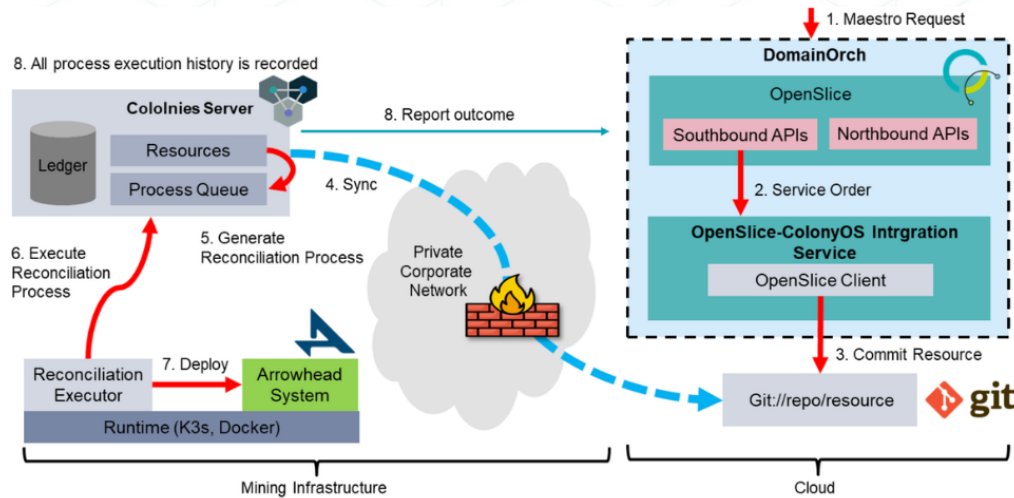


Cluster 1: Business Integration In Mining

Use Case Overview Diagram



Ambition, Mission and Objectives

- Enable secure, service-oriented integration for mining with trusted data access and flexible IoT–Edge–Cloud workload placement under strict safety and governance constraints.
- Demonstrate multi-vendor, multi-technology integration across key mining functions and validate automated, scalable deployment in realistic operating conditions.
- Replace manual, site-specific solutions with interoperable, scalable patterns that accelerate digitalisation and reduce operational and IT complexity.

Description

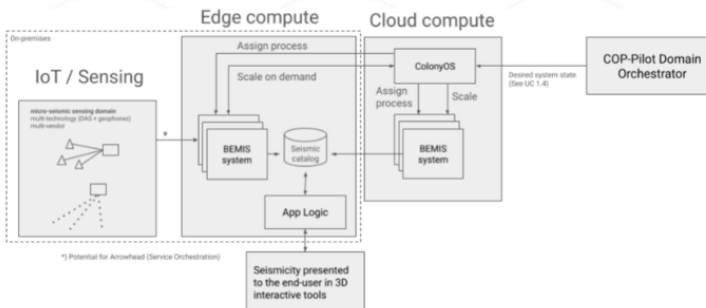
Business Integration in Mining addresses the integration of computing platforms, data services, and deployment models in highly constrained mining environments. It demonstrates secure, interoperable solutions that operate across on-prem edge systems and controlled cloud resources. Through use cases in seismic monitoring, underground logistics and asset tracking, and conveyor condition monitoring, the cluster shows how scalable orchestration and open interfaces can reduce silos and accelerate digitalisation in mining operations.

Pathway to Execution

Execution requires close alignment between business value drivers and technical delivery. Use cases must clearly target safety, productivity, cost efficiency, and compliance, while shared architectures, open interfaces, and common orchestration frameworks ensure consistent deployment across diverse mine environments. Continuous feedback between operators, technology providers, and platform developers is essential to balance operational constraints with innovation and ensure technical scalability and security deliver measurable business impact.

Cluster 1 Use Case Summary

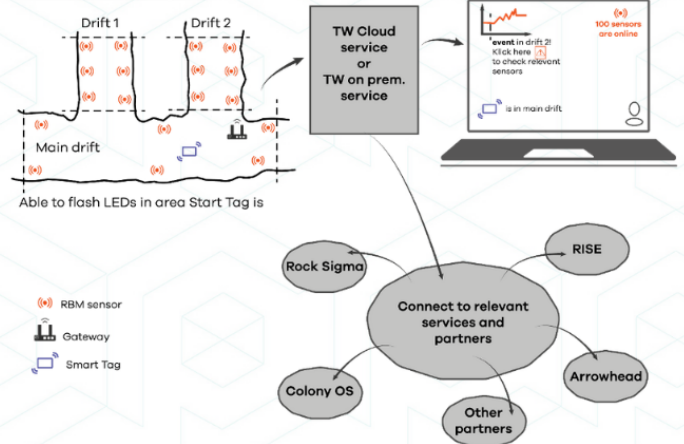
UC 1.1



UC 1.1 enhances underground mining safety by using microseismic sensing and data processing to better understand rock mass behaviour through a unified, interoperable edge-to-cloud workflow.

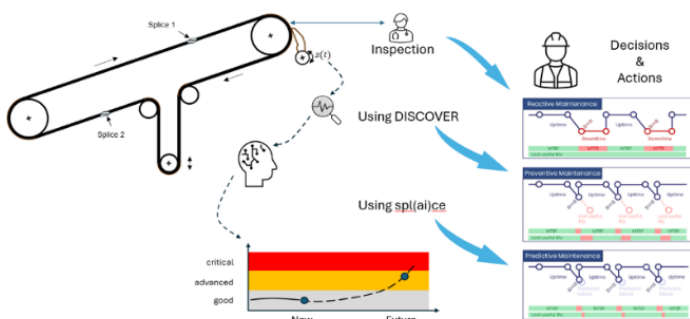
UC 1.2

TW UC overview diagram



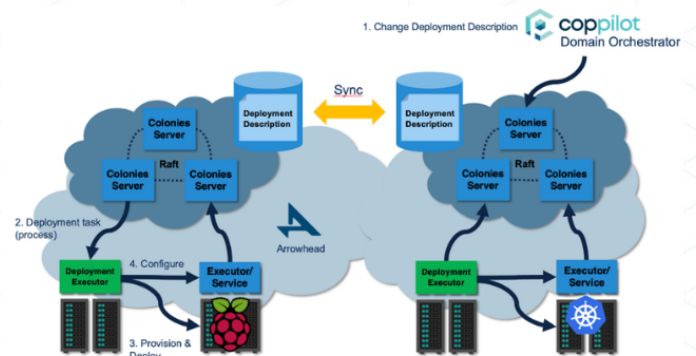
Through this use case, IoT-enabled smart rock bolts accurately track personnel, vehicles, and equipment underground, improving operational efficiency and reducing time lost locating assets.

UC 1.3



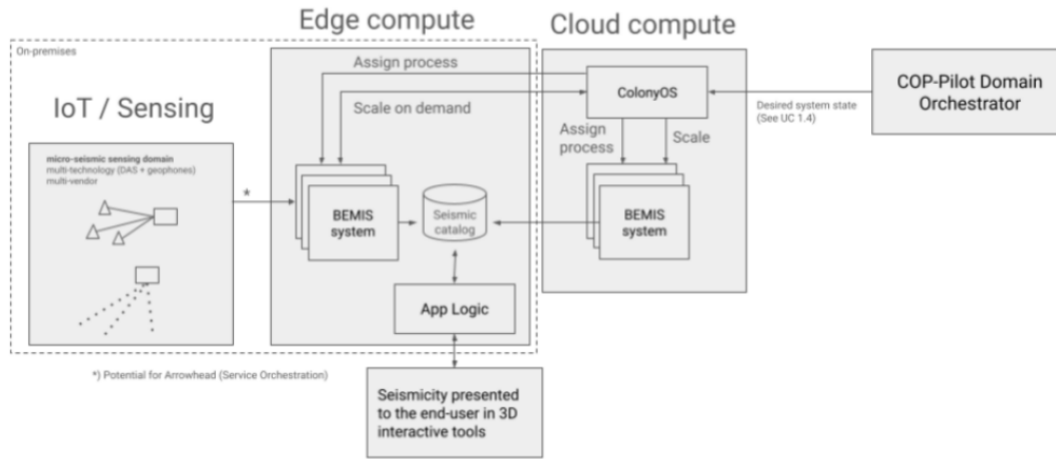
UC1.3 uses data from IoT-enabled belt scrapers, Edge/IoT devices and SCADA, to monitor components in belt conveyors to detect/predict damages reducing failures and downtime. A scalable edge-cloud computing and analytics continuum is demonstrated.

UC 1.4



Use Case 1.4 demonstrates a unified IoT-Edge-Cloud architecture for digital mining, enabling low-latency, scalable, and resilient operations by integrating earlier Cluster 1 use cases.

IoT Mining Seismics



Description

This use case focuses on microseismic sensing and data processing to improve safety and rock mass understanding in underground mining. Mining activities induce seismic events as stress conditions change, which must be monitored to manage the risk of damaging seismicity. The solution enables a unified, multi-vendor and multi-technology workflow covering sensing, data acquisition, processing, and visualisation. RockSigma's BEMIS platform, enhanced with COP-PILOT features, supports interoperable sensor networks, flexible deployment models, and edge-to-cloud processing while meeting mine operator data and infrastructure requirement

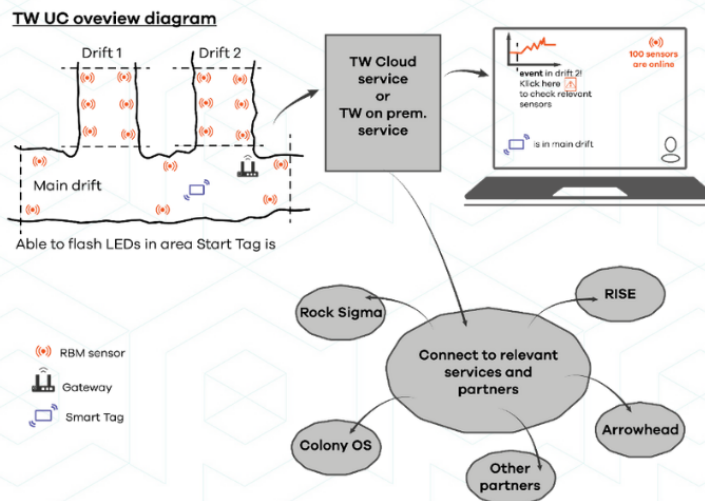
Functional Requirements

This system supports reliable microseismic monitoring through trigger-based seismic sensing and intuitive data visualisation of both historical and near-real-time events. It should enable automated compute provisioning via COP-PILOT integration where feasible, while prioritising low-latency event processing (≈ 50 ms under nominal conditions). Communication links are designed to ensure robust data transfer with a target uptime of approximately 99.9%, accounting for challenging underground environments.

Market Business Requirements

The market business requirements aim to improve productivity and technical flexibility. Enhanced seismic data processing supports a deeper understanding of rock mass behaviour, reducing incident-related production disruptions for mine operators. For application developers, the solution should enable flexible placement of computational workloads across the compute continuum and support scalable processing power. A distributed, microservice-based architecture allows systems to adapt to customer-specific needs and efficiently handle increasing data volumes as operational demands

Logistics IoT



Description

Use Case 1.2 focuses on high-accuracy asset tracking in underground mining using IoT-enabled smart rock bolts. Assets include personnel, vehicles, and equipment, reducing time lost locating resources and improving operational efficiency. The solution builds on ThingWave's Digitalised Ground Support (DGS) system, extending it with enhanced sensors, positioning, and tracking capabilities. Smart rock bolts form a wireless IoT network that supports asset localisation.

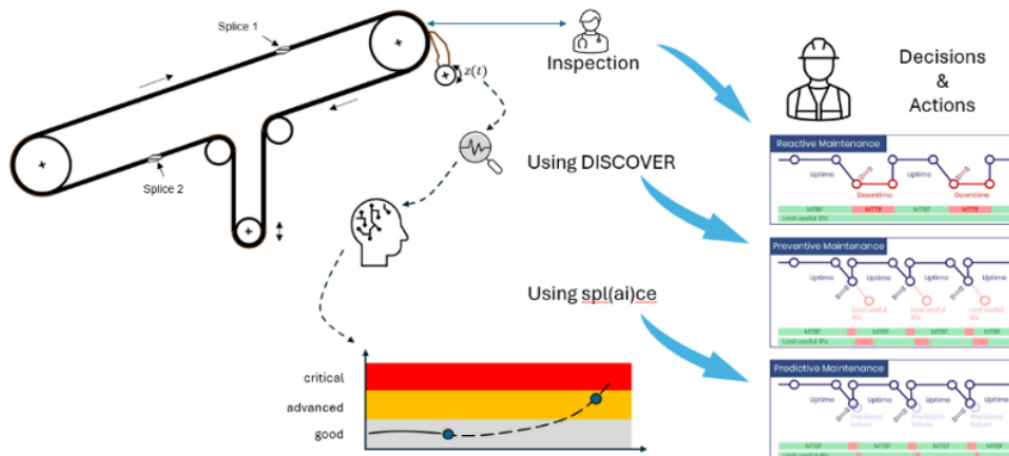
Functional Requirements

The functional requirements for this use case include high-performance, secure monitoring and asset tracking within the TAB DGS solution. The system must support high data-stream bandwidth (up to 10,000 packets per second), low-latency alarm detection (≤ 10 seconds), and scalability to at least 1,000 sensors per gateway. It must ensure accurate rock bolt rupture detection ($\pm 10\%$ of bolt length), rapid fault identification, and regular positional updates for asset tracking. Integration with the ColonyOS/Arrowhead platform is required, alongside robust data security for platform authentication and data transmission.

Market Business Requirements

The market business requirements focus on cost efficiency, scalability, and operational productivity. The solution must significantly reduce deployment costs by cutting physical installation time by over 50% and configuration time by more than 60%. Improved asset monitoring is expected to lower asset-related costs by reducing losses and replacement needs. Additionally, automated rock bolt status reporting replaces frequent manual tunnel inspections, delivering over 100 status reports per day and substantially reducing ongoing operational costs.

Condition Monitoring and Predictive Maintenance In Mining



Description

Continuous material flow is critical in mining, making belt conveyor reliability and their uptime essential. This use case exploits data from IoT-enabled belt scrapers, SCADA systems, and other IoT/edge devices to monitor conveyor condition during operation. Combining *Hosch-Iris* sensing technologies and *Predge Conveyor Analytics and AI*, conveyor components degradation, like e.g. belt or rollers, can be continuously assessed and damages/failures are detected/predicted, enabling timely alerts, predictive maintenance. A scalable edge/cloud compute and analytics continuum to reduce risks and downtimes is demonstrated.

Functional Requirements

The functional requirements for this use case cover the full data lifecycle, from sensing to decision-making. The system must capture condition data, like e.g. scraper movement data tracking the belt surface, securely transmit measurements to the Hosch Iris and Predge cloud, and ingest data into the storage systems. Bidirectional data provisioning services support multiple users, while analytics processes generate actionable insights on component condition. These insights are provisioned using decision support system for maintenance.

Market Business Requirements

The business requirements focus on maintenance predictability and cost-efficient deployment. The solution must detect conveyor belt damage at least eight hours before it becomes critical in over 90% of cases, reducing the risk of unplanned downtime. In addition, automated deployment and orchestration should significantly improve scalability while cutting installation and commissioning time by more than 50%.

IoT-Edge-Cloud-Continuum For Digital Mines

Description

Use Case 1.4 demonstrates a unified IoT-Edge-Cloud continuum for digital mining operations, enabling low-latency processing, scalability, and resilience across distributed computing resources. A testbed at RISE's ICE Datacentre simulates underground mining conditions to validate dynamic resource provisioning and data pipelines. ColonyOS provides federated orchestration and autoscaling, while Eclipse Arrowhead ensures secure edge-level interoperability. UC1.4 integrates earlier Cluster 1 use cases to demonstrate the COP-PILOT edge-to-cloud architecture.

Functional Requirements

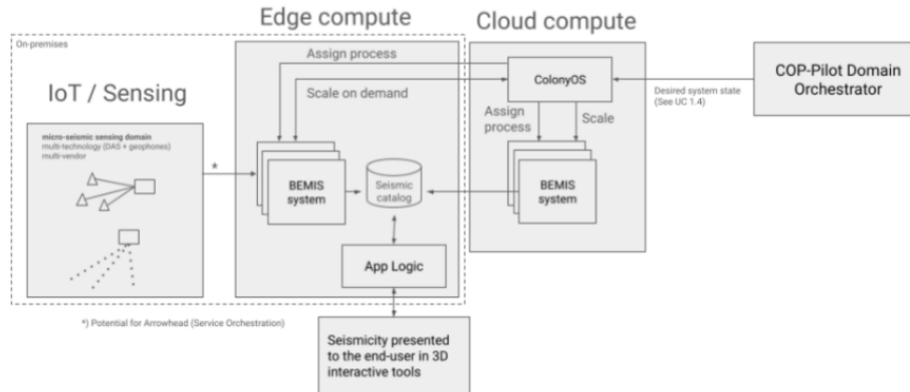
The functional requirements for this use case define how services, compute, and deployments are orchestrated across the Edge-to-Cloud continuum. Service orchestration ensures secure connectivity, identity management, and federated data exchange between sensors, controllers, and platforms. Compute orchestration enables resilient, policy-driven execution of distributed workloads, while deployment orchestration automates provisioning, scaling, recovery, and lifecycle management to optimise performance, reliability, cost, and sustainability across edge and cloud environments.

Market Business Requirements

This business requirement focuses on reducing IT-related costs through advanced automation and orchestration. By efficiently deploying, configuring, and scaling computational resources, the solution minimises manual intervention and operational overhead. This reduces the time, effort, and cost associated with managing IT infrastructure and platforms, delivering measurable efficiency and cost savings for the organisation.

Use Case 1.1

IoT Mining Seismics



Description

This use case focuses on microseismic sensing and data processing to improve safety and understanding of rock mass behaviour in underground mining. Mining activities induce seismic events as stress conditions change, which must be monitored to manage the risk of damaging seismicity. The solution enables a unified, multi-vendor and multi-technology workflow covering sensing, data acquisition, processing, and visualisation. RockSigma's BEMIS platform, enhanced with COP-PILOT features, supports interoperable sensor networks, flexible deployment models, and edge-to-cloud processing while meeting mine operator data and infrastructure requirement

Functional Requirements

This system supports reliable microseismic monitoring through trigger-based seismic sensing and intuitive data visualisation of both historical and near-real-time events. It should enable automated compute provisioning via COP-PILOT integration where feasible, while prioritising low-latency event processing (≈ 50 ms under nominal conditions). Communication links are designed to ensure robust data transfer with a target uptime of approximately 99.9%, accounting for challenging underground environments.

Market Business Requirements

The market business requirements aim to improve productivity and technical flexibility. Enhanced seismic data processing supports a deeper understanding of rock mass behaviour, reducing incident-related production disruptions for mine operators. For application developers, the solution should enable flexible placement of computational workloads across the compute continuum and support scalable processing power. A distributed, microservice-based architecture allows systems to adapt to customer-specific needs and efficiently handle increasing data volumes as operational demands

Instantiation of Use Case

Dense microseismic sensors are deployed underground to continuously capture rock activity. Data is processed across an IoT–edge–cloud continuum, combining on-site sensing, edge analytics, and cloud platforms (i.e., BEMIS). COP-PILOT orchestrates data flows and compute resources, enabling interoperable, multi-vendor integration and scalable deployment across mining environments.

The real benefit in the use case

The solution enables early detection of seismic risks and improved understanding of rock mass behaviour. This enhances worker safety, reduces unexpected shutdowns, and prevents loss of valuable ore. Automated data processing and orchestration support faster decision-making, lower operational costs, and more reliable mining operations.



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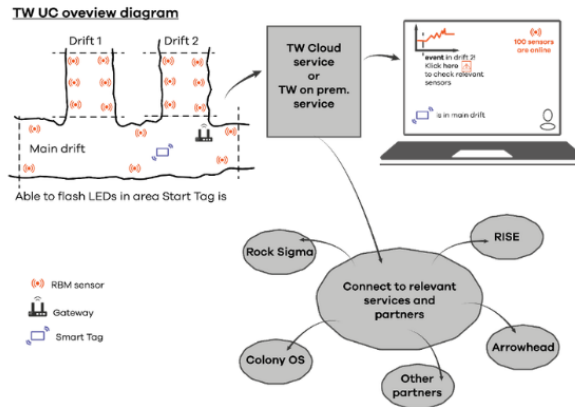
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Use Case 1.2

Logistics of IoT



Description

Use Case 1.2 focuses on high-accuracy asset tracking in underground mining using IoT-enabled smart rock bolts. Assets include personnel, vehicles, and equipment, reducing time lost locating resources and improving operational efficiency. The solution builds on ThingWave's Digitalised Ground Support (DGS) system, extending it with enhanced sensors, positioning, and tracking capabilities. Smart rock bolts form a wireless IoT network that supports asset localisation

Instantiation of Use Case

IoT-enabled smart rock bolts and sensors are deployed across underground infrastructure to track personnel, vehicles, and equipment. Data is transmitted via wireless networks and integrated into the ThingWave's DGS, with COP-PILOT enabling real-time data aggregation and analytics across interoperable systems.

Functional Requirements

The functional requirements for this use case include high-performance, secure monitoring and asset tracking within the TAB DGS solution. The system must support high data-stream bandwidth (up to 10,000 packets per second), low-latency alarm detection (≤ 10 seconds), and scalability to at least 1,000 sensors per gateway. It must ensure accurate rock bolt rupture detection ($\pm 10\%$ of bolt length), rapid fault identification, and regular positional updates for asset tracking. Integration with the ColonyOS/Arrowhead platform is required, alongside robust data security for platform authentication and data transmission.

The real benefit in the use case

The solution improves operational efficiency by enabling accurate, real-time asset tracking and reducing time spent locating resources. It enhances safety by maintaining visibility of personnel and equipment, while lowering costs through reduced manual inspections and optimised logistics workflows.

Market Business Requirements

The market business requirements focus on cost efficiency, scalability, and operational productivity. The solution must significantly reduce deployment costs by cutting physical installation time by over 50% and configuration time by more than 60%. Improved asset monitoring is expected to lower asset-related costs by reducing losses and replacement needs. Additionally, automated rock bolt status reporting replaces frequent manual tunnel inspections, delivering over 100 status reports per day and substantially reducing ongoing operational costs.



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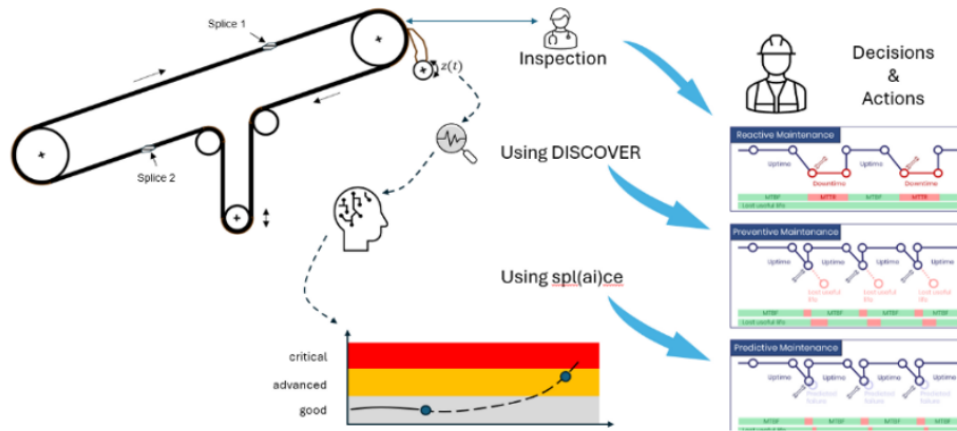
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Use Case 1.3

Condition Monitoring and Predictive Maintenance In Mining



Description

Continuous material flow is critical in mining, making belt conveyor reliability and their uptime essential. This use case exploits data from IoT-enabled belt scrapers, SCADA systems, and other IoT/edge devices to monitor conveyor condition during operation. Combining Hosch-Iris sensing technologies and Predge Conveyor Analytics and AI, conveyor components degradation, such as belt or rollers, can be continuously assessed and damages/failures are detected/predicted, enabling timely alerts, predictive maintenance. A scalable edge/cloud compute and analytics continuum to reduce risks and downtimes is demonstrated.

Functional Requirements

The functional requirements for this use case cover the full data lifecycle, from sensing to decision-making. The system must capture condition data, like e.g. scraper movement data tracking the belt surface, securely transmit measurements to the Hosch Iris and Predge cloud, and ingest data into the storage systems. Bidirectional data provisioning services support multiple users, while analytics processes generate actionable insights on component condition. These insights are provisioned using decision support system for maintenance.

Market Business Requirements

The business requirements focus on maintenance predictability and cost-efficient deployment. The solution must detect conveyor belt damage at least eight hours before it becomes critical in over 90% of cases, reducing the risk of unplanned downtime. In addition, automated deployment and orchestration should significantly improve scalability while cutting installation and commissioning time by more than 50%.

Instantiation of Use Case

IoT sensors and SCADA systems monitor conveyor belts and critical equipment in real time. Data is processed at the edge and in the cloud using analytics platforms (i.e., Hosch-Iris and the Predge platform), with COP-PILOT orchestrating data ingestion, processing, and service delivery across distributed environments.

The real benefit in the use case

The system enables early detection of faults and predictive maintenance, reducing unplanned downtime and maintenance costs. It ensures continuous material flow, improves equipment reliability, and extends asset lifespan, supporting more efficient and resilient mining operations.



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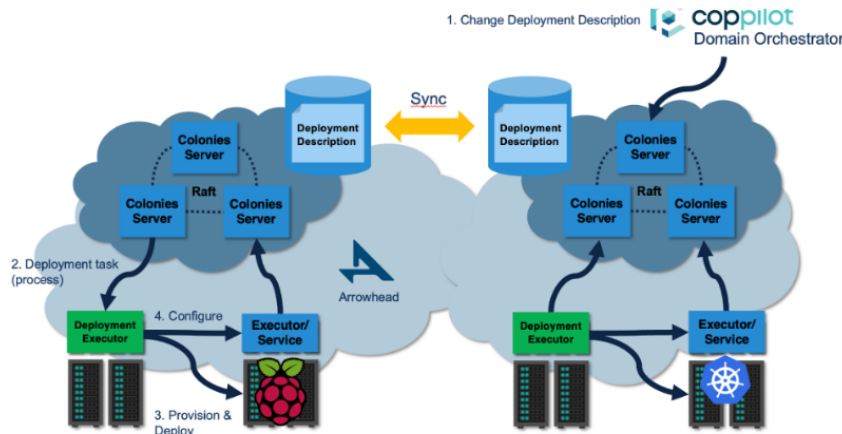
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Use Case 1.4

IoT-Edge-Cloud-Continuum For Digital Mines



Description

Use Case 1.4 demonstrates a unified IoT-Edge-Cloud continuum for digital mining operations, enabling low-latency processing, scalability, and resilience across distributed computing resources. A testbed at RISE's ICE Datacentre simulates underground mining conditions to validate dynamic resource provisioning and data pipelines. ColonyOS provides federated orchestration and autoscaling, while Eclipse Arrowhead ensures secure edge-level interoperability. UC1.4 integrates earlier Cluster 1 use cases to demonstrate the COP-PILOT edge-to-cloud architecture.

Functional Requirements

The functional requirements for this use case define how services, compute, and deployments are orchestrated across the Edge-to-Cloud continuum. Service orchestration ensures secure connectivity, identity management, and federated data exchange between sensors, controllers, and platforms. Compute orchestration enables resilient, policy-driven execution of distributed workloads, while deployment orchestration automates provisioning, scaling, recovery, and lifecycle management to optimise performance, reliability, cost, and sustainability across edge and cloud environments.

Market Business Requirements

This business requirement focuses on reducing IT-related costs through advanced automation and orchestration. By efficiently deploying, configuring, and scaling computational resources, the solution minimises manual intervention and operational overhead. This reduces the time, effort, and cost associated with managing IT infrastructure and platforms, delivering measurable efficiency and cost savings for the organisation.

Instantiation of Use Case

This use case integrates sensing and analytics from UC 1.1, 1.2, and 1.3 into a unified IoT-edge-cloud architecture. Distributed IoT devices, edge nodes, and cloud systems are orchestrated via COP-PILOT, using technologies like ColonyOS and Eclipse Arrowhead to enable seamless deployment, scaling, and data exchange.

The real benefit in the use case

The integrated continuum enables low-latency, scalable, and resilient operations by optimising resource usage across edge and cloud. It reduces IT overhead through automation, improves interoperability, and accelerates digital transformation with real-time insights and more efficient mining processes.