Real-Time & Big Data GIS: Leveraging the spatiotemporal big data store

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Agenda

1. Overview
2. Real-time data ingestion using GeoEvent Server
3. Storage, visualization & replay
4. Big data analytics using GeoAnalytics Server
1 Overview
ArcGIS Enterprise
with real-time & big data capabilities

- Ingest high velocity real-time data into ArcGIS
- Perform continuous analytics on events as they are received
- Store observations in a spatiotemporal big data store
- Run batch analytics on stored observations
- Visualize high velocity & volume data:
  - as an aggregation
  - or as discrete features
- Notify about patterns of interest
Observation data

types of observation data

moving
something that moves

- planes
- vehicles
- animals
- satellites
- storms

stationary
stands still but attributes change

- water gauges
- weather stations
- traffic sensors
- air quality

discrete
something that “just happens”

- crimes
- lightning
- accidents
Observation

- An observation is a recording of a feature’s attribute values and location at a specific moment in time
  - Observations are immutable, they happen and are typically not edited
  - Observations can be replayed over space & time
  - Moving observations are identifiable by a unique attribute, known as a track id
Visualization of observation data

• Map & Feature services that use data in the spatiotemporal big data store enable you to:
  - Visualize on-the-fly aggregations of data
  - Perform exploratory queries over any combination of space, time, and attributes
  - Switch visualization from aggregation to raw features
  - Inspect feature-level attributes while in aggregation or raw feature view
  - Replay (via time slider) historic observations in aggregation or raw feature view
Visualizing observation data

Map & feature services using data from the spatiotemporal big data store
Real-Time data ingestion using GeoEvent Server
Web GIS with real-time capabilities

10.3

GeoEvent Server

3K e/s

200 e/s

relational data store

store

3K e/s

200 e/s

visualize

analyze & big data

store

real-time & big data

web GIS ingest, analyze

PostgreSQL
Web GIS
with real-time capabilities

10.4

IoT

GeoEvent Server

4K e/s

visualize

4K e/s

spatiotemporal big data store

store

elasticsearch

ingest, analyze

Ingest 4K e/s

Analyze 4K e/s

Real-time & big data

Visualize millions

Store 10Ks e/s
ArcGIS Enterprise
with real-time capabilities

10.5

IoT

GeoEvent Server
ingest, analyze
4K e/s

ArcGIS Enterprise
visualize
4K e/s

spatiotemporal
big data store
store
10Ks e/s

verify
real-time & big data

verify
millions

verify
4K e/s

verify
4K e/s

verify
4K e/s
ArcGIS Enterprise
with real-time capabilities

10.5

ArcGIS Enterprise

IoT

kafka

bring your own gateway

GeoEvent Server

ingest, analyze

12K e/s

visualize

spatiotemporal big data store

ingest
12K e/s

analyze & big data

store
12Ks e/s

real-time & big data

visualize
millions

bring your own gateway
ArcGIS Enterprise
with real-time capabilities

10.6

ArcGIS Enterprise with real-time capabilities

IoT

GeoEvent Server

spatiotemporal big data store

Ingest, analyze

6K e/s

visualize

6K e/s

analyse & big data

6K e/s

store

10K e/s

real-time data

visualize

millions

ingest

6K e/s

store

10K e/s
ArcGIS Enterprise
with real-time capabilities

10.6

IoT

ArcGIS Enterprise

visualize

GeoEvent Server
ingest, analyze

spatiotemporal big data store
store

ingest 18K e/s
analyze 18K e/s
store 18Ks e/s
real-time & big data
visualize millions

millions
18K e/s
18Ks e/s

18K e/s
Real-Time data ingestion into a spatiotemporal big data store using GeoEvent Server

ArcGIS Enterprise
map & feature service

IoT
GeoEvent Service
input
GeoEvent Server
ingest, analyze
output
spatiotemporal big data store
store

Demo
3 Storage, visualization & replay
Spatiotemporal big data store
geohash spatial indexing to support on-the-fly aggregation

- As data is written to a dataset in the spatiotemporal big data store
  - A spatial index for geohash aggregation is continuously updated
Spatiotemporal big data store
gеоhаsh & squаrе spatiаltеmрораl инdеxing tо sупроrt оn-thе-flу аggrеgаtіоn

• As data is written to a dataset in the spatiotemporal big data store
  - A spatial index for geohash aggregation is continuously updated
  - A spatial index for square aggregation is continuously updated

геоhаsh аggrеgаtіоn (bаsеd оn а gеоhаsh іnдеx)

squаrе аggrеgаtіоn (bаsеd оn а squаrе іnдеx)
Spatiotemporal big data store

*triangle spatial indexing to support on-the-fly aggregation*

- As data is written to a dataset in the spatiotemporal big data store
  - A spatial index for ‘pointy triangle’ aggregation is continuously updated
  - A spatial index for ‘flat triangle’ aggregation is continuously updated
Spatiotemporal big data store

*hexagon (same as triangle) spatial indexing to support on-the-fly aggregation*

- As data is written to a dataset in the spatiotemporal big data store
  - A spatial index for ‘pointy hexagon’ (pointy triangle) aggregation is continuously updated
  - A spatial index for ‘flat hexagon’ (flat triangle) aggregation is continuously updated

**pointy hexagon aggregation** (based on a pointy triangle index)  
**flat hexagon aggregation** (based on a flat triangle index)
As data is written to a dataset in the spatiotemporal big data store:

- Up to four types of spatial indices are supported: geohash, square, pointy & flat hexagon/triangle
- This is in addition to a temporal index on the time field
- And an inverted index on each of the attribute fields
Some of the spatial indices support projections

- The geohash spatial index only supports WGS 1984; however you can project on-the-fly
- Square, pointy & flat hexagon/triangle spatial indices are defined with a spatial reference
Visualization

Map or feature services: geohash aggregation response

- Map & feature services can query a dataset in the spatiotemporal big data store with results aggregated on-the-fly.

```json
{  
  "features": [{  
    "attributes": {  
      "objectid": 1,  
      "Geohash": "dp",  
      "Count": 216747  
    },  
    "geometry": {  
      "rings": [  
        [-90.0, 39.375],  
        [-90.0, 45.0],  
        [-78.75, 45.0],  
        [-78.75, 39.375],  
        [-90.0, 39.375]  
      ],  
      "spatialReference": {  
        "wkid": 4326  
      }  
    }  
  },  
  {  
    "attributes": {  
      "objectid": 2,  
      "Geohash": "dn",  
      "Count": 216878  
    },  
    "geometry": {  
      "rings": [  
        [-90.0, 39.375],  
        [-90.0, 45.0],  
        [-78.75, 45.0],  
        [-78.75, 39.375],  
        [-90.0, 39.375]  
      ],  
      "spatialReference": {  
        "wkid": 4326  
      }  
    }  
  }  
}
```
Visualization

**map or feature services: square aggregation response**

- Map & feature services can query a dataset in the spatiotemporal big data store with results aggregated on-the-fly.

---

**feature service**

```
lodType=square&lod=2
```

```json
{
  "features": [{
    "attributes": {
      "objectId": 1,
      "Geohash": "BDD",
      "Count": 1474465
    },
    "geometry": {
      "rings": [
        [0.0, 66.51360351837927],
        [-90.00086084300868, 66.51360351837927],
        [-90.00086084300868, 0.0],
        [0.0, 0.0],
        [0.0, 66.51360351837927]
      ],
      "spatialReference": {
        "wkid": 4326
      }
    }
  }, {
```

**map service**

- map service

**square aggregation response**

- square aggregation response
Visualization

map or feature services: discover which aggregations are enabled

![MapServer output](arggis/rest/services/safegraph/MapServer/0?f=json)
Visualization

map services: on-the-fly aggregation of polyline and polygon features
Storage

*expanded spatiotemporal big data store capabilities*

- **Enhanced data retention control:**
  - Allows users to define both a maximum feature age and create exemptions for features based on a WHERE clause.
Storage

expanded spatiotemporal big data store capabilities

• Enhanced manual deletion of features.
Storage
expanded spatiotemporal big data store capabilities

- Z-value support for point geometries:
  - Enabled during dataset creation
  - Allows 3D rendering of discrete features
Demo

Storage, visualization & replay

gEOHASH, square & hexagon aggregation
4 Big data analysis using GeoAnalytics Server
Big data analysis
using GeoAnalytics Server

10.6

ArcGIS Enterprise

IoT

GeoEvent Server

GeoAnalytics Server

Big Data

visualize

spatiotemporal big data store

ingest, analyze

store

analyze
Batch analysis
GeoAnalytics Server: analytic capabilities

“I want to…”

Summarize Data

Use Proximity

Find Locations

Analyze Patterns

Manage Data

Join Features
Aggregate Points
Summarize Within
Summarize Attributes
Reconstruct Tracks

Create Buffers

Detect Incidents
Find Similar Locations
Geocode Locations

Calculate Density
Find Hot Spots
Create Space Time Cube

Calculate Field
Copy To Data Store
“Where can I perform analysis?”

- GeoAnalytics Server
- ArcGIS Pro
- Portal for ArcGIS
- ArcGIS API for Python
- ArcGIS REST API
Batch analysis

GeoAnalytics Server: analytic workflow

- GeoAnalytics Server has the ability to:
  - Perform analytics against data in the spatiotemporal big data store
  - Write analytic results to the spatiotemporal big data store

use your Web GIS layers through Pro, Portal, Python notebooks or the REST API
Batch analysis

GeoAnalytics Server: analytic workflow

- GeoAnalytics Server has the ability to:
  - Perform analytics against data in the spatiotemporal big data store
  - Write analytic results to the spatiotemporal big data store
Batch analysis

summarize data

• Reconstruct Tracks

- “What is the path of each ship entering a port, based on millions of point observations of ship location?”
- “Which planes fly within 1 mile of each other, based on millions of point observations of plane location?”
Batch analysis

summarize data

- Reconstruct Tracks
  - Input 1: Points
  - Output: Polylines or Polygons

- Creates polyline tracks from time-enabled point data, or polygon tracks by buffering input data
- Buffers can be calculated using a field or expression
Batch analysis
summarize data: using the reconstruct tracks tool

GeoAnalytics tool interface
Batch analysis

summarize data: using the reconstruct tracks tool

input features

GeoAnalytics tool interface

output features
Batch analysis

summarize data

- Aggregate Points
- “How does the spatial distribution of vehicle collisions change over time?”
- “What zip codes have the highest count of crime incidents?”
- “Where are there the most power outages?”
- “What does my data look like?”
Batch analysis

- **Aggregate Points**

  - Input 1: Points, Input 2: Polygons (*or generate bins*)
  - Output: Polygons

- Aggregates point data into a either square or hexagonal grid, or user-supplied polygon features
- Users can choose to aggregate spatially or spatiotemporally
- A count of point features is returned for each grid cell (*bins*) or polygon, in addition to optional field statistics
Batch analysis

summarize data

- Aggregate Points

Methods of Aggregation

Spatial, into bins:

Spatial, into polygons:
<table>
<thead>
<tr>
<th>Methods of Aggregation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spatial, into bins:</strong></td>
</tr>
<tr>
<td><img src="image1.png" alt="Aggregate Points" /></td>
</tr>
<tr>
<td><strong>Spatial, into polygons:</strong></td>
</tr>
<tr>
<td><img src="image2.png" alt="Aggregate Points" /></td>
</tr>
<tr>
<td><strong>Spatiotemporal, into bins:</strong></td>
</tr>
<tr>
<td><img src="image3.png" alt="Aggregate Points" /></td>
</tr>
<tr>
<td><strong>Spatiotemporal, into polygons:</strong></td>
</tr>
<tr>
<td><img src="image4.png" alt="Aggregate Points" /></td>
</tr>
</tbody>
</table>
Batch analysis
summarize data: using the aggregate points tool

input features
GeoAnalytics tool interface
output features
Summary

The spatiotemporal big data store enables:
- GeoEvent Server to write high velocity and high volume observation data
- On-the-fly aggregations and raw features to be visualized using Map & Feature Services
- GeoAnalytics Server to read and write high volume analytic results
To learn more …

spatiotemporal big data store

- See the ‘Spatiotemporal Big Data Store’ tutorial
  - http://links.esri.com/geoevent-sbds

- Sample JavaScript Aggregation Viewers:
  - Map Service:
    https://github.com/Esri/aggregation-viewer-server-map-service
  - Feature Service:
    https://github.com/Esri/aggregation-viewer-client-feature-layer
Please Attend Our Other **Sessions**!

- **Developing Real-Time Web Apps with the ArcGIS API for JavaScript**  
  Thu, 9:00-9:30 am, Demo Theater 1: Oasis 1-2
- **Real-Time GIS: Road Ahead**  
  Thu, 4:00-5:00 pm, Pasadena/Sierra/Ventura
- **GeoEvent Server: Creating Connectors and Processors Using the GeoEvent SDK**  
  Fri, 8:30-9:30 am, Mesquite B
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Questions / Feedback?

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