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Building the Data Lake

with Microsoft Azure Data Factory and Data Lake Analytics

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Outline

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- What is a Data Lake?
- Data Lake Architecture & Technologies
- Data Ingestion – Populating the Data Lake
- Azure Data Lake Store Overview
- Introducing Azure Data Factory
- Data Lake Ingestion Scenarios with Azure Data Factory
- Introduction to Azure Data Lake Analytics
- Processing Data Using U-SQL + .net Extensibility
- Running U-SQL Jobs on Azure

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Data Lake – The Concept

What is that? And Why it is needed?

What is a Data lake

A repository that holds raw data file extracts of all the Enterprise source systems

Usually a Distributed File System (HDFS, Blob Storage, Amazon S3, GFS, etc.) to support Big Data Processing

Pentaho (Hitachi Data Systems) co-founder and CTO, James Dixon coined the term 'Data Lake'

Why a Data Lake

Single and cheap repository of Enterprise-wide (raw) data

Abstracts your DW/ Business Intelligence Solutions from source systems

Supports potential Big Data Processing and Analytics

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Data Lake – The Concept

What is that? And Why it is needed?

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*If you think of a datamart/DW as a store of **bottled water** – cleansed, packaged and structured for easy consumption – the Data lake is a **large body of water** in a more **natural** state.*

*The contents of the data lake, stream in from many source to fill the lake, and various users of the lake can come to **examine**, **dive** in, or take samples."*

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Data Lake

Overall Architecture

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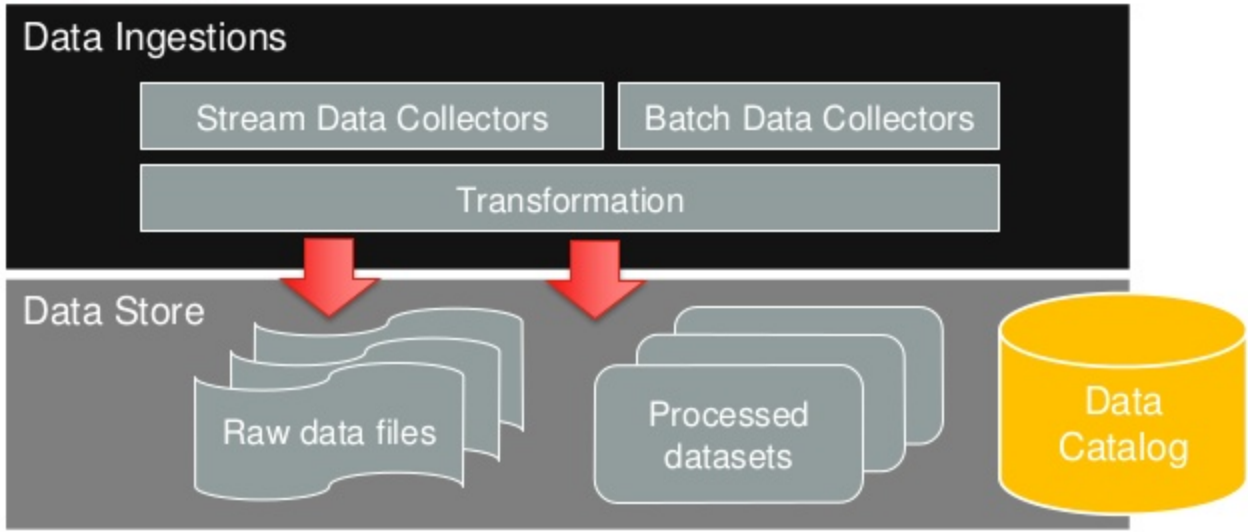
Data Lake

Overall Architecture



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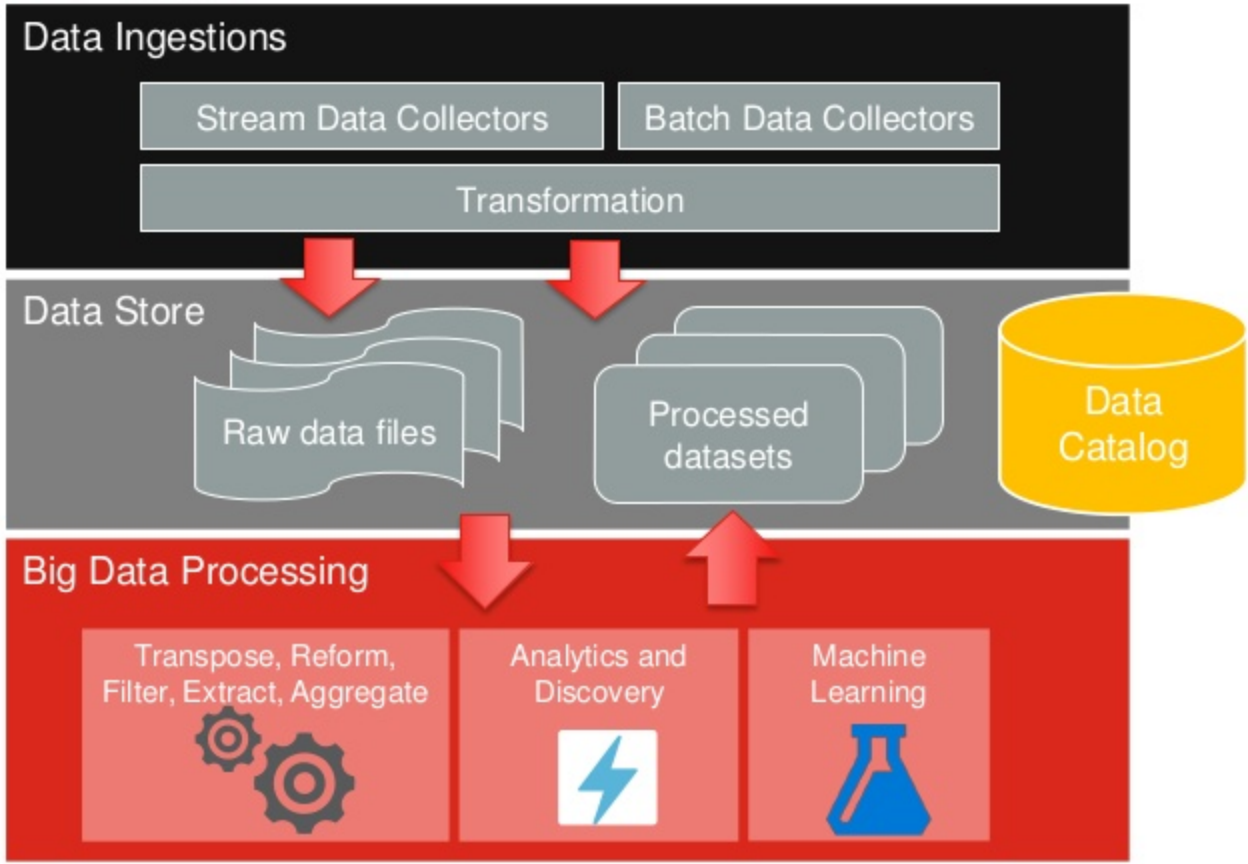
Data Lake

Overall Architecture



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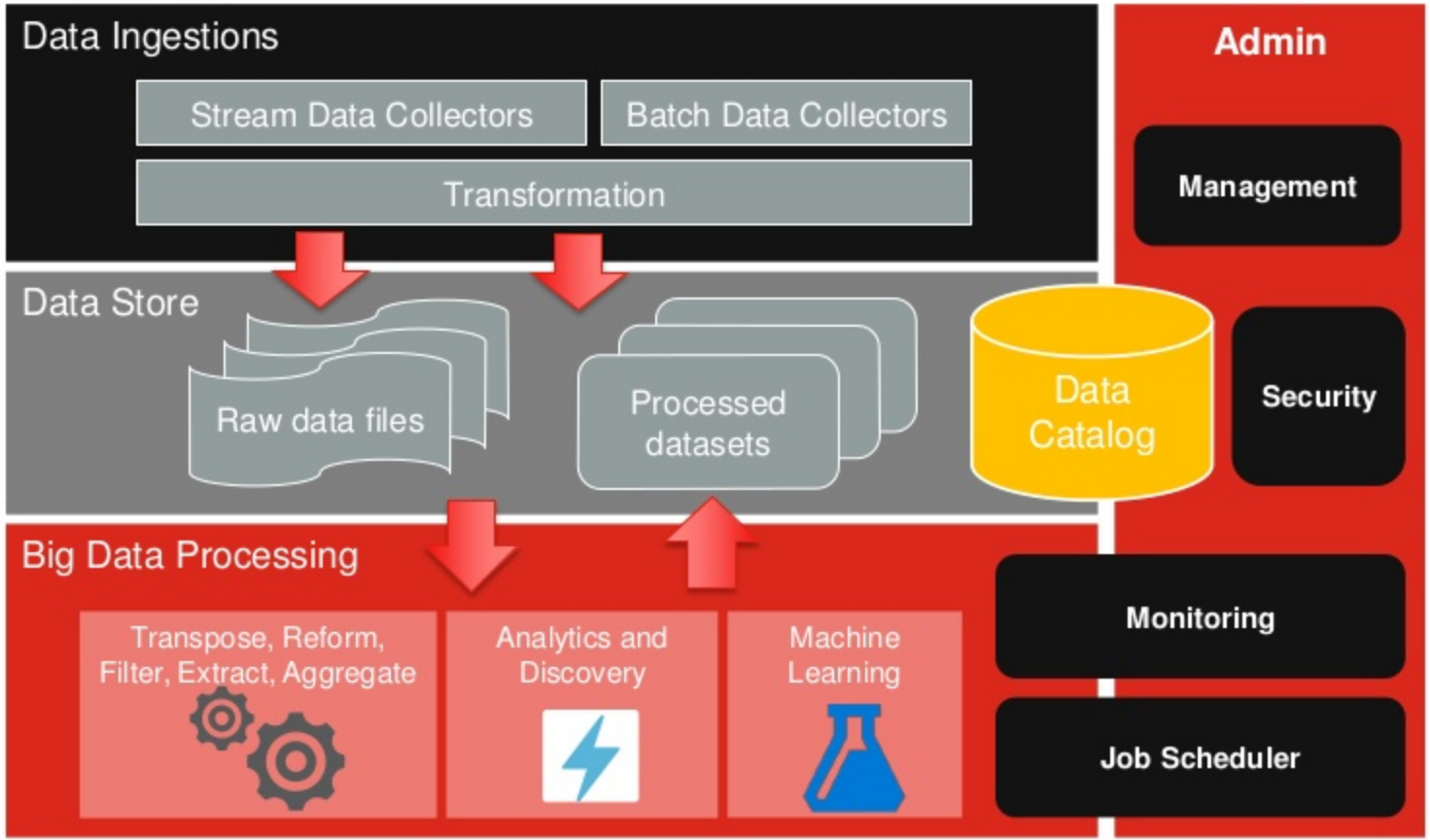
Data Lake

Overall Architecture



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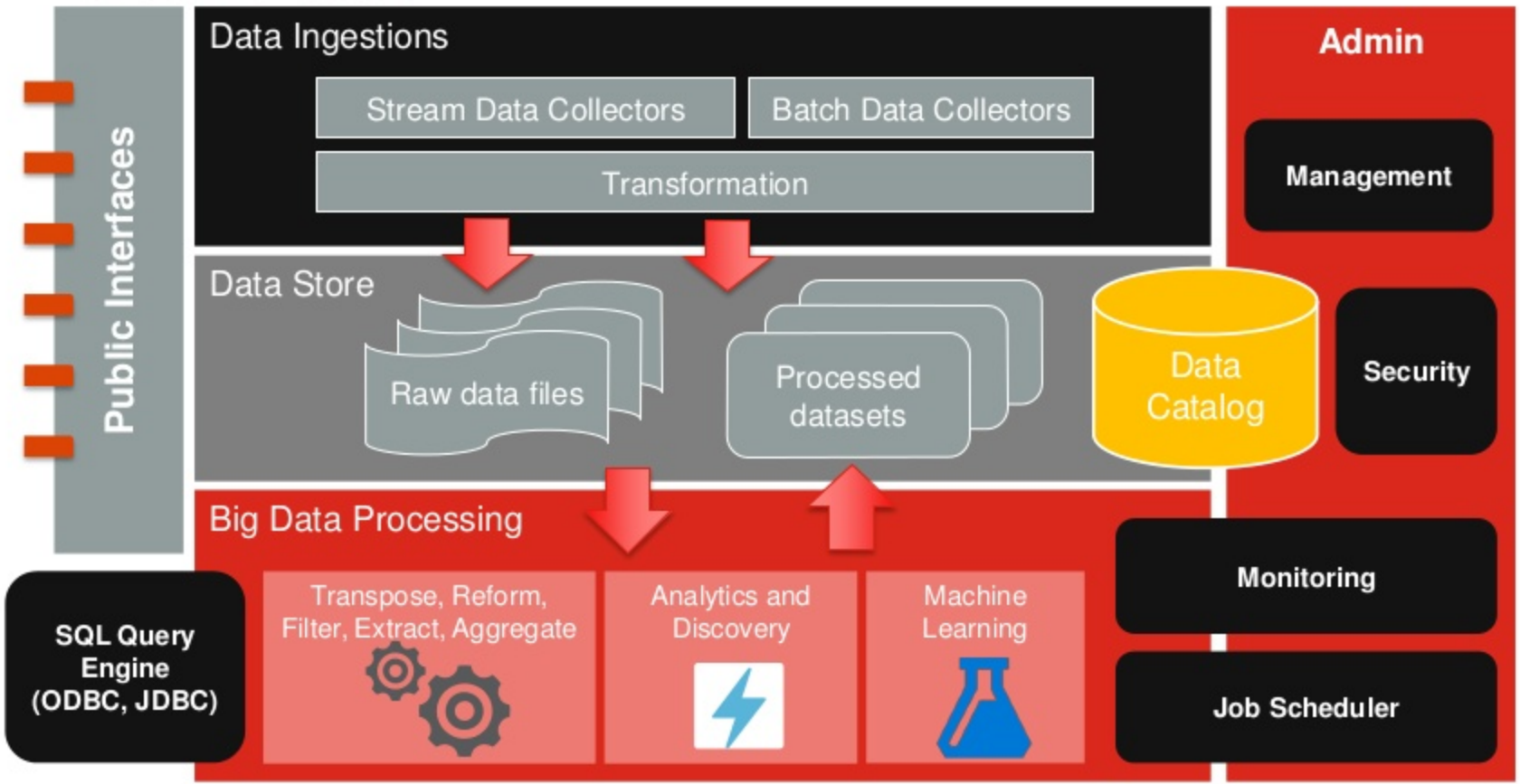
Data Lake

Overall Architecture



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Data Lake

Overall Architecture

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Data Ingestion	Batch Data Collectors	Pull data from data sources using batch connectors E.g. SQL, NoSQL, File Systems, (s)FTP, etc.
	Stream Data Collectors	Consumes data streams in using real-time data connectors. E.g. queues (kafka, rabbitmq, MQTT, eventshub, etc.), WebSockets, http, etc.
	Transformation	Performs basic data transformation & enrichment, rather than processing, including format conversion (encoding), compression, merge, spilt, etc.
Data Store (Distributed File System)	Raw Data Files	Data stored in files in its raw form (either in its original format, or a standardized format/compression applied in the transformation stage) – XML, JSON, BSON, Text, Avro, Parquet, ORC, etc.
	Processed Datasets	The results of (big) data processing jobs, which is a set of tabular dataset (files) in a query-optimized format
	Data Catalog	Usually a relational database that includes a catalog for the datasets in the data lake
Big Data Processing	Data Processing Jobs	Big data processing jobs (MapReduce, Hive, Pig, Spark, U-SQL) that process the data and apply advanced analytics, including ML and pattern discovery
	Jobs Scheduler	A scheduler that Orchestrate the execution of the data processing jobs
SQL Query Engine		ODBC, JDBC APIs to query the datasets in the data lake using SQL-like scripts
Public APIs		APIs for retrieving the datasets in the data lake - In some cases, for ingesting data

Data Lake

Technologies

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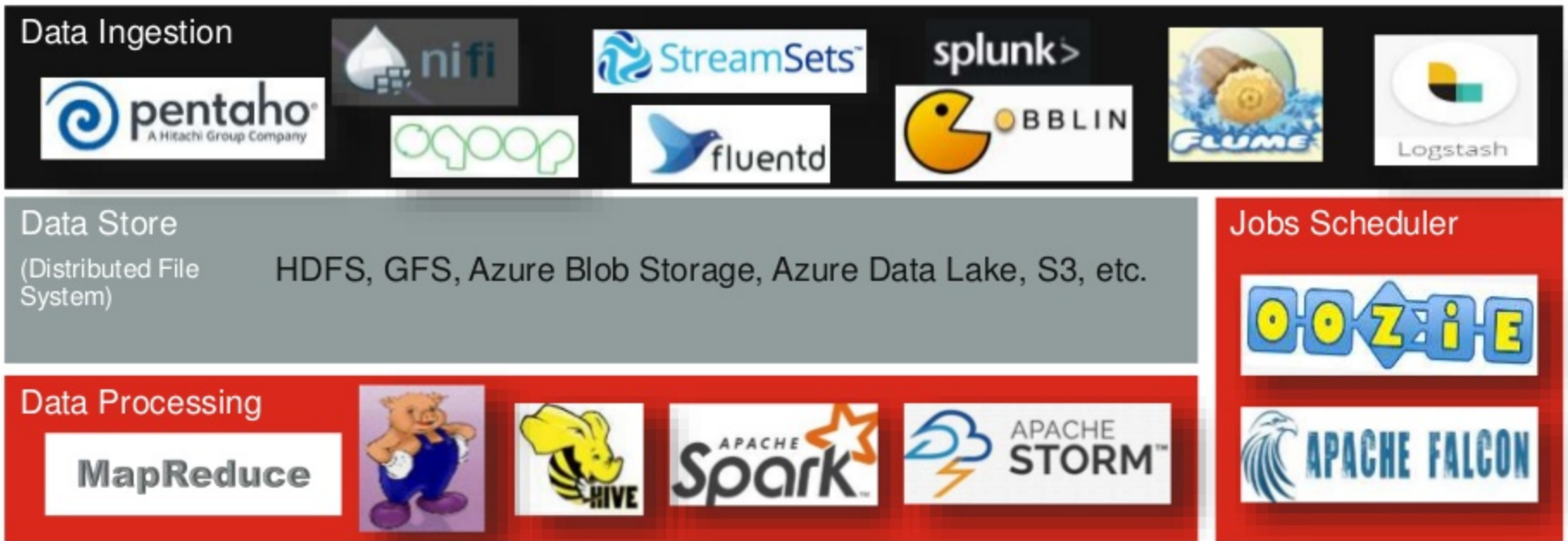

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Data Lake & Enterprise Data Platform

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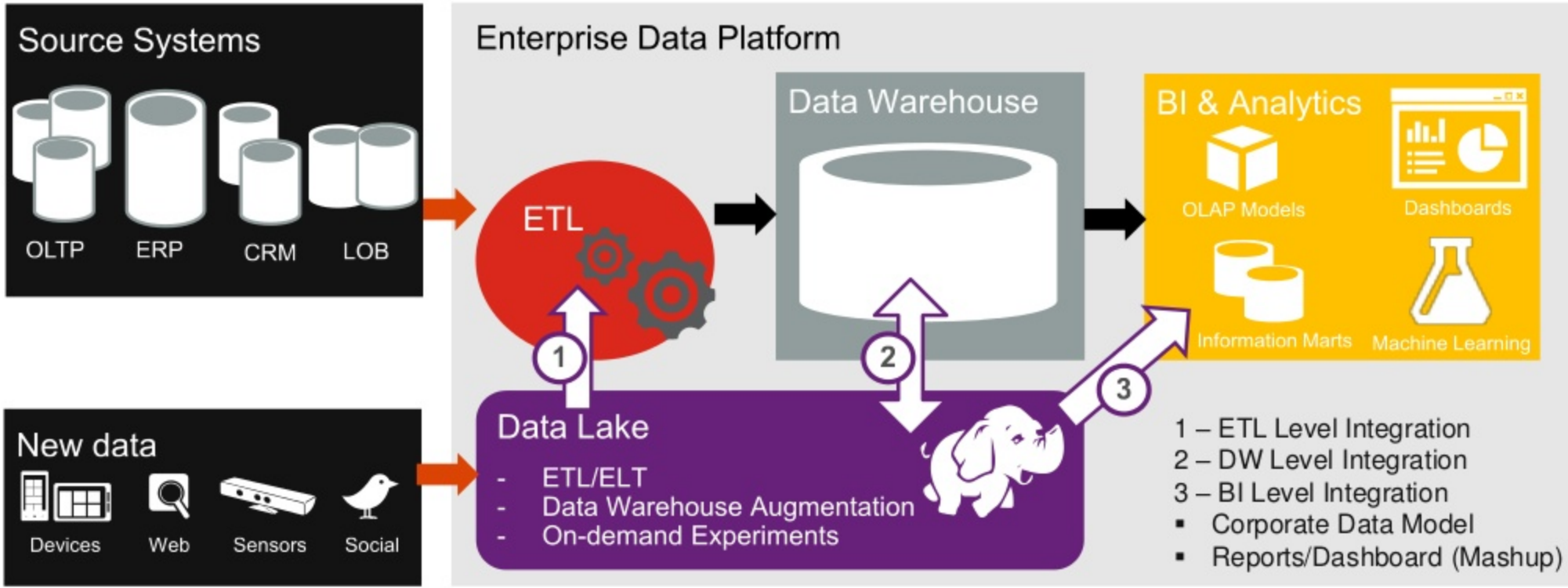

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Data Ingestion – Populating the Data Lake

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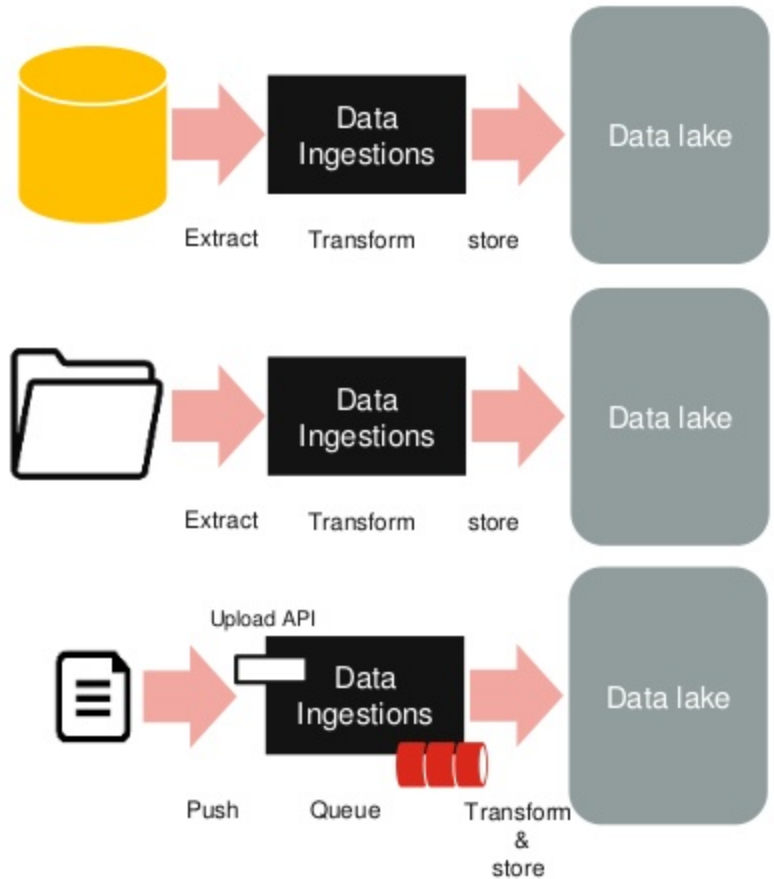
Data Ingestion

Batch Data Ingestion

- Refers to ingesting **large amount** of data into the data lake in **low-frequency** (hourly, daily, monthly, etc.)
- Data sources
  - RDBMS
  - NoSQL data stores
  - File systems
  - Blob storages
- Data is extracted from the source using time **window filter** (from-to), or based on **existing files** in the source location.
- If data file is pushed to data lake using **ingestion APIs**, they are received in **an internal queue** before they are consumed and stored in data lake
- Runs on **schedule**



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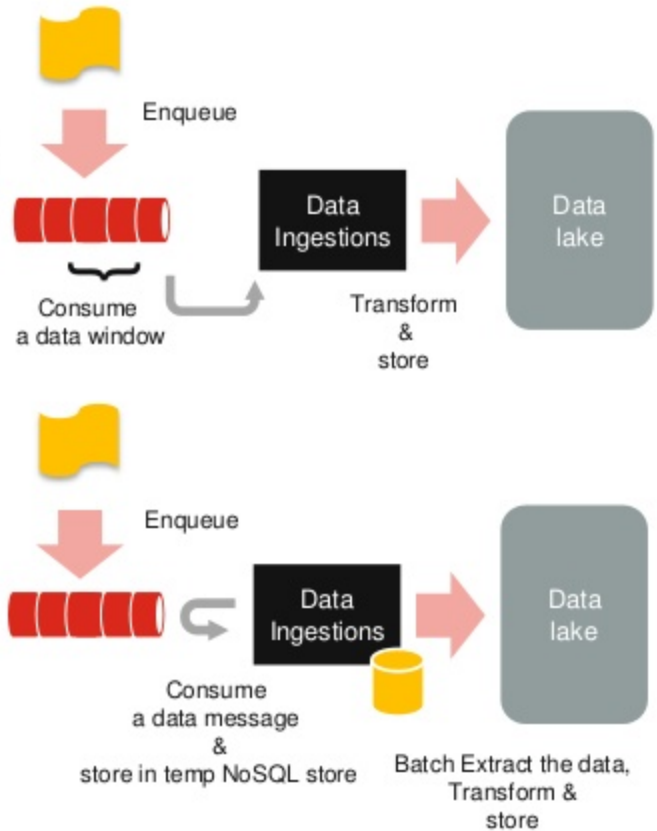
Data Ingestion

Real-time Data Ingestion

- Refers to ingesting **small data messages** into the data lake in **high-frequency** (near-real time)
- In some scenarios, data message are pushed into a **message queue**, where the data ingestion tool **consumes** these messages from the queue and store them in the data lake.
- In other scenarios, the data generator calls an **ingestion API** to push the data to the data lake, where the **data message is received initially in an internal queue** before it is transformed and stored in the lake
- If the data **message is small**, it is preferable to consume a **"window" of messages** at a time before the are **stored (as one file)** in the data lake to avoid having many small files, one per each message in the data lake.
- One idea is to store each message in a **intermediate NoSQL store**, in real time, where a batch data ingestion retrieve all the data inserted at once to store them in one file in the data lake



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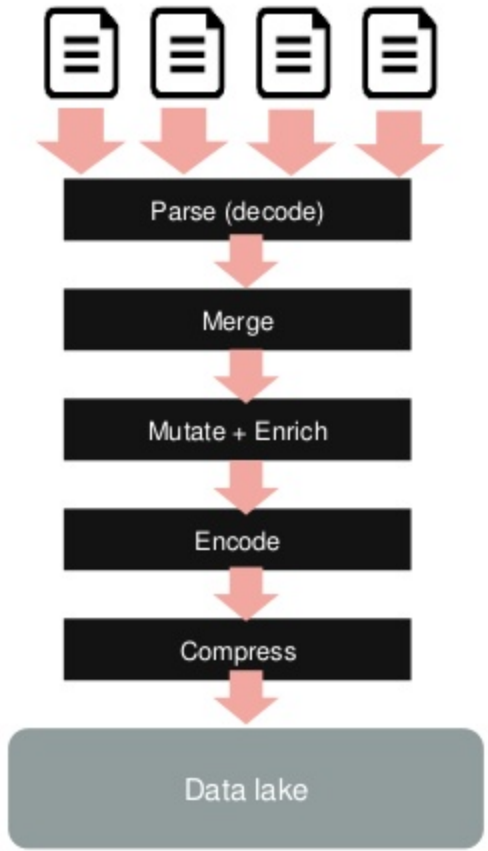
Data Ingestion

Transformation

Data ingestion tools are **not meant to perform data processing**, rather some data **transformation** tasks are applied during ingesting data to data lake:

- **File format change** (decode/encode) – optimize the data file for read/write
- **File compression** before store – optimize storage and files shuffling
- **Merging** multiple file (or data messages) from source into one file to be stored (to avoid having many small files)
- Adding **metadata** columns to the dataset in-flight (enrichment)
- **Mutate**: Removing, renaming columns, etc.

In some cases, if the source data is a file system, **binary (blind) file ingestion** can be performed (without parsing the file content) if no transformations or encoding are needed – maybe just compression



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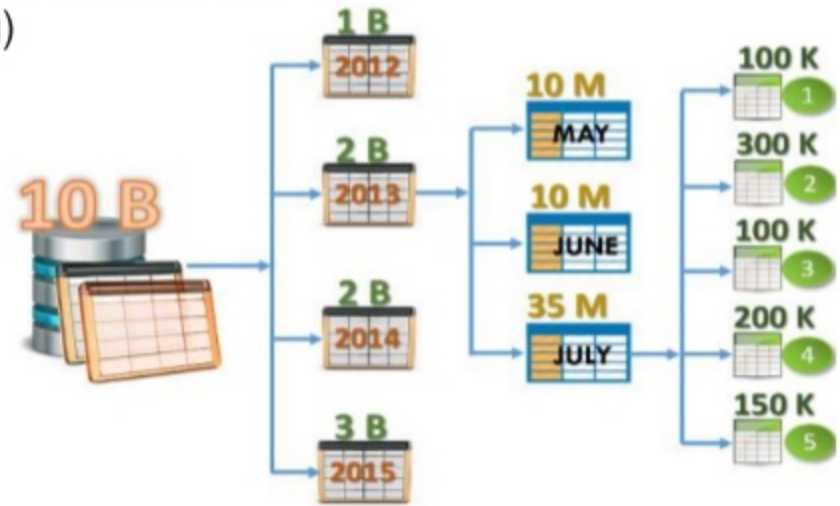
Data Ingestion

Data Partitioning

- The incoming data is partitioned and the files are stored in different **(hierarchical) directories** in the file system
- Partitioning is typically based on date/time (year/month/day/…) and/or any data element used in the “where” clause (country, site, category, etc.)
- The reason is achieve **partitions elimination** while processing data (if the partition is part of the **where/filter criteria** of the processing)
- **Improves the performance** of the query/processing jobs as **less data files** are considered.



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Data Ingestion

File Formats & Compression

Raw Files

- Raw data files maybe stored in its **original format** (TEXT/XML/JSON)
- Original format **allow users** to download the original files and **work with them**
- **Compression** is applied to improve **query/processing performance**
  - For very **large** file, **splittable** compression is applied (e.g. bzip2, LZO) – usually **slow to compress**
  - For **normal** files, high speed (**less efficient**) compression can be applied (e.g. gzip, deflate)
- **Splitability** is important as multiple **processing** task can work on different parts of the file **simultaneously**

Processes Data Files

- **All** the processed data files (dataset) should follow the **same format**
- Since the processed datasets are query intensive (used to perform aggregations, etc.), **Columnar-oriented formats** are recommended (for **better read performance**) – e.g. Parquet, ORC
- For supporting **schema evolution** (e.g. expected changes in schema), formats Parquet and Avro are recommended.
- Since Columnar-oriented format are binary and compressed, no compression, or snappy (fast, less effecient) compression can be applied

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Data Ingestion

File Formats

Format	Description	Content	Splitable	Schema Evolution	Size	Read Perfom.
TEXTFILE	▪ Delimited text file ▪ Any Platform	Plain Text	Yes	No	6	6
SEQUENCEFILE	▪ Binary key-value pairs ▪ Optimized for MapReduce	Plain Text	Yes	No	5	4
PARQUET	▪ Columnar storage format ▪ Optimized for querying “wide” tables	Binary (Compressed)	No	Yes	2	2
RCFile	▪ Columnar storage format	Binary (Compressed)	No	No	3	3
ORC	▪ Columnar storage format ▪ Optimized for distinct selection and aggregations ▪ Vectorization: Batch Processing. Each batch is a column vector.	Binary (Highly Compressed)	No	No	1	1
AVRO	▪ serialization system with evolvable schema-driven binary data ▪ Cross-platform inter-operability.	Binary	Yes	Yes	4	5

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Note that, if Text and Avro files are compressed, they perform pretty well in terms of query performance

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Data Ingestion

Compression

Compression	Extension	Codec	Splittable	Efficacy (Compression Ratio)	Speed (to compress)
DEFLATE	.deflate	org.apache.hadoop.io.compress.DefaultCodec	No	Medium	Medium
gzip	.gz	org.apache.hadoop.io.compress.GzipCodec	No	Medium	Medium
bzip2	.bz2	org.apache.hadoop.io.compress.BZip2Codec	Yes	High	Low
LZO	.lzo	com.hadoop.compression.lzo.LzopCodec	Yes*	Low	High
LZ4	.lz4	org.apache.hadoop.io.compress.Lz4Codec	No	Low	High
Snappy	.snappy	org.apache.hadoop.io.compress.SnappyCodec	No	Low	High

Reduces space needed to store files

Speeds up data transfer across the network or to or from disk

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Azure Data Lake Store

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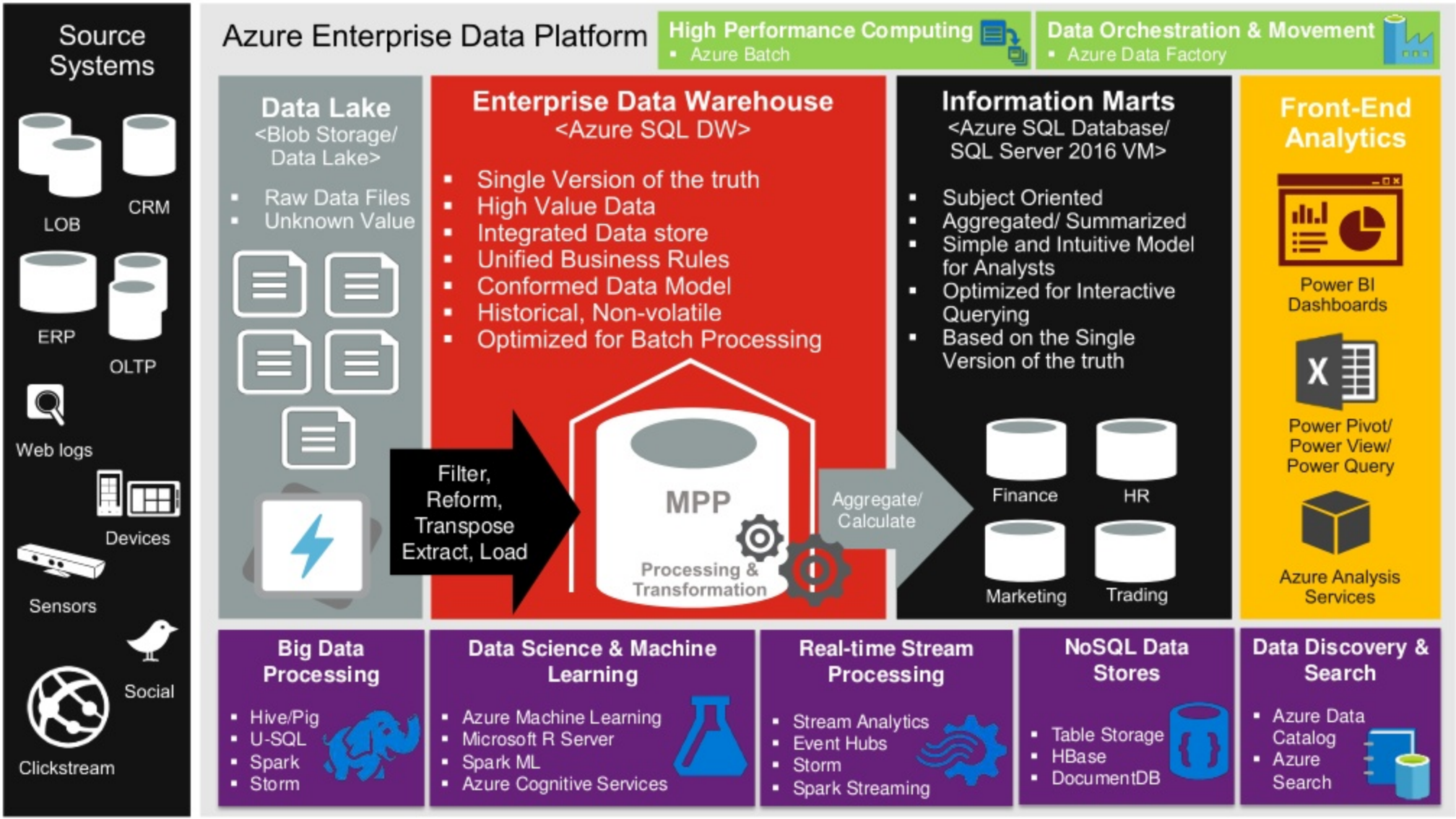
Source Systems
LOB
CRM
ERP
OLTP
Web logs
Devices
Sensors
Social
Clickstream
Azure Enterprise Data Platform
High Performance Computing
Azure Batch
Data Orchestration & Movement
Azure Data Factory
Data Lake
<Blob Storage/ Data Lake>
Raw Data Files
Unknown Value
Filter, Reform, Transpose Extract, Load
Enterprise Data Warehouse
<Azure SQL DW>
Single Version of the truth
High Value Data
Integrated Data store
Unified Business Rules
Conformed Data Model
Historical, Non-volatile
Optimized for Batch Processing
MPP
Processing & Transformation
Aggregate/ Calculate
Information Marts
<Azure SQL Database/ SQL Server 2016 VM>
Subject Oriented
Aggregated/ Summarized
Simple and Intuitive Model for Analysts
Optimized for Interactive Querying
Based on the Single Version of the truth
Finance
HR
Marketing
Trading
Front-End Analytics
Power BI Dashboards
Power Pivot/ Power View/ Power Query
Azure Analysis Services
Big Data Processing
Hive/Pig
U-SQL
Spark
Storm
Data Science & Machine Learning
Azure Machine Learning
Microsoft R Server
Spark ML
Azure Cognitive Services
Real-time Stream Processing
Stream Analytics
Event Hubs
Storm
Spark Streaming
NoSQL Data Stores
Table Storage
HBase
DocumentDB
Data Discovery & Search
Azure Data Catalog
Azure Search

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Azure Data Lake Store

Azure Data Lake Services

HDInsight

- Hadoop Cluster as a Service
- MapReduce | Pig | Hive | Spark HBase | Oozie | Storm
- Unit of Cost: Running nodes

Data Lake Analytics

- Big Data Jobs as a Service
- Built on Appache YARN
- U-SQL
- Unit of Cost: running Job

Data Lake Store

- Built for data files, rather than Blobs
- WebHDFS REST APIs for Hadoop integration
- Optimized for distributed analytical workloads
- Unlimited Storage, petabyte files
- Security: AAD an ACL, Encryption
- Built-in Catalog for “virtual” databases and .net assemblies

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Azure Data Lake Store

Azure Portal

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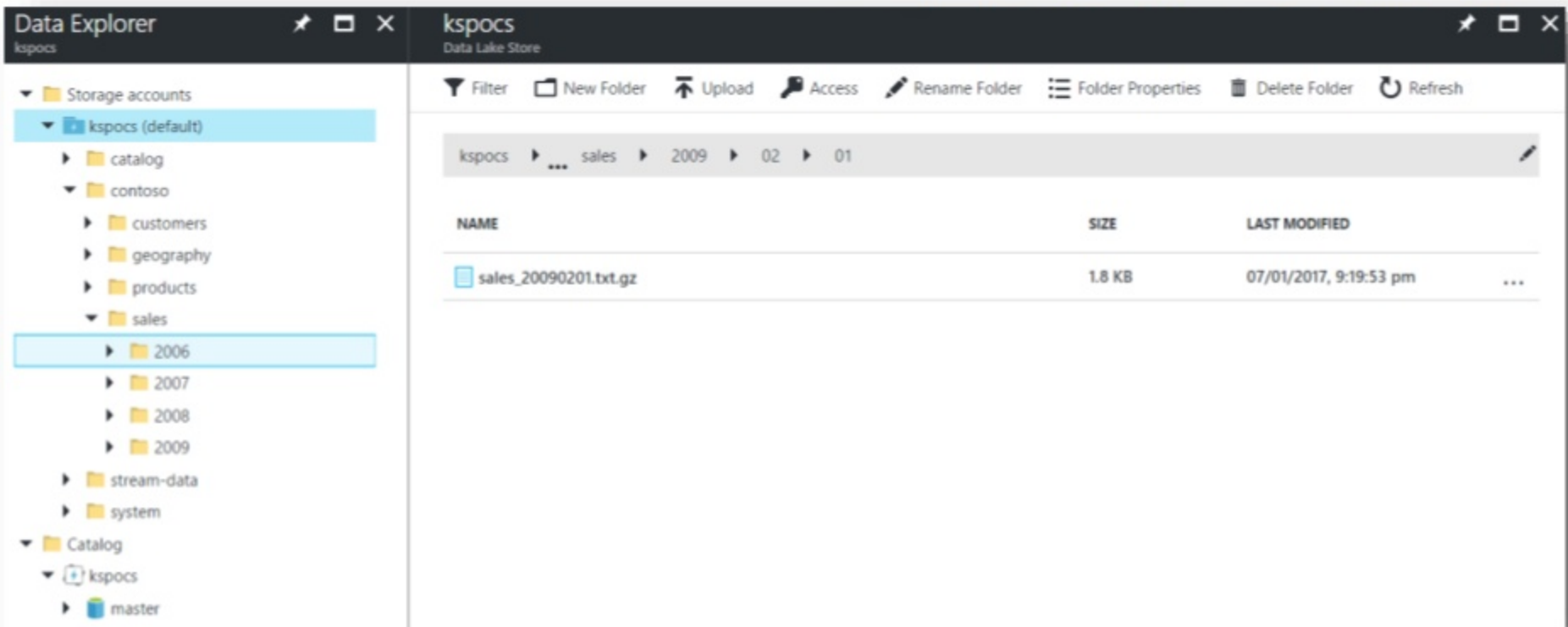
adl://<data_lake_store_name>.azuredatalakestore.net



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Azure Data Lake Store

Ingest Data

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Interactively

- Azure Portal
- Azure PowerShell
- Azure Cross-platform CLI
- Data Lake Tools for Visual Studio
- AdlCopy Tool: From Blob

Programmatically

- .Net SDK
- Java SDK
- Node.js SDK
- REST APIs

Azure Stream Analytics

- Real-time
- Event-based
- From Events Hub/IoT Hub

Azure Data Factory

- Batch
- Scheduled
- From SQL/NoSQL/File Systems

Azure HDInsight

- Sqoop: From SQL
- Distcp: From Blob/HDFS
- Oozie is used for Scheduling

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Azure Data Lake Store

Secure Data

Authentication

- Azure Active Directory (ADD)
- Users and service identities defined in your ADD can access your Data Lake Store account,
- Key advantages of using Azure Active Directory as a centralized access control mechanism are:
  - Simplified identity lifecycle management.
  - Authentication from any client through a standard open protocol, such as OAuth or OpenID.
  - Federation with enterprise directory services and cloud identity provide

Authorization

- Role-based access control (Owner/Reader/Contributor/Administrator)
- Access Control list (Read/Write/Execute)
- Files and folders both have Access ACLs

Network Isolation

- Firewall with IP address range for your trusted clients

Data Protection

- In transient - Transport Layer Security (TLS) protocol to secure data over the network.
- At rest - provides transparent encryption for data that is stored in the account.
  - Data Lake Store automatically encrypts data prior to persisting and decrypts data prior to retrieval,
  - Completely transparent to the client accessing the data

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Azure Data Lake Store

.Net SDK

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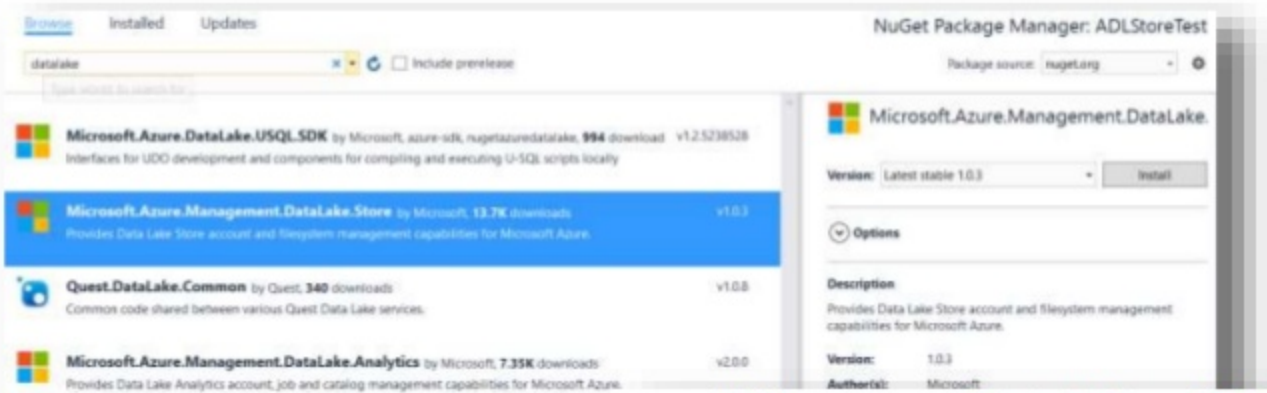
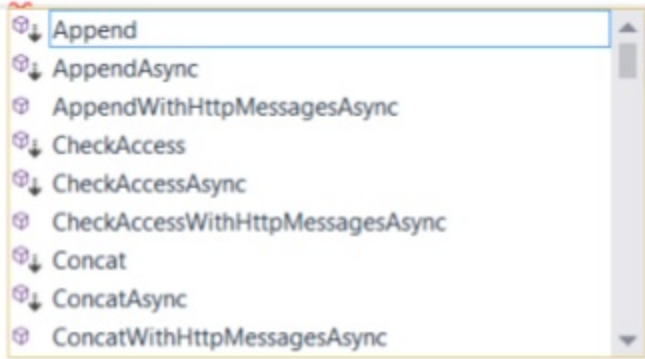



```
var adlClient = new DataLakeStoreFileSystemManagementClient(credentials);
adlClient.FileSystem.
```




```
using Microsoft.Azure.Management.DataLake.Store;
```

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Azure Data Lake Store

Data Lake vs Blob Storage

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https://docs.microsoft.com/en-us/azure/data-lake-store/data-lake-store-comparison-with-blob-storage

	Azure Data Lake Store	Azure Blob Storage
Purpose	Optimized performance for parallel analytics workloads. High Throughput and IOPS.	General purpose object store for a wide variety of storage scenarios
Use Cases	Batch, interactive, streaming analytics and machine learning data such as log files, IoT data, click streams, large datasets	Any type of text or binary data, such as application back end, backup data, media storage for streaming and general purpose data
Key Concepts	Data Lake Store account contains folders, which in turn contains data stored as files	Storage account has containers, which in turn has data in the form of blobs
Structure	Hierarchical file system	Object store with flat namespace
HDFS Client	Yes	Yes
Server-side API	WebHDFS-compatible REST API	Azure Blob Storage REST API
Security - Authentication	Based on Azure Active Directory Identities	Based on shared secrets - Account Access Keys and Shared Access Signature Keys.
Security - Authorization	POSIX Access Control Lists (ACLs). ACLs based on Azure Active Directory Identities can be set file and folder level.	For account-level authorization – Use Account Access Keys For account, container, or blob authorization - Use Shared Access Signature Keys
Encryption data at rest	Transparent, Server side	Transparent, Server side
Developer SDKs	.NET, Java, Python, Node.js	.Net, Java, Python, Node.js, C++, Ruby
Size limits	No limits on account sizes, file sizes or number of files	Specific limits documented here
Redundancy	Locally-redundant (multiple copies of data in one Azure region)	Locally redundant (LRS), globally redundant (GRS), read-access globally redundant (RA-GRS). See here for more information

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Azure Data Factory

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Azure Data Factory

Cloud data processing & movement services

A managed Azure cloud service for building & operating data pipelines

- Scalable
- Reliable
- Pay-as-you use

Batch Data Ingestion & Movement

- No real-time data collection (use stream Analytics instead)
- Format conversion, compression, files merge, column mapping

Data Processing Orchestration and Scheduling

- Not a data processing engine, but uses different compute platforms

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Azure Data Factory

Concepts & Components

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Data Factory

Linked Service

A connection information to a data store or a compute resource

Dataset

A pointer to the data object to be used as input or an output of an Activity

Pipeline

logical grouping of Activities with certain sequence & schedule

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Azure Data Factory

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Data Factory

Pipeline

Activity

actions to perform on data.
Input 0-N dataset(s) - Output 1-N dataset(s)

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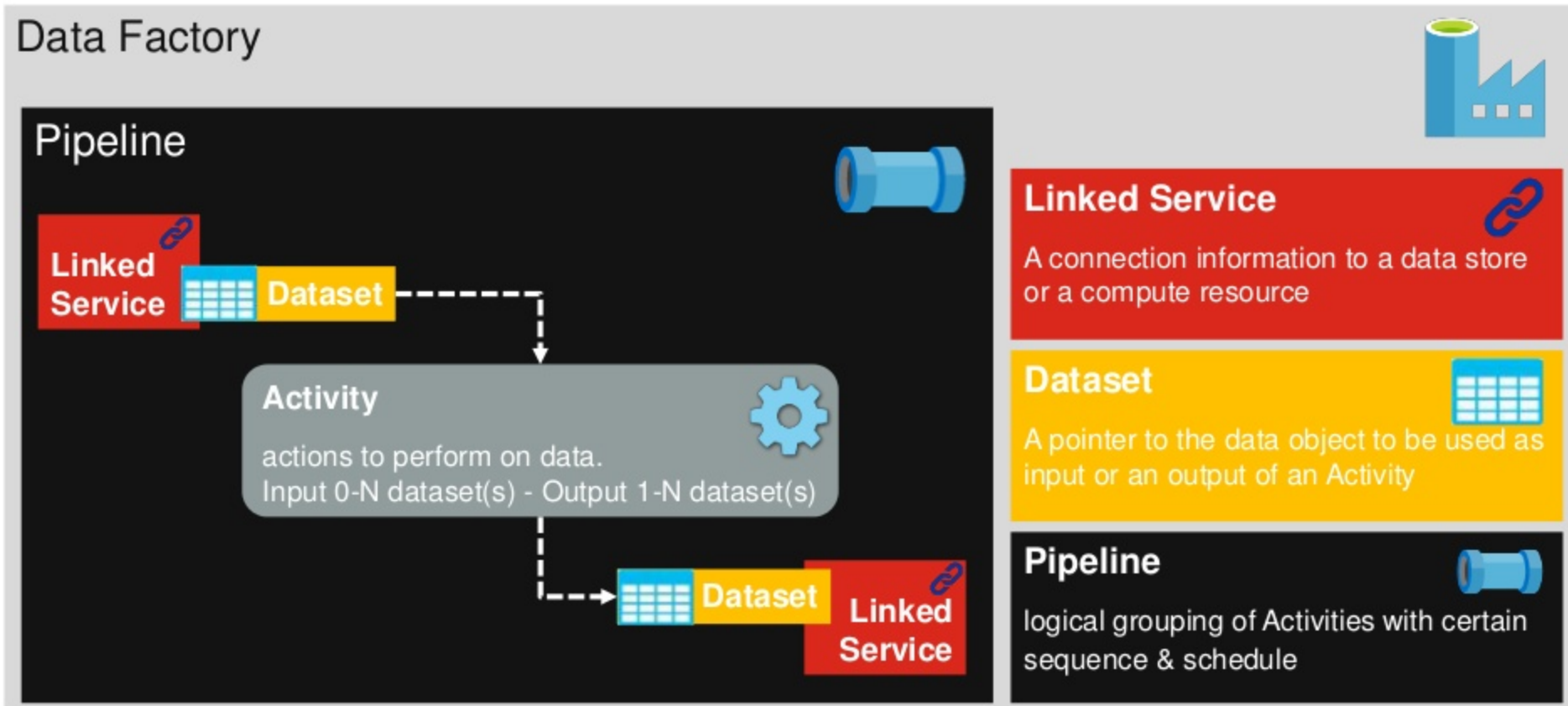

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Azure Data Factory

Concepts & Components

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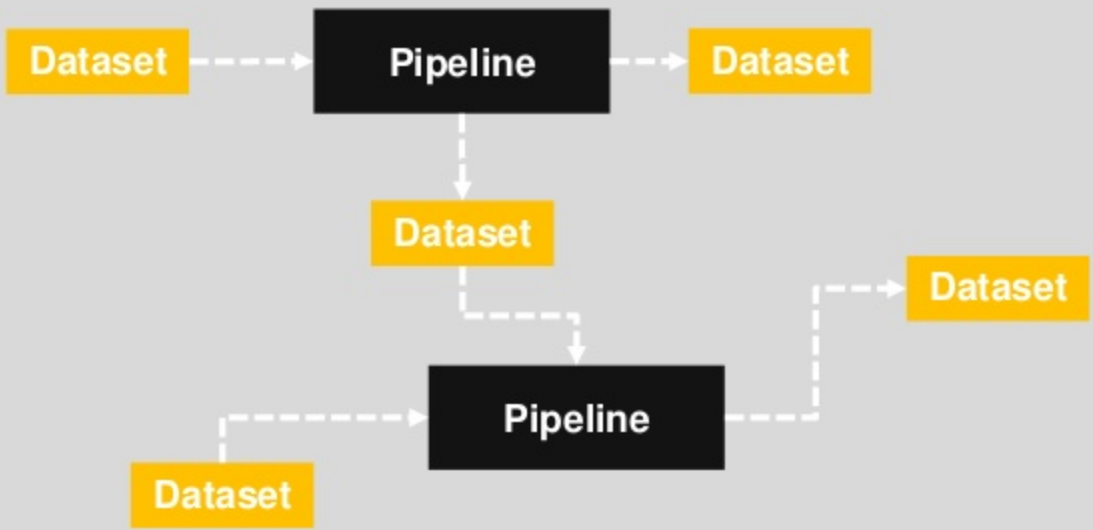
Data Factory



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Azure Data Factory

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Azure Data Factory

Features

Linked Service – Data

- Azure Blob
- Azure Table
- Azure SQL Database
- Azure SQL Data Warehouse
- Azure DocumentDB
- Azure Data Lake Store
- SQL Server
- ODBC data sources
- Hadoop Distributed File System (HDFS)

Linked Service - Compute

- Azure HDInsight On-Demand
  Azure Batch
- Azure Machine Learning
- Azure Data Lake Analytics
- Azure SQL DW (StoredProc)
- Azure SQL DB (StoredProc)
- SQL Server (StoredProc)

Activities

- Data Movement
  (copy Data from Source to sink)
- Data Transformation
  - (on-demand) HDInsight
    (Hive | Pig | MapReduce | Spark)
  - Azure ML Batch
  - Stored Procedure
  - Data Lake U-SQL Jobs
  - Custom .NET
    (Azure Batch)

Data Gateway - Connect to an on-prem data source

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Azure Data Factory - Taxonomy

Dataset

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```
{
  "name": "input-azblobstorage-test_data_v8",
  "properties": {
    "structure": ...,
    "published": false,
    "description": "true",
    "type": "AzureBlob",
    "linkedServiceName": "azstorage-kspocs",
    "typeProperties": ...,
    "availability": ...,
    "external": true,
    "policy": ...
  }
}
```

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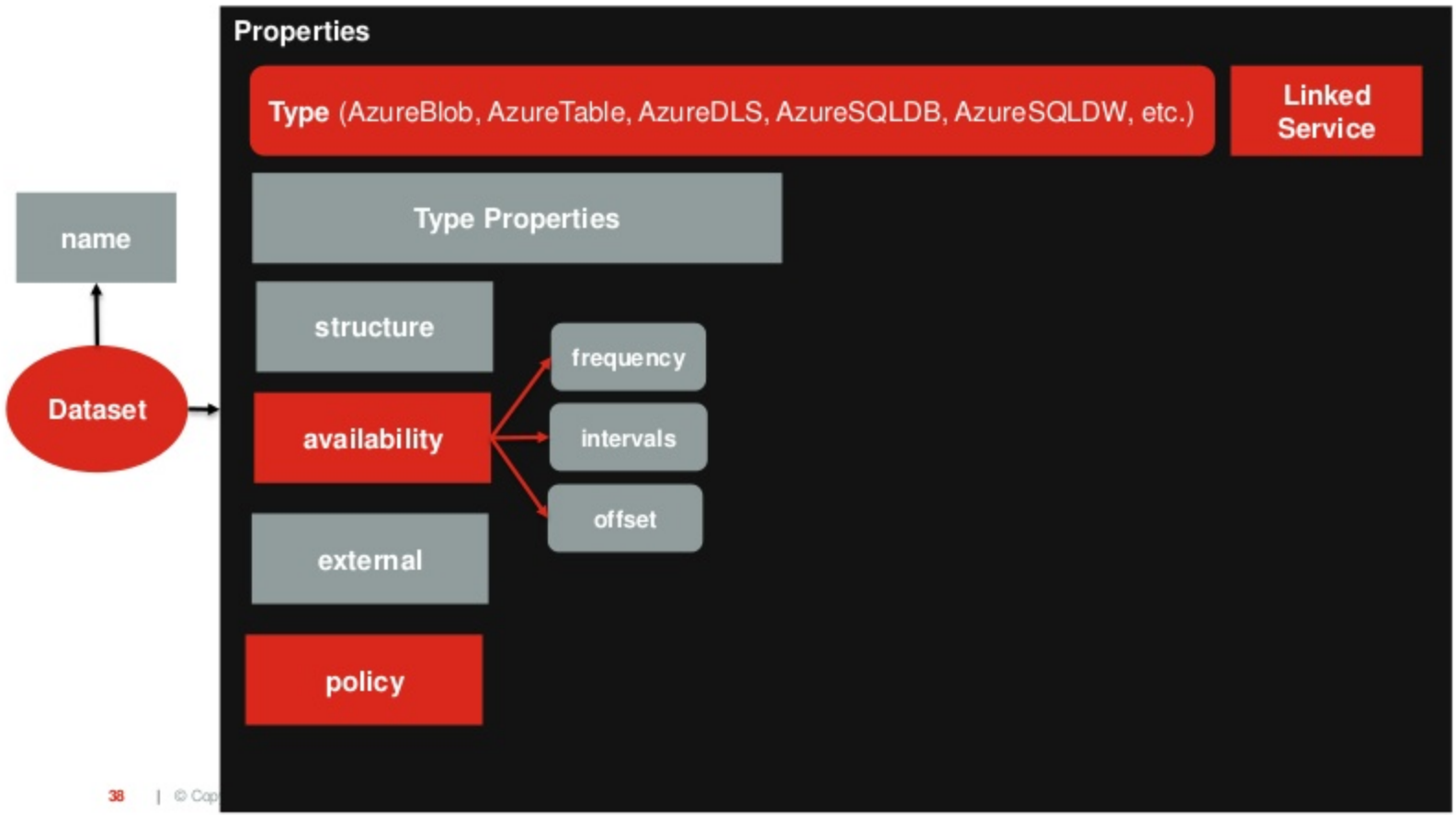
Azure Data Factory - Taxonomy

Dataset



Azure Data Factory - Taxonomy

Dataset

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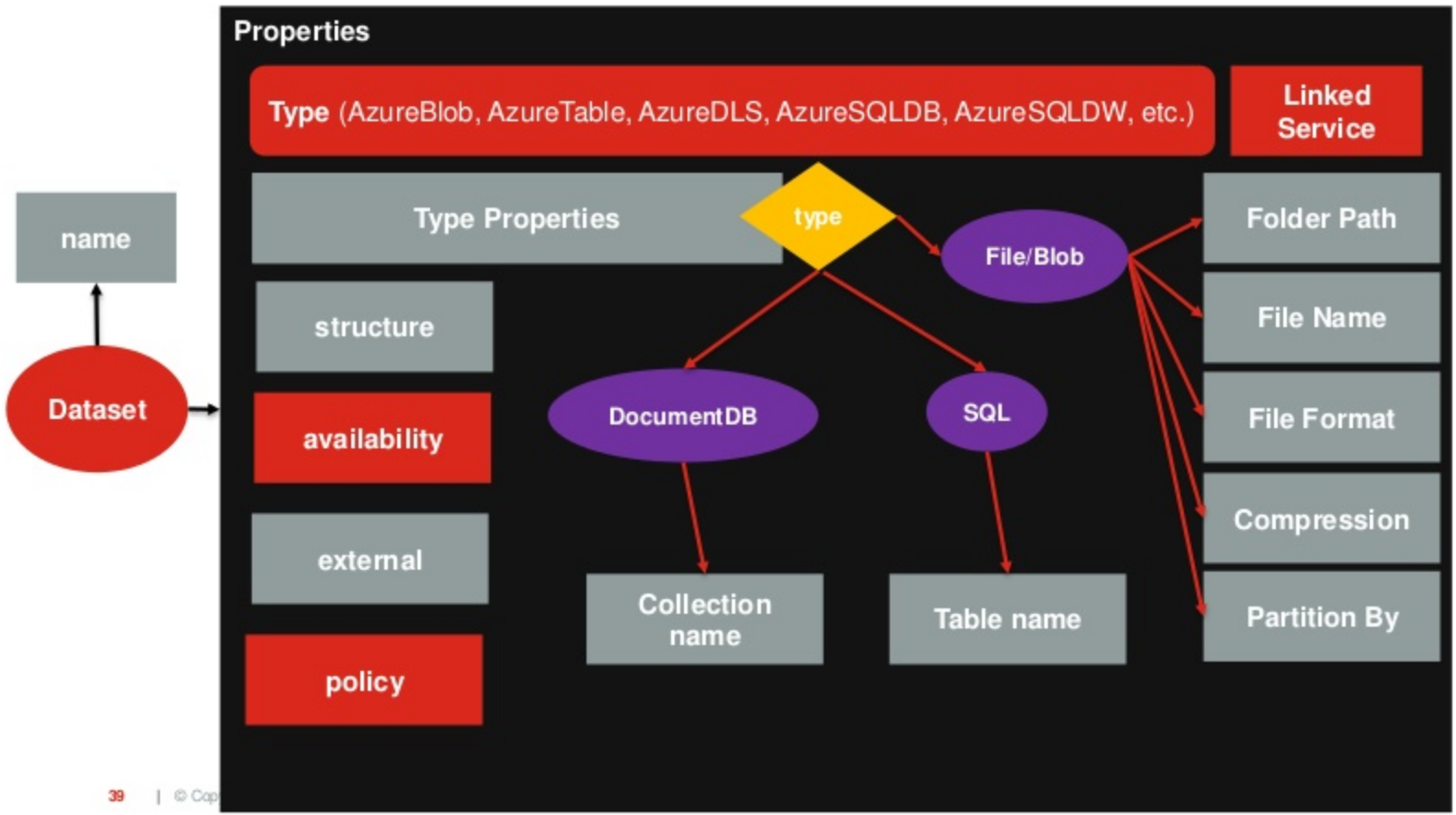

Azure Data Factory - Taxonomy

Dataset

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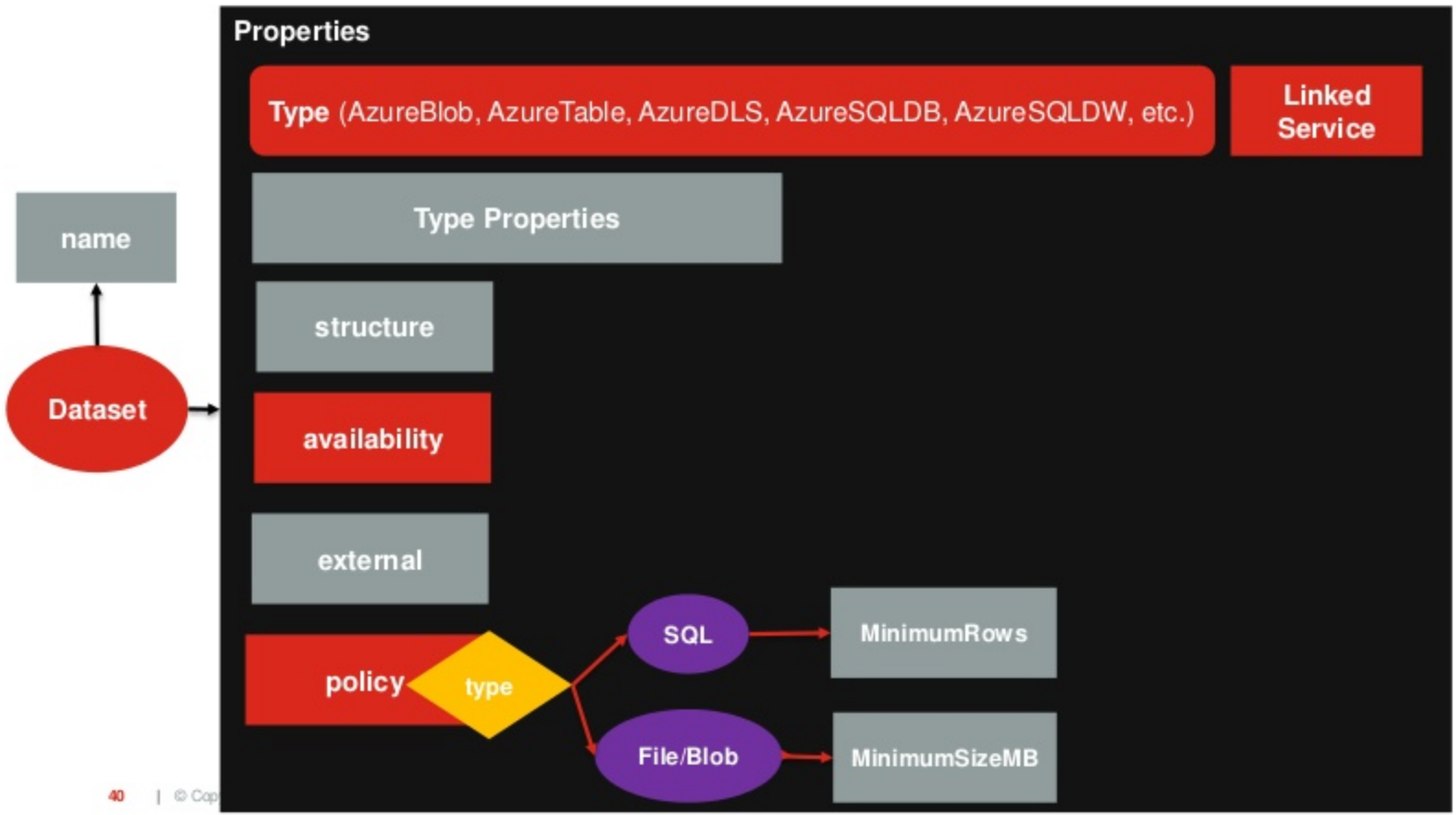

Azure Data Factory - Taxonomy

Pipeline

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```
{
  "name": "contoso_customer-pipeline",
  "properties": {
    "activities": ...,
    "start": "2017-01-06T08:00:00.0106386Z",
    "end": "2017-01-07T08:00:00.0106386Z",
    "isPaused": false,
    "pipelineMode": "Scheduled"
  },
}
```

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Azure Data Factory - Taxonomy

Pipeline

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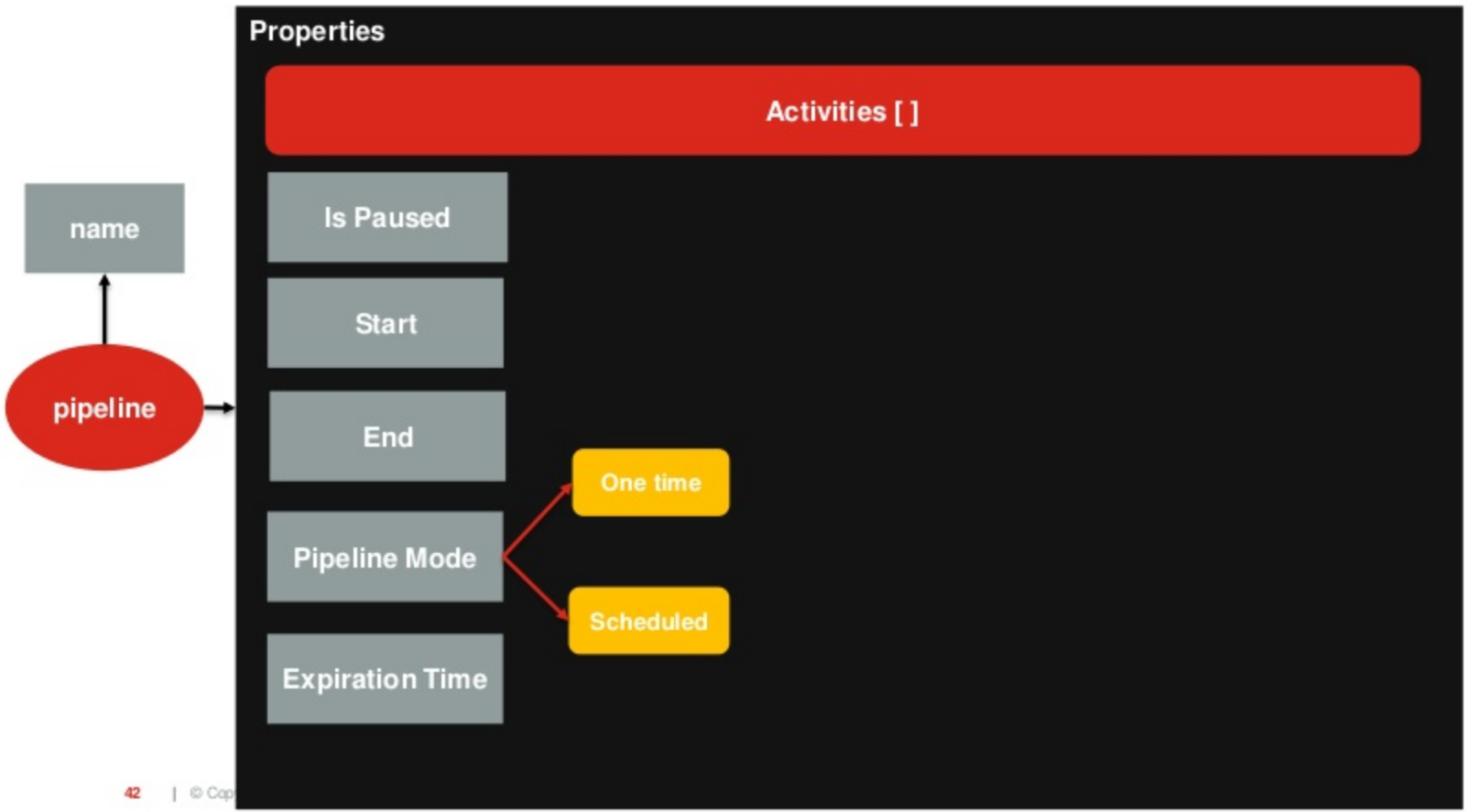

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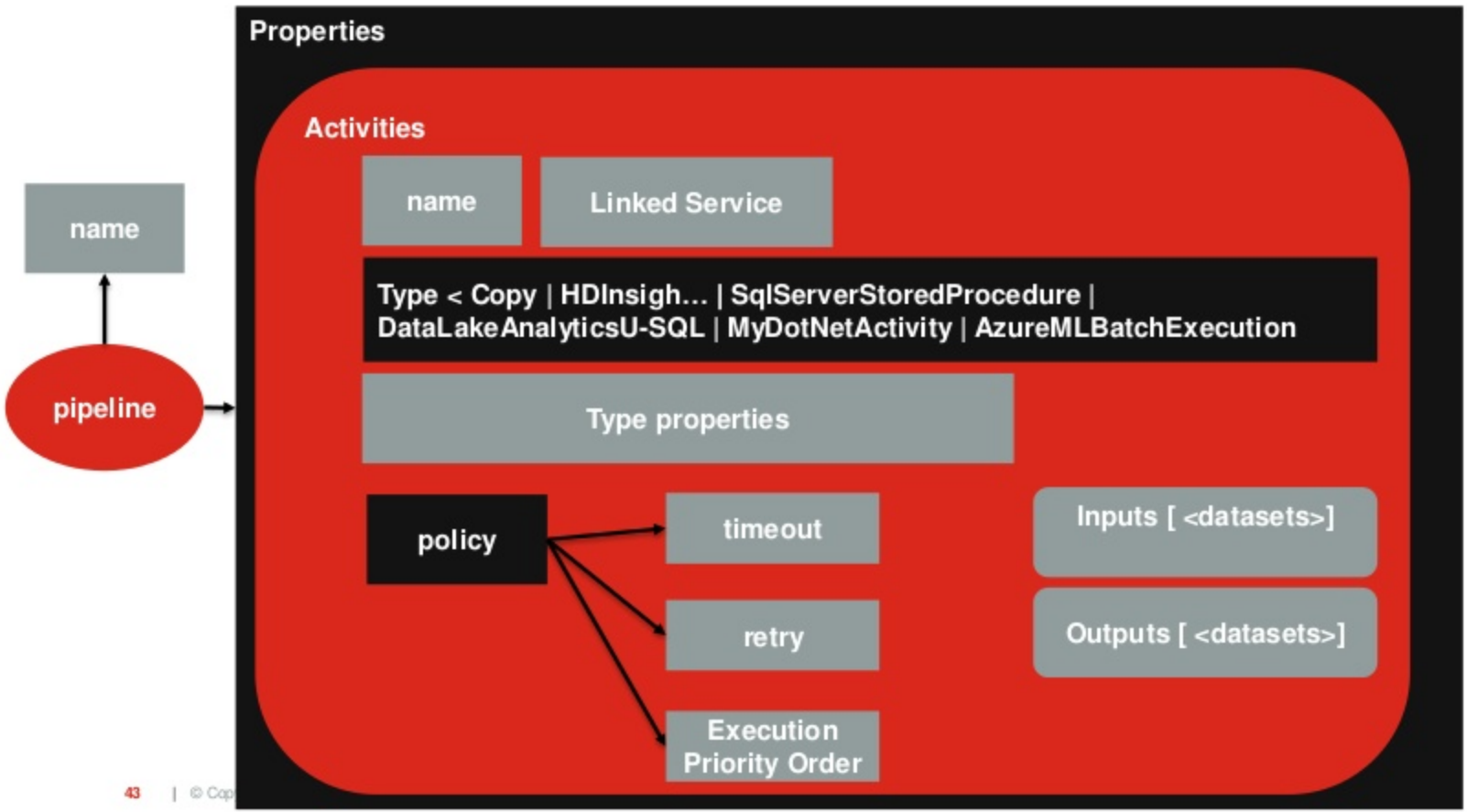
Azure Data Factory - Taxonomy

Pipeline - Activity



Azure Data Factory - Taxonomy

Data Movement Activity

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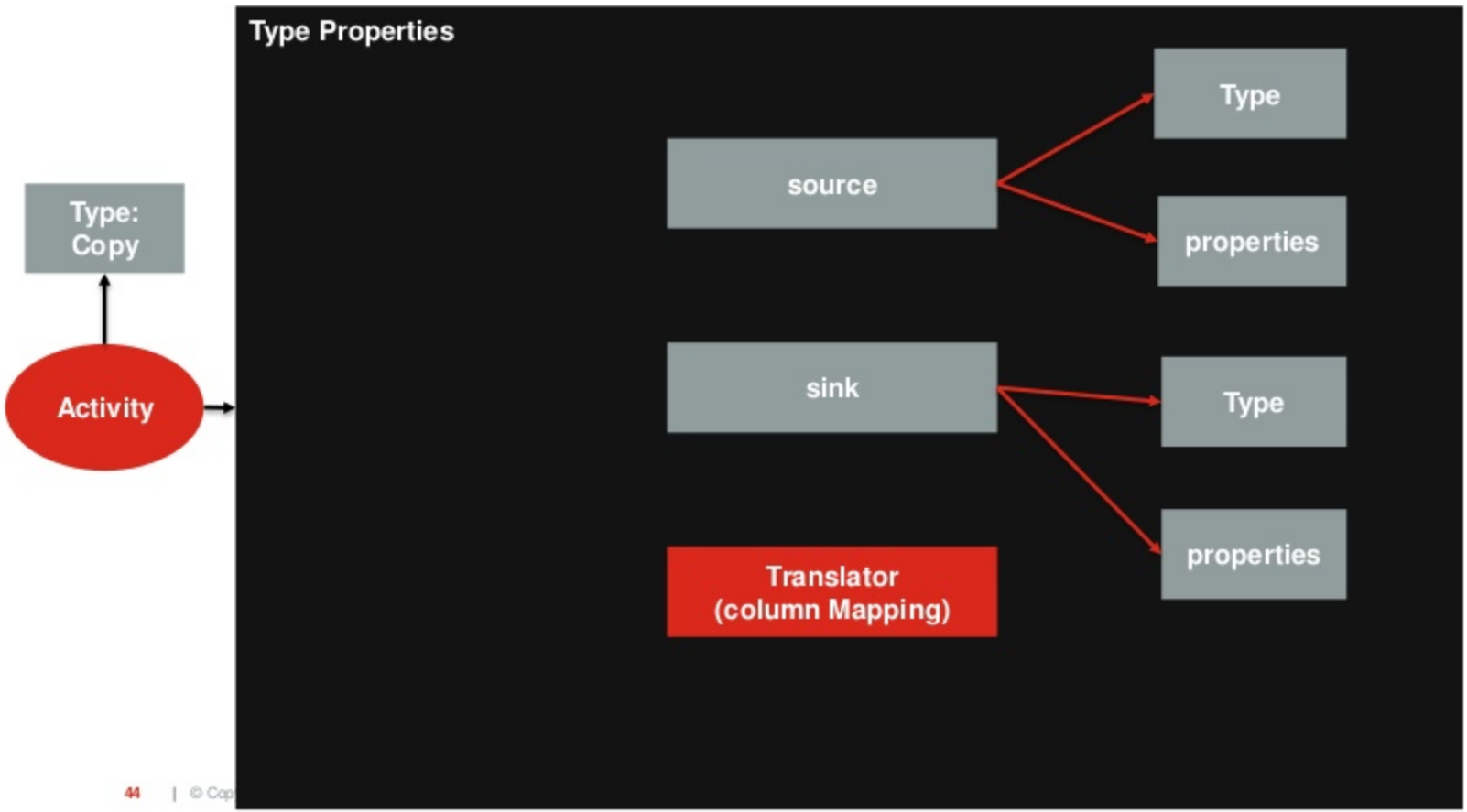

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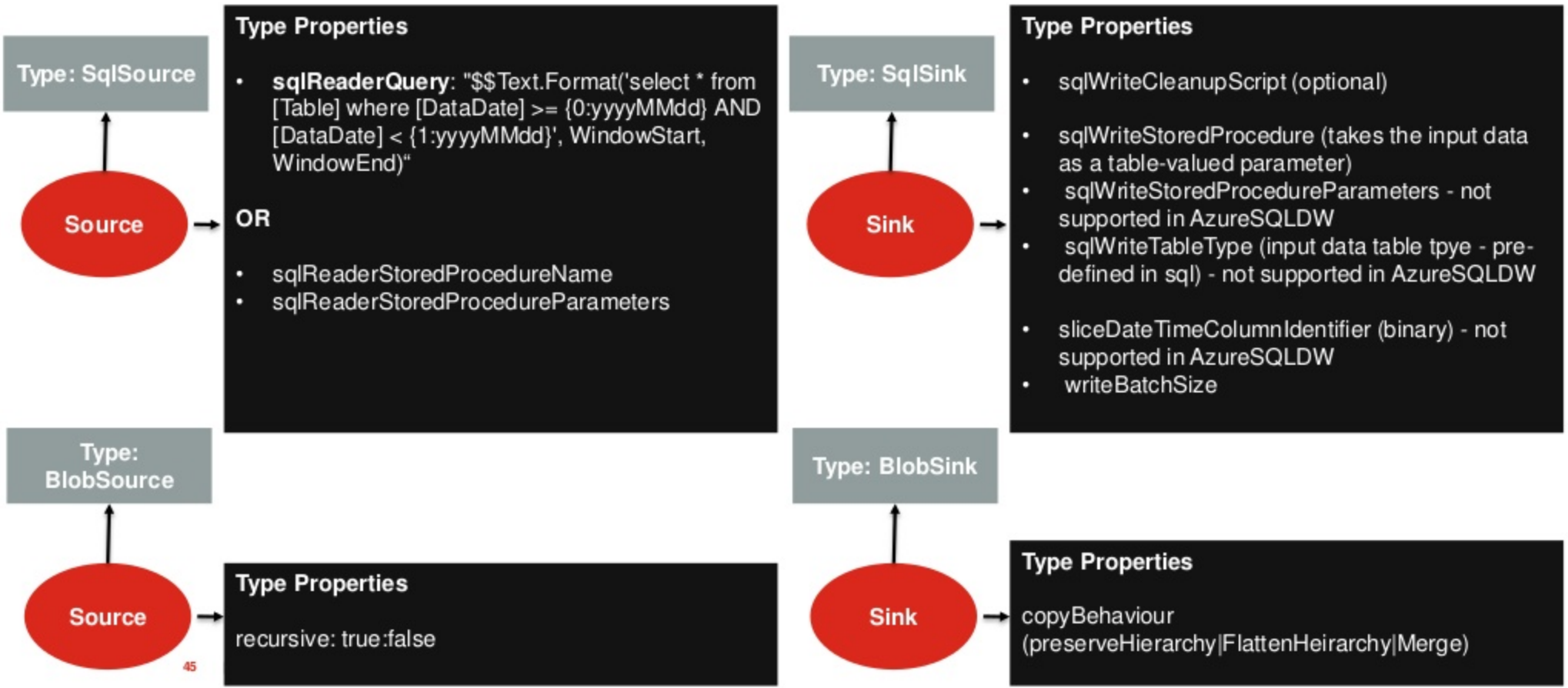
Azure Data Factory - Taxonomy

Data Movement Activity – SQL & Blob



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Azure Data Factory - Taxonomy

Copy Performance Tuning Elements

activity

concurrency	runs multiple data slices concurrently – data migration
parallelCopies	multiple threads, depending on source/sink
cloudMovementUnits	(1,2,4,8) - CPU/Memory allocation
EnableStaging	Useful when moving data from on-prem to cloud

```
"enableStaging": true,
"stagingSettings": {
    "linkedServiceName": "MyStagingBlob",
    "path": "stagingcontainer/path",
    "enableCompression": true
```

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Data Lake Ingestion Scenarios with Azure Data Factory

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Azure Data Lake Ingestion Scenarios

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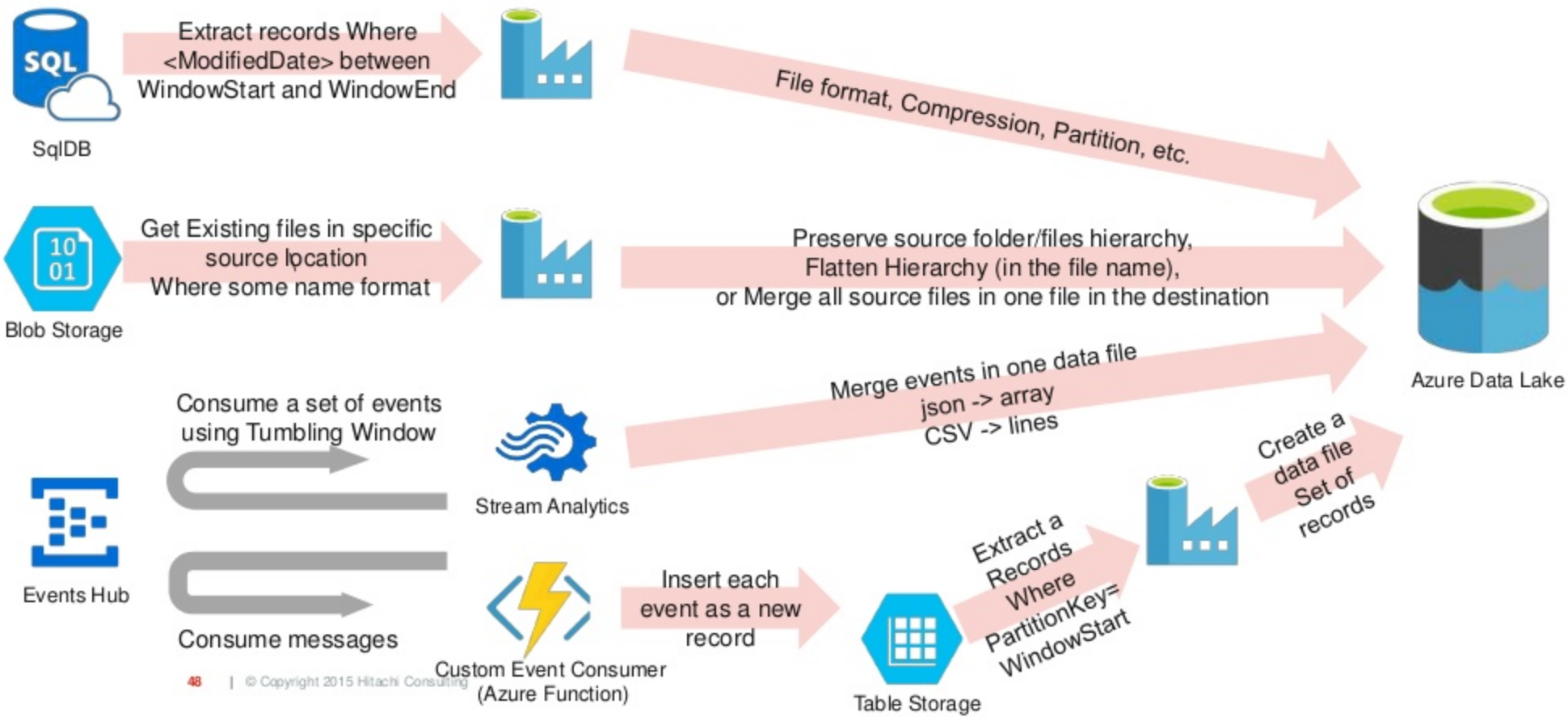

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Azure Data Lake Ingestion Scenarios

Data Factory - ADLS Dataset Definition

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Define Destination File Format, Compression, and Partitioning - in the DL Store

```
{
  "name": "output-azdlsfolder-contoso_customer",
  "properties": {
    "published": false,
    "type": "AzureDataLakeStore",
    "linkedServiceName": "azdls_kspocs",
    "typeProperties": {
      "folderPath": "contoso/customers/{Year}/{Month}/{Day}",
       "format": {
              "type": "TextFormat", "rowDelimiter": "\n",
              "columnDelimiter": "|", "nullValue": "NA",
              "quoteChar": "\"", "firstRowAsHeader": true
            },
      "partitionedBy": [
        {"name": "Year", "value": {"type": "DateTime", "date": "SliceStart","format": "yyyy"}},
        {"name": "Month",  value": {"type": "DateTime", "date": "SliceStart","format": "MM"}},
        {"name": "Day",  "value": {"type": "DateTime", "date": "SliceStart","format": "dd"}}
      ],
      "compression": {"type": "GZip","level": "Optimal"}
    },
    "availability": {
      "frequency": "Day",
      "interval": 1
    },
    "external": false
  }
}
```

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Azure Data Lake Ingestion Scenarios

Data Factory – Copy Activity (SqlSource)

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Parameterizing the fetch query to get only the current data slice (based on the WindowStart & WindowEnd)

```
"activities": [
    {
      "type": "Copy",
      "typeProperties": {
        "source": {
          "type": "SqlSource",
          "sqlReaderQuery": "$$Text.Format('select * from cso.FactOnlineSales where CAST(CONVERT(VARCHAR(10), DateKey, 112)
AS INT) >= {0:yyyyMMdd} AND CAST(CONVERT(VARCHAR(10), DateKey, 112) AS INT) < {1:yyyyMMdd}', WindowStart, WindowEnd)"
        },
        "sink": {
          "type": "AzureDataLakeStoreSink", "writeBatchSize": 0,"writeBatchTimeout": "00:00:00"
        }
      },
      "inputs": [{"name": "input-azsqldbtable-contoso_sales"}],
      "outputs": [{"name": "output-azdlsfolder-contoso_sales"}],
      "policy": {
        "timeout": "01:00:00",
        "concurrency": 1,
        "retry": 1
      },
      "scheduler": {
        "frequency": "Day",
        "interval": 1
      },
      "name": "act-copy-sales_SQLDB-DLS"
    }
  ]
```

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Azure Data Lake Ingestion Scenarios

Data Factory – Copy Activity (BlobSource)

```
{
  "name": "contoso_product-pipeline",
  "properties": {
    "activities": [
      {
        "type": "Copy",
        "typeProperties": {
          "source": {
            "type": "BlobSource",
            "recursive": true
          },
          "sink": {
            "type": "AzureDataLakeStoreSink",
            "copyBehavior": "MergeFiles",
          }
        },
        "inputs": [{"name": "input-azstorage-contoso_product"}],
        "outputs": [{"name": "output-azdlsfolder-contoso_product_v3"}],
        "policy": {"timeout": "1.00:00:00","concurrency": 1,"retry": 1},
        "scheduler": {"frequency": "Day","interval": 1},
        "name": "act-copy-customer_AZS->DLS"
      }
    ],
    "start": "2017-01-06T08:00:00.0106386Z",
    "end": "2017-01-07T08:00:00.0106386Z",
    "isPaused": false,
    "pipelineMode": "Scheduled"
  }
}
```

Fetches all the files with in the input dataset specified path (folder) and sub folders

Merges all the fetched files data into one file to be stored in the destination – Other Options: PerserveHierarchy & Flatten

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Azure Data Lake Ingestion Scenarios

Stream Analytics – From Events Hub

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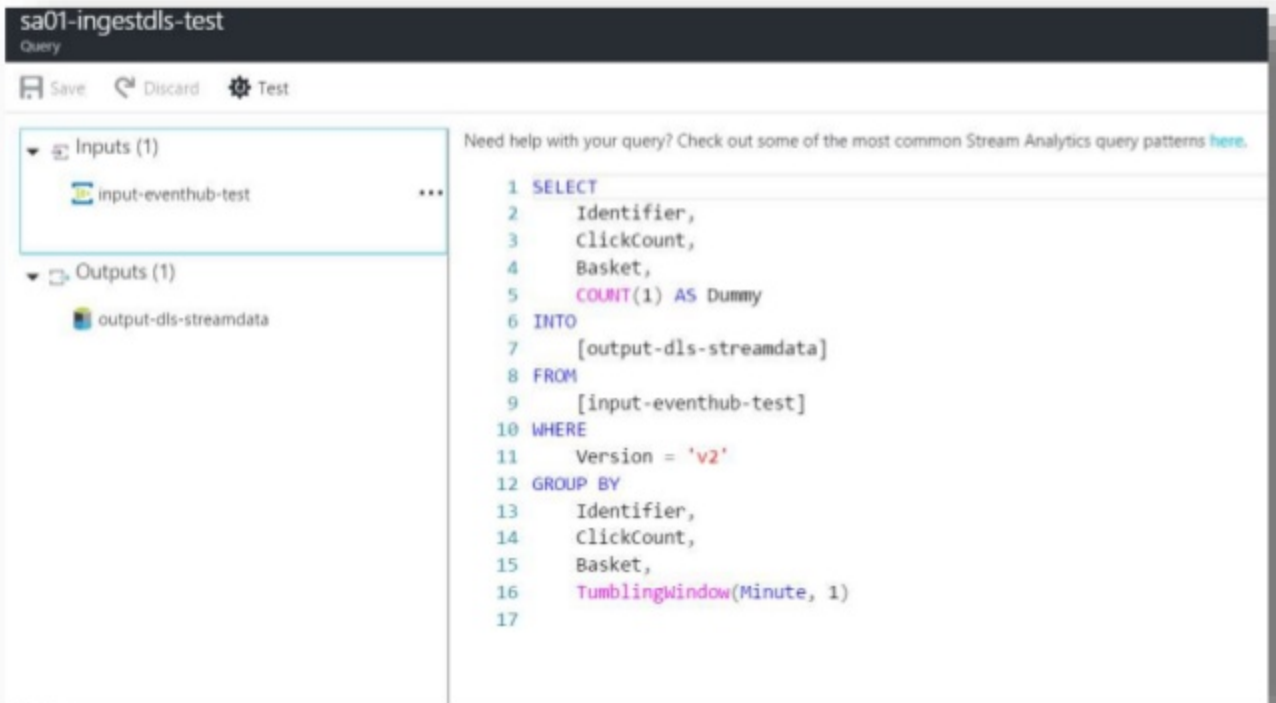

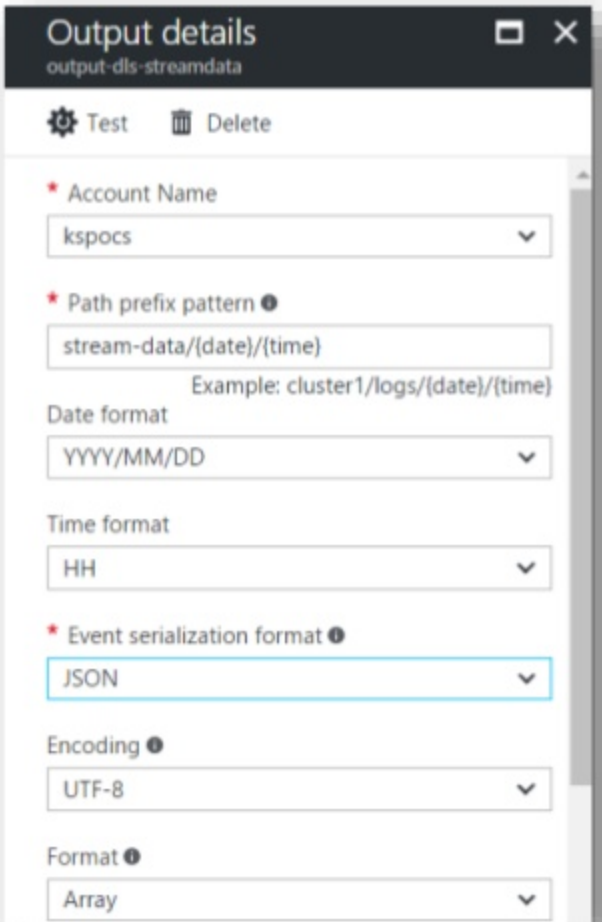

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Azure Data Lake Analytics

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Azure Data Lake Analytics

Big Data Processing Jobs

Big Data Processing Jobs as Service

Dynamic scaling

U-SQL: simple and familiar, powerful, and extensible

Develop faster, debug, and optimize smarter using familiar tool

Deploy on Azure & schedule using Data Factory

Integrates seamlessly with your IT investments

Affordable and cost effective: Pay as you use

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Azure Data Lake Analytics

U-SQL

C# meets SQL
(.NET data type, C# expressions + SQL set statements)

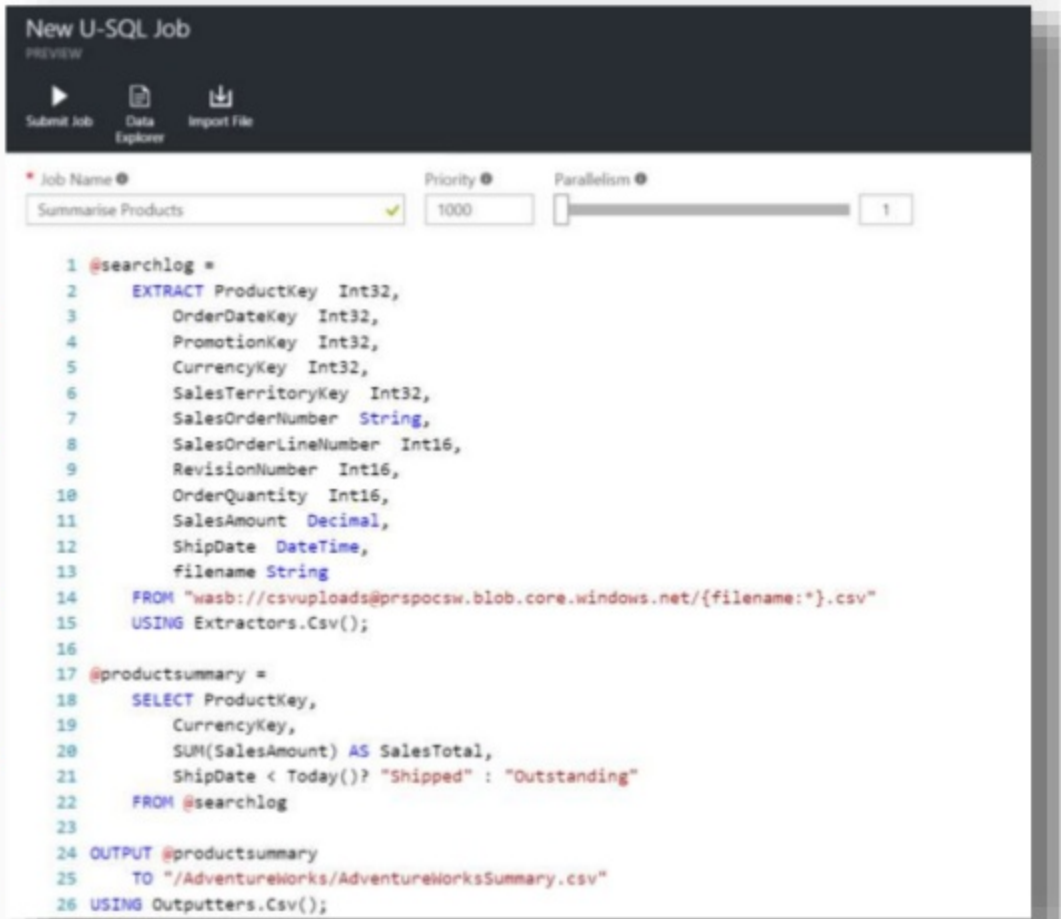
Works with structured and unstructured data

Set-based and procedural processing

Reuse of custom build .NET assemblies

Extensible (User-defined Functions, Operators and Aggregate Functions)

Natively Parallel



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Azure Data Lake Analytics

U-SQL – Processing Model

- **Create a Managed Data Model** (database, schemas, tables, functions)
  - Only a schema on top of existing files
  - Allow querying data files using SQL on top with tables/views
  - Reuse of procs and functions
- **Retrieve data:**
  - From data lake files using **EXTRACT** – apply schema on read
  - From Managed table using **SELECT**
  - From external data sources (Azure SQL DB/DW, SQLServer)
- **Data is retrieved as @rowset**
- A **rowset is processed** (aggregated, joined with other rowset, etc.) using SQL and C# to **produce another rowset**
- A rowset is **stored:**
  - As data lake file using OUTPUT
  - In managed table using **INSERT** (apply schema on write) or **CREAT TABLE AS SELECT**

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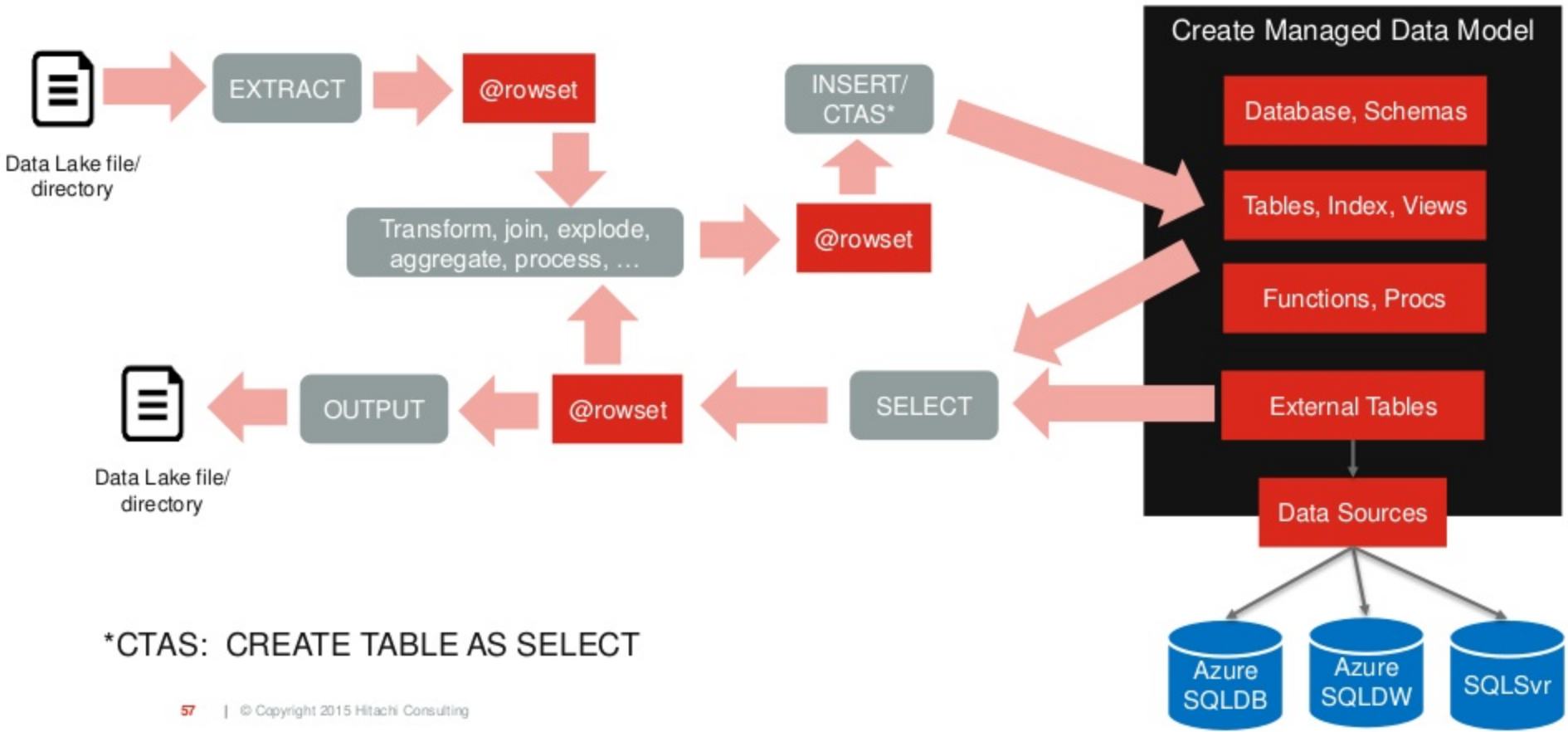
U-SQL – Processing Model



*CTAS: CREATE TABLE AS SELECT

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Azure Data Lake Analytics

U-SQL – Script Structure

- Use statement: USE Database

- Declare Variables: DECLARE @input string = <File Location>

- Register Assembly: CREATE ASSEMBLY <myDotNetLib> FROM "<dll location>
- Reference Assembly: REFERENCE ASSEMBLY <myDotNetLib>

- DLL Statement: CREATE TABLE | VIEW |…
  →Create Table: Index, Partition, Distribution

- Query statement: @rowset = SELECT … FROM <@set>|<table>
- Extract statement: @rowset = EXTRACT <columns> FROM <file location> USING **<Extractor>**

- DML Statement: INSERT INTO <Table> SELECT … FROM @rowset
- CTAS: CREATE TABLE <Table> AS SELECT … FROM @rowset
- Output Statement: OUTPUT @rowset TO <file location> USING **<Outputer>**

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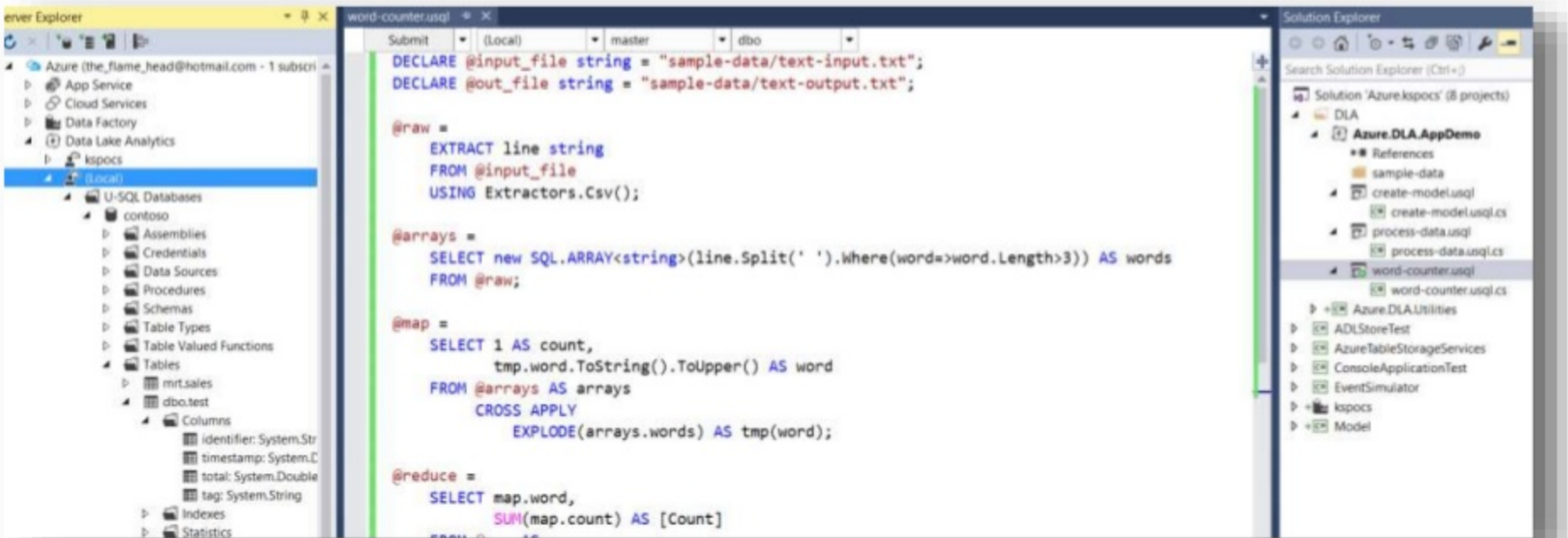
Azure Data Lake Analytics

Dev and Test U-SQL locally (using Visual Studio Data Lake Analytics Tools)



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Azure Data Lake Analytics

U-SQL Example – data aggregation

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Create Managed Model

```
USE DATABASE master;

CREATE DATABASE IF NOT EXISTS contoso;

USE DATABASE contoso;

CREATE SCHEMA IF NOT EXISTS mrt;

DROP TABLE IF  EXISTS mrt.sales;

CREATE TABLE mrt.sales
(
    Year int,
    Month int,
    Country string,
    ProductSubCategory string,
    TotalSales double,

    INDEX index_sales CLUSTERED(ProductSubCategory ASC)
    PARTITIONED BY (Year,Month)
    DISTRIBUTED BY HASH (Country)
);
```

Proccess Data

```
DECLARE @datafolder string = "sample-data/data-files/{*).txt";

@data =
        EXTRACT
            identifier string,
            value      double
        FROM @datafolder
        USING Extractors.Csv();
@result =
        SELECT
            identifier,
            DateTime.Now AS timestamp,
            SUM(value) AS total
        FROM @data
        GROUP BY
            identifier,
            DateTime.Now;

USE DATABASE contoso;

DROP TABLE IF EXISTS dbo.test;

CREATE TABLE dbo.test
(
       INDEX [idx_test] CLUSTERED (identifier ASC)
       PARTITIONED BY HASH (identifier)
)
AS
SELECT
    *
FROM @result;
```

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U-SQL Example – data aggregation

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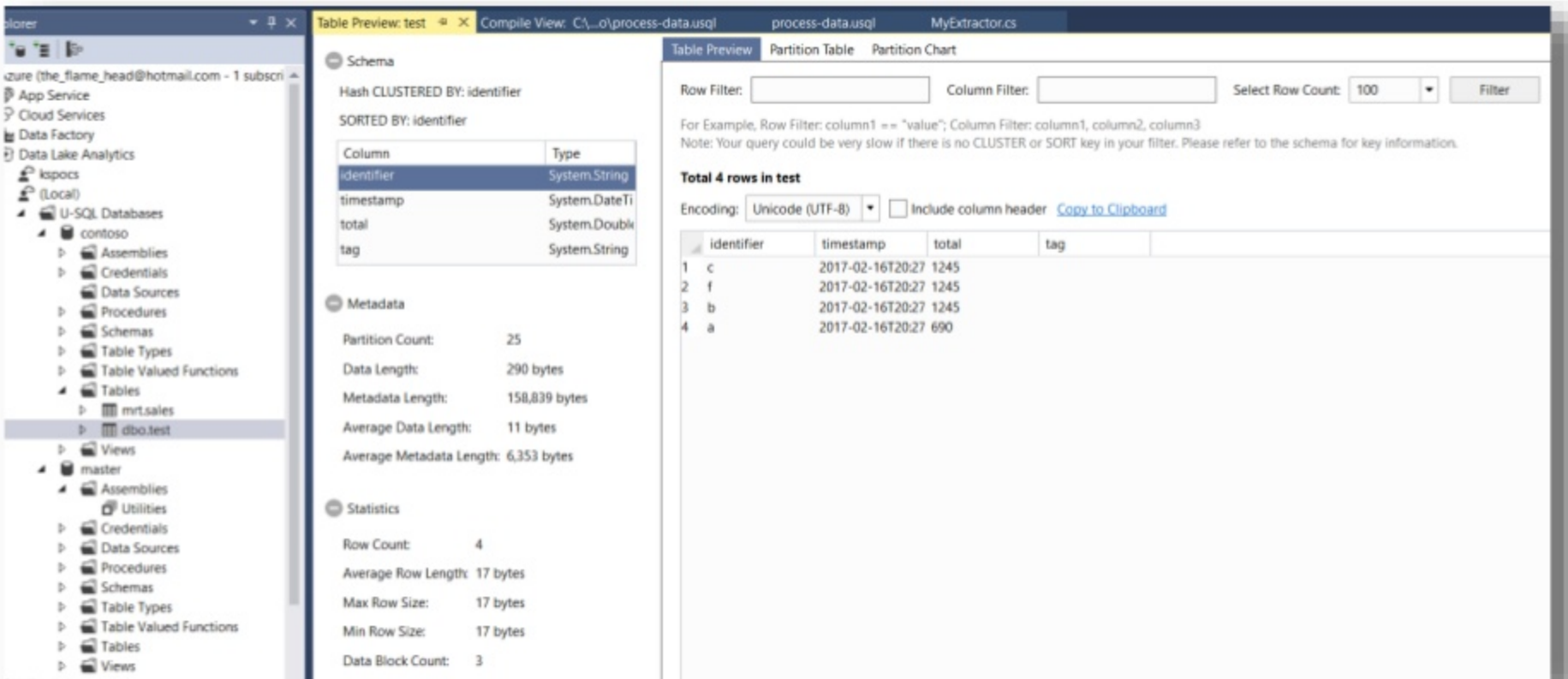

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U-SQL – Example Word Count

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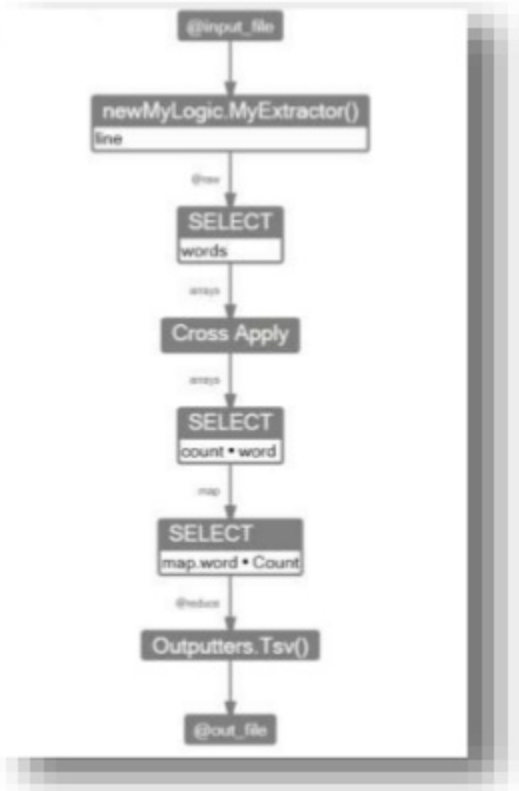


```
DECLARE @input_file string = "sample-data/text-input.txt";
DECLARE @out_file string = "sample-data/text-output.txt";


@raw =
    EXTRACT line string
    FROM @input_file
    USING Extractors.Csv();

@arrays =
    SELECT new SQL.ARRAY<string>(line.Split(' ').Where(word=>word.Length>1)) AS
words
    FROM @raw;

@map =
    SELECT 1 AS count,
           tmp.word.ToString().ToUpper() AS word
    FROM @arrays AS arrays
         CROSS APPLY
             EXPLODE(arrays.words) AS tmp(word);

@reduce =
    SELECT map.word,
           SUM(map.count) AS [Count]
    FROM @map AS map
    GROUP BY map.word;

OUTPUT @reduce
TO @out_file
ORDER BY [Count] DESC
USING Outputters.Tsv();
```

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U-SQL .net Extensibility

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U-SQL – .net extensibility

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- **Code-behind** (script.usql.cs) – Write Static Methods and use in the u-sql script

- **Assemblies**
  - Create dlls with processing logic
  - Upload dlls to dls
  - Register assemblies in a data lake managed database
  - Reference assembly in u-sql script and use code

Implement custom:
- Extractors
- Outputters
- Aggregators
- Appliers
- Combiners
- Processor

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U-SQL – .net extensibility | terms frequency example

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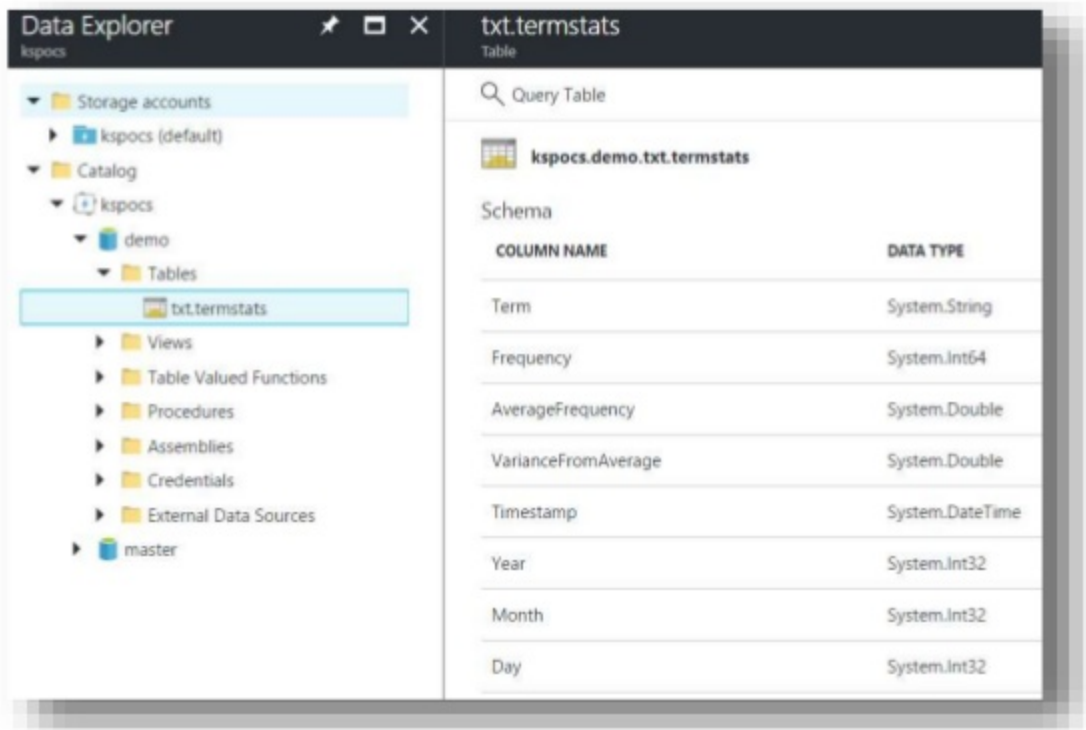
Managed Model

```
USE DATABASE master;

CREATE DATABASE IF NOT EXISTS demo;

USE DATABASE demo;

CREATE SCHEMA IF NOT EXISTS txt;

DROP TABLE IF  EXISTS txt.termstats;

CREATE TABLE txt.termstats
(
    Term string,
    Frequency long?,
    AverageFrequency double,
    VarianceFromAverage double,
    Timestamp DateTime,
    Year int,
    Month int,
    Day int,

    INDEX index_termstats CLUSTERED(Term ASC)
    PARTITIONED BY (Year,Month,Day)
    DISTRIBUTED BY HASH (Term)
);
```



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U-SQL – .net extensibility | terms frequency example

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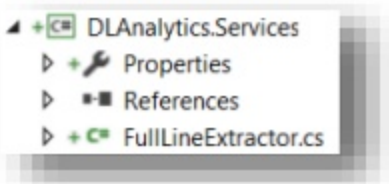
Implement Full-line Extractor




```
[SqlUserDefinedExtractor]
1 reference | 0 changes | 0 authors, 0 changes
public class FullLineExtractor : IExtractor
{
    private int _linstToSkip;
    private Encoding _encoding;
    0 references | 0 changes | 0 authors, 0 changes
    public FullLineExtractor(int linesToSkip = 0)...
    1 reference | 0 changes | 0 authors, 0 changes
    public override IEnumerable<IRow> Extract(IUnstructuredReader input, IUpdatableRow output)
    {
        string line;
        //Read the input line by line
        foreach (Stream current in input.Split(_encoding.GetBytes("\r\n")))
        {
            using (var streamReader = new StreamReader(current, this._encoding))
            {
                line = streamReader.ReadToEnd().Trim();
                output.Set<string>(0, line);
            }
            yield return output.AsReadOnly();
        }
        yield break;
    }

}
```

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U-SQL – .net extensibility | terms frequency example

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Registering Assembly

register-assemblies.usql

```
DECLARE @ASSEMBLY_PATH string = "resources/demo-libraries/";
DECLARE @DLAServices string = @ASSEMBLY_PATH+"DLAnalytics.Services.dll";

CREATE DATABASE IF NOT EXISTS demo;

USE DATABASE demo;

DROP ASSEMBLY IF EXISTS DLAServices;
CREATE ASSEMBLY DLAServices
FROM @DLAServices;
```

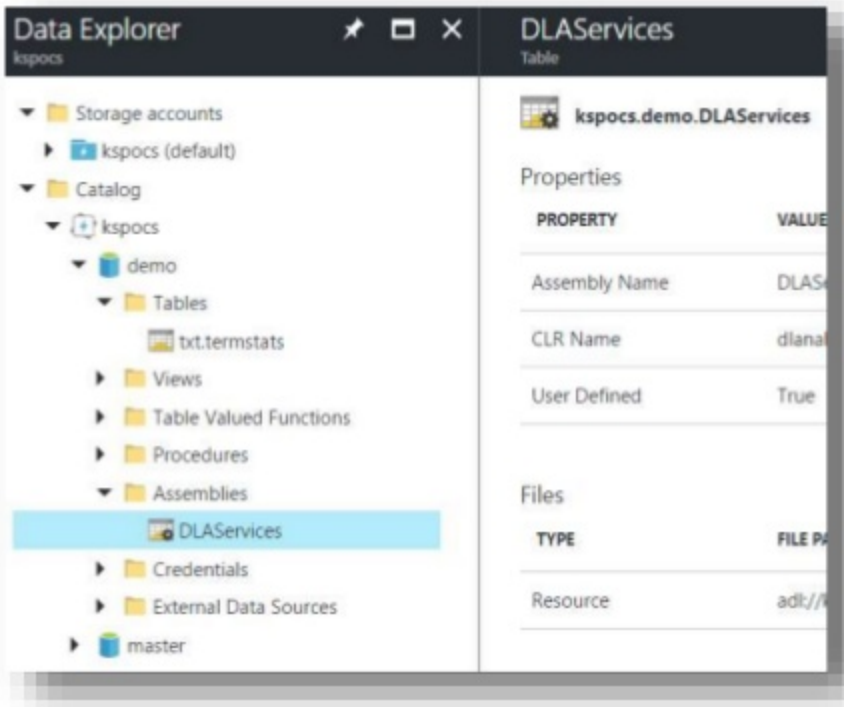
Reference, and use the Assembly

process-termstats.usql

```
USE DATABASE demo;

REFERENCE ASSEMBLY DLAServices;

USING MyServices = DLAnalytics.Services;
```



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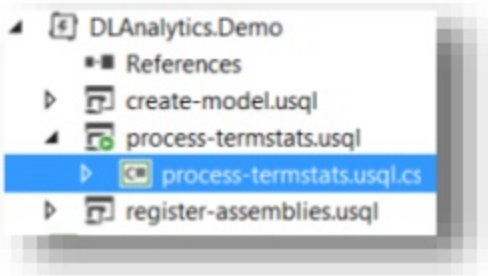
Code-behind




```
namespace DLAnalytics.Demo
{
    0 references | 0 changes | 0 authors, 0 changes
    public static class Tokenizer
    {
        private static List<string> StopWords = new List<string>(
            "a has be here an and the this on  with that to other others th

        1 reference | 0 changes | 0 authors, 0 changes
        public static string RemoveStopWords(string text)...
        0 references | 0 changes | 0 authors, 0 changes
        public static IEnumerable<string> Tokenize(int n, string text)
        {
            text = RemoveStopWords(text);

            var nGrams = new StringBuilder();
            var queue = new Queue<int>();
            int wordCount = 0;
            int lastWordLength = 0;

            if (!string.IsNullOrEmpty(text) && char.IsLetterOrDigit(text[0]
            {
                nGrams.Append(text[0]);
                lastWordLength++;
            }

            for (int charIndex = 1; charIndex < text.Length-1; charIndex++)
            {
                char before = text[charIndex - 1];
                char after = text[charIndex + 1];
```

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Azure Data Lake Analytics

U-SQL – .net extensibility | term frequency example

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process-termstats.usql

```
DECLARE @input_file string = "demo-data/doc1.txt";

USE DATABASE demo;

REFERENCE ASSEMBLY DLAServices;
USING MyServices = DLAnalytics.Services;

@raw =
    EXTRACT line string
    FROM @input_file
    USING new MyServices.FullLineExtractor();

@arrays =
    SELECT new
SQL.ARRAY<string>(DLAnalytics.Demo.Tokenizer.Tokenize(2,line))
AS terms  FROM @raw;

@map =
    SELECT 1 AS frequency, tmp.term.ToUpper() AS term
    FROM @arrays AS arrays
         CROSS APPLY
             EXPLODE(arrays.terms) AS tmp(term);
@reduce =
    SELECT map.term,
           SUM(map.frequency) AS frequency
    FROM @map AS map
    GROUP BY map.term
   HAVING SUM(map.frequency) >= 3;

@aggregates =
    SELECT Convert.ToDouble(AVG(frequency)) AS averageFrequency
    FROM @reduce;

@output =
    SELECT term,
           frequency,
           averageFrequency,
           Convert.ToDouble(frequency - averageFrequency) AS
varianceFromAverage,
           DateTime.Now AS timestamp
    FROM @reduce  CROSS JOIN  @aggregates;

DECLARE @Year int = DateTime.Now.Year;
DECLARE @Month int = DateTime.Now.Month;
DECLARE @Day int = DateTime.Now.Day;

ALTER TABLE txt.termstats
ADD IF NOT EXISTS PARTITION(@Year, @Month, @Day);

INSERT INTO txt.termstats
(Term, Frequency, AverageFrequency, VarianceFromAverage, Timestam )
PARTITION
(   @Year,
    @Month,
    @Day
)
SELECT *
FROM @output;
```


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Running U-SQL Jobs on Azure

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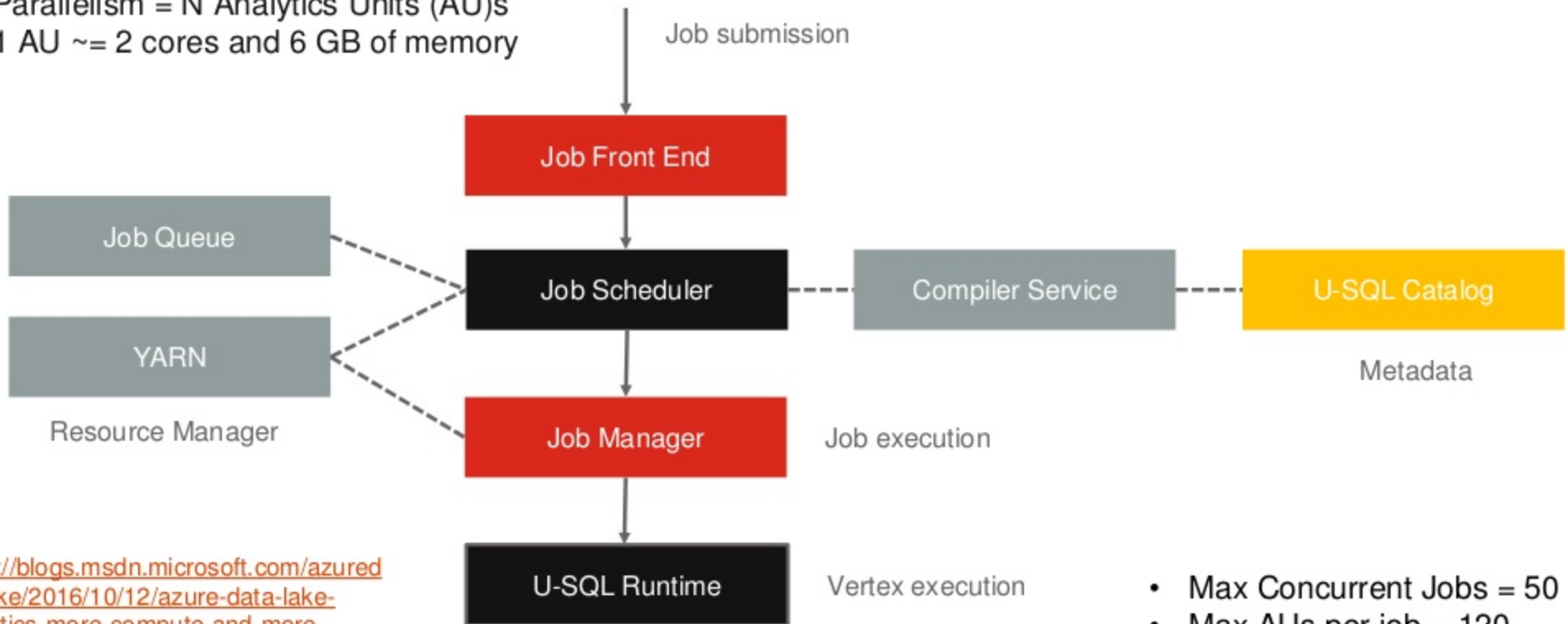
Azure U-SQL Jobs

Simplified Workflow

- Parallelism = N Analytics Units (AU)s
- 1 AU ~= 2 cores and 6 GB of memory



https://blogs.msdn.microsoft.com/azuredatalake/2016/10/12/azure-data-lake-analytics-more-compute-and-more-control

- Max Concurrent Jobs = 50
- Max AUs per job = 120
- Max Queue Length = 200

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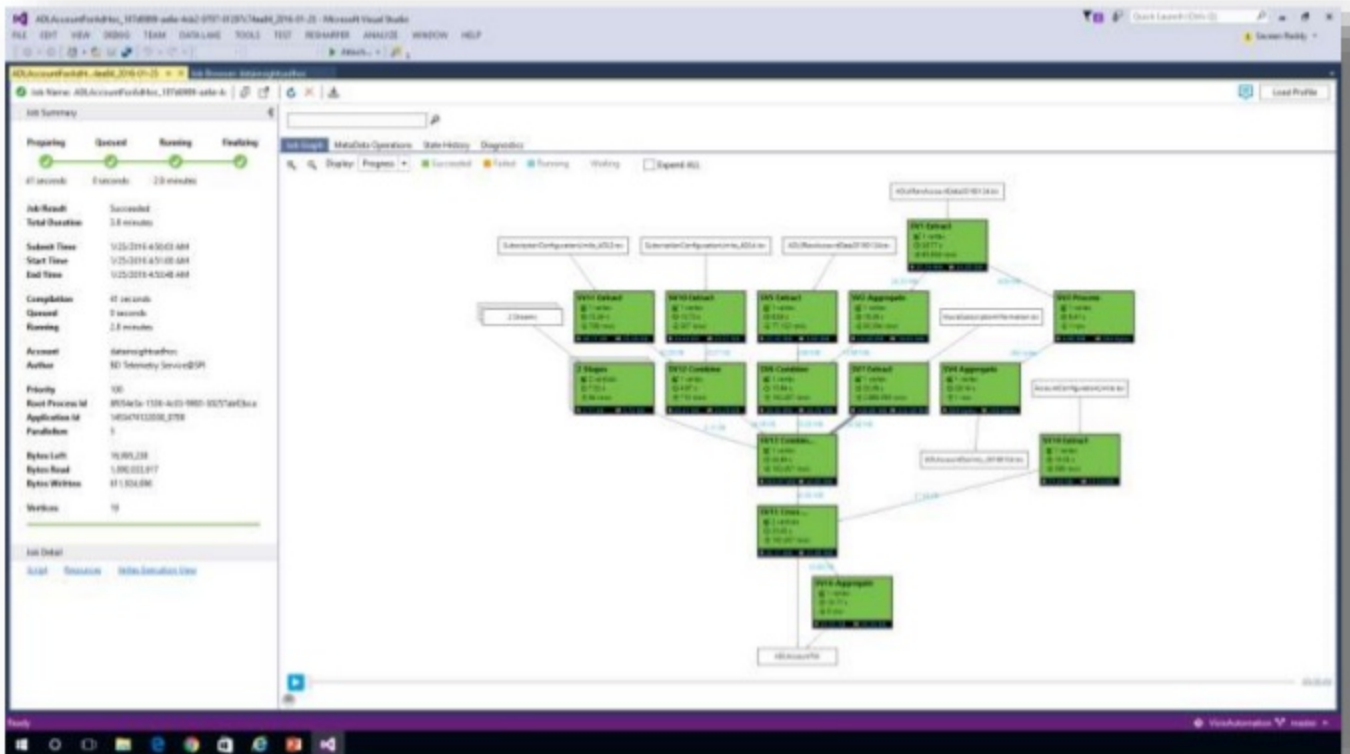
Azure U-SQL Jobs

Monitoring Jobs running on Azure



Job Summary

Preparing	Queued	Running	Finalizing
37 seconds	0 seconds	9.9 minutes	

Job Result	Succeeded
Total Duration	10.8 minutes
Submit Time	1/24/2016 10:14:52 AM
Start Time	1/24/2016 10:15:48 AM
End Time	1/24/2016 10:25:42 AM
Compilation	37 seconds
Queued	0 seconds
Running	9.9 minutes
Account	datainsightsadhoc
Author	BD Telemetry Service@SPI

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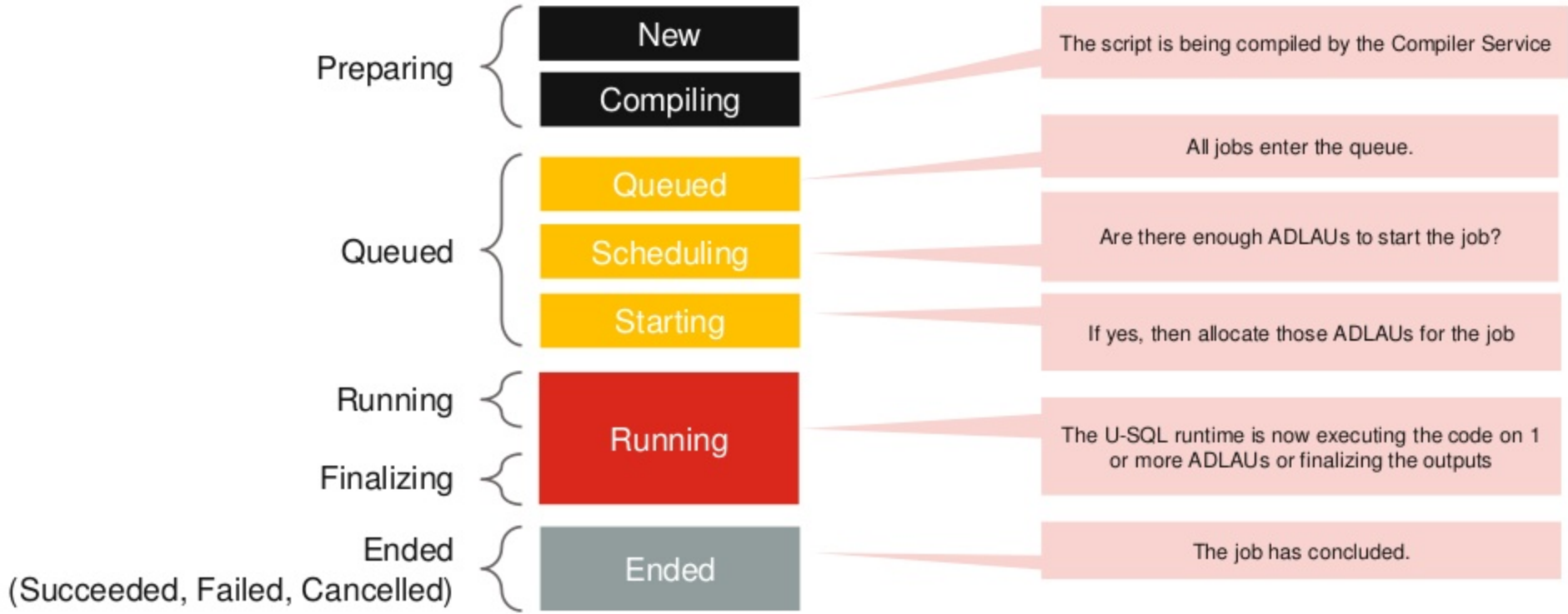
Azure U-SQL Jobs

Job Status



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Azure U-SQL Jobs

Monitoring Jobs running on Azure

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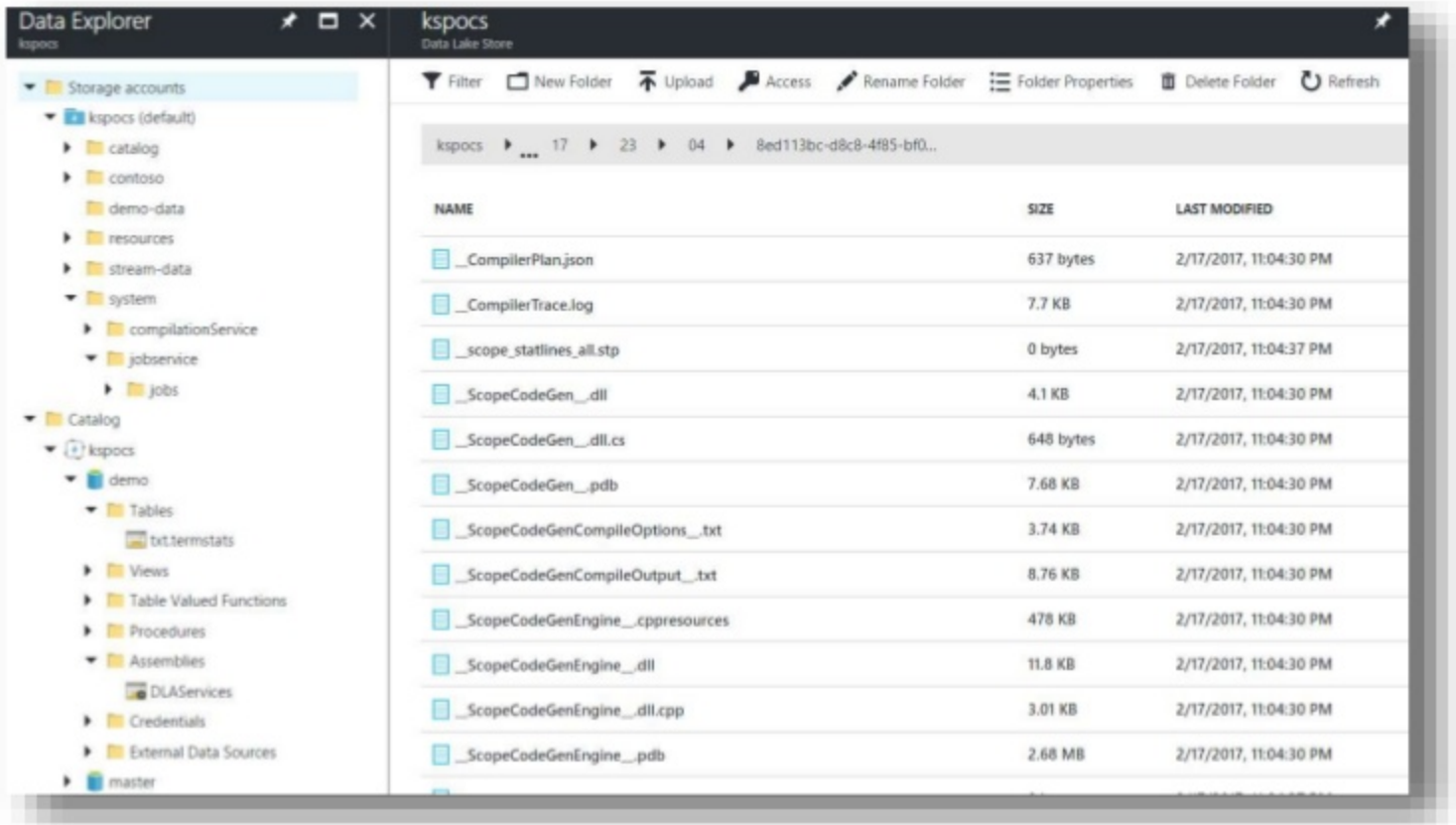
Job files: system/jobservice/jobs/yyyy/MM/dd/jobid/..



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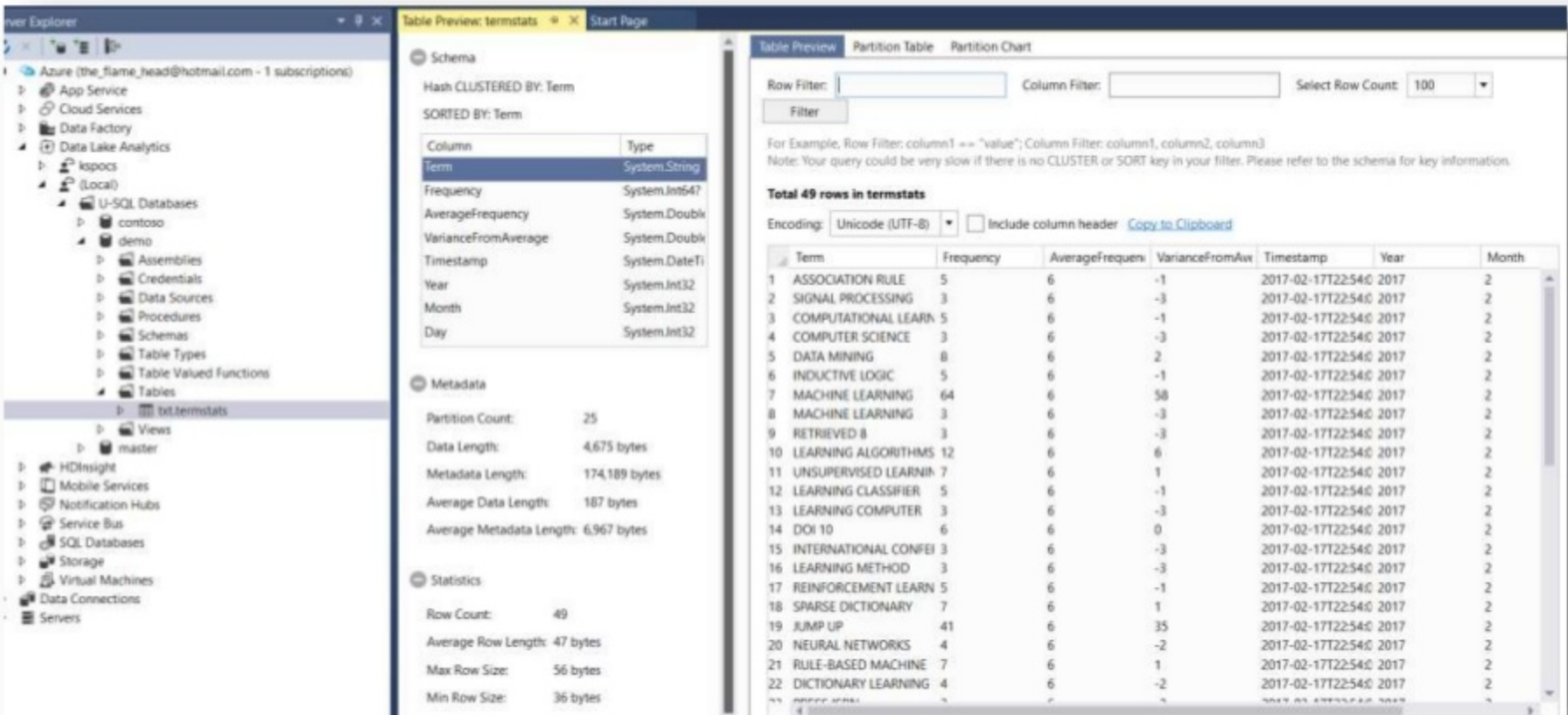
Azure U-SQL Jobs

Monitoring Jobs running on Azure



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Azure U-SQL Jobs

Running U-SQL Jobs Using Azure Data Factory

```
{
    "name": "pipeline-dla-test",
    "properties": {
       "activities":
        [
            {
                "type": "DataLakeAnalyticsU-SQL",
                "typeProperties": {
                    "scriptPath": “pipelines\\test\\process-data.usql",
                    "scriptLinkedService": "StorageLinkedService",
                    "degreeOfParallelism": 3,
                    "priority": 100,
                    "parameters": {
                        "in": "/datalake/input/data-input.tsv",
                        "out": "/datalake/output/data-output.tsv"
                    }
                },
```

Parameters can be passed to the U-SQL Script to be executed

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My Background

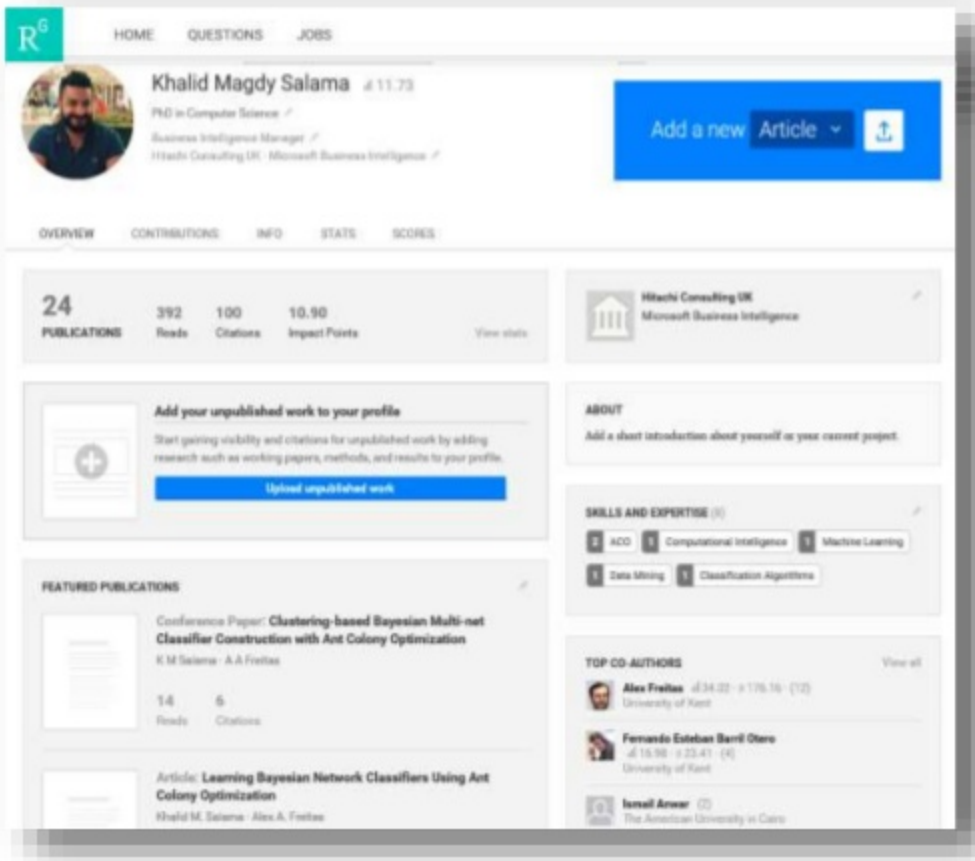
Applying Computational Intelligence in Data Mining

- Honorary Research Fellow, School of Computing , University of Kent.
- Ph.D. Computer Science, University of Kent, Canterbury, UK.
- M.Sc. Computer Science , The American University in Cairo, Egypt.

- 25+ published journal and conference papers, focusing on:
  - *classification rules induction,*
  - *decision trees construction,*
  - *Bayesian classification modelling,*
  - *data reduction,*
  - *instance-based learning,*
  - *evolving neural networks*, and
  - *data clustering*

- **Journals**: *Swarm Intelligence, Swarm & Evolutionary Computation, , Applied Soft Computing, and Memetic Computing.*

- **Conferences**: *ANTS, IEEE CEC, IEEE SIS, EvoBio, ECTA, IEEE WCCI and INNS-BigData.*



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Thank you!

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