# RAJANT

# Scalable, Real-Time Reliable Wireless Networking
## FOR SHALE ENERGY OPERATIONS

The U.S. Energy Information Agency (EIA) reports* that over **750 trillion cubic feet** of technically **recoverable shale gas** and **24 billion barrels** of technically **recoverable shale oil** resources currently exist in discovered shale plays in the United States alone. These huge reserves are spread over vast areas of the country – from Louisiana and Texas to North Dakota to Ohio and Pennsylvania – **providing abundant domestically produced energy while stimulating local economies.**

Along with the discovery of these shale plays, new extraction techniques and advances in computer hardware and software technology are helping to unlock previously untapped oil and natural gas while protecting natural resources.

Similar to mining and battlefield situations, shale operations consist of multiple vehicles, equipment and personnel, dispersed across rugged terrain – all of which require constant, reliable connectivity while on the move. The vast and geographically dispersed nature of these shale fields, meanwhile, presents significant challenges. As with offshore oil extraction and transportation, shale energy involves a considerable amount of unmanned infrastructure that requires careful and constant monitoring. In many situations, there is no existing cellular, 3G or Wi-Fi infrastructure available to assist with the network.

These are the challenges that Rajant's Kinetic Mesh Networking technology was designed for – and where it has proven its value over and over again for more than a decade.

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As the number and variety of **mission-critical applications** supporting shale energy increases, so does the need for **flexible, readily-deployed, high-availability broadband connectivity.**

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## Node-to-Node Communications

Rajant's Kinetic Mesh Networking technology builds **resilient wireless mesh networks** capable of any-node to any-node communications. If a wide area link is required, the BreadCrumb network can easily transmit and receive data through a **satellite, point-to-point wireless, or wired link.**

Given the mobility of equipment, and line-of-sight issues posed by topography, providing this level of wireless coverage in Shale Oil and Shale Gas Fields can require an inordinate amount of coordination, scale, planning and support infrastructure. Flexibility, scalability, and availability are paramount – **as the network must be easily deployed, exceptionally rugged to endure harsh conditions, and be able to reliably cover expansive areas without constantly moving, adding or rebuilding infrastructure.**

**Secure Rajant BreadCrumb nodes scale to much higher node densities as the network grows and bandwidth availability actually increases.** They securely interact with the data command center **across a meshed, self-healing network to provide critical, real-time information** that touches all aspects of shale oil and gas operations. The nodes rapidly adapt to any changes in the network topology, assuring that IP traffic uptime and bandwidth are maximized.

Today, Rajant is the standard for reliable, resilient, flexible broadband connectivity in some of largest and most productive mining operations in the world. Rajant Kinetic Mesh networks currently provide robust, scalable connectivity in over 50 mines worldwide.

Unlike other available mesh technologies, **Rajant networks are truly scalable – and actually grow stronger and more robust as nodes are added to the network.** At the same time, Rajant networks do not employ a root "controller" node, which **reduces both capital and operating expenses.**

Rajant BreadCrumb nodes **employ multiple radios** to operate on **multiple frequencies.**

## Radio Frequencies and Programmability

In Rajant BreadCrumb network nodes, radios are purchased to operate within a specific band of frequencies, and then are programmable to certain channels within that band. If an end customer has a license for 20 MHz of bandwidth at a specific frequency, then Rajant can make a radio for that specific licensed frequency anywhere from 400 MHz to 6 GHz. Our standard license-free ISM frequency bands are: 900 MHz, 2.4 GHz, and 5.8 GHz, as well as a soft license for 3.65 GHz. Rajant also has produced1.4 GHz, 4.8 GHz (Military), 4.9 GHz (Public Safety) radios that require a license.

An individual BreadCrumb network node can hold up to four radios – 900 MHz, 2.4 GHz, 4.9 GHz, and 5.8 GHz in a variety of combinations. Nobody has a product and functionality like this.

## Multiple Ethernet Components & Network Transport

Rajant Kinetic Mesh networking products become an extension of the wired LAN. If a user has setup their wired LAN to use Virtual Local Area Networks (VLANs) to logically separate and/or prioritize Ethernet traffic, **BreadCrumb network nodes can extend that functionality to the wireless mesh.** BreadCrumb nodes support separate VLAN settings at every port for maximum flexibility.

## Multi-Frequency vs. Single Frequency

*Note: Because radio frequency (RF) coverage is dependent upon the topography of the area being covered by a Kinetic Mesh Network, Rajant develops specific RF models for each site. We can arrange a web-conference session to demonstrate the various coverages for each frequency range at a typical site, and can also model your specific site based on topography data files.*

Rajant multi-frequency BreadCrumbs do a better job of load balancing, and are **capable of simultaneously sending and receiving on different frequencies,** unlike standard single-frequency radios which use store and forward, receiving packets on the radio, storing the packet, and then forwarding it by transmitting when the channel is in available mode.

This is why standard Client Access Point Single Frequency systems using half duplex mode always cut the available bandwidth in half going across each hop, whereas in full duplex mode we have higher bandwidth speeds across multiple hops (Mesh nodes) so the data packet gets to its destination much faster using our InstaMesh routing protocol. In other words, **BreadCrumb nodes exhibit extremely low latency compared to other products.**

Competitive solutions claim to use multiple frequencies, but, in reality, they use one frequency for the WLAN and another for backhaul. If there is congestion or interference on any one band, the whole network is impacted. Only Rajant has the ability to use all frequencies on any device to provide both local access and backhaul, so if there is interference on any one frequency, the BreadCrumb node automatically switches to another. This way, the network never goes down; productivity and safety are never compromised.

## One Network

Because shale energy operations are so geographically dispersed and the applications they deploy are so bandwidth-intensive, many locations are forced to operate on multiple networks that run in parallel. These networks quickly reach their limits, so new applications and updates to existing applications can't be run. Overtaxed networks lead to downtime, applications running in isolation from each other and, ultimately, decreased productivity and safety. **Rajant's unique architecture and ability to dynamically select the best (fastest) available frequency and compensate for changing network node status enables facilities to run all applications over a single network** – and to transition to the new architecture without incurring costly downtime.

## No Single Point of Failure

Competitive mesh networks rely on a hierarchal network topography along with a root node, to manage routing. In their design, only access point nodes mesh. Mobile equipment uses single-channel radios that can only connect to one access point at a time. In the event of an access point failure, all of the nodes connected to that failed access point are disconnected from the network. Therefore, such access points have the potential to be a single point of failure.  In the case of root nodes, one device manages all routing for the wireless network. If the root node fails, the entire wireless network goes offline. So the root node also has the potential to be a single point of failure.

The Rajant BreadCrumb routing protocol, InstaMesh, constantly discovers and maintains information at each BreadCrumb in the network about the cost of multiple routes and forwards traffic as needed through the best available link. This enables the BreadCrumb wireless mesh network to use the best routes even in a constantly changing network – without interrupting network availability or flooding the network with routing requests.

There is true redundancy on all frequencies. Each BreadCrumb node proactively scans the environment and takes corrective action the moment it senses an interference or obstruction to route around the problem via a different path. Rajant's Automatic Protocol Tunneling technology allows for multiple ingress and egress points into the wired network – eliminating the single point of failure.

As a result of all these features, there is No Single Point of Failure in a typical Rajant Network, which distinguishes it from other wireless technologies.



## Rajant Networks Ensure No Single Point of Failure

Rajant engineers have extensive background in transitioning its customers from multiple networks to a single Rajant network. The team begins with site surveys and site assessments that help determine proper configuration and more importantly, mitigate any risks involved. With more than fifty deployments at mines worldwide, Rajant understands the needs for a successful deployment without service interruptions.

Rajant's Automatic Protocol Tunneling technology allows for **multiple ingress and egress points into the wired network** – eliminating the single point of failure.

Rajant Kinetic Mesh networks can be **deployed in parallel** with the existing networks they replace – **ensuring optimal availability and zero downtime.**

## Lower CAPEX and OPEX

- Low cost of ownership, high-value network

- Lower infrastructure requirements

- Lower ongoing administration and support costs

- Eliminates the need to deploy and maintain multiple radio solutions on mobile equipment. (Consolidates the communication requirements for high precision GPS, drilling and dispatching functions.)

- Going forward, there will be **increased maintenance savings** – which are soft savings, over and above savings on the Operational Expenses, as one would not require different teams and skill sets to maintain multiple networks.

## Deployments/Upgrades

The reliability and continuous connectivity provided by Rajant extend to implementation as well. Many facilities today operate multiple networks out of necessity – either because their existing individual networks lack the capacity to accommodate all applications, or because they run application-specific networks. **Operating on a single network, however, is much more efficient and is a better use of spectrum.** Mission-critical shale energy applications such as dispatch and equipment health monitoring require continuous connectivity and availability.

In most cases, whether a site runs single or multiple networks, Rajant Kinetic Mesh networks can be deployed in parallel with the existing networks they replace – ensuring optimal availability and zero downtime. Rajant implementation specialists have extensive experience in deploying networks and upgrading existing networks without incurring downtime or network outages – ensuring connectivity for all applications. Please refer to the case study, "Upgrading Mine-Wide Wireless Network – with Zero Downtime," to learn more about how Rajant transitioned a 70-square mile mine from multiple networks to a single network – with no operational downtime, no loss of data – in a manner that was seamless to the user.

Rajant's ease of deployment extends to upgrades as well. Customers benefit from Rajant's development philosophy, which requires every major version of our firmware to be backward-compatible with previous versions. As Rajant introduces new technology, customers maintain connectivity without incurring downtime via live upgrades.

## Cost Benefit Analysis/ROI

Technology applications such as Fleet Management (Dispatch), Machine Health, and High Precision Drilling, Excavating and Grading represent a significant investment in any mining operation. However, simply installing these applications does not automatically ensure the expected ROI. Such applications rely on the availability of reliable, "always-on" wireless communications. Rajant is the only wireless network that does not lose network connectivity as a normal part of its operation. Shale operators seeking to achieve maximum ROI on technology investments can rely on Rajant – the most reliable, scalable, and proven networks available.

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## Load Balancing

BreadCrumb® models currently hold up to four radios – 900 MHz, 2.4 GHz, 4.9 GHz, and 5.8 GHz – in a variety of combinations. However, there is the potential to create BreadCrumb® configurations that support more radios with additional frequencies as needed. Again, unique to Rajant is the fact that **BreadCrumb® nodes make use of all installed radios for multiple functions at the same time.** This capability is crucial, and runs counter to other mesh networking strategies.

Most multi-radio network solutions separate traffic into two types: client access traffic – communication between access points and Wi-Fi clients (mobile equipment, laptops, video cameras, VoIP phones); and backhaul traffic, which connects access points over long distances. The theory is that if at least two radios are performing the "backhaul" function on two different channels, then all traffic can be smoothly transferred from node to node without the need for any retransmission.

Rajant BreadCrumbs®, however, are designed differently. Because the radios in BreadCrumb® devices are capable of simultaneously sending and receiving on different frequencies, Rajant delivers even greater network availability. **Only Rajant has the ability to use**

**BreadCrumb® devices actively use multiple radios to perform multiple functions at the same time.** This capability is crucial, and runs counter to other mesh networking strategies.

**any one of multiple radio frequencies for conducting local-access traffic and backhaul traffic. And if there is interference on any one frequency, a Rajant BreadCrumb® node will automatically switch to another.** This feature ensures users maintain critical access to communications applications in the most challenging environments.

*In Figure 1, node "C" for example would always use the fastest link available at any given time in communicating to the network, rather than collecting data from one node first and then turning it around and retransmitting it to the other. By focusing on creating no single point of failure, Rajant networks are uniquely capable of balancing traffic loads so that* **users get the maximum amount of throughput at all times.**
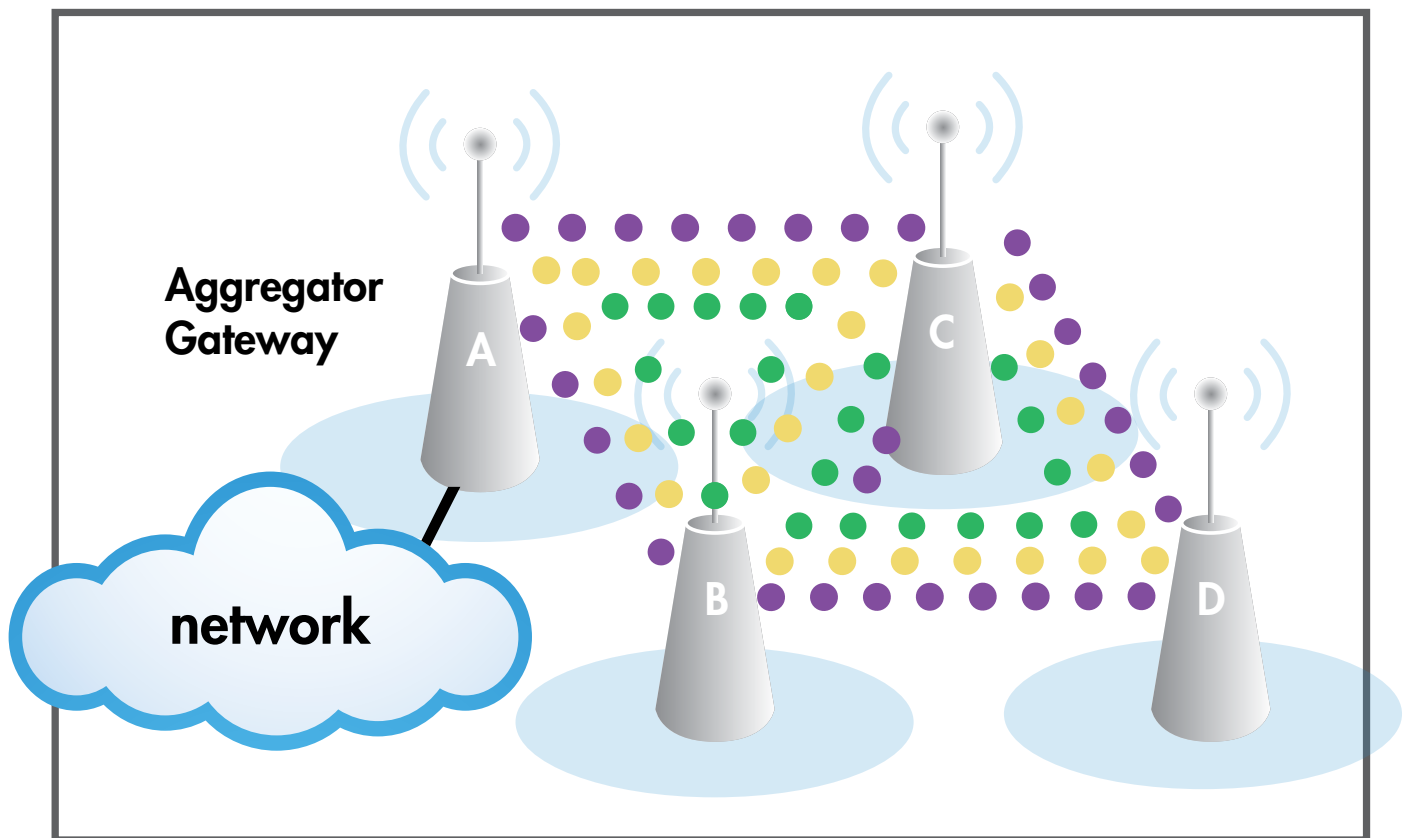


Figure 1. Multi-Frequency Mesh Network

## Management of Multi-Application Environments

Note: Rajant can provide a real-world demonstration of this capability at a working location that has 17 different applications running across the same Kinetic Mesh network. This network features 14 different VLANs to keep the packets for each application logically separated on the Wireless Local Area Network (WLAN) and wired LAN.

Shale energy operations are governed, fine-tuned, analyzed, and optimized using applications designed specifically for the industry. Equipment health monitoring applications keep trucks operating at peak efficiency. Dispatch systems deploy equipment to locations where it's best utilized.

**The backbone of this complex operation is the network.** It is the linchpin on which the productivity, safety, and profitability of the facility relies. Bandwidth is precious. Downtime is unacceptable. Application data, voice, and video flowing over the network are as essential to operations and efficiency as the fuel in haul trucks. To ensure peak productivity and savings, bandwidth-intensive applications should run on a single network. However, most mesh networking technology today is unable to scale to accommodate all needed applications – forcing operators to run multiple networks and/or forego application updates and deployment.

Rajant BreadCrumb network nodes are powered by the InstaMesh advanced routing protocol to enable voice, video, and data communications to operate over a common wireless infrastructure – even while all nodes are moving. In addition to providing true mobility, InstaMesh enables dynamic frequency utilization – allowing network nodes to seamlessly switch between available radio frequencies based on best-path analysis at the node level. Multi-frequency BreadCrumb nodes avoid frequency lock-in and provide operators greater flexibility to utilize additional spectrum.

**InstaMesh allows for continuous and instantaneous routing of wireless and wired connections,** and enables complete network mobility, robust fault tolerance, high throughput and low latency – all with minimal maintenance and administration.
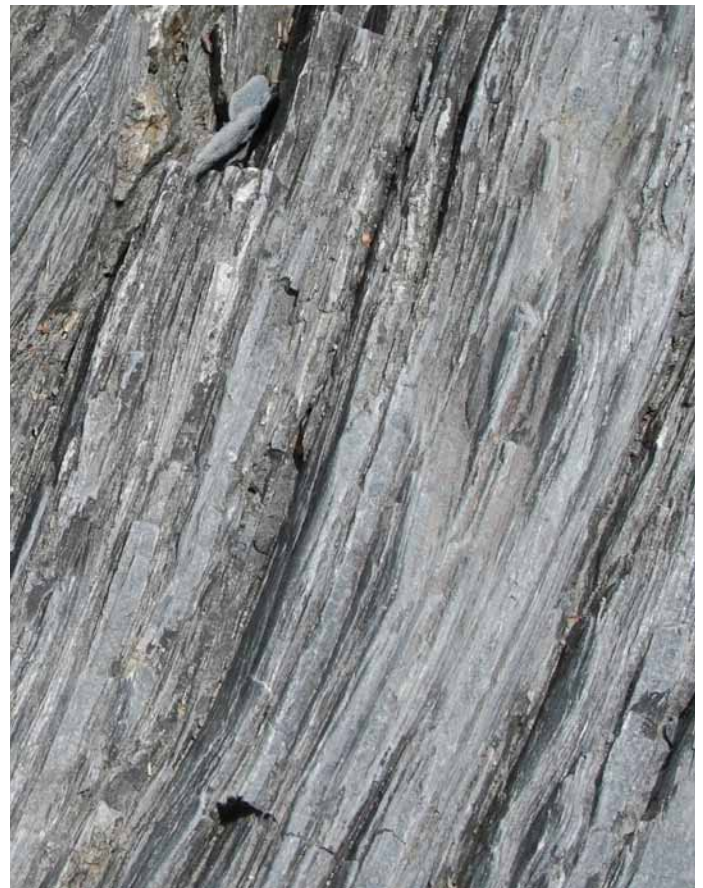
Rajant BreadCrumb network nodes are powered by the **InstaMesh advanced routing protocol** to enable voice, video, and data communications to operate over a common wireless infrastructure – **even while all nodes are moving.**

# Shale Field Applications Supported by Rajant Kinetic Mesh Networking Technology

- High-speed network access for PDAs, laptops & tablets
- Real-time, ubiquitous communications
- GPS-based location services - personnel and assets
- Safety enhancement
- Security systems (cameras and access systems)
- Operational oversight
- Vendor communication access
- Risk mitigation (SOX)
- Remote access
- Remote management

- Reliability improvement
- Asset management (RFID)
- VoIP or TRoIP
- Cyber security
- Data center backup, storage & data management
- Timekeeping systems (Chronos)
- 24-Hour system control
- Integrated Business Analytics (Similar to the SAP & Oracle- petroleum suite)
- Electronic Gas Measurement
- ESD
- Flow/Pressure Control

- Intermitting
- Plunger Lift Control
- Casing & Tubing Pressure
- Chemical Injection Control
- Water & Oil Production
- Tank Level Monitoring
- Individual Well Site / Pump control
- Telemetry data and enhancement lifecycle of assets – based upon well maintenance schedules controlled via connect field.
- Real-time troubleshooting of pump controllers

## Scalability

In shale operations, as in mining, the only constant is change – changing topology, changing locations, changing weather. **As operations expand, so must the network carrying vital applications.** The problem with most mesh technologies is that scaling the network with additional nodes results in a degradation of performance. As a result, applications are ported to additional networks, operating in isolation and with limited bandwidth.

One of the critical differentiators of Rajant's technology is its ability to scale. **BreadCrumb nodes can scale to much higher densities and, as the network grows, the bandwidth availability actually increases as opposed to competitive offerings.** The nodes rapidly adapt to any changes in the network topology, assuring that IP traffic uptime and bandwidth are maximized. There is no practical limit to the number of BreadCrumb nodes that can operate in a network, or how large a network can be. Each BreadCrumb is 'intelligent,' and utilizes InstaMesh to calculate best available frequency to transport data loads. Additionally, our ability to have multiple connections to the wired LAN further improves scalability without introducing a single point of failure. For example, one of our largest networks consists of several 250-plus nodes with nearly 70% of them mobile

in an area 1 mile long x 2.5 miles wide x 1 mile deep and 6.4 miles of mobile travel. Rajant networks are scalable and designed to provide ample bandwidth to accommodate the demands of multiple applications. Unlike many other wireless networks, **Rajant Kinetic Mesh networks are not application-specific, and do not limit users.** The premise is simple: Rajant sells and deploys high-performance, high-availability, high-bandwidth networks to carry data for applications that require constant connectivity.

## Connectivity

One widely held assumption in wireless networking is that good coverage means good connectivity. This simply is not true. Continuous connectivity is only available with a network designed for continuous connectivity. Most wireless mesh networks utilize low-cost, low-capability radios on their mobile equipment. These low-cost clients can only maintain one connection at a time. As part of the Wi-Fi standard, clients will hold onto an access point as long as possible. So, as a machine drives down a haul road, away from its current access point, the signal becomes weaker and weaker – in much the same way as when you drive away from a city and gradually lose a radio station. As this occurs, the transmission rate also slows down. **Eventually the signal will become so weak, the client will drop the connection.** In the best case scenario, it will find a new access point to reconnect to in less than a second. However, in the worst case scenario, **when networks are large and traffic is heavy, it can take up to two minutes.**

Rajant networks utilize the same hardware in mobile equipment as the infrastructure. These multi-radio, multi-frequency BreadCrumb nodes have the ability to connect to multiple nodes – on every frequency. In other words, Rajant BreadCrumbs can maintain multiple persistent network connections.

So, **as a piece of equipment equipped with a Rajant BreadCrumb travels across a site, it is continually adding new connections** – as well as dropping poor connections – but, at any given point, it always has multiple connections to choose from. Rajant BreadCrumbs are designed for continuous connectivity.

- High-speed connectivity
- Continuous connectivity
- Reliability
- Scalability
- Coverage everywhere, all the time
- Mobility
- Security
- Standards-based

"We tasked our development team with anticipating the future needs of Rajant users across multiple industries. The result is a routing technology and network management platform that is flexible, secure, and allows for the rapid deployment and management of Kinetic Mesh Networks."

- Paul Hellhake, CTO, Rajant Corporation

## About Rajant Corporation

Based in Malvern, PA, Rajant Corporation enables secure communications-on-the-move through a portable meshed wireless network that can rapidly reconfigure and adapt in real-time. Rajant's BreadCrumb® Wireless solutions provide networks for Military, Mining, Oil and Gas, Homeland Security, First Responders, Telecommunications Service Providers and Public Safety and provide voice and data communications across a meshed, self-healing network. Rajant's BreadCrumb network nodes communicate with IP based client devices such as laptops, PDAs, video cameras, satellite terminals, networked radios, RFID's and sensor devices. Please visit www.rajant.com or call (484) 595-0233.

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20+ Years OF GAME-CHANGING **WIRELESS**

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