Architect's Open-Source Guide for a Data Mesh Architecture

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Azure Engineering

- ✓ Architecture
- ✓ Cloud
- ✓ Data
- ✓ ML/AI

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Entry Point

How to Move Beyond a Monolithic Data Lake to a Distributed Data Mesh
https://martinfowler.com/articles/data-monolith-to-mesh.html

Data Mesh Principles and Logical Architecture

https://martinfowler.com/articles/data-mesh-principles.html

Slack for Data-Mesh-Learning
https://launchpass.com/data-mesh-learning

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Talk Snapshot

- What is Data Mesh
- When is Data Mesh a Good Idea
- Core Principles and Concepts
- Example: Drone Delivery Service
- Challenges
- OSS and Open Standards

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When and Why Data Mesh

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Data Mesh is Not For Everyone

Challenges Indicating Data Mesh May Be Considered

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Drone Delivery Service

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WHYs

- Ambiguity in Ownership and Responsibility
- Slow Change due to Coupling to Monolithic System
- Data Engineering Resources Bottleneck

Ideas Composing Data Mesh Concept

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Core Ideas

✓ Decentralized teams and data ownership

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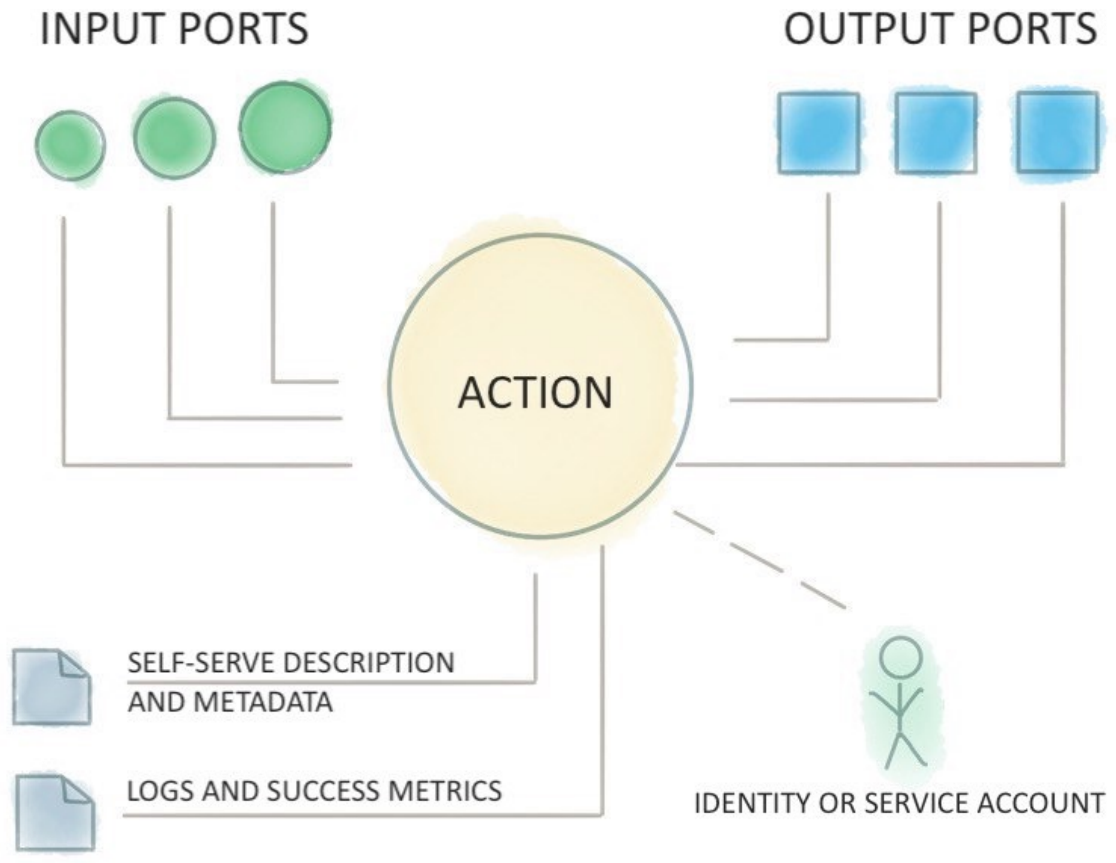
Core Ideas

- ✓ Decentralized teams and data ownership
- ✓ Data Products powered by Domain Driven Design

High-Level View of a Data Product


INPUT PORTS
OUTPUT PORTS
ACTION
SELF-SERVE DESCRIPTION AND METADATA
LOGS AND SUCCESS METRICS
IDENTITY OR SERVICE ACCOUNT

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Core Ideas

- ✓ Decentralized teams and data ownership
- ✓ Data Products powered by Domain Driven Design
- ✓ Self-serve Shared Data Infrastructure

Core Ideas

- ✓ Decentralized teams and data ownership
- ✓ Data Products powered by Domain Driven Design
- ✓ Self-serve Shared Data Infrastructure
- ✓ Global Federated Governance

Drone Delivery Service Data Products

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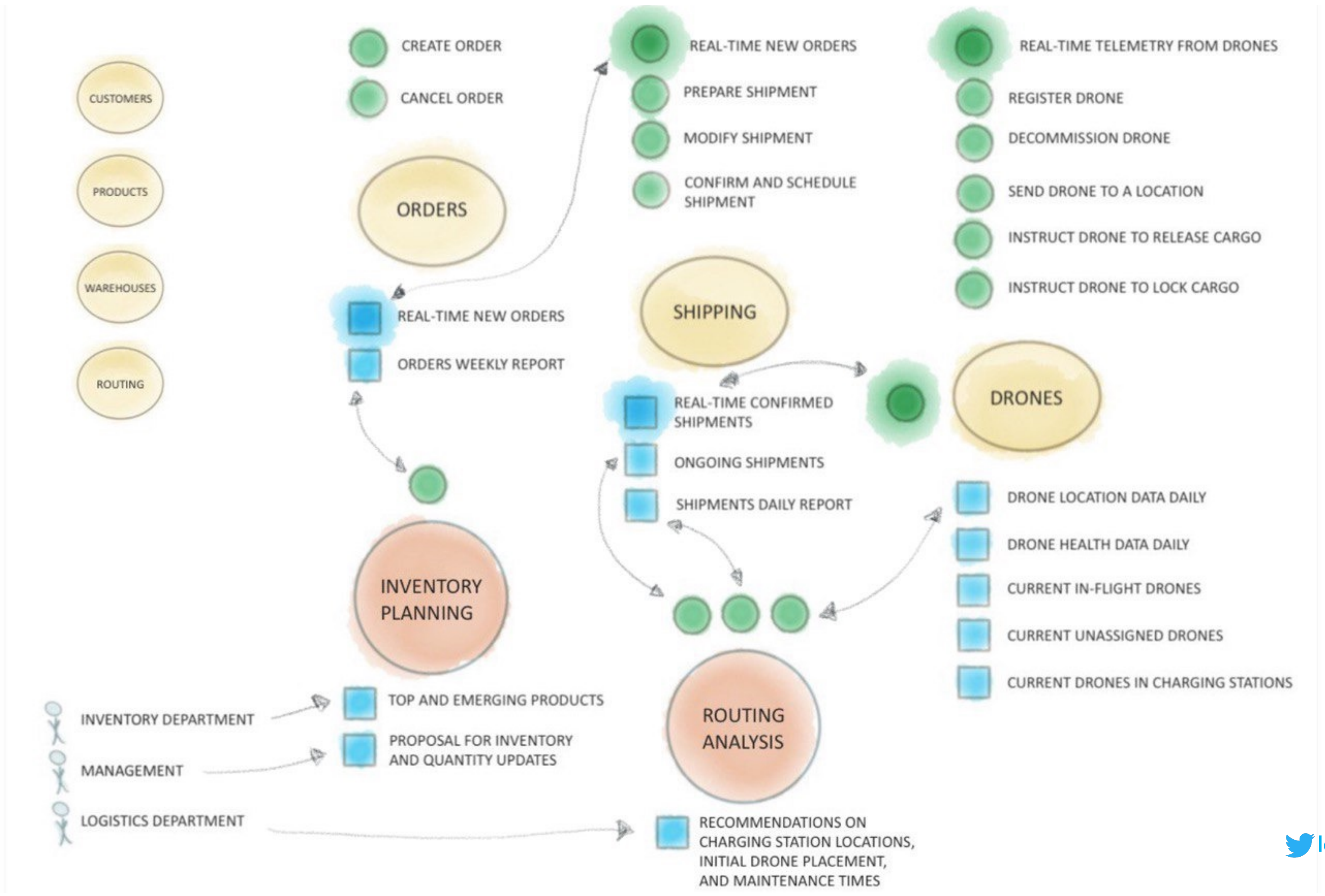
CUSTOMERS
PRODUCTS
WAREHOUSES
ROUTING
CREATE ORDER
CANCEL ORDER
ORDERS
REAL-TIME NEW ORDERS
ORDERS WEEKLY REPORT
INVENTORY PLANNING
REAL-TIME NEW ORDERS
PREPARE SHIPMENT
MODIFY SHIPMENT
CONFIRM AND SCHEDULE SHIPMENT
SHIPPING
REAL-TIME CONFIRMED SHIPMENTS
ONGOING SHIPMENTS
SHIPMENTS DAILY REPORT
REAL-TIME TELEMETRY FROM DRONES
REGISTER DRONE
DECOMMISSION DRONE
SEND DRONE TO A LOCATION
INSTRUCT DRONE TO RELEASE CARGO
INSTRUCT DRONE TO LOCK CARGO
DRONES
DRONE LOCATION DATA DAILY
DRONE HEALTH DATA DAILY
CURRENT IN-FLIGHT DRONES
CURRENT UNASSIGNED DRONES
CURRENT DRONES IN CHARGING STATIONS
ROUTING ANALYSIS
INVENTORY DEPARTMENT
MANAGEMENT
LOGISTICS DEPARTMENT
TOP AND EMERGING PRODUCTS
PROPOSAL FOR INVENTORY AND QUANTITY UPDATES
RECOMMENDATIONS ON CHARGING STATION LOCATIONS, INITIAL DRONE PLACEMENT, AND MAINTENANCE TIMES

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Core Principles for Data Products

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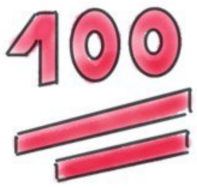
Core Principles for Data Products

DISCOVERABLE

Core Principles for Data Products

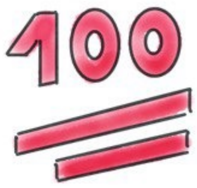
DISCOVERABLE



SELF-DESCRIBING

Core Principles for Data Products

DISCOVERABLE



SELF-DESCRIBING

ADDRESSABLE

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Core Principles for Data Products

DISCOVERABLE

SELF-DESCRIBING

ADDRESSABLE

SECURE

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Core Principles for Data Products

- DISCOVERABLE
- SELF-DESCRIBING
- ADDRESSABLE
- SECURE
- TRUSTWORTHY

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Core Principles for Data Products

DISCOVERABLE

SELF-DESCRIBING

ADDRESSABLE

SECURE

TRUSTWORTHY

INTEROPERABLE

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Cheat Sheet for Planning Data Products

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Input Ports Questions

- Data Source - Where is the data coming from? External dataset or another data product?
- Data Format - What is the format of the source input?
- Rate of Updates - How frequently does the input need to be updated?

Output Ports Questions

- End-consumers - Who are the end-users of the data product?
- Data purpose - What are they planning to do with the data outputs?
- Data access - Who needs to have access? How do they prefer to access the data output?
- Data address - How do they prefer to access the data output?
- Data Format - What format of the data do they expect?

Identity and Permission Policies Questions

- Which resources can this data product be allowed to access?
- Which data products or users can read which output ports of this data product?
- Are all sensitive resources this data product offers protected according their required privacy standards (e.g. HIPAA, GDPR, PII, CCPA, etc.)
- Is the permissions policy stored and managed in the same package as the data product?

Data Product Action Questions

- What is the action that needs to happen to produce the outcomes for the end-users?
- What are the required adjustments, transformations, filters, updates, or quality improvements to the input data?

Operational Questions

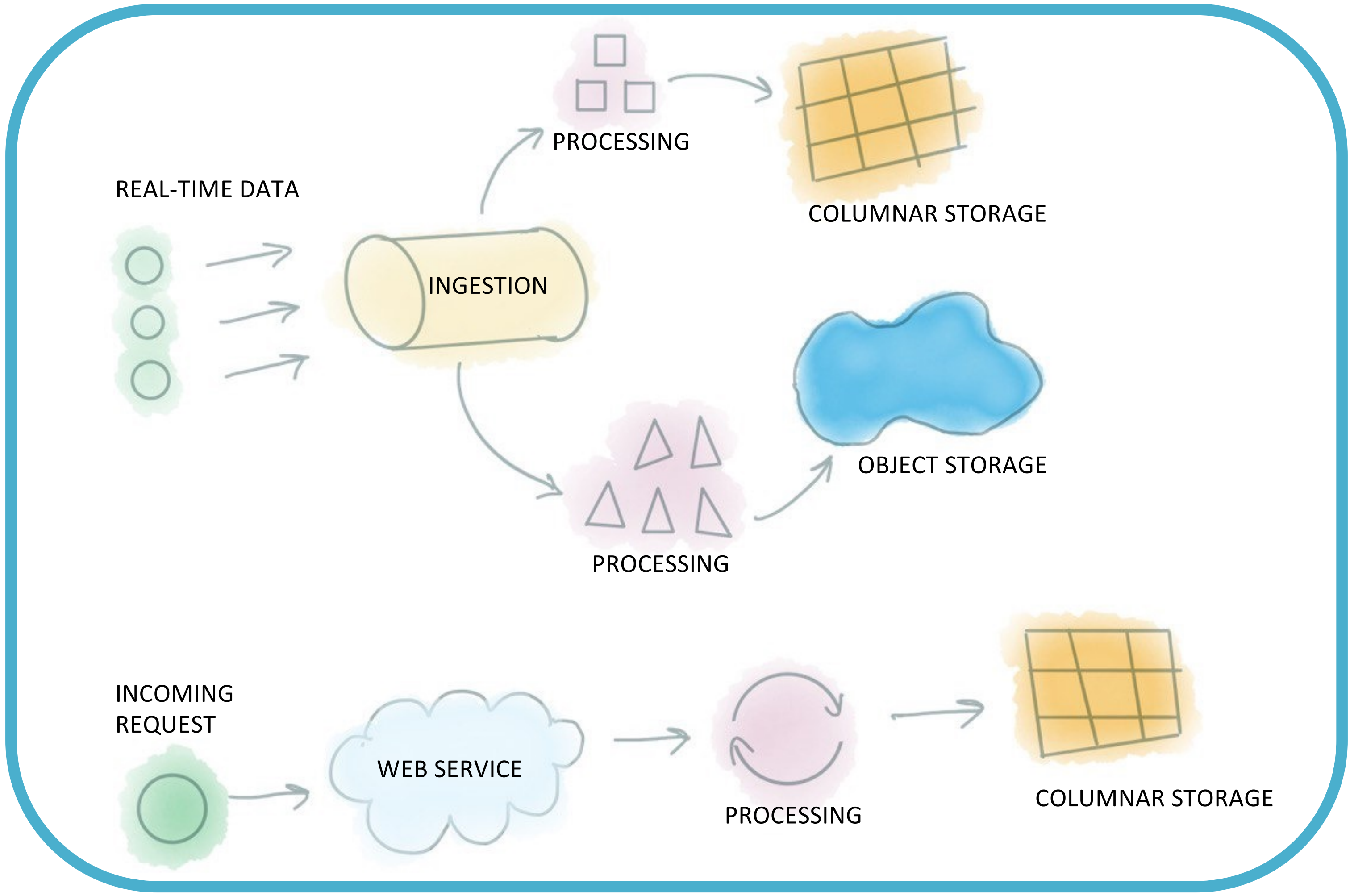
- How can this data product be discovered and how should it be described to other data products that might want to consume it?
- Which metadata and information should it make available to the end-users?
- Where and how should data product versioning be managed during updates to ensure consistency with how the end-users consume it?
- Which SLAs or SLOs does the data product provide?
- Which product success metrics can this data product expose and keep track of? (adoption, usage, quality)
- Is the automation/resource orchestration logic stored in the same package?

Other Questions

- Is this product not tightly coupled to any other data source, data product, or any other resource that makes him not interoperable?
- Does this data product follow the defined global governance standards and practices defined by the organization?
- Does this data product have any implementation details that could interfere with its portability?

Self-Serve Shared Infrastructure

Types of Workloads Within a Data Product



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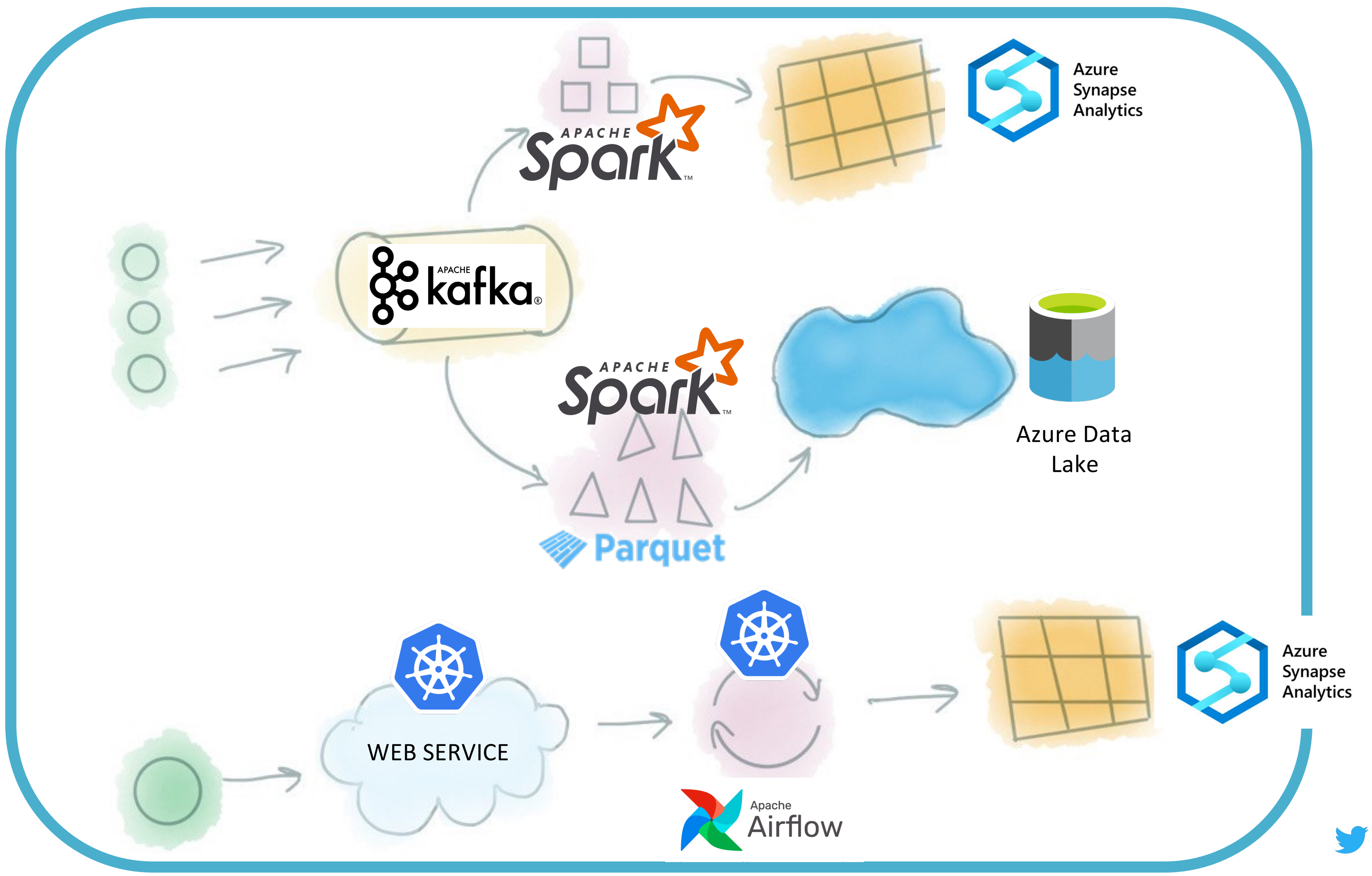
It can look like this



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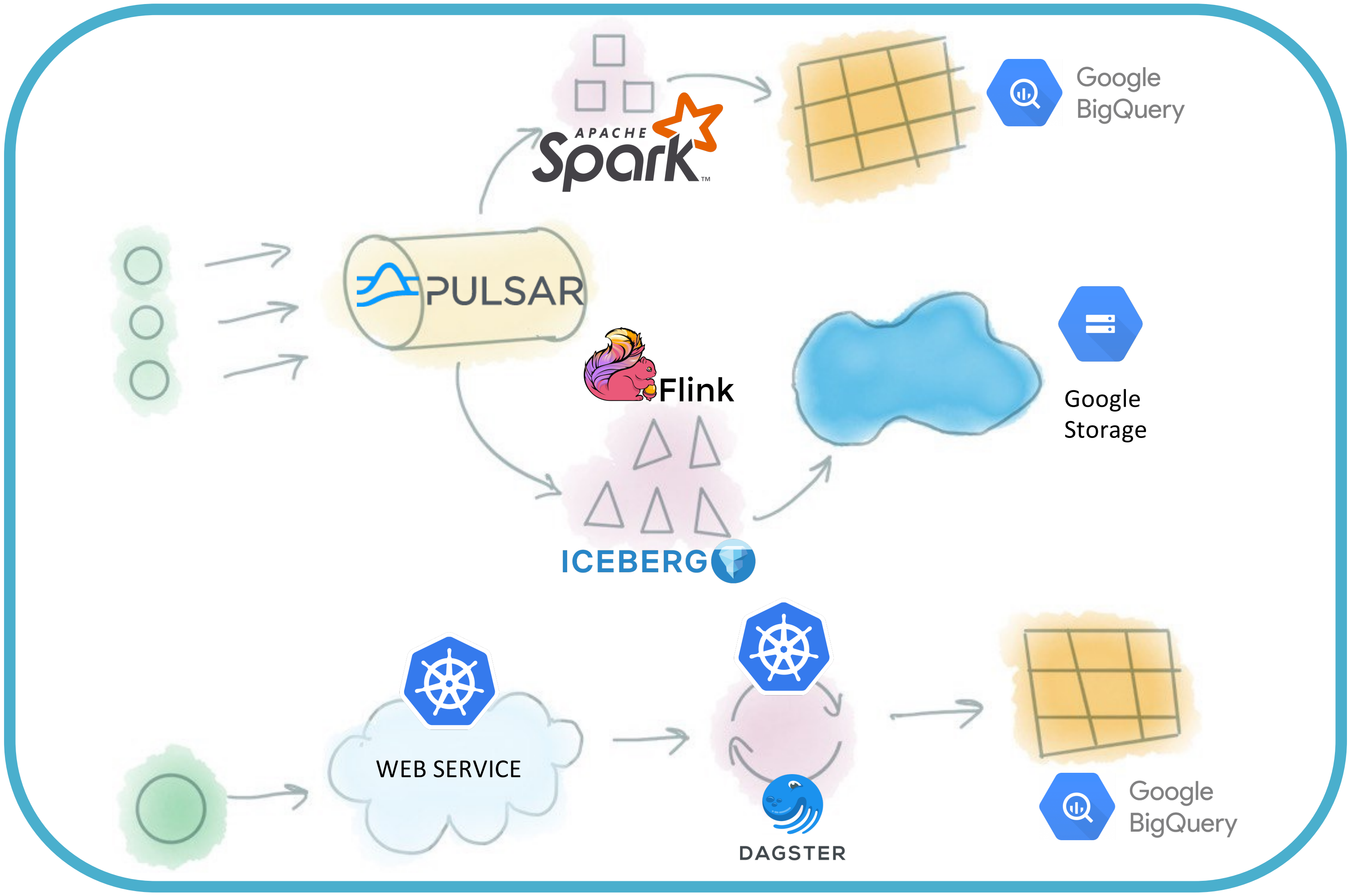
Or, it can look like this



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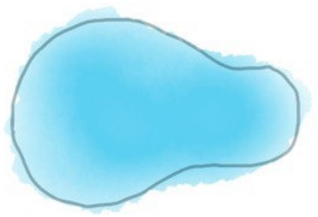
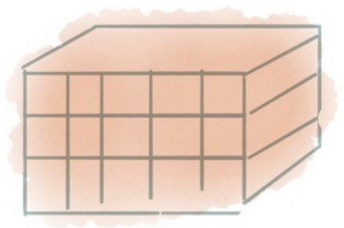
Self-Serve Shared Infrastructure

SHARED PLATFORM FOR
STREAMING INGESTION

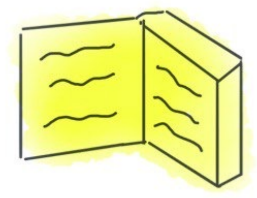
SHARED PLATFORM FOR
RAW DATA STORAGE



SHARED PLATFORM FOR
COLUMNAR DATA STORAGE



DATA CATALOGUE



SHARED PLATFORM FOR
CONTAINER WORKLOADS

SHARED PLATFORM FOR
CONTINUOUS DELIVERY

SHARED PLATFORM
FOR OBSERVABILITY

AND MORE…

DEPENDING ON THE ORGANIZATION

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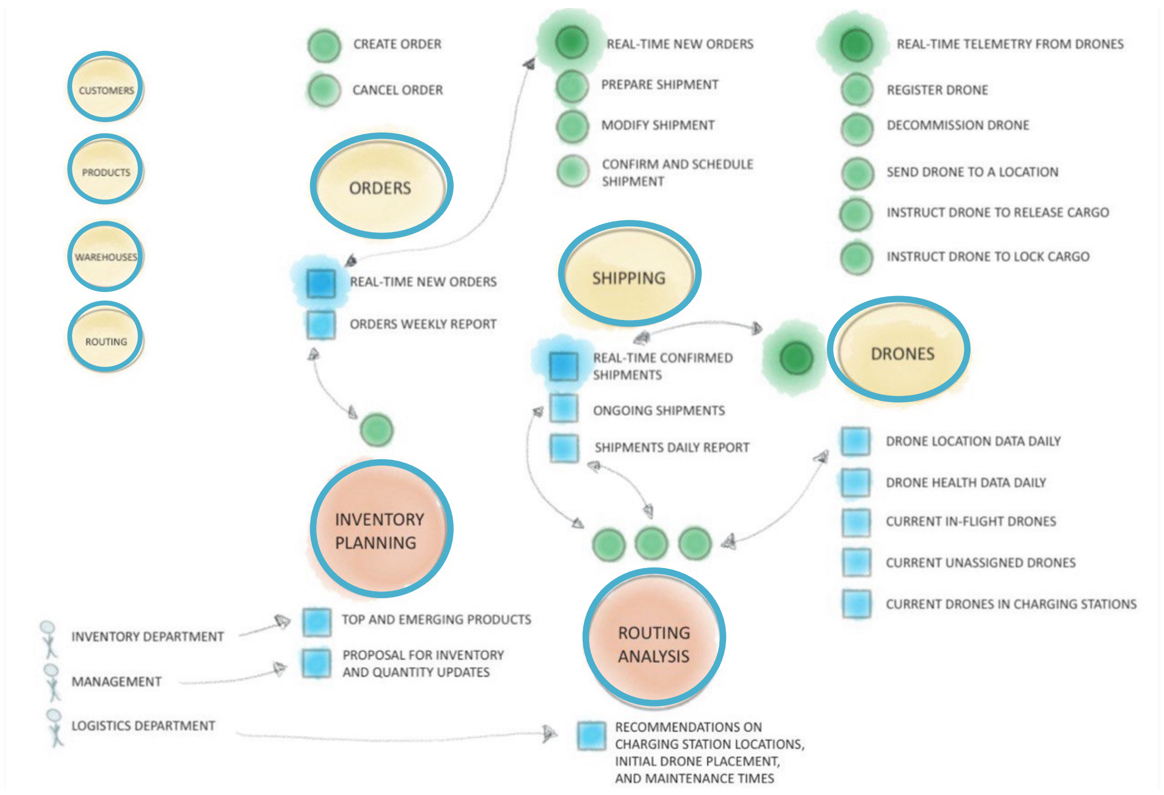
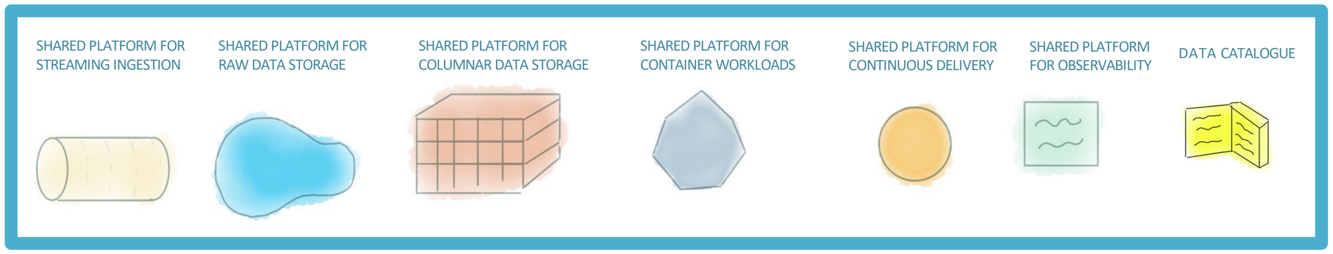
Data Mesh

- DISCOVERABLE
- SELF-DESCRIBING
- ADDRESSABLE
- SECURE
- TRUSTWORTHY
- INTEROPERABLE





SHARED PLATFORM FOR STREAMING INGESTION
SHARED PLATFORM FOR RAW DATA STORAGE
SHARED PLATFORM FOR COLUMNAR DATA STORAGE
SHARED PLATFORM FOR CONTAINER WORKLOADS
SHARED PLATFORM FOR CONTINUOUS DELIVERY
SHARED PLATFORM FOR OBSERVABILITY
DATA CATALOGUE

Wait, What About the OSS Tools for Data Mesh??

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Challenges with Data Mesh

Challenges

- Cost questions
- Lack of end-to-end examples
- Efforts to shift from centralized architecture to decentralization-friendly techniques
- Automation required for enabling creating data products
- Underestimating the importance organizational aspects

Considerations for Technology Choices

Considerations for Technology Choices

- Workload sharing and multi-tenancy
- No-copy data and compute mobility support
- Granularity of access-control
- Richness of automation and extensibility capabilities
- Flexibility and elasticity
- Provider-agnostic/multi-cloud operations support
- Variety of limitations
  (quotas, data volume, resource count, etc.)

- **Open Standards, Open Protocols, Open-Source Integrations**

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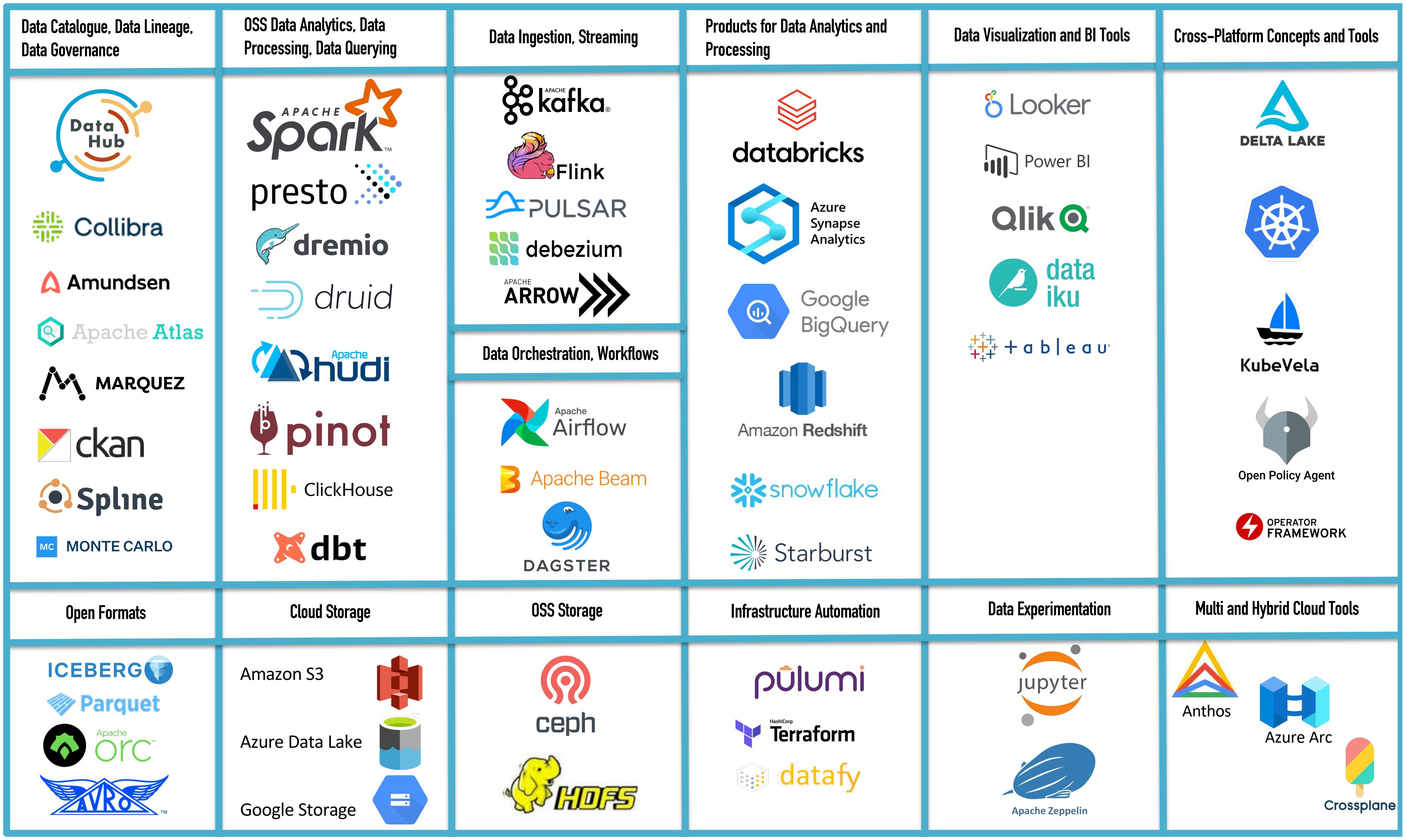
Examples of Data Mesh-friendly Technologies



Data Catalogue, Data Lineage, Data Governance
- Data Hub
- Collibra
- Amundsen
- Apache Atlas
- MARQUEZ
- ckan
- Spline
- MONTE CARLO

OSS Data Analytics, Data Processing, Data Querying
- Apache Spark
- presto
- dremio
- druid
- Apache hudi
- pinot
- ClickHouse
- dbt

Data Ingestion, Streaming
- Apache kafka
- Flink
- PULSAR
- debezium
- Apache ARROW

Data Orchestration, Workflows
- Apache Airflow
- Apache Beam
- DAGSTER

Products for Data Analytics and Processing
- databricks
- Azure Synapse Analytics
- Google BigQuery
- Amazon Redshift
- snowflake
- Starburst

Data Visualization and BI Tools
- Looker
- Power BI
- Qlik
- dataiku
- tableau

Cross-Platform Concepts and Tools
- DELTA LAKE
- KubeVela
- Open Policy Agent
- OPERATOR FRAMEWORK

Open Formats
- ICEBERG
- Parquet
- Apache orc
- AVRO

Cloud Storage
- Amazon S3
- Azure Data Lake
- Google Storage

OSS Storage
- ceph
- HDFS

Infrastructure Automation
- pulumi
- HashiCorp Terraform
- datafy

Data Experimentation
- jupyter
- Apache Zeppelin

Multi and Hybrid Cloud Tools
- Anthos
- Azure Arc
- Crossplane

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Data Governance Systems

- Metadata
- Data lineage
- Data schemas
- Data relationships
- Data classification
- Data security
- Data catalog

Data Hub

Collibra

Amundsen

Apache Atlas

MARQUEZ

ckan

Spline

MC MONTE CARLO

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Open Formats

- Open standard
- Atomic updates, serializable isolation, transactions
- Concurrent operations
- Versioning, rollbacks, time-travel
- Schema Evolution
- Scale, Efficiency, Data Volumes
- Compatibility with existing data stores and languages

ICEBERG
Parquet
AVRO™
Apache orc™

Data Platforms (Cloud or OSS)

- Separation of storage and compute
- Support for no-copy data sharing
- Bringing compute to data
- Fine-tuned granularity of permissions for access
- Support for automation and resource management
- Open standards and interoperability with other platforms and tools for governance, visualization, analytics, etc.

databricks
APACHE Spark
Azure Synapse Analytics
presto
dremio
Google BigQuery
druid
Apache hudi
Amazon Redshift
pinot
snowflake
ClickHouse
Starburst
dbt

Multi-Cloud Infrastructure Management

- Terraform

  Open-source infrastructure as code software tool that enables you to safely and predictably create, change, and improve infrastructure.

- Pulumi

  Open-source infrastructure as code SDK that enables you to create, deploy, and manage infrastructure on any cloud, using your favorite languages.

- Crossplane

  Assemble infrastructure from multiple vendors, and expose higher level self-service APIs for application teams to consume, without having to write any code.

Multi-Cloud Workload Portability

- Azure Arc

  Build cloud-native apps anywhere, at scale. Run Azure services in any Kubernetes environment, whether it’s on-premises, multi-cloud, or at the edge

- Google Athnos

  A modern application management platform that provides a consistent development and operations experience for **cloud** and on-premises environments

Kubernetes Open-Standard Technologies

NOT AN EXHAUSTIVE LIST

- Open Application Model
  An open standard for defining cloud native apps.
  KubeVella - https://kubevela.io/docs/concepts
- Open Policy Agent
  Declarative Policy-as-Code, enables portability, combination with Infra-as-Code.
  https://www.openpolicyagent.org/docs/latest
- Service Catalog
  Provision managed services and make them available within a Kubernetes cluster.
  https://kubernetes.io/docs/concepts/extend-kubernetes/service-catalog/

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Benefits Brought by Data Mesh

- Data Quality
- Tailored resource and focus allocation
- Organizational cohesion while allowing flexibility
- Reducing complexity
- Democratizing creating value
- Better understanding of value and innovation opportunities
- Empowering a more consistent and fast change

Important Focus Areas for Technology Providers

- **Open Standards, Open Protocols, Open-Source Integrations**
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(quotas, data volume, resource count, etc.)

Data Mesh will drive better Interoperability, Open Standards, and Data Quality in the Industry

Thank you!

Follow lenadroid for more insights