Graphing Your Way Through the Cosmos

Chad Green

South Florida Software Developer's Conference
February 29, 2020

Who is Chad Green

Director of Software Development
ScholarRx

Microsoft® MVP Most Valuable Professional

chadgreen@chadgreen.com

chadgreen.com

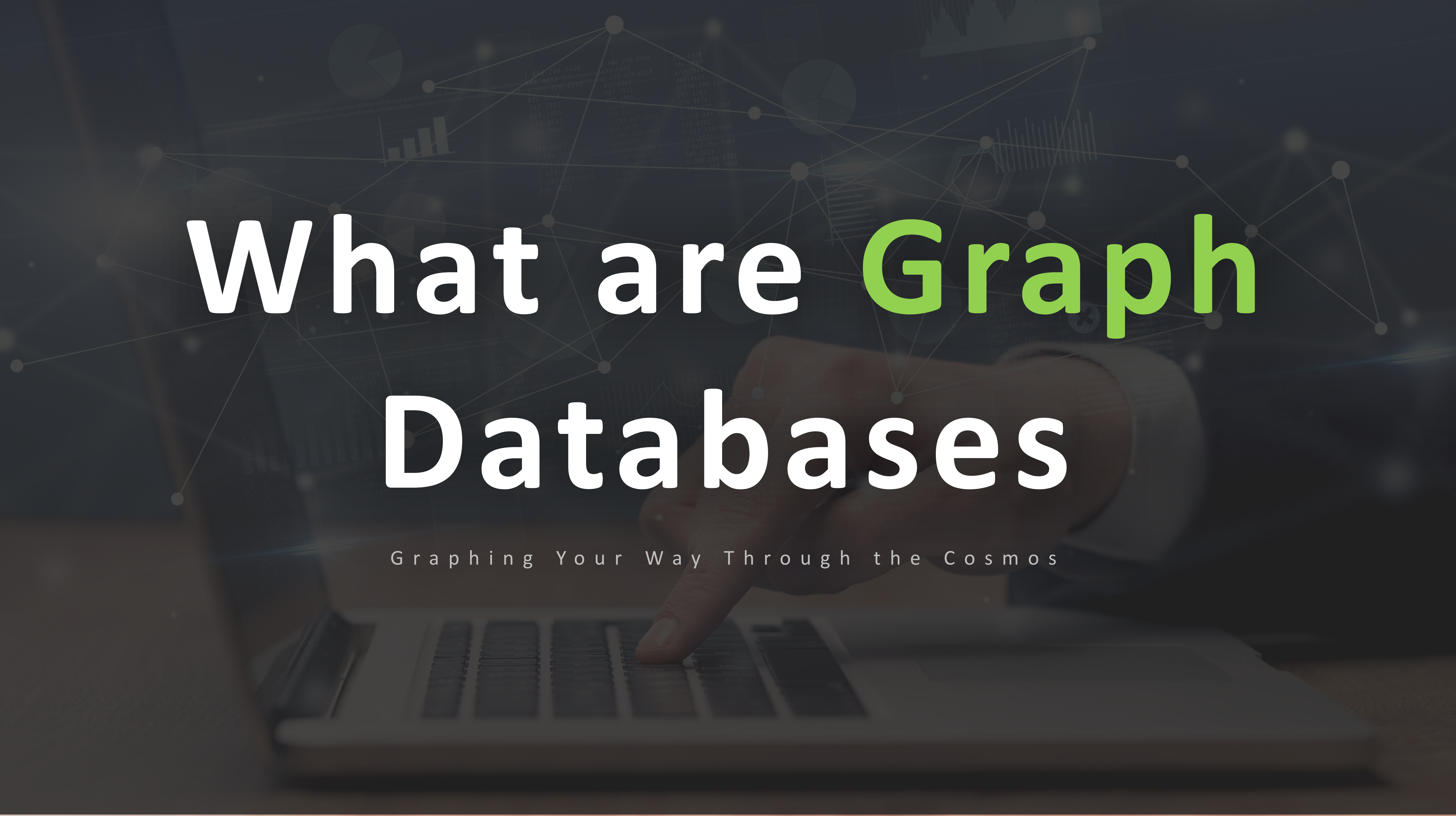
ChadGreen

ChadwickEGreen

{Code PaLOUsa}
IT'S SOFTWARE DEVELOPMENT MADNESS

What are Graph Databases

Graphing Your Way Through the Cosmos

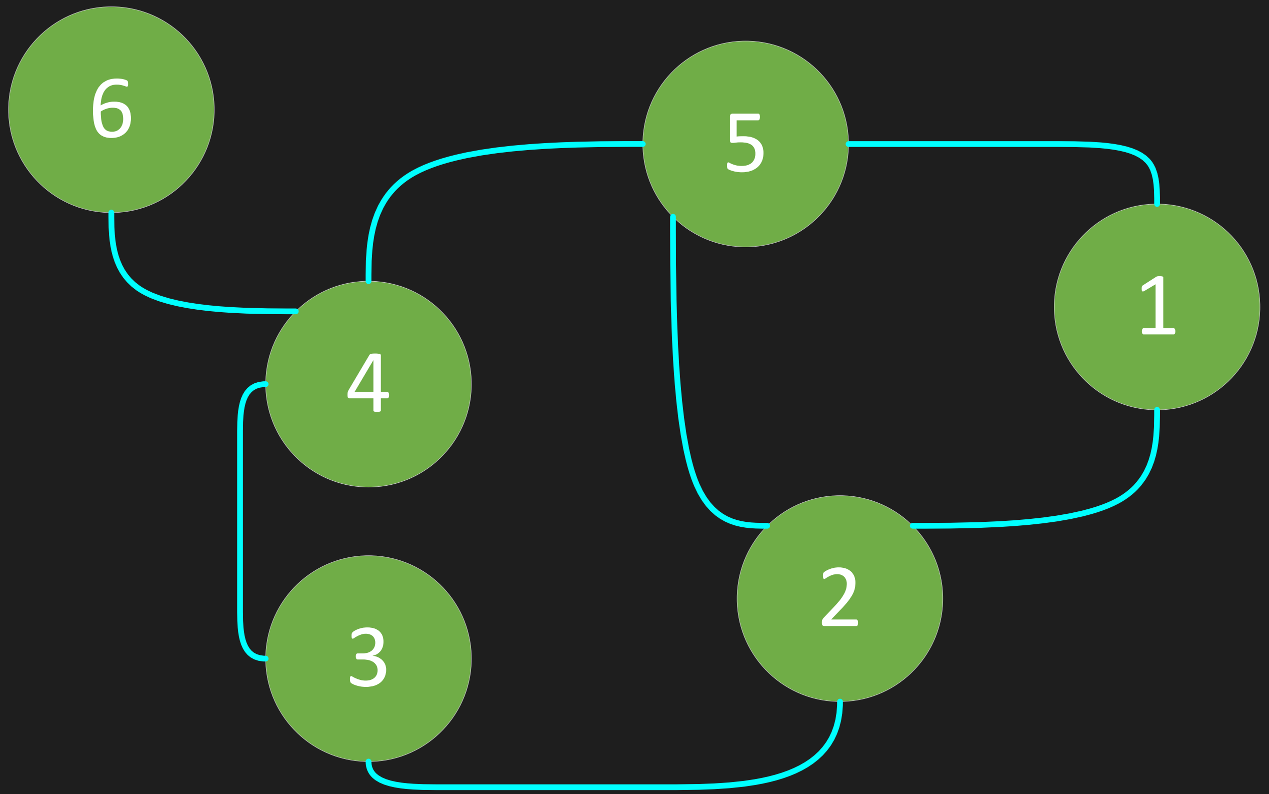


What is a Graph

- Discrete mathematics
- Structure amounting to a set of objects in which some pairs of the objects are in some sense related
- Objects correspond to mathematical abstractions called vertices and each of the related pairs of vertices is called an edge
- Graph Theory is the study of graphs

What is a Graph

- Depicted in diagrammatic form as a set of dots or circles for the vertices, joined by lines or curves for the edges



@chadgreen

What is a Graph

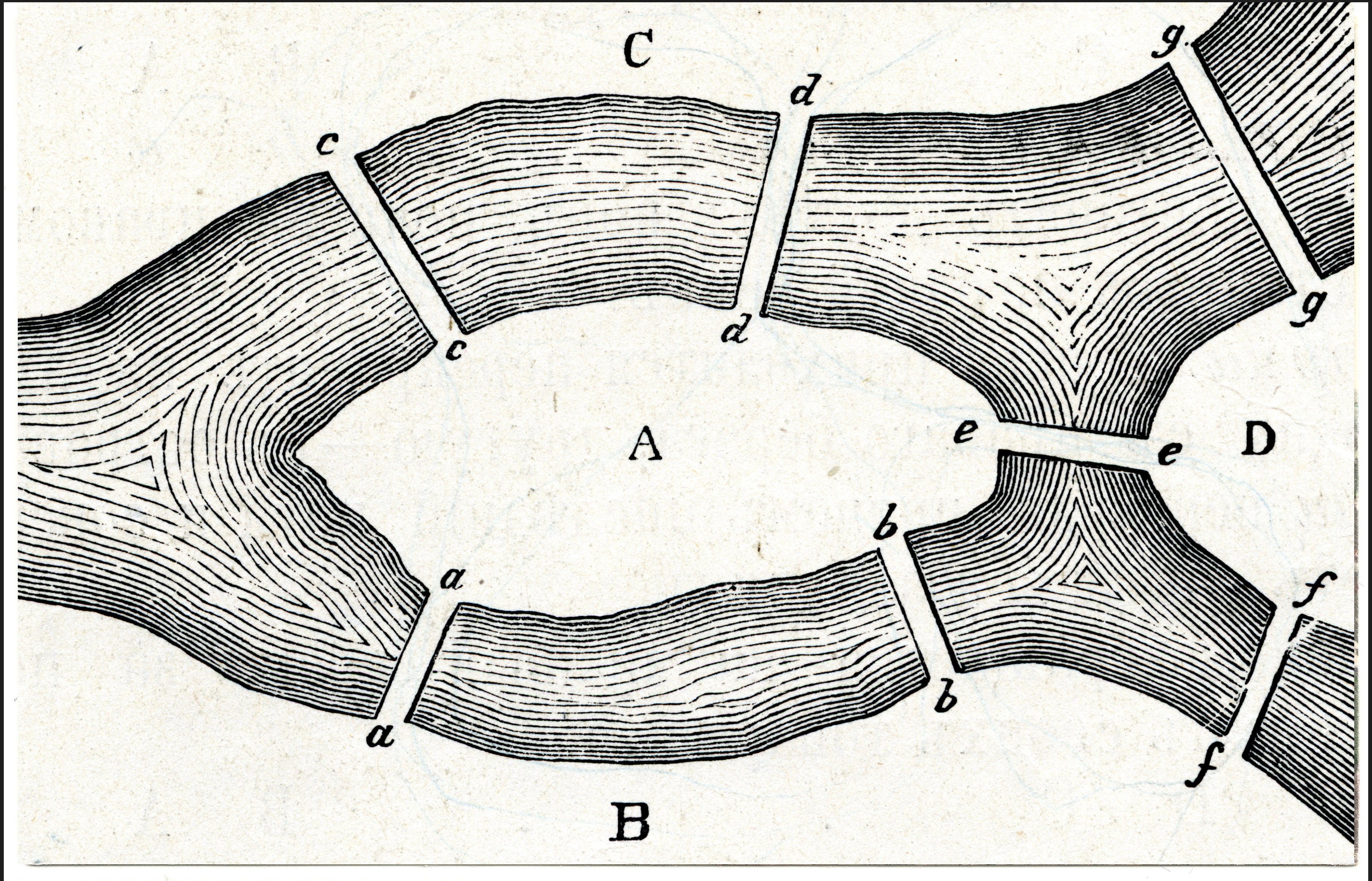
$$G = (V, E)$$

@chadgreen

History of Graph Theory

@chadgreen

History of Graph Theory

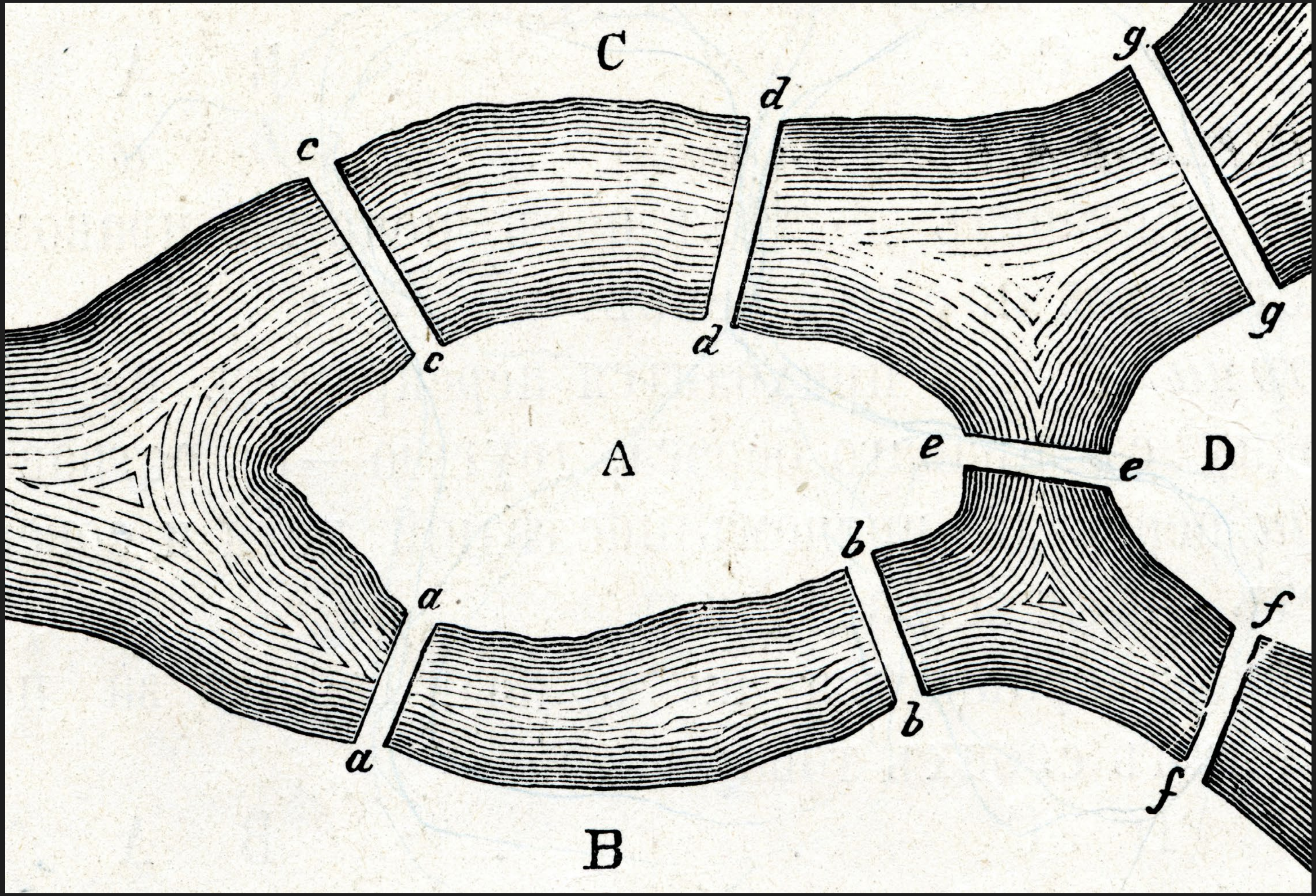


@chadgreen

History of Graph Theory

Leonard Euler

History of Graph Theory



Solutio problematis ad geometriam situs pertinentis

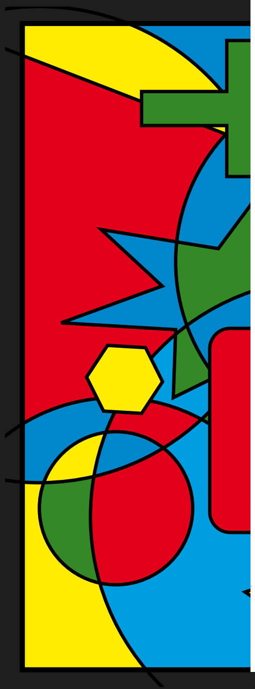
The solution of a problem relating to the geometry of position

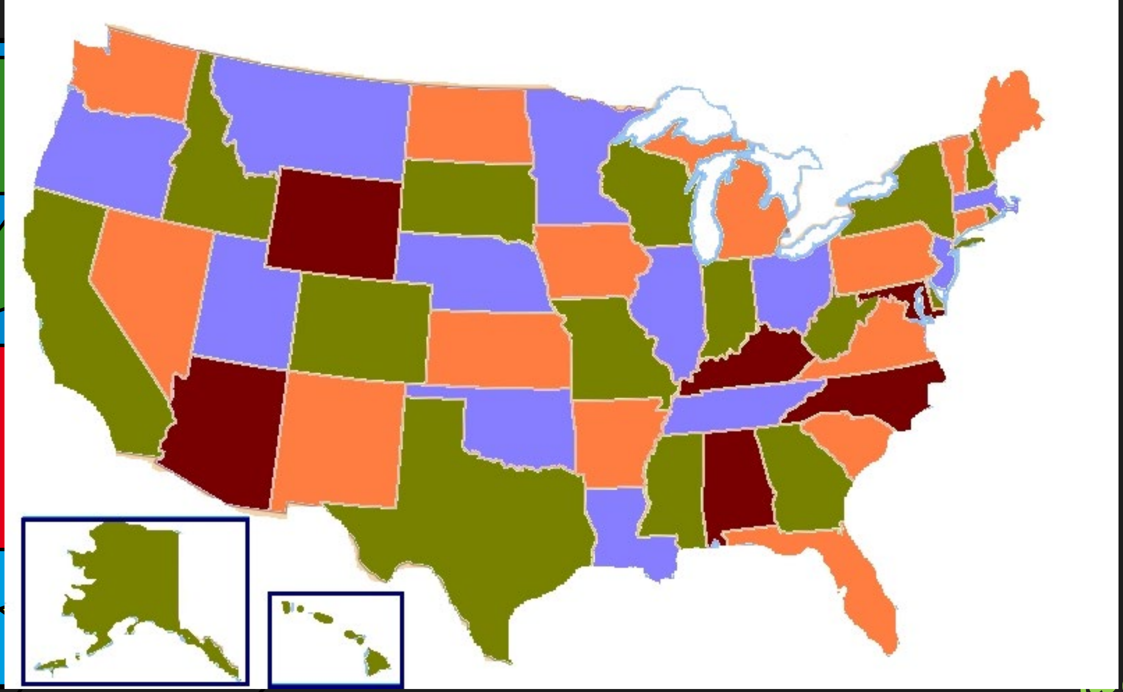
History of Graph Theory

- Alexandre-Théophile Vandermonde publishes paper on the knight problem
- Augustin-Louis Caunchy & Simon Antoine Jean L’Huilier used Euler’s formula to begin topology
- Term “graph” introduced in 1878 by James Joseph Sylvester
- First textbox on graph theory written by Dénes Kőnig in 1936
- In 1969, Frank Harary publishes the “definitive textbook on the subject"

History of Graph Theory

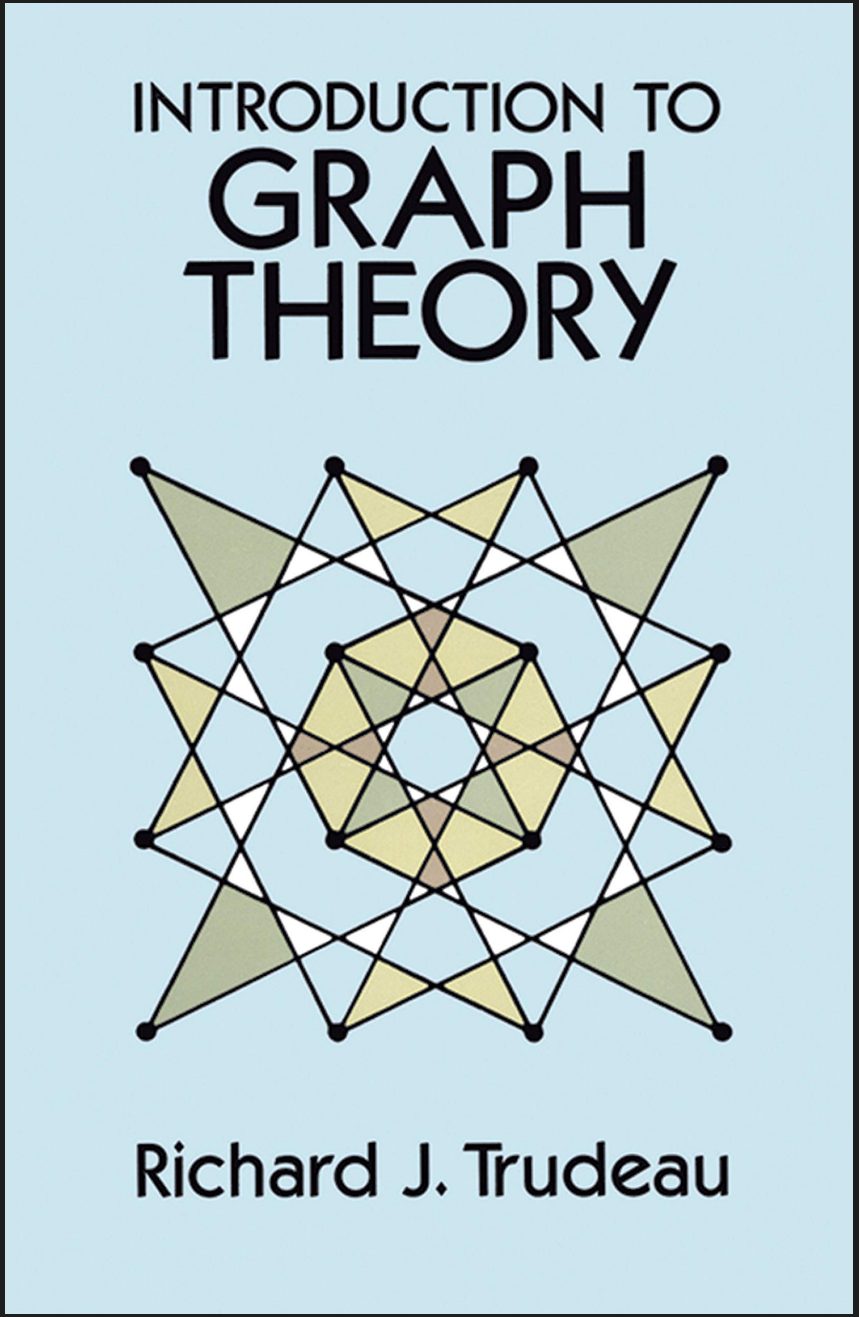
- Four color problem posed by Francis Guthrie in 1852; Heinrich Heesch published method for solving in 1969 using computers; computer-aided proof produced in 1976 by Kenneth Appel and Wolfgang Haken





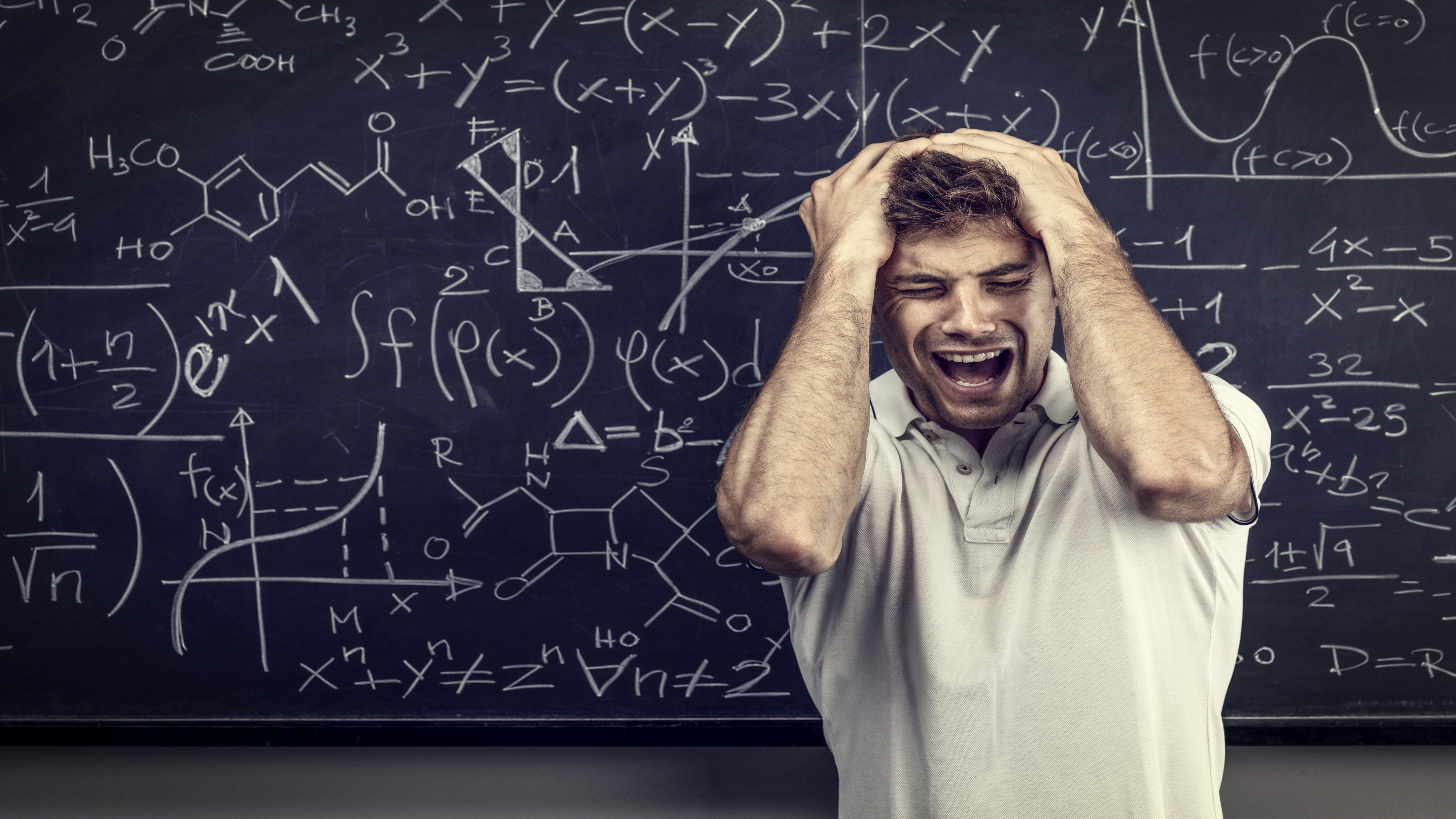
Applications of Graph Theory

- Linguistics
- Physics and Chemistry
- Social Sciences
- Biology
- Computer Science



INTRODUCTION TO
GRAPH
THEORY

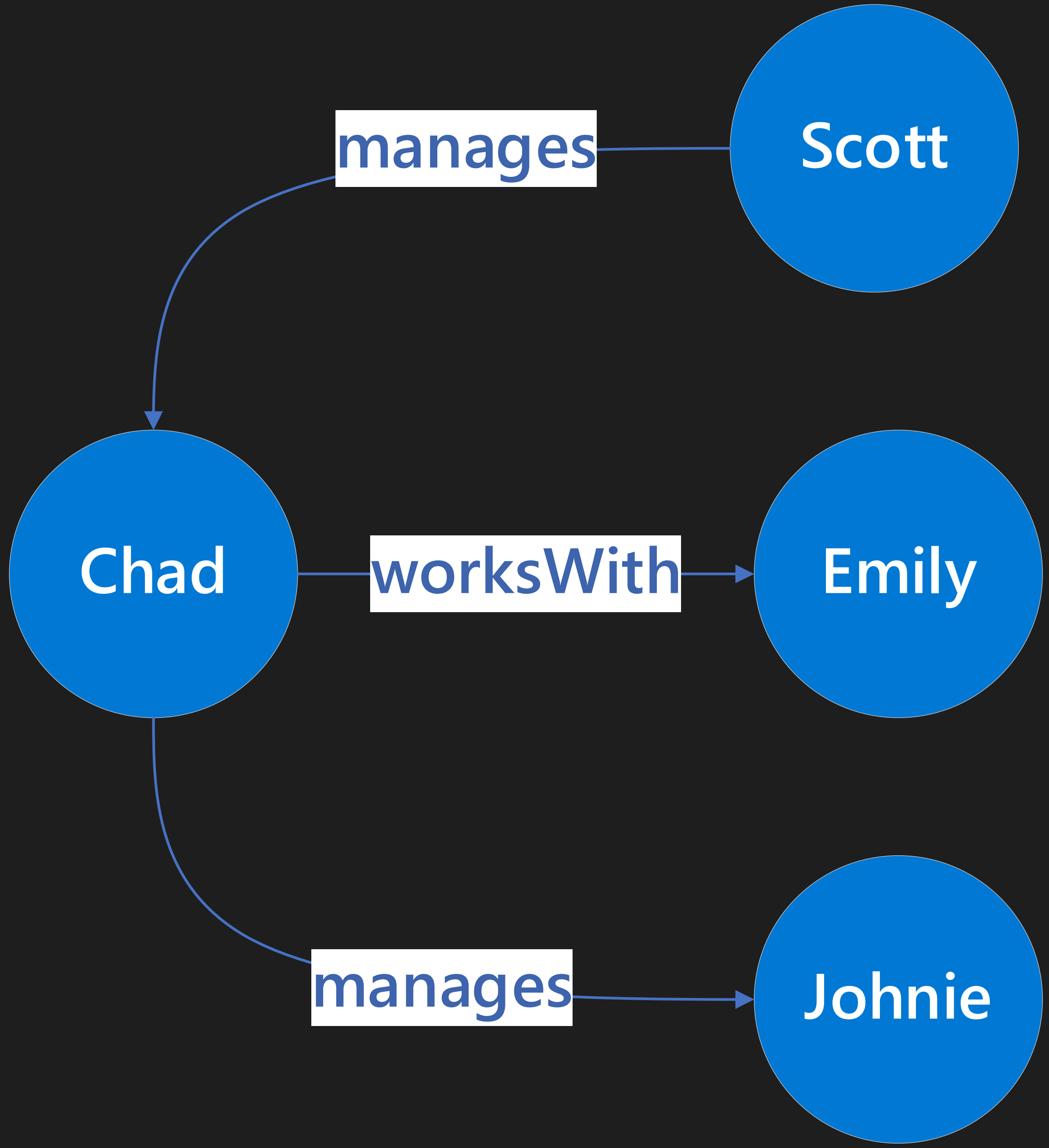
Richard J. Trudeau


CH3
COOH
(x-y)^2+2xy
x^3+y^3=(x+y)^3-3xy(x+y)
f(c=0)
f(c>0)
f(c<0)
H3CO
OH
HO
1/(x^2-9)
E
D
A
C
B
(1+n/2)
e^iπ
∫f(φ(x))φ'(x)d
x^0
4x-5
x^2-x
32/(x^2-25)
Δ=b^2
R
f(x)
1/√n
M
x
S
N
O
HO
1±√9/2
x^n+y^n≠z^n ∀n≠2
D=R

What is a Graph

- Collection of *vertices* and *edges*
- Represent entities as vertices and the ways in which those entities relate to the world as relationships
- Allow us to model all kinds of scenarios

What is a Graph



@chadgreen

What is a Graph Database

A graph database is a database that uses graph structures to represent and store data.

What is a Graph Database

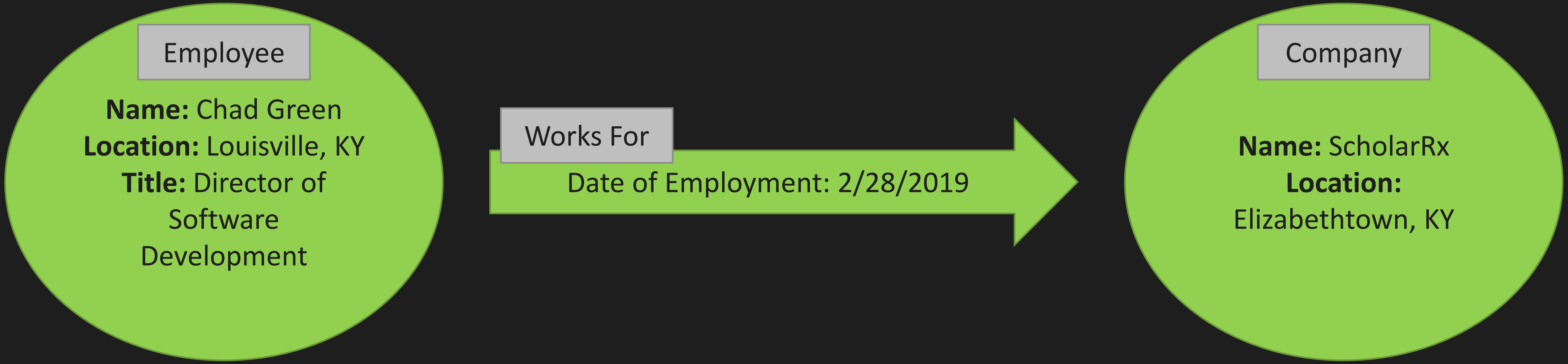
- Represents data as it exists in the real world that are naturally connected
- Does not try to change them in any way to define them as entities
- Graphs are composed of *vertices* and *edges*
- Vertices represent specific objects
- Edge is a relation between vertices
- Both vertices and edges can have any number of properties

Property Graph Model

Contains **nodes** (vertices) and **relationships** (edges)

Nodes and relationships contain **properties**

Relationships are **named** and **directed** with a **start** and **end** node


Employee
Name: Chad Green
Location: Louisville, KY
Title: Director of Software Development
Works For
Date of Employment: 2/28/2019
Company
Name: ScholarRx
Location: Elizabethtown, KY

@chadgreen

The Power of Graph Databases

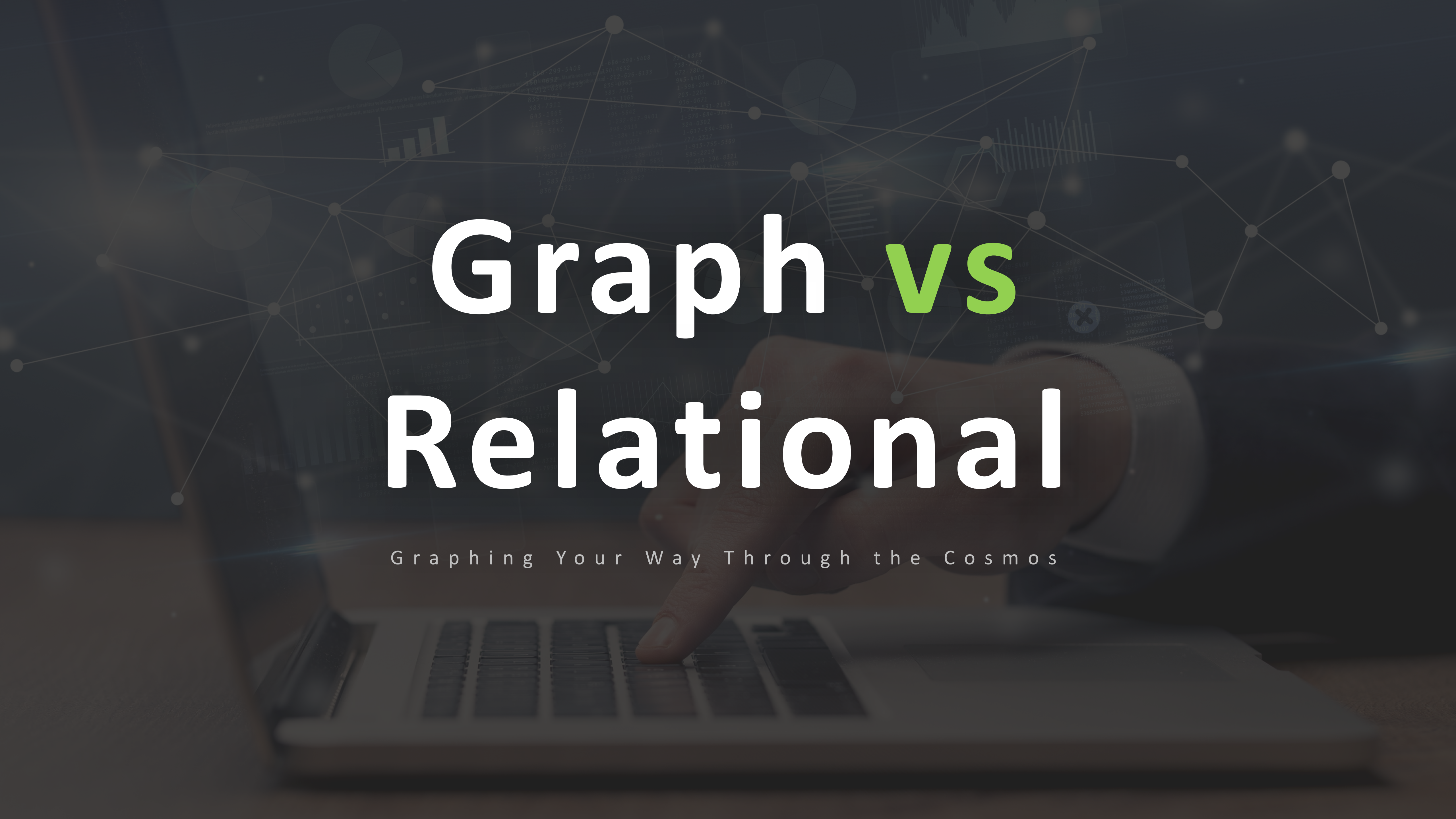
Performance

Flexibility

Agility

Common Graph Use Cases

- Internet of Things
- Customer 360
- Asset management
- Recommendations
- Fraud detection
- Data Integration
- Identity and access management
- Social networks
- Communication networks
- Genomics
- Epidemiology
- Semantic Web
- Search



Graph vs Relational

Graphing Your Way Through the Cosmos

Graph Databases vs Relational Databases

Relational	Graph
Tables	Vertices (Nodes)
Schema with nullables	No schema
Relations with foreign keys	Relation is first class citizen
Related data fetched with joins	Related data fetched with a pattern

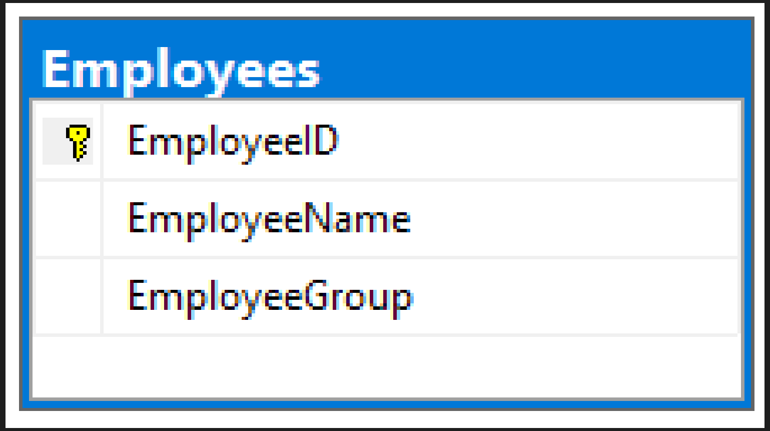
Human Resource Data

Graph Databases vs Relational Databases

Human Resource Data

Graph Databases vs Relational Databases

EmployeeId	EmployeeName	EmployeeGroup
1	Willis B. Hawkins	Sales
2	Neil S. Vega	Sales
3	Ada C. Lavigne	Engineering



Employees

- EmployeeID
- EmployeeName
- EmployeeGroup

Human Resource Data

Graph Databases vs Relational Databases

```
-- Create the Employee Table
CREATE TABLE Employees
(
    EmployeeID    INT          IDENTITY(1,1),
    EmployeeName  VARCHAR(64),
    EmployeeGroup VARCHAR(32),
    CONSTRAINT pkcEmployees PRIMARY KEY CLUSTERED (EmployeeId)
)
GO

-- Populate the Employee Table
INSERT INTO Employees (EmployeeName, EmployeeGroup)
               VALUES ('Willis B. Hawkins', 'Sales'),
                      ('Neil S. Vega',      'Sales'),
                      ('Ada C. Lavigne',    'Engineering');
GO
```

Human Resource Data

Graph Databases vs Relational Databases

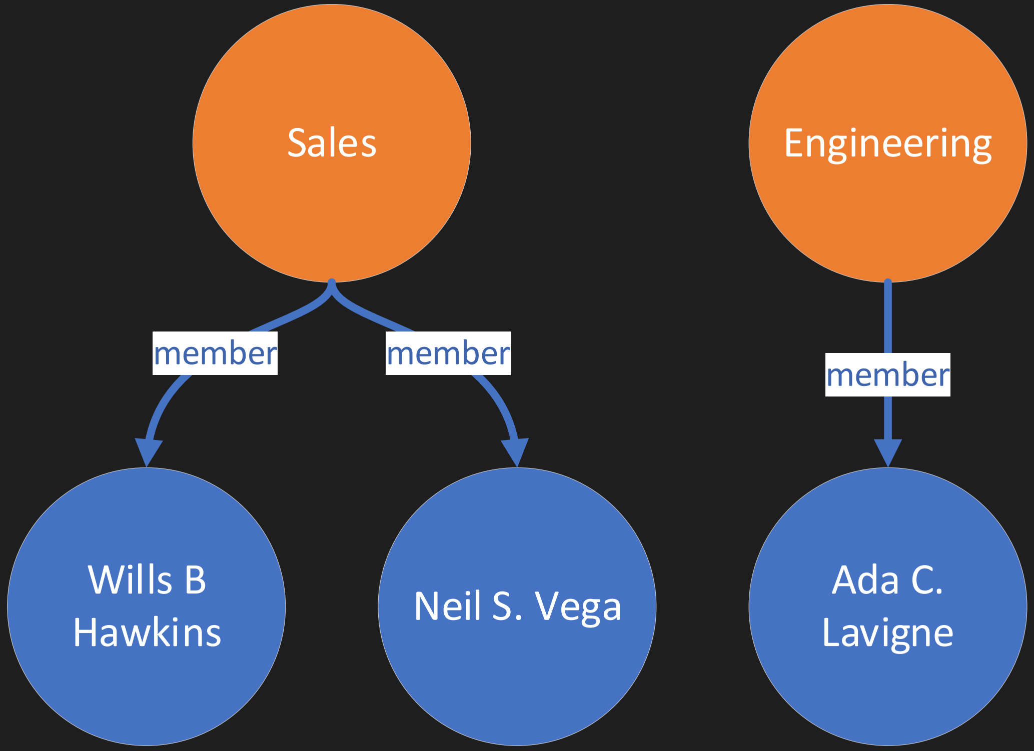
```
// Create group nodes
g.addV('group').property('id', 'Sales')
g.addV('group').property('id', 'Engineering')

// Create employee nodes
g.addV('employee').property('id', 'Willis B. Hawkins')
g.addV('employee').property('id', 'Neil S. Vega')
g.addV('employee').property('id', 'Ada C. Lavigne')

// Create relationships between groups and employees
g.V('Sales').addE('member').to(g.V('Willis B. Hawkins'))
g.V('Sales').addE('member').to(g.V('Neil S. Vega'))
g.V('Engineering').addE('member').to(g.V('Ada C. Lavignee'))
```

Human Resource Data

Graph Databases vs Relational Databases

EmployeeId	EmployeeName	EmployeeGroup
1	Willis B. Hawkins	Sales
2	Neil S. Vega	Sales
3	Ada C. Lavigne	Engineering

3 rows, 3 columns

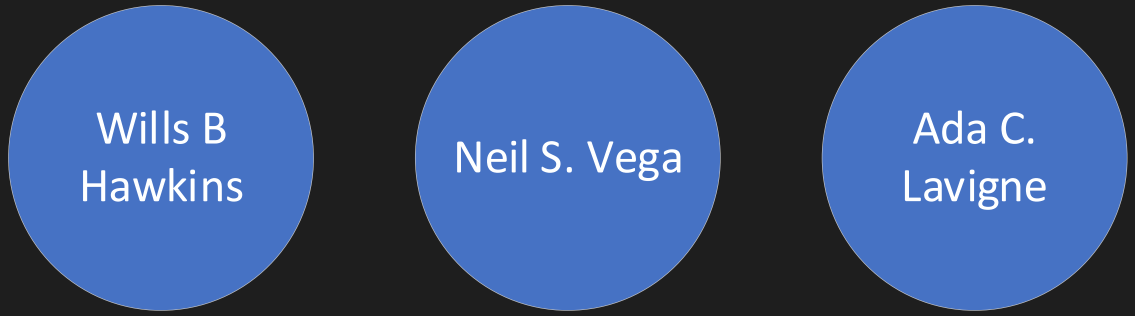


8 documents (vertices and edges)

Human Resource Data

Graph Databases vs Relational Databases

EmployeeId	EmployeeName	EmployeeGroup
1	Willis B. Hawkins	Sales
2	Neil S. Vega	Sales
3	Ada C. Lavigne	Engineering



Wills B Hawkins

Neil S. Vega

Ada C. Lavigne

```
SELECT * FROM Employees;
```

```
g.V().hasLabel('employee')
```

Company Reorganization

Employees can now belong to multiple groups

Graph Databases vs Relational Databases

```sql
-- Create the Groups table
CREATE TABLE Groups
(
  GroupId   INT         IDENTITY(1,1),
  GroupName VARCHAR(64),
  CONSTRAINT pkcGroups PRIMARY KEY CLUSTERED (GroupId)
)
```

Employees can now belong to multiple groups

Graph Databases vs Relational Databases

```
-- Create the Employee_Group join table
CREATE TABLE Employee_Group
(
  GroupId INT,
  EmployeeId INT,
  CONSTRAINT pkcEmployeeGroup PRIMARY KEY CLUSTERED (GroupId, EmployeeId),
  CONSTRAINT fkEmployeeGroup_Groups    FOREIGN KEY (GroupId)    REFERENCES Groups(GroupId),
  CONSTRAINT fkEmployeeGroup_Employees FOREIGN KEY (EmployeeId) REFERENCES Employees(EmployeeId)
)
```

Employees can now belong to multiple groups

Graph Databases vs Relational Databases

```
-- Populate the Employee_Group table from Employees and Groups
INSERT INTO Employee_Group (GroupId, EmployeeId)
SELECT Groups.GroupId,
       Employees.EmployeeId
  FROM Employees,
       Groups
 WHERE Groups.GroupName = Employees.EmployeeGroup
```

Employees can now belong to multiple groups

Graph Databases vs Relational Databases

```
-- Drop the Employees.EmployeeGroup column that is no longer valid
ALTER TABLE Employees DROP COLUMN EmployeeGroup
```

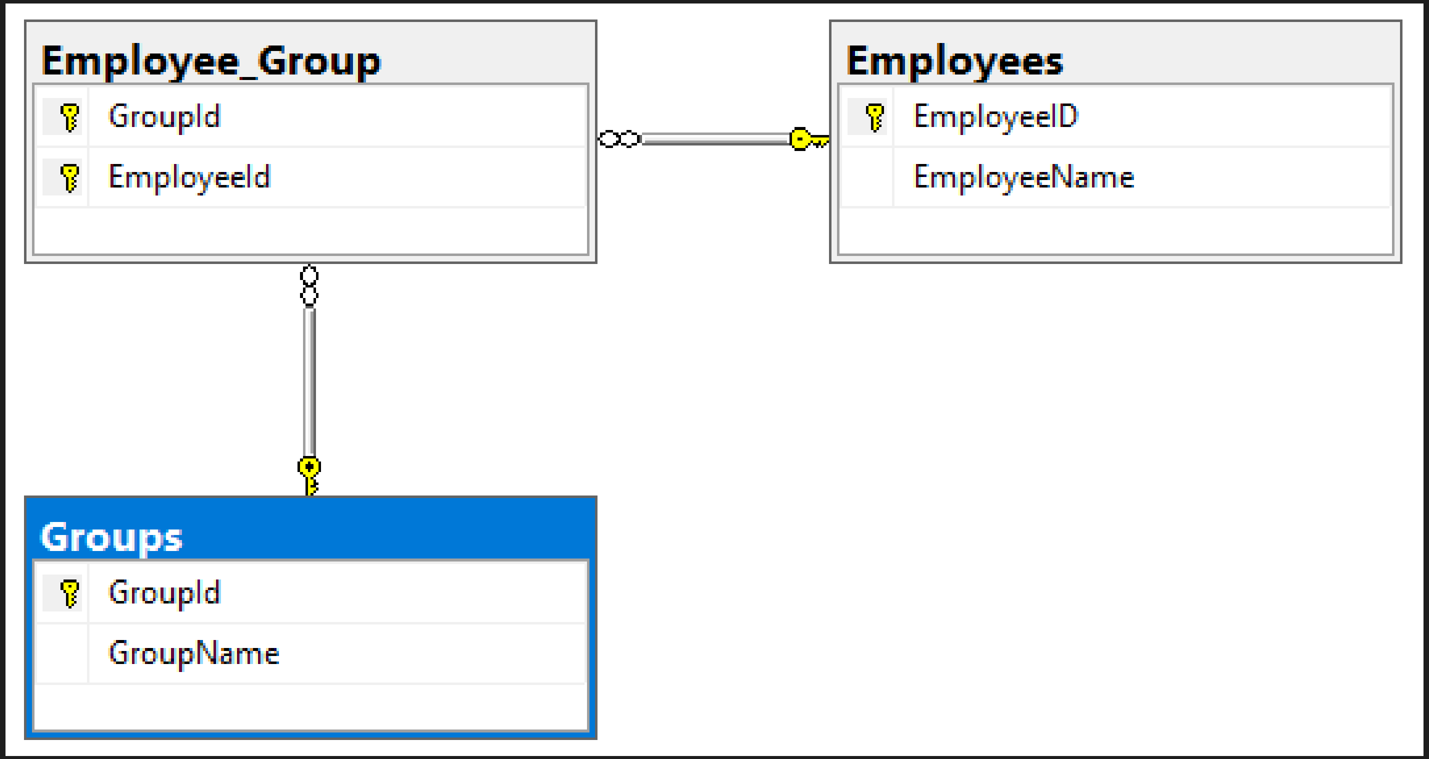
Employees can now belong to multiple groups

Graph Databases vs Relational Databases

EmployeeId	EmployeeName
1	Willis B. Hawkins
2	Neil S. Vega
3	Ada C. Lavigne

GroupId	GroupName
1	Engineering
2	Sales

GroupId	EmployeeId
1	3
2	1
2	2



@chadgreen

Employees can now belong to multiple groups

Graph Databases vs Relational Databases

```
// Add link to existing node
g.V('Sales').addE('member').to(g.V('Ada C. Lavigne'))
```

Employees can now belong to multiple groups

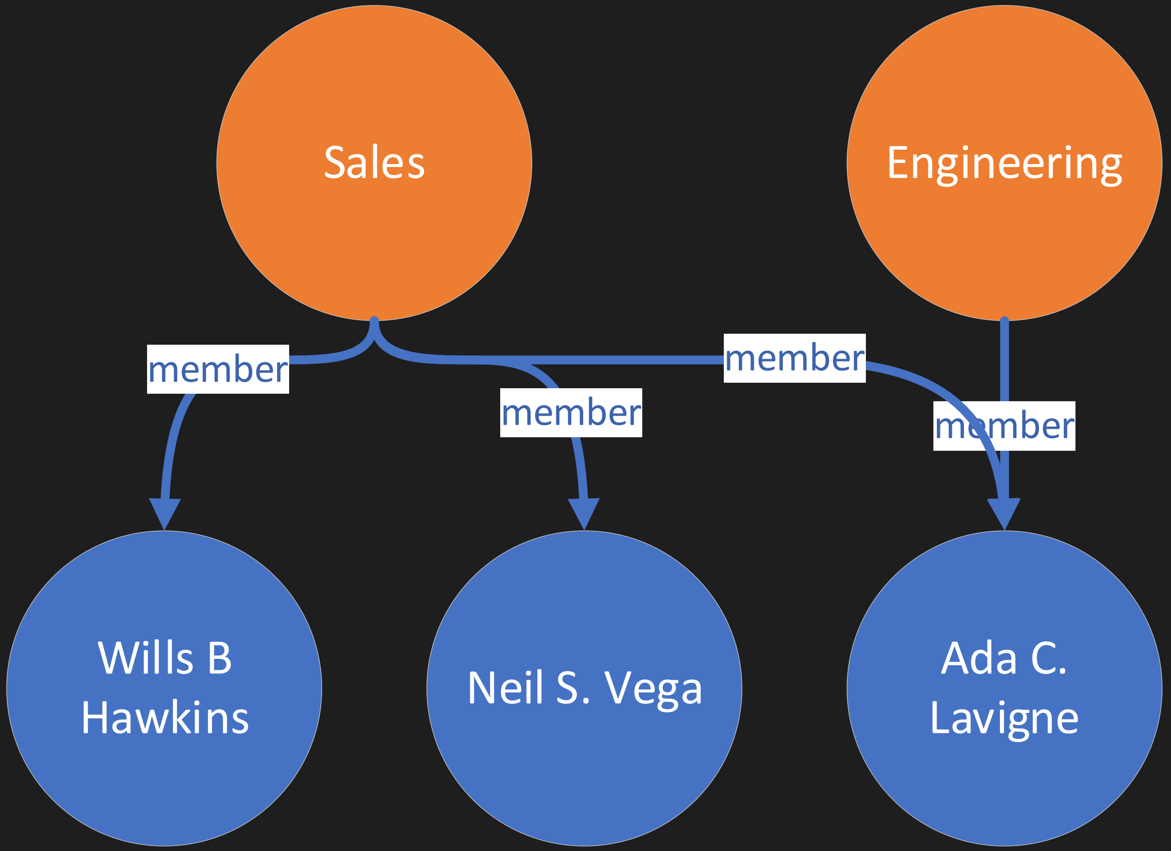
Graph Databases vs Relational Databases

EmployeeId	EmployeeName
1	Willis B. Hawkins
2	Neil S. Vega
3	Ada C. Lavigne

GroupId	GroupName
1	Engineering
2	Sales

GroupId	EmployeeId
1	3
2	1
2	2

Added 2 tables; 6 rows; 4 new columns
Removed a column



+1 document

@chadgreen

Employees can now belong to multiple groups

Graph Databases vs Relational Databases

EmployeeId	EmployeeName
1	Willis B. Hawkins
2	Neil S. Vega
3	Ada C. Lavigne

Wills B Hawkins
Neil S. Vega
Ada C. Lavigne

```
SELECT Employees.EmployeeId,
       Employees.EmployeeName
  FROM Employees
 INNER JOIN Employee_Group
         ON Employee_Group.EmployeeId = Employees.EmployeeId
 INNER JOIN Groups
         ON Groups.GroupId = Employee_Group.GroupId
 WHERE Groups.GroupName = 'Sales'
```

```
g.V('Sales').outE('member').inV()
```

Corporate Merger

Nested Groups

Graph Databases vs Relational Databases

```
-- Create the new Product Group
INSERT INTO Groups (GroupName) VALUES ('Product Group')
```

Nested Groups

Graph Databases vs Relational Databases

```sql
-- Associate everyone to the new Product Group
INSERT INTO Employee_Group (GroupId, EmployeeId)
SELECT Groups.GroupId,
       Employees.EmployeeId
  FROM Groups,
       Employees
 WHERE Groups.GroupName = 'Product Group'
```

Nested Groups

Graph Databases vs Relational Databases

```
-- Create the Group/Group union table
CREATE TABLE Group_Group
(
  ParentGroupId INT,
  ChildGroupId  INT,
  CONSTRAINT pkcGroup_Group PRIMARY KEY CLUSTERED (ParentGroupId, ParentGroupId),
  CONSTRAINT fkGroupGroup_Groups_Parent FOREIGN KEY (ParentGroupId) REFERNCES Groups(GroupId),
  CONSTRAINT fkGroupGroup_Groups_Child  FOREIGN KEY (ChildGroupId)  REFERNCES Groups(GroupId)
)
```

Nested Groups

Graph Databases vs Relational Databases

```sql
-- Relate the child groups to the parent group
INSERT INTO Group_Group (ParentGroupId, ChildGroupId)
SELECT (SELECT GroupId FROM Groups WHERE GroupName = 'Product Group'),
       Groups.GroupId
  FROM Groups
 WHERE Groups.GroupName <> 'Product Group'
```

Nested Groups

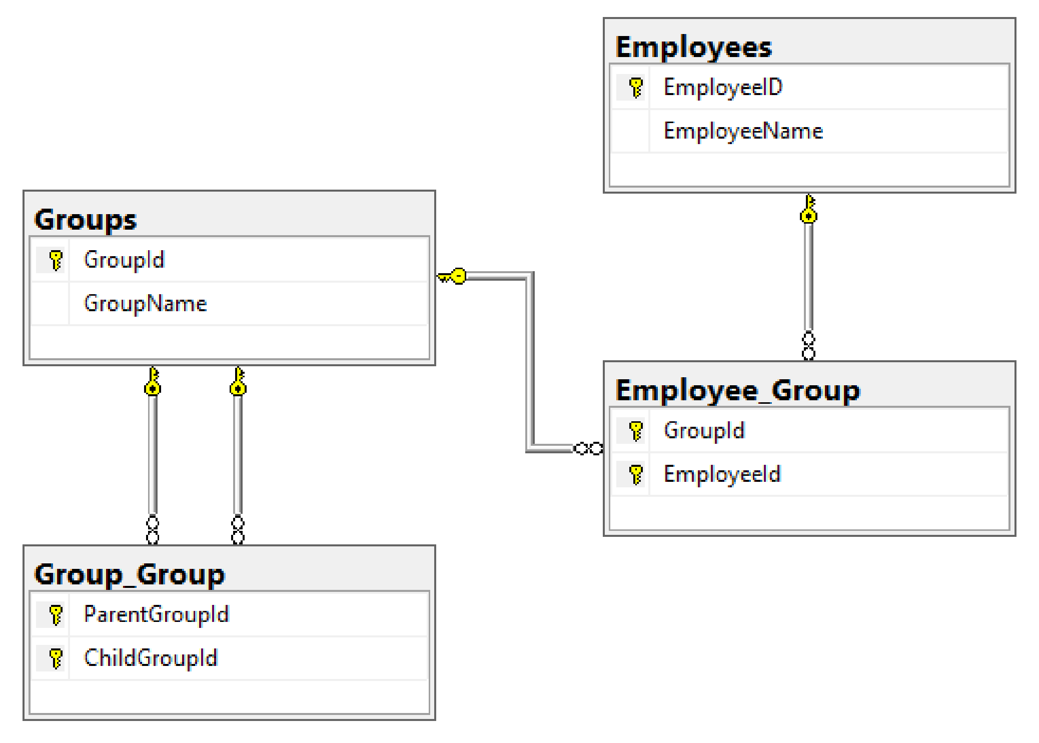
Graph Databases vs Relational Databases

EmployeeId	EmployeeName
1	Willis B. Hawkins
2	Neil S. Vega
3	Ada C. Lavigne

GroupId	GroupName
1	Engineering
2	Sales
3	Product Group

ParentGroupId	ChildGroupId
3	1
3	2

GroupId	EmployeeId
1	3
2	1
2	2
2	3
3	1
3	2
3	3



Employees
- EmployeeID
- EmployeeName

Groups
- GroupId
- GroupName

Employee_Group
- GroupId
- EmployeeId

Group_Group
- ParentGroupId
- ChildGroupId

@chadgreen

Nested Groups

Graph Databases vs Relational Databases

```
// Add supergroup node
g.addV('group').property('id', 'Product Group')

// Link to adjacent nodes
g.V('Product Group').addE('contains_subgroup').to(g.V('Engineering'))
g.V('Product Group').addE('contains_subgroup').to(g.V('Sales'))
```

Nested Groups

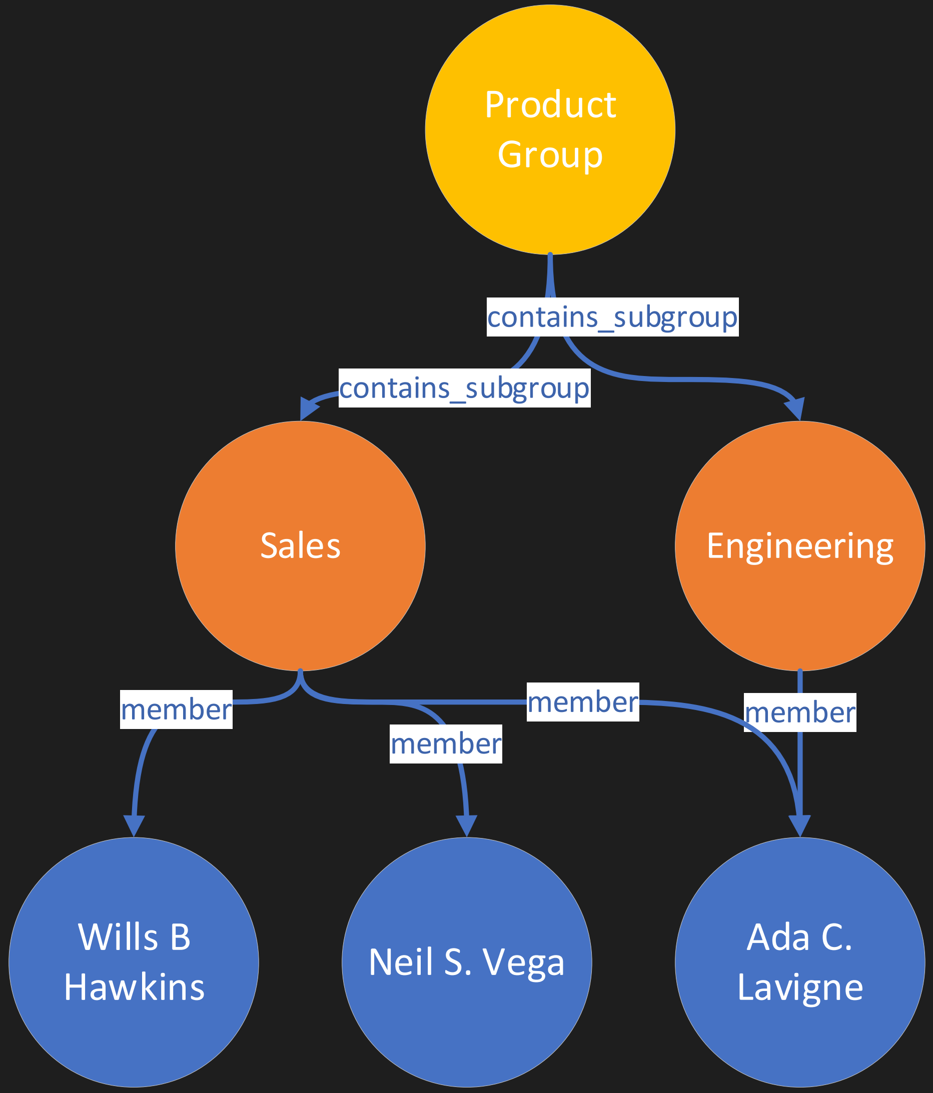
Graph Databases vs Relational Databases

EmployeeId	EmployeeName
1	Willis B. Hawkins
2	Neil S. Vega
3	Ada C. Lavigne

GroupId	GroupName
1	Engineering
2	Sales
3	Product Group

ParentGroupId	ChildGroupId
3	1
3	2

GroupId	EmployeeId
1	3
2	1
2	2
2	3
3	1
3	2
3	3



Added 1 table; 6 rows; 2 new columns

+3 documents

@chadgreen

Nested Groups

Graph Databases vs Relational Databases

GroupId	GroupName
1	Engineering
2	Sales

Sales
Engineering

```
SELECT Groups.GroupId,
       Groups.GroupName
  FROM Groups
 INNER JOIN Group_Group ON Group_Group.ChildGroupId = Groups.GroupId
 WHERE Group_Group.ParentGroupId = (SELECT GroupId
                                      FROM Groups
                                     WHERE GroupName = 'Product Group')
```

```
g.V('Product Group')
.outE('contains_subgroup')
.inV()
```

@chadgreen

Management

Additional Hierarchies

Graph Databases vs Relational Databases

```sql
-- Create the Employee/Employee join table
CREATE TABLE Employee_Employee
(
  ParentEmployeeId INT,
  ChildEmployeeId  INT,
  CONSTRAINT pkcEmployeeEmployee PRIMARY KEY CLUSTERED (ParentEmployeeId, ChildEmployeeId),
  CONSTRAINT fkEmployeeEmployee_Employee_Parent FOREIGN KEY (ParentEmployeeId) REFERENCES Employees(EmployeeId),
  CONSTRAINT fkEmployeeEmployee_Employee_Child  FOREIGN KEY (ChildEmployeeId)  REFERENCES Employees(EmployeeId)
)
```

Additional Hierarchies

Graph Databases vs Relational Databases

```sql
-- Make Ada the boss
INSERT INTO Employee_Employee (ParentEmployeeId, ChildEmployeeId)
SELECT (SELECT EmployeeId FROM Employees WHERE EmployeeName = 'Ada C. Lavigne'),
       EmployeeId
  FROM Employees
 WHERE EmployeeId IN (SELECT EmployeeId
                        FROM Employee_Group
                       WHERE Employee_Group.GroupId = (SELECT GroupId
                                                         FROM Groups
                                                        WHERE GroupName = 'Sales'))
```

@chadgreen

Additional Hierarchies

Graph Databases vs Relational Databases

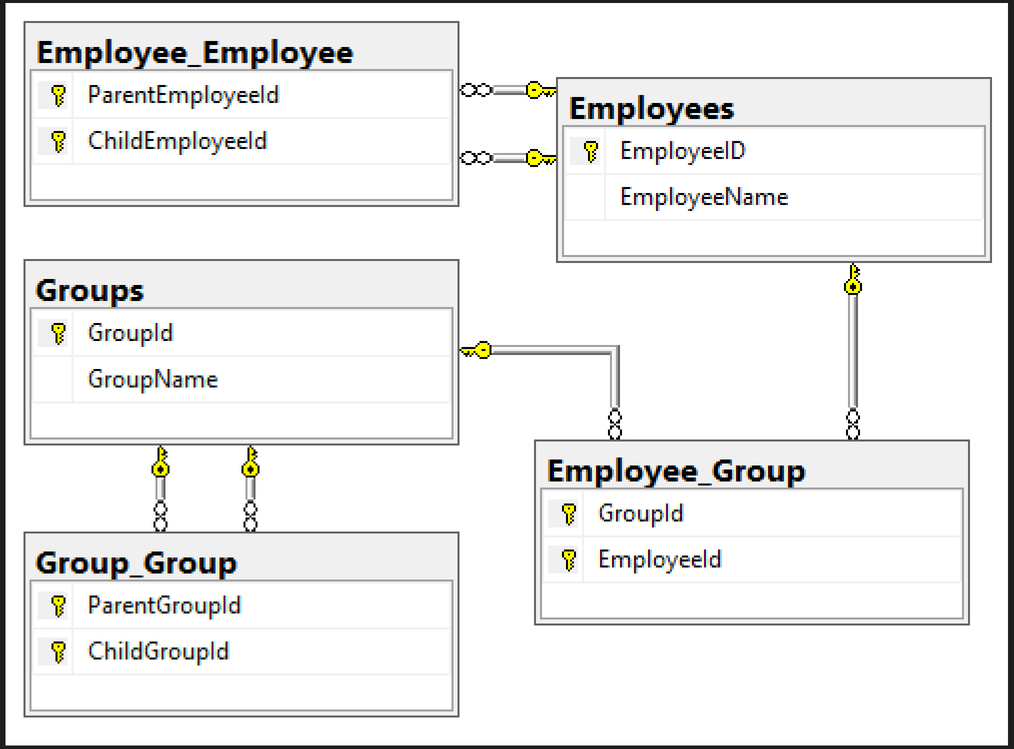
EmployeeId	EmployeeName
1	Willis B. Hawkins
2	Neil S. Vega
3	Ada C. Lavigne

GroupId	GroupName
1	Engineering
2	Sales
3	Product Group

ParentGroupId	ChildGroupId
3	1
3	2

GroupId	EmployeeId
1	3
2	1
2	2
2	3
3	1
3	2
3	3

ParentEmployeeId	ChildEmployeeId
3	1
3	2
3	3



Additional Hierarchies

Graph Databases vs Relational Databases

```
// Add relationships
g.V('Ada C. Lavigne').addE('has_report').to(g.V('Willis B. Hawkins'))
g.V('Ada C. Lavigne').addE('has_report').to(g.V('Neil S. Vega'))
```

Additional Hierarchies

Graph Databases vs Relational Databases

EmployeeId	EmployeeName
1	Willis B. Hawkins
2	Neil S. Vega
3	Ada C. Lavigne

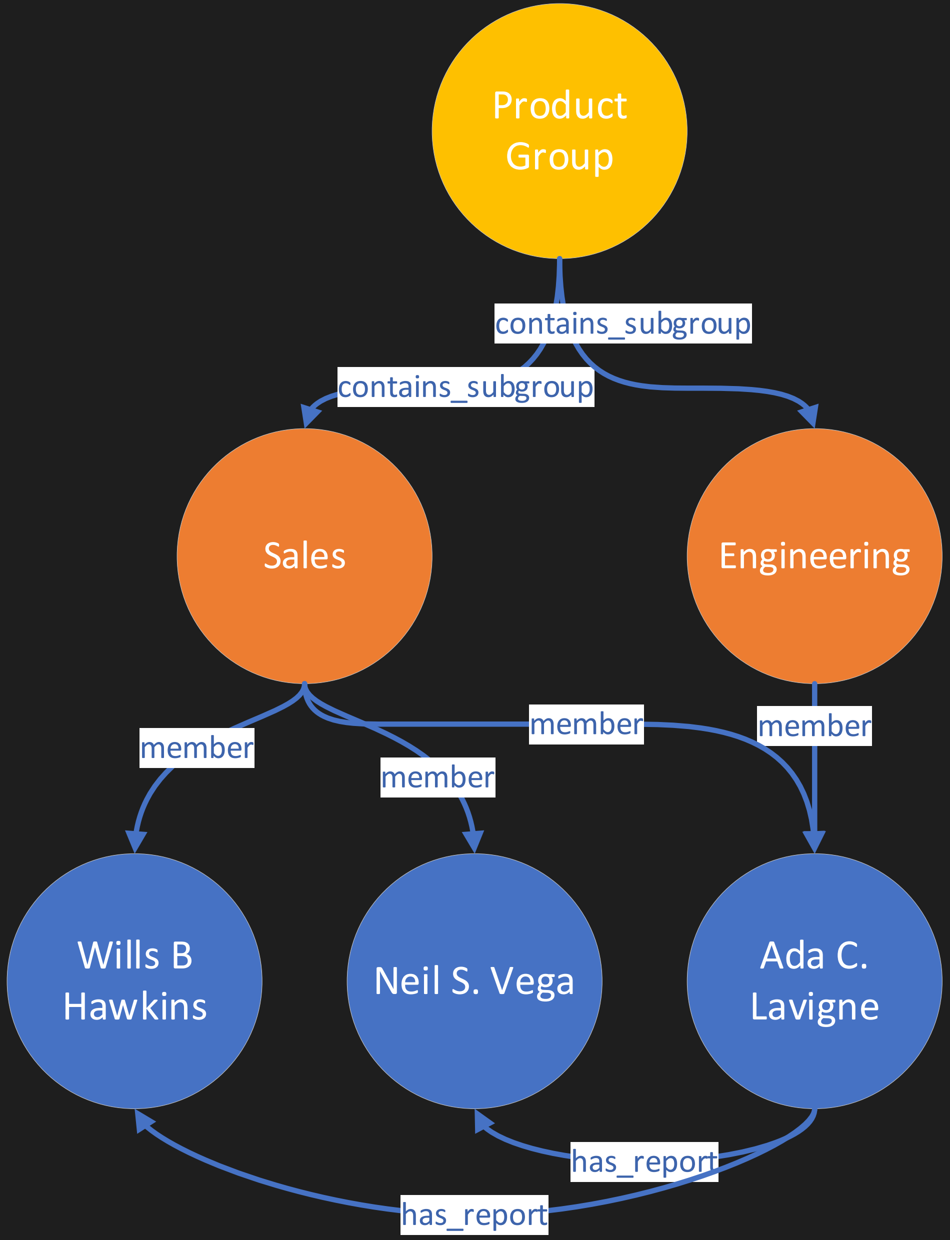
GroupId	GroupName
1	Engineering
2	Sales
3	Product Group

ParentGroupId	ChildGroupId
3	1
3	2

GroupId	EmployeeId
1	3
2	1
2	2
2	3
3	1
3	2
3	3

ParentEmployeeId	ChildEmployeeId
3	1
3	2
3	3

Added 1 table; 2 rows; 2 new columns



+2 documents

@chadgreen

Additional Hierarchies

Graph Databases vs Relational Databases

EmployeeName
Ada C. Lavigne

Ada C. Lavigne

```sql
SELECT DISTINCT EmployeeName
  FROM Employees
 INNER JOIN Employee_Group
    ON Employee_Group_EmployeeId = Employes.EmployeeId
 INNER JOIN Employee_Employee
    ON Employee_Employee.ParentEmployeeId = Employees.EmployeeId
 WHERE Employee_Group.GroupId = (SELECT GroupId
                                      FROM Groups
                                     WHERE GroupName = 'Engineering')
```

```
g.V('Engineering')
.outE('member')
.inV()
.outE('has_report')
.values('id')
```

@chadgreen

Challenges of Relational Databases

Graph Databases vs Relational Databases

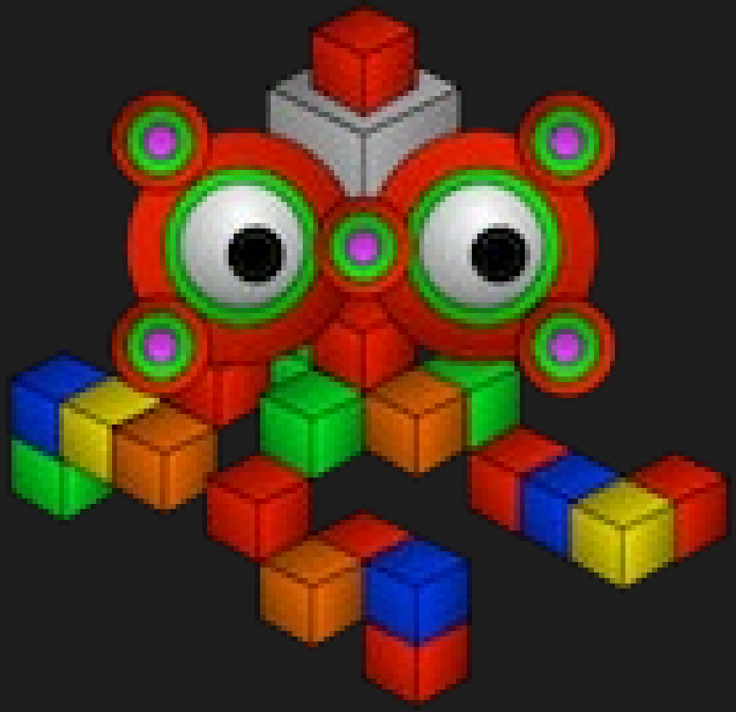
- Schema Management
- Table Alterations
- Costly Writes Against Multiple Tables
- Multiple JOIN Operations
- Complex Read Queries

What is Gremlin

Graphing Your Way Through the Cosmos

What is a TinkerPop

- Open source, vendor-agnostic, graph computing framework
- Apace2 license
- Allows users to model their domain as graph and analyze using Gremlin
- TinkerPop-enable systems integrate with one another



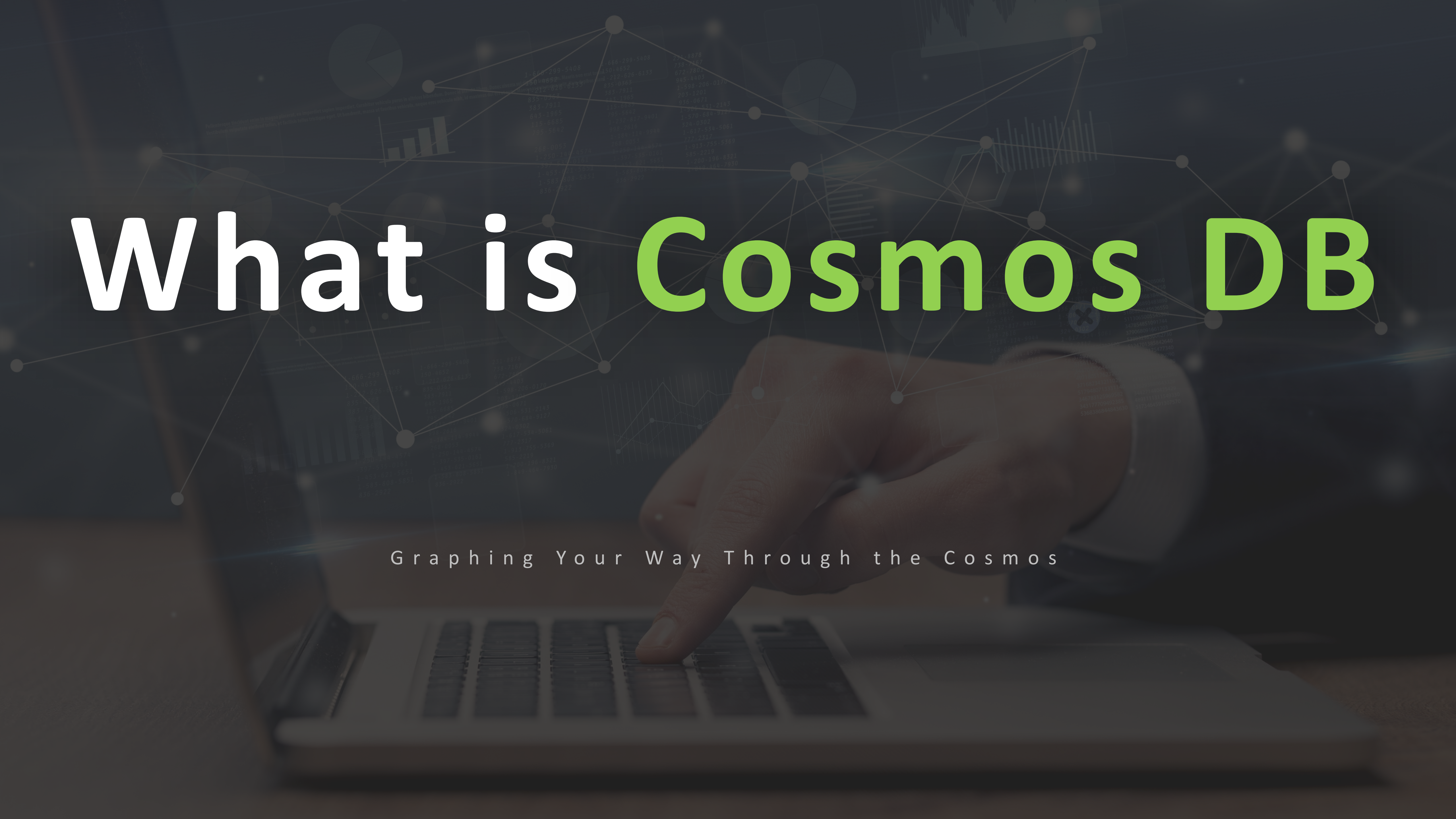
@chadgreen

What is a TinkerPop

- Gremlin
- Gremlin Console
- Gremlin Server
- TinkerGraph
- Programming Interfaces
- Documentation
- Useful Recipes

What is a Gremlin

- Graph traversal language and virtual machine
- Supports OLTP and OLAP
- Supports imperative and declarative querying
- Supports user-defined domain specified languages



What is Cosmos DB

Graphing Your Way Through the Cosmos

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Turnkey global distribution

@chadgreen

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Elastic scale out of storage & throughput

Turnkey global distribution

@chadgreen

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Guaranteed low latency at the 99th percentile

Elastic scale out
of storage & throughput

Turnkey global
distribution

@chadgreen

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Five well-defined consistency models

Turnkey global distribution

Elastic scale out of storage & throughput

Guaranteed low latency at the 99th percentile

@chadgreen

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Comprehensive SLAs

Guaranteed low latency at the 99th percentile
Elastic scale out of storage & throughput
Five well-defined consistency models
Turnkey global distribution

@chadgreen

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Battle tested database service

XBOX LIVE

Office 365

skype™

Turnkey global distribution

Elastic scale out of storage & throughput

Five well-defined consistency models

Guaranteed low latency at the 99th percentile

Comprehensive SLAs

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Battle tested database service

Coca-Cola

AVEVA Schneider Electric

Albertsons Safeway

Johnson Controls

SIEMENS Healthineers

BMI

Liberty Mutual. INSURANCE

jet

Rolls-Royce

ExxonMobil

Cincinnati Children's

scholarRx

Five well-defined consistency models

Elastic scale out of storage & throughput

Guaranteed low latency at the 99th percentile

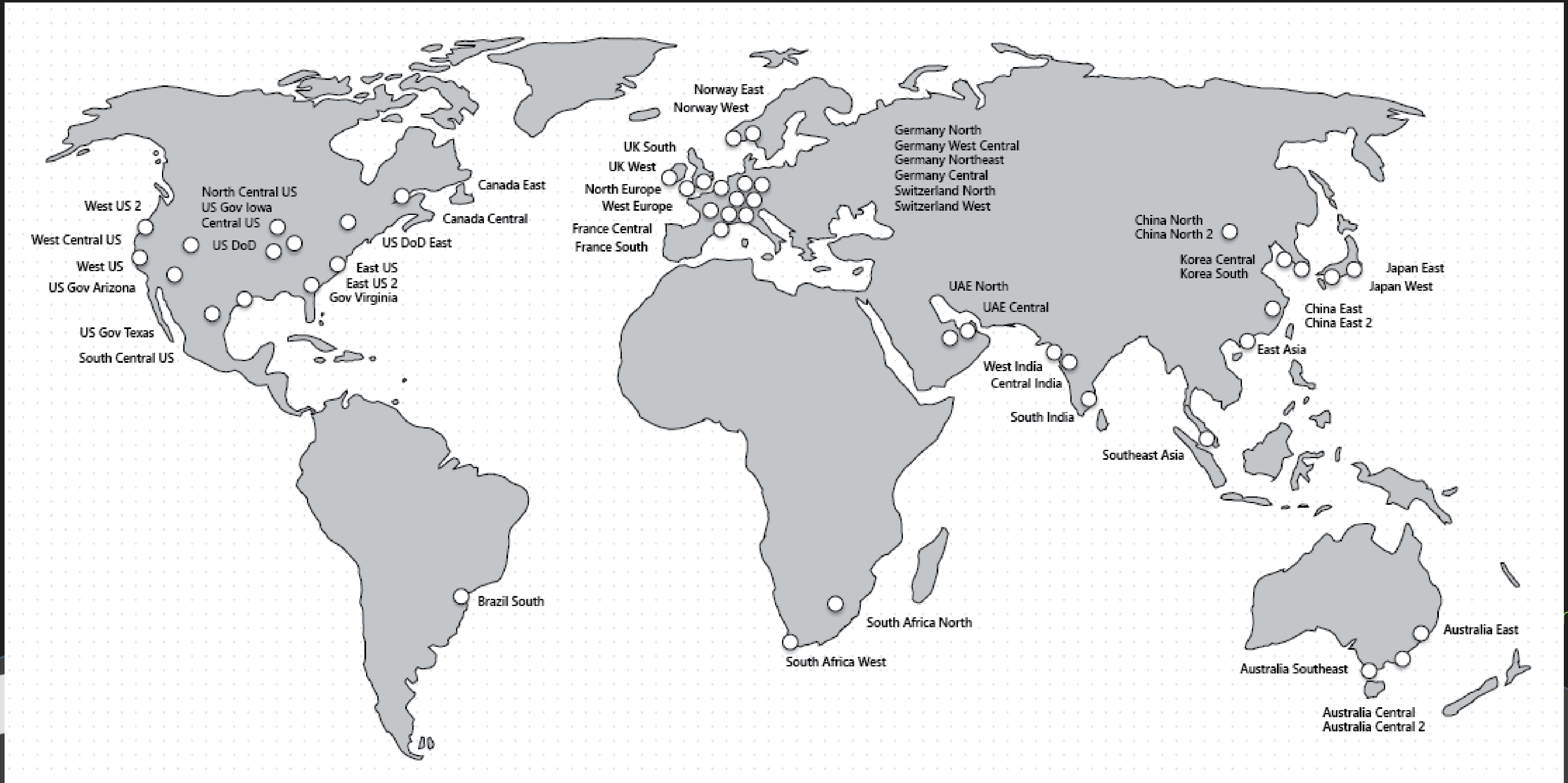
Turnkey global distribution

Comprehensive SLAs

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Ubiquitous regional presence



Regions where Azure Cosmos DB is available

Turnkey global distribution

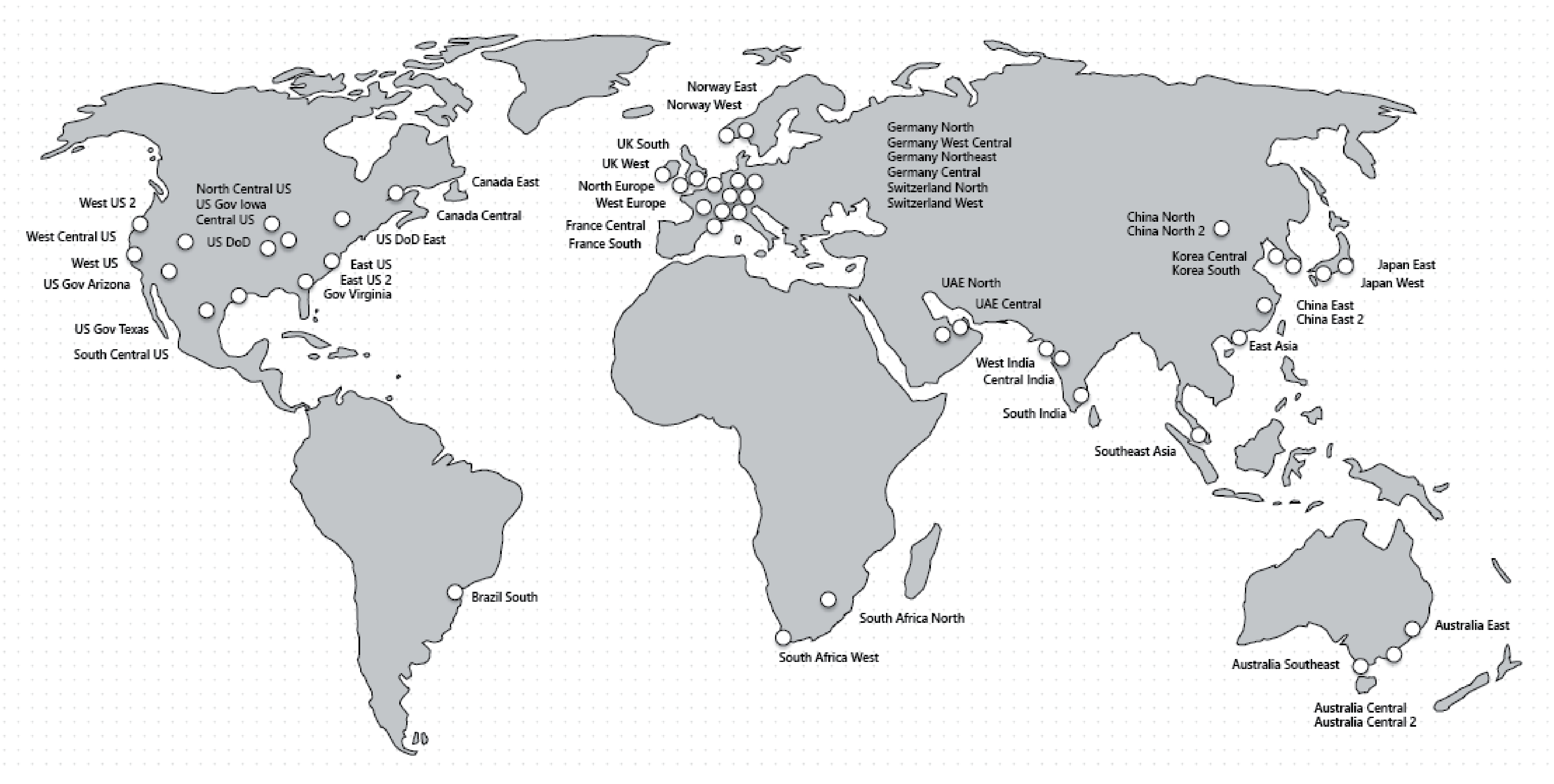
nprehensive SLAs

@chadgreen

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Secure by default and enterprise ready



Regions where Azure Cosmos DB is available

Turnkey global distribution

nprehensive SLAs

@chadgreen

Azure Cosmos DB

A globally distributed, massively scalable, multi-model database service

Table API

cassandra

SQL

MongoDB

Gremlin

Turnkey global distribution

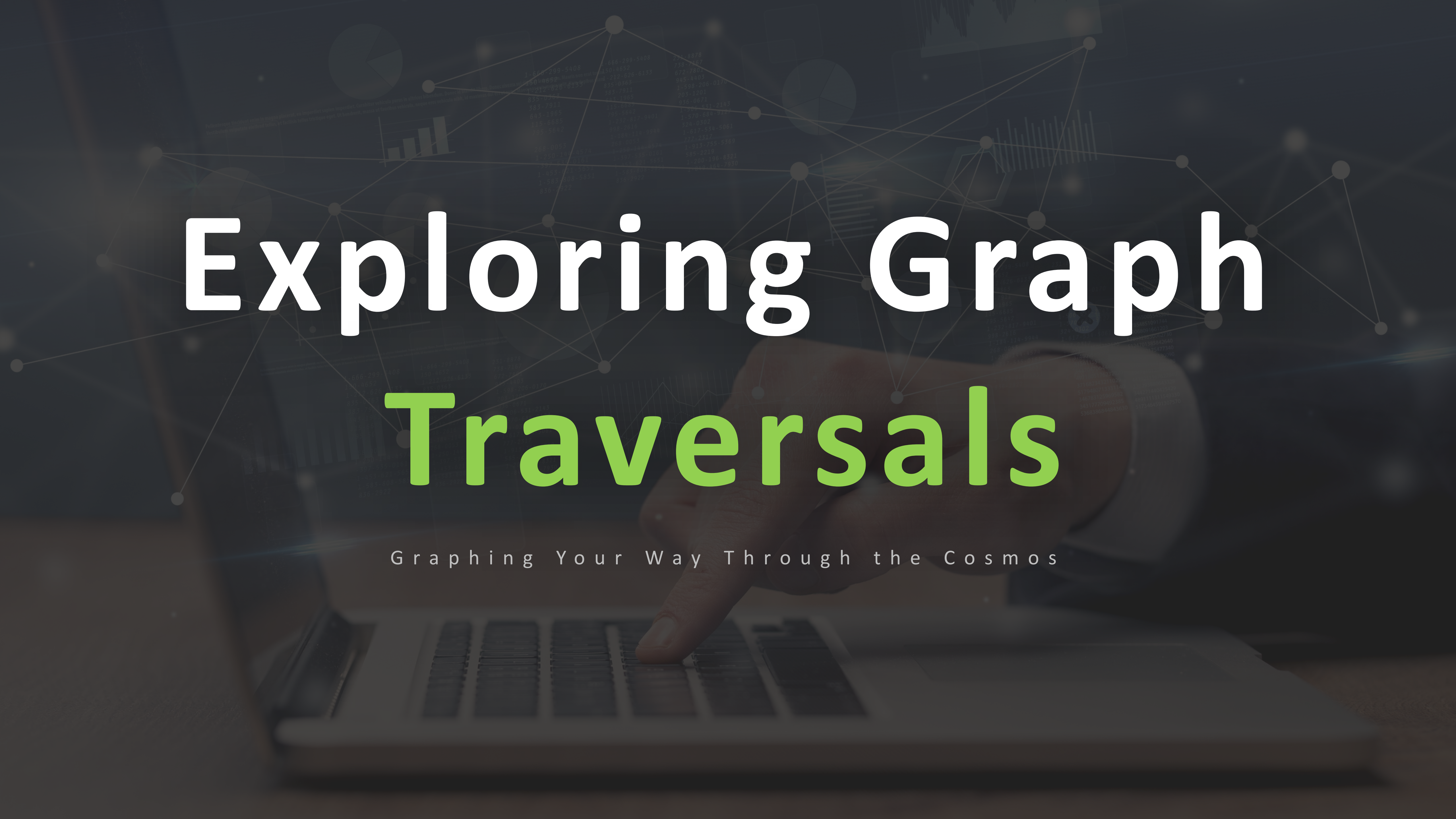
Elastic scale out of storage & throughput

Five well-defined consistency models

Guaranteed low latency at the 99th percentile

Comprehensive SLAs

@chadgreen



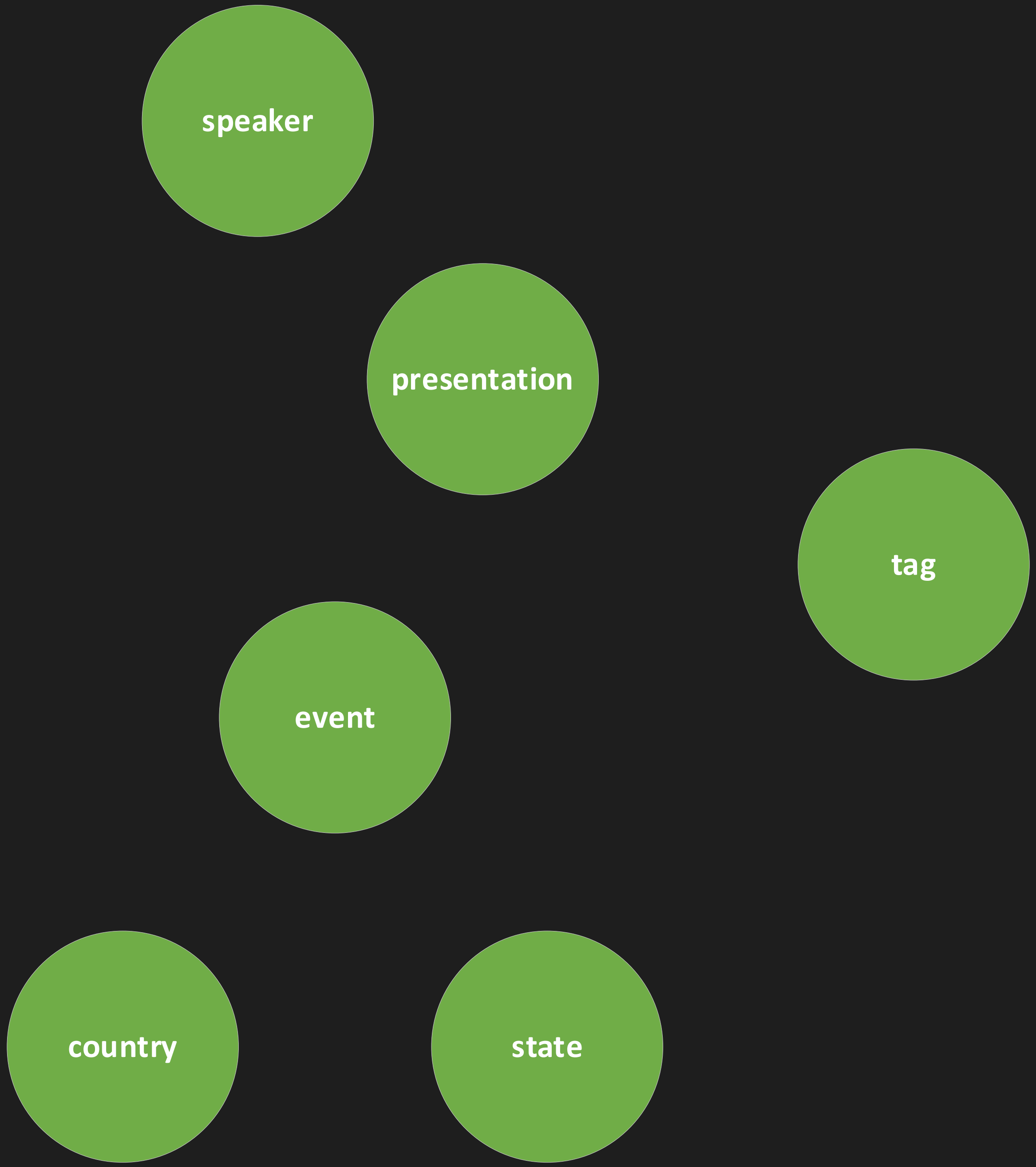
Exploring Graph Traversals

Graphing Your Way Through the Cosmos

Requirements for Speaking Engagement Management

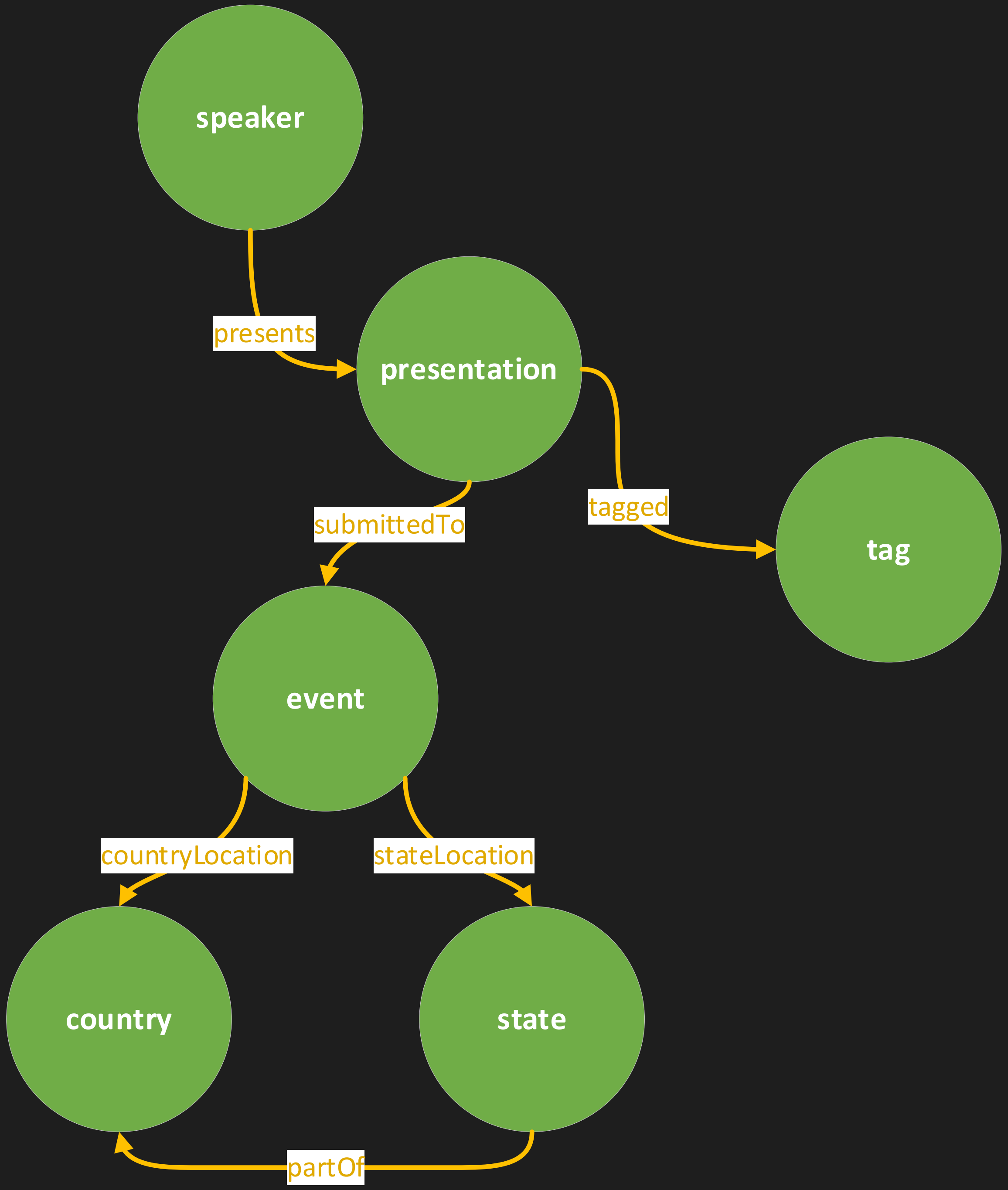
- Where has a presentation been submitted?
- What presentations are tagged with a particular tag?
- Where have presentations tagged with a particular tag been accepted?
- What events has a speaker been accepted at?
- Where were the events a speaker has been accepted to?

“Schema”



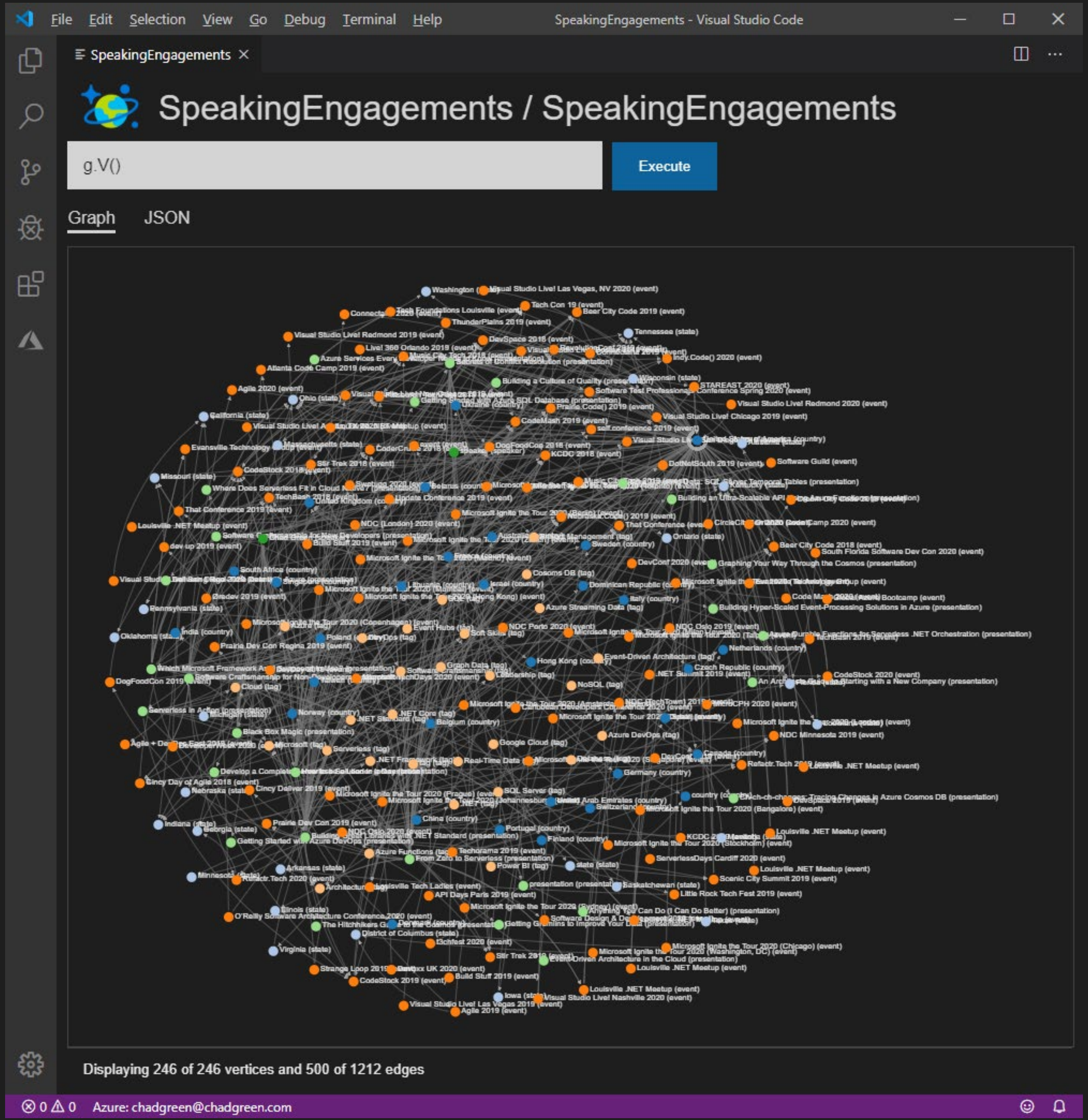
@chadgreen

“Schema”



@chadgreen

View the whole graph


File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
Azure: chadgreen@chadgreen.com

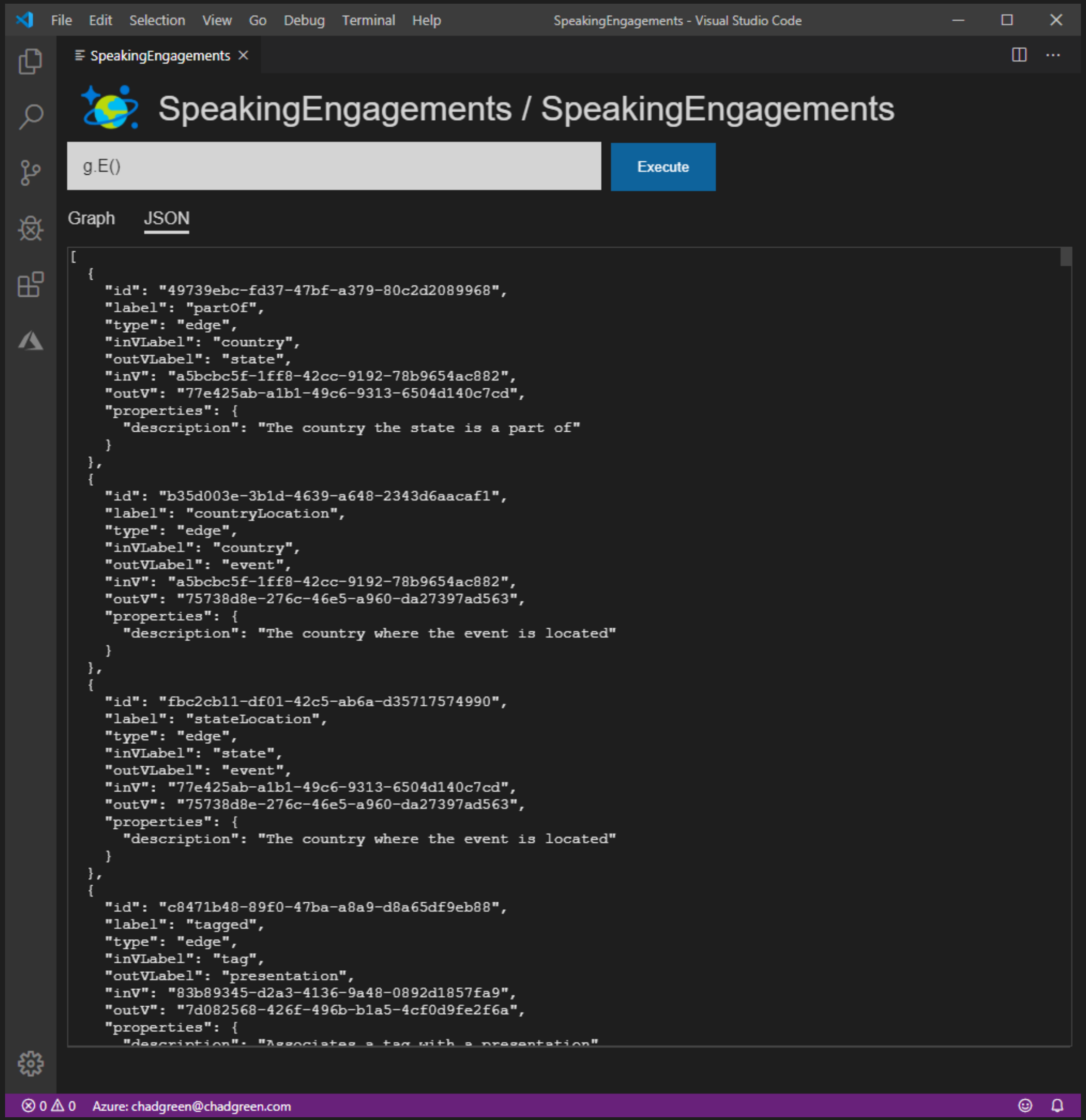
```
g.V()
```

Displaying 246 of 246 vertices and 500 of 1212 edges

g.V()

@chadgreen

View all of the edges


File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
⊗ 0 ⚠ 0
Azure: chadgreen@chadgreen.com

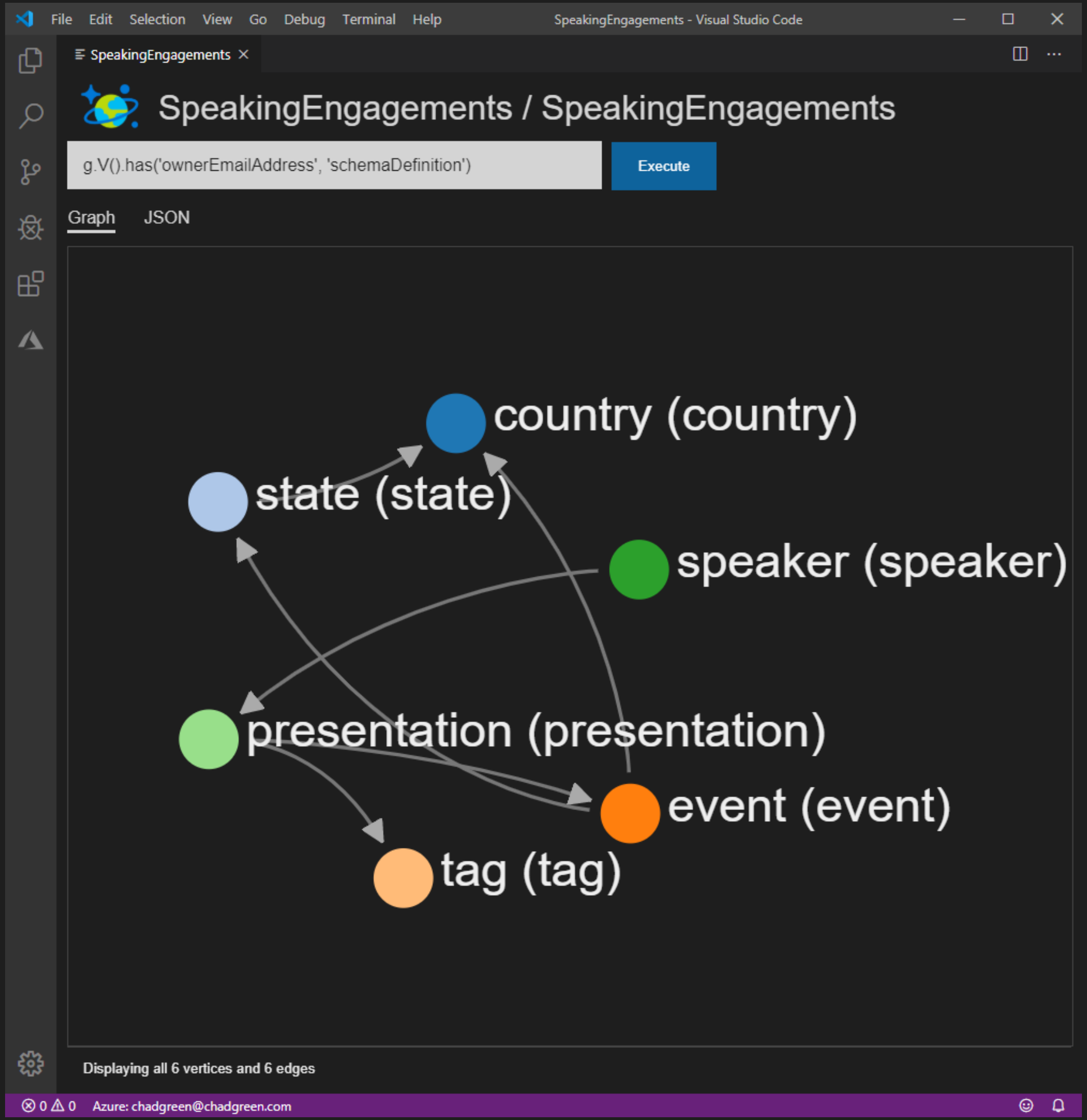
```
g.E()
```

```
[
  {
    "id": "49739ebc-fd37-47bf-a379-80c2d2089968",
    "label": "partOf",
    "type": "edge",
    "inVLabel": "country",
    "outVLabel": "state",
    "inV": "a5bcbc5f-1ff8-42cc-9192-78b9654ac882",
    "outV": "77e425ab-a1b1-49c6-9313-6504d140c7cd",
    "properties": {
      "description": "The country the state is a part of"
    }
  },
  {
    "id": "b35d003e-3b1d-4639-a648-2343d6aacaf1",
    "label": "countryLocation",
    "type": "edge",
    "inVLabel": "country",
    "outVLabel": "event",
    "inV": "a5bcbc5f-1ff8-42cc-9192-78b9654ac882",
    "outV": "75738d8e-276c-46e5-a960-da27397ad563",
    "properties": {
      "description": "The country where the event is located"
    }
  },
  {
    "id": "fbc2cb11-df01-42c5-ab6a-d35717574990",
    "label": "stateLocation",
    "type": "edge",
    "inVLabel": "state",
    "outVLabel": "event",
    "inV": "77e425ab-a1b1-49c6-9313-6504d140c7cd",
    "outV": "75738d8e-276c-46e5-a960-da27397ad563",
    "properties": {
      "description": "The country where the event is located"
    }
  },
  {
    "id": "c8471b48-89f0-47ba-a8a9-d8a65df9eb88",
    "label": "tagged",
    "type": "edge",
    "inVLabel": "tag",
    "outVLabel": "presentation",
    "inV": "83b89345-d2a3-4136-9a48-0892d1857fa9",
    "outV": "7d082568-426f-496b-b1a5-4cf0d9fe2f6a",
    "properties": {
      "description": "Associates a tag with a presentation"
```

g.E()

@chadgreen

View the schema definition



File Edit Selection View Go Debug Terminal Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
country (country)
state (state)
speaker (speaker)
presentation (presentation)
event (event)
tag (tag)
0 0
Azure: chadgreen@chadgreen.com

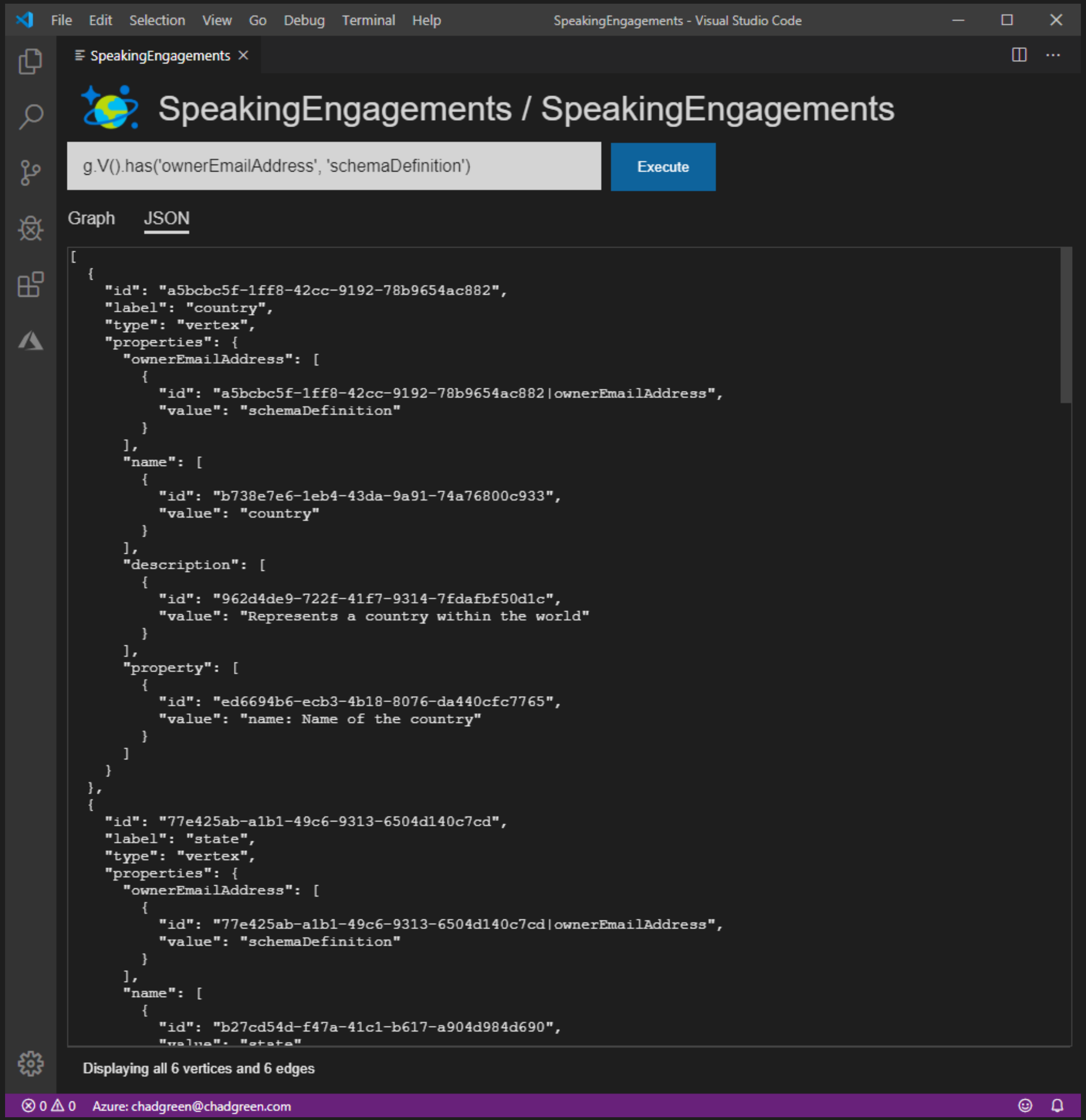
```
g.V().has('ownerEmailAddress', 'schemaDefinition')
```

Displaying all 6 vertices and 6 edges

g.V()
.has(‘ownerEmailAddress’,
‘schemaDefinition’)

@chadgreen

View the schema definition


File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON

g.V().has('ownerEmailAddress', 'schemaDefinition')

```
[
  {
    "id": "a5bcbc5f-1ff8-42cc-9192-78b9654ac882",
    "label": "country",
    "type": "vertex",
    "properties": {
      "ownerEmailAddress": [
        {
          "id": "a5bcbc5f-1ff8-42cc-9192-78b9654ac882|ownerEmailAddress",
          "value": "schemaDefinition"
        }
      ],
      "name": [
        {
          "id": "b738e7e6-1eb4-43da-9a91-74a76800c933",
          "value": "country"
        }
      ],
      "description": [
        {
          "id": "962d4de9-722f-41f7-9314-7fdafbf50d1c",
          "value": "Represents a country within the world"
        }
      ],
      "property": [
        {
          "id": "ed6694b6-ecb3-4b18-8076-da440cfc7765",
          "value": "name: Name of the country"
        }
      ]
    }
  },
  {
    "id": "77e425ab-a1b1-49c6-9313-6504d140c7cd",
    "label": "state",
    "type": "vertex",
    "properties": {
      "ownerEmailAddress": [
        {
          "id": "77e425ab-a1b1-49c6-9313-6504d140c7cd|ownerEmailAddress",
          "value": "schemaDefinition"
        }
      ],
      "name": [
        {
          "id": "b27cd54d-f47a-41c1-b617-a904d984d690",
          "value": "state"
```

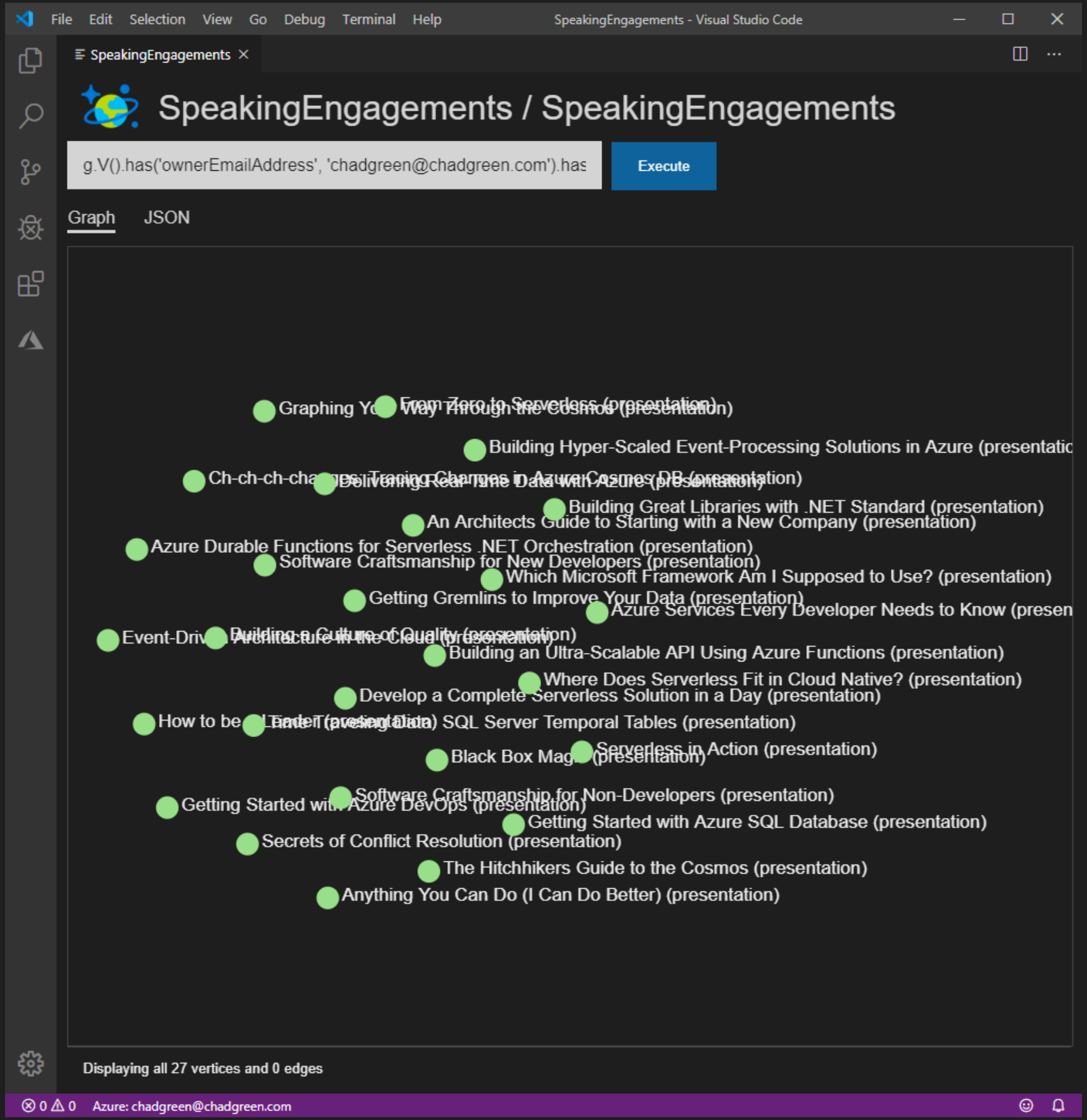
Displaying all 6 vertices and 6 edges

⊗ 0 ⚠ 0 Azure: chadgreen@chadgreen.com

g.V()
.has(‘ownerEmailAddress’,
‘schemaDefinition’)

@chadgreen

What presentations are in my repertoire?

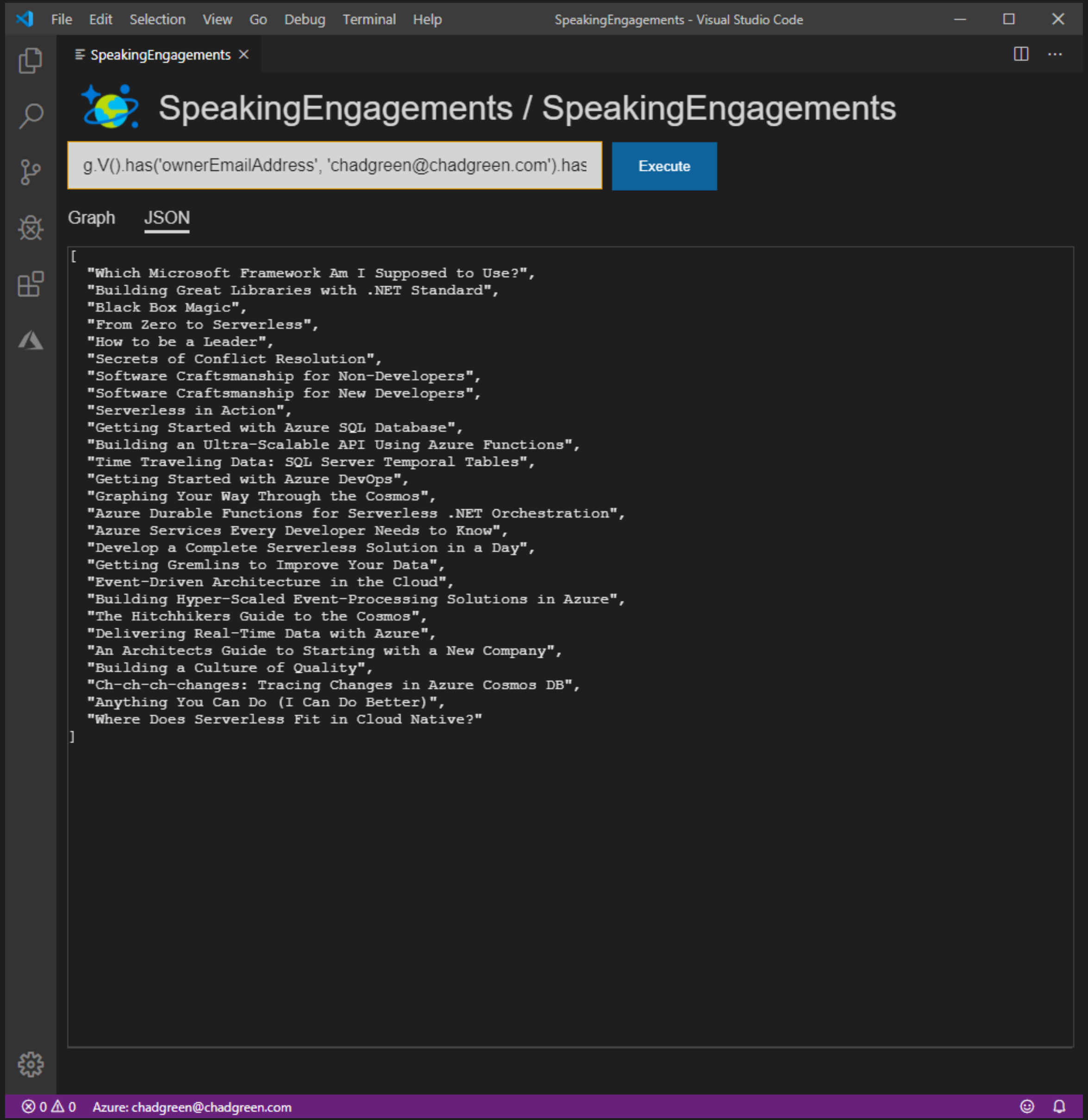

File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
Graphing Y
From Zero to Serverless (presentation)
Way Through the Cosmos (presentation)
Building Hyper-Scaled Event-Processing Solutions in Azure (presentatic
Ch-ch-ch-changes: Tracing Changes in Azure Cosmos DB (presentation)
Delivering Real-Time Data with Azure (presentation)
Building Great Libraries with .NET Standard (presentation)
An Architects Guide to Starting with a New Company (presentation)
Azure Durable Functions for Serverless .NET Orchestration (presentation)
Software Craftsmanship for New Developers (presentation)
Which Microsoft Framework Am I Supposed to Use? (presentation)
Getting Gremlins to Improve Your Data (presentation)
Azure Services Every Developer Needs to Know (presen
Event-Driv
Building a Culture of Quality (presentation)
Architecture in the Cloud (presentation)
Building an Ultra-Scalable API Using Azure Functions (presentation)
Where Does Serverless Fit in Cloud Native? (presentation)
Develop a Complete Serverless Solution in a Day (presentation)
How to be
Leader (presentation)
Time Traveling Data) SQL Server Temporal Tables (presentation)
Black Box Mag
Serverless in Action (presentation)
(presentation)
Getting Started wit
Software Craftsmanship for Non-Developers (presentation)
Azure DevOps (presentation)
Getting Started with Azure SQL Database (presentation)
Secrets of Conflict Resolution (presentation)
The Hitchhikers Guide to the Cosmos (presentation)
Anything You Can Do (I Can Do Better) (presentation)
⊗ 0 ⚠ 0
Azure: chadgreen@chadgreen.com

```
g.V().has('ownerEmailAddress', 'chadgreen@chadgreen.com').has
```

Displaying all 27 vertices and 0 edges

```
g.V()
.has('ownerEmailAddress',
'chadgreen@chadgreen.com')
.hasLabel('presentation')
```

What presentations are in my repertoire?

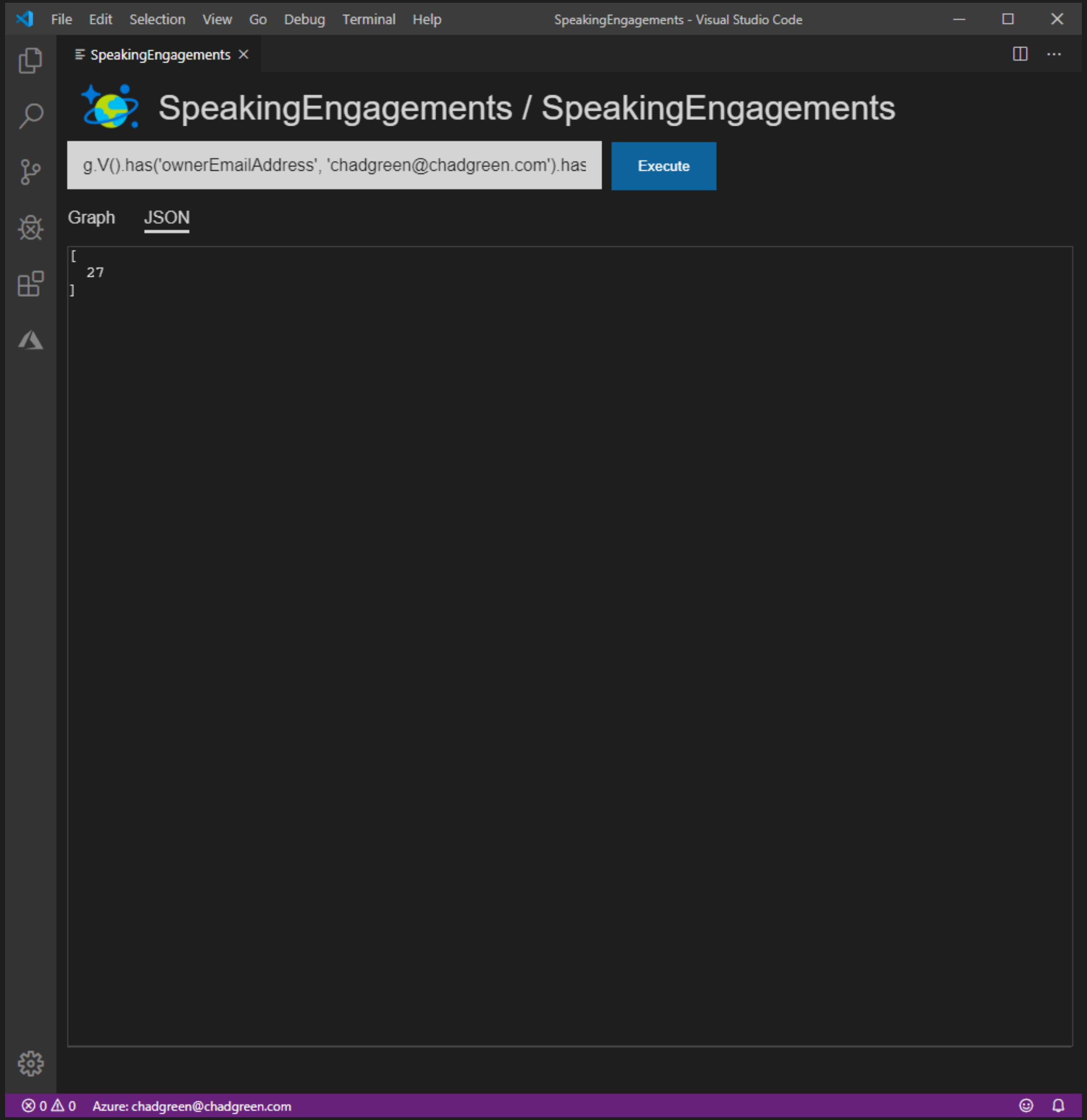

File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
⊗ 0 ⚠ 0
Azure: chadgreen@chadgreen.com

```
g.V().has('ownerEmailAddress', 'chadgreen@chadgreen.com').has
```

```
[
  "Which Microsoft Framework Am I Supposed to Use?",
  "Building Great Libraries with .NET Standard",
  "Black Box Magic",
  "From Zero to Serverless",
  "How to be a Leader",
  "Secrets of Conflict Resolution",
  "Software Craftsmanship for Non-Developers",
  "Software Craftsmanship for New Developers",
  "Serverless in Action",
  "Getting Started with Azure SQL Database",
  "Building an Ultra-Scalable API Using Azure Functions",
  "Time Traveling Data: SQL Server Temporal Tables",
  "Getting Started with Azure DevOps",
  "Graphing Your Way Through the Cosmos",
  "Azure Durable Functions for Serverless .NET Orchestration",
  "Azure Services Every Developer Needs to Know",
  "Develop a Complete Serverless Solution in a Day",
  "Getting Gremlins to Improve Your Data",
  "Event-Driven Architecture in the Cloud",
  "Building Hyper-Scaled Event-Processing Solutions in Azure",
  "The Hitchhikers Guide to the Cosmos",
  "Delivering Real-Time Data with Azure",
  "An Architects Guide to Starting with a New Company",
  "Building a Culture of Quality",
  "Ch-ch-ch-changes: Tracing Changes in Azure Cosmos DB",
  "Anything You Can Do (I Can Do Better)",
  "Where Does Serverless Fit in Cloud Native?"
]
```

```
g.V()
.hasLabel('presentation')
.values('name')
```

How many presentations are in my repertoire?


File Edit Selection View Go Debug Terminal Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
⊗ 0 ⚠ 0
Azure: chadgreen@chadgreen.com

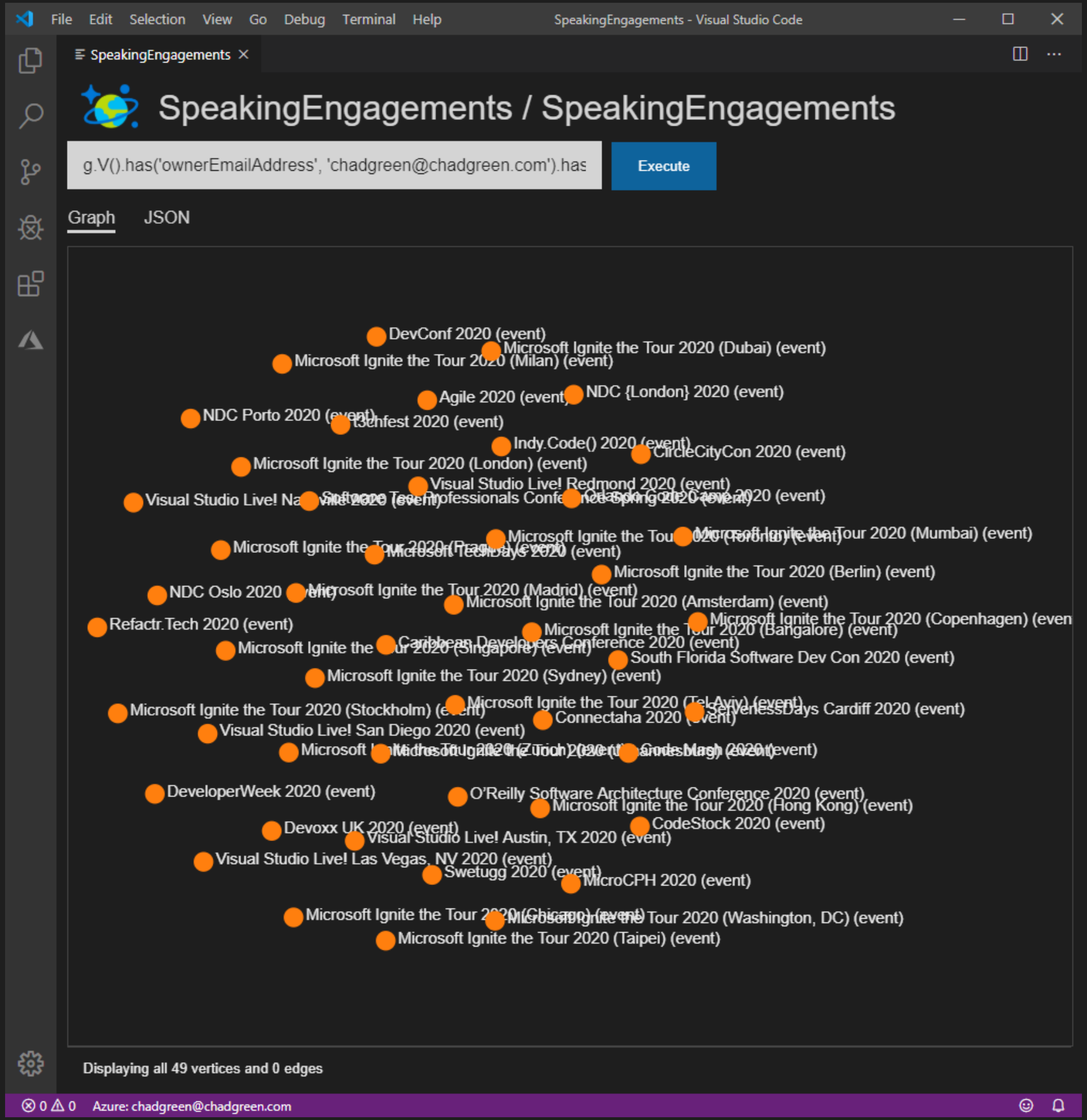
```
g.V().has('ownerEmailAddress', 'chadgreen@chadgreen.com').has
```

```
[
  27
]
```

```
g.V()
.hasLabel('presentation')
.count()
```

@chadgreen

What are the events that I have submitted to?



SpeakingEngagements - Visual Studio Code

SpeakingEngagements / SpeakingEngagements

```
g.V().has('ownerEmailAddress', 'chadgreen@chadgreen.com').has
```

Displaying all 49 vertices and 0 edges

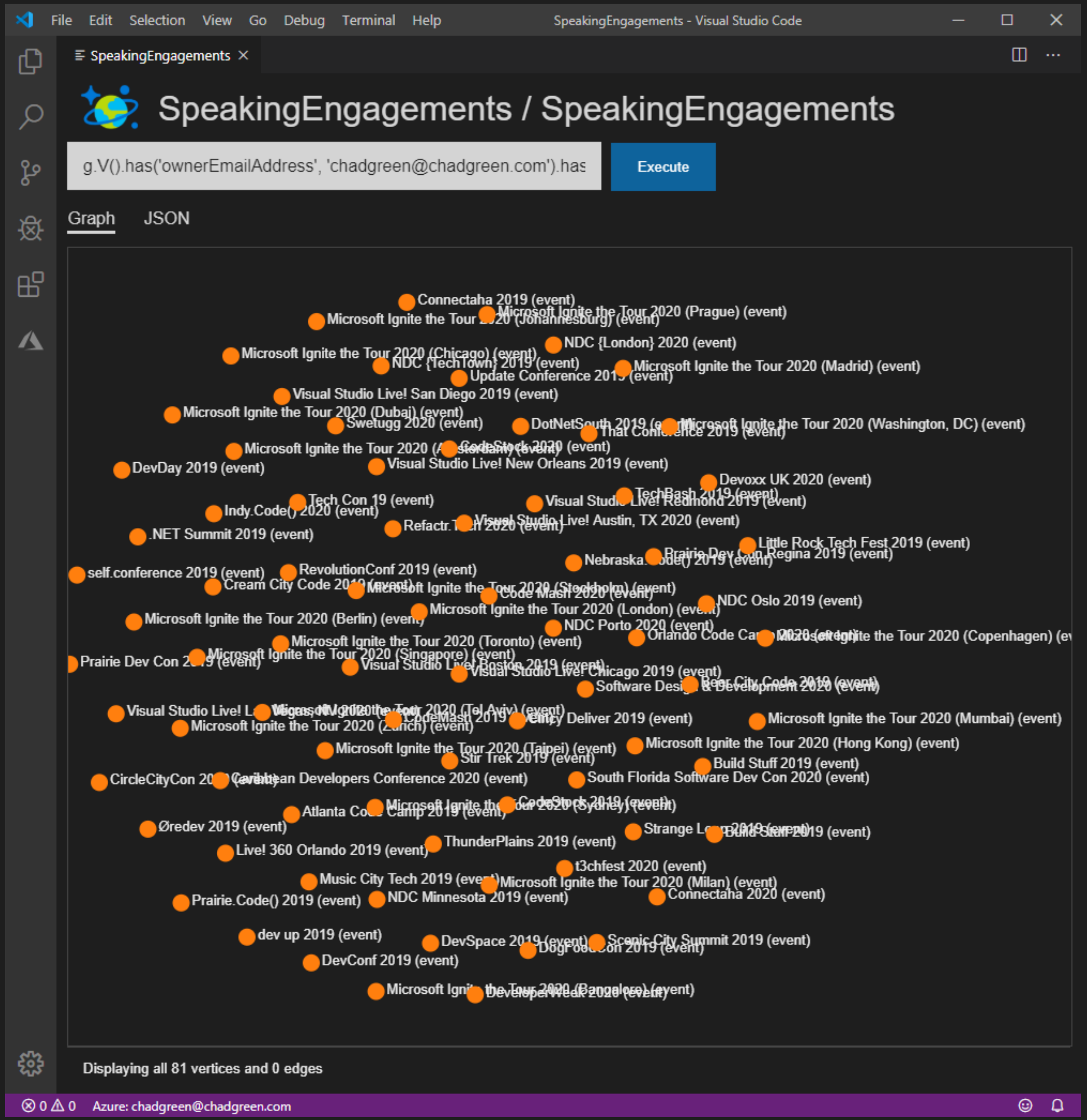
Azure: chadgreen@chadgreen.com

File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements
Execute
Graph
JSON
DevConf 2020 (event)
Microsoft Ignite the Tour 2020 (Dubai) (event)
Microsoft Ignite the Tour 2020 (Milan) (event)
Agile 2020 (event)
NDC {London} 2020 (event)
NDC Porto 2020 (event)
Techfest 2020 (event)
Indy.Code() 2020 (event)
CircleCityCon 2020 (event)
Microsoft Ignite the Tour 2020 (London) (event)
Visual Studio Live! Redmond 2020 (event)
Visual Studio Live! Nashville 2020 (event)
Software Test Professionals Conference Spring 2020 (event)
Orlando Code Camp 2020 (event)
Microsoft Ignite the Tour 2020 (Prague) (event)
Microsoft TechDays 2020 (event)
Microsoft Ignite the Tour 2020 (Toronto) (event)
Microsoft Ignite the Tour 2020 (Mumbai) (event)
Microsoft Ignite the Tour 2020 (Berlin) (event)
NDC Oslo 2020 (event)
Microsoft Ignite the Tour 2020 (Madrid) (event)
Microsoft Ignite the Tour 2020 (Amsterdam) (event)
Refactr.Tech 2020 (event)
Microsoft Ignite the Tour 2020 (Copenhagen) (even
Microsoft Ignite the Tour 2020 (Bangalore) (event)
Microsoft Ignite the Tour 2020 (Singapore) (event)
Caribbean Developers Conference 2020 (event)
South Florida Software Dev Con 2020 (event)
Microsoft Ignite the Tour 2020 (Sydney) (event)
Microsoft Ignite the Tour 2020 (Stockholm) (event)
Microsoft Ignite the Tour 2020 (Tel Aviv) (event)
ServerlessDays Cardiff 2020 (event)
Connectaha 2020 (event)
Visual Studio Live! San Diego 2020 (event)
Microsoft Ignite the Tour 2020 (Zurich) (event)
Microsoft Ignite the Tour 2020 (Johannesburg) (event)
CodeMash 2020 (event)
DeveloperWeek 2020 (event)
O'Reilly Software Architecture Conference 2020 (event)
Microsoft Ignite the Tour 2020 (Hong Kong) (event)
Devoxx UK 2020 (event)
CodeStock 2020 (event)
Visual Studio Live! Austin, TX 2020 (event)
Visual Studio Live! Las Vegas, NV 2020 (event)
Swetugg 2020 (event)
MicroCPH 2020 (event)
Microsoft Ignite the Tour 2020 (Chicago) (event)
Microsoft Ignite the Tour 2020 (Washington, DC) (event)
Microsoft Ignite the Tour 2020 (Taipei) (event)
⊗ 0 ⚠ 0

```
g.V()
.hasLabel('event')
.has('year', '2020')
```

@chadgreen

Where has *Graphing Your Way Through the Cosmos* been submitted to?



File Edit Selection View Go Debug Terminal Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
Connectaha 2019 (event)
Microsoft Ignite the Tour 2020 (Johannesburg) (event)
Microsoft Ignite the Tour 2020 (Prague) (event)
NDC {London} 2020 (event)
Microsoft Ignite the Tour 2020 (Chicago) (event)
NDC {Tech Town} 2019 (event)
Microsoft Ignite the Tour 2020 (Madrid) (event)
Update Conference 2019 (event)
Visual Studio Live! San Diego 2019 (event)
Microsoft Ignite the Tour 2020 (Dubai) (event)
Swetugg 2020 (event)
DotNetSouth 2019 (event)
That Conference 2019 (event)
Microsoft Ignite the Tour 2020 (Washington, DC) (event)
CodeStock 2020 (event)
DevDay 2019 (event)
Visual Studio Live! New Orleans 2019 (event)
Devoxx UK 2020 (event)
Tech Con 19 (event)
TechBash 2019 (event)
Visual Studio Live! Redmond 2019 (event)
Indy.Code() 2020 (event)
Visual Studio Live! Austin, TX 2020 (event)
.NET Summit 2019 (event)
Little Rock Tech Fest 2019 (event)
Prairie Dev Con Regina 2019 (event)
Nebraska.Code() 2019 (event)
self.conference 2019 (event)
RevolutionConf 2019 (event)
Cream City Code 2019 (event)
Microsoft Ignite the Tour 2020 (Stockholm) (event)
Code Mash 2020 (event)
NDC Oslo 2019 (event)
Microsoft Ignite the Tour 2020 (Berlin) (event)
Microsoft Ignite the Tour 2020 (London) (event)
NDC Porto 2020 (event)
Microsoft Ignite the Tour 2020 (Toronto) (event)
Orlando Code Camp 2020 (event)
Microsoft Ignite the Tour 2020 (Copenhagen) (ev
Prairie Dev Con 2019 (event)
Microsoft Ignite the Tour 2020 (Singapore) (event)
Visual Studio Live! Boston 2019 (event)
Visual Studio Live! Chicago 2019 (event)
Beer City Code 2019 (event)
Software Design & Development 2020 (event)
Microsoft Ignite the Tour 2020 (Tel Aviv) (event)
CodeMash 2019 (event)
Deliver 2019 (event)
Microsoft Ignite the Tour 2020 (Mumbai) (event)
Microsoft Ignite the Tour 2020 (Zurich) (event)
Microsoft Ignite the Tour 2020 (Taipei) (event)
Microsoft Ignite the Tour 2020 (Hong Kong) (event)
Stir Trek 2019 (event)
Build Stuff 2019 (event)
CircleCityCon 2019 (event)
Caribbean Developers Conference 2020 (event)
South Florida Software Dev Con 2020 (event)
Atlanta Code Camp 2019 (event)
Microsoft Ignite the Tour 2020 (Sydney) (event)
CodeStock 2019 (event)
Strange Loop 2019 (event)
Øredev 2019 (event)
ThunderPlains 2019 (event)
Live! 360 Orlando 2019 (event)
t3chfest 2020 (event)
Music City Tech 2019 (event)
Microsoft Ignite the Tour 2020 (Milan) (event)
Prairie.Code() 2019 (event)
NDC Minnesota 2019 (event)
Connectaha 2020 (event)
dev up 2019 (event)
DevSpace 2019 (event)
Scenic City Summit 2019 (event)
DogFoodCon 2019 (event)
DevConf 2019 (event)
Microsoft Ignite the Tour 2020 (Bangalore) (event)
DeveloperWeek 2020 (event)
Azure: chadgreen@chadgreen.com

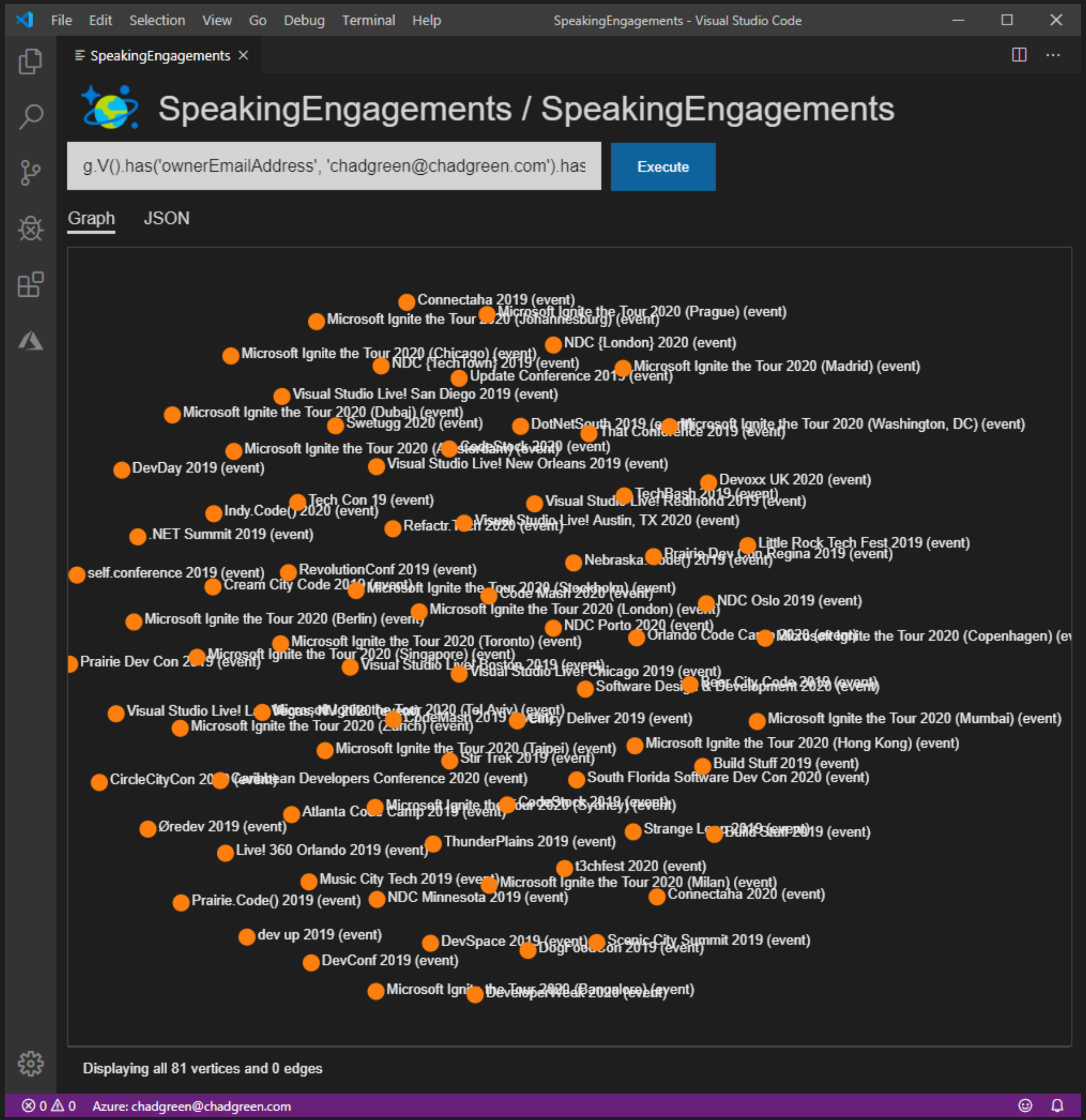
```
g.V().has('ownerEmailAddress', 'chadgreen@chadgreen.com').has
```

Displaying all 81 vertices and 0 edges

```
g.V()
.hasLabel('presentation’)
.has('name', 'Graphing Your
Way Through the Cosmos’)
.outE('submittedTo’)
.inV()
```

@chadgreen

Where has *Graphing Your Way Through the Cosmos* been submitted to?


File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
Connectaha 2019 (event)
Microsoft Ignite the Tour 2020 (Johannesburg) (event)
Microsoft Ignite the Tour 2020 (Prague) (event)
NDC {London} 2020 (event)
Microsoft Ignite the Tour 2020 (Chicago) (event)
NDC {Tech Town} 2019 (event)
Microsoft Ignite the Tour 2020 (Madrid) (event)
Update Conference 2019 (event)
Visual Studio Live! San Diego 2019 (event)
Microsoft Ignite the Tour 2020 (Dubai) (event)
Swetugg 2020 (event)
DotNetSouth 2019 (event)
Microsoft Ignite the Tour 2020 (Washington, DC) (event)
That Conference 2019 (event)
Microsoft Ignite the Tour 2020 (Amsterdam) (event)
CodeStock 2020 (event)
DevDay 2019 (event)
Visual Studio Live! New Orleans 2019 (event)
Devoxx UK 2020 (event)
Tech Con 19 (event)
Visual Studio Live! Redmond 2019 (event)
TechBash 2019 (event)
Indy.Code() 2020 (event)
Refactr.Tech 2020 (event)
Visual Studio Live! Austin, TX 2020 (event)
.NET Summit 2019 (event)
Little Rock Tech Fest 2019 (event)
Nebraska.Code() 2019 (event)
Prairie Dev Con Regina 2019 (event)
self.conference 2019 (event)
RevolutionConf 2019 (event)
Cream City Code 2019 (event)
Microsoft Ignite the Tour 2020 (Stockholm) (event)
Code Mash 2020 (event)
NDC Oslo 2019 (event)
Microsoft Ignite the Tour 2020 (Berlin) (event)
Microsoft Ignite the Tour 2020 (London) (event)
NDC Porto 2020 (event)
Orlando Code Camp 2020 (event)
Microsoft Ignite the Tour 2020 (Copenhagen) (ev
Microsoft Ignite the Tour 2020 (Toronto) (event)
Prairie Dev Con 2019 (event)
Microsoft Ignite the Tour 2020 (Singapore) (event)
Visual Studio Live! Boston 2019 (event)
Visual Studio Live! Chicago 2019 (event)
Beer City Code 2019 (event)
Software Design & Development 2020 (event)
Visual Studio Live! Las Vegas 2020 (event)
Microsoft Ignite the Tour 2020 (Tel Aviv) (event)
CodeMash 2019 (event)
Agile Deliver 2019 (event)
Microsoft Ignite the Tour 2020 (Mumbai) (event)
Microsoft Ignite the Tour 2020 (Zurich) (event)
Microsoft Ignite the Tour 2020 (Taipei) (event)
Stir Trek 2019 (event)
Microsoft Ignite the Tour 2020 (Hong Kong) (event)
Build Stuff 2019 (event)
CircleCityCon 2019 (event)
Caribbean Developers Conference 2020 (event)
South Florida Software Dev Con 2020 (event)
Atlanta Code Camp 2019 (event)
Microsoft Ignite the Tour 2020 (Sydney) (event)
CodeStock 2019 (event)
Øredev 2019 (event)
Strange Loop 2019 (event)
Build Stuff 2019 (event)
Live! 360 Orlando 2019 (event)
ThunderPlains 2019 (event)
t3chfest 2020 (event)
Music City Tech 2019 (event)
Microsoft Ignite the Tour 2020 (Milan) (event)
Prairie.Code() 2019 (event)
NDC Minnesota 2019 (event)
Connectaha 2020 (event)
dev up 2019 (event)
DevSpace 2019 (event)
DogFoodCon 2019 (event)
Scenic City Summit 2019 (event)
DevConf 2019 (event)
Microsoft Ignite the Tour 2020 (Bangalore) (event)
DeveloperWeek 2020 (event)

SpeakingEngagements / SpeakingEngagements

```
g.V().has('ownerEmailAddress', 'chadgreen@chadgreen.com').has
```

Execute

Graph JSON

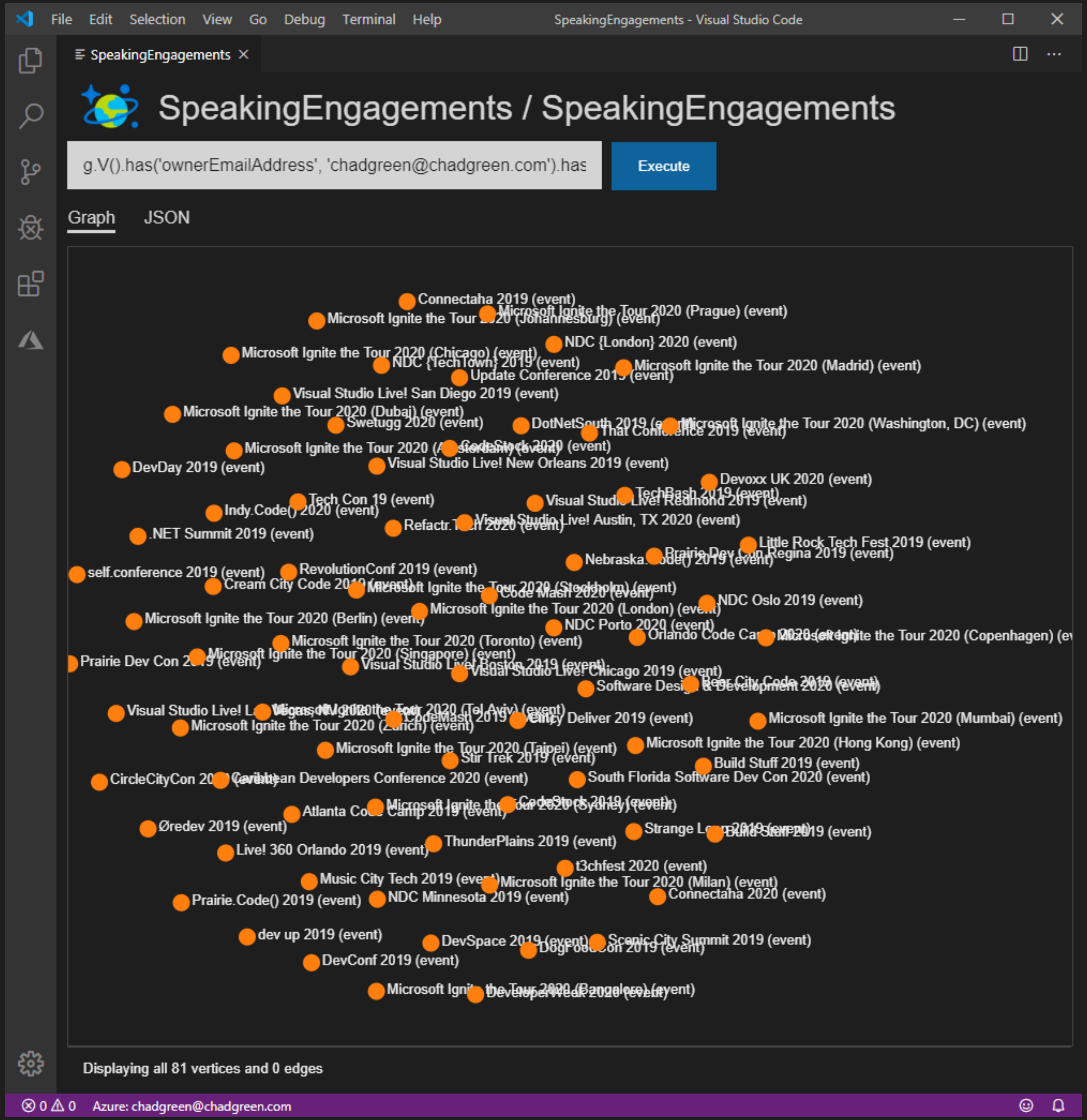
Displaying all 81 vertices and 0 edges

⊗ 0 ⚠ 0 Azure: chadgreen@chadgreen.com

```
g.V()
.hasLabel('presentation')
.has('name', 'Graphing Your
Way Through the Cosmos')
.outE('submittedTo')
.inV()
.has('year', '2020')
```

@chadgreen

Where has *Graphing Your Way Through the Cosmos* been submitted to?



File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
Connectaha 2019 (event)
Microsoft Ignite the Tour 2020 (Johannesburg) (event)
Microsoft Ignite the Tour 2020 (Prague) (event)
NDC {London} 2020 (event)
Microsoft Ignite the Tour 2020 (Chicago) (event)
NDC {Tech Town} 2019 (event)
Microsoft Ignite the Tour 2020 (Madrid) (event)
Update Conference 2019 (event)
Visual Studio Live! San Diego 2019 (event)
Microsoft Ignite the Tour 2020 (Dubai) (event)
Swetugg 2020 (event)
DotNetSouth 2019 (event)
That Conference 2019 (event)
Microsoft Ignite the Tour 2020 (Washington, DC) (event)
Microsoft Ignite the Tour 2020 (Amsterdam) (event)
CodeStock 2020 (event)
DevDay 2019 (event)
Visual Studio Live! New Orleans 2019 (event)
Devoxx UK 2020 (event)
Tech Con 19 (event)
Visual Studio Live! Redmond 2019 (event)
TechBash 2019 (event)
Indy.Code() 2020 (event)
Refactr.Tech 2020 (event)
Visual Studio Live! Austin, TX 2020 (event)
.NET Summit 2019 (event)
Little Rock Tech Fest 2019 (event)
Nebraska.Code() 2019 (event)
Prairie Dev Con Regina 2019 (event)
self.conference 2019 (event)
RevolutionConf 2019 (event)
Cream City Code 2019 (event)
Microsoft Ignite the Tour 2020 (Stockholm) (event)
Code Mash 2020 (event)
NDC Oslo 2019 (event)
Microsoft Ignite the Tour 2020 (Berlin) (event)
Microsoft Ignite the Tour 2020 (London) (event)
NDC Porto 2020 (event)
Orlando Code Camp 2020 (event)
Microsoft Ignite the Tour 2020 (Copenhagen) (event)
Microsoft Ignite the Tour 2020 (Toronto) (event)
Prairie Dev Con 2019 (event)
Microsoft Ignite the Tour 2020 (Singapore) (event)
Visual Studio Live! Boston 2019 (event)
Visual Studio Live! Chicago 2019 (event)
Beer City Code 2019 (event)
Software Design & Development 2020 (event)
Visual Studio Live! Las Vegas 2020 (event)
Microsoft Ignite the Tour 2020 (Tel Aviv) (event)
CodeMash 2019 (event)
Agile Deliver 2019 (event)
Microsoft Ignite the Tour 2020 (Zurich) (event)
Microsoft Ignite the Tour 2020 (Mumbai) (event)
Microsoft Ignite the Tour 2020 (Taipei) (event)
Stir Trek 2019 (event)
Microsoft Ignite the Tour 2020 (Hong Kong) (event)
Build Stuff 2019 (event)
CircleCityCon 2019 (event)
Caribbean Developers Conference 2020 (event)
South Florida Software Dev Con 2020 (event)
Atlanta Code Camp 2019 (event)
Microsoft Ignite the Tour 2020 (Sydney) (event)
CodeStock 2019 (event)
Øredev 2019 (event)
Strange Loop 2019 (event)
Build Stuff 2019 (event)
Live! 360 Orlando 2019 (event)
ThunderPlains 2019 (event)
t3chfest 2020 (event)
Music City Tech 2019 (event)
Microsoft Ignite the Tour 2020 (Milan) (event)
Prairie.Code() 2019 (event)
NDC Minnesota 2019 (event)
Connectaha 2020 (event)
dev up 2019 (event)
DevSpace 2019 (event)
Scenic City Summit 2019 (event)
DogFoodCon 2019 (event)
DevConf 2019 (event)
Microsoft Ignite the Tour 2020 (Bangalore) (event)
DeveloperWeek 2020 (event)
Azure: chadgreen@chadgreen.com

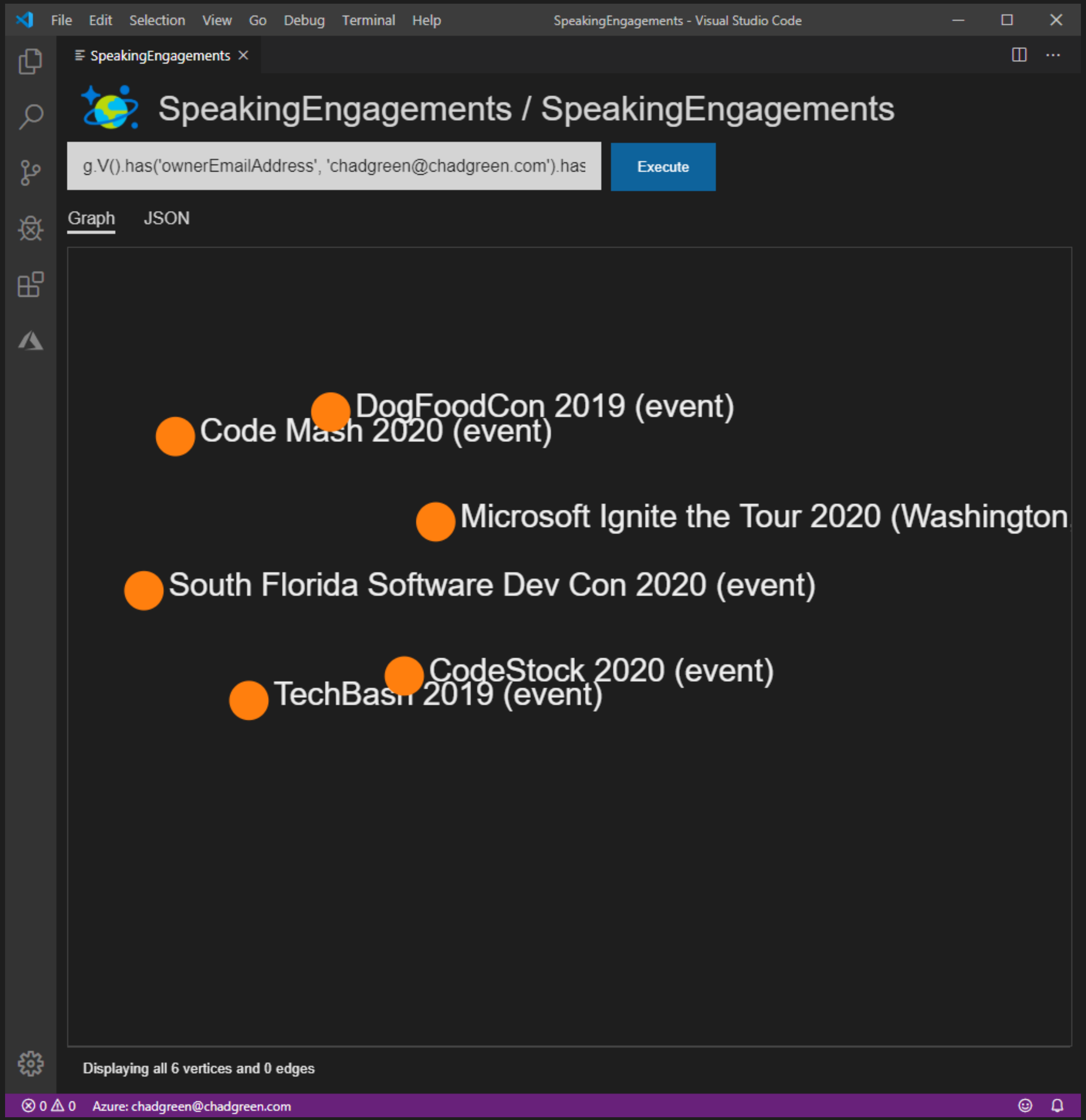
```
g.V().has('ownerEmailAddress', 'chadgreen@chadgreen.com').has
```

Displaying all 81 vertices and 0 edges

```
g.V()
.hasLabel('presentation’)
.has('name', 'Graphing Your Way Through the Cosmos’)
.outE('submittedTo’)
.inV()
```

@chadgreen

Where has *Graphing Your Way Through the Cosmos* been scheduled?


File Edit Selection View Go Debug Terminal Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
DogFoodCon 2019 (event)
Code Mash 2020 (event)
Microsoft Ignite the Tour 2020 (Washington
South Florida Software Dev Con 2020 (event)
CodeStock 2020 (event)
TechBash 2019 (event)
⊗ 0 ⚠ 0
Azure: chadgreen@chadgreen.com

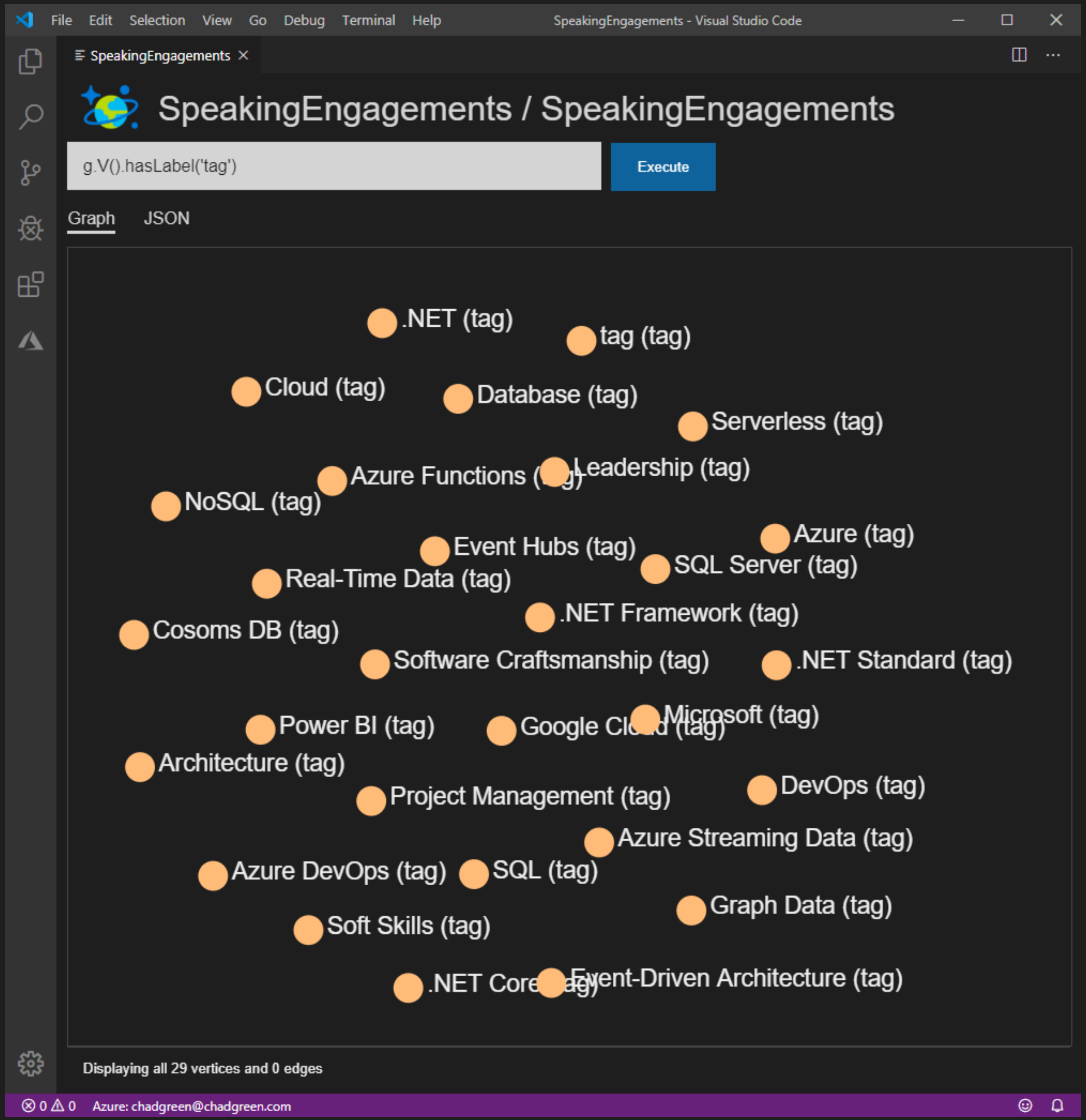
```
g.V().has('ownerEmailAddress', 'chadgreen@chadgreen.com').has
```

Displaying all 6 vertices and 0 edges

```
g.V()
.hasLabel('presentation’)
.has('name', 'Graphing Your
Way Through the Cosmos’)
.outE('submittedTo’)
.has('status', 'Confirmed’)
.inV()
```

@chadgreen

View all of the tags



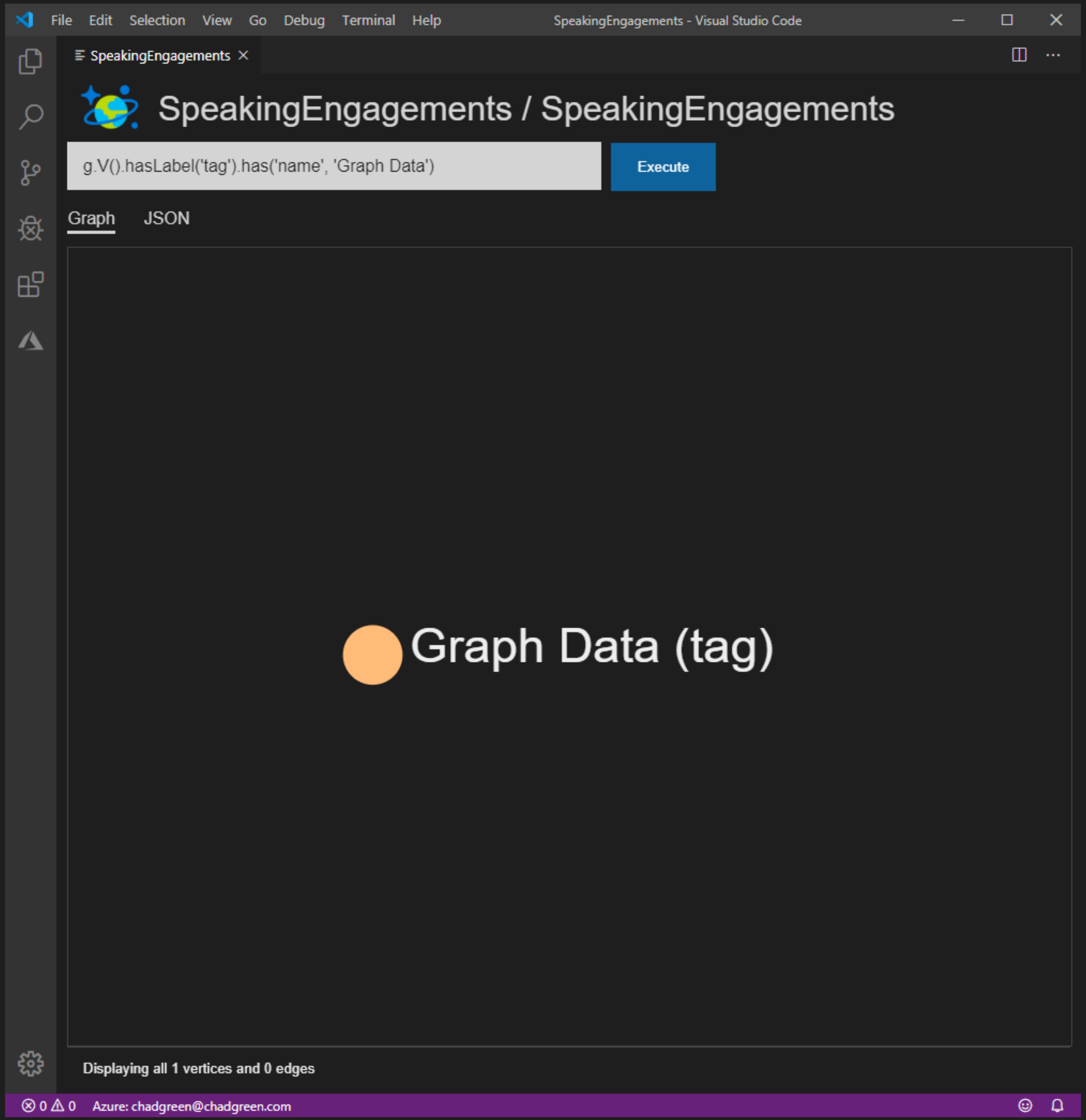
```
g.V().hasLabel('tag')
```

Displaying all 29 vertices and 0 edges

```
g.V()
.hasLabel('tag')
```

@chadgreen

Focus on the *Graph Data* tag

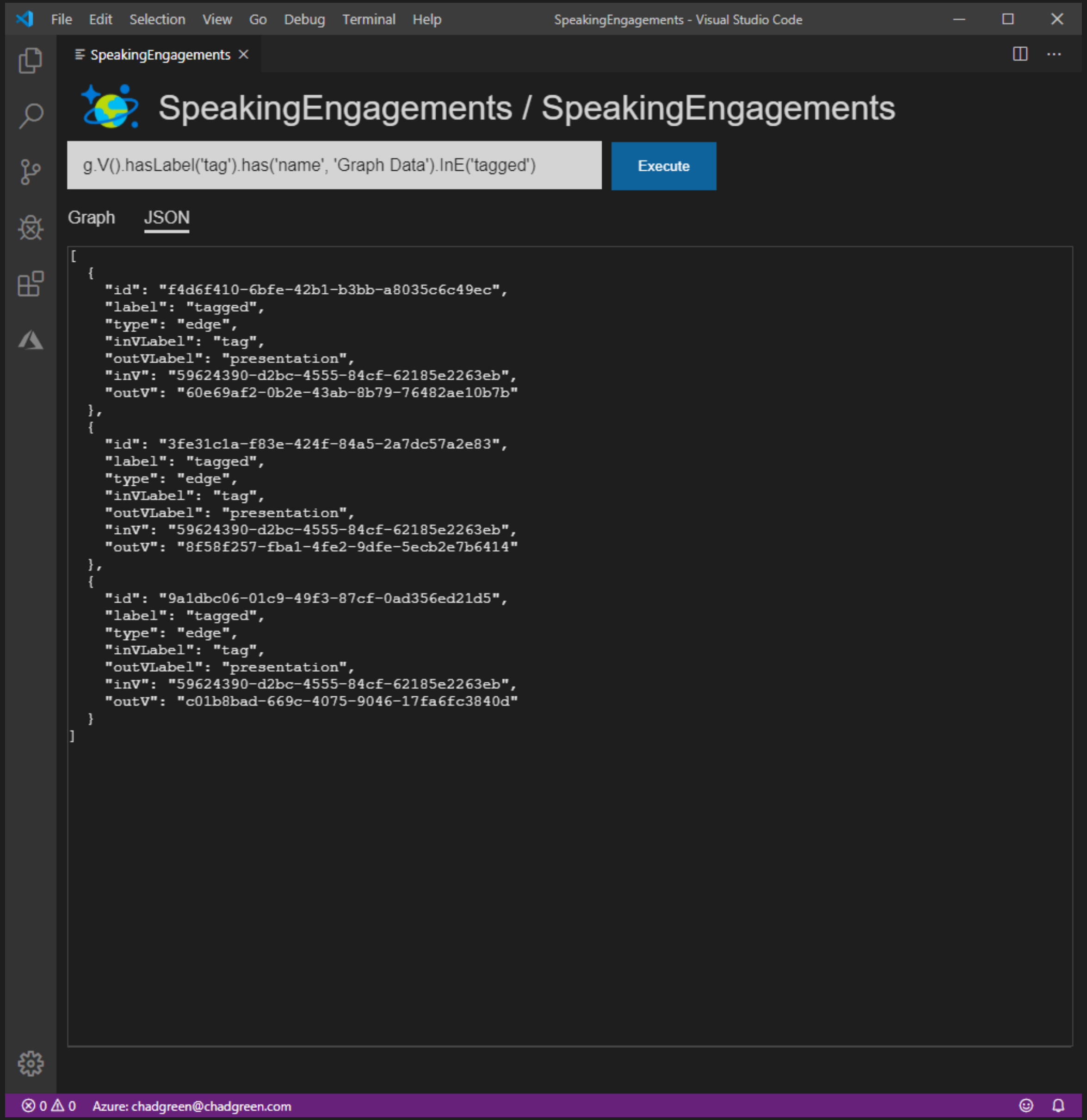

File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
Graph Data (tag)
⊗ 0 ⚠ 0
Azure: chadgreen@chadgreen.com

```
g.V().hasLabel('tag').has('name', 'Graph Data')
```

Displaying all 1 vertices and 0 edges

```
g.V()
.hasLabel('tag’)
.has('name', 'Graph Data')
```

What presentations are tagged with *Graph Data?*


File Edit Selection View Go Debug Terminal Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
⊗ 0 ⚠ 0 Azure: chadgreen@chadgreen.com

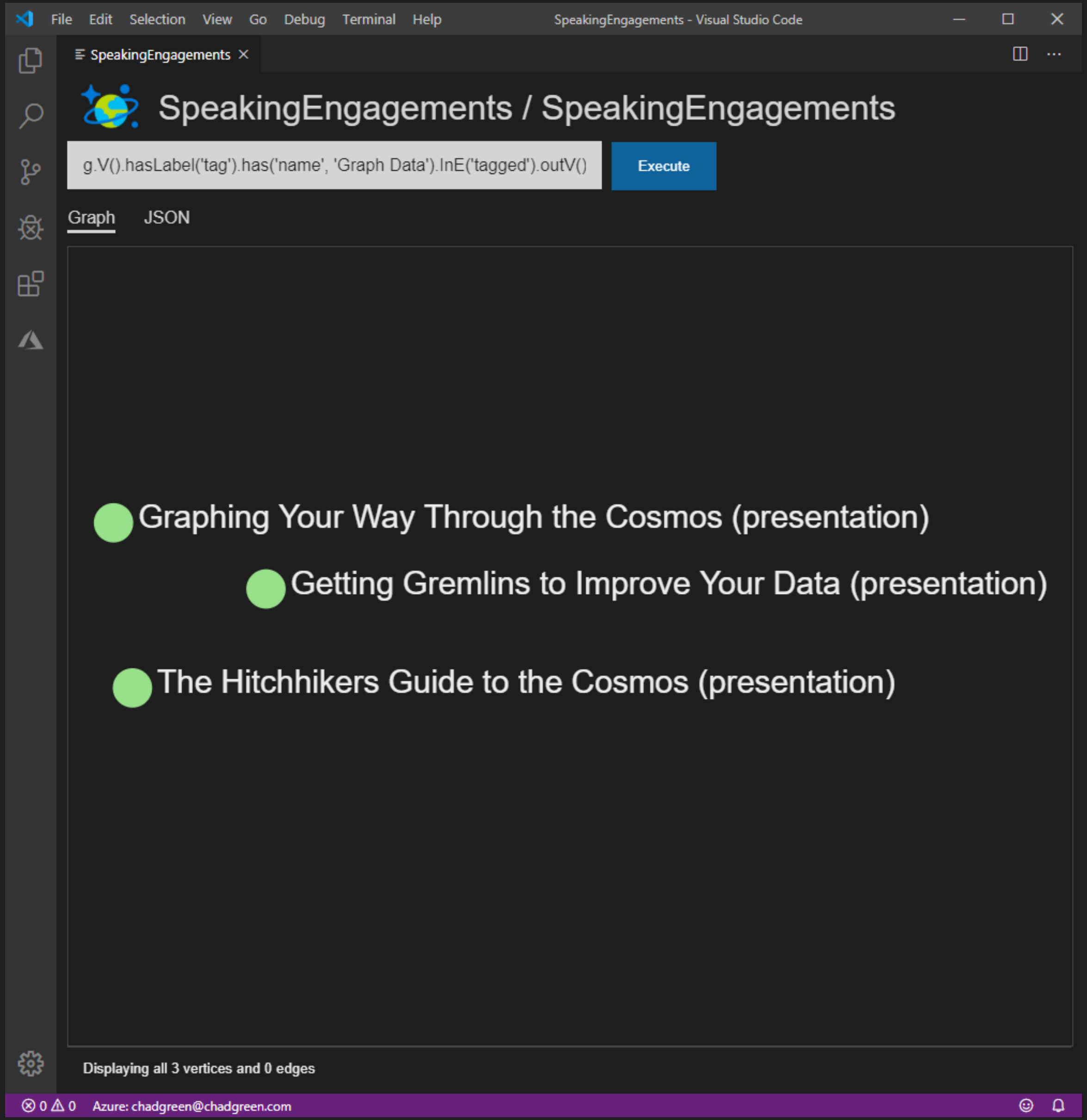
```
g.V().hasLabel('tag').has('name', 'Graph Data').InE('tagged')
```

```
[
  {
    "id": "f4d6f410-6bfe-42b1-b3bb-a8035c6c49ec",
    "label": "tagged",
    "type": "edge",
    "inVLabel": "tag",
    "outVLabel": "presentation",
    "inV": "59624390-d2bc-4555-84cf-62185e2263eb",
    "outV": "60e69af2-0b2e-43ab-8b79-76482ae10b7b"
  },
  {
    "id": "3fe31c1a-f83e-424f-84a5-2a7dc57a2e83",
    "label": "tagged",
    "type": "edge",
    "inVLabel": "tag",
    "outVLabel": "presentation",
    "inV": "59624390-d2bc-4555-84cf-62185e2263eb",
    "outV": "8f58f257-fba1-4fe2-9dfe-5ecb2e7b6414"
  },
  {
    "id": "9a1dbc06-01c9-49f3-87cf-0ad356ed21d5",
    "label": "tagged",
    "type": "edge",
    "inVLabel": "tag",
    "outVLabel": "presentation",
    "inV": "59624390-d2bc-4555-84cf-62185e2263eb",
    "outV": "c01b8bad-669c-4075-9046-17fa6fc3840d"
  }
]
```

```
g.V()
.hasLabel('tag’)
.has('name', 'Graph Data’)
.inE('tagged')
```

@chadgreen

What presentations are tagged with *Graph Data?*


File Edit Selection View Go Debug Terminal Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON

```
g.V().hasLabel('tag').has('name', 'Graph Data').InE('tagged').outV()
```

Graphing Your Way Through the Cosmos (presentation)

Getting Gremlins to Improve Your Data (presentation)

The Hitchhikers Guide to the Cosmos (presentation)

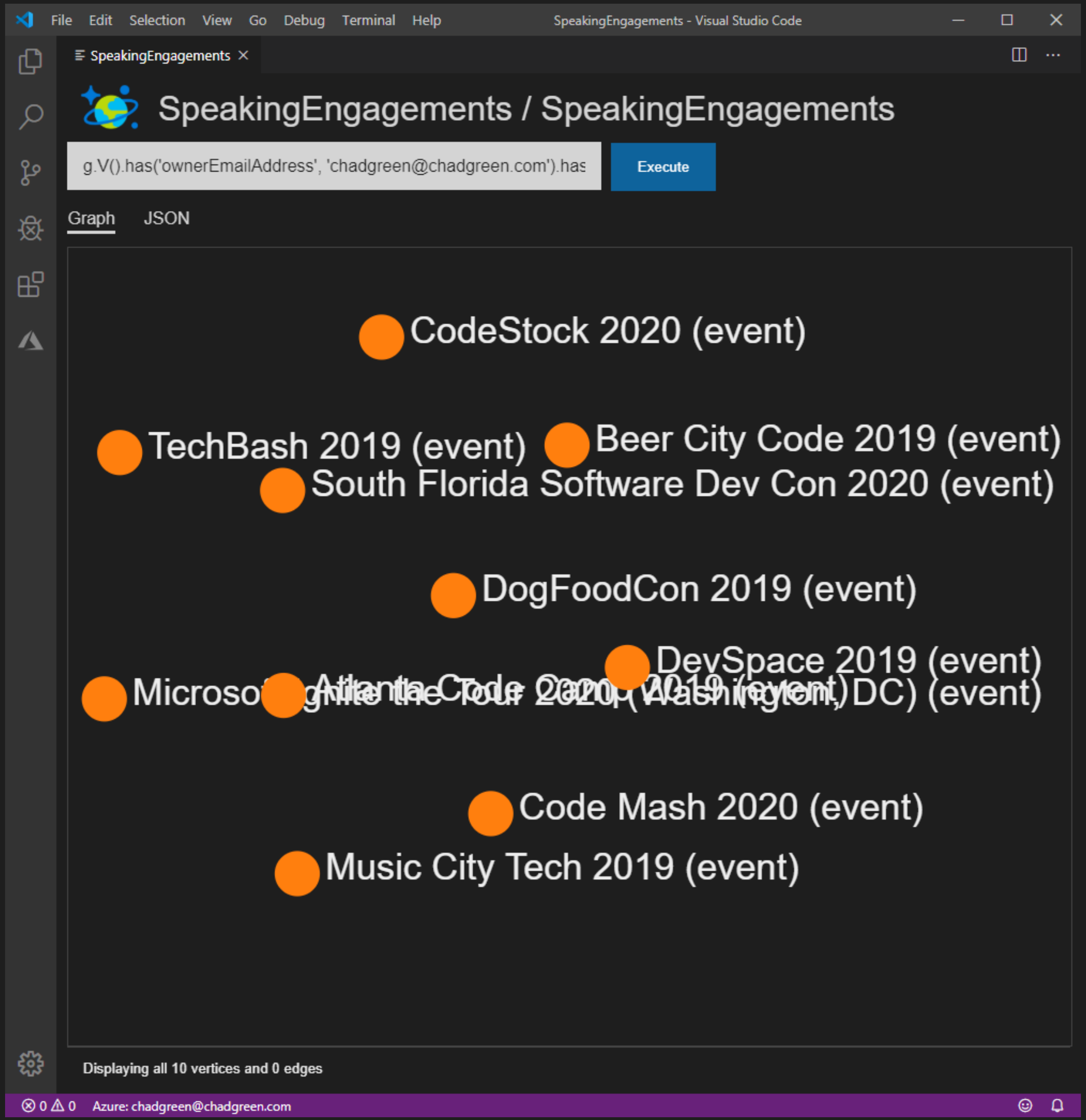
Displaying all 3 vertices and 0 edges

⊗ 0 ⚠ 0 Azure: chadgreen@chadgreen.com

```
g.V()
.hasLabel('tag’)
.has('name', 'Graph Data’)
.inE('tagged’)
.outV()
```

@chadgreen

Where have the presentations tagged *Graph Data* been scheduled?



File Edit Selection View Go Debug Terminal Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON

g.V().has('ownerEmailAddress', 'chadgreen@chadgreen.com').has

CodeStock 2020 (event)
TechBash 2019 (event)
Beer City Code 2019 (event)
South Florida Software Dev Con 2020 (event)
DogFoodCon 2019 (event)
DevSpace 2019 (event)
Microsoft Ignite the Tour 2020 (Washington, DC) (event)
Atlanta Code Camp 2019 (event)
Code Mash 2020 (event)
Music City Tech 2019 (event)

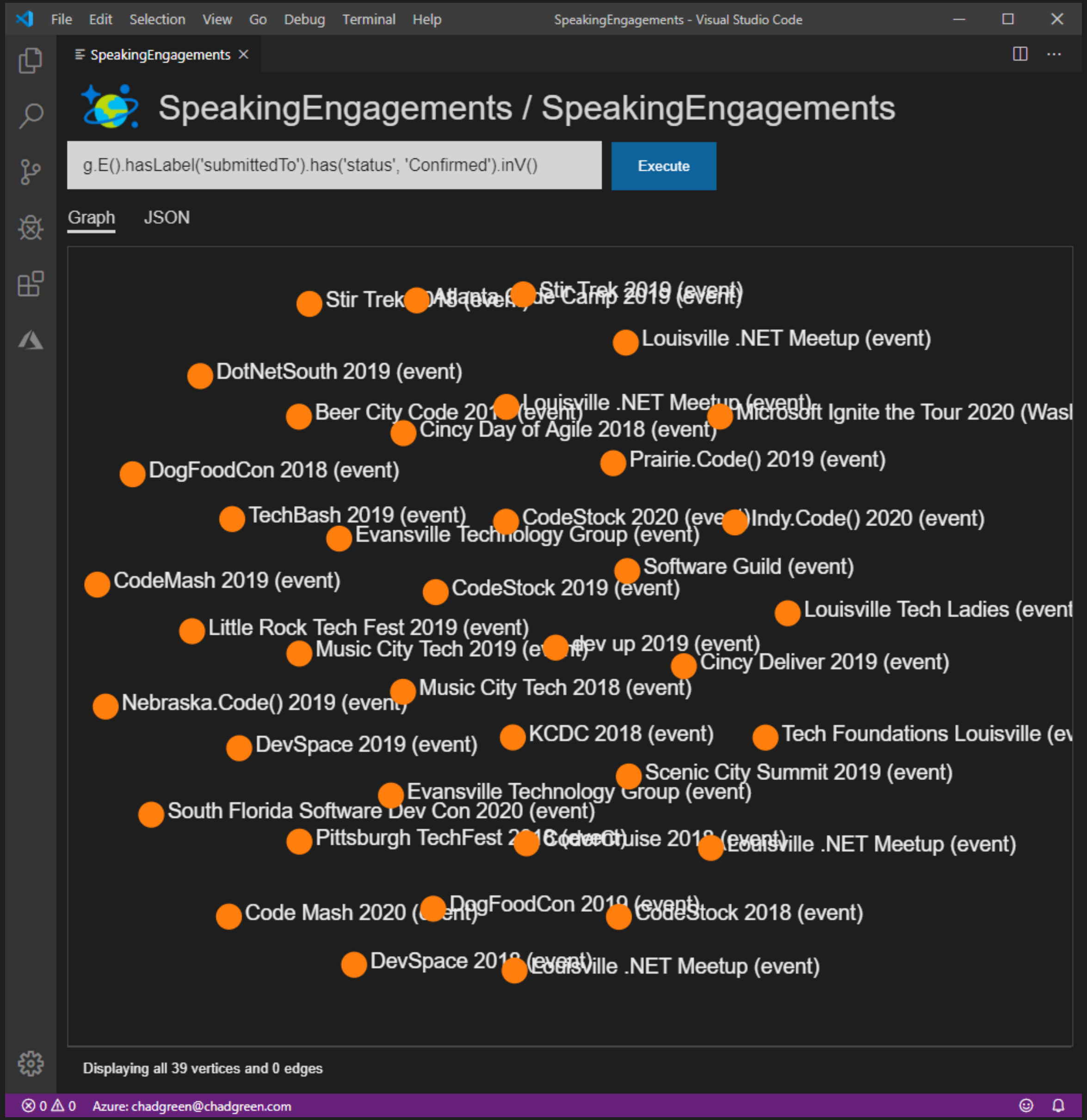
Displaying all 10 vertices and 0 edges

⊗ 0 ⚠ 0 Azure: chadgreen@chadgreen.com

```
g.V()
.hasLabel('tag’)
.has('name', 'Graph Data’)
.inE('tagged’)
.outV()
.outE('submittedTo’)
.has('status', 'Confirmed’)
.inV()
```

@chadgreen

What events have I been scheduled for?


File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
Stir Trek
Atlanta Code Camp 2019 (event)
Stir Trek 2019 (event)
Louisville .NET Meetup (event)
DotNetSouth 2019 (event)
Beer City Code 2019 (event)
Louisville .NET Meetup (event)
Microsoft Ignite the Tour 2020 (Wasl
Cincy Day of Agile 2018 (event)
DogFoodCon 2018 (event)
Prairie.Code() 2019 (event)
TechBash 2019 (event)
CodeStock 2020 (event)
Indy.Code() 2020 (event)
Evansville Technology Group (event)
Software Guild (event)
CodeMash 2019 (event)
CodeStock 2019 (event)
Louisville Tech Ladies (event
Little Rock Tech Fest 2019 (event)
Music City Tech 2019 (event)
dev up 2019 (event)
Cincy Deliver 2019 (event)
Music City Tech 2018 (event)
Nebraska.Code() 2019 (event)
DevSpace 2019 (event)
KCDC 2018 (event)
Tech Foundations Louisville (ev
Scenic City Summit 2019 (event)
Evansville Technology Group (event)
South Florida Software Dev Con 2020 (event)
Pittsburgh TechFest 2018 (event)
CodeCruise 2018 (event)
Louisville .NET Meetup (event)
Code Mash 2020 (event)
DogFoodCon 2019 (event)
CodeStock 2018 (event)
DevSpace 2018 (event)
Louisville .NET Meetup (event)
Ⓧ 0 ⚠ 0
Azure: chadgreen@chadgreen.com

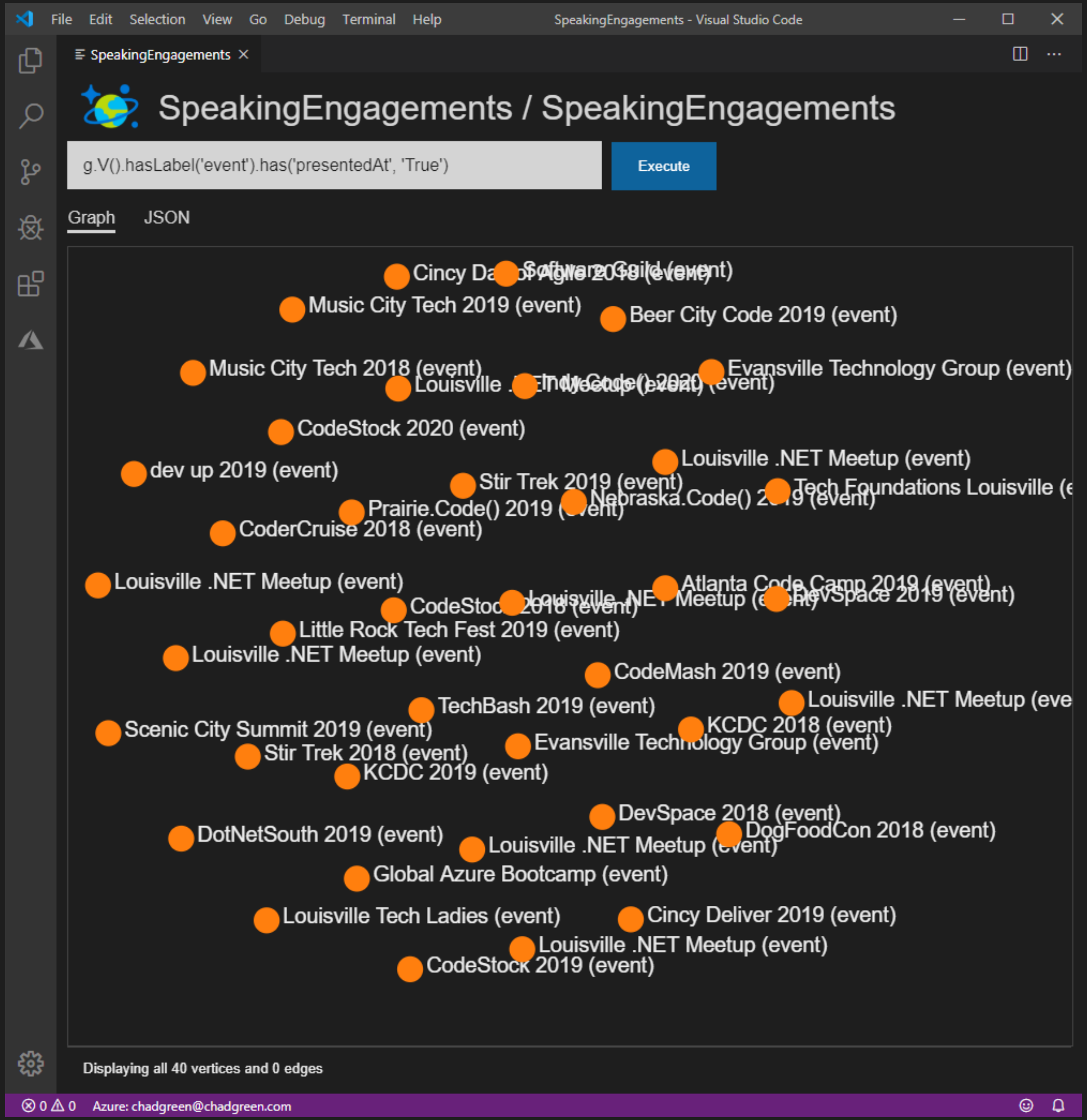
```
g.E().hasLabel('submittedTo').has('status', 'Confirmed').inV()
```

Displaying all 39 vertices and 0 edges

```
g.E()
.hasLabel('submittedTo’)
.has('status', 'Confirmed’)
.inV()
```

@chadgreen

What events have I been scheduled for?


File
Edit
Selection
View
Go
Debug
Terminal
Help
SpeakingEngagements - Visual Studio Code
SpeakingEngagements
SpeakingEngagements / SpeakingEngagements
Execute
Graph
JSON
Cincy Deliver 2019 (event)
Software Guild (event)
Music City Tech 2019 (event)
Beer City Code 2019 (event)
Music City Tech 2018 (event)
Louisville .NET Meetup (event)
Indy.Code() 2020 (event)
Evansville Technology Group (event)
CodeStock 2020 (event)
Louisville .NET Meetup (event)
dev up 2019 (event)
Stir Trek 2019 (event)
Tech Foundations Louisville (e
Prairie.Code() 2019 (event)
Nebraska.Code() 2019 (event)
CoderCruise 2018 (event)
Louisville .NET Meetup (event)
Atlanta Code Camp 2019 (event)
CodeStock 2018 (event)
Louisville .NET Meetup (event)
DevSpace 2019 (event)
Little Rock Tech Fest 2019 (event)
Louisville .NET Meetup (event)
CodeMash 2019 (event)
TechBash 2019 (event)
Louisville .NET Meetup (eve
Scenic City Summit 2019 (event)
KCDC 2018 (event)
Stir Trek 2018 (event)
Evansville Technology Group (event)
KCDC 2019 (event)
DevSpace 2018 (event)
DotNetSouth 2019 (event)
DogFoodCon 2018 (event)
Louisville .NET Meetup (event)
Global Azure Bootcamp (event)
Louisville Tech Ladies (event)
Cincy Deliver 2019 (event)
Louisville .NET Meetup (event)
CodeStock 2019 (event)

```
g.V().hasLabel('event').has('presentedAt', 'True')
```

Displaying all 40 vertices and 0 edges

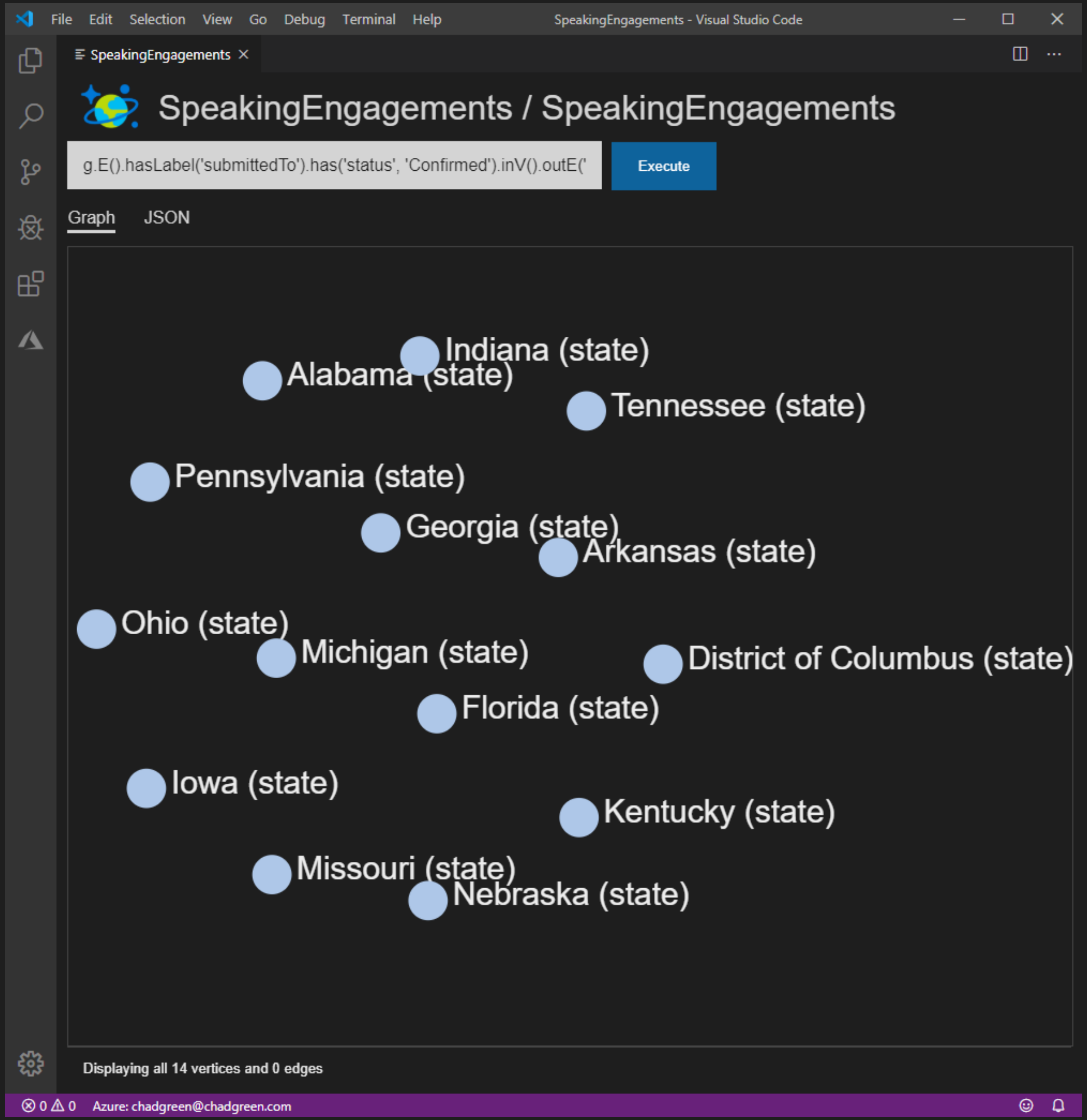
⊗ 0 ⚠ 0 Azure: chadgreen@chadgreen.com

```
g.E()
.hasLabel('submittedTo’)
.has('status', 'Confirmed’)
.inV()
```

```
g.V()
.hasLabel(‘event’)
.has(‘presentedAt’, ‘True’)
```

@chadgreen

What states have I been scheduled to speak in?



```
g.E().hasLabel('submittedTo').has('status', 'Confirmed').inV().outE('
```

Displaying all 14 vertices and 0 edges

```
g.E()
.hasLabel('submittedTo’)
.has('status', 'Confirmed’)
.inV()
.outE('stateLocation’)
.inV()
```

@chadgreen

Wrapping Up

- Graphs – set of objects in which pairs are in some sense related
- Graph Theory – Starts with the 7 bridges of Königsberg
- Graph databases – use graph structure to represent and store data
- Azure Cosmos DB – globally distributed, multi-model database service
- Graph vs Relational – lots of benefits that make graph database worth a look
- Graph Traversal – Navigating graph data using patterns

Thank You

chadgreen@chadgreen.com

chadgreen.com

ChadGreen

ChadwickEGreen