



Azure CosmosDB – AltGraph

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<https://github.com/cjoakim/azure-cosmosdb-altgraph>



What is AltGraph?

AltGraph is an alternative graph implementation built on:

A Design:

- Azure **CosmosDB SQL API**
- Azure Redis Cache or CosmosDB Integrated **Cache**
- **In-memory** processing

A Reference Implementation:

- Java programming language
- **Spring Boot** and **Spring Data** frameworks
- <https://github.com/cjoakim/azure-cosmosdb-altgraph>

Presentation Outline

- **Influences**
 - Previous CosmosDB Live TV Sessions
 - Real-world Use Cases
- **Perception:** How you See the Problem often determines your solution
 - Sample Database Diagrams
 - Types of Databases
- **Think Differently:** Why another Graph Implementation?
- **Design**
- **Demonstration** of the Reference Application

Influences

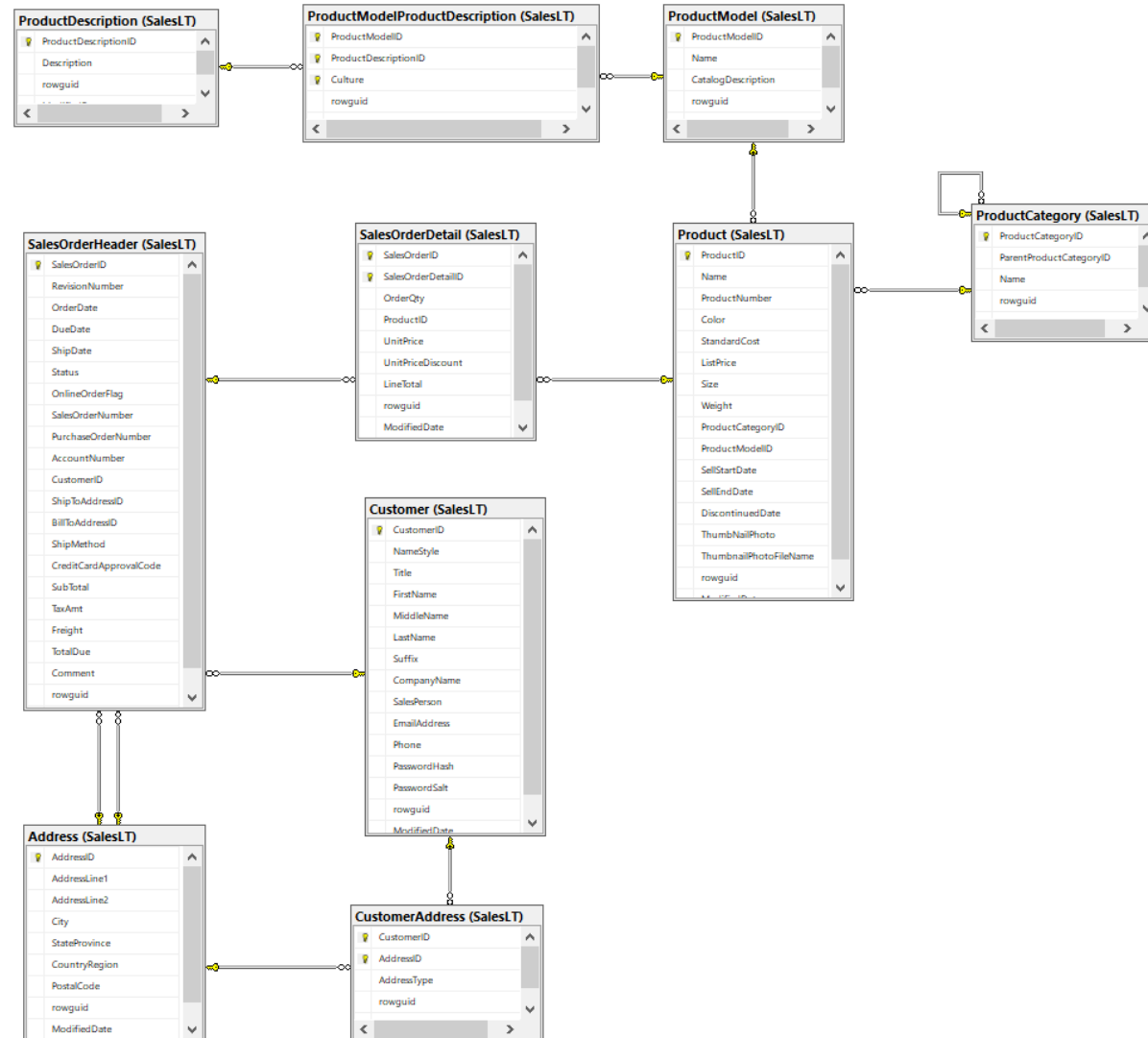
Previous CosmosDB Live TV Sessions

- **Kushagra Thapar, Spring Data**, 2022/02/03
- **Mark Heckler, Spring Boot**, 2022/06/23
Spring Boot: Up and Running – O'Reilly Media Book
- List of Episodes
<https://www.youtube.com/playlist?list=PLmamF3YkHLoKMzT3gP4oqHiJbjMaiiLEh>

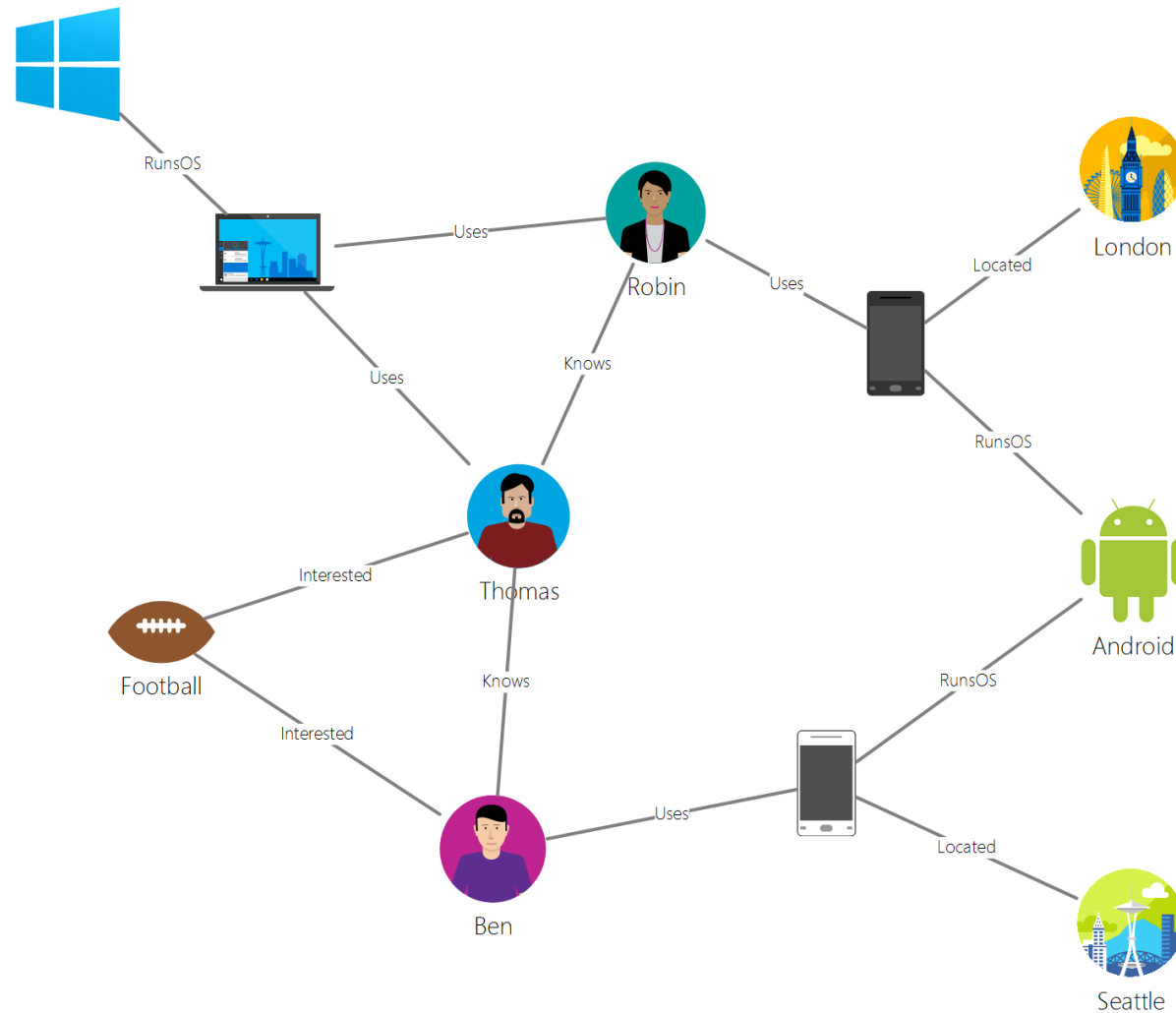
Real-World Customer Use-Cases

- Manufacturing Bill-of-Material (BOM)
- Social Network Systems - People, Messages, Posts, Tags, etc.
- Knowledge Graphs
- Java and Spring and Spring Data

Perception: What solution would you use if the problem was drawn like this?



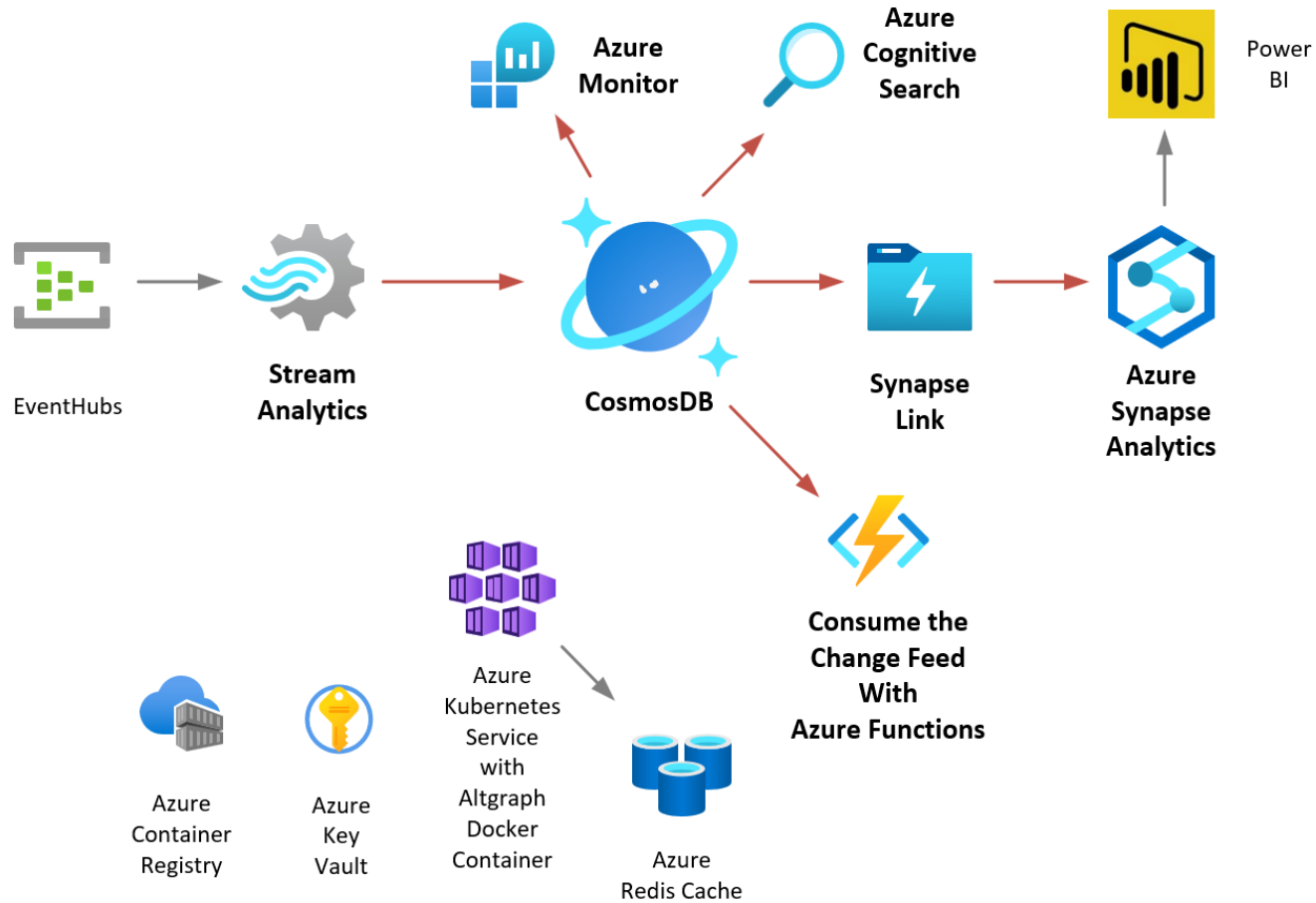
Perception: Or if the problem was drawn like this?



I see this a lot in the field.

AltGraph Architecture and CosmosDB SQL API Integrations

Direct Integrations in **Bold** and with **Red Lines**



Consider the entire system, and the integrated services. Not just the Database.

Database Solutions

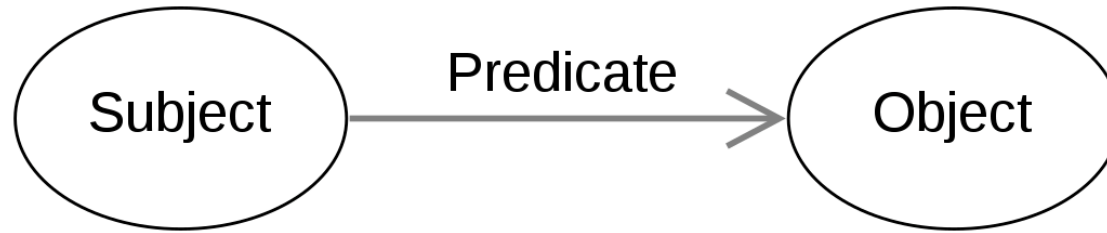
- **Types of Databases**

- **Relational**: Transactional use-cases
- **Graph**: Graph-specific use-cases. **RDF (triplestores)** and **LPG (vertices, edges)**
- **NoSQL**: including the CosmosDB SQL API: General Purpose

- **Think Differently; Why another Graph Solution?**

- **Fast execution speed**, and **lower CosmosDB RU costs**
- Lower barrier to entry for new apps: **conceptual simplicity, based on SQL**
- **Reusable design**
- **Faster time-to-market**. Zero to POC in days
- Enables **better integration** with the rest of Azure

Design Foundations: The concept of RDF Triples



Examples:

Microsoft	is_a	Technology Company
Java	is_a	Programming Language
C	is_a	Programming Language
CosmosDB	is_a	Database System
CosmosDB	is_a	NoSQL Database System
CosmosDB	has_a_sdk_for	Java
CosmosDB	has_a_sdk_for	C
Chris	works_at	Microsoft
Chris	has_role	GBB

The triples are quite granular, typical solution has many many of these

Design Foundations: The concept of an Index (as in Book)

Indexes enable you to quickly find what you're looking for.

It's quite small relative to the size of the Book it indexes.

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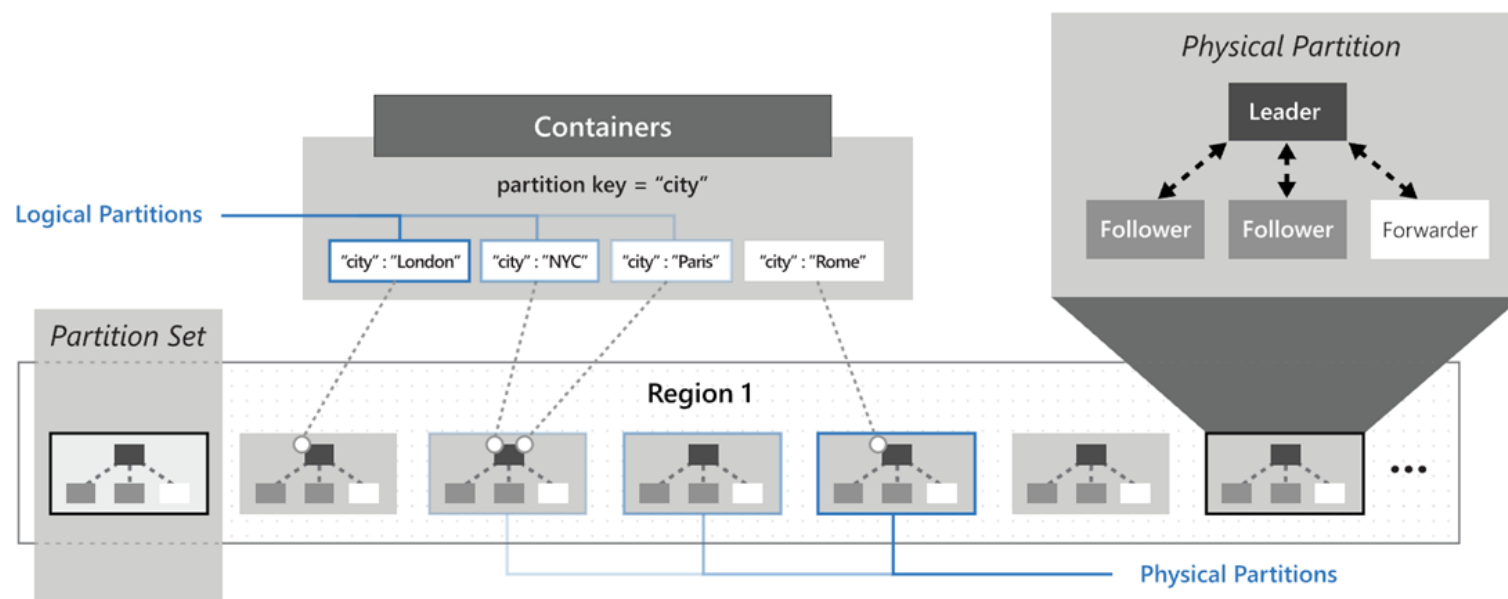
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Design Foundations: CosmosDB Partitioning



Reads within the same logical and physical partition are faster.

Design Foundations: Performance Optimizations

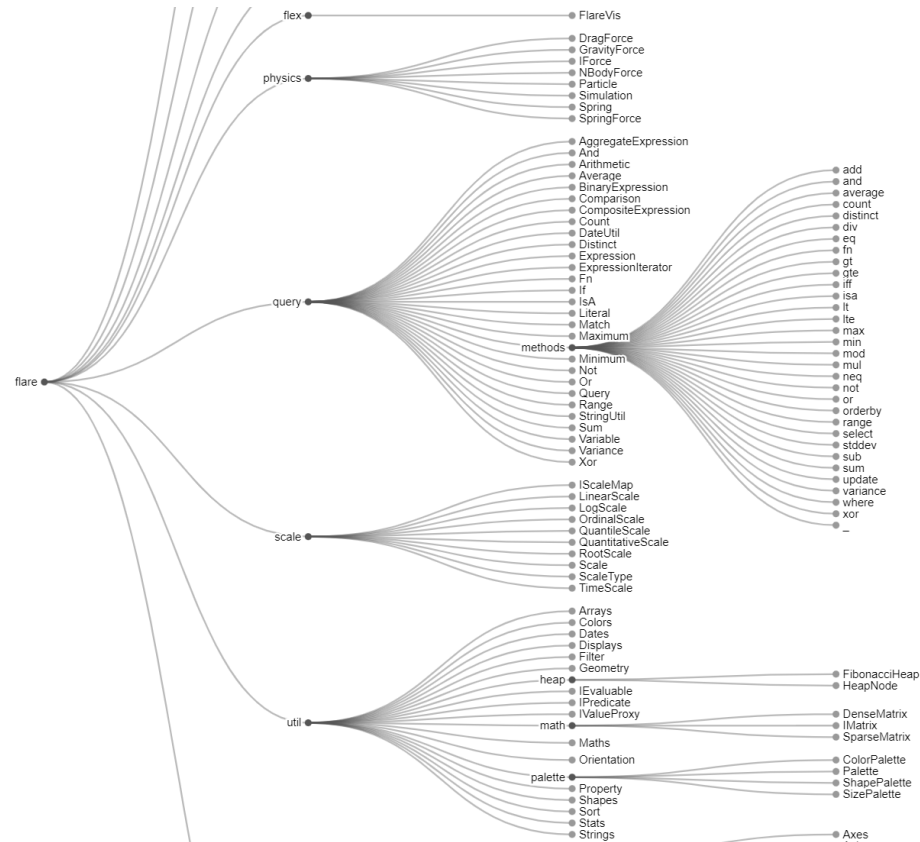
- **CosmosDB Indexing and Composite Indexes**
Index individual attributes, and as well as sets of attributes (i.e. – composite indexes) to match your queries
- **CosmosDB "Point Reads"**
Read by Document ID and Partition Key for fastest speed and lowest cost
- **In-Memory Processing is much faster than DB Processing**
Traversing an in-memory data structure is 1000s of times faster than reading a DB or disk
- **Caching**
 - Eliminate costly and redundant reads to the database
 - **Azure Redis Cache**
 - <https://azure.microsoft.com/en-us/services/cache/>
 - **CosmosDB Integrated Cache** (currently in preview mode)
 - <https://docs.microsoft.com/en-us/azure/cosmos-db/integrated-cache>

Design Foundations: Spring Boot, Spring Data, Project Lombok

- **Spring Boot**
 - Dependency Injection, "Convention over Configuration"
 - Similar to Ruby on Rails – lots of magick happens if you follow the conventions
 - Thus, high Developer productivity
 - <https://spring.io/projects/spring-boot>
- **Spring Data**
 - Nice abstraction and simplification for database access. Repositories, Templates
 - <https://spring.io/projects/spring-data>
 - **Spring Data for CosmosDB SDK**
 - <https://docs.microsoft.com/en-us/azure/developer/java/spring-framework/how-to-guides-spring-data-cosmosdb>
- **Project Lombok**
 - Eliminates verbose and low-value boilerplate code. Getters, setters, constructors, etc.
 - Generates bytecode at compile time. Nice IDE support, too
 - <https://projectlombok.org>

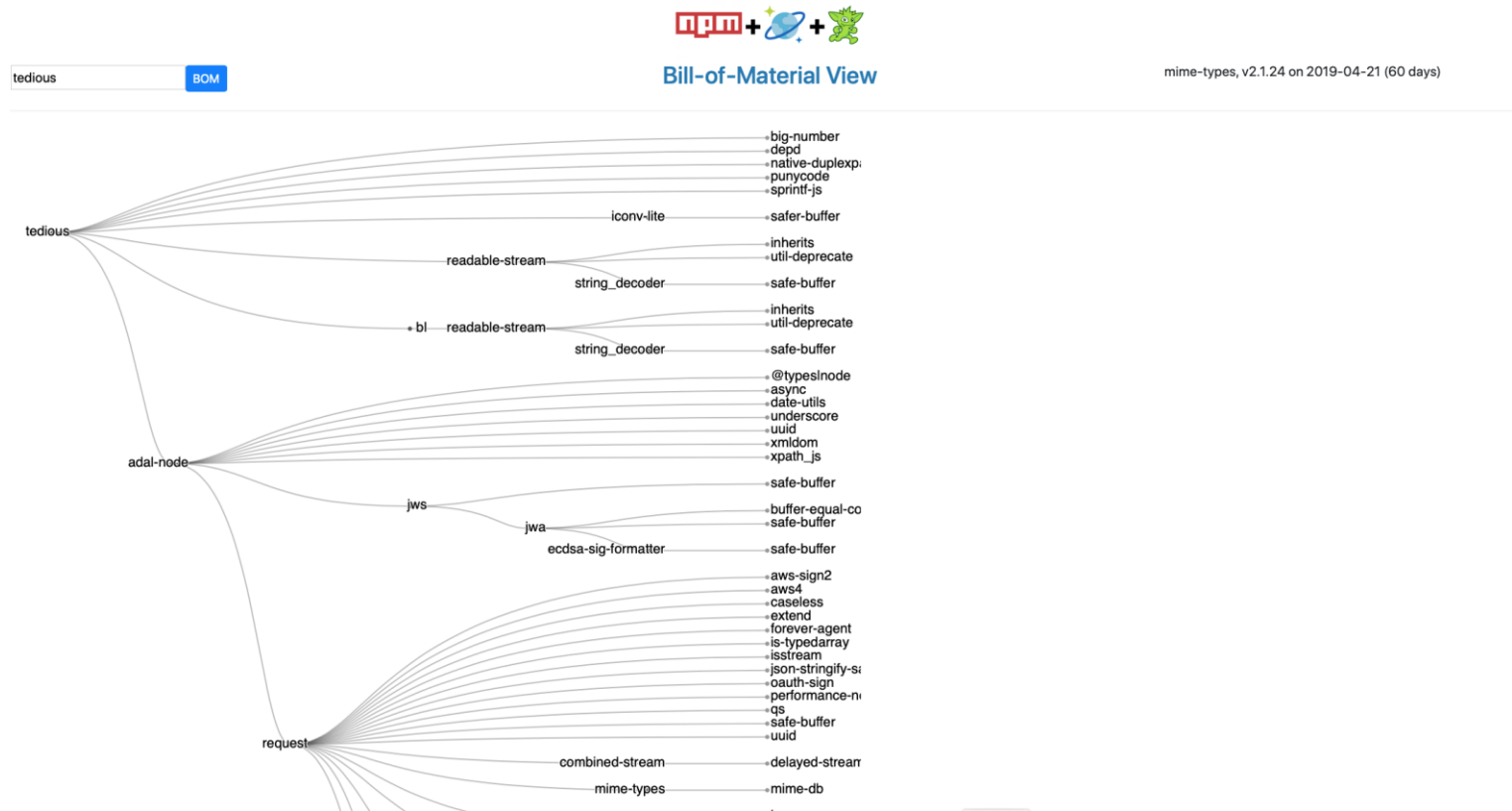
Design Foundations: D3.js

- **D3.js JavaScript library for in-browser data visualizations**
 - Many out-of-the-box visualizations. Open-source
 - <https://d3js.org>



Design Foundations: My Previous Implementation

- **CosmosDB Gremlin API Implementation of a Node.js NPM “Bill-of-Material” Graph**
 - Wanted to use the **same data** in AltGraph, but re-implement the solution w/AltGraph
 - <https://github.com/Azure-Samples/azure-cosmos-db-graph-npm-bom-sample>



Implementation: CosmosDB SQL API

- **Use a Single Container: altgraph**
 - Partition key is **/pk**
 - Each document has a **doctype** attribute to distinguish the various entities
 - Reference implementation has a **tenant Id** attribute for multi-tenant use-cases
 - Reference implementation has a **lob** attribute for multiple lines-of-business in a tenant
 - Document types for this NPM graph are: **triple, library, author, maintainer**
- Enabling **Synapse Link** is optional, depending on your requirements
 - This is one of the excellent integrations that CosmosDB offers
 - <https://docs.microsoft.com/en-us/azure/cosmos-db/synapse-link>
 - <https://github.com/cjoakim/azure-cosmosdb-synapse-link>
- **Heirarchical Partition Keys** (currently in preview mode) may also be used
 - <https://docs.microsoft.com/en-us/azure/cosmos-db/hierarchical-partition-keys>
- Provision the Request Units (RU) as necessary – Serverless, Manual, or Autoscale
 - <https://docs.microsoft.com/en-us/azure/cosmos-db/set-throughput>
 - <https://docs.microsoft.com/en-us/azure/cosmos-db/serverless>

Implementation: Sample Library Document

This is a JSON document which describes a Node.js NPM Library. Libraries are the “raw material” for the graph.

The **dependencies** object (at line 14) is the data that we’ll use to build a graph. This sample document is intentionally small. This library has only one dependency: **xml2js**

Note the **author** and **maintainers** attributes, as well. The graph will include these.

```
1  {
2    "doctype" : "library",
3    "label" : "tcx-js",
4    "id" : "f0b734d9-3240-44c5-9868-cb25597f1e3b",
5    "pk" : "tcx-js",
6    "_etag" : "\"9c00f125-0000-0100-0000-62d9c5440000\"",
7    "tenant" : "123",
8    "lob" : "npm",
9    "cacheKey" : "library|tcx-js",
10   "graphKey" : "library^tcx-js^f0b734d9-3240-44c5-9868-cb25597f1e3b^tcx-js",
11   "name" : "tcx-js",
12   "desc" : "A Node.js library for parsing TCX/XML files, such as from a Garmin GPS device.",
13   "keywords" : [ "tcx", "garmin", "forerunner", "gps" ],
14   "dependencies" : {
15     "xml2js" : "^0.4.19"
16   },
17   "devDependencies" : {
18     "mocha-multi-reporters" : "^1.1.7",
19     "chai" : "^4.2.0",
20     ... others omitted ...
21     "typescript" : "^3.5.2"
22   },
23   "author" : "Chris Joakim",
24   "maintainers" : [ "cjoakim <christopher.joakim@gmail.com>" ],
25   "version" : "1.0.1",
26   "versions" : [ "0.0.1", "0.1.0", "0.1.1", "0.1.2", "1.0.0", "1.0.1" ],
27   "homepage" : "https://github.com/cjoakim/tcx-js",
28   "library_age_days" : 1755,
29   "version_age_days" : 32
30 }
```

Implementation: Sample Array of Triples

Triple documents have a Subject, Predicate, and Object just like RDF triples.

This graph contains 6382 triples. They are small in size (1kb) and many can be read into the JVM for in-memory processing and traversal. Or Paginated.

They point to the adjacent “Vertices” via the Id/Pk attributes for **point-reads**.

The **tags** enable optimized searching of important Vertex attributes.

```
22949 }, {
22950   "id" : "0e2cc67f-b566-4b22-aba3-b9a9a7cb6b81",
22951   "pk" : "triple|123",
22952   "_etag" : "\"0f0082b6-0000-0100-0000-62d9c5840000\"",
22953   "tenant" : "123",
22954   "lob" : "npm",
22955   "doctype" : "triple",
22956   "subjectType" : "library",
22957   "subjectLabel" : "tedious",
22958   "subjectId" : "4cc0e552-e501-47d4-ada1-2e0cfdaafc388",
22959   "subjectPk" : "tedious",
22960   "subjectKey" : "library^tedious^4cc0e552-e501-47d4-ada1-2e0cfdaafc388^tedious",
22961   "subjectTags" : [ "author|Mike D Pilsbury <mike.pilsbury@gmail.com>", "maintainer|artl",
22962   "predicate" : "used_in_lib",
22963   "objectType" : "library",
22964   "objectLabel" : "mssql",
22965   "objectId" : "2aa4fc9e-7cd5-41a7-a521-b303ff184303",
22966   "objectPk" : "mssql",
22967   "objectKey" : "library^mssql^2aa4fc9e-7cd5-41a7-a521-b303ff184303^mssql",
22968   "objectTags" : [ "author|Patrik Simek (https://patriksimek.cz)", "maintainer|artl",
22969 }, {
```

Implementation: Primary Java Classes

Cache.java - implements caching logic, to local disk or Azure Redis Cache

D3CsvBuilder.java - Creates node and edge CSV files for D3.js

Graph.java - An in-memory graph created from a TripleQueryStruct

GraphBuilder.java - Builds a graph by iterating an in-memory TripleQueryStruct

TripleQueryStruct.java - Represents **an Array of the Triples** for your graph. It is the "Index".

Library.java - An NPM library document

Triple.java - One Triple document

LibraryRepository.java - **Spring Data Repository** for Libraries

TripleRepository.java - Spring Data Repository for Libraries

TripleRepositoryExtensions.java - Extensions of the Repository for more complex SQL

TripleRepositoryExtensionsImpl.java

GraphController.java - The primary Controller, handles interaction with the UI

Implementation: The Spring Data TripleRepository

```

17  @Component
18  @Repository
19  public interface TripleRepository extends CosmosRepository<Triple, String>, TripleRepositoryExtensions {
20      Iterable<Triple> findBySubjectType(String subjectType);
21      Iterable<Triple> findBySubjectLabel(String subjectLabel);
22      Iterable<Triple> findByTenantAndSubjectLabel(String tenant, String subjectLabel);
23      @Query("select value count(1) from c")
24      long countAllTriples();
25      @Query("select value count(1) from c where c.subjectLabel = @subjectLabel")
26      long getNumberOfDocsWithSubjectLabel(@Param("subjectLabel") String subjectLabel);
27      @Query("select * from c where c.pk = @pk and c.lob = @lob and c.subjectType = @subjectType and c.objectType = @objectType")
28      List<Triple> getByPkLobAndSubjects(
29          @Param("pk") String pk,          // "pk": "triple|123"
30          @Param("lob") String lob,
31          @Param("subjectType") String subjectType,
32          @Param("objectType") String objectType);
33

```

Method **getByPkLobAndSubjects** is used to query the Triples and load them into memory as a **TripleQueryStruct** that can then be **cached**. It is the “Index” to your graph.

Implementation: Building the Graph and Creating D3.js CSV

- **Ok, great, we have a TripleQueryStruct in memory, now what?**
- **Cache it for the next Web Request**
 - Class **Cache**. Can save to disk or Azure Redis Cache.
 - Or use the CosmosDB Integrated Cache.
- **Build The Graph in Memory**
 - Class **GraphBuilder**
 - **Iterates, in memory**, the many Triples in the TripleQueryStruct to build the Graph object
- **Build the two CSV files for D3.js UI visualizations**
 - Class **D3CsvBuilder**
- **Can we please see the demo now?**

Demonstration: The Search Form

AltGraph

Graph Solutions with the Azure CosmosDB SQL API

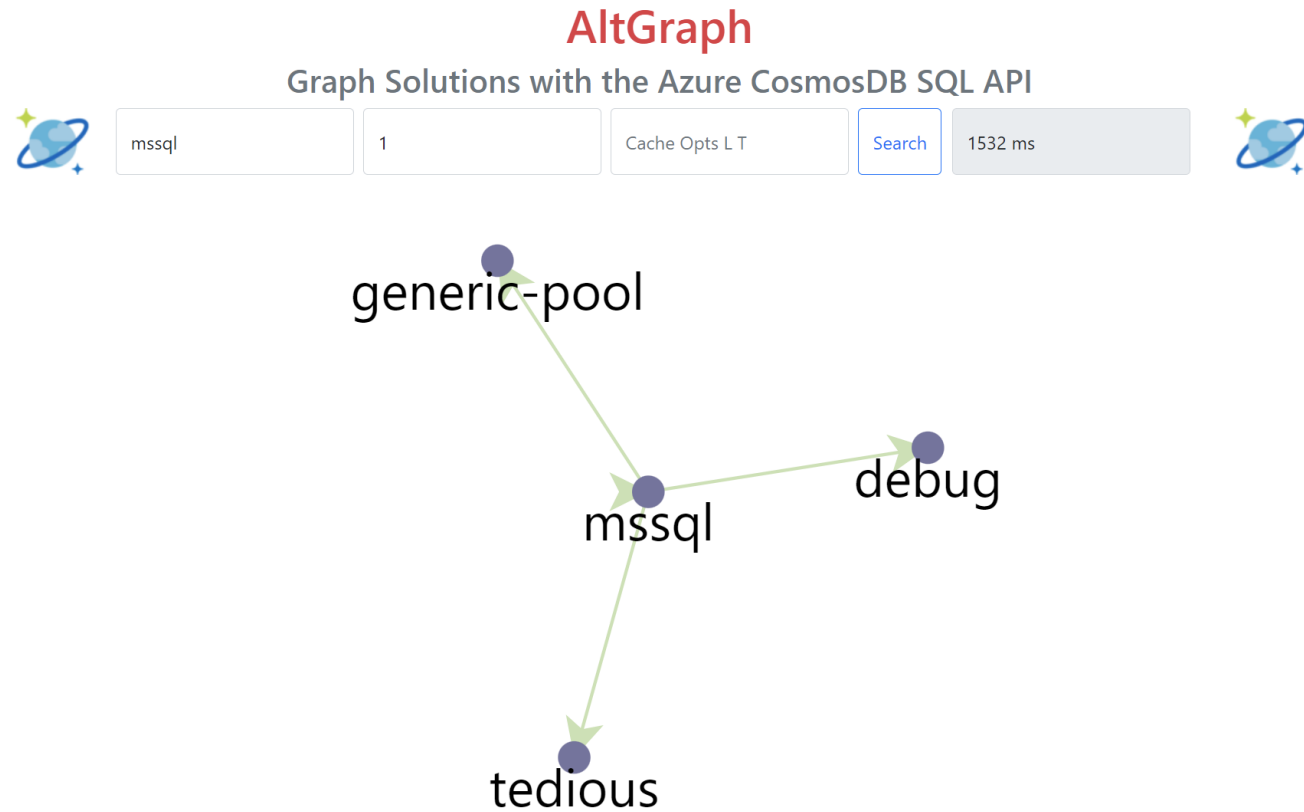


Library Name	1	Cache Opts L T	Search	Elapsed ms
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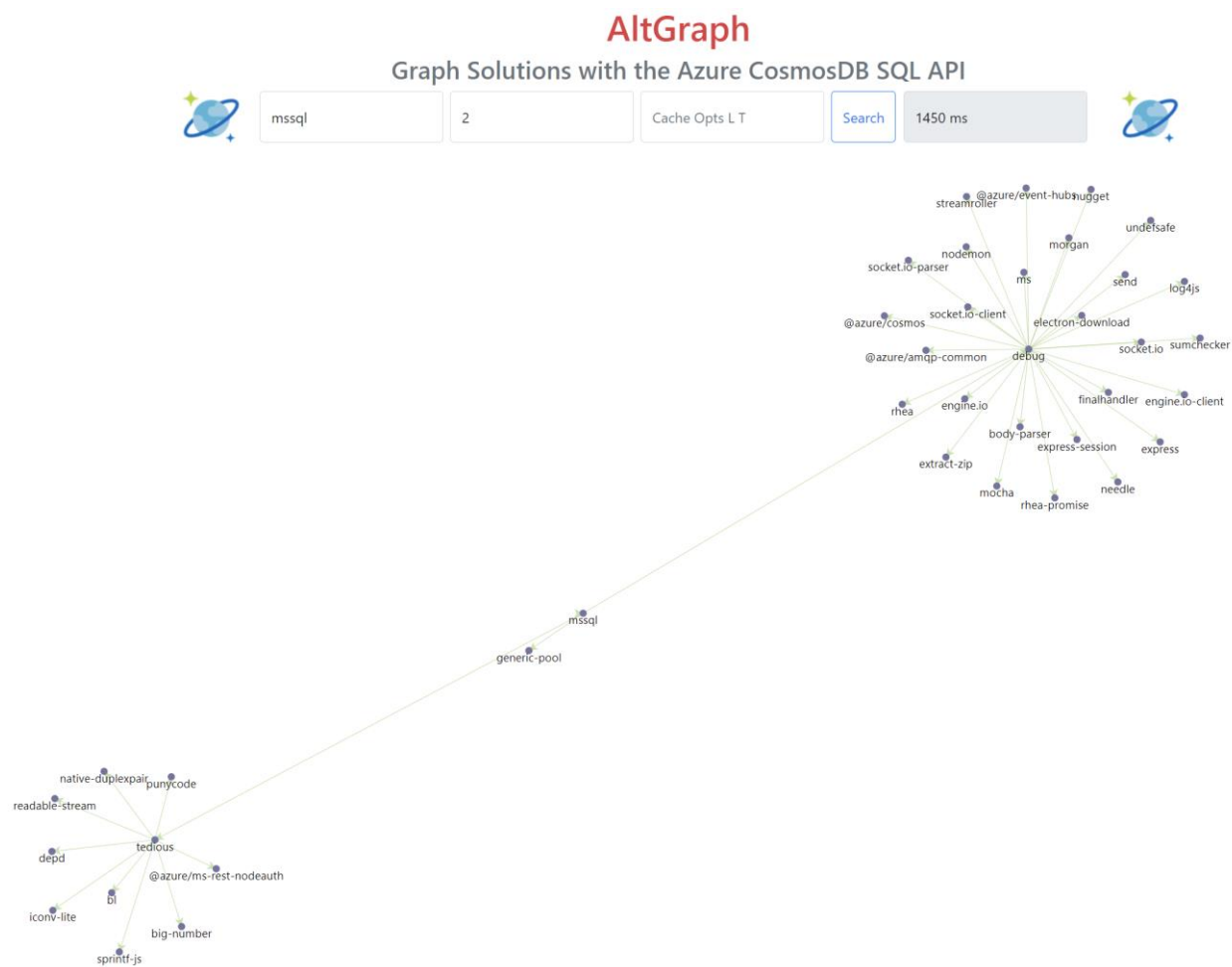
Enter a Library name, and integer graph "depth".
Optional Cache Opts "L" for Library caching, "T" for Triple caching.
The Elapsed ms field will be populated when the graph is displayed.

Demonstration: Graph with a Depth of 1



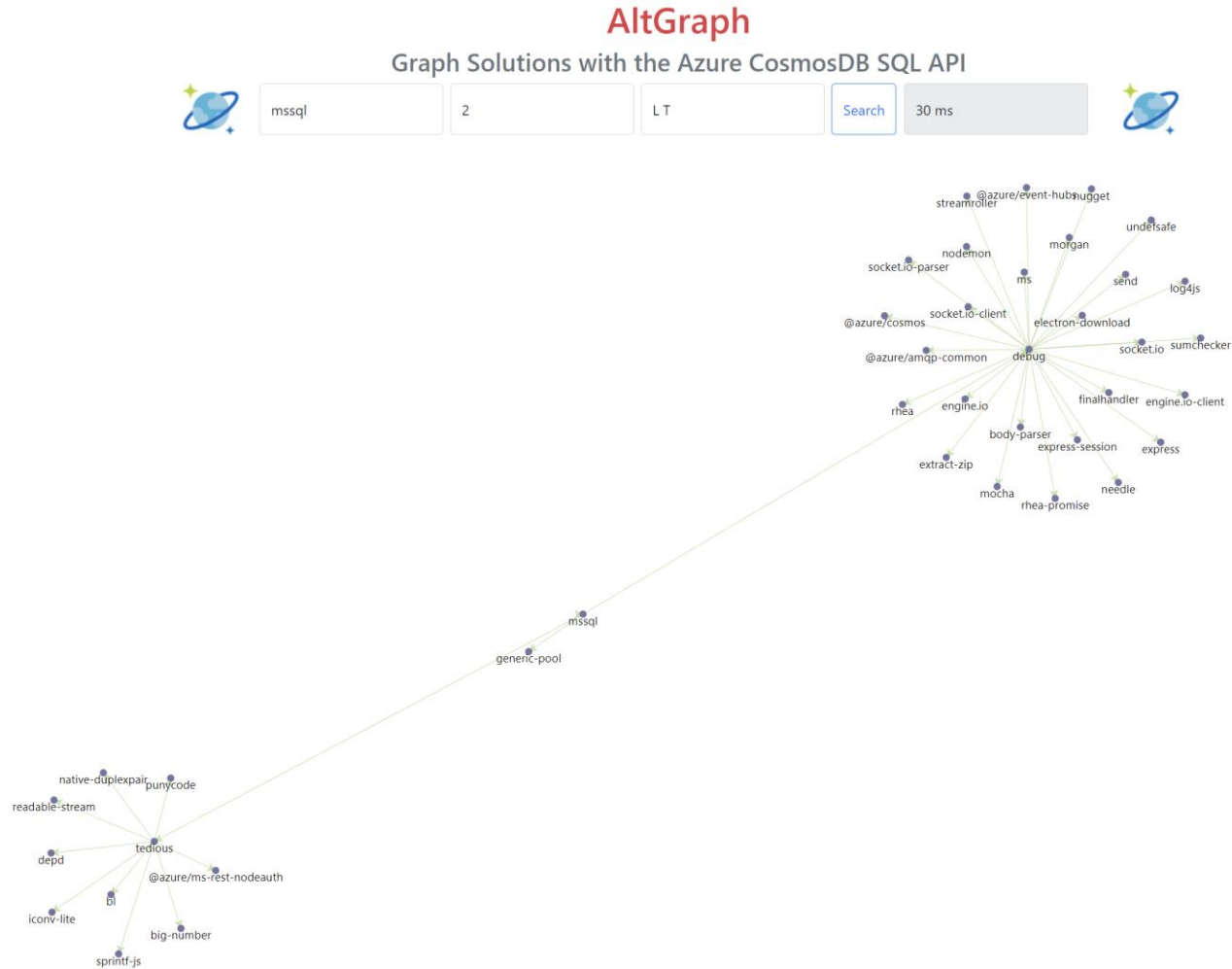
Graph with a depth of 1 and no caching.
Single click a node for Library info. Double-click to show the graph for that node.

Demonstration: Graph with a Depth of 2



Graph with a depth of 2 and no caching. D3.js positions the nodes.

Demonstration: Graph with a Depth of 2, with Caching



Graph with a depth of 2 and **caching**. Notice the **speed improvement**.



Thank you!

Questions?