Managing Service Dependency for Cloud Reliability
The Industrial Practice

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ARISE
Automated Reliable Intelligent Software Engineering

香港中文大學
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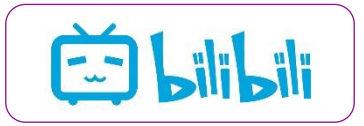
Online Cloud Services Are Everywhere

To-Consumer services



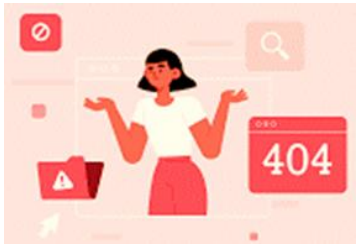
To-Business services

Cloud services

Online Cloud Services' Reliability Is Crucial

-- to both service providers and end users!

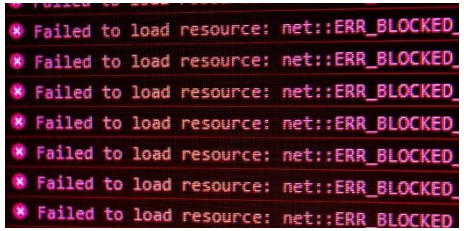
A Tiny Error

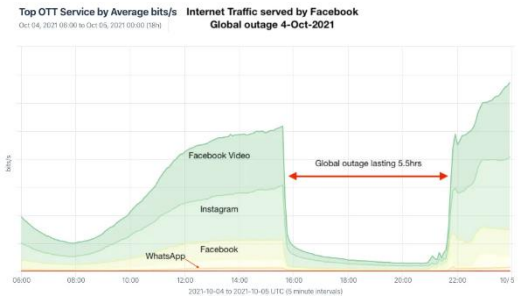


System Outage

User Dissatisfaction

Revenue Loss





User satisfaction study shows Facebook vulnerable to Google+

Facebook, which ranked last in a customer satisfaction study, has benefited from 'a monopoly of sorts' in the social networking market

Facebook Parent Loses More Than $230 Billion in Market Value, Biggest U.S. Stock Market Drop in History

Meta Platforms shares drops after company cites headwinds from Apple iOS privacy changes, TikTok competition

By Todd Spangler

Update about the 4 October outage | Meta for Business (facebook.com)

Real-world Examples

MyBroadband

Major Microsoft Teams and A

It warned customers may experience laten
when trying to access their Azure cloud re

1 week ago

Data Center Dynamics

AWS us-east-1 outage brings
world

An outage at Amazon Web Services' us-ea
globally on December 6. Amazon subsidia

Dec 7, 2021

9to5Google

Gmail outage impacted email
afternoon [Updated]

Gmail very rarely goes down, but an hour-
service not work for some. Not all users w

Apr 27, 2022

9News

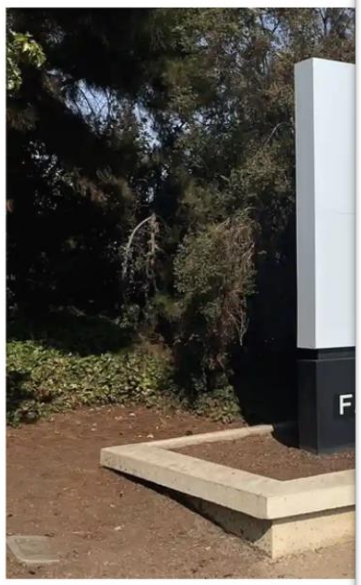
Zuckerberg loses $8 billion d

About 9.30 am (AEDT) Mr Zuckerberg co
platforms used were back online, with an

Oct 5, 2021

Facebook outage: what went wrong and why did it take so long to fix after social platform went

Billions of users were unable
WhatsApp for hours while th
restore services



Facebook, Instagram and WhatsA
global outage. Photograph: Anadolu

CLOUD

Extended AWS outage disrupts services a

By Diana Goovaerts · Dec 7, 20

Amazon Web Services | AWS

The outage hit a number of AWS serv
others. (Photo by Diana Goovaerts fo

Lloyd's Estimates the Impact of a U.S. Cloud Outage at $19 Billion

By **Sean Michael Kerner** - January 24, 2018

Share

As organizations around the world increasingly rely on the cloud, the impact of a public cloud failure is something that insurance companies are now concerned about. A 67-page report released on Jan. 23 from Lloyd's of London and AIR Worldwide provides some insight and estimates on the potential losses from a major cloud services outage—and the numbers are large.

According to the report, a cyber-incident that impacted the operations of one of the top three public cloud providers in the U.S. for three to six days, could result in total losses of up to $19 billion. Of those loses, only $1.1 to $3.5 billion would be insured, leaving organizations left to cover the rest of the costs.

Facebook outage: what went wrong and why did it take so long to fix after social platform went down? | Facebook | The Guardian
Extended AWS outage disrupts services across the globe | Fierce Telecom

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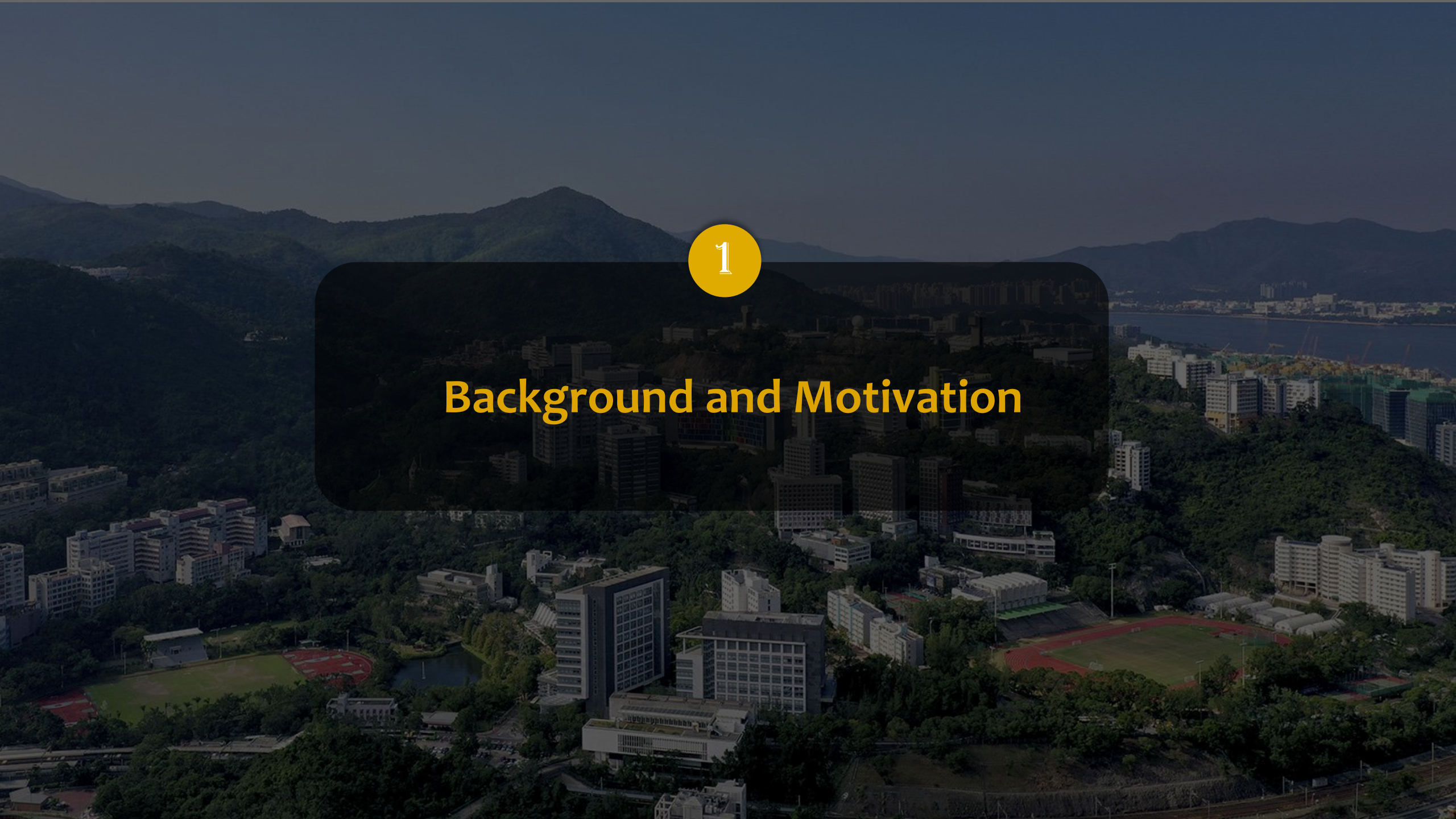
3 Dependency Analysis

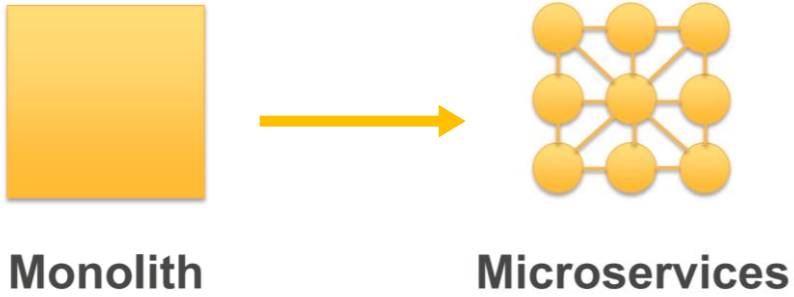
4 Application Scenarios

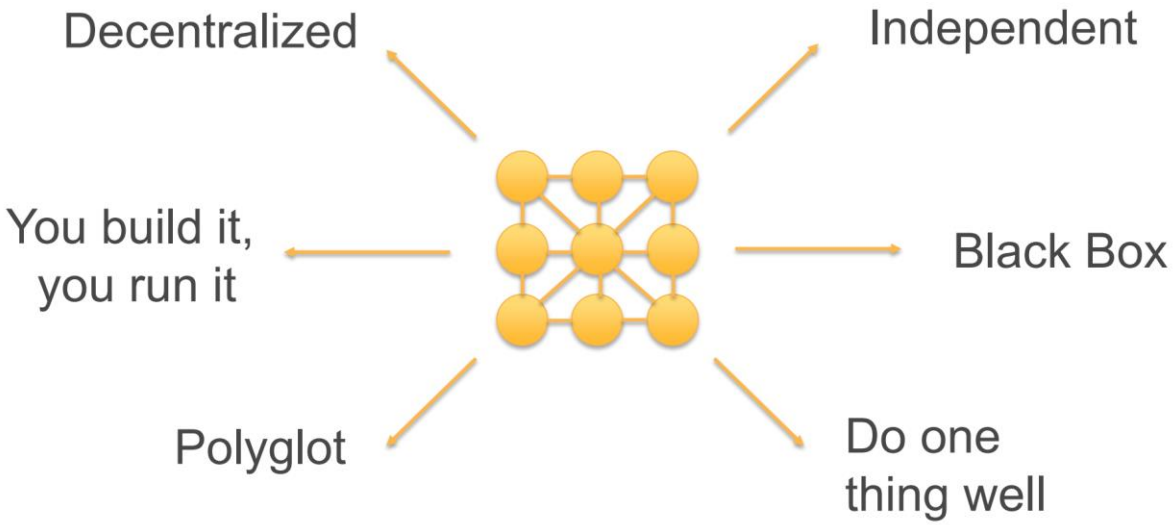


1

Background and Motivation

The Microservice Architecture





docker

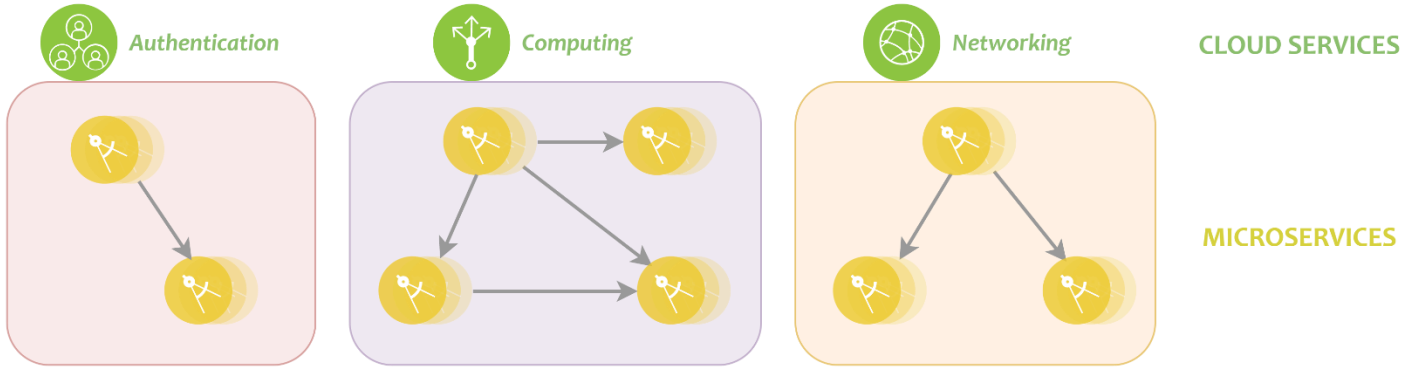
kubernetes

Microservices architecture is an approach in which a single application is composed of many **loosely coupled** and **independently deployable** small programs.

Microservices on AWS, AWS Summit Berlin 2016, Apr 12, 2016
What are Microservices? | IBM

Complex Dependencies Threaten System Reliability

- Microservices collectively comprise multiple cloud services.
  - *Cloud services*: provide high-level APIs.
  - *Microservices*: collectively handle the external request via multiple chained invocations.



1. Due to the complex dependencies , minor anomalies may magnify impact and escalate into system outages.

2. Loosely-coupled nature results in complex dependencies, hindering failure diagnosis.

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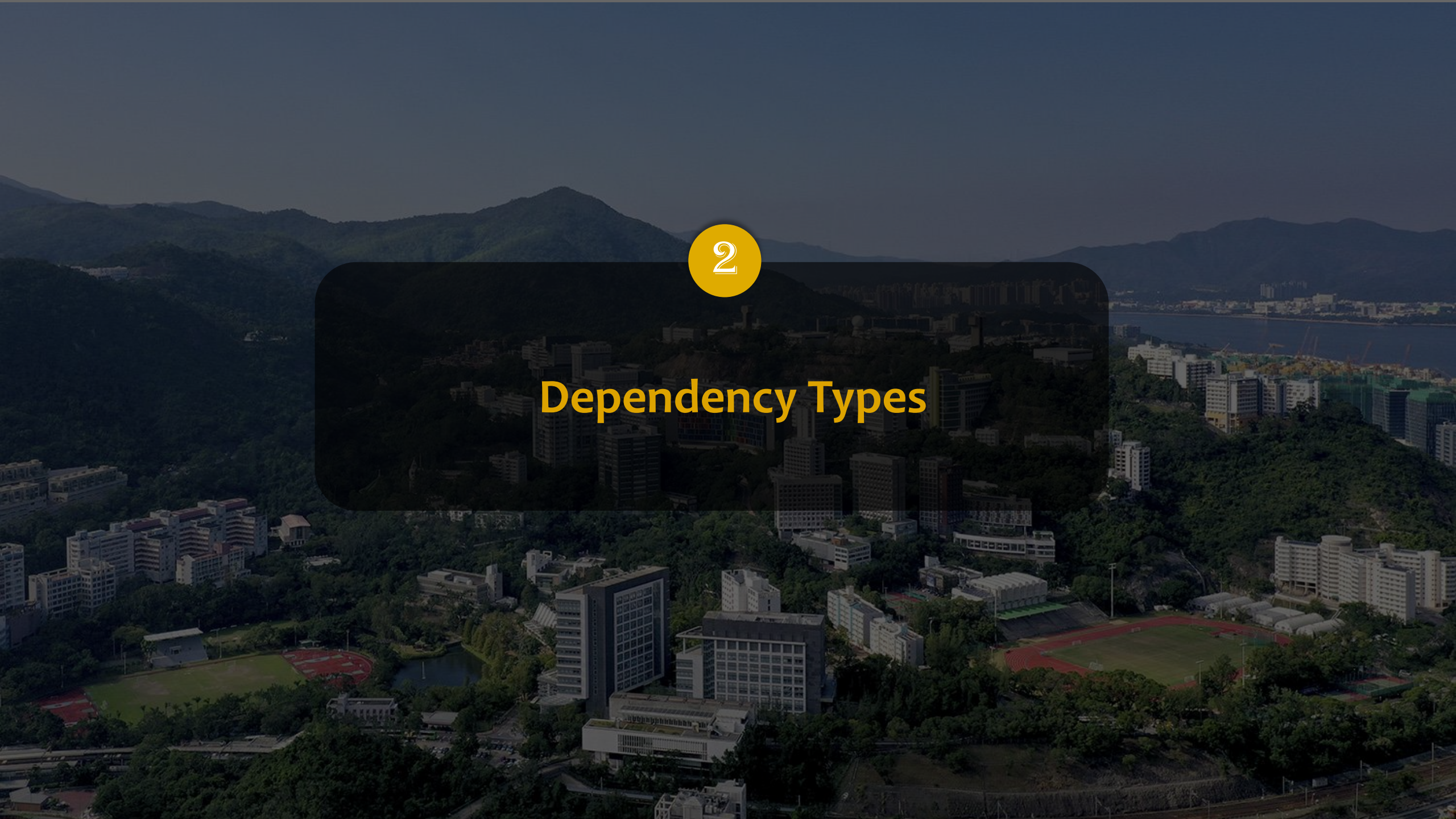

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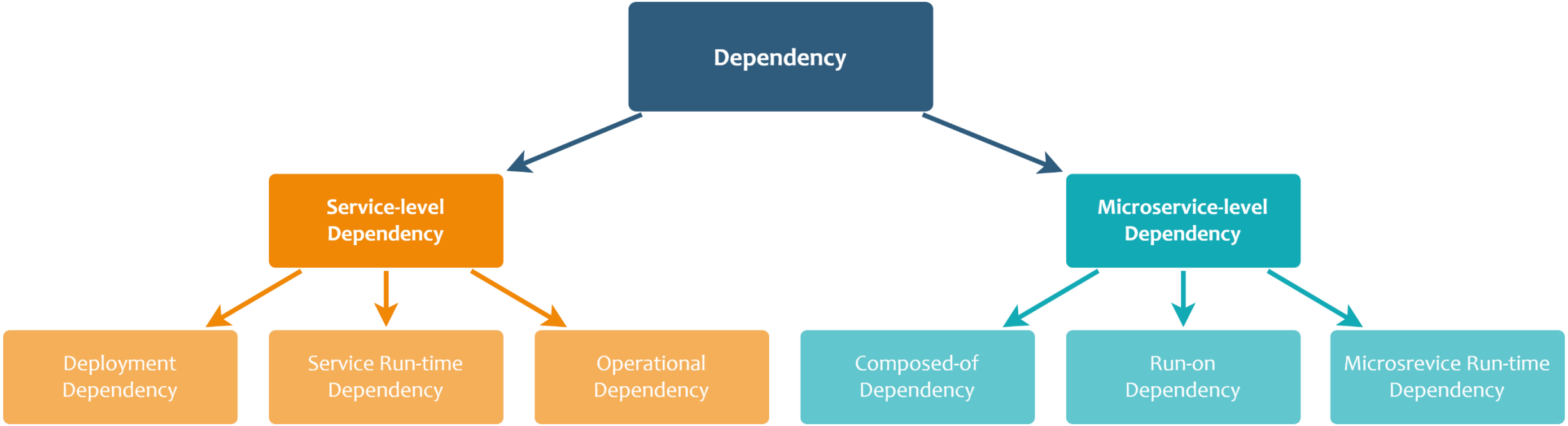
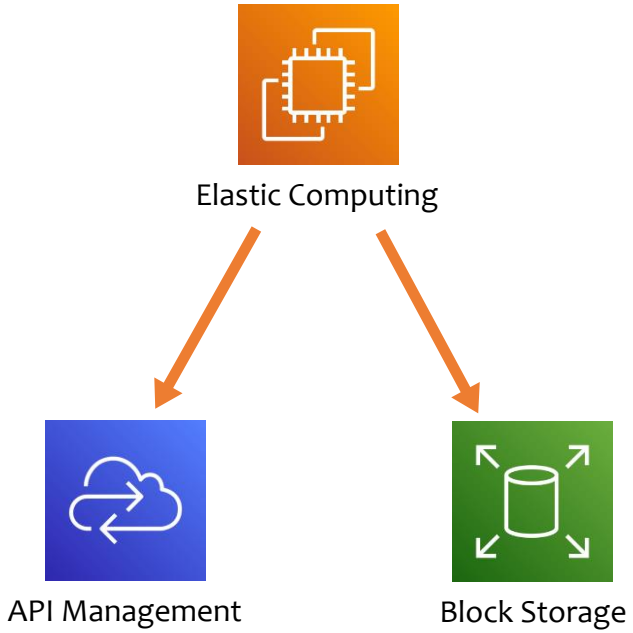
Dependency Types

Categorization of Dependencies



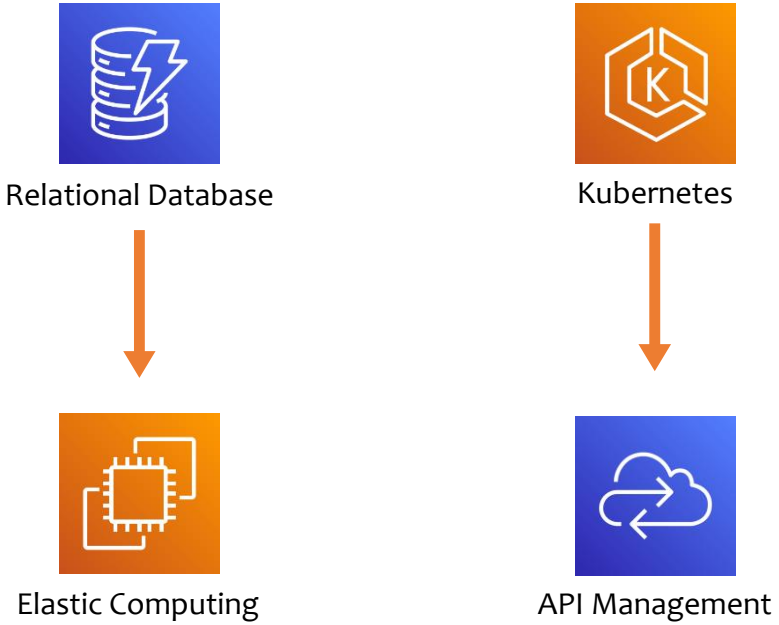
Deployment Dependency

- Deployment dependency.
  - The dependency during the deployment of a cloud service.
  - The deployment phase may rely on some cloud services to create and configure resources.



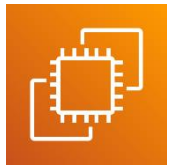
Service Run-time Dependency

- Service run-time dependency.
  - The dependency required for the cloud service to run normally.
  - When a cloud service is running, it may rely on other cloud services.



Operational Dependency

- *Operational dependency*
  - The dependency required by the manual and automatic operations.
  - This type of dependency usually indicates weak cascading impacts because the core functionalities will not be affected.



Elastic Computing

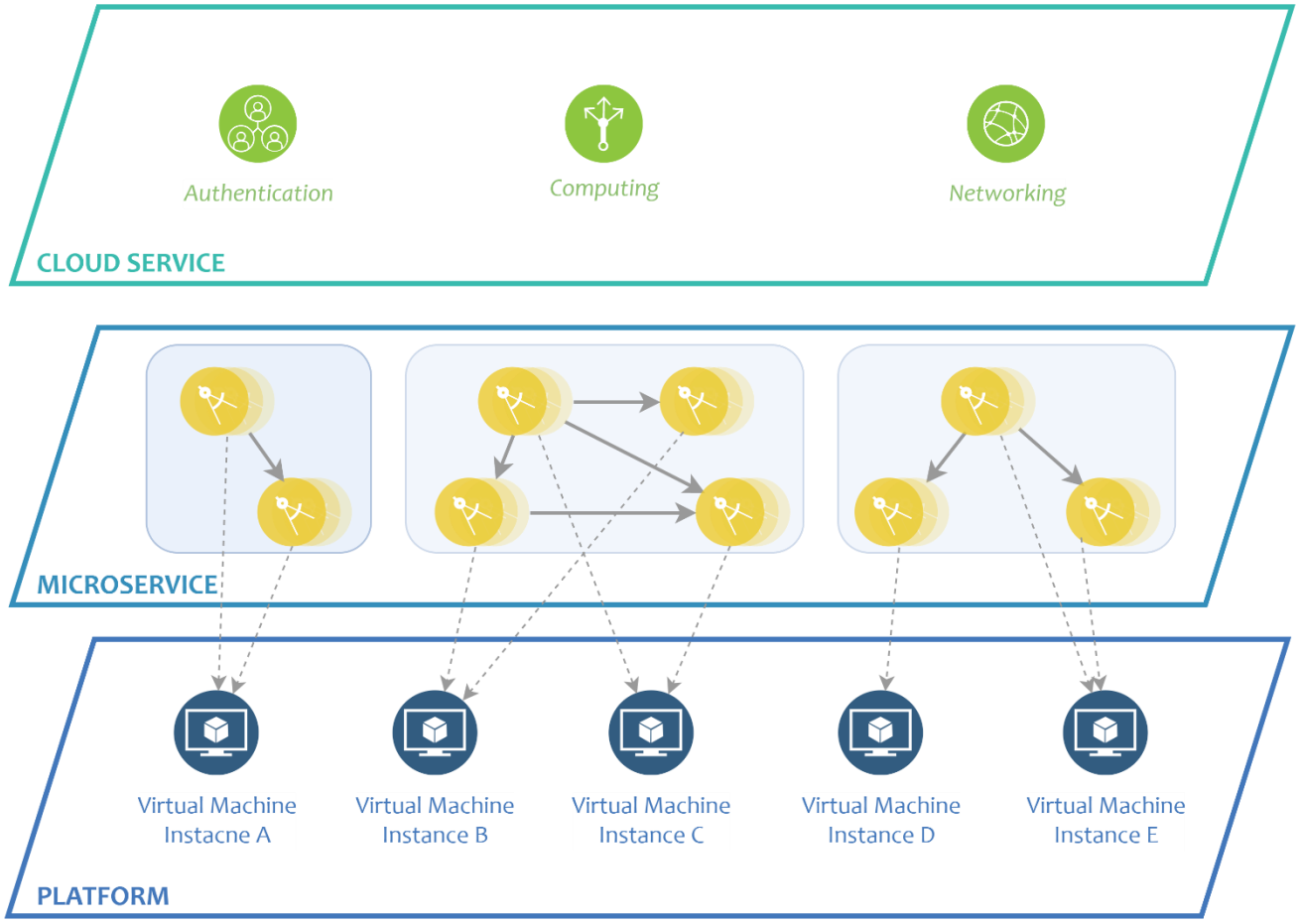
Amazon Kinesis

Service-Level Dependency Summary

Cascading Impact	Dependency Type
The deployment phase	Deployment dependency
The run-time functionality	Service run-time dependency
Operational impact	Operational dependency

Microservice-level Dependency Summary

- Composed-of dependency
  - Between a cloud service and the microservices that comprise it.
- Run-on dependency
  - Between a microservice's instance and the underlying run-time environments.
- Microservice run-time dependency
  - Between the caller microservice to the callee microservice when running.



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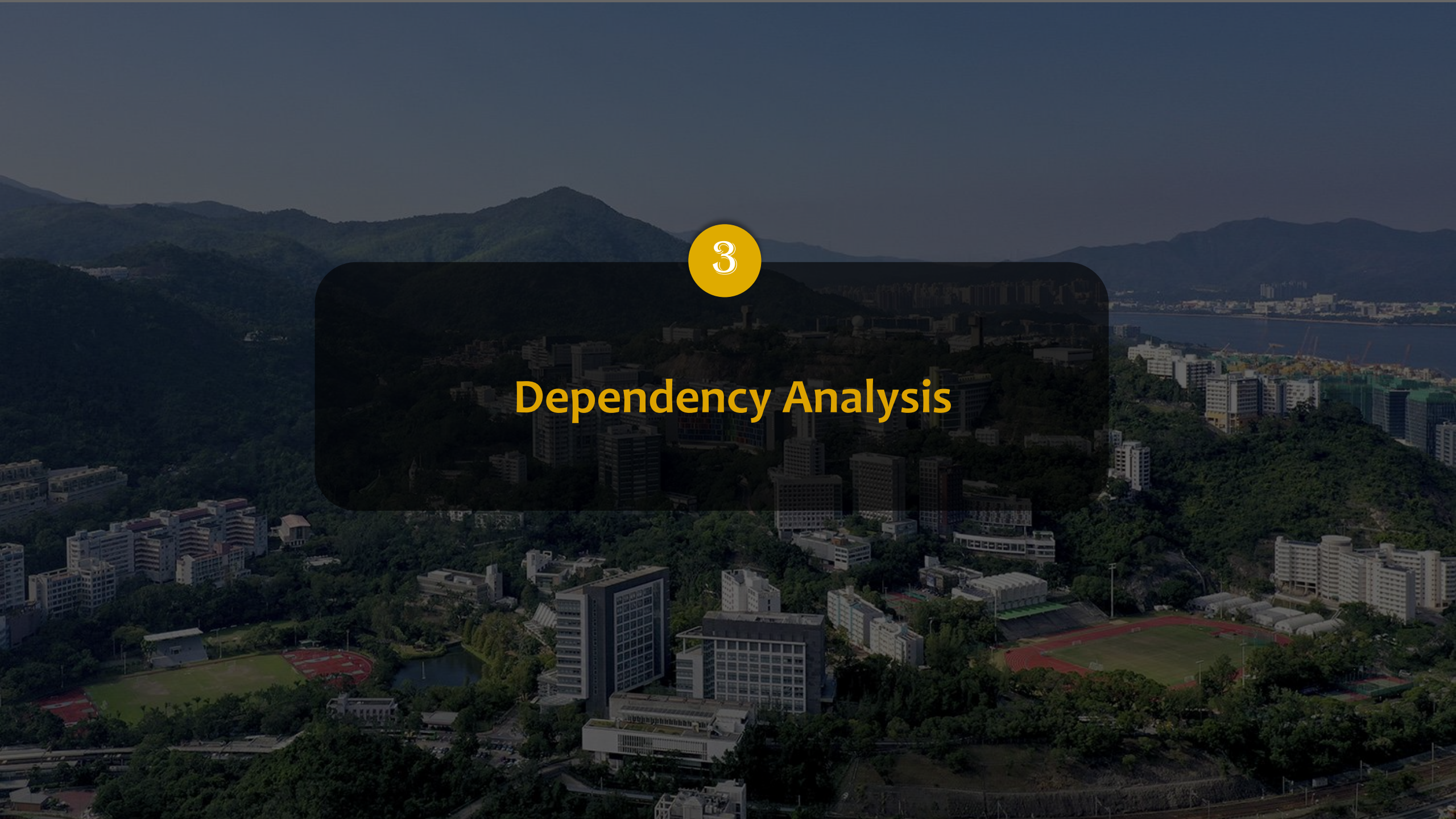

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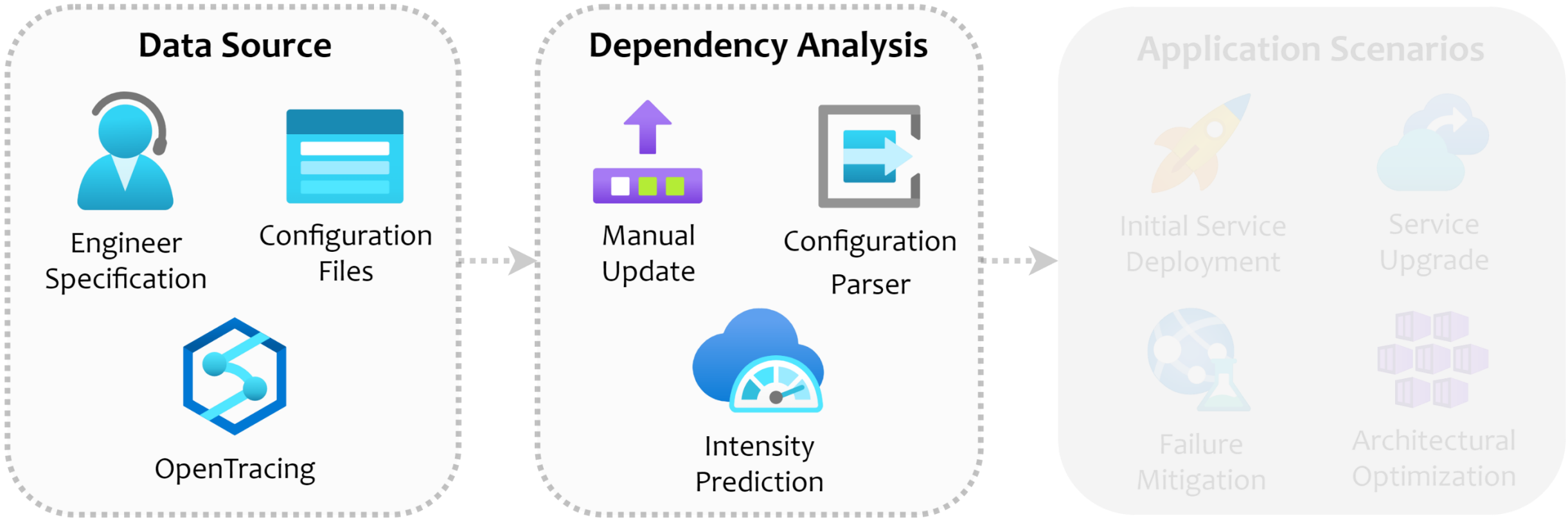
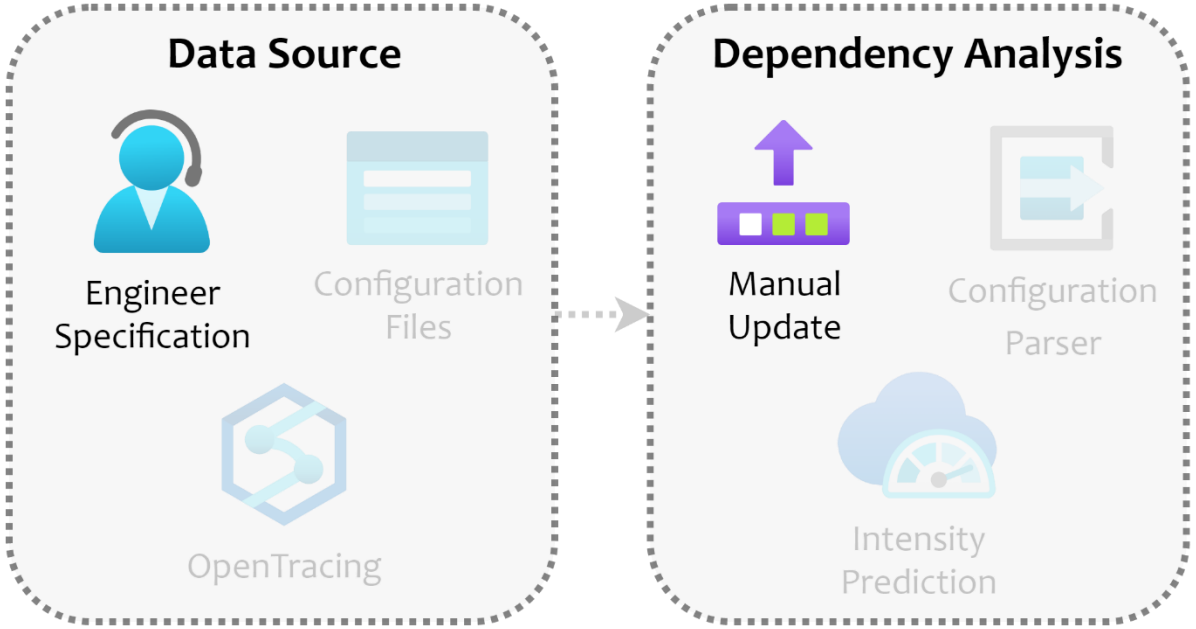
Dependency Analysis

Dependency Analysis Overview



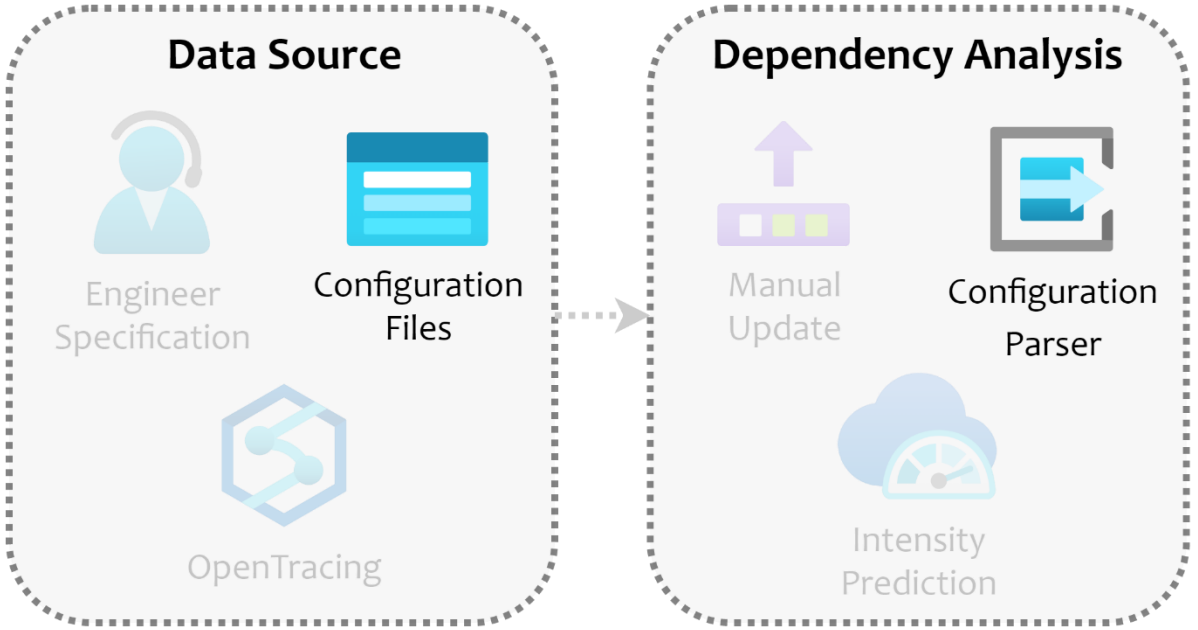
Dependency Analysis

- Engineer Specification
  - Developers may specify the dependencies in the centralized database.
  - Dependencies obtained:
    - Deployment dependency.
    - Operational dependency.



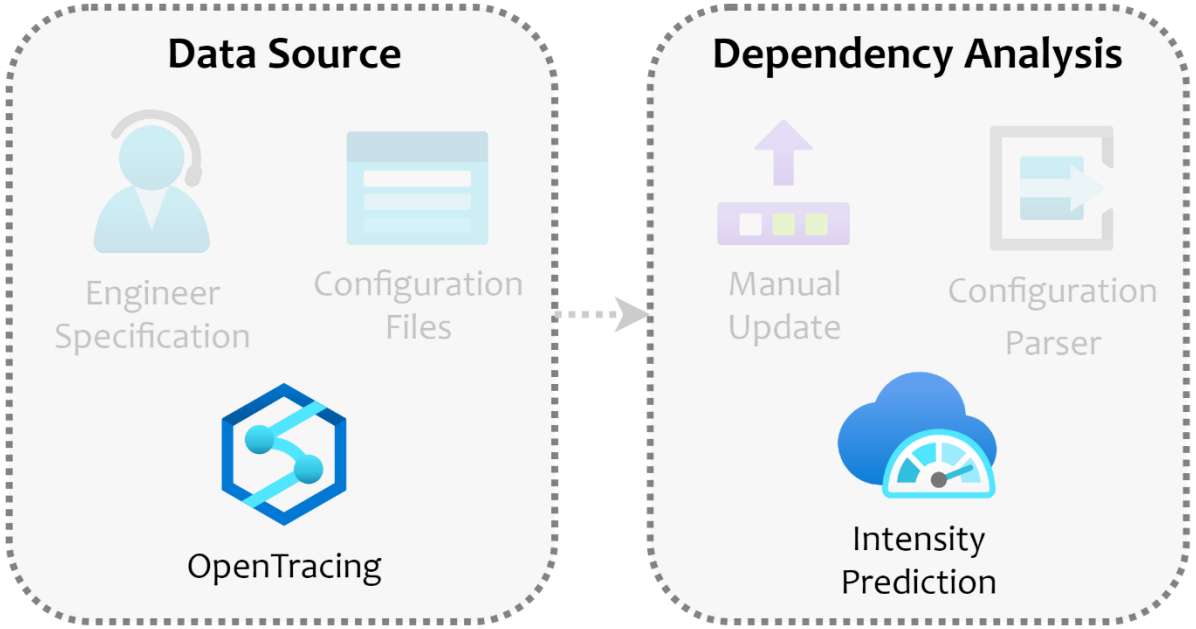
Dependency Analysis

- Configuration Files
  - Records the system configurations.
  - Dependencies obtained:
    - Composed-of dependency.
    - Run-on dependency.



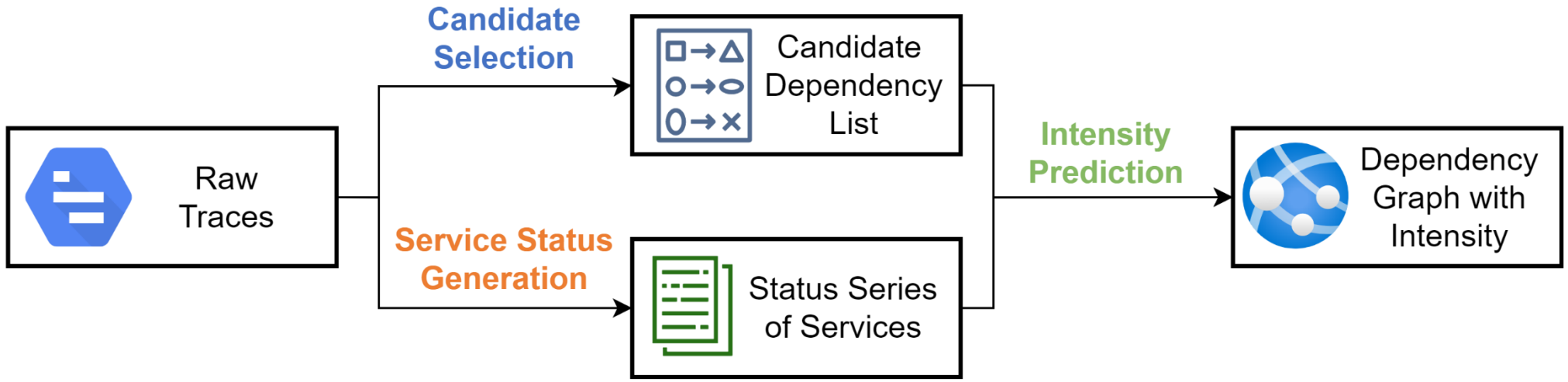
Dependency Analysis

- OpenTracing
  - Tracks the invocations between microservices.
  - Dependencies obtained:
    - Service run-time dependency.
    - Microservice run-time dependency.
    - Operational dependency.



Intensity Prediction with AID

We define the intensity of dependency between two microservices as how much the status of the callee microservice influences the status of the caller microservice.



T. Yang, J. Shen, Y. Su, X. Ling, Y. Yang, and M. R. Lyu, "AID: efficient prediction of aggregated intensity of dependency in large-scale cloud systems," in 36th IEEE/ACM International Conference on Automated Software Engineering, ASE 2021,November 15-19, 2021. IEEE, 2021.

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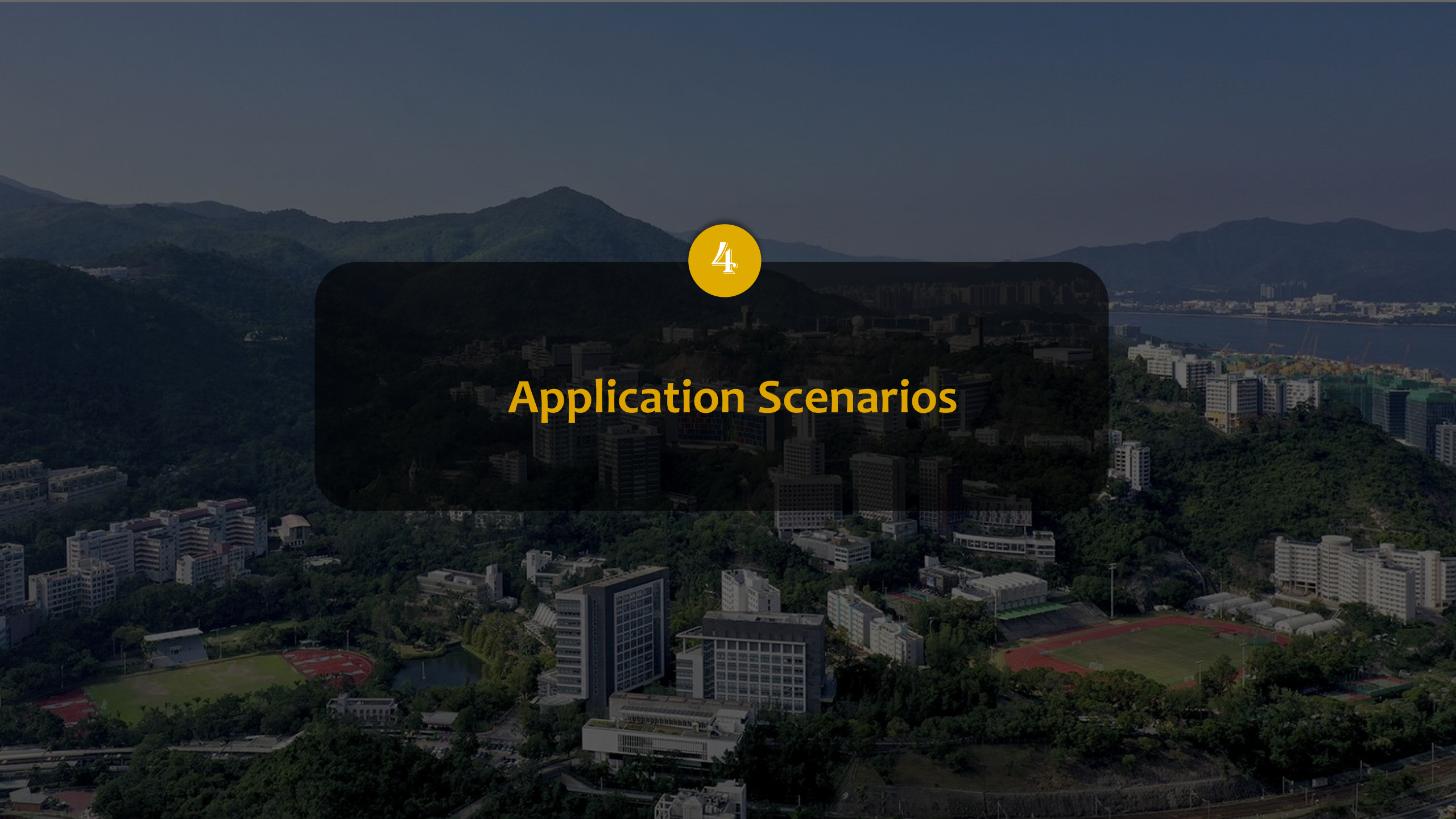

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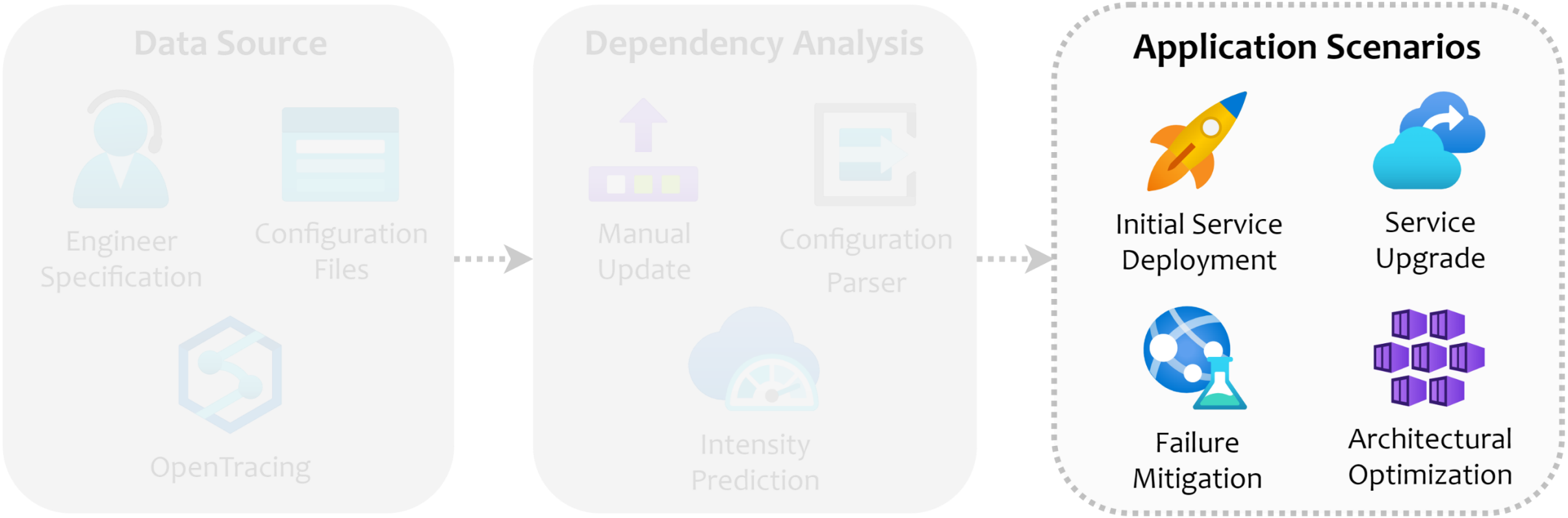
Application Scenarios

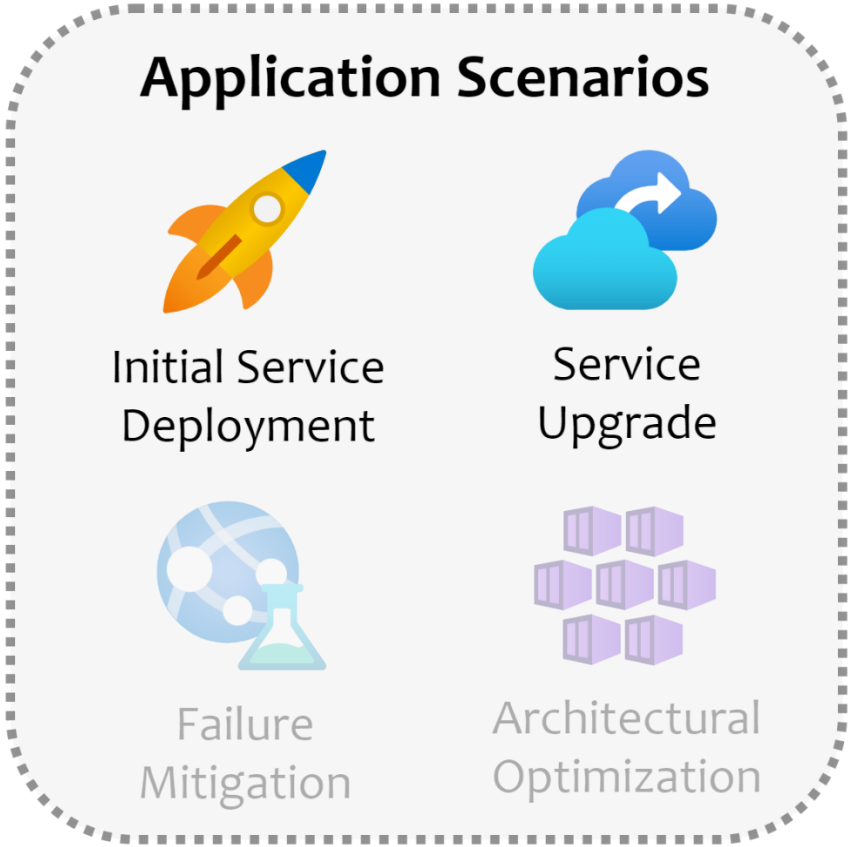
Application Scenarios Overview



Initial Service Deployment & Service Upgrade

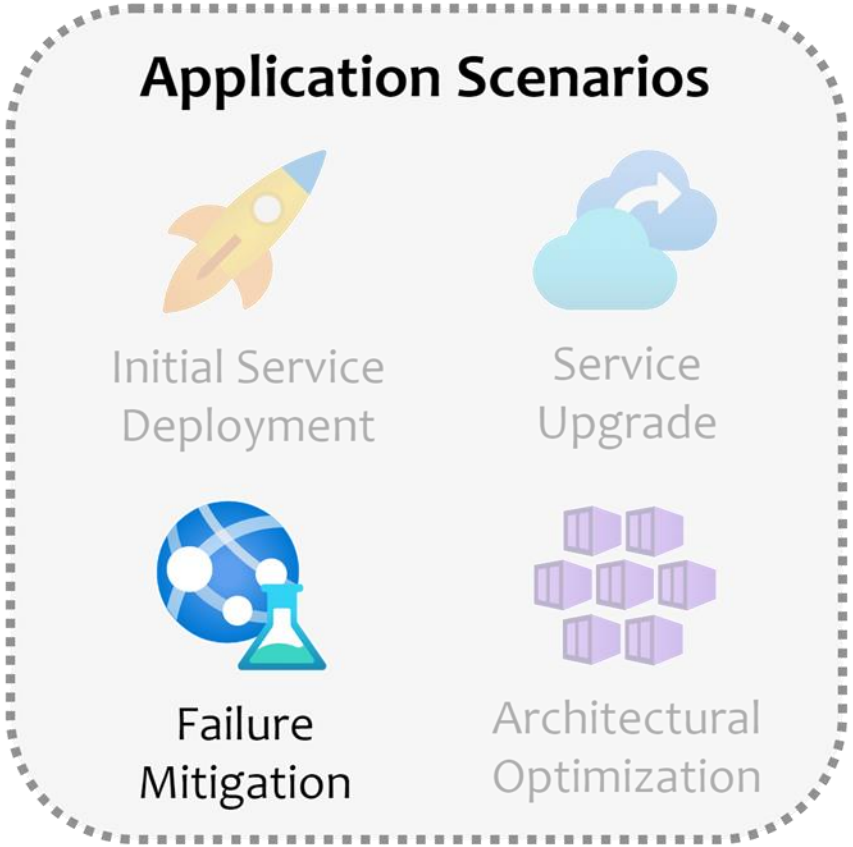
- Initial Service Deployment
  - Automatically discriminate between the compulsory and optional cloud services.
  - Assure the correct deployment of the new service.

- Service Upgrade
  - Check the status of the cloud services and microservices it depends on.
  - Helps avert multi-point failures affecting changes.



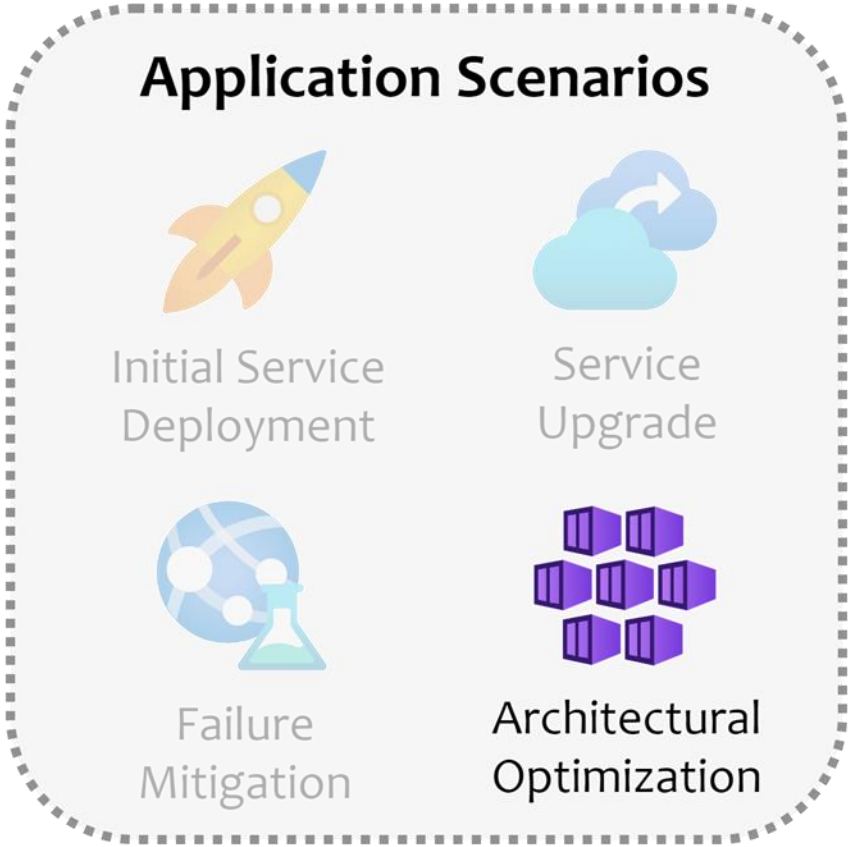
Failure Mitigation

- Failure Mitigation
  - Limit the traffic to critical cloud services.
  - Recover the dependencies marked as “strong” first.



Architectural Optimization

- Optimization of Dependencies
  - Dependency management system detects strong dependencies and reminds engineers.
  - Discovered more than ten unnecessary dependencies within four months.



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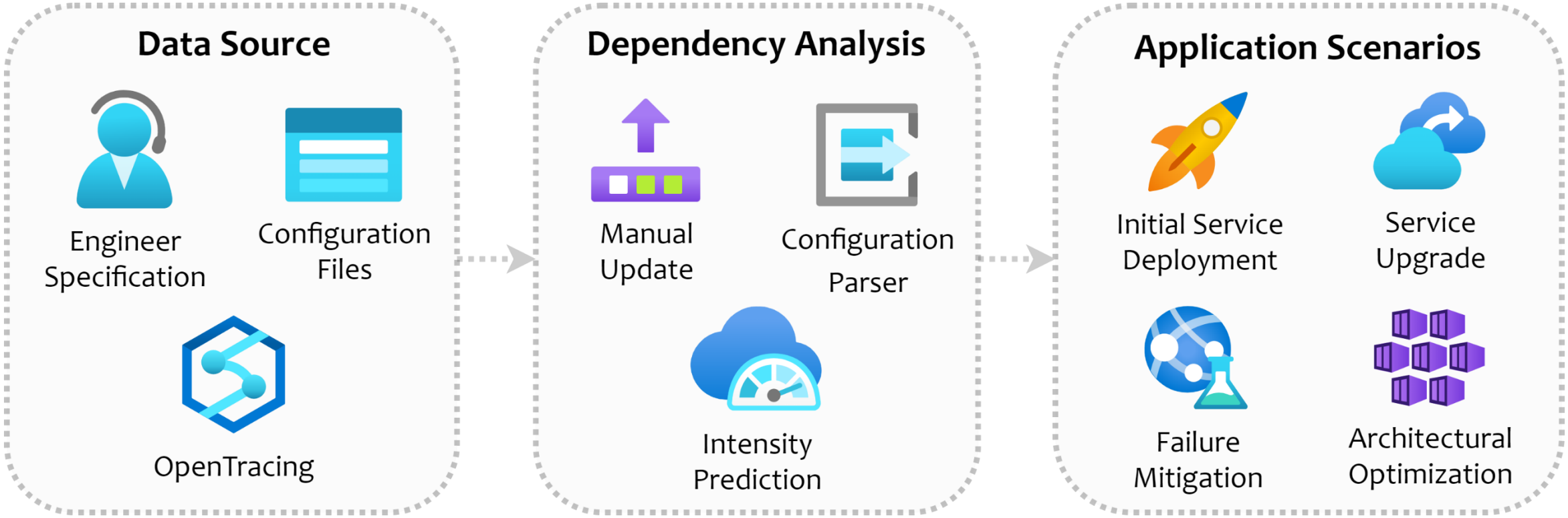

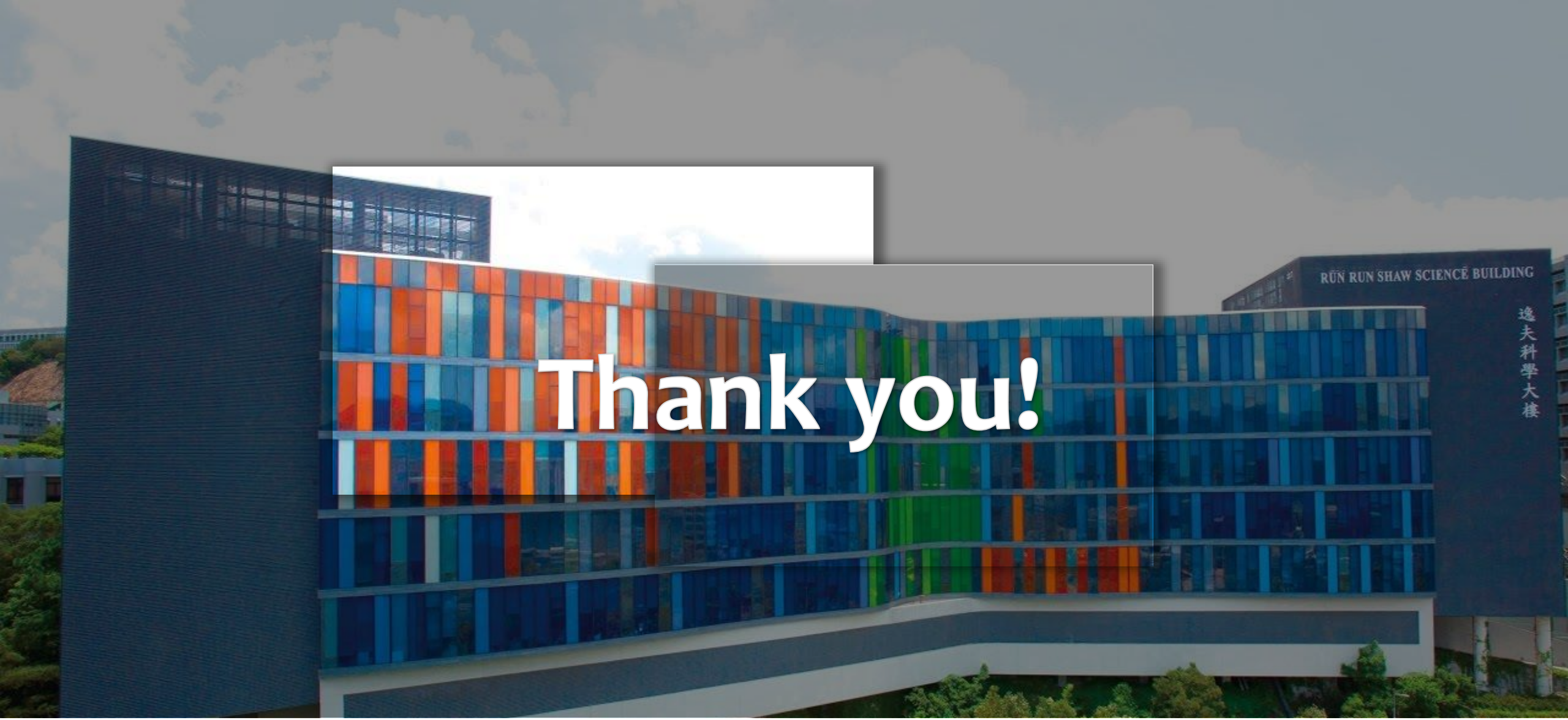

Thank you!

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