RAJANT

CASE STUDY

Kennecott Utah Copper Mine

Mining Communications Using Wireless Mesh Networking - Case Study

Figure 1. *Rio Tinto Kennecott Utah Copper Mine*

Background

Kennecott Utah Copper Corporation (KUCC) at Bingham Canyon is wholly owned by Rio Tinto, one of the leading mining companies in the world, which employs over 30,000 people in 40 countries. Rio Tinto's worldwide operations supply a wide range of minerals and metals, including gold, silver, coal, iron, aluminum, borates and copper.

Figure 2. *KUCC Location*

As the second largest copper producer in the United States, Kennecott Utah Copper provides about 13 per cent of US copper needs. Kennecott Bingham Canyon Mine, located in the Salt Lake City Valley, is the largest man-made excavation in the world. It has been in operation for more than 100 years and has produced more copper, 16.4 million tonnes, than any mine in the world. Every year, Kennecott produces approximately 272,000 tonnes of copper, along with 500,000 ounces of gold, 4 million ounces of silver, about 30 million pounds of molybdenum, and about 0.9 million tonnes of sulphuric acid, a by-product of the smelting process.

The Challenge

The KUCC mining operations run non-stop for 24 hours a day, 7 days a week and 365 days a year. The requirement was to manage over 85 300–ton haul trucks and 62 pieces of auxiliary gear that include dozers and graders. In addition, KUCC would need to connect 12 shovels, pumps, operations vehicles and other production equipment in to the wireless network for control and management.

The overall dimensions of the mine are approximately 2.5 miles (4.02 km) across by 1 mile (1.61 km) deep. The furthest dump site is 6.4 miles from the pit. This wireless network would require an enormous amount of coordination, scale, planning and support infrastructure.

Wireless Mobility

One of the high level KUCC requirements was to design and implement a wireless network that could connect the hundreds of moving devices within the mine (haul trucks, shovels, dozers, graders, etc) and allow them to communicate with each other in real-time while keeping the network intact. Only a small portion of the mine network has fixed wireless nodes—everything else is moving in real time. KUCC needed a high-bandwidth mobile wireless solution that could

Figure 3. *Aerial view of Kennecott Copper Mine*

provide maximum network availability, redundancy and low-latency for managing the mining operations.

Scale

Being able to connect hundreds of devices and grow the network on demand was very important. Mining operations required that any change in the network—moving or adding of wireless nodes, or changing the configuration of a wireless node, would not disrupt the rest of the network. Disrupting the network meant

> *"Operating one of the largest open-pit copper mines in the world, we required a wireless network that could* ***scale*** *with our mine expansion and non-stop operations. We also needed a true* ***mobile solution*** *that could adapt to our constantly moving equipment."*
>
> SCOTT BEER, GENERAL MANAGER–RIO TINTO IS&T

potentially slowing down operations and production output of the mine. The mine required a network that could scale with their growth in size, number of applications, type of applications and new operational demands.

Application Requirements

KUCC runs many advanced mining applications which require a stable network that can handle all the unique characteristics of each application. Some examples of these wireless applications include:

Modular MineCare® System

This is a maintenance software tool designed to reduce mobile equipment lifecycle costs through the real-time management of equipment health and maintenance processes. Remote condition monitoring, maintenance history, and operational data are integrated to provide the end user with sufficient information to make optimal maintenance decisions.

Modular Dispatch® System

This is a mine management system that can integrate an entire mining process by providing automatic, optimized haul truck assignments, GPS-based equipment positioning, equipment health monitoring, maintenance tracking, blending and production reporting.

Caterpillar VIMS®

The Vital Information Management System (VIMS) is a tool for machine management that provides operators, service personnel and managers information on a wide range of vital machine functions. Numerous sensors are integrated into the vehicle design.

If VIMS detects an impeding or abnormal condition in any of the machine's systems, it will alert the operator and instruct them to take appropriate action, whether it is to modify machine operation, notify the shop of needed maintenance, or perform a safe shutdown of the machine. This improves availability, component life and production while reducing both repair cost and the risk of a catastrophic failure.

Figure 4. Kennecott Copper Mine at Bingham Canyon

Banlaw FuelTrack™

This is an electronic fuel monitoring system that provides a secure hydrocarbon management solution. The fuel use of every machine and vehicle can be individually monitored and analyzed with precision. Banlaw FuelTrack™ provides an exact record of all fuel used on site, including that supplied by service trucks and automatically keeps track of fuel and oil inputs and outputs and is able to export this information to a computer either on-site or at a remote location.

Novariant High Precision Global Positioning Systems (GPS)

This is a GPS tool for positioning and managing equipment in open-pit mining. Haul trucks, shovels, drills, dozers, mobile conveyors, and other mission critical machines are optimized by the use of real-time positioning applications enabled by GPS.

Aquila Drill Management Systems

This is an application to make drilling and blasting operations more accurate, productive, and profitable. Proven in harsh, demanding mining conditions, these information products help mines lower their production cost-per-ton, shift after shift, year after year.

The Advanced Monitoring Platform (AMP-II) and centimeter-accurate GPS technology can virtually eliminate traditional surveying, staking, and human error. Operators are empowered to know exactly what and where they are drilling. Management is provided with comprehensive production information to make informed, profitable decisions in near real time.

Email and File Sharing

KUCC had a requirement for basic intra-mine email and Windows file sharing for increased communications.

Ground Probe Radar (GPR)

Ground probes are used for slope monitoring applications.

Future Applications

Voice-over-IP Phones—These portable handheld phones can utilize the Wi-Fi wireless network for communication within the mine and external to the mine. These VoIP phones do not rely on the services and coverage from the cellular companies. Many VoIP phones have a dual-mode which allow the the phone to connect to a Wi-Fi network or a traditional cellular network if available.

> *"We could not afford to have a **single point of failure** in our network. Our demanding applications mandated a network with a **quick healing time** and **low latency**."*
>
> DAN BERG, COMMUNICATIONS MGR–KUCC

Video surveillance

Video cameras to be used for safety monitoring, mine mapping, collision avoidance and security.

Photogrammetry–Unmanned Aerial Vehicles (UAV)

Photogrammetry is the science of making measurements from photographs. The output of photogrammetry is typically a map, drawing or a 3d model of some real-world object or scene. Many of the maps are created with photogrammetry and photographs taken from UAVs.

Network Management

KUCC needed a network management tool that could monitor, alarm, manage, configure and report on the network status and health. Since the health of the network is critical for the mine operator, they also had a requirement for additional remote monitoring of the network.

Service and Support

KUCC required a network provider to be able to support the daily operations of the mine by providing support either by onsite applications engineers or technical support by phone to help them effectively troubleshoot and repair problems. Additionally, remote network monitoring would be used to effectively find problems at the software level as well as remotely upgrade firmware as necessary.

Vendor Requirements–Selection Summary

1. Compliance to Industry Standards (802.xx)–A single standards-based wireless mesh network for all applications.
2. The ability to cover an ever-changing topography without continuously moving, adding and rebuilding infrastructure such as towers.
3. Direct vendor support with commitment to the mining industry.
4. Network redundancy with no single points for failure.
5. Willingness to work with application vendors to integrate a cohesive system.

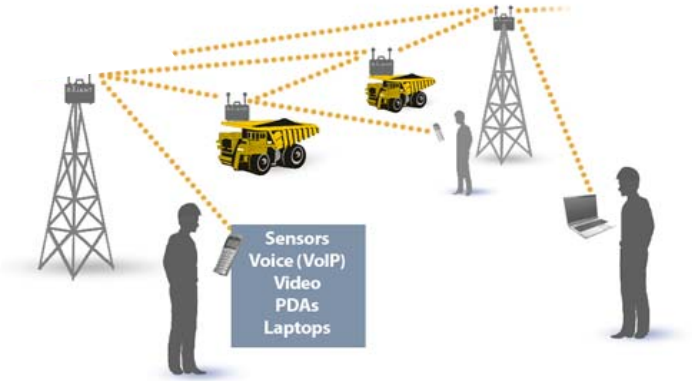

Figure 5. *Rajant Wireless Mesh in Mining*

The Solution

Rajant is the Key Enabling Technology Needed for Mining Applications to Function

After evaluating and testing several wireless vendors, Rio Tinto–KUCC selected the Rajant BreadCrumb® wireless mesh solution. The next step was a mine site survey and analysis to determine the locations of the fixed BreadCrumbs and configuration of the entire network. BreadCrumbs were installed on all haul trucks using Rajant shock-absorbing mounting-plate assemblies with omni-directional antennas mounted externally.

Figure 6. *Haul truck mounting plate with BreadCrumb*

The initial installation consisted of 140 Rajant BreadCrumb XL and ME systems in an interconnected network. Each breadcrumb has dual 802.11 radios. This 280 radio network now allowed their loader trucks, shovels, pumps, laptops and dispatch/control office to communicate with each other in real-time. Since the initial installation another 60 BreadCrumb radios have been added (totaling over 340) without disruption to the mine operations.

As the mine grows over time, more BreadCrumbs will be added. The network currently accommodates the Dispatch, MineCare®, VIMS®, GPS, Aquila Drill Management and FuelTrack™ application systems and there is enough bandwidth available to support many new applications in the future.

Why Wireless Mesh Networks?

Wireless mesh networks are multi-hop systems in which wireless devices assist each other in transmitting packets through the network, especially in adverse conditions such as open-pit and underground mines. A node can send and receive messages, and in a mesh network, a node also functions as a router and can relay messages for its neighbors. Through the relaying process, a packet of wireless data will find its way to its destination,

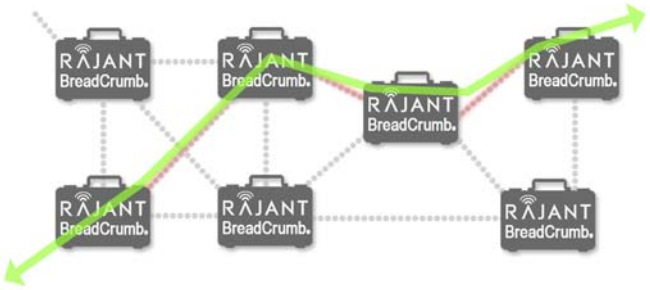

Figure 7. *A Rajant wireless mesh network.*

passing through intermediate nodes with reliable communication links with minimal loss of throughput with multiple hops as there might be with other wireless mesh providers.

Similar to the Internet and other peer-to-peer router-based networks, the Rajant wireless mesh network offers multiple redundant communications paths throughout the network. If one link fails for any reason (including the introduction of strong RF interference), the network automatically routes messages through alternate paths.

Self-Configuring and Self-Healing Network

A network shouldn't need a system administrator to tell it how to get a message to its destination. The Rajant wireless mesh network is self-organizing and doesn't require manual configuration. Because of this, adding new BreadCrumbs or relocating existing ones is as simple as plugging it in and turning it on. The BreadCrumb network discovers the new node and automatically incorporates it into the existing system. It is not necessary to restart, and thus disrupt, the entire network as some other network providers require.

A mesh network is not only inherently reliable, it is also highly adaptable. On the Internet, if one router goes down, messages are sent through an alternate path by other routers. Similarly, if a device or its link in a mesh network fails, messages are sent around it via other devices. Loss of one or more nodes does not necessarily affect the network's operation. A mesh network is self-healing because human intervention is not necessary for re-routing of messages.

Redundancy and Scalability

In a wireless mesh network, the degree of redundancy is essentially a function of node density. A network can be deliberately over-designed for reliability simply by adding extra nodes, so each device has two or more paths for sending data. This is a simpler way of obtaining redundancy than is possible in most other types of systems. In the KUCC mine, many of the BreadCrumb devices are connected to hundreds of other BreadCrumbs.

A mesh network is also scalable and can handle hundreds or thousands of nodes. Because the network's operation doesn't depend on a central control point, adding multiple data collection points or gateways is convenient.

Reliability, adaptability, and scalability are the most important attributes of a wireless network for mining applications. Point-to-point networks can provide reliability, but they don't scale to handle more than one pair of end points. Point-to-multipoint networks can handle more end points but their reliability is determined by the placement of the access point and end points. By contrast, mesh networks are inherently reliable, adapt easily to environmental or architectural constraints and can scale to handle thousands of end points.

Figure 9. *BreadCrumb® XL*

Many competing wireless mesh systems use protocols that can take as much as 30 seconds for the network to readjust to changing conditions. This is unacceptable to mine operators because in the time it takes the network to adjust, a vehicle is now in a new position and the network must once again re-adjust. The network bandwidth goes down considerably as it attempts to 'catch up' with moving nodes. In a high density, or high-number-of-nodes network, these competing mesh systems remain in a constant unstable equilibrium state.

LAN Controllers and Root Nodes

Unlike many other wireless mesh providers, the Rajant BreadCrumb network does not utilize a LAN controller, root node, or master intelligent access point architecture. These centralized schemes mandate that traffic be routed through a single point for decision making. This is inefficient and puts a single point of failures into the network. Even with redundant LAN controllers, the

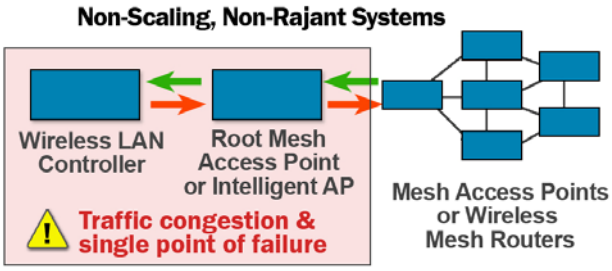

Figure 10. *Non-Rajant mesh systems can not scale and adapt because of root node congestion and latency.*

network is hostage to the traffic jams that can occur by having decisions made by just one device. Additional latency is introduced through extra hops and packet processing.

The Rajant architecture is a distributed intelligence model as opposed to a centralized model. Each BreadCrumb is outfitted with an on-board computer that can assist in bridging, forwarding and routing packets to the necessary destination. Since each BreadCrumb can literally have hundreds of connections, there are no single points of failure and it can choose the optimum path depending on availability, signal strength, connection speed and congestion factors.

Scalability Through InstaMesh

Rajant has developed state-of-the-art software over the last 6 years for mission critical military and mining applications. InstaMesh resides on each BreadCrumb, allowing for hundreds of resilient mesh connections to other BreadCrumb devices, even while they are moving.

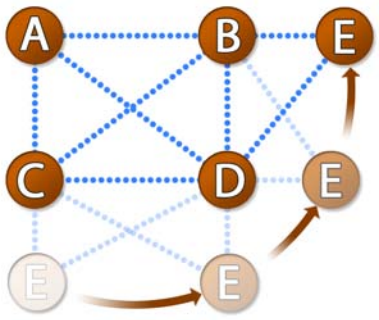

Figure 8. *The Rajant mesh network quickly adapts to the changes caused by the movement of Node E. New resilient links are established in real-time.*

BCAdmin® and BC Commander®

Rajant Corporation has created comprehensive software packages for graphically monitoring and administering the BreadCrumb wireless network. The software graphically depicts both the BreadCrumb devices and any associated wireless clients. Status and configuration information can easily be determined by the administrative operator. Security and other settings can also be managed.

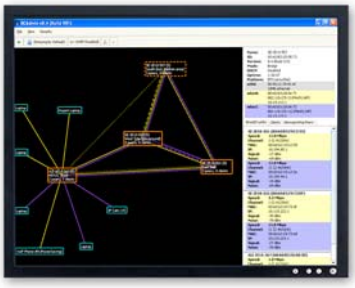

Figure 11. *Rajant BCAdmin© Network Management Tool*

BCAdmin and BC Commander also can be configured to provide information to third-party applications through APIs developed by Rajant.

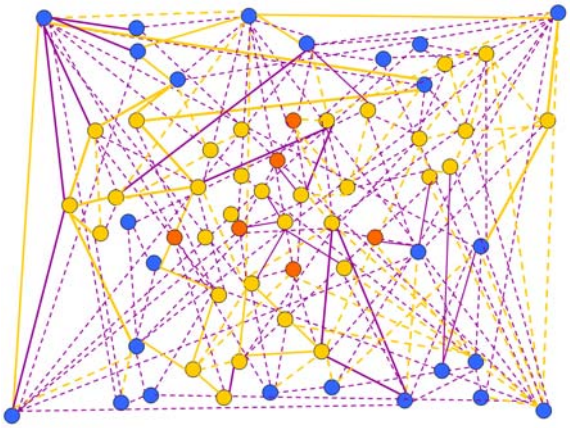

Figure 11. *The Rajant BreadCrumb network handles hundreds of moving nodes with ease.*

The Results

Operational Cost Savings and Production Boost

The Rajant BreadCrumb system has enabled KUCC to gain additional operational efficiencies by simultaneously running applications that track, monitor and manage its copper mining operations. In addition, Rajant had the unique ability to satisfy "real-time" application requirements. The cost savings to the mine were substantial—amounting to over $7,000,000 in the first 3 months of operation.

> *"As a result of the Rajant wireless network enabling our applications, we were able to save KUCC more than **$7 Million** in operational cost in the first 90 days alone."*
>
> AMANDA SMITH, MINE MONITORING AND CONTROL MANAGER–KENNECOTT UTAH COPPER

Maintenance

At any given moment, the KUCC mine will have dozens of haul trucks in maintenance bays for various procedures, upgrades, or replacement of parts. Since they are occupied in the maintenance cycle, these 300-ton trucks can not be assisting in production of the mine. Because of the Rajant network running many comprehensive maintenance and health monitoring applications (Modular MineCare®, System Caterpillar VIMS®, etc), the KUCC mine was able to reduce the maintenance cycle for many vehicles, and instead, place them directly into production roles within the mine. As a direct result of the Rajant wireless network, KUCC was able to have ten extra haul trucks in production at all times.

Support and Services

Additional services were provided to KUCC including on-site engineering, on-site training, remote monitoring (redundant), installation and configuration assistance.

> *"In my 27 years in mining I have never had better customer support than Rajant Corporation provided us here at Kennecott."*
>
> BOB KUMMER, PROJECT MANAGER–RIO TINTO IS&T

Rajant has also partnered with leading mining integrators such as Caterpillar dealers and Mine Site Technologies to provide mining operators with comprehensive care, support and services.

Rajant
BreadCrumb® LX

Based on feedback from customers, Rajant has developed a new rugged BreadCrumb LX family with a flexible and modular design that can support up to 3 radios in the 900MHz, 2.4GHz, 4.9Ghz and 5GHz ranges.

Rajant wishes to thank Rio Tinto, KUCC and all the mining application companies for their support in building this world–class wireless network.

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