Mining in the cloud: disruptive innovation

How will the next generation of mining software be delivered?

Andy Mulholland, GEOVIA Portfolio Management Director, Dassault Systèmes

Mining has historically been a conservative industry — slow to adopt new technology, and slow to change. The more recent mining super cycle exit has seen an enormous push (through necessity) to squeeze every last piece of productivity out of incumbent assets. But there is only so far that this approach can go, and incremental productivity gain is not going to move the needle now.

The mining industry is ripe for disruption, and we hear the term ‘digital transformation’ starting to take hold in the industry. This requires a step change in the way mining software is delivered and thus the way mining itself is executed. We have already seen the first waves of disruption to traditional jobs in mining. Remote operations centres lead to a significant increase in safety by removing people from an inherently dangerous environment. However, the positive knock-on effect also means an operator can live in the city, drop their kids to school in the morning, spend their day at work in the safe surrounds of a remote operations room and go home to the family every night. No fly-in, fly-out and weeks away from home to worry about. The resource pool for this job function suddenly expands hugely, not to mention the considerable reduction in employment cost.

The big mining companies, with the support of the big original equipment manufacturers (OEMs), are already making ground in this space. However, there is a significant opportunity to democratis the technology across the broader mining industry through new emerging technologies, particularly those that make use of the cloud.

In the near future, machines (or rather their software) will make many of the traditional deterministic decisions that a human would otherwise make, and artificial intelligence applications will facilitate even more abstract decisions through machine learning and deep-learning algorithms.

There are many cases in mining that can benefit from this level of automation, and there are many more yet that we can’t even imagine, but which will appear as the technology starts to pervade the mining industry. The sorts of things that we expect to be able to do include:

- apply machine learning to drilling data to guide exploration drill programs
- predict grind settings in advance using fragmentation image analytics and blast drill hardness data
- automatically optimise and control the entire pit-to-port process to maximise net present value (NPV) to the mine plan.

Figure 1. The Mining Internet of Things.
In the near future, machines (or rather their software) will make many of the traditional deterministic decisions that a human would otherwise make.

This level of automation requires several fundamental technologies to succeed and truly transform the digital landscape of the mining industry.

The Mining Internet of Things
Access to real-time data is needed in order to make real-time decisions. This can be achieved through technologies emerging within the domain of the ‘Internet of Things’ (IoT). The mine needs to be instrumented and connected to gather data from the ‘things’ such as haul trucks, shovels, drones, drill rigs and conveyors. In mining, this concept is not new – Supervisory Control and Data Acquisition (SCADA) has long been employed to collect data and control the system. However, the Mining Internet of Things (MIoT) is more than this – it provides embedded technologies to turn a ‘dumb’ machine into an intelligent machine, and allows both centralised and distributed analytics, as well as control and ubiquitous connectivity via the internet. In the evolving field of the industrial internet, decisions are often made centrally in monolithic data analytics applications sitting over ‘data lakes’, but also in a distributed fashion through edge analytics. Any future autonomous mining platform will need to support both scenarios in order to be successful.

The MIoT will be:
- digitally connected; ie connected and monitored centrally
- data driven, meaning new data will drive real-time decisions and contribute to new knowledge
- model-based, allowing (for example) new geology models to automatically influence the mining schedule
- simulated; ie playing forward scenarios in the virtual world before they are implemented in the real world.

Semantic data
However, there’s no point in collecting mass amounts of data unless it can be understood, especially by machines. Big data or, more importantly, semantic data, allows this. The semantic web was first termed in 2001 by Tim Berners-Lee (founder of the World Wide Web) as a way for both machines and humans to be able to read and understand data on the Web. New data that comes to a semantic model is indexed and automatically linked to other existing available data, and contributes to building a linked graph of information and helps create knowledge.

Immersive visualisation
Remotely operated mines and autonomous equipment is generally visualised today with a combination of CCTV video feeds and aerial photogrammetry. A more immersive experience is necessary to truly understand what’s happening in the mine, and to visualise an evolving mine plan. New technology is emerging in this field to capture aerial photogrammetry for open pit mining, light detection and ranging (LiDAR) and vehicle-mounted stereoscopic photogrammetry for underground mining, all to reconstruct a three-dimensional digital twin of the in situ mine. This creates a need and a great opportunity for immersive visualisation such as virtual reality, holography and augmented reality.

Parametric design
In order for machines to make decisions, the applications need to be fully and intimately connected. If geology changes, then the downstream ripple effect must be automatic, thus updating the mine plan and engineering design without the need for human intervention. Today’s general

OCTOBER 2017  BULLETIN MAGAZINE  19
mine planning solutions are disconnected, siloed and only loosely based on shared data standards. The future of geology, engineering and mine planning software is parametric design, whereby these processes are defined by rules, algorithms and discrete parameter inputs that establish the design intent and response. Any change in an input can then be automatically propagated by the software according to the rules, thus producing new outputs for feeding into the next process. Parametric design removes much of the need for human interpretation and intervention, thus moving the industry one step further towards autonomous mining.

Stochastic planning and simulation
Deterministic mine plans are the result of many assumptions and perceived optimum decisions and, to a great extent, neglect the level of uncertainty that exists throughout the mining process. The earlier it is in the mining design cycle, the more uncertainty there exists. The mere process of geological modelling and resource estimation alone makes assumptions (albeit based on strong geostatistical science) for understanding what is under the earth. The approximations that are made have varying levels of uncertainty attached, but ultimately are used downstream by engineers and mine planners to schedule the extraction activities and sequence of mining. Mining company CEOs are praised when they conform to the plan, and decried by shareholders when they deviate. But in reality, there is never one definitive deterministic plan that is right.

Stochastic mine planning is the science of modelling the uncertainty in all aspects of the modelling, design and mining process, such that a series of mine plans are produced that all honour the uncertainty in the inputs. So long as the mine is operating somewhere between the boundaries of the stochastic plans, it is effectively conforming to plan.

Cloud computing
To truly exploit emerging technologies as they become available, digital innovation must embrace the cloud. Cloud computing is the key enabler for bringing the technologies discussed above to fruition, connecting MIIoT data, unified across all mine sites and across the end-to-end mine value chain, with external data such as market information, customer contracts and weather forecast data.

There are several technologies that lend themselves specifically to the cloud, most notably simulation, which requires access to high compute resources (usually for small periods while the rest of the time they run idle). The elasticity of cloud computing allows for the scaling up of compute resources as they’re needed and scaling down when done, significantly reducing simulation infrastructure costs.

Challenges facing digital transformation
It would be remiss to discuss the benefits of cloud computing without addressing some of the challenges that go with it in the journey towards digital transformation. The first is connectivity, both within the mine and from the mine to the cloud. Much of the equipment in a mine is still not instrumented. It is true that most heavy haul trucks and shovels are instrumented; however, lighter fleet haul trucks, light vehicles, weather stations, drones and even people will need to become connected ‘things’ in the MIIoT. Technology such as wireless mesh networking is solving this problem, particularly for underground and in-pit communication. In wireless mesh networking, participants in the network become self-meshing nodes carrying and extending the network to the far reaches of the operation.

As for cloud connectivity, this is a much larger challenge for remote mining sites. Luckily, edge computing limits the amount of data required to be streamed to the cloud, and the advances in low-power, low-cost IoT sensors that can communicate via cellular network can also reduce the need for high bandwidth connections. Mining is not alone in this challenge though. In Australia at least, the agriculture sector is going through a similar digital transformation with the advent of the digital farm. Many farmers are finding creative ways to access high-speed internet connectivity. There are lessons to be learnt from both industries on how to solve this problem.

Applying approaches from outside mining
Dassault Systèmes is building mining software on the foundations of the 3DEXPERIENCE platform that will provide a pathway to the autonomous, connected mine. Central to this vision are all of the technologies described above. The platform will unify data across the mining process, thus enabling transformative technologies such as integrated analytics, parametric design, stochastic mine planning, immersive mining experiences and rapid geological modelling.

Dassault Systèmes is drawing on the vast experience across many other industries to complete this project. For example, another project is currently in progress in Singapore, which aims to create an immersive digital twin of the entire city, inherently linked to underlying data such as building occupancy and use, traffic flow simulation and parking space availability. This technology can be adapted for mining to create a similar experience for visualising the above-surface infrastructure and below-surface mining development. This is an example of how non-mining applications can be brought to mining to enable digital transformation of the industry.

Although the mining industry has unique challenges when it comes to digital transformation, the adoption of cloud technology and the MIIoT will set our industry on the path to becoming more sustainable and productive.