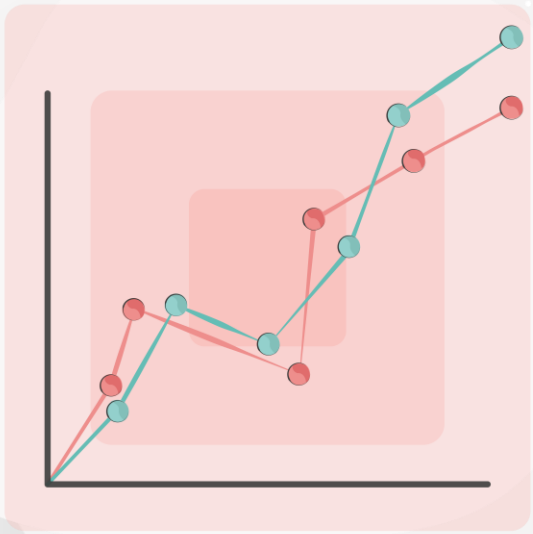
Data engineering

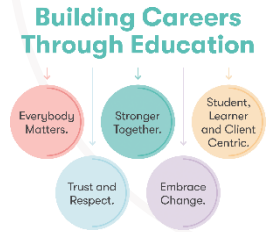
Module: Data pipelines

Topic: Workflow management for data pipelines



Welcome to today's webinar.

Ice breaker



Discussion…

- How are you feeling today? Motivated, happy etc?
- What is your key takeaway from the e-learning topic?
- What is one key skill or insight you hope to gain from today's session?

Submit your responses to the chat or turn on your microphone

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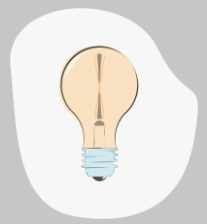
Why workflow management matters

Building Careers Through Education

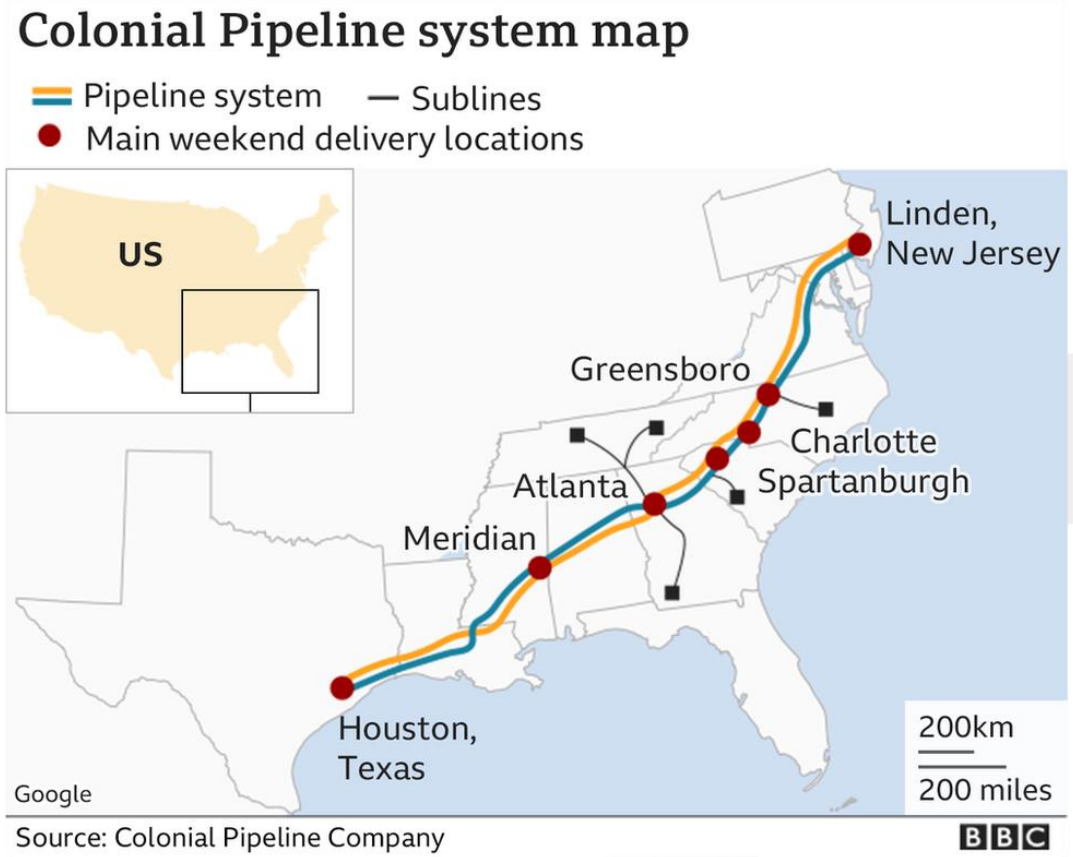
Everybody Matters. Stronger Together. Student, Learner and Client Centric. Trust and Respect. Embrace Change.

Case study: The cost of broken pipelines…

- Missed runs = outdated reports → misleading decisions
- Failed jobs = blocked processes → operational delays
- Poor scheduling = system overload → performance bottlenecks



Real-world example: Colonial Pipeline outage → $4.4M loss due to lack of workflow resilience



The colonial hack, How did cyber-attackers shut off pipeline? ***Image source:*** *BBC*

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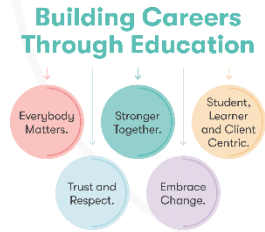
e-learning recap



Reflecting on your learning…

The e-learning for this topic, covered the following areas:

- **Workflows** are structured sequences of tasks that move and transform data reliably.
- **Workflow management** ensures control, visibility, and resilience in data pipelines.
- Core principles include **clear task boundaries**, **dependency-driven execution**, and **modular design.**
- **Workflow orchestration tools** (e.g., Airflow, Prefect) automate, schedule, and monitor pipelines.
- **Optimisation techniques** like parallelism, caching, and resource scaling improve efficiency.
- **Automation** reduces manual effort using schedules, triggers, and reusable templates.
- **Monitoring and maintenance** ensure workflows remain reliable, observable, and scalable.

- Do you have any questions about any of these areas?

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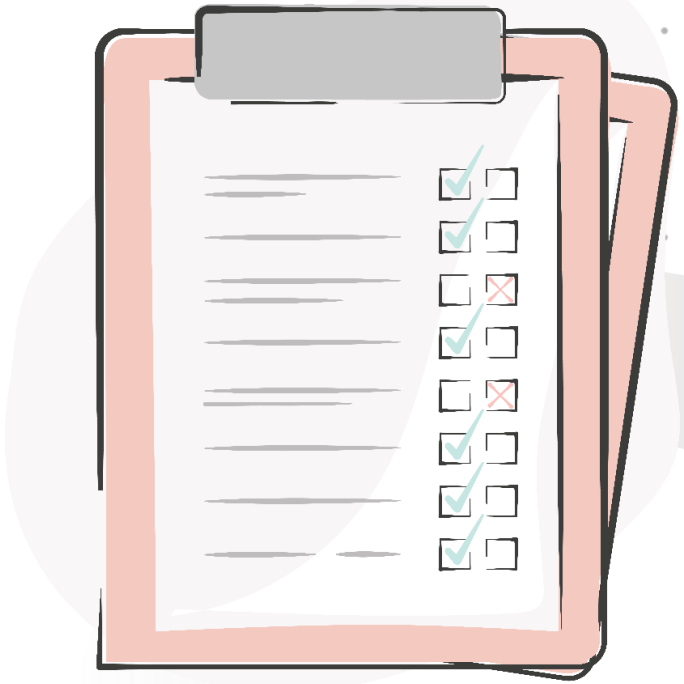
Webinar Agenda

Today, we will cover the following:

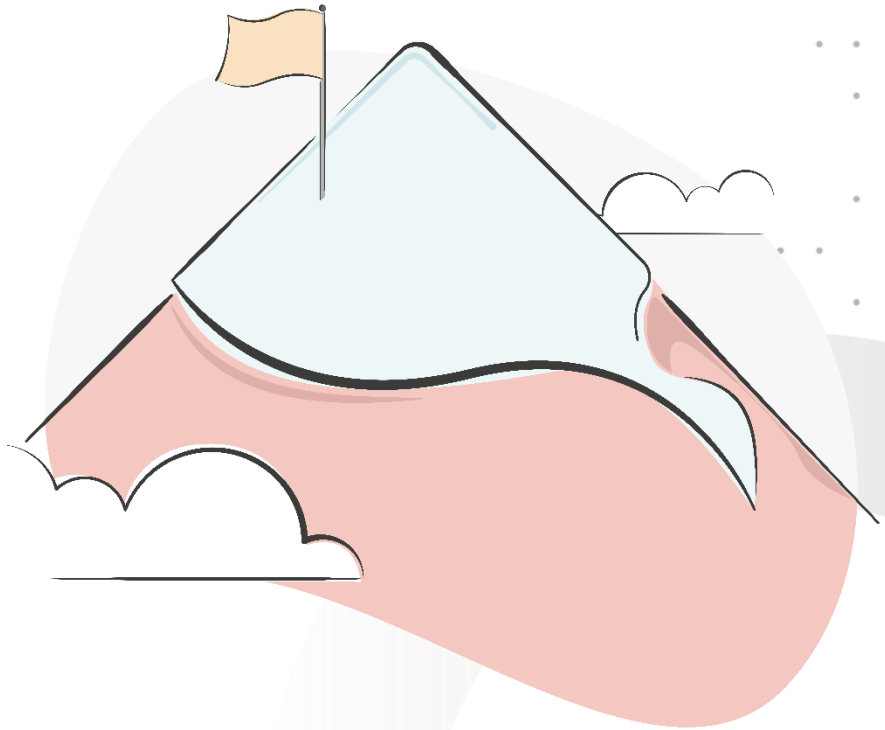
1. Recap of core concepts, including:
    - Workflow definition
    - Core principles of workflow management
    - From script to pipeline
    - Workflow patterns
    - Orchestration tools
    - Optimising workflows
    - Automating repetitive tasks
    - Monitoring and maintenance
2. Practical lab
3. Q&A and Wrap-Up



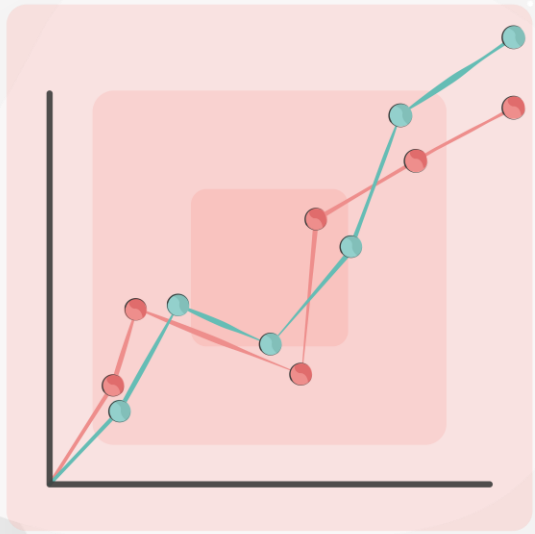
Session aim and objectives

By the end of this session, you should be able to:

- Design and automate robust workflows that power data pipelines from start to finish.
- Understand the role of orchestration tools in managing dependencies, schedules, and error handling across complex data systems.
- Apply optimisation and automation strategies to ensure workflows run efficiently and scale reliably over time.



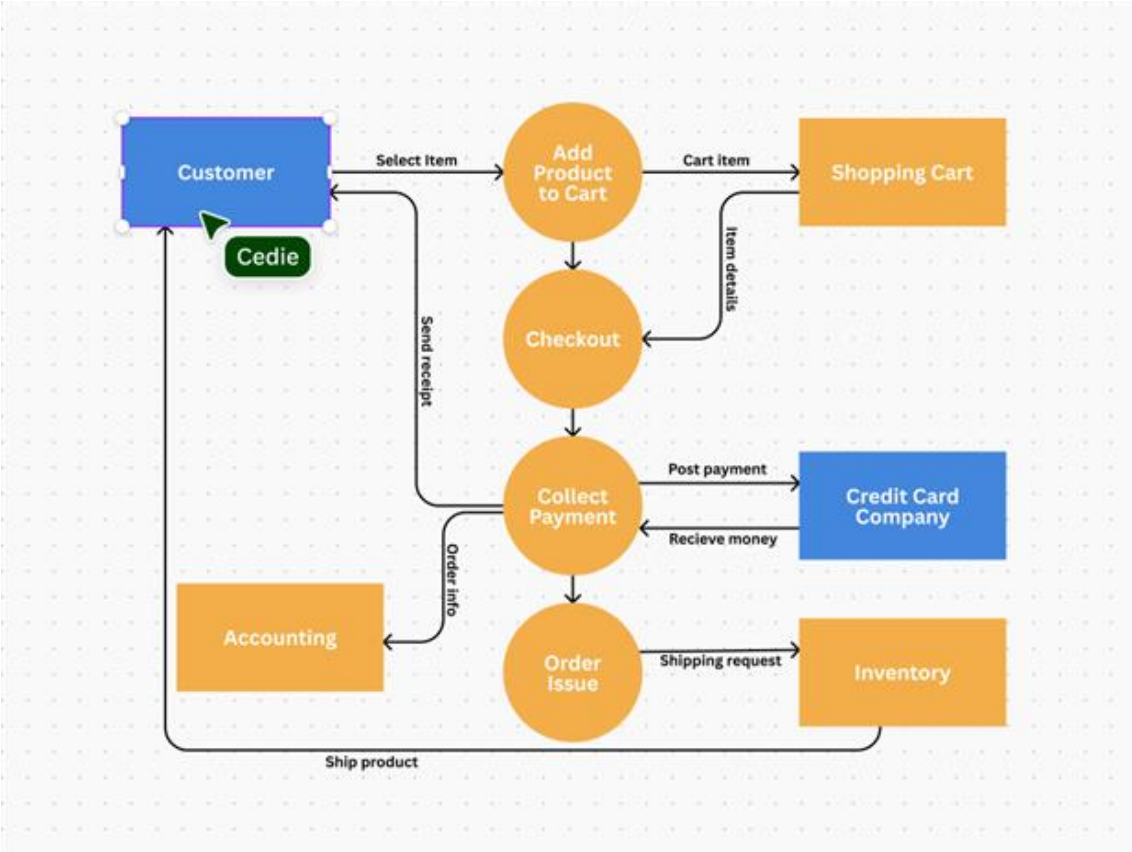
Recap of core concepts



What is a data workflow?

More than just a script

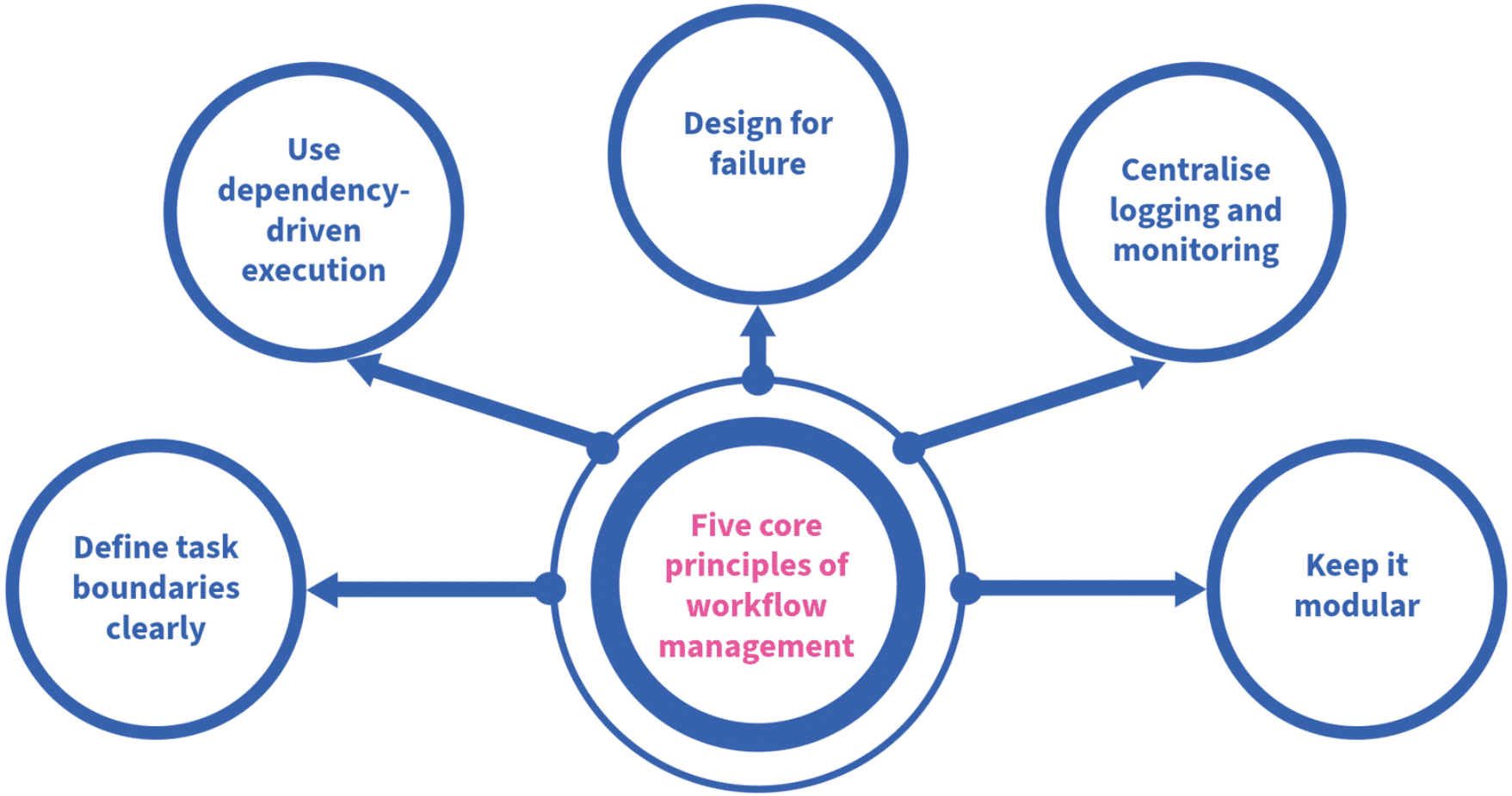
- Sequence of dependent tasks
- Moves and transforms data
- Requires control and visibility



A data flow diagram visualises the flow of data within a system or process, image source: Canva

Core principles of workflow management

Achieving good workflow management



The five core principles of workflow management

From script to pipeline

Coordinating tasks

- A workflow is more than just code—it's about task coordination.
- Each task has dependencies that define execution order.
- These dependencies form the structure of the workflow.
- Managing workflows means defining tasks and their relationships

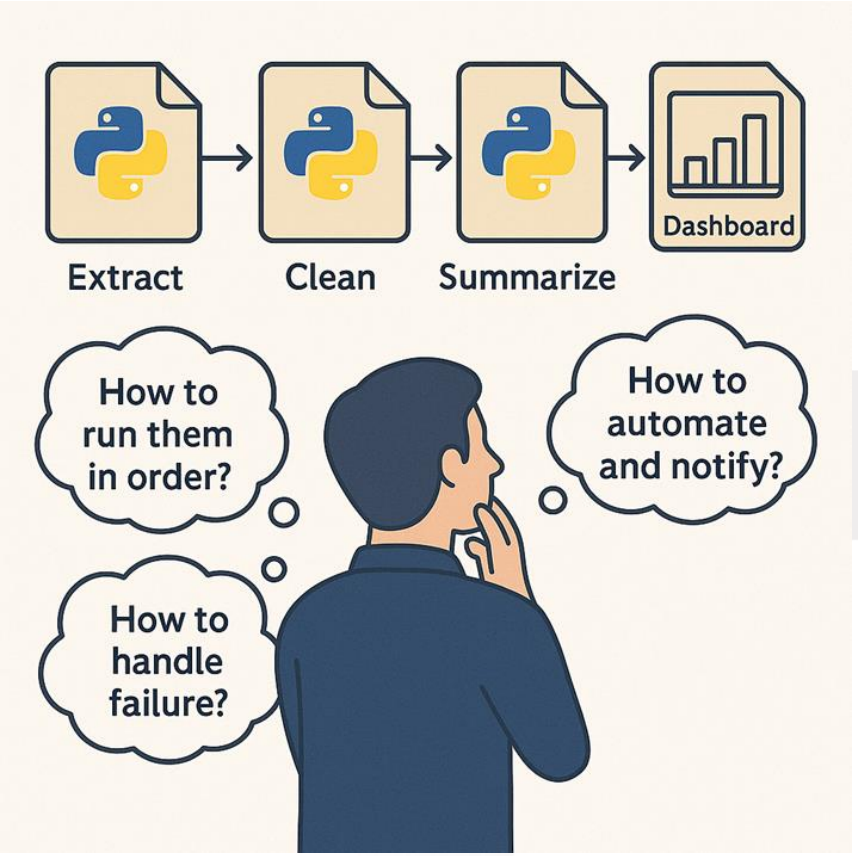


Figure: From script to pipeline

Workflow patterns

Recognise and reuse

- Linear Chains – Simple A → B → C sequences. Easy to follow, common in batch processing.
- Fan-out/Fan-in – A single task splits into parallel tasks (e.g., processing multiple datasets), which then merge back into a single task.
- Conditional Branching – The path changes based on task outputs (e.g., only clean data if the file exists).
- Sensor-Driven – Workflows that wait for an external event, like a new file or a message.

```
<!DOCTYPE html>
<html lang="en">
        <head>
                <meta charset="utf-8">
                <title>title</title>
                <link rel="stylesheet" href="style.css">
                <script src="script.js"></script>
        </head>
        <body>
                <!-- page content -->
        </body>
</html>
```

Computer code showcasing a simple Airflow code with four stages: extract, clean, summarise, and load.

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Orchestration tools

Airflow vs Prefect

Feature	Apache Airflow	Prefect
Adoption	Widely adopted, industry standard	Gaining popularity, especially with developers
Workflow Definition	Uses DAGs (Directed Acyclic Graphs) in Python	Python-native syntax, more intuitive
Best For	Batch processing, ETL pipelines	Dynamic workflows, real-time triggers
Ease of Use	More boilerplate, steeper learning curve	Simpler, more developer-friendly
Monitoring	Built-in UI for tracking and retries	Cloud dashboard with rich observability
Deployment Options	Self-hosted, Kubernetes, cloud integrations	Cloud-native or self-hosted
Key Strength	Mature ecosystem, strong community support	Flexibility, modern developer experience

Apache Airflow

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Optimising workflows

Speed and efficiency

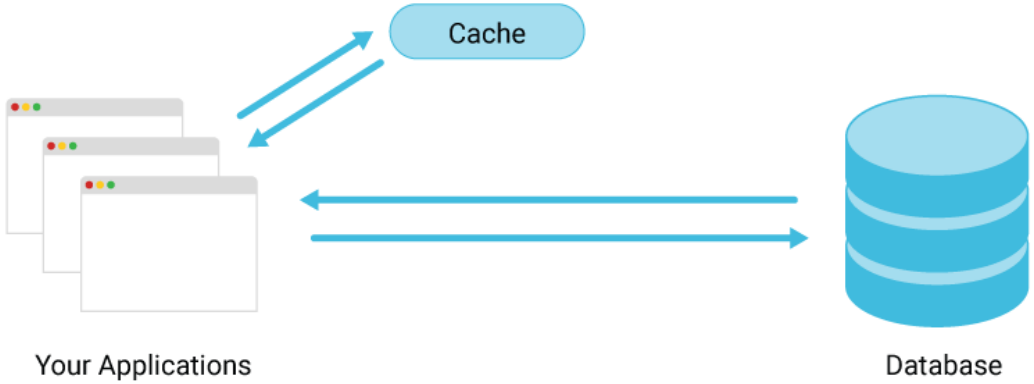
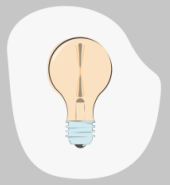


Figure: caching can help save time and resources
Source: ScyllaDB



Three techniques:

- Parallelism and concurrency
- Caching intermediate results
- Resource scaling

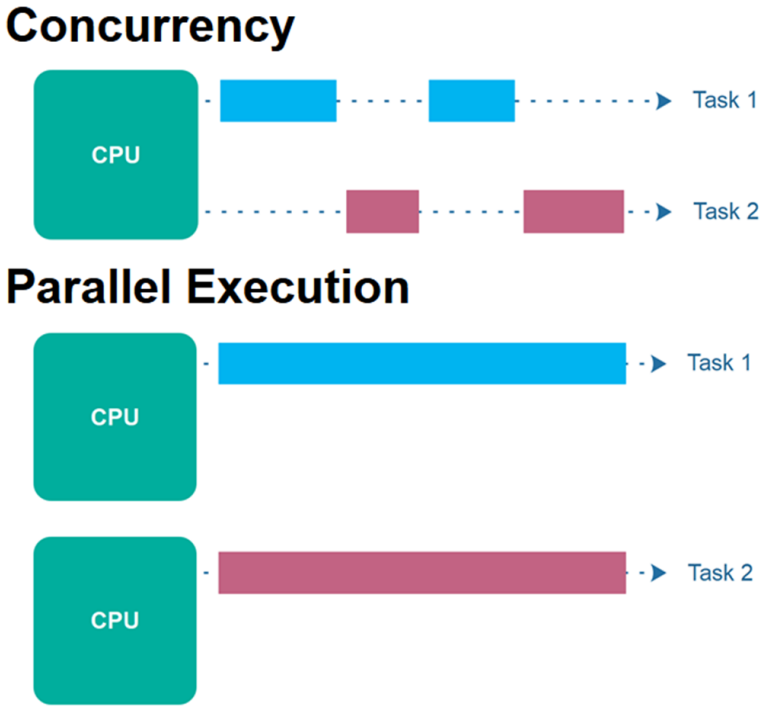
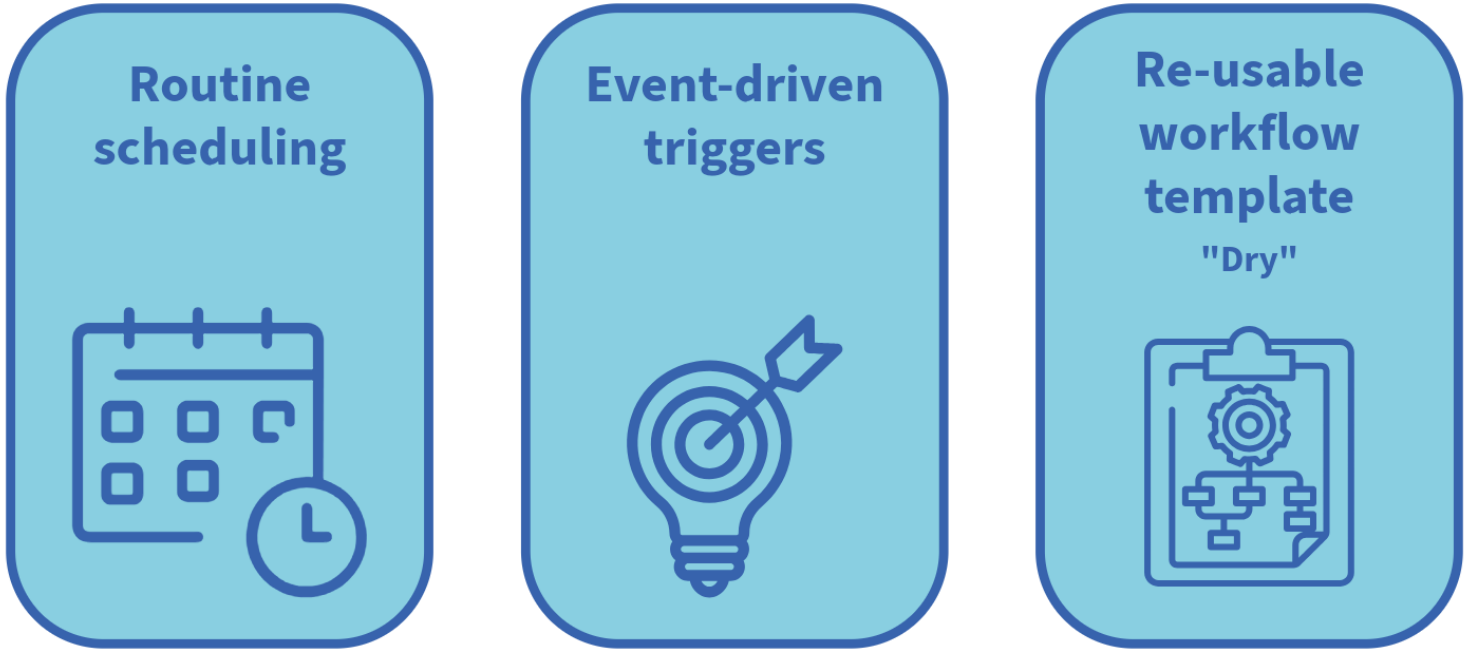


Figure: Concurrency vs Parallel Execution, Source: JENKOV

Automating repetitive tasks

Save time, reduce errors

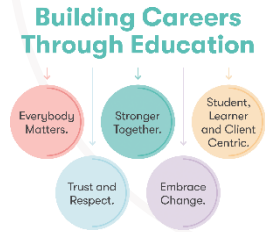


Task categories that are strong candidates for automation

Good practice:

- Version controlled (e.g., in Git)
- Documented with clear instructions
- Modular enough to be reused and extended

Monitoring and maintenance



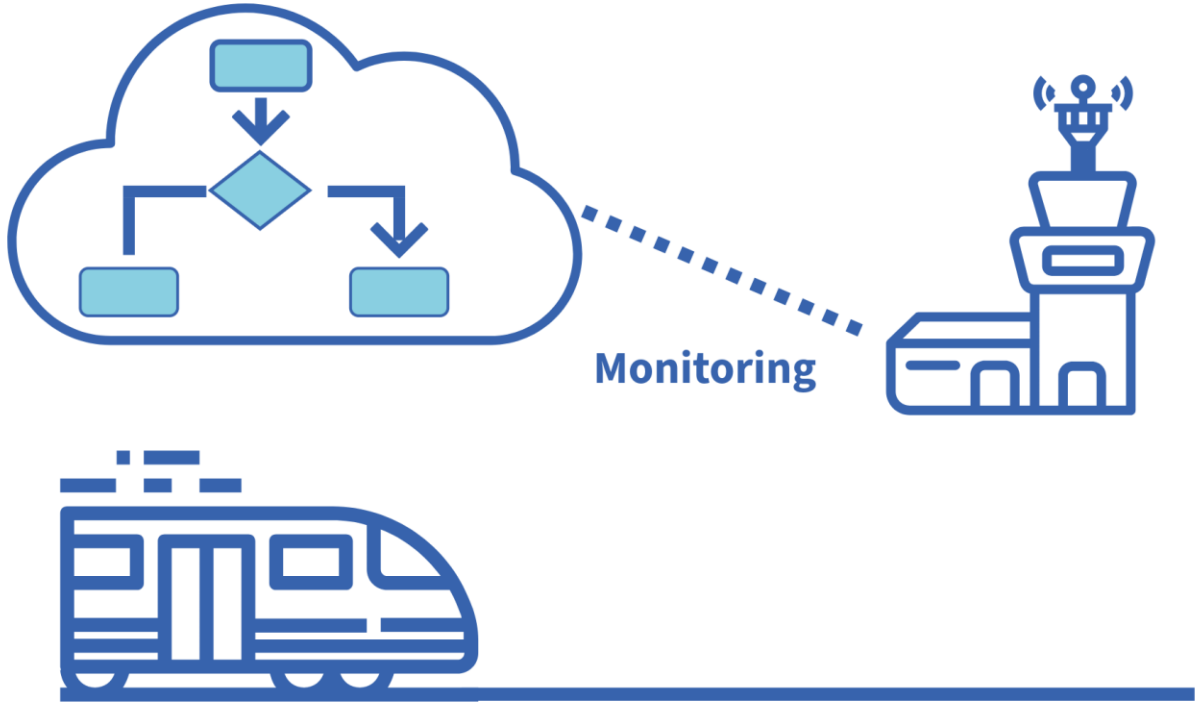
For workflow efficiency

At a minimum, good workflow monitoring tracks:

- Task Success/Failure Rates
- Execution Times
- Resource Usage
- Queue Backlogs.

Think of your data pipeline like a commuter train system.

Each task is a train, and the orchestrator is the control tower.



Monitoring data pipelines are like monitoring trains.

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Maintaining workflow health

A proactive approach

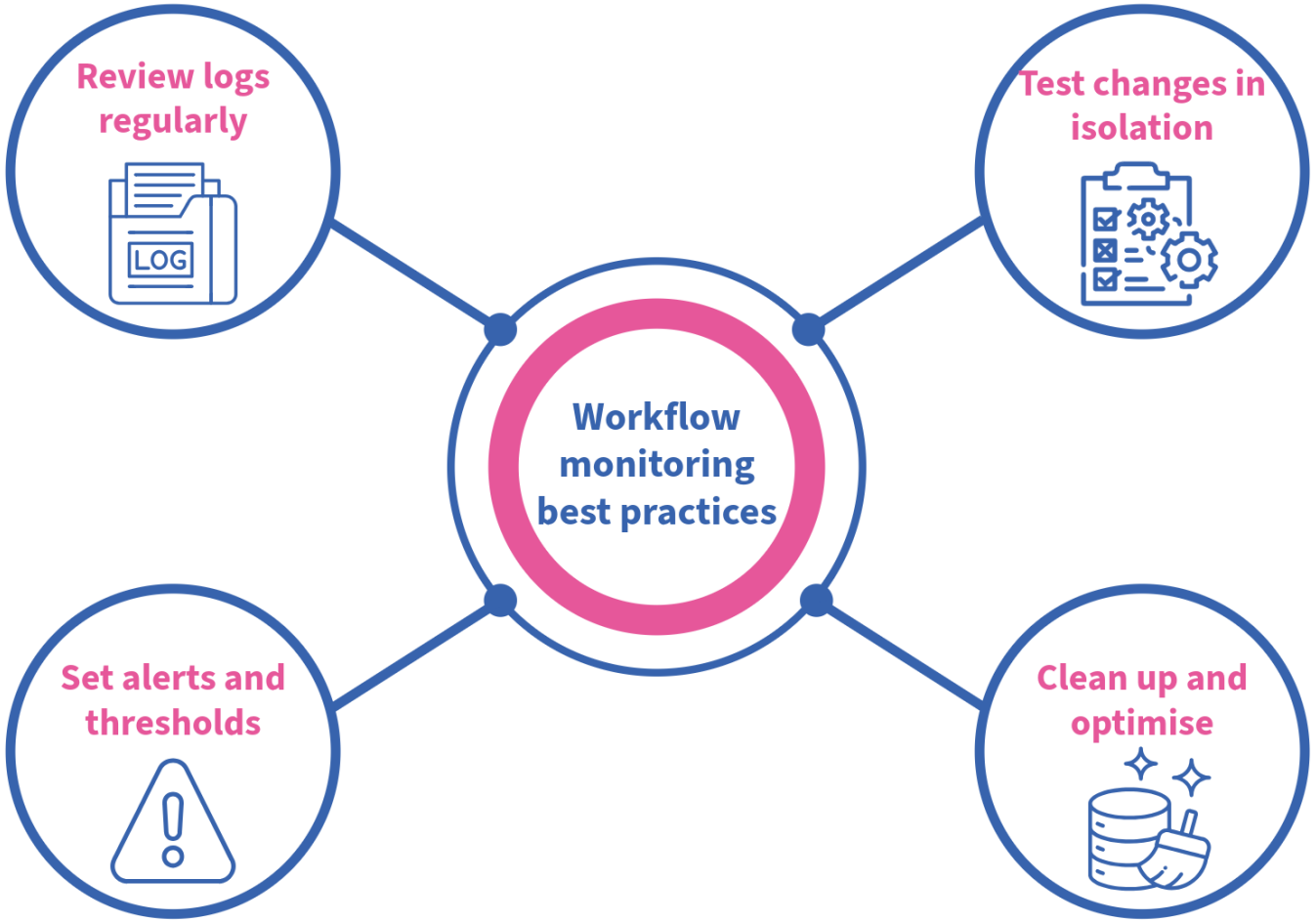
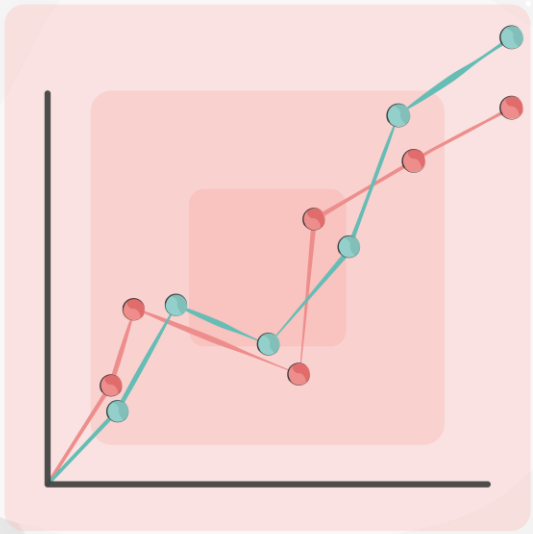


Figure: Best practices when it comes to monitoring workflows.

Practical lab



Exercise part 2

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Everybody Matters. Stronger Together. Student, Learner and Client Centric. Trust and Respect. Embrace Change.

Next phase of design based on FR data

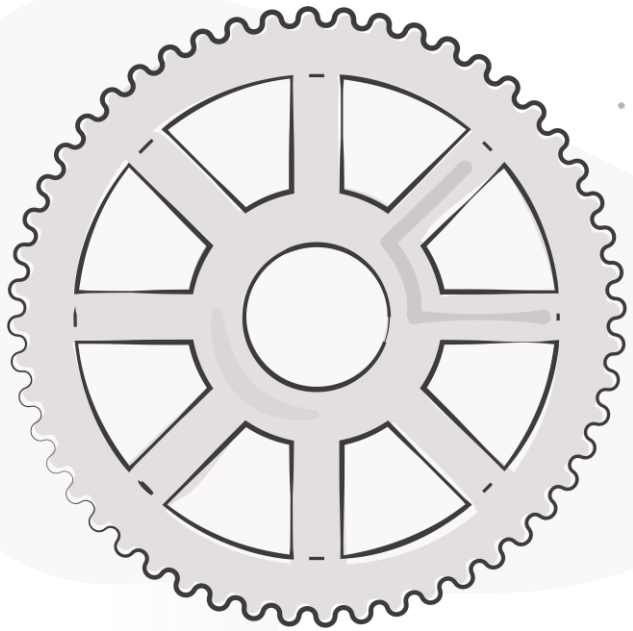
1.Update Database Schema: Modify the schema to accommodate data from the French version of the software application.

2.Re-implement Data Pipeline: Develop a pipeline to clean, validate, and load both UK and French data into the revised schema.

3.Use Test Data: Utilise provided test data for 10 French users and their login timestamps.

4.Future Phases: Prepare to integrate data from additional countries with varying formats.

5.Documentation: Establish comprehensive documentation for the schema and pipeline for future implementation by other teams.



Practical challenge

Files Provided in the Hub:

- FR User Data.csv: Contains 10 sample records.
- FR-User-LoginTS.csv: Contains login timestamps for January 2025.

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Key Learning Summary

- **Workflows** in data engineering are structured sequences of dependent tasks that manage how data is moved and transformed.
- Effective **workflow design** involves clear task boundaries, defined dependencies, and scheduled execution using tools or code.
- **Workflow orchestration tools** like Apache Airflow and Prefect allow engineers to schedule, monitor, and automate complex pipelines.
- **Optimisation techniques** such as parallelism, caching, and resource tuning improve the speed and efficiency of data workflows.
- **Automation** reduces manual repetition by using time-based or event-driven triggers and reusable workflow templates.
- **Monitoring and maintenance** involve tracking workflow performance, setting alerts, and regularly reviewing logs to ensure reliability.

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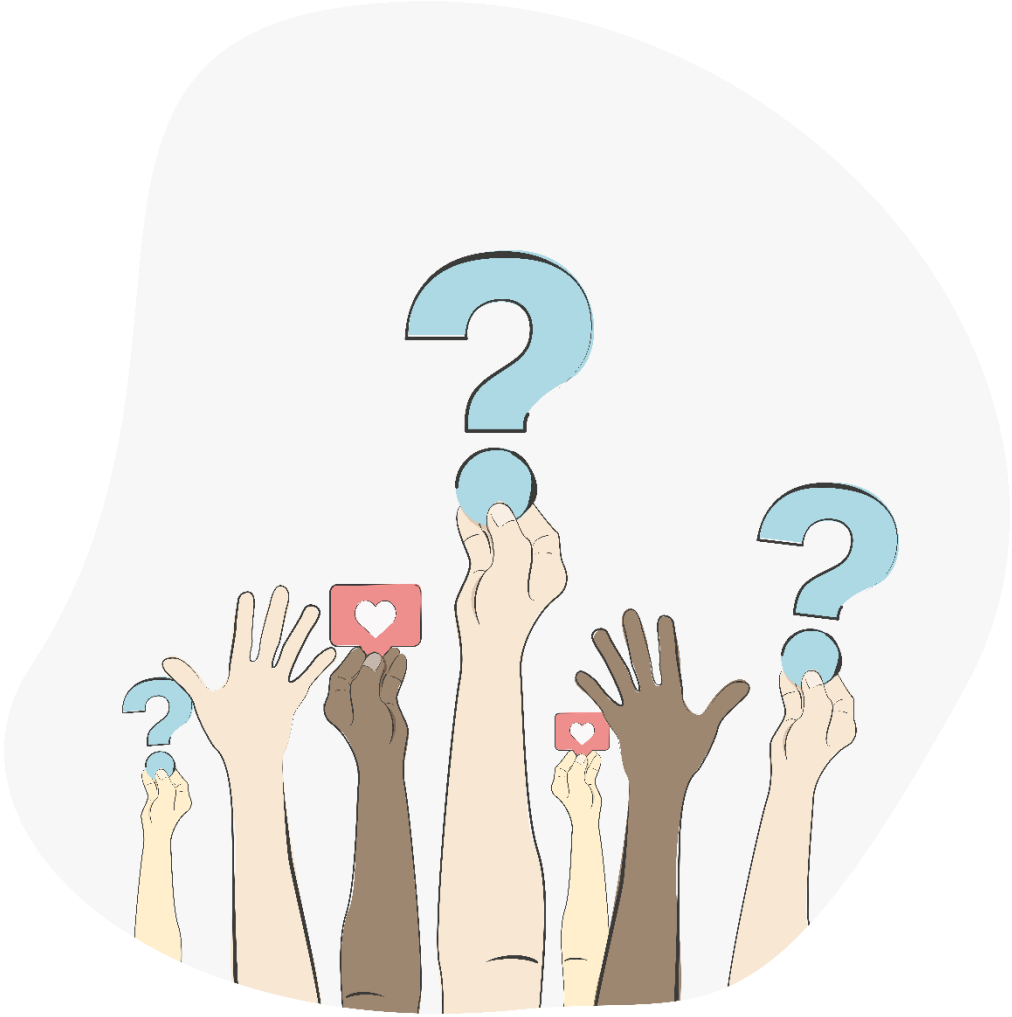
Any questions or feedback?



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Thank you