Recap

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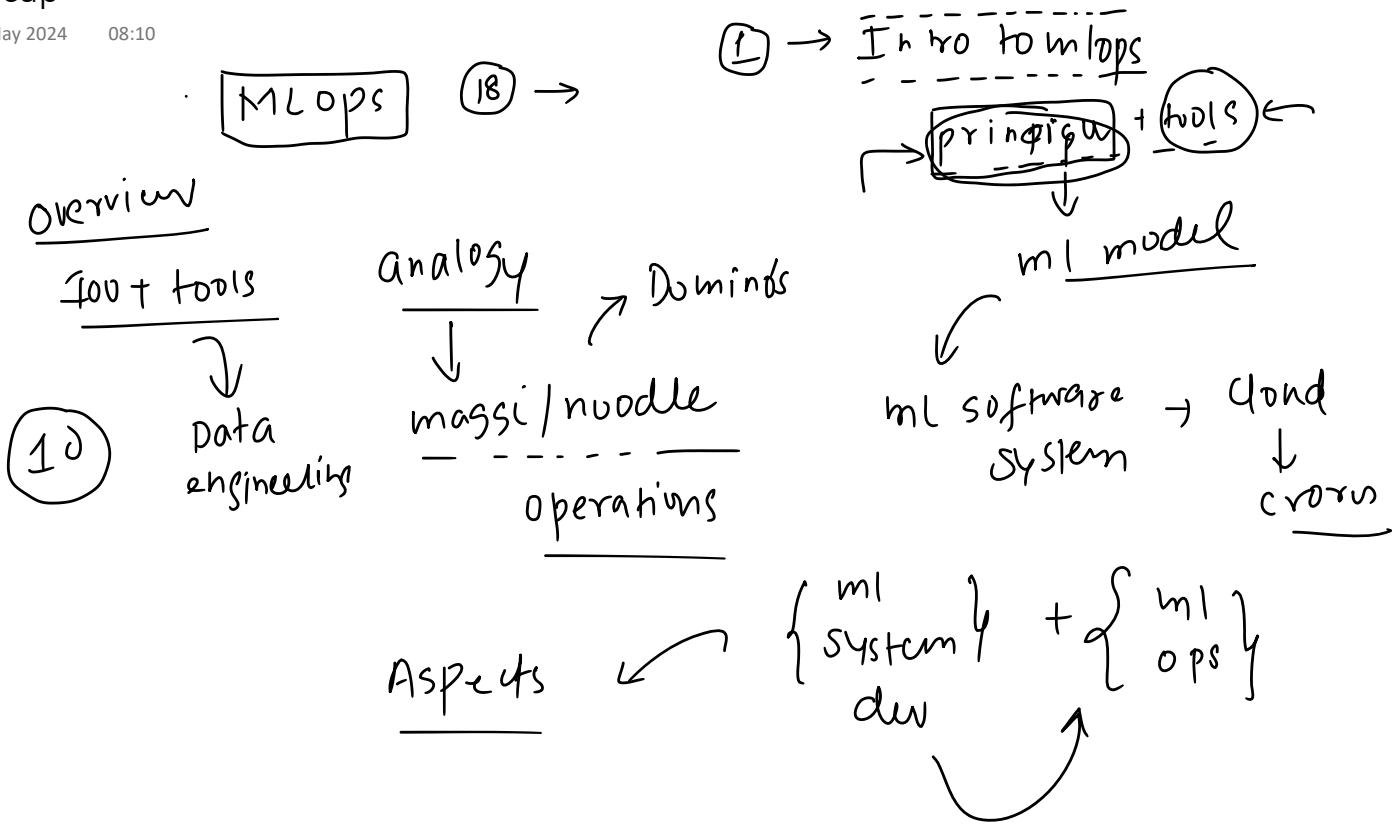

Core Aspects [Revision]

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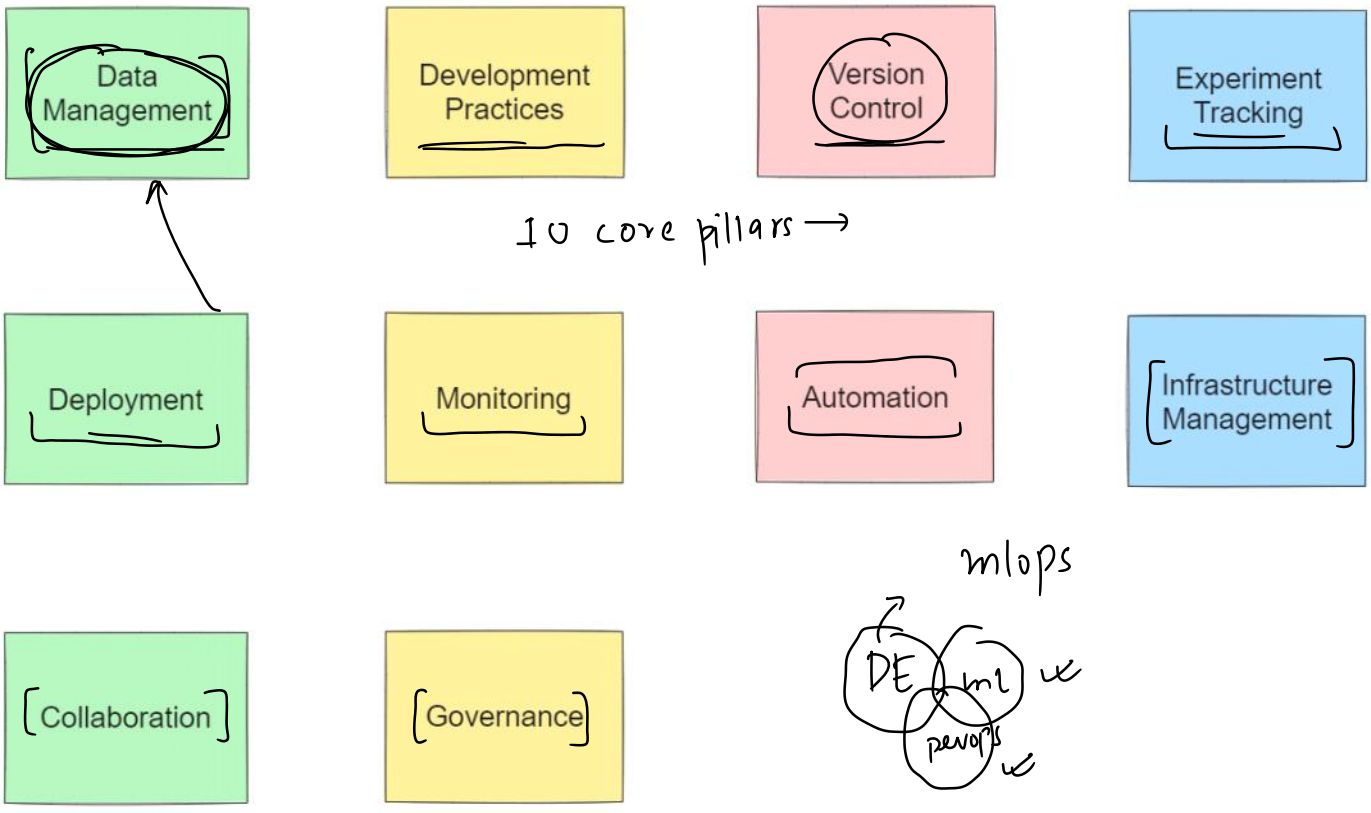

Benefits of MLOps

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1. Scalability
2. Improved performance
3. Reproducibility
4. Collaboration and efficiency
5. Risk reduction
6. Cost Savings
7. Faster time to market
8. Better compliance and governance

Swiggy

1. Data Management
2. Development Practices
3. Version Control
4. Experiment Tracking/Model Registry
5. Model Serving and CI/CD
6. Automation
7. Monitoring and Retraining
8. Infrastructure Management
9. Collaboration and Operations
10. Governance and Ethics

Challenges

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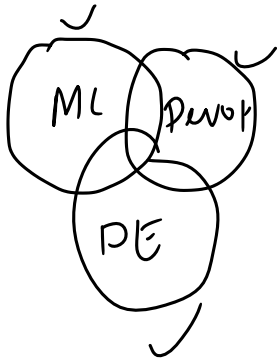
1. Complexity of ml models [variability, black box nature]
2. Multitude of models
3. Quality of data
4. Cost and resource constraints
5. Handling scale
6. Security risks
7. Compliance and regulatory concerns
8. Integration with existing systems
9. Limited Expertise/Skill gap



Prerequisites

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1. Basic understanding of ML
    a. Cleaning and preprocessing
    b. Feature engineering
    c. Model building
2. Software development skills
    a. Python
    b. Git
    c. Software development best practices [OOP, Design Patterns]
    d. Linux
3. Data Engineering
    a. SQL
    b. Big Data Tech [Spark, Kafka]
    c. Data Storage Solutions [Databases, Data Warehouses, Data lakes]
4. DevOps Principles and Tools
    a. CI/CD Pipeline
    b. Automation
5. Familiarity with cloud platforms
    a. AWS, GCP and Azure
6. Containerization technologies
    a. Docker
    b. Kubernetes
7. Networking Principles
    a. Distributed computing
8. Security Fundamentals
    a. Cybersecurity fundamentals
9. Soft Skills

MLOps Tools Stack

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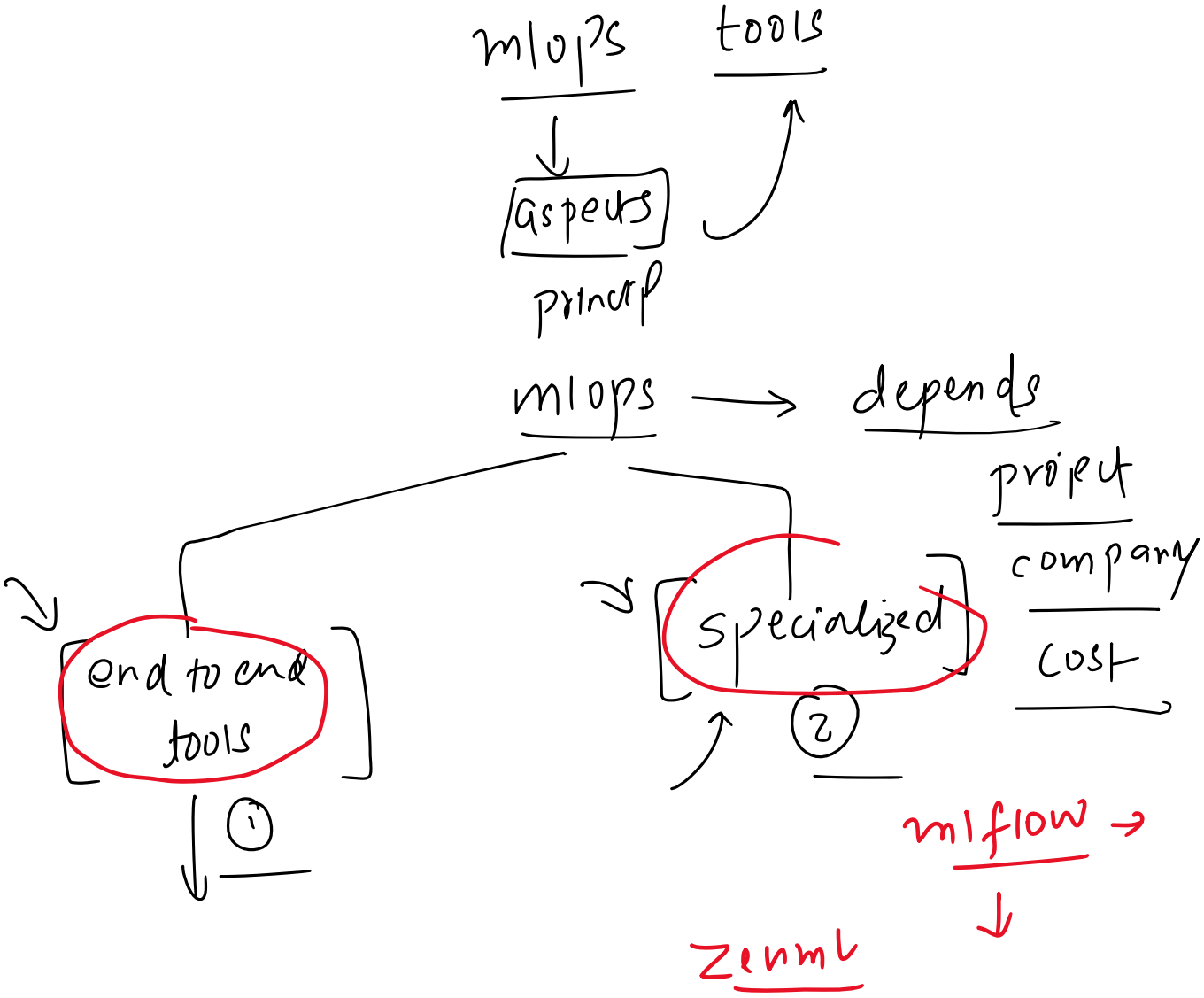
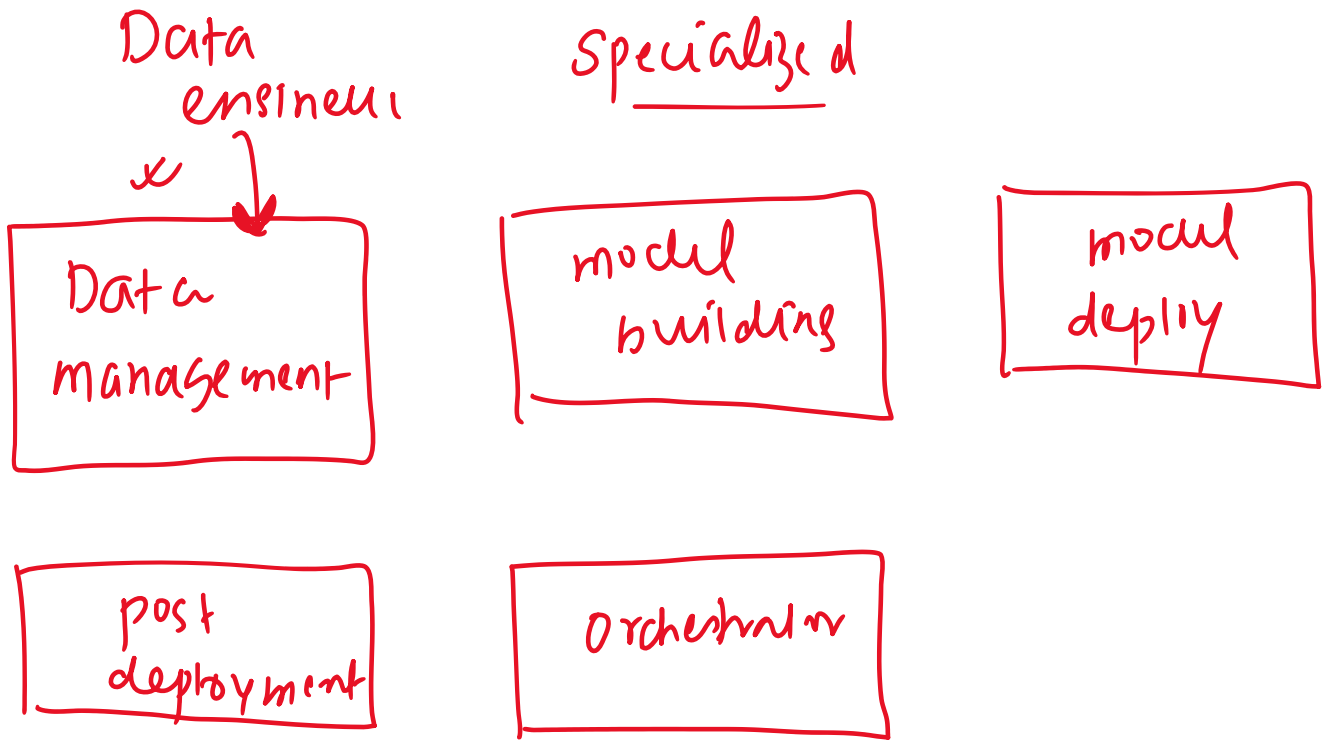
full stack web dev
↳ backend + frontend

An MLOps tool stack refers to the set of tools and technologies used together to facilitate the practice of Machine Learning Operations (MLOps). This involves managing the lifecycle of machine learning models from development through deployment and maintenance, incorporating principles from DevOps in the machine learning context. The goal of an MLOps tool stack is to streamline the process of turning data into actionable insights and models into reliable, scalable, and maintainable production systems.



Data Specialized


Data engineer
Specialized
Data management
model building
model deploy
post deployment
Orchestrator

1. End to End MLOps Platforms

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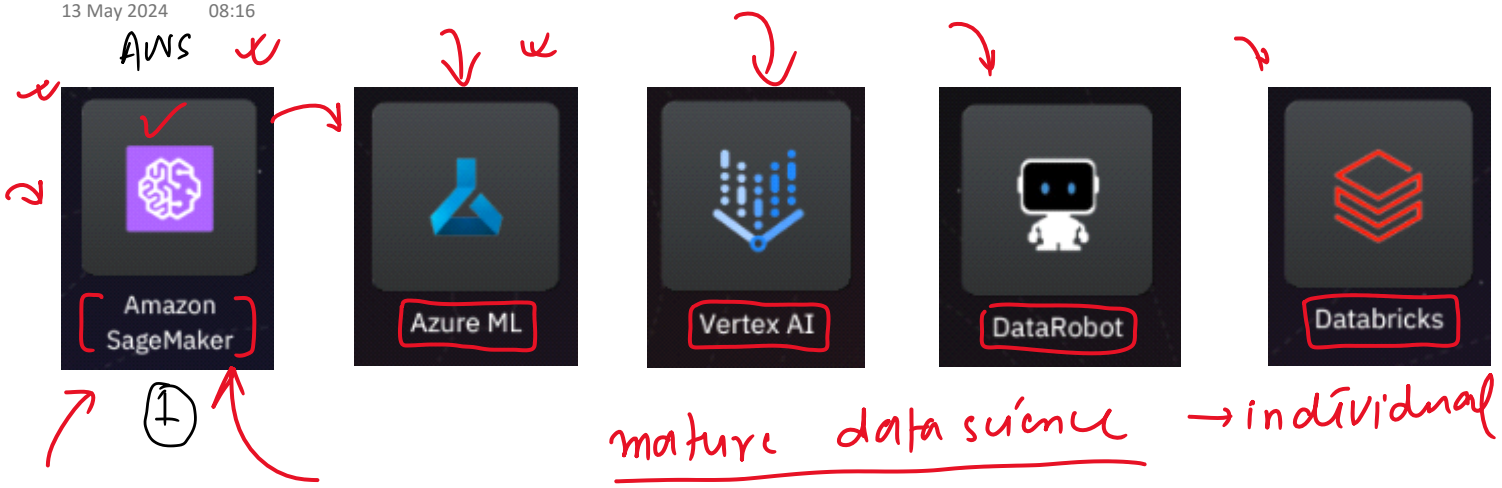

Advantages

- Easy to setup and use
- Standardization and consistency across projects
- Good for quick experimentation
- Reduced IT overheads
- Enhanced security
- Better support

Disadvantages

- Cost
- Vendor lock-in
- Limited options to customize
- Privacy concerns

2. Data Management Tools

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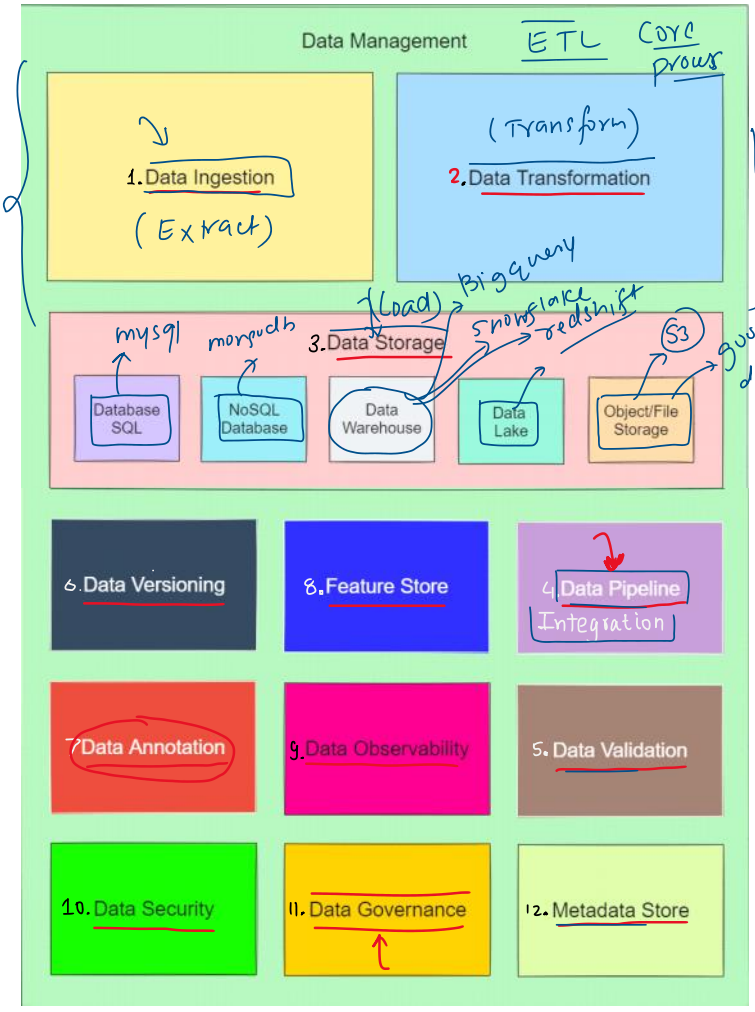
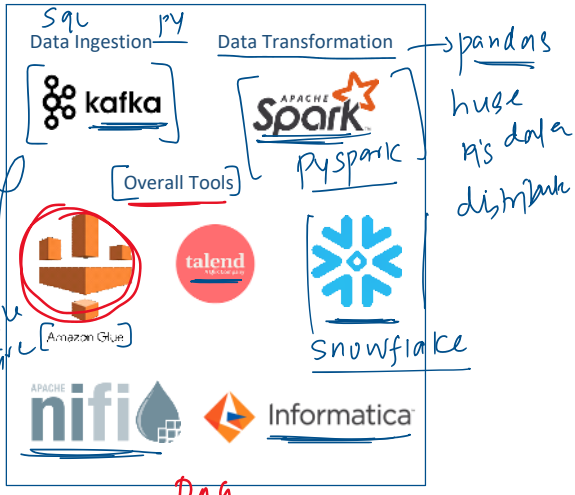
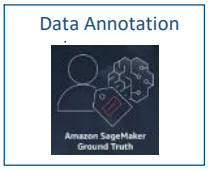






- **Task 1**: Trigger data extraction jobs from the sales and inventory systems.
- **Task 2**: Run data cleaning and transformation scripts.
- **Task 3**: Load the cleaned and transformed data into the data warehouse.
- **Task 4**: Execute SQL queries in the data warehouse to generate analytical reports.
- **Task 5**: Distribute reports via email to the inventory management and marketing teams.

1. Extraction Phase

- **Pre-Extraction Validation**: Before extracting data from the source systems, initial validation checks can be performed to ensure that the source systems are accessible, and that the data is available and in an expected format. This might include checking file sizes, timestamps, or the presence of specific files or tables.

2. Transformation Phase

- **During Transformation**: This is where the bulk of data validation occurs. As data is transformed, various checks are implemented to ensure data quality:
  - **Data Type Checks**: Ensuring that data types are consistent with expected formats (e.g., dates, numeric values, strings).
  - **Range Checks**: Validating that data falls within acceptable ranges (e.g., age, prices, quantities).
  - **Consistency Checks**: Ensuring data across different fields or records is consistent (e.g., a state field matches the corresponding ZIP code).
  - **Completeness Checks**: Verifying that essential data fields are not missing values.
  - **Uniqueness Checks**: Ensuring that data meant to be unique (like transaction IDs or user IDs) does not have duplicates.
  - **Business Rule Validation**: Applying domain-specific rules to ensure the data adheres to business logic (e.g., a customer's credit limit must not be exceeded).

3. Loading Phase

- **Pre-Loading Validation**: Before loading the transformed data into the target system (like a data warehouse or database), final validations ensure the data is ready for integration. This might include:
  - **Referential Integrity Checks**: Ensuring foreign keys correctly link to primary keys in related tables.
  - **Data Formatting Checks**: Confirming that data formatting aligns with the schema of the destination system.
  - **Aggregation Checks**: Verifying sums, averages, counts, and other aggregates are calculated correctly and match expected values.

Data Observability

1. Data drift
2. Pipeline failure
3. Monitoring resource usage
4. Throughput
5. Latency

Data Governance

- Data Cataloguing: Helps organizations organize and access their data assets.
- Policy Management: Allows the creation and enforcement of data governance policies.
- Automated Data Lineage: Tracks the origin, movement, and transformation of data.
- Privacy and Security: Helps organizations comply with data protection regulations like GDPR.

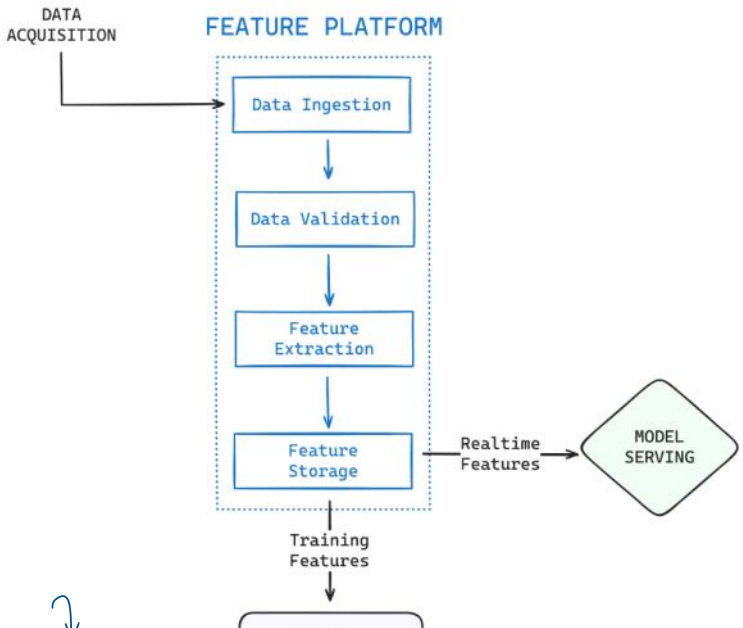
Data Security

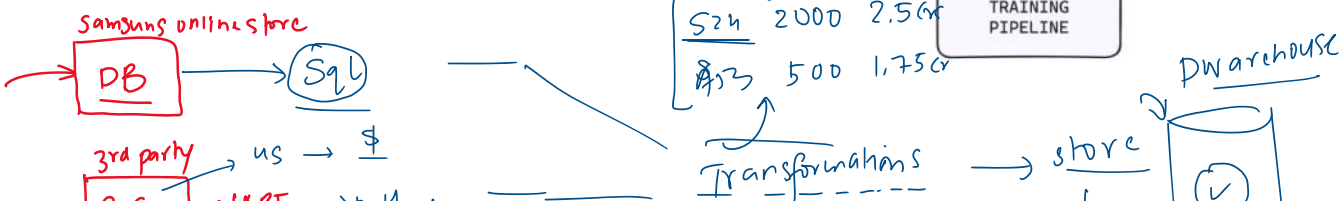
1. Data Encryption at rest, in transit and in use
2. Role based access control
3. Data masking and anonymization
4. Audit Trails - Keeping detailed logs of all data access and changes to track how data is used and by whom.
5. Backup and Disaster recovery

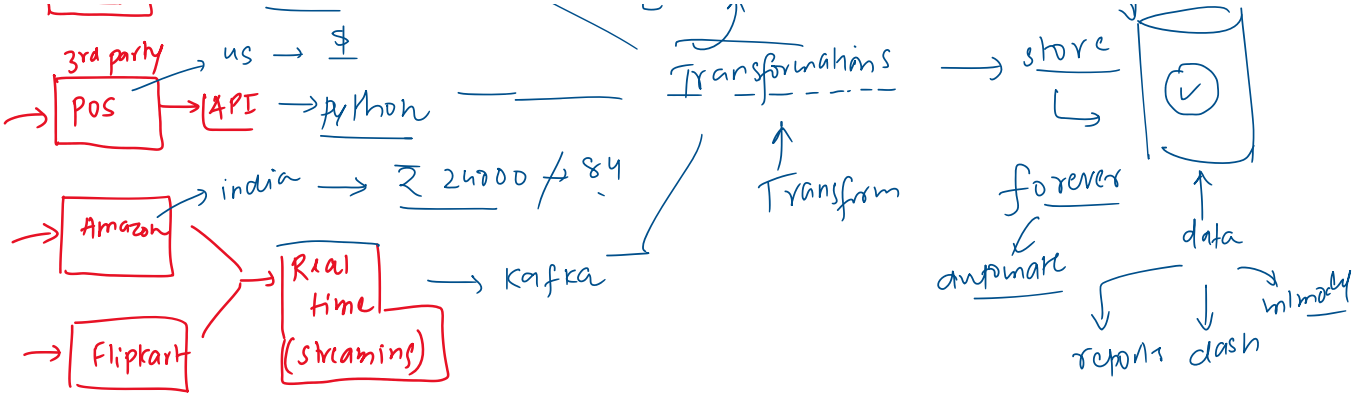
A feature store in the context of Machine Learning Operations (MLOps) is a centralized repository for managing, storing, and accessing features (i.e., individual measurable properties or characteristics used in the construction of machine learning models) across various machine learning projects and teams. It plays a critical role in bridging the gap between data engineering and machine learning by ensuring that features used for training models are consistent with those used for making predictions in production environments.

Key Functions of a Feature Store

1. **Feature Management**: Manages the lifecycle of features, including their creation, versioning, and retirement. This ensures that features are kept up-to-date and remain consistent across different models and applications.
2. **Feature Sharing and Reuse**: Facilitates the sharing and reuse of features among multiple data science teams and projects, reducing duplication of effort and ensuring that improvements to features are propagated across all models that use them.
3. **Feature Consistency**: Ensures consistency between training and inference stages. Features used to train models are exactly the same as those used during model predictions, which helps in maintaining model accuracy and performance in production.
4. **Feature Serving**: Provides low-latency access to feature data for real-time model predictions. This can involve serving features directly to online applications or through APIs that applications can query to get the necessary features for making predictions.
5. **Feature Engineering**: Some feature stores also provide tools to assist in the process of feature engineering, such as transformation functions and pipelines that can be applied to raw data to generate features automatically.
6. **Monitoring and Governance**: Monitors the usage and performance of features and provides tools for governance, such as tracking data lineage, managing metadata, and ensuring that data privacy regulations are followed.






3rd party
POS
API
us → $
python
Amazon
Flipkart
india → ₹ 24000 / 84
Real time (streaming)
kafka
Transformations
Transform
store
forever
automate
data
report
dash
minute

3. Model Building

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4. Model Deployment

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5. Post Deployment

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6. Orchestrators

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MLOps Maturity Levels

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How to select a MLOps tool?

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