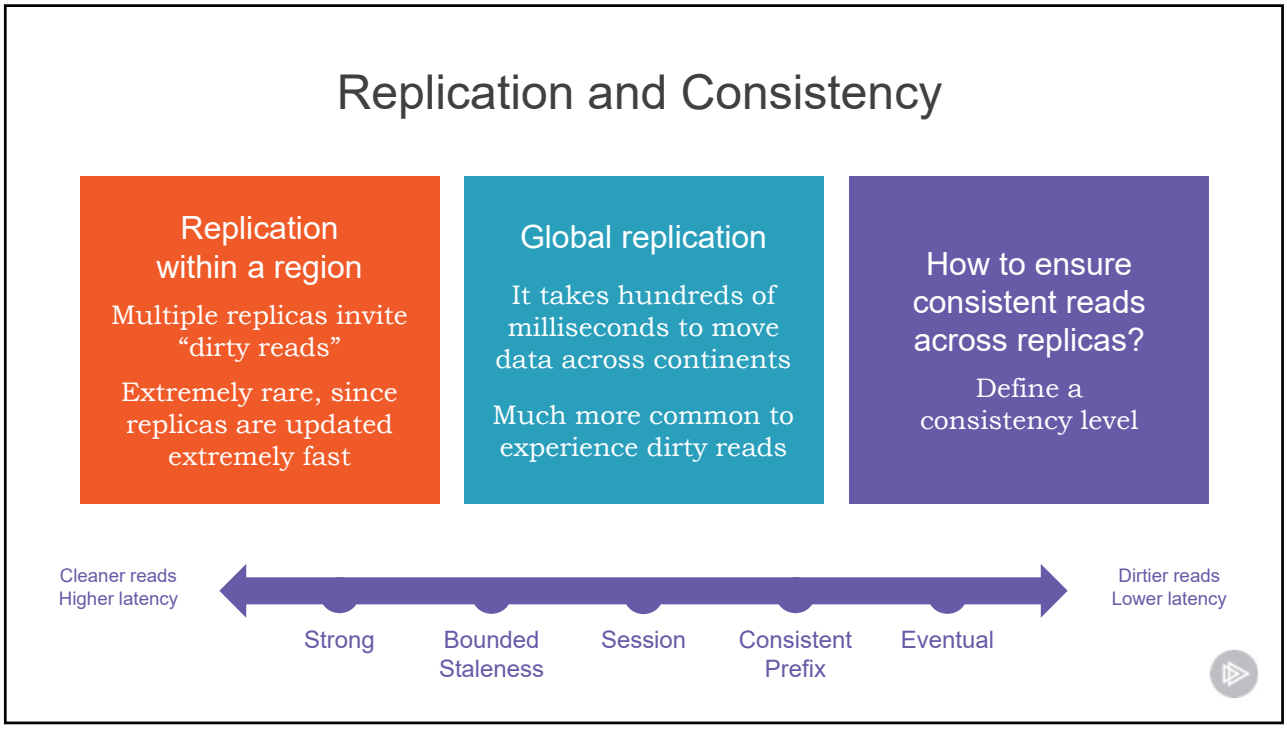
Custom procedure

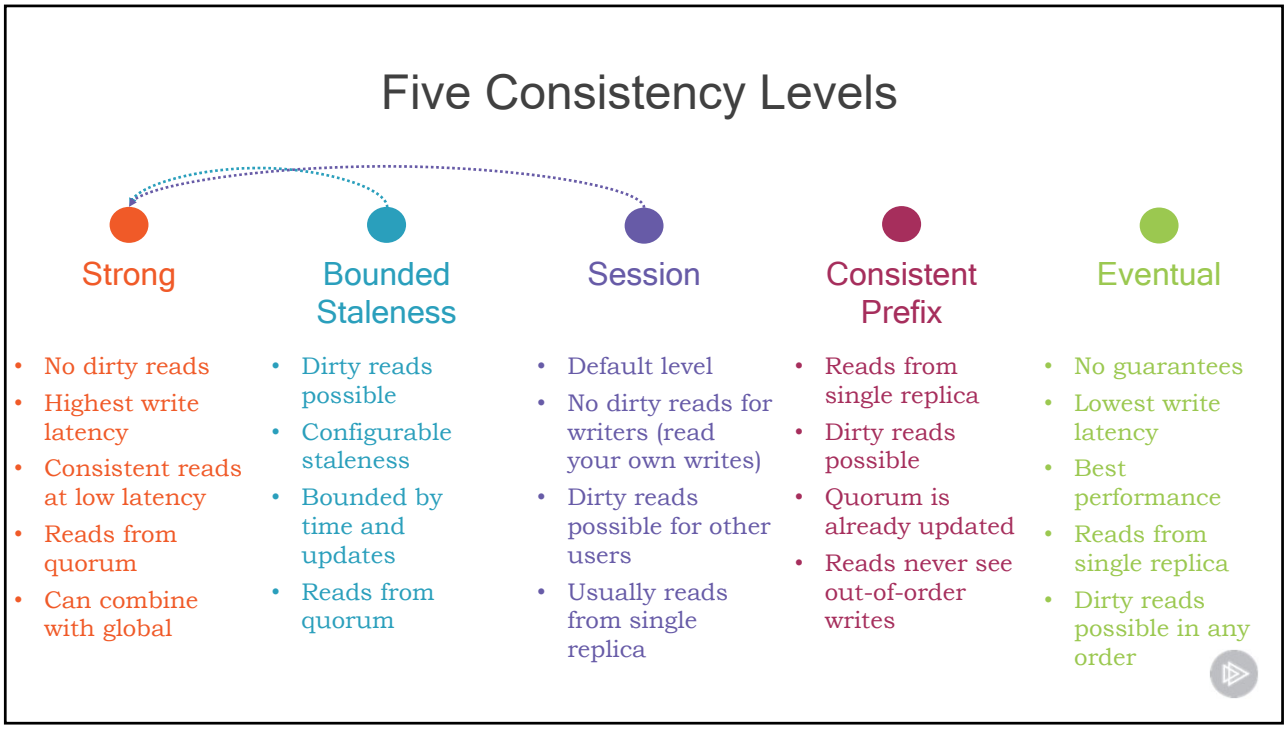
Based on stored procedure result

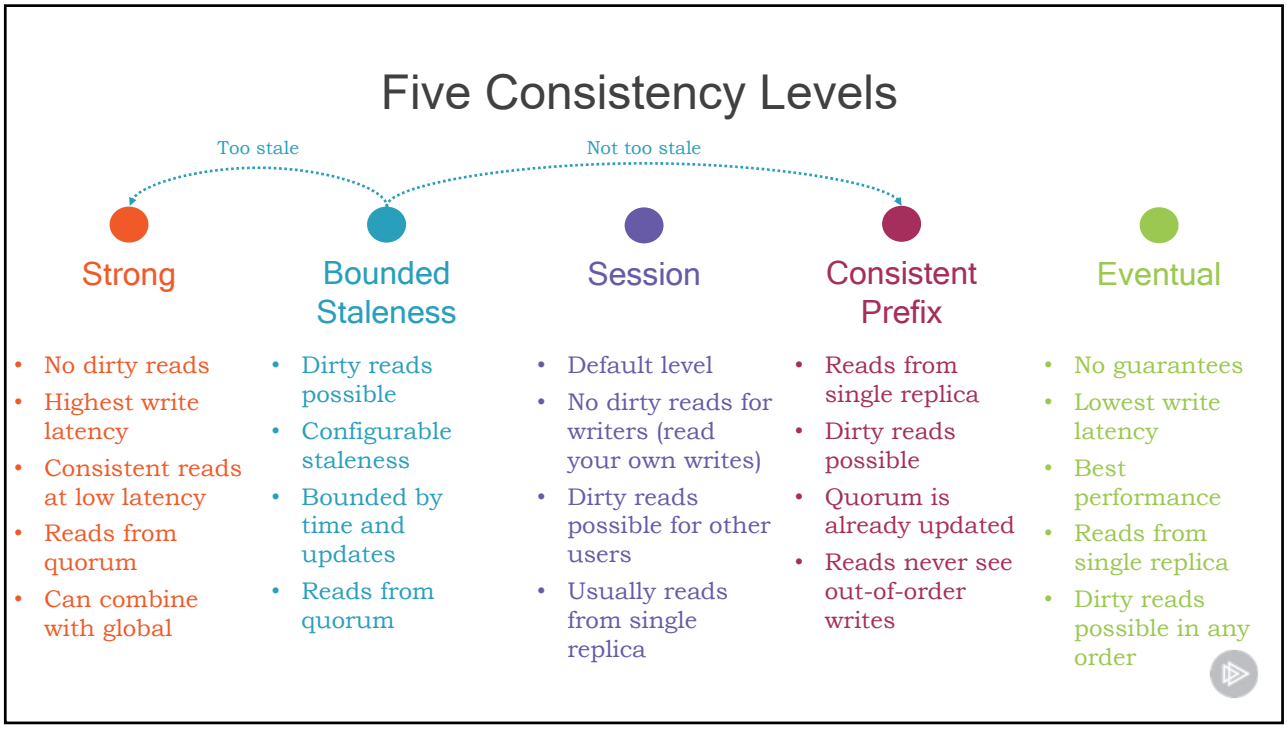

cdb-wus | Data Explorer - Micros
portal.azure.com/#@lennilhotmail.onmicrosoft.com/resource/subscriptions/6327c571-12f0-4634-9d3e-404ad37e6...
Microsoft Azure
Search resources, services, and docs (G+/)
lennil@hotmail.com
LENNI LOBEL
Dashboard
cdb-wus | Data Explorer
Azure Cosmos DB account
Save
Discard
SQL API
Families
Families
Items
Scale & Settings
Stored Procedures
User Defined Functions
Triggers
Conflicts
Scale & Settin...
Conflict resolution
Mode
Last Write Wins (default)
Merge Procedure (custom)
Stored procedure
resolveConflict
Settings
0
0
2


Multi-master Conflict Resolution
Every region is enabled for writes
Three options for conflict resolution
Last writer wins
Based on highest timestamp value in _ts
Custom procedure
Based on stored procedure result
Conflicts feed
Offline resolution


cdb-wus | Data Explorer - Micros
portal.azure.com/#@lennilhotmail.onmicrosoft.com/resource/subscriptions/6327c571-12f0-4634-9d3e-404ad37e6...
Microsoft Azure
Search resources, services, and docs (G+/)
lennil@hotmail.com
LENNI LOBEL
Dashboard
cdb-wus | Data Explorer
Azure Cosmos DB account
Save
Discard
SQL API
Families
Families
Items
Scale & Settings
Stored Procedures
User Defined Functions
Triggers
Conflicts
Scale & Settin...
Conflict resolution
Mode
Last Write Wins (default)
Merge Procedure (custom)
Stored procedure
Settings
0
0
2


Replication and Consistency
Replication within a region
Multiple replicas invite "dirty reads"
Extremely rare, since replicas are updated extremely fast
Global replication
It takes hundreds of milliseconds to move data across continents
Much more common to experience dirty reads
How to ensure consistent reads across replicas?
Define a consistency level
Cleaner reads
Higher latency
Dirtier reads
Lower latency
Strong
Bounded Staleness
Session
Consistent Prefix
Eventual


Five Consistency Levels
Strong
Bounded Staleness
Session
Consistent Prefix
Eventual
No dirty reads
Highest write latency
Consistent reads at low latency
Reads from quorum
Can combine with global
Dirty reads possible
Configurable staleness
Bounded by time and updates
Reads from quorum
Default level
No dirty reads for writers (read your own writes)
Dirty reads possible for other users
Usually reads from single replica
Reads from single replica
Dirty reads possible
Quorum is already updated
Reads never see out-of-order writes
No guarantees
Lowest write latency
Best performance
Reads from single replica
Dirty reads possible in any order


Five Consistency Levels
Too stale
Not too stale
Strong
Bounded Staleness
Session
Consistent Prefix
Eventual
No dirty reads
Highest write latency
Consistent reads at low latency
Reads from quorum
Can combine with global
Dirty reads possible
Configurable staleness
Bounded by time and updates
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Default level
No dirty reads for writers (read your own writes)
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Usually reads from single replica
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Reads never see out-of-order writes
No guarantees
Lowest write latency
Best performance
Reads from single replica
Dirty reads possible in any order

Five Consistency Levels

Strong

- No dirty reads
- Highest write latency
- Consistent reads at low latency
- Reads from quorum
- Can combine with global

Bounded Staleness

- Dirty reads possible
- Configurable staleness
- Bounded by time and updates
- Reads from quorum

Session

- Default level
- No dirty reads for writers (read your own writes)
- Dirty reads possible for other users
- Usually reads from single replica

Consistent Prefix

- Reads from single replica
- Dirty reads possible
- Quorum is already updated
- Reads never see out-of-order writes

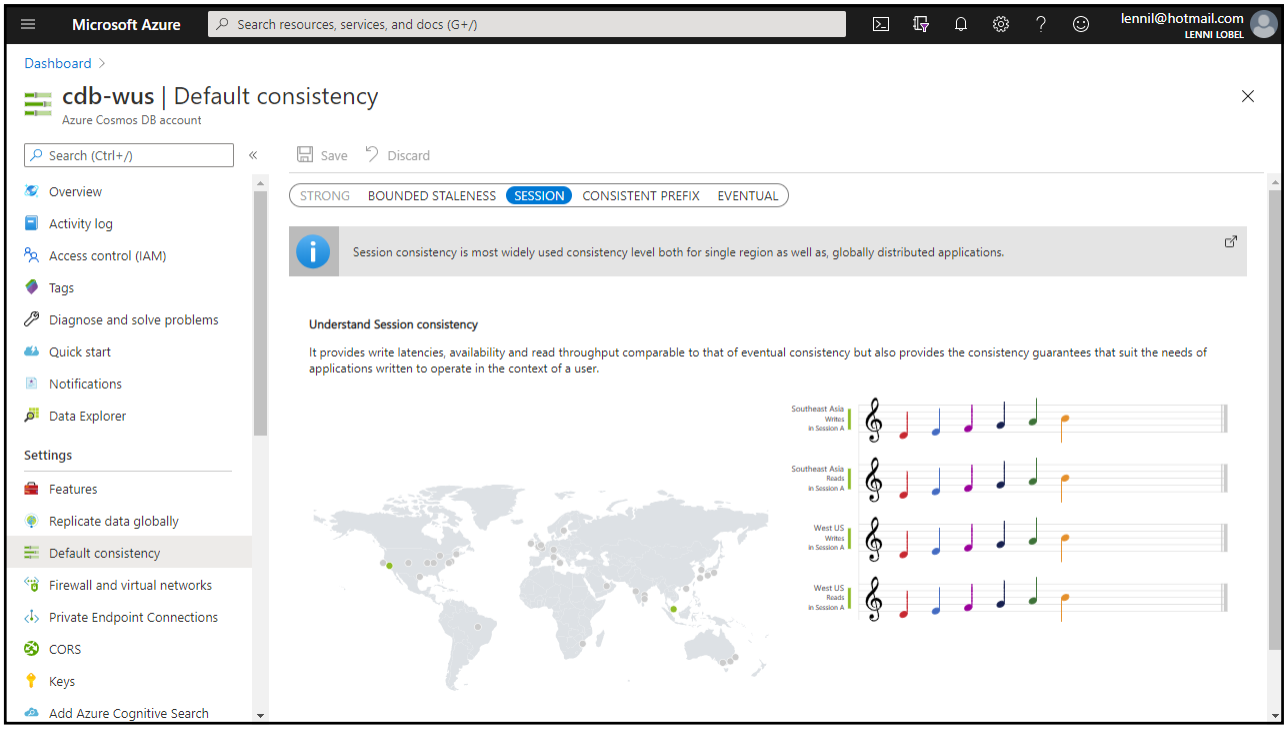
Eventual

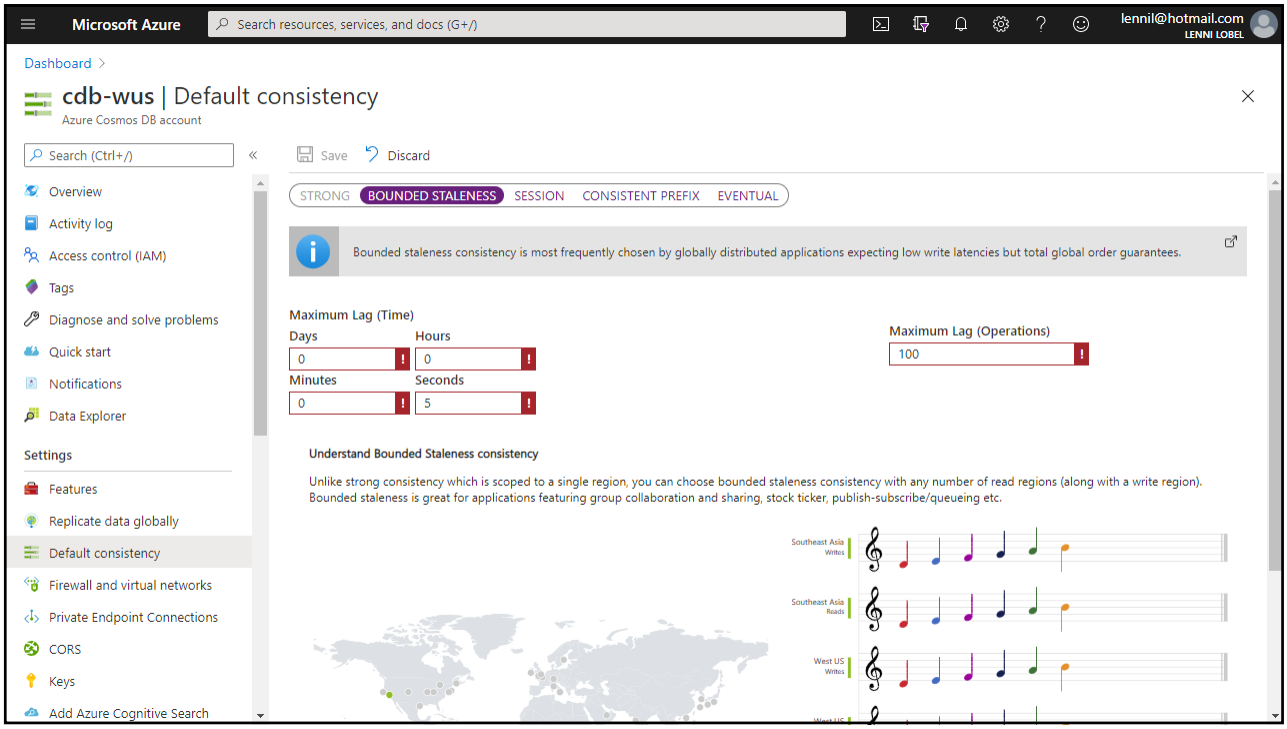
- No guarantees
- Lowest write latency
- Best performance
- Reads from single replica
- Dirty reads possible in any order

Setting the Consistency Level

Set default for entire account

Can be changed at any time


Microsoft Azure
Search resources, services, and docs (G+/)
lennil@hotmail.com
LENNI LOBEL
Dashboard
cdb-wus | Default consistency
Azure Cosmos DB account
Search (Ctrl+/)
Save
Discard
Overview
Activity log
Access control (IAM)
Tags
Diagnose and solve problems
Quick start
Notifications
Data Explorer
Settings
Features
Replicate data globally
Default consistency
Firewall and virtual networks
Private Endpoint Connections
CORS
Keys
Add Azure Cognitive Search
STRONG
BOUNDED STALENESS
SESSION
CONSISTENT PREFIX
EVENTUAL
Session consistency is most widely used consistency level both for single region as well as, globally distributed applications.
Understand Session consistency
It provides write latencies, availability and read throughput comparable to that of eventual consistency but also provides the consistency guarantees that suit the needs of applications written to operate in the context of a user.


Microsoft Azure
Search resources, services, and docs (G+/)
lennil@hotmail.com
LENNI LOBEL
Dashboard
cdb-wus | Default consistency
Azure Cosmos DB account
Search (Ctrl+/)
Save
Discard
Overview
Activity log
Access control (IAM)
Tags
Diagnose and solve problems
Quick start
Notifications
Data Explorer
Settings
Features
Replicate data globally
Default consistency
Firewall and virtual networks
Private Endpoint Connections
CORS
Keys
Add Azure Cognitive Search
STRONG
BOUNDED STALENESS
SESSION
CONSISTENT PREFIX
EVENTUAL
Bounded staleness consistency is most frequently chosen by globally distributed applications expecting low write latencies but total global order guarantees.
Maximum Lag (Time)
Days
Hours
0
0
Minutes
Seconds
0
5
Maximum Lag (Operations)
100
Understand Bounded Staleness consistency
Unlike strong consistency which is scoped to a single region, you can choose bounded staleness consistency with any number of read regions (along with a write region). Bounded staleness is great for applications featuring group collaboration and sharing, stock ticker, publish-subscribe/queueing etc.

Setting the Consistency Level

Set default for entire account

Can be changed at any time

Override at the request level

Any request can weaken the default consistency level

```
new ItemRequestOptions { ConsistencyLevel = ConsistencyLevel.| }
```

BoundedStaleness
Eventual
Session
Strong

Cleaner reads
Higher latency

Strong | Bounded Staleness | Session | Consistent Prefix | Eventual

Dirtier reads
Lower latency

Building Event-driven Microservices using the Change Feed

Agenda

Part I

Introduction to Azure Cosmos DB

- Overview
- Management
- Indexing
- Multiple APIs
- Migration
- Throughput
- Partitioning
- Global distribution

Part II

Building Event-driven Microservices with the Cosmos DB Change Feed

- Replication
- Denormalization
- Notifications
- Materialized views
- Data movement

Objectives

Cosmos DB

Review partitioning

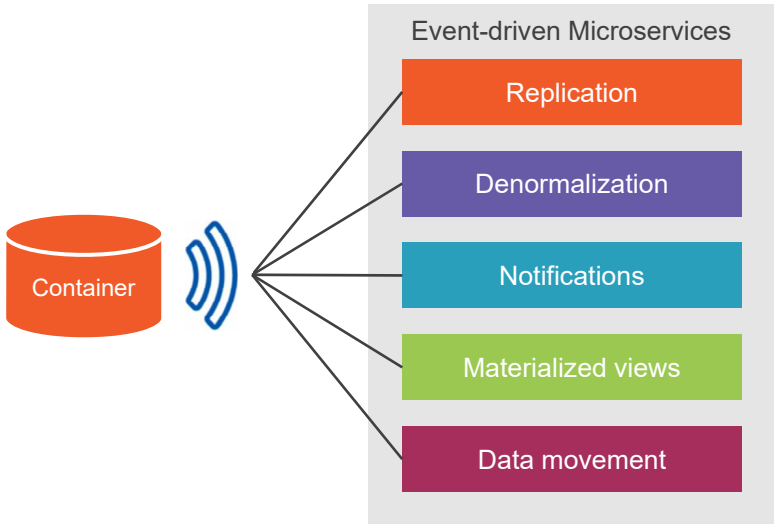
Change feed

Learn about Cosmos DB change feed

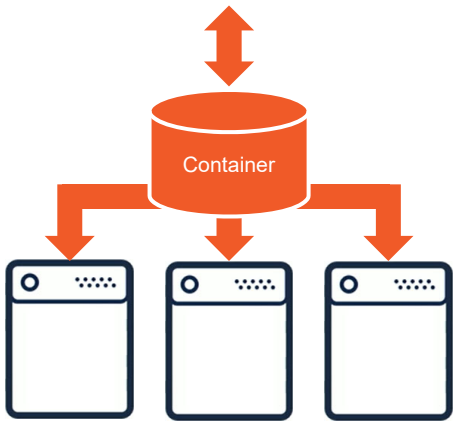
Microservices

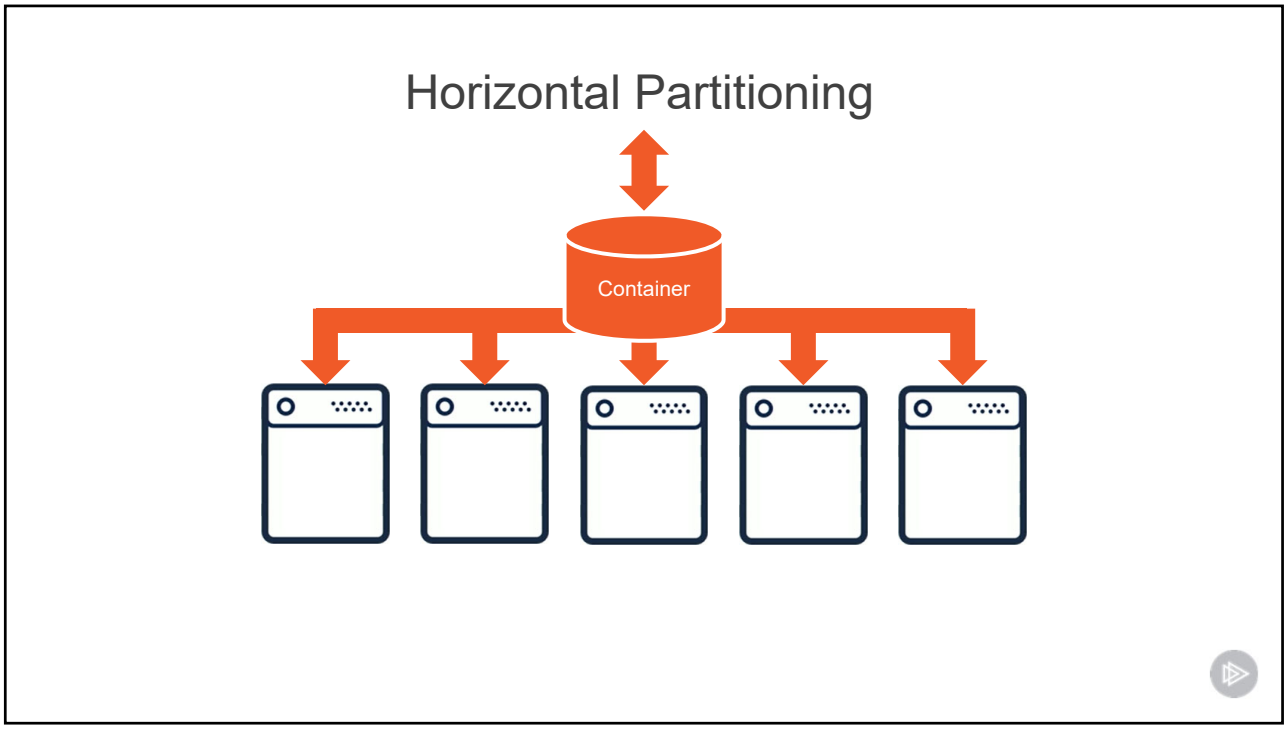
Apply these concepts to build event-driven microservices

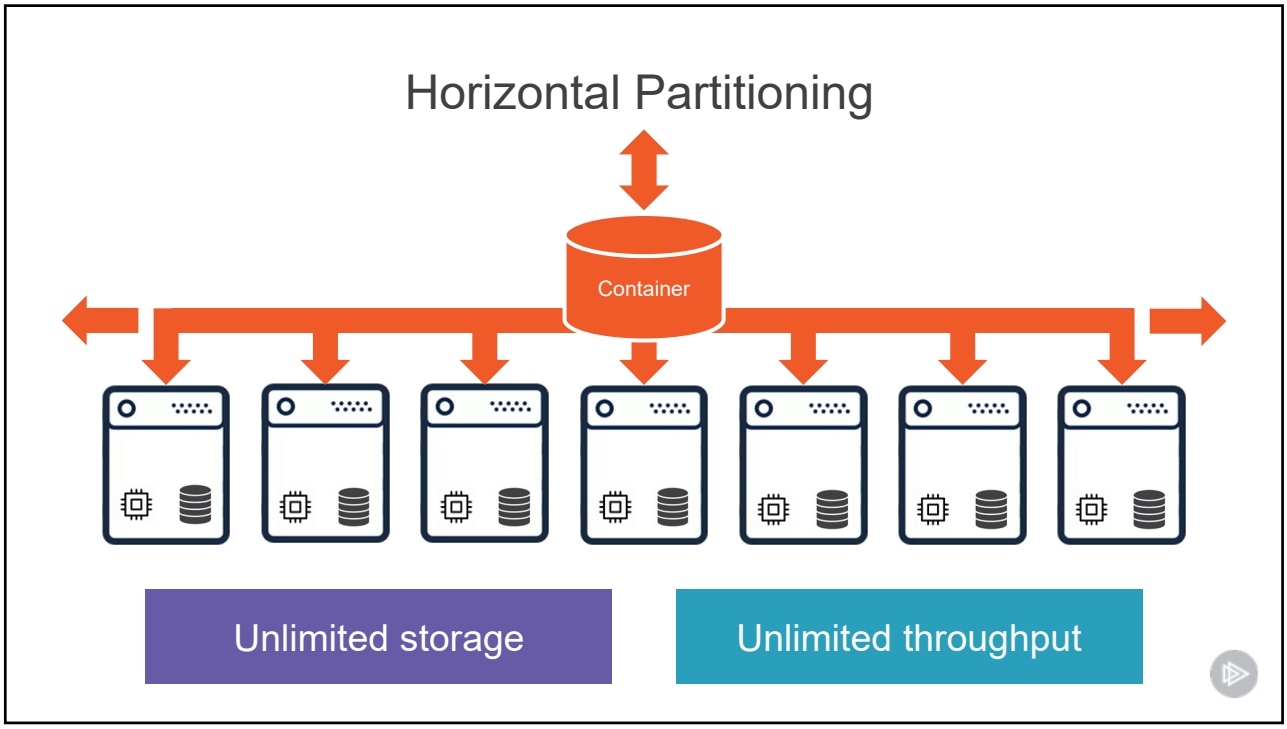
Introducing Change Feed

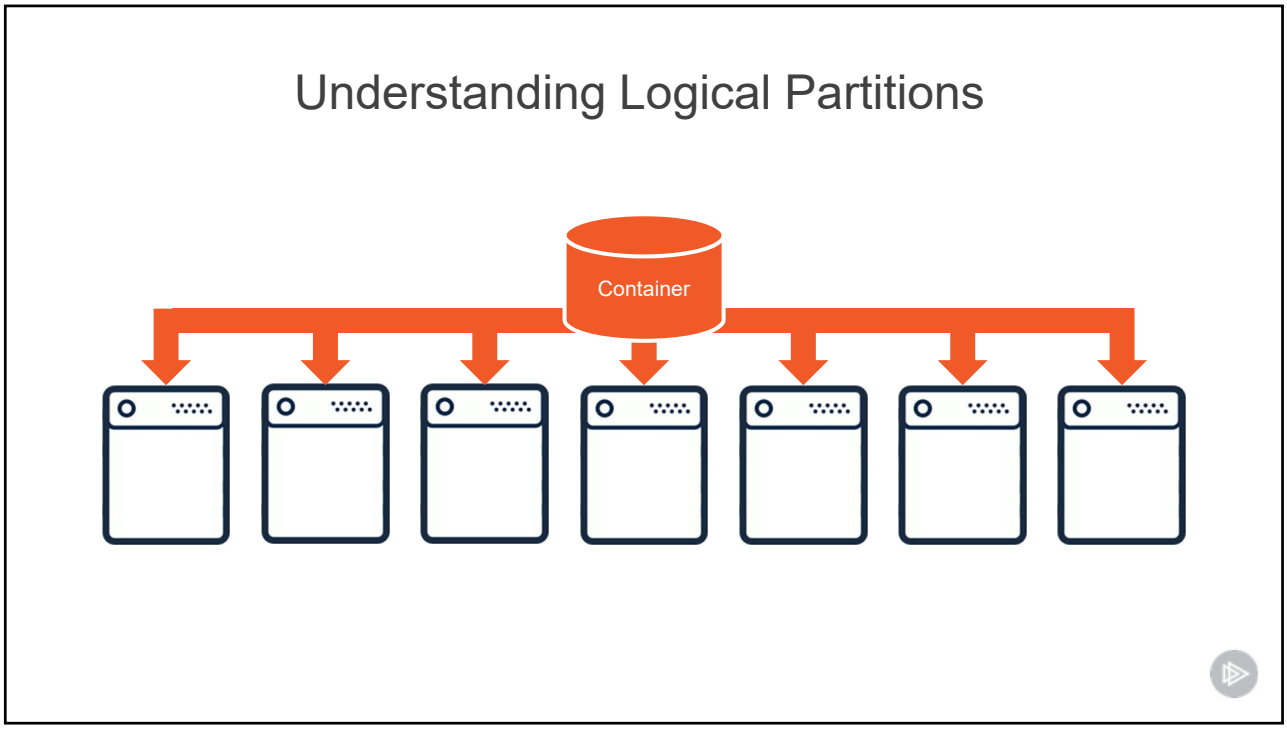


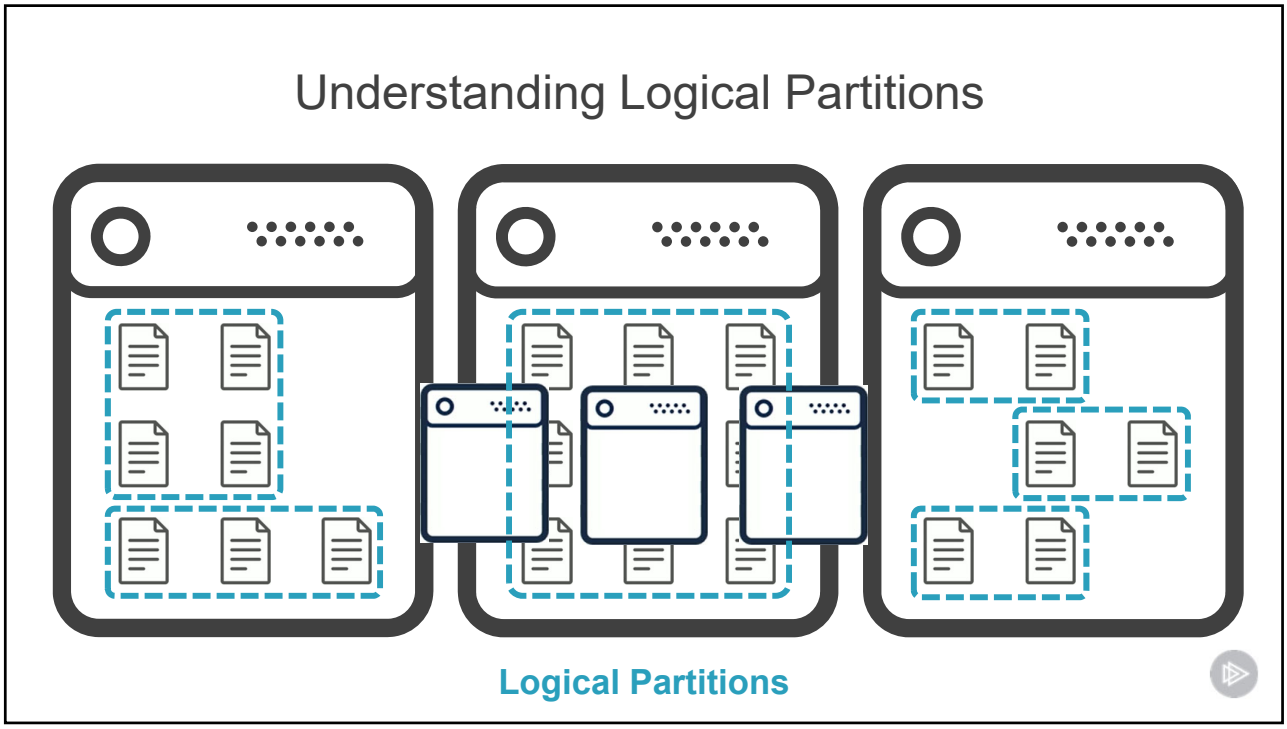
Horizontal Partitioning



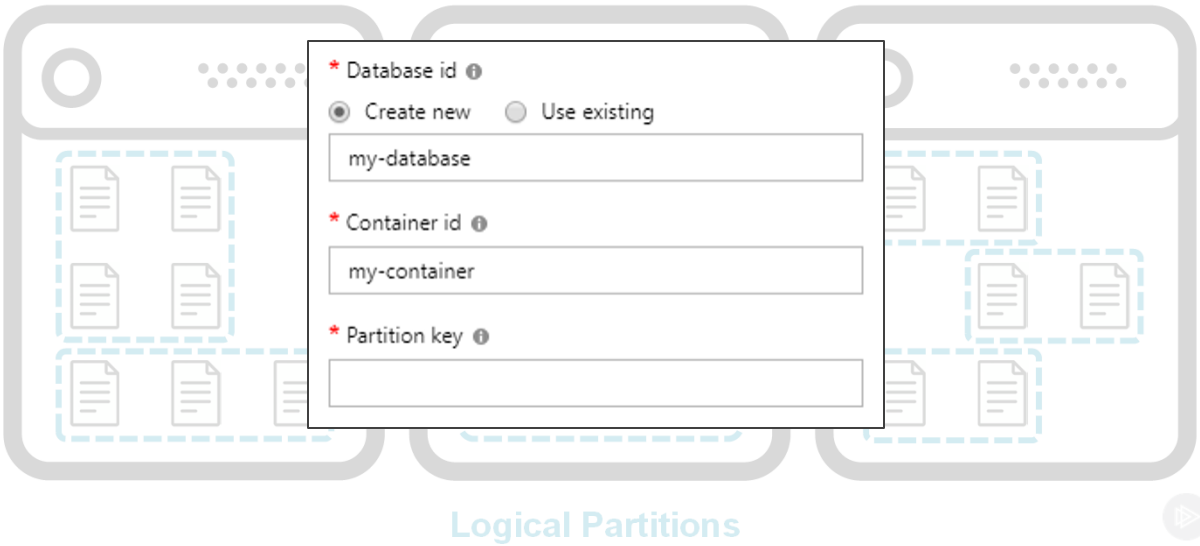

Horizontal Partitioning
Container


Horizontal Partitioning
Container
Unlimited storage
Unlimited throughput

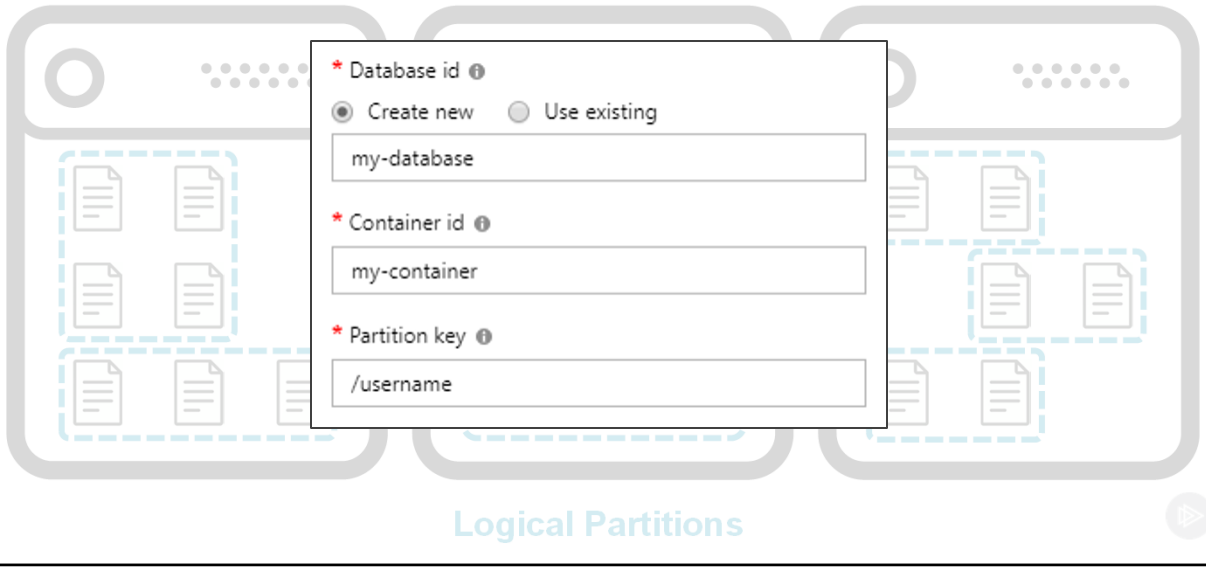

Understanding Logical Partitions
Container

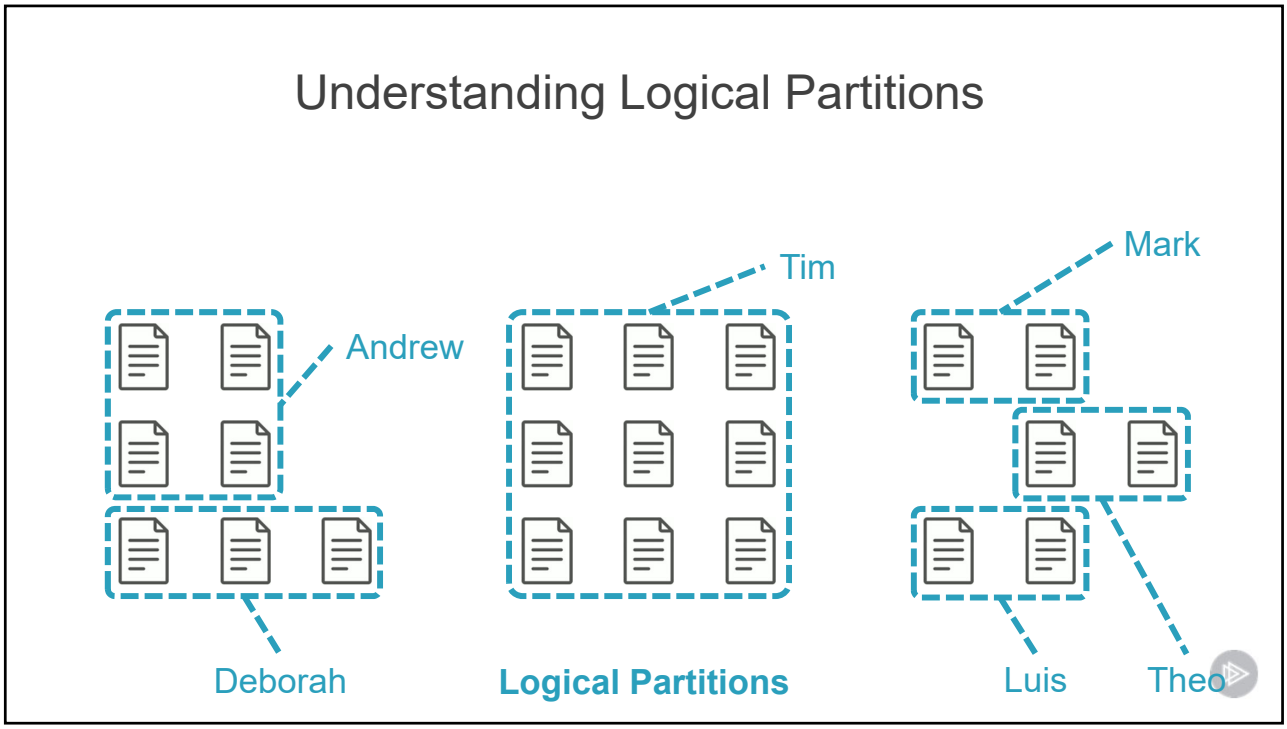

Understanding Logical Partitions
Logical Partitions

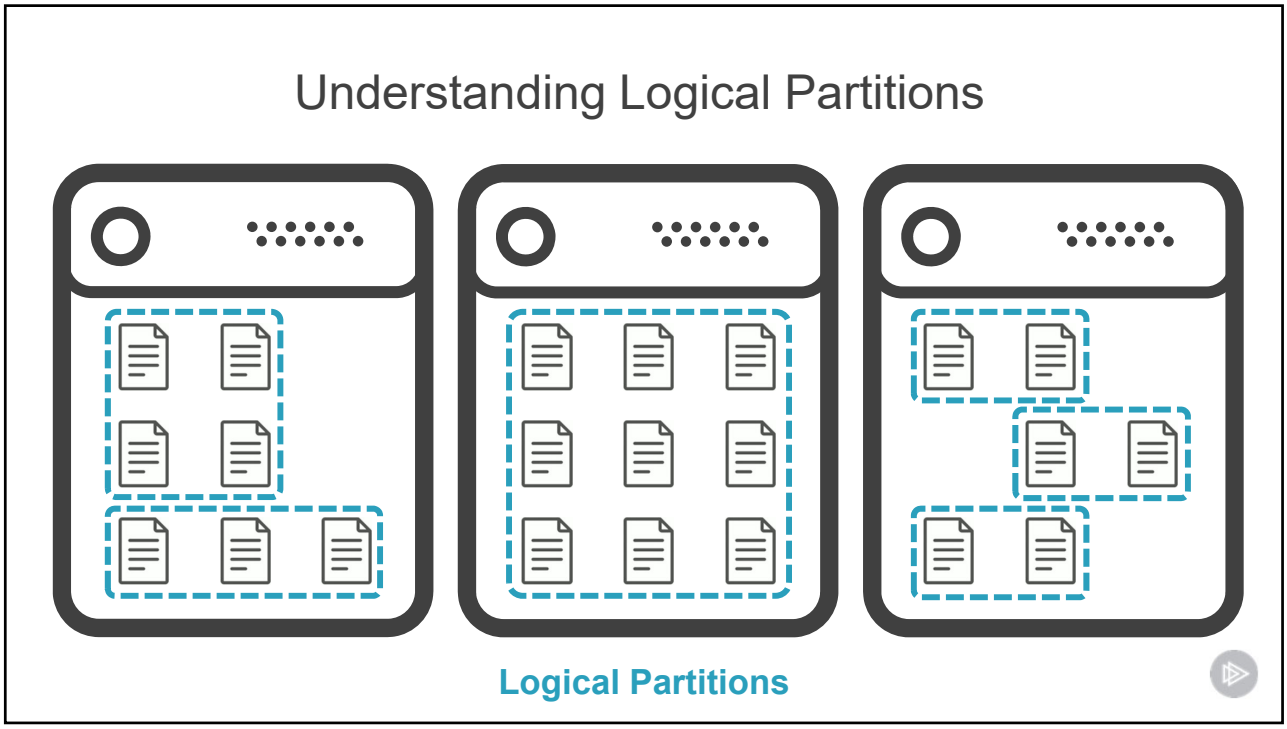
Understanding Logical Partitions



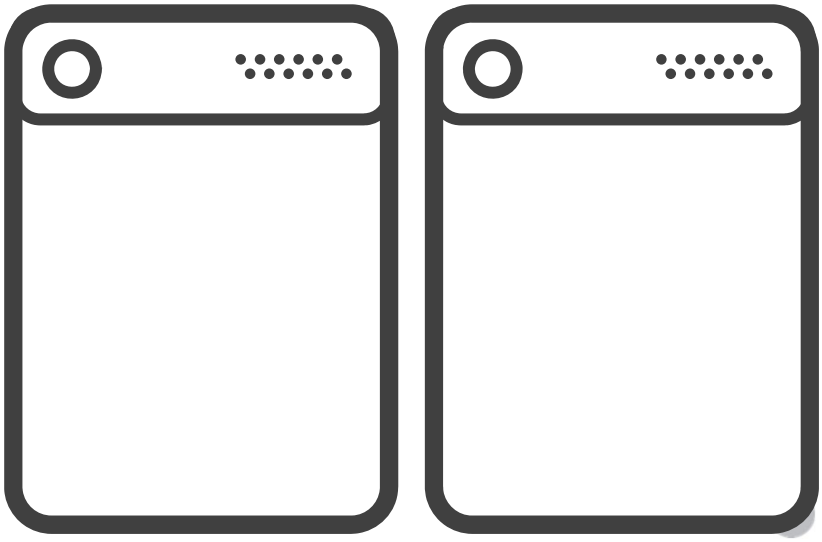
Understanding Logical Partitions




Understanding Logical Partitions
Andrew
Tim
Mark
Deborah
Logical Partitions
Luis
Theo


Understanding Logical Partitions
Logical Partitions

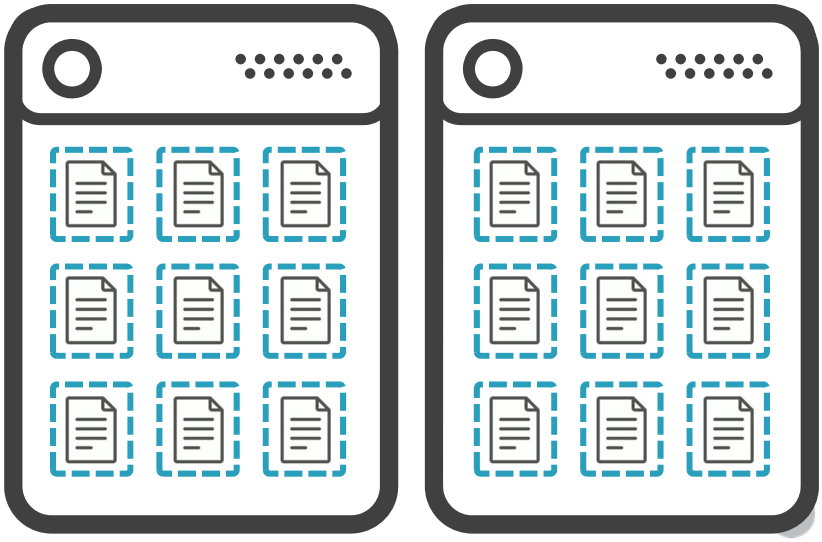
Common Partitioning Patterns



Common Partitioning Patterns

/id

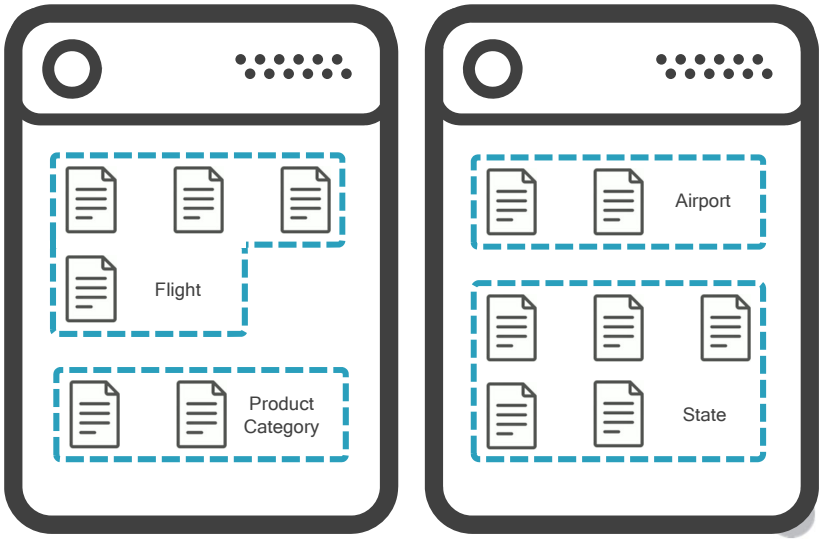
Single-documents



Common Partitioning Patterns

/id
Single-documents

/type
Small lookup lists

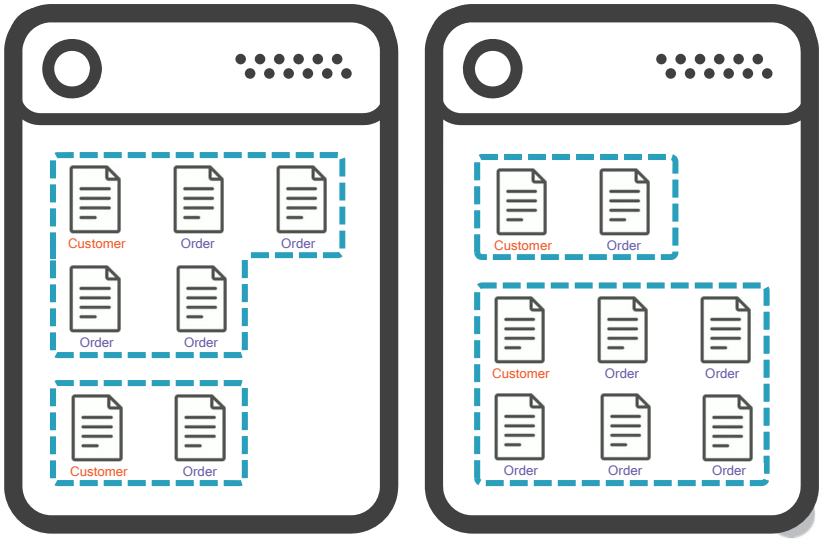


Common Partitioning Patterns

/id
Single-documents

/type
Small lookup lists

Other
Example: **/customerId**
Optimize for queries

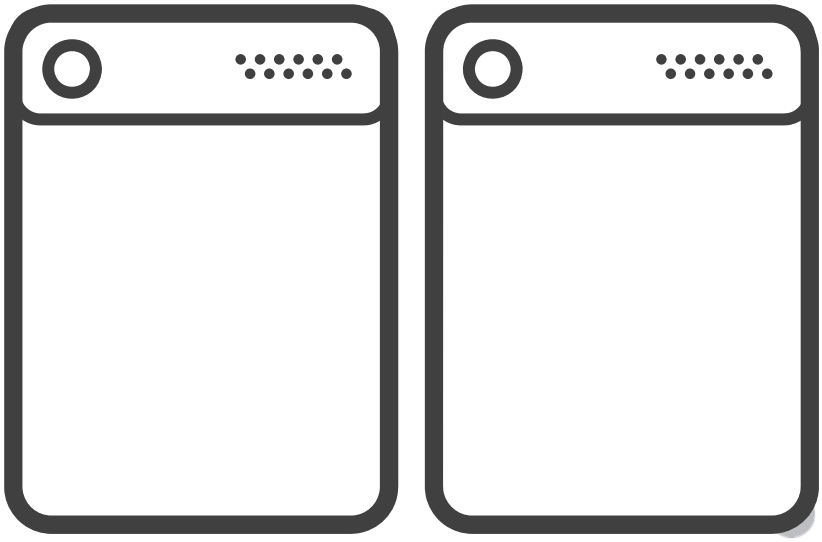


Common Partitioning Patterns

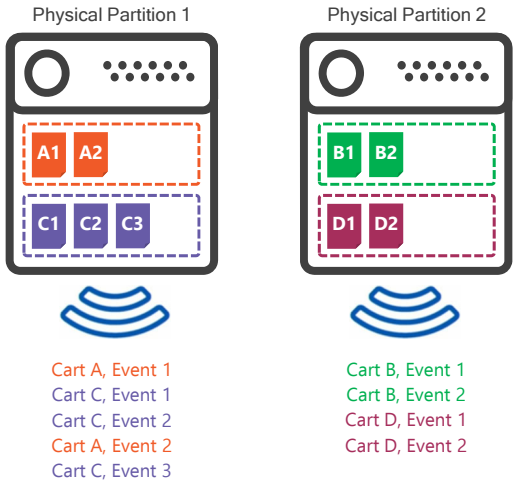
/id
Single-documents

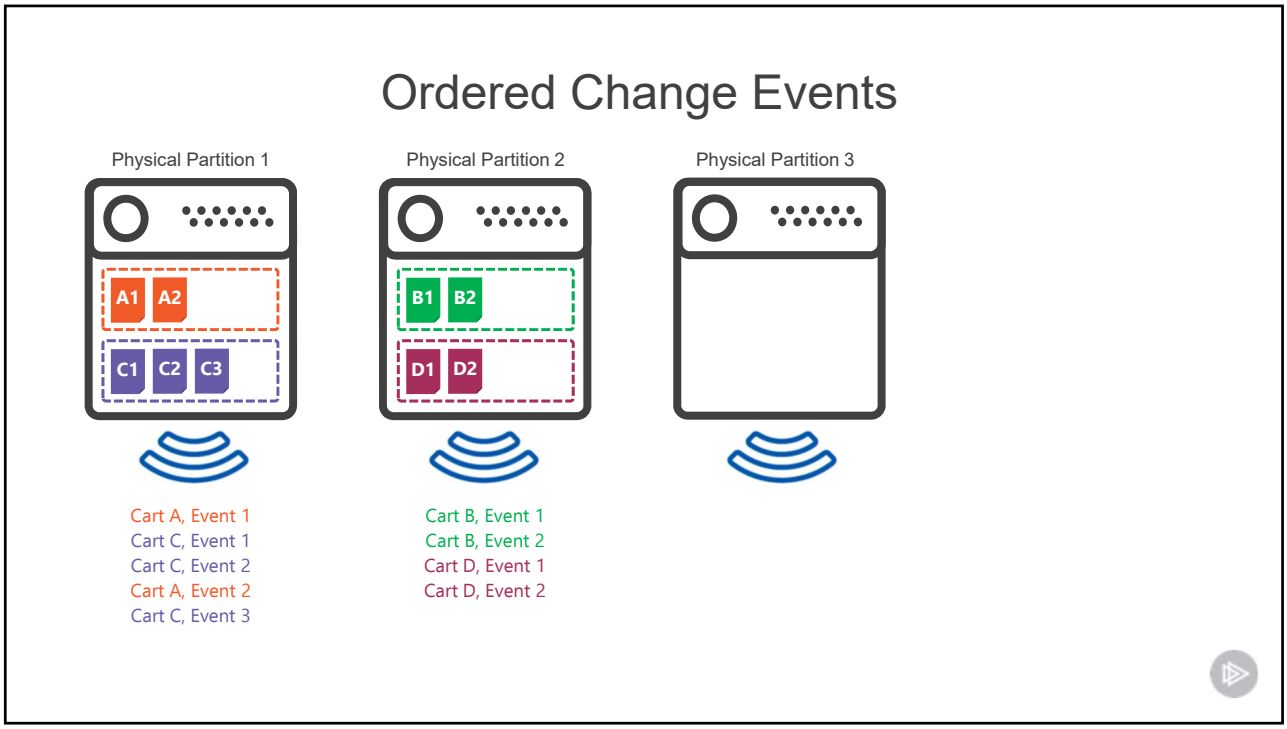
/type
Small lookup lists

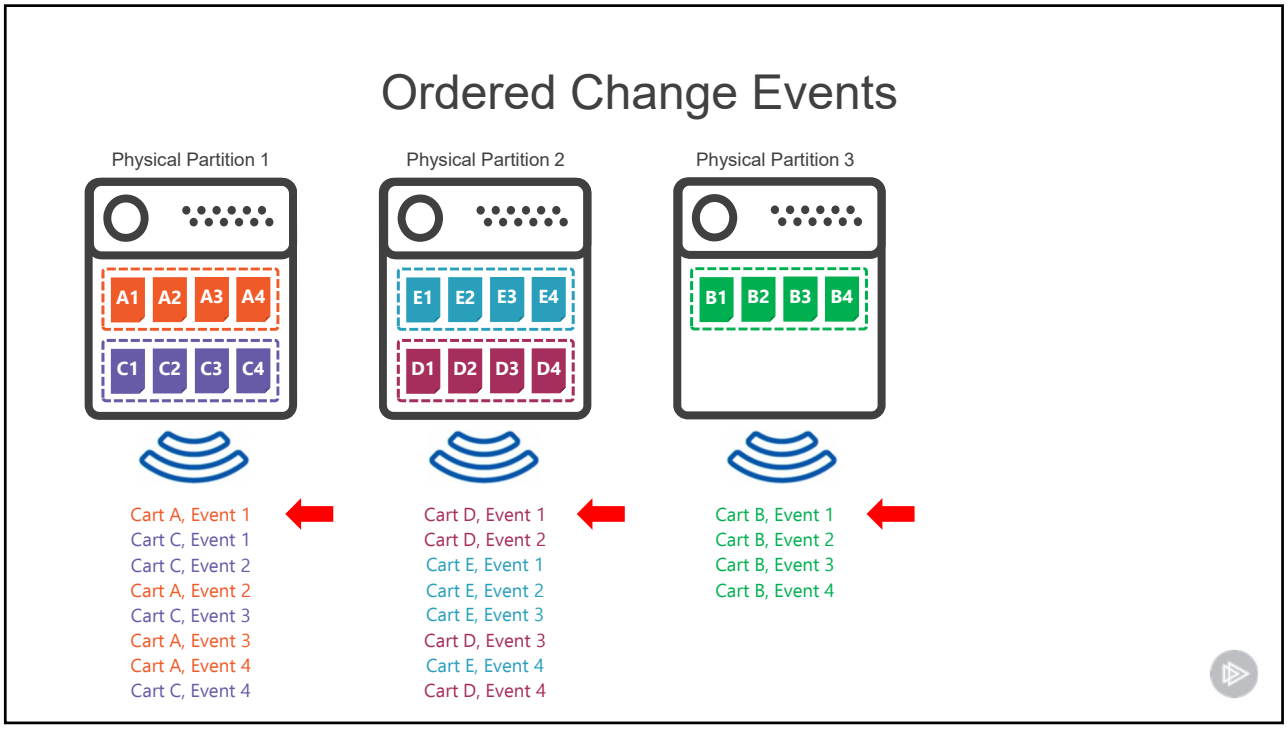
Other
Example: /customerId
Optimize for queries



Ordered Change Events




Ordered Change Events
Physical Partition 1
Physical Partition 2
Physical Partition 3
A1
A2
C1
C2
C3
B1
B2
D1
D2
Cart A, Event 1
Cart C, Event 1
Cart C, Event 2
Cart A, Event 2
Cart C, Event 3
Cart B, Event 1
Cart B, Event 2
Cart D, Event 1
Cart D, Event 2


Ordered Change Events
Physical Partition 1
Physical Partition 2
Physical Partition 3
A1
A2
A3
A4
C1
C2
C3
C4
E1
E2
E3
E4
D1
D2
D3
D4
B1
B2
B3
B4
Cart A, Event 1
Cart C, Event 1
Cart C, Event 2
Cart A, Event 2
Cart C, Event 3
Cart A, Event 3
Cart A, Event 4
Cart C, Event 4
Cart D, Event 1
Cart D, Event 2
Cart E, Event 1
Cart E, Event 2
Cart E, Event 3
Cart D, Event 3
Cart E, Event 4
Cart D, Event 4
Cart B, Event 1
Cart B, Event 2
Cart B, Event 3
Cart B, Event 4

Ordered Change Events

Physical Partition 1	Physical Partition 2	Physical Partition 3	Logical Change Feed
			Cart A, Event 1
			Cart D, Event 1
			Cart C, Event 1
			Cart D, Event 2
			Cart B, Event 1
			Cart D, Event 3
			Cart E, Event 1
			Cart C, Event 2
			Cart A, Event 2
			Cart B, Event 2
			Cart C, Event 3
			Cart E, Event 2
Cart A, Event 1	Cart D, Event 1	Cart B, Event 1	Cart A, Event 3
Cart C, Event 1	Cart D, Event 2	Cart B, Event 2	Cart E, Event 3
Cart C, Event 2	Cart E, Event 1	Cart B, Event 3	Cart B, Event 3
Cart A, Event 2	Cart E, Event 2	Cart B, Event 4	Cart A, Event 4
Cart C, Event 3	Cart E, Event 3		Cart E, Event 4
Cart A, Event 3	Cart D, Event 3		Cart B, Event 4
Cart A, Event 4	Cart E, Event 4		Cart D, Event 4
Cart C, Event 4	Cart D, Event 4		Cart C, Event 4

Consuming the Change Feed

Directly

Low-level direct access, per partition

Change Feed Processor (CFP) Library

Stateful and scalable

Azure Functions

Serverless wrapper around the CFP Library

Curing Analysis Paralysis

Choose a partition key

Based on your most common querying patterns

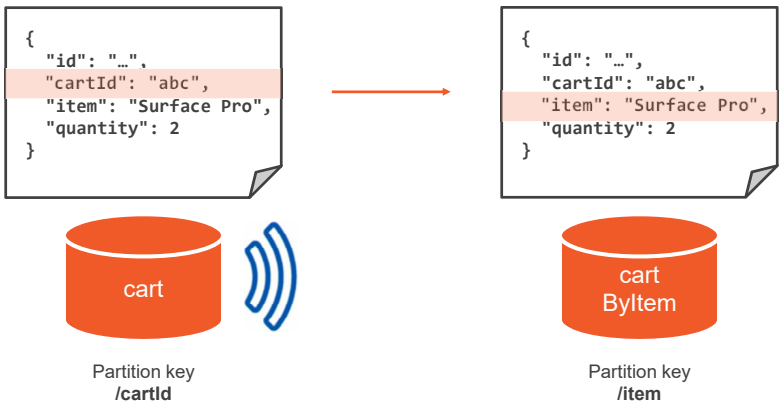
Only ONE partition key

What if you have more than just one common querying pattern?

Replication

Synchronize multiple containers with the same data, partitioned differently

Using Change Feed for Replication




```
SELECT * FROM c WHERE c.cartId = 'abc'
SELECT * FROM c WHERE c.item = 'Surface Pro'
```

Partition key

Processing Updates and Deletes

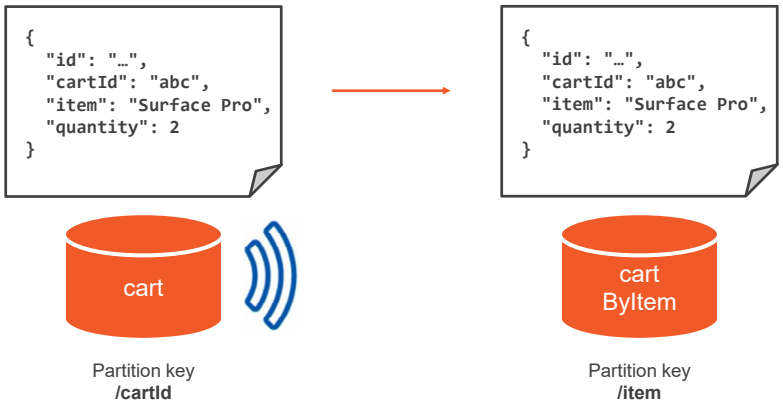
Updates

Interim updates are not retained by the change feed

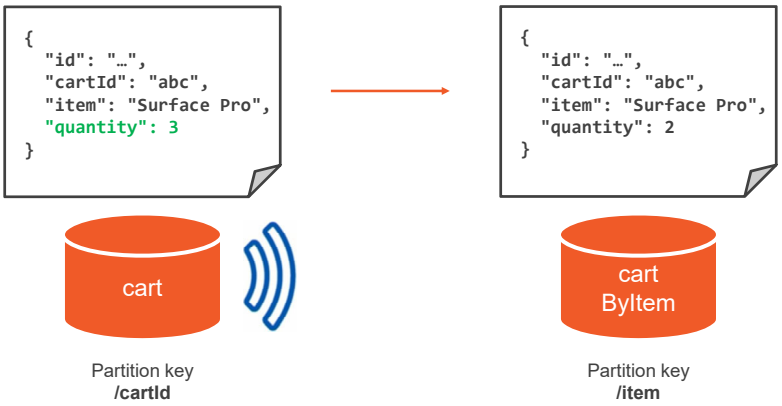
Deletes

Deletes are not written to the change feed

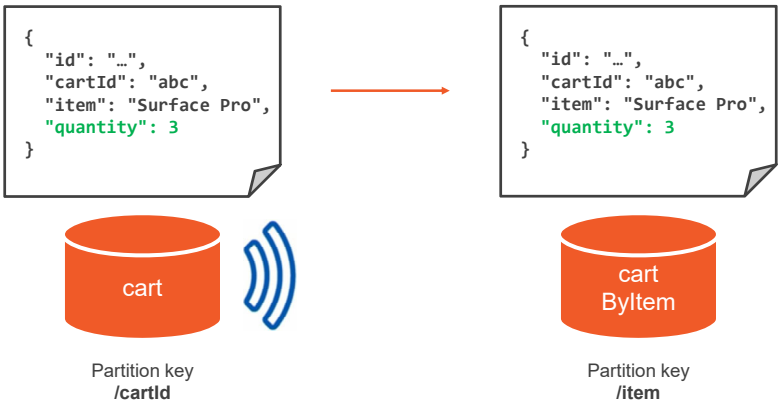
Processing Updates and Deletes



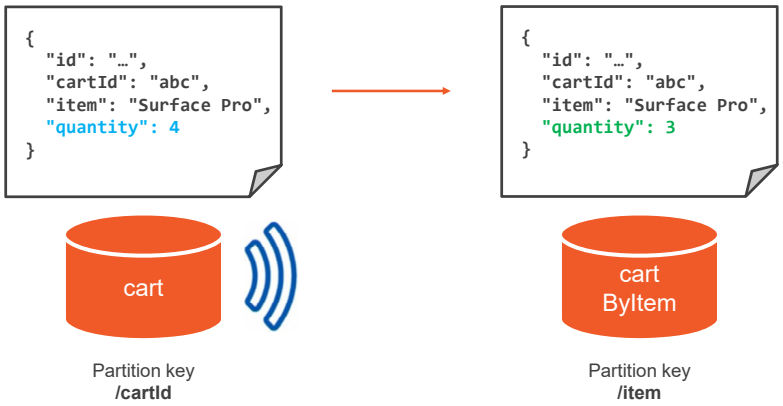
Processing Updates and Deletes



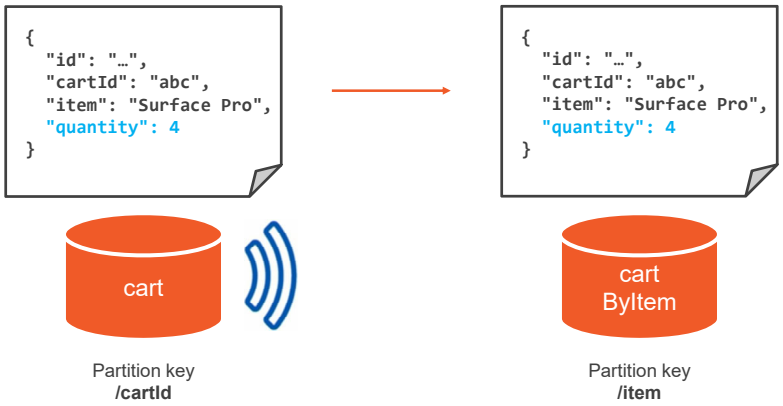
Processing Updates and Deletes



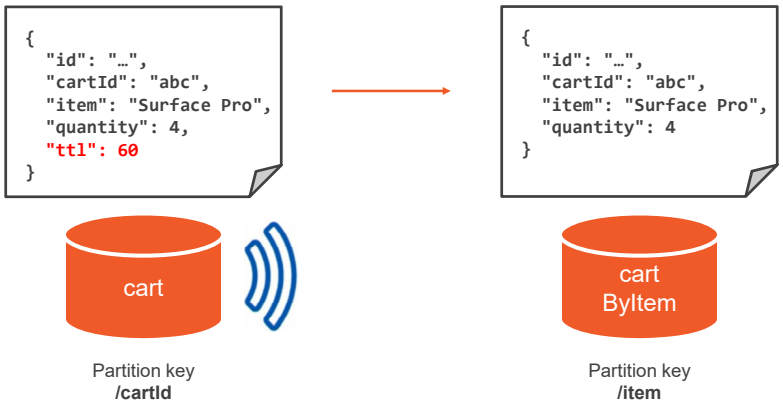
Processing Updates and Deletes



Processing Updates and Deletes



Processing Updates and Deletes



Full Fidelity Change Feed

Currently in Private Preview

Signup:
https://forms.office.com/r/zFYSrQuJVV

	Item Log	Operation Log
Operations	Inserts / latest updates only	All inserts, updates, and deletes
Retention	Infinite	Finite (max 30 days)
Optional metadata	None	Operation type, previous item version, delete via TTL

Using Azure Functions

CFP Library

Host is deployed to an Azure service

E.g., web job, worker role

Dedicated capacity

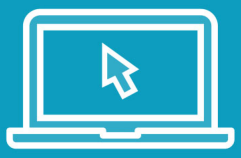
Azure Functions

Serverless, reactive functions

Shared capacity

Dedicated capacity with AF Premium

Demo



Replication Microservice

Handling Relational Workloads

Cosmos DB is non-relational

No JOINs

No relational constraints

Paradigm shift

Need to use different techniques to implement relations between entities

Denormalize

Duplicate specific properties

Satisfy queries with a single request

Querying Products

Category name?

Tag names?

product

```
SELECT * FROM c WHERE c.categoryId = '<categoryId>'
```

category

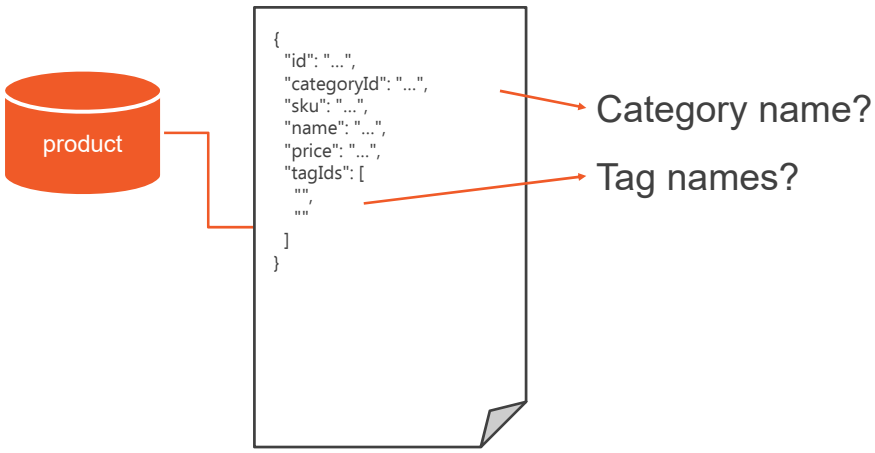
tag

product Meta

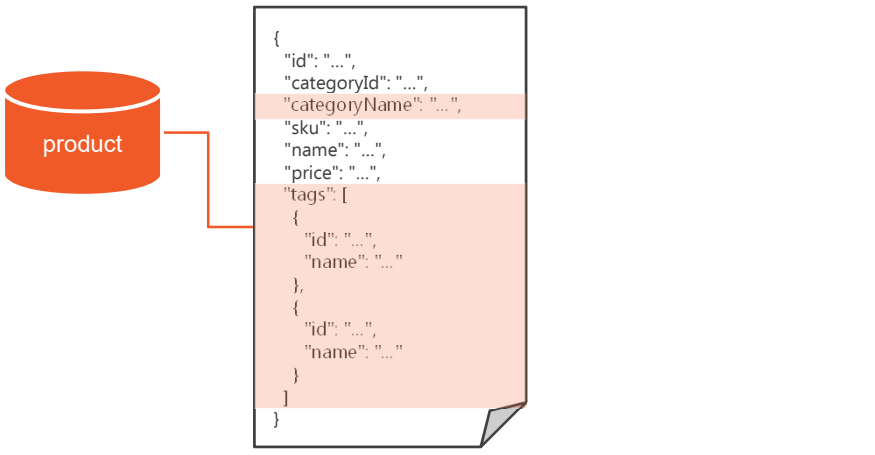
```
SELECT c.name FROM c WHERE c.type = 'category'
 AND c.id = '<categoryId>'
```

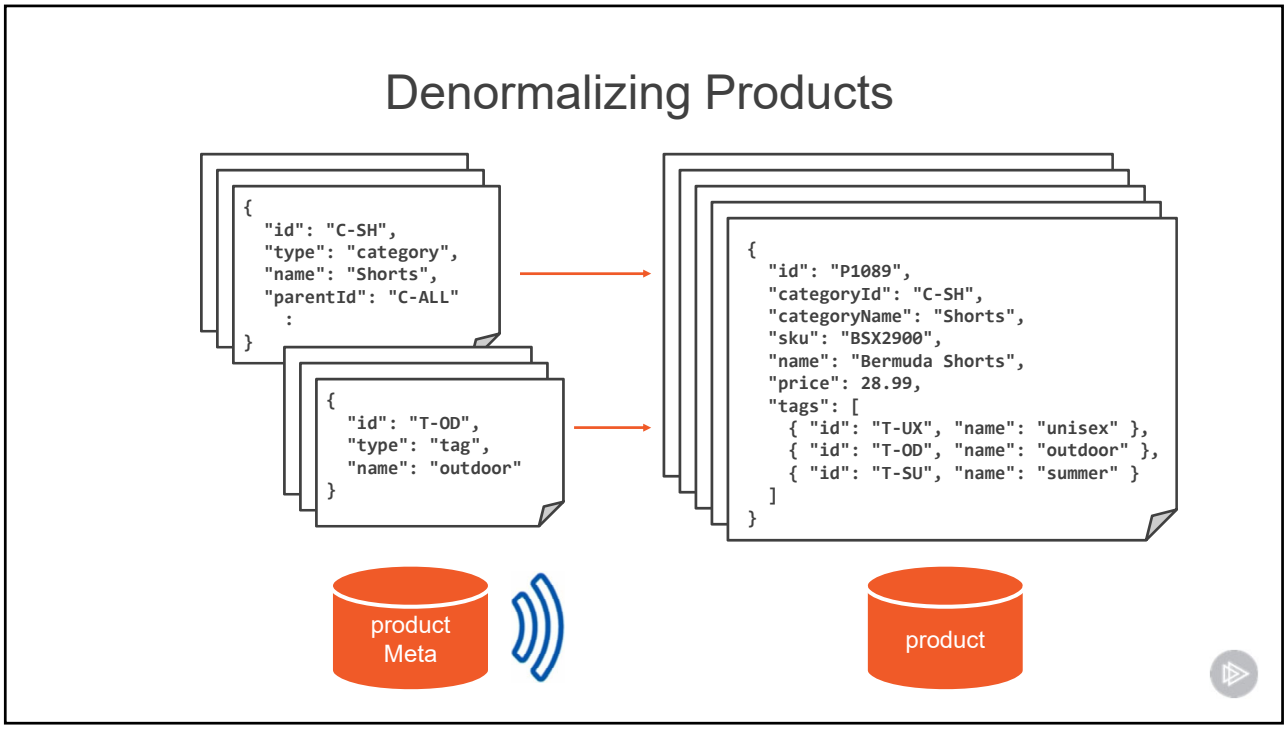
```
SELECT c.name FROM c WHERE c.type = 'tag'
 AND c.id IN '<tagId1>, <tagId2>, ..., <tagIdN>'
```

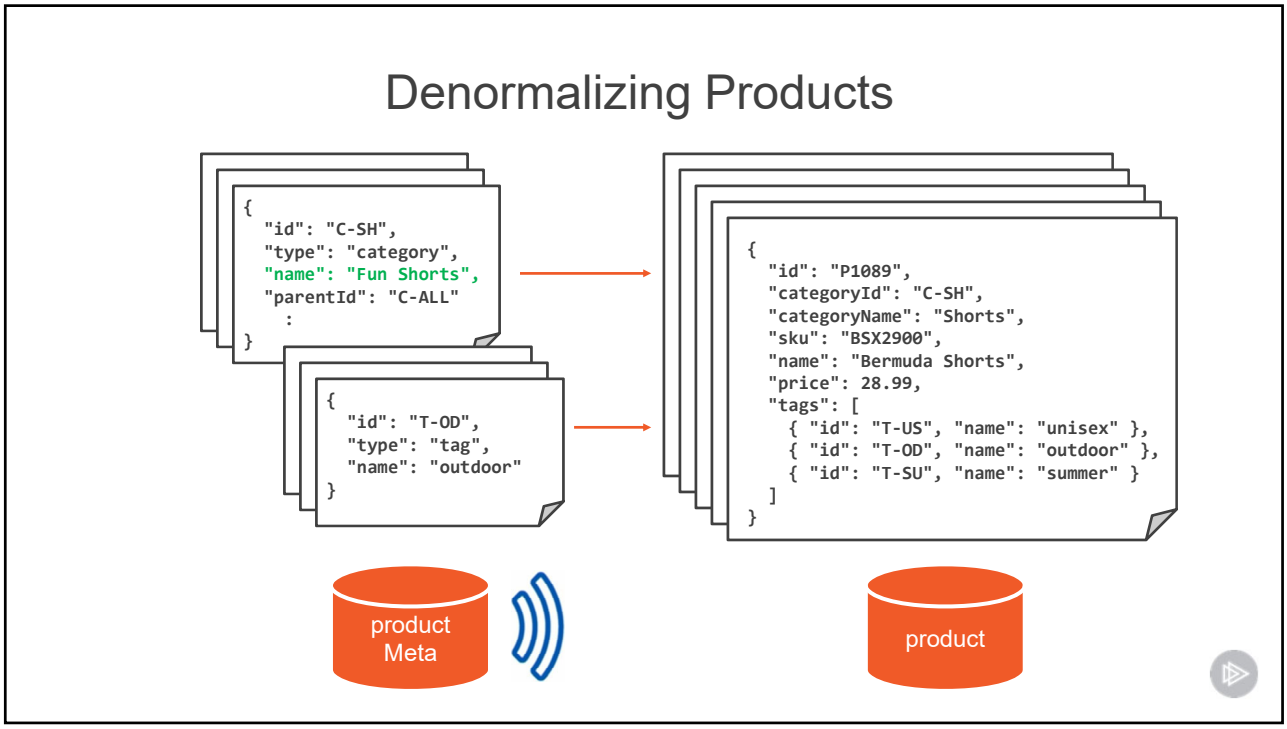
Denormalizing Products



Denormalizing Products




Denormalizing Products
{
"id": "C-SH",
"type": "category",
"name": "Shorts",
"parentId": "C-ALL"
:
}
{
"id": "T-OD",
"type": "tag",
"name": "outdoor"
}
{
"id": "P1089",
"categoryId": "C-SH",
"categoryName": "Shorts",
"sku": "BSX2900",
"name": "Bermuda Shorts",
"price": 28.99,
"tags": [
{ "id": "T-UX", "name": "unisex" },
{ "id": "T-OD", "name": "outdoor" },
{ "id": "T-SU", "name": "summer" }
]
}
product
Meta
product


Denormalizing Products
{
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:
}
{
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"name": "outdoor"
}
{
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"categoryName": "Shorts",
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"name": "Bermuda Shorts",
"price": 28.99,
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{ "id": "T-US", "name": "unisex" },
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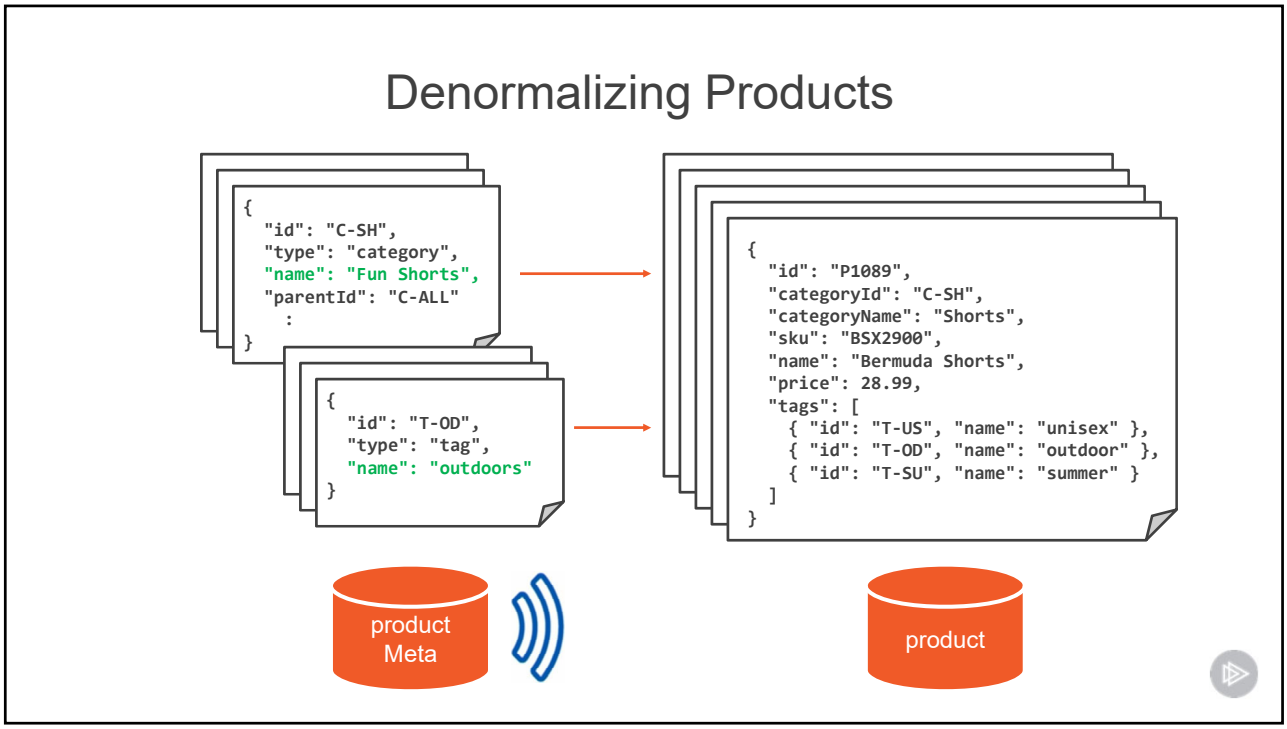
{ "id": "T-SU", "name": "summer" }
]
}
product
Meta
product


Denormalizing Products
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"name": "outdoors"
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"categoryId": "C-SH",
"categoryName": "Shorts",
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"name": "Bermuda Shorts",
"price": 28.99,
"tags": [
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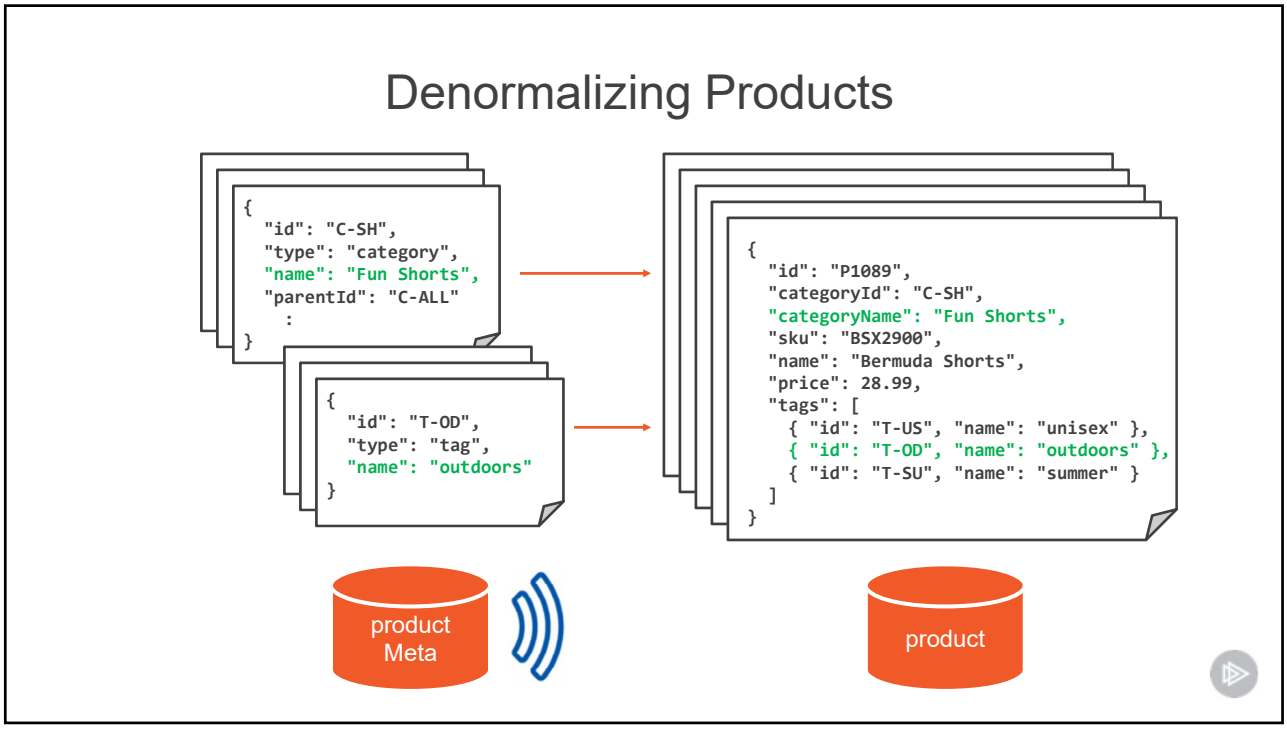
{ "id": "T-OD", "name": "outdoor" },
{ "id": "T-SU", "name": "summer" }
]
}
product Meta
product


Denormalizing Products
{
"id": "C-SH",
"type": "category",
"name": "Fun Shorts",
"parentId": "C-ALL"
:
}
{
"id": "T-OD",
"type": "tag",
"name": "outdoors"
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{
"id": "P1089",
"categoryId": "C-SH",
"categoryName": "Fun Shorts",
"sku": "BSX2900",
"name": "Bermuda Shorts",
"price": 28.99,
"tags": [
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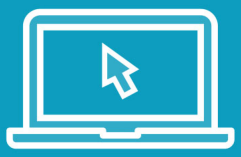
{ "id": "T-SU", "name": "summer" }
]
}
product Meta
product

Demo



Denormalization Microservice

Contoso Airlines IoT Scenario

We're a small airline

Continental U.S.

12 flights

6 airports

Requirements

Real-time flight info

No-fly zone alerts

Up-to-date arrivals

Permanent archival

Solution

Ingest flight telemetry

Implement microservices

Email alerts

Materialized views

Archive to Blob Storage

Ingesting Flight Telemetry

location container

Receives flight telemetry

Speed, altitude, duration, location (lat/long)

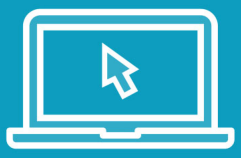
Every 10ms, per flight

Partitioned on /id

Exactly one document per logical partition

Optimized for bulk loading of device telemetry in real-time

Demo



Flight Telemetry Generator

No-fly Zone Alerts

Track all flights

Constantly monitor each flight location

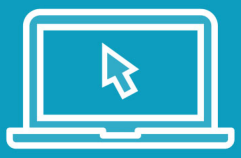
Issue alerts when a flight enters a no-fly zone

Monitor the change feed

Examine each telemetry document

Run a spatial query against designated no-fly zones

Demo



Email Alert Microservice

Querying Real-time Flight Data

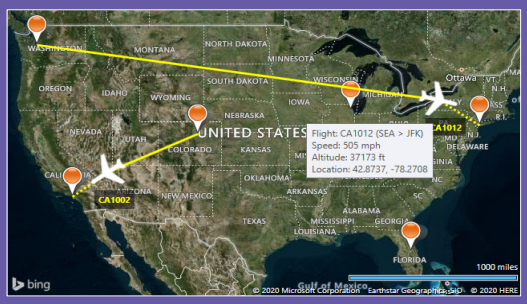
Get current telemetry

Query the location container for each flight in the air

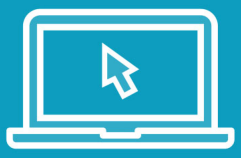
```
SELECT TOP 1 *
FROM c
WHERE
 c.flightNumber = 'CA1012'
ORDER BY
 c._ts DESC
```

Present a live map

Bing Maps mashup



Demo



Flight Location Map

Introducing Materialized Views

Get current location

Continuous querying for each flight's current telemetry

Expensive operation over voluminous raw data using cross-partition query

Build a materialized view

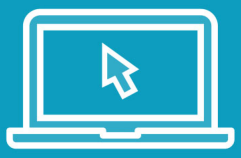
Materialize a tiny view – one document per flight

Partition on /type

Set /id to flight number

Extremely cheap to query the materialized view

Demo



Current Location Microservice

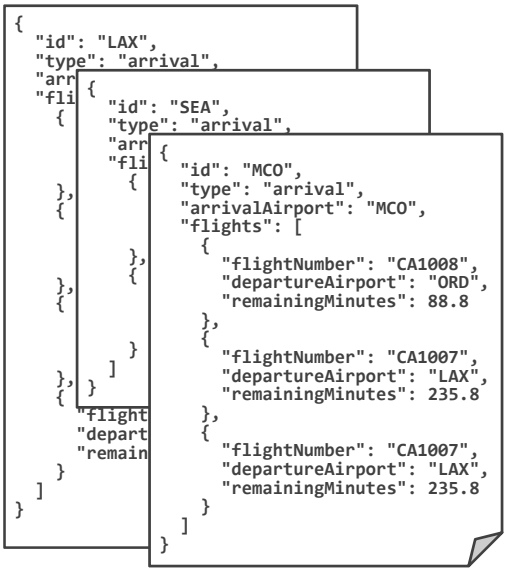
Querying Arrival Data

Get current telemetry

Query the remaining time for each flight in the air

Group the flights by airport

Create a materialized view



Querying Arrival Data

Get current telemetry

Query the remaining time for each flight in the air

Group the flights by airport

Create a materialized view

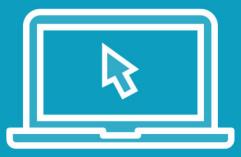
Present an arrivals board

Query the materialized view

ARRIVALS

Flight	From	To	Status
CA1001	JFK	LAX	10:49 PM
CA1002	DEN	LAX	ARRIVED
CA1003	ORD	LAX	09:33 PM
CA1005	MCO	LAX	10:06 PM
CA1010	SEA	LAX	ARRIVED

Demo



Arrivals Board Microservice

Data Movement

Replicate to Secondary Data Store

Feed data changes to downstream systems

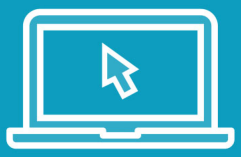
SQL Database

Archive to Cold Storage

Use TTL to establish a retention period

E.g., Azure Blob Storage, Azure Data Lake

Demo



Data Archival Microservice

Using the Pull Model Alternative

Consume at your own pace

Get all changes, or by partition key

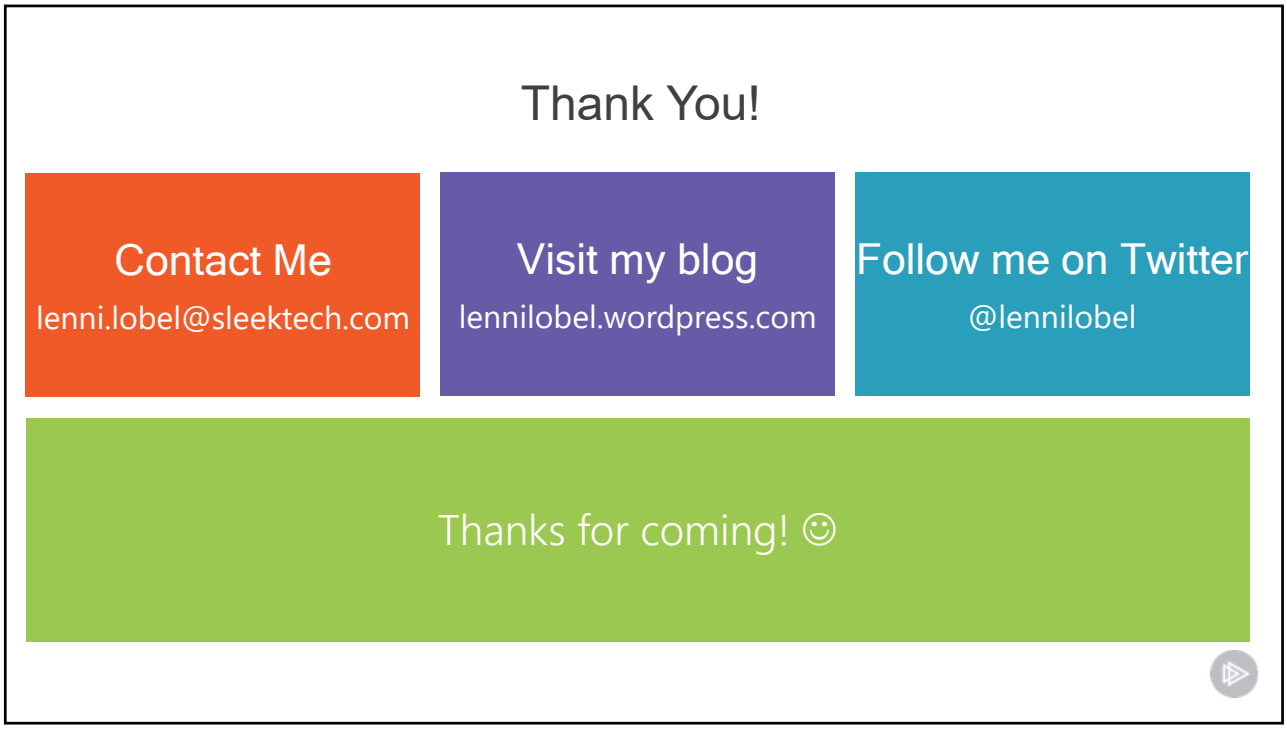
Specify an optional start time

When to use the pull model?

Reading changes by partition key

Controlling the pace

One-time migrations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