ecosystm

SOFTWARE-DEFINED MINING

Underpinning the Digital Mine of the Future

AUTHORED BY
DARIAN BIRD
Principal Advisor

MARCH 2021

NetApp

INTRODUCTION

The Mining industry faces several significant challenges including volatility of commodity prices, environmental risks, and ensuring health and safety of the employees.

The industry has been undergoing transformation leveraging machine generated data from multiple assets – such as wearables, drones, trucks, and crushers. This blending of the physical and digital worlds results in innovation in safety, productivity, resiliency, and sustainability. In the Mine of the Future, data will be captured, analysed, and will flow across the entire mining process – from mine to market – breaking down silos. Data can become a competitive advantage for mining companies as they use it to automate operations, increase efficiency, and deliver improved outcomes for employees. Leading mining companies have reported 15-20% gains in productivity from their digital initiatives.

Ecosystm research shows that mining companies are exploring ways to leverage data for optimisation and automation (Figure 1).

Figure 1: Mining Industry Ready to Leverage Data

Source: Ecosystm, 2021 *N=56*

Underpinning advancements such as autonomous equipment, predictive maintenance, and AI-enhanced safety, is Software-defined Mining – a solution that integrates information from edge, core, and cloud computing through the implementation of a data fabric strategy.

This whitepaper discusses the challenges faced by the industry and how Software-defined Mining can improve safety, reduce costs, and increase efficiency.

CHALLENGES OF THE MINING INDUSTRY

SAFETY

In an industry where employees face danger each day, safety is of paramount importance in Mining.

Major mining companies aspire to zero fatalities – however, they are aware that without diligence they are one moment away from potential tragedy. While modern operations have created environments that make fatalities rare, preventing injury is a continual endeavour. Accidents range from high potential incidents like rock fall, to long-term health complications due to persistent dust exposure. It is important to collect not only historical data when injuries occur but also leading indicators to shape safety policies.

The International Council on Mining and Metals (ICMM), whose 27 members include leading companies, such as Rio Tinto, BHP, Vale, and Glencore, has reported a steadily decreasing injury rate over the last decade. The total recordable injury frequency rate (TRIFR) among members fell to 3.20 injuries per million hours worked in 2019 – down from 5.07 in 2012. As mining companies strive for zero-harm workplaces, technology will play a significant role in driving down the injury rate further.

ROLE OF TECHNOLOGY IN ENSURING SAFETY

Removing workers from dangerous environments

A key tool in improving safety is to remove workers from situations that have potential for danger. Historically, vehicle collision, runaway, over edge, and rollover incidents have been leading causes of injury. A significant safety innovation was autonomous haul trucks to keep drivers out of harm's way. Similarly, drones for inspection of high walls, unstable ground, and stopes provide 3D assessments without requiring employees to physically approach high-risk areas.

Location-based hazard avoidance

Dangers in mining operations are dynamic, often presenting themselves without the awareness of workers. Location tracking in wearables, such as smart hardhats, identify dangerous situations that alert workers to take action to avoid injury. Geo-fencing to enforce blast area security can trigger workers' mobile alarms if they stray into an unsafe zone. Likewise, underground ventilation systems can intensify when diesel equipment is in proximity to personnel.

AI-enforced safety compliance and response

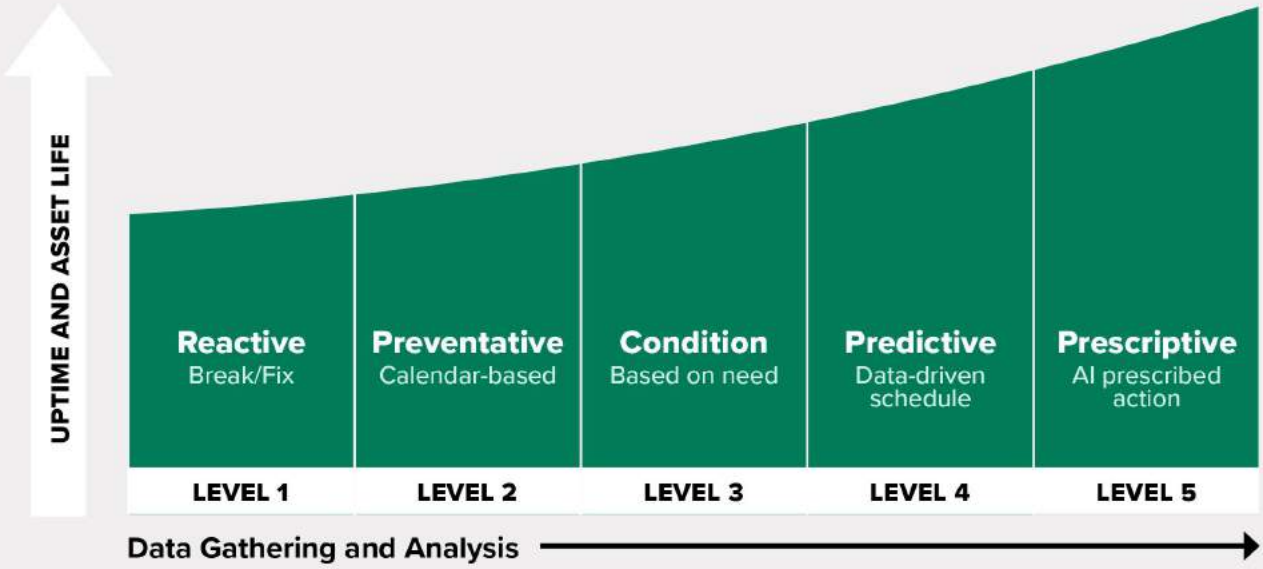
Safety policies are only as strong as their supporting enforcement practices. Video with machine learning can identify workers not wearing protective equipment and alert management. Rapid first aid response is made possible by accident detection systems that recognise workers in prone positions based on video feeds, falls from height, and anomalous cardiac events.

PRODUCTIVITY

The length of time required to shift from exploration to production and fluctuations in commodity prices makes access to capital one of the greatest financial challenges in Mining.

Companies therefore attempt to squeeze every ounce of productivity from their assets, whether it is a train or a server. This means ensuring assets are productive as often as possible and that their lifecycle is maximised.

Figure 2: Prescriptive Maintenance for Improved Asset Productivity



Source: Ecosystm, 2021

ROLE OF TECHNOLOGY IN IMPROVING PRODUCTIVITY

Automation and Remote Operations

Automation boosts productivity while prolonging equipment life. For example, innovations such as automated levelling and fibre optic survey systems refine drilling and blasting precision. As mining companies make the shift from isolated control rooms to fully integrated remote operations centres (ROCs), gains are made in productivity, safety, and employee experience. Automation of repetitive tasks and remote control allows a single operator to monitor multiple machines. Idle time is reduced when machinery is stationary or performing tasks autonomously, leaving operators to focus on higher value work. Moreover, employees based in urban areas no longer require transportation to distant mines. This also provides the opportunity to create centres of excellence to serve multiple sites.

Predictive and Prescriptive Maintenance

The advent of condition monitoring using sensors and analytics has enabled the shift from calendar-based to predictive maintenance, developing an optimised service schedule for each asset. The next step will be prescriptive maintenance, suggesting and even implementing proactive adjustments such as temporarily reduced payload weights to extend the life of a worn part until it can be replaced. Baseline conditions and failure signatures are improved using machine learning based on feeds from multiple sensors, such as those that monitor vibration, sound, temperature, pressure, and humidity.

BUSINESS CONTINUITY AND RESILIENCY

Disruptions have challenged the Mining industry throughout its long history. The remote and dangerous nature of Mining means there are many sources of disruptions, including natural disasters, political disturbances, labour actions, injuries, equipment failures, power failures, and IT outages. As in most industries, pandemics have now been added to the list of disruptors. State and national border closures have affected employee movements and many sites have either closed or limited arrivals. In many cases, non-critical activities have been postponed during the pandemic. These unplanned disruptions can cost organisations hundreds of millions of dollars each year.

TECHNOLOGY SOLUTIONS TO MITIGATE DISRUPTION INCLUDE

Automation-assisted social distancing

Even those workers with positions that do not require close contact with colleagues will struggle to adhere to social distancing guidelines in areas of congregation, such as transportation, dining halls, and changing rooms. Reducing the number of employees on-site by using autonomous machinery and remote operations reduces the risk of outbreak.

Energy management

Disruption of power can leave miners stranded without lifts and destroy smelters if molten metal is left to harden. As the industry shifts towards on-site renewable energy with storage, power management systems will be used to optimise generation and consumption and minimise outages.

Equipment failure

Employing predictive maintenance ensures lower rates of equipment failure. Creating a network of intelligent machines means, for example, that autonomous haul trucks can decide to remain in line while another vehicle is repaired or head to an alternative destination depending on predicted wait times.

SUSTAINABILITY AND SOCIAL RESPONSIBILITY

The Mining industry is responding to increasing pressure to address the climate crisis, limit its impact on local environments, and responsibly engage with indigenous communities.

The primary focus areas for decarbonisation are:

- **Scope 1. Reduce diesel consumption in transportation. This includes efficiency and electrification of haul trucks. Reduce fugitive methane emissions in coal mining.**
- **Scope 2. Transition to renewable sources for electricity generation and energy efficiency measures to reduce consumption.**

Major mining companies that have committed to becoming net zero carbon emitters include BHP, Rio Tinto, and Vale (by 2050) and Fortescue (by 2040). These goals include Scope 1 emissions – directly associated with company-controlled activities – and Scope 2 emissions – indirectly arising from the generation of purchased electricity.

The industry has yet to reach a consensus about who is responsible for and the level of control mining companies have over Scope 3 emissions – those produced by upstream suppliers and downstream consumers. Coal-fired power plants, aluminium smelters, and steel mills are among the most carbon-intensive facilities in the world meaning Scope 3 accounts for well over 90% of emissions for most mining companies. Some of the more promising solutions being trialled include partnerships to research more sustainable metallurgical techniques, alternative shipping fuels, and alliances to develop blockchain platforms that accurately report carbon emissions through the value chain.

The development of wirelessly connected sensors ensures environmental monitoring systems deliver real-time data that can be acted on immediately rather than relying on intermittent and labour-intensive manual collection. Moreover, solar-powered units can be deployed further from central electricity sources reducing limitations on placement. As a result, readings for ground water quality, dust, and emissions can be measured not only close to main work sites but at the mine perimeter. Forecasts from on-site weather stations can reduce environmental effects, for example by informing blasting scheduling decisions during windy conditions, which would otherwise carry dust to nearby populations.

THE NEED FOR SOFTWARE-DEFINED MINING

A legacy characteristic of many mining operations is their highly siloed divisions, which when digitalised translates into small, isolated operations rooms that lack integration.

Data generated at each stage of the mining process tends not to be accessible throughout the value chain. As a growing number of machines become connected, data flows will increase, leaving valuable insights untapped. Software-defined Mining is a solution that enables companies to use data fabric to securely synch and integrate data of all types through the mining process. A data fabric is a set of hardware and software-based solutions that enables organisations to capture data at the edge, cloud and core, and seamlessly allows applications deployed across those locations to access data – irrespective of where it was generated. This simplification of the data layer in complex and often a challenging architecture is necessary to build and deploy AI-enhanced software, giving rise to the Software-defined Mines. When data is combined with deep learning and AI, it becomes the lifeblood of the Digital Mine.

Figure 3: Mining Value Chain: From Mine to Market

Source: Ecosystm, 2021

EDGE COMPUTING

In the remote mining environment – spread over geographically broad areas – connectivity to a central data centre or the cloud presents a challenge.

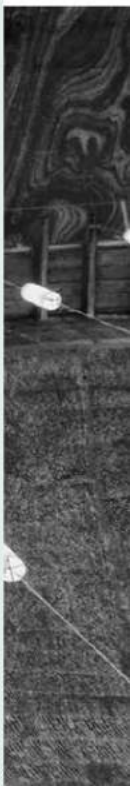
Moreover, vast streams of machine data are generated and in the case of autonomous vehicles, condition monitoring, and safety alerting, low latency takes on great importance. Edge computing devices connected directly or closely to sensors with onboard compute power can pre-process data before uploading only pertinent insights. For example, this might include analysing performance data of an ore crusher locally for automatic calibration, with only urgent alarms and meta data transmitted to the remote operations centre and additional feeds optionally stored to feed into new inference models.

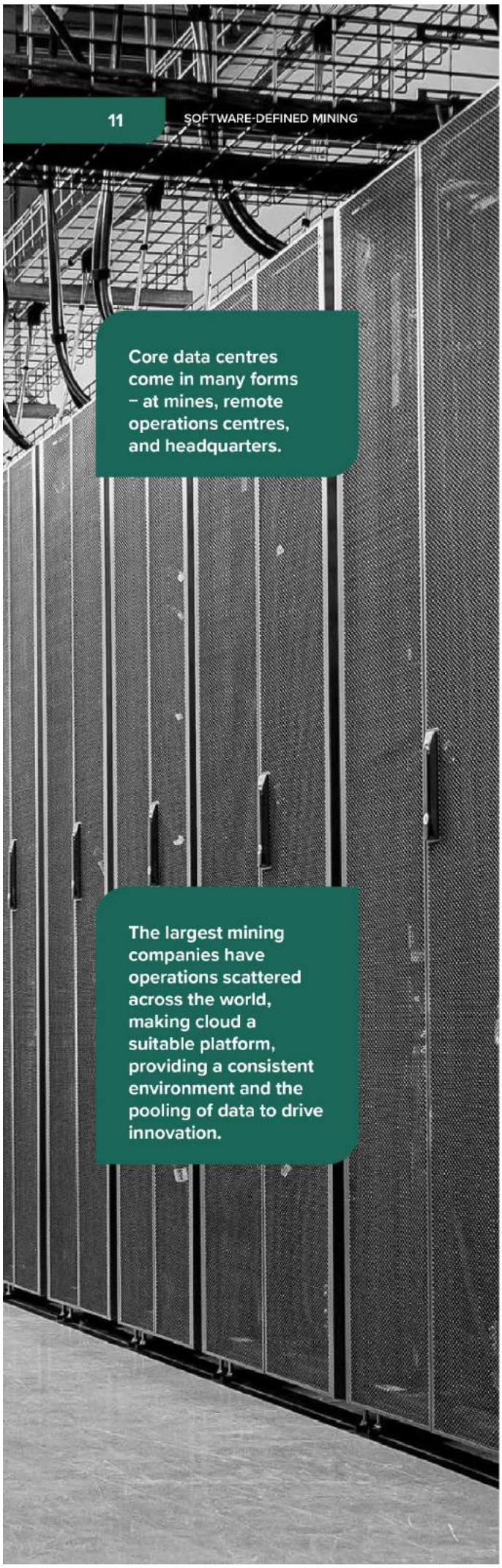
The roll out of 5G will be a gamechanger for edge computing, creating an optimal blend of processing power in or near the field and low-latency connectivity to the cloud. A mining use case could be robotic dogs for visual inspection connected by 5G to AI systems either at an operations centre or in the cloud.

A Software-defined Mining platform deployed to manage edge devices should be flexible enough to handle the broad range of applications needed at a Digital Mine. An orchestration platform ensures lightweight containers can be deployed even on smaller, limited devices, and offers high availability and scalability. The most important aspect of Software-defined Mining is the ability to deliver updates and new applications in a non-disruptive manner, ensuring that equipment benefits from the latest inference models available.

EDGE DEVICES SHOULD HAVE MULTIPLE FEATURES

1. **Software-defined**
   Non-disruptive updates to system software and inference models; vendor agnostic
2. **Configurability**
   Range of configurations e.g. smaller and power-efficient for drone applications; larger for condition monitoring of stationary equipment; or ruggedised for vehicles and other exposed scenarios
3. **Seals**
   Against dust and weather
4. **Protection against temperature extremes**
   Heat exchanger and powered heater
5. **Redundant hardware**
   Ensure redundancy and reduce maintenance
6. **Security**
   Physical intrusion prevention and detection
7. **Connectivity options**
   Accommodate wired and wireless networks and futureproofed with 5G antennas
8. **GPU Options**
   Improved performance for machine learning, video processing, and other 3D computation





Core data centres come in many forms – at mines, remote operations centres, and headquarters.

The largest mining companies have operations scattered across the world, making cloud a suitable platform, providing a consistent environment and the pooling of data to drive innovation.

CORE DATA CENTRES

The requirements of each site differ, in terms of physical conditions and workloads carried out. A mine-based data centre will be focused on data historian and supply chain management. Preconfigured, container-based data centres, requiring only power and connectivity before being deployed remotely, are particularly suitable in this environment. Automation assists with simplifying set up and improving time to value. Meanwhile, remote operations centres or headquarters will be tasked with improving learning models rolled out at the edge. This requires HPC-AI infrastructure. Headquarters will also be host to more traditional workloads, such as ERP and archiving. These core data centres become on-ramps to the cloud for data gathered from edge infrastructure.

CLOUD SERVICES

Moreover, the cyclical nature of each mine requires the scalability that cloud offers as computing needs shift through the lifecycle from exploration to restoration. Scalability is particularly important with investment levels fluctuating according to commodity prices and global demand, making long-term demand for infrastructure difficult to predict. Cloud services also provide the benefit of resiliency and low up-front and long-term costs.

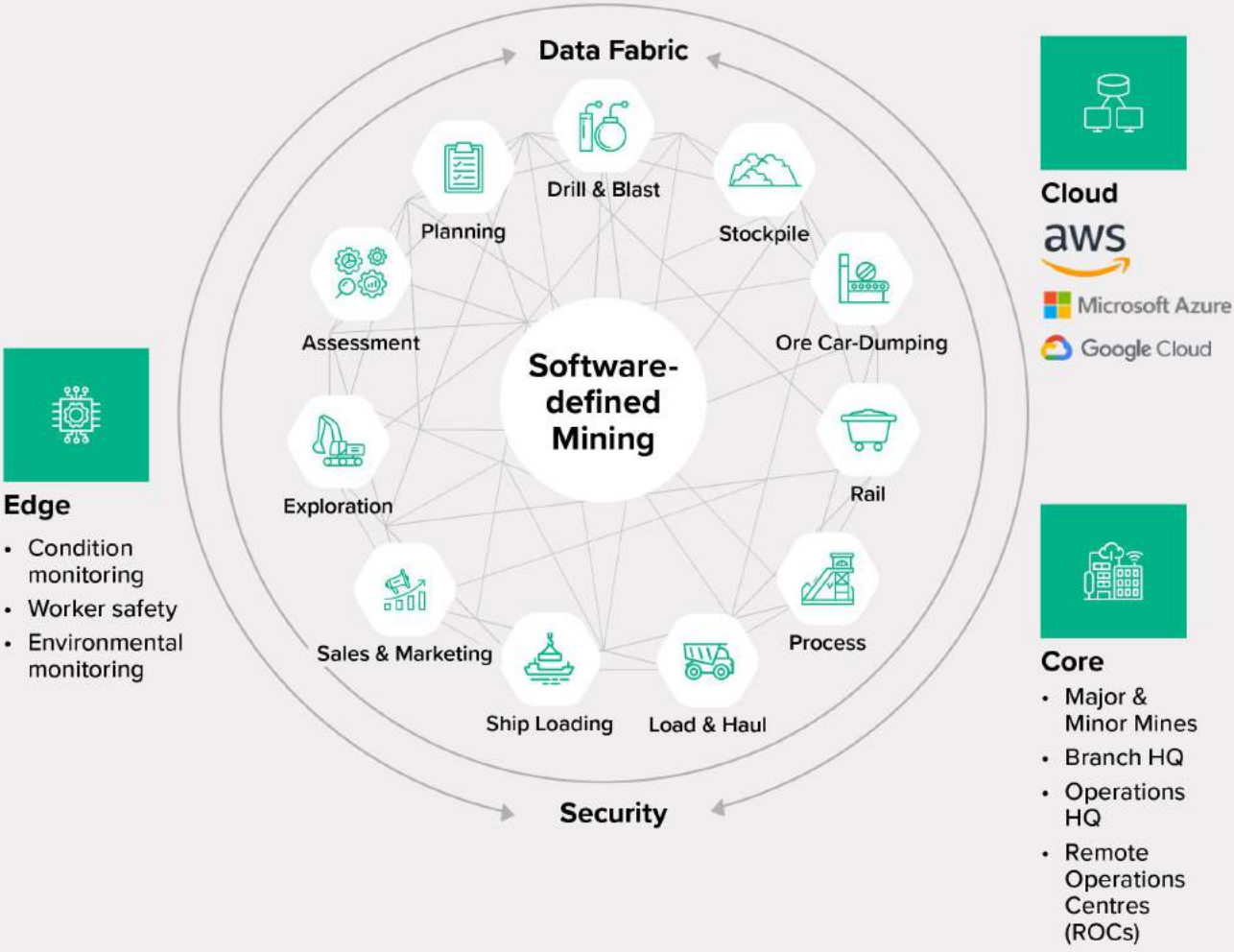
A Software-defined Mining solution should integrate with the largest cloud providers, namely AWS, Microsoft Azure, and Google Cloud. Developing a multi-cloud strategy enables users to adopt a diversity of cloud types, e.g., Graphcore intelligence processing units (IPUs) on Azure for natural language processing or tensor processing units (TPUs) on Google Cloud for machine learning. Offerings suited to the Mining industry include HPC, time-series databases, IoT platforms, and AI and machine learning. Containerised versions of some of these applications are available to be run on edge devices.

DATA FABRIC

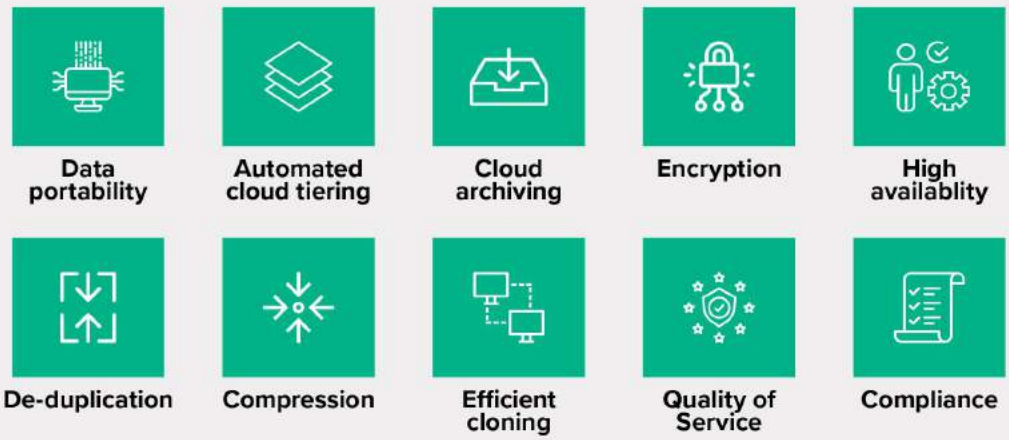
Key to a Software-defined Mining platform is the creation of a simple and secure data fabric that spans edge, cloud, and core data centres.

The development of data fabric comes in response to the ever-growing number of data types, computing environments, and distributed locations, in which insights may be generated. This approach to data management employs pre-packaged connectors and components to support seamless integration of data from edge, core, and cloud sources. Today's data silos can be dismantled and unified to provide mining companies with access to new insights across the whole process from mine to market. Data fabric enables the ingestion and movement of IoT data from edge devices back to the core or cloud to deliver machine and deep learning training data that can be accessed by data scientists. Upon improving inferencing models, a push service updates edge devices in the field after validating as a trusted source. Another example is delivering fragmentation data from the drilling and blasting phase further downstream to optimise the beneficiation phase.

Figure 4: Software-defined Mining



ENHANCED DATA MANAGEMENT



Source: Ecosystm, 2021

IMPLICATIONS FOR MINING CIOs AND IT TEAMS

Mining companies must transform to take advantage of new streams of information generated by their assets.

The Digital Mine requires computing at every level – from conveyers, to drones, to remote operations centres, and ERP systems. Selecting the right compute type – edge, cloud, or core data centre – for the right workload is crucial. Deploying data fabric ties these computing models together and helps mining companies to extract the full value of the enterprise data. It is important to select a data fabric that is flexible enough to grow incrementally and encompass additional parts of the business over time.

Software-defined Mining integrates the diversity of data types, sources, and computing environments across the phases of the mining process to break down silos. Having ready access to data when and wherever it is needed, results in greater safety, productivity, resiliency, and sustainability for mining companies.

Outcomes that a robust Software-defined Mining solution will help mining organisations to achieve:

- **Greater resiliency.** In the event of device, power, or connectivity failure, redundant resources ensure continuity.
- **Migration to cloud.** Seamless integration of edge, core, and cloud provides a path to infrastructure modernisation.
- **Faster deployment.** Capacity can be scaled by adding new machines, physical or virtual, into the resource pool. Plug-and-play simplicity provides the ability to deploy new infrastructure remotely.
- **Increased security and compliance.** Secure movement of data between computing environments and mining phases.
- **Efficient data management.** Deduplication, compression, efficient cloning, encryption, and automated cloud tiering.

About the Author
DARIAN BIRD

Principal Advisor, Ecosystm

Darian helps businesses navigate the path towards digital transformation, providing insight into cloud, automation, cybersecurity, and outsourcing. He has spent two decades advising business leaders on using technology to enter new markets, improve client experience, and enhance service delivery.

Previously, Darian spent ten years at IBM, where he was a principal advisor for infrastructure services and hybrid cloud in Europe. Prior to this, he was a research manager at IDC, gaining emerging markets experience in Asia Pacific, Central Eastern Europe, Middle East, and Africa. In his final position, Darian headed up IDC's ANZ offshore research team based in Kuala Lumpur.

Originally from New Zealand, Darian is based in Prague, the Czech Republic. He holds a Bachelor of Business, majoring in marketing, from the University of Auckland. Outside of the office, Darian enjoys running up mountains, biking with his young daughters, and researching his family tree.