RAJANT

Kinetic Mesh Networking Can Enable **Fully-Integrated, Secure Oil, Gas, and Petrochemical Operations**

Scalable, High-Bandwidth Kinetic Mesh® Networks Provide Unmatched Connectivity for Upstream, Midstream, and Downstream Applications

Industry 4.0, the Internet of Things (IoT), autonomy, advanced data analytics, and anywhere, anytime mobility are helping a variety of industrial organizations significantly improve productivity and reduce operating costs.

At the same time, advanced communications, surveillance, and sensor technologies are helping increase safety, protect assets, improve productivity and reduce downtime. In order to achieve the desired benefits of these evolving digital technologies, the communication network must have infrastructure that is capable of supporting these business enablers.

A private Rajant Kinetic Mesh network can enable the always-on, continuous communications required to support such technologies while providing reliable, secure, mobile access to vital data and applications. Rajant's self-healing, layer 2 peer-to-peer mesh networks have been operating successfully in a wide variety of industrial environments, including mining, military, oil and gas, ports, manufacturing, transportation, agriculture, and government.

Similar to many other industries, oil, gas, and petrochemical operations depend on a variety of vehicles, equipment, heavy machinery, and personnel, dispersed across vast, rugged terrain—all of which require reliable, high-bandwidth, mobile communications. Every aspect of exploration, extraction, and production must be carefully monitored and managed to ensure continuous operations and cost containment—24x7x365. A Rajant mesh network can provide real-time, site-wide communications for employees, contractors, vehicles, drills, well heads, video cameras, smart meters, sensors, laptops, smart phones, and an abundance of other assets.

Given personnel and asset mobility, line-of-sight issues posed by rapidly changing environments, and the growing demand for autonomous vehicles and equipment, providing the needed level of wireless coverage requires thorough planning, coordination, and support. Network flexibility, scalability, availability, and ease of use are paramount. Plus, network infrastructure must be easily deployed, be exceptionally rugged to endure harsh conditions, and be able to provide communications over an ever-changing landscape without constantly moving, adding or rebuilding infrastructure. Today, Rajant is the standard for reliable, resilient, adaptable broadband connectivity in evolving, mobility-driven industrial environments.

Rajant's Unique **Technology**

Rajant Kinetic Mesh® networks consist of Rajant BreadCrumb® nodes powered by Rajant's patented[1] InstaMesh® networking protocol, enabling voice, video, and data communications—even while people and assets are in-motion.

BreadCrumbs are rugged, IP-67 certified[2] wireless nodes that create a mesh network when deployed with other neighboring BreadCrumbs. They can function as infrastructure or mobile nodes and can rapidly adapt to changes in the network topology to assure that IP traffic uptime and bandwidth are optimized.

With any-node to any-node connectivity, BreadCrumb networks can scale to hundreds of interconnected mobile nodes, providing thousands of potential pathways over which data can be sent and received. Since BreadCrumbs automatically form multiple connections with other nodes within the mesh, the networks are inherently redundant. Unlike many competitive wireless technologies, Rajant networks actually grow stronger and more resilient as nodes are added. In addition, the networks can easily transmit and receive data through a satellite, point-to-point wireless, or wired link if a wide area link is required.

InstaMesh networking software is the mobility enabler in Rajant solutions and responsible for the continuous and virtually instantaneous forwarding of all wired and wireless connections within the network. While InstaMesh utilizes a proprietary routing algorithm, it is fully compatible with 802.11 standards. If the information can be sent over Ethernet, it can be sent over a Kinetic Mesh network.

As nodes are added, moved, or removed, InstaMesh automatically adapts to the changes, establishing new links in real time while keeping the network available, intact, and secure. The software enables complete network mobility, robust fault tolerance, and high throughput with minimal maintenance and administration.

Intrinsically Safe Design for C1D2 Hazardous Locations

Rajant's BreadCrumb ME4, model 2450R is intrinsically safe in C1D2[3] petrochemical, oil, and gas environments where flammable gases, vapors, or liquids may be present, but are not present under normal operating conditions.

[1] U.S. patent 8341289B2 | [2] IP67 certification applies to BreadCrumb LX5 models; other models are designed for IP67 | [3] Completion of C1D2 certification is expected in Q2-2018.

Multi-Radio, Multi-Frequency Advantages

Rajant BreadCrumbs® operate within a specific band of frequencies and are programmable to certain channels within that band. They support the simultaneous use of 900 MHz and 2.4, 4.9, and 5 GHz frequencies for redundancy and interference mitigation, and individual network nodes can accommodate up to four radios. In addition, custom transceiver configurations and frequencies are available for development upon request and may include a mix of licensed, military, or unlicensed frequencies.

Rajant's multi-frequency BreadCrumbs are capable of simultaneously sending and receiving on different frequencies. In competitive wireless networks, standard single-frequency radios use store and forward—receiving a packet on the radio, storing the packet, and then forwarding it when the channel is available. Standard client access-point, single-frequency systems use half duplex mode which cuts the available bandwidth in half across each hop. In full duplex mode, Rajant networks have higher bandwidth speeds across multiple hops (mesh nodes). As a result, data packets get to their destination much faster with extremely low latency when compared to other solutions.

MULTIPLE FREQUENCIES

900 MHz

2.4 GHz

4.9 GHz

5 GHz

Custom Frequencies

No Single Point of Failure

While many competing solutions claim to use multiple frequencies, in reality, they use one frequency for mobile nodes and another for infrastructure nodes or access points. Only access points mesh because mobile nodes cannot talk to each other directly. In addition, mobile nodes with single-channel radios can connect to only one access point at a time. When an access point fails, all nodes connected to the failed access point are disconnected from the network. As a result, access points have the potential to be a single point of failure. In the case of a root node, that 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.

INTELLIGENT, AUTONOMOUS TRAFFIC ROUTING

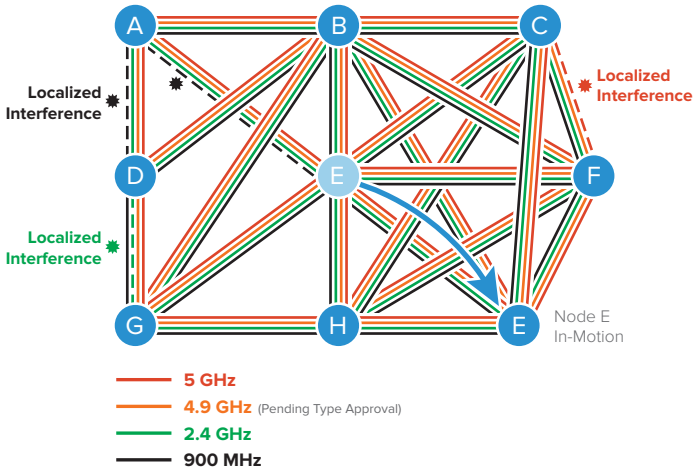
Rajant networks do not employ root "controller" nodes, eliminating the possibility of a root node being a point of failure. In a Rajant network, InstaMesh® continually discovers and maintains information about the cost of multiple routes at each BreadCrumb in the network and forwards traffic as needed through the best available path. InstaMesh proactively scans nodes and takes corrective action the instant it encounters interference or an obstruction, redirecting traffic as needed. In addition, Rajant's Automatic Protocol Tunneling (APT) technology allows for multiple ingress and egress points into the wired network, further eliminating the possibility of a single point of failure. The result is that communications continue unbroken, and productivity and safety are not compromised.

Continuous 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.

Many competitive networks use a handoff technique called "break-before-make," meaning that as people and assets move, the network must break an old connection before forming a new one. Because most Wi-Fi networks utilize low-cost, low-capability radios on their mobile equipment, client devices can maintain only one connection at a time. When a vehicle travels down a road, away from its current access point, the signal will become weaker and weaker—in much the same way as when driving away from a city and gradually losing a radio station. While a client device will hold onto an access point as long as possible, the transmission rate will slow down, and eventually the signal will become so weak that the client device will lose the connection which can cause dropped packets and communication outages.

Rajant networks do not break connectivity during mobile communications. Instead, InstaMesh® uses a "make-make-make-never-break" approach. As a vehicle or other mobile equipment equipped with a BreadCrumb® travels across a site, it is continually adding new connections and always has multiple connection options available at any given time. Nodes never break connections to form new connections with approaching nodes, and all connections are maintained until they are no longer needed. These capabilities enable Rajant networks to support a wide variety of mission-critical applications, including Industry 4.0 and autonomy which require constant communications.



This diagram illustrates how a multi-frequency BreadCrumb network adapts to changes caused by the movement of BreadCrumb node E. New links are established in real time, keeping the network available, intact, and secure. The dotted lines show locations where radio frequencies experience interference. In such situations, InstaMesh instantly reroutes traffic over a clear frequency.

Military-Grade Security

Petrochemical, oil, and gas organizations are high-risk targets for potential malicious attacks. Should a cyber attack block the flow of sensor data, halt the flow of communications to an unmanned ground vehicle (UGV), or inject malware into production control systems, the results could be devastating. The consequences can include everything from significant business and service disruption to financial systems collapse, and even catastrophic situations impacting human safety and well-being.

Recognizing how absolutely essential security is, Rajant has made significant investments in providing multi-level, military-grade security to protect Kinetic Mesh® network traffic. Rajant networks offer several robust security features, including multiple cryptographic options, configurable data and MAC address encryption, and configurable per-hop, per-packet authentication.

RAJANT'S ACTIVE SECURITY CERTIFICATIONS

FIPS 140-2 Level 2

Suite A—Classified

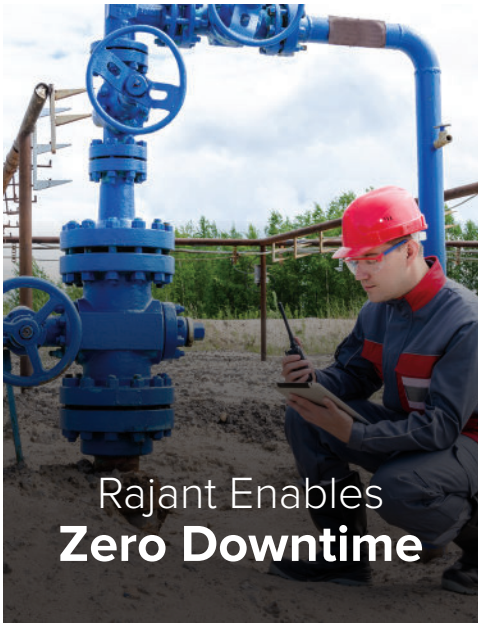
AES Suite B—Secret and Below

Load Balancing

Because BreadCrumbs® can accommodate up to four radios and frequencies in a variety of combinations, the nodes can make use of all installed radios for multiple functions at the same time. This capability is crucial, and runs counter to other mesh networks.

Most multi-radio wireless networks separate traffic into two types: client access traffic which includes communications between access points and Wi-Fi clients such as laptops, tablets, smart phones, and sensors; and backhaul traffic which connects access points over long distances.

Rajant networks are designed differently. The radios in BreadCrumbs are capable of simultaneously sending and receiving on different frequencies, enabling exceptionally high availability. The mesh can use any one of its multiple radio frequencies for conducting local-access traffic and backhaul traffic. This design allows users to maintain critical access to mission-critical data and applications, even in the most challenging environments.



Scalability

In oil, gas, and petrochemical operations the only constant is change—changing topology, changing locations, changing weather, changing applications. As operations expand, so must the network that is responsible for carrying the data and applications. The problem with most wireless technologies is that scaling the network with additional nodes results in performance degradation. As a result, applications are often ported to additional networks that operate in isolation and with limited bandwidth.

One key advantage of Rajant's technology is its ability to extend coverage and support new applications as needs grow. BreadCrumb-based networks can scale to hundreds of interconnected mobile nodes and higher densities. As the network grows, bandwidth availability actually increases. Plus, with multiple ingress and egress points into the wired Ethernet network via Rajant's Automatic Protocol Tunneling feature, usable bandwidth increases and data can be delivered to client devices faster.

Oil, gas, and petrochemical operations are typically geographically dispersed, operating many applications that are extremely bandwidth-intensive. Consequently, organizations are often forced to operate multiple networks running in parallel. In most cases, these networks have reached their limits. So, new applications and updates to existing applications cannot be run. These overtaxed networks can lead to downtime, applications running in isolation from each other, and ultimately decreased productivity and safety. Rajant's unique architecture and scalability, plus its abilities to autonomously select the best available traffic path and compensate for changing network status, enable enterprises to run applications over a single network and transition to new architecture and applications without incurring costly downtime.

TYPICAL APPLICATIONS SUPPORTED

Process Control

Production Automation and Control

Platform and Well Monitoring

Video Surveillance

Vehicle and Equipment Health

Precision Drilling & Excavation

Vehicle Dispatch and Routing

Autonomous Vehicle and Equipment Control

Industry 4.0 Connectivity

Cost Benefit and **ROI**

Implementing applications such as process and production control, vehicle dispatch and routing, machine health, precision drilling, and surveillance represents a significant investment in any gas, oil, or petrochemical operation. Simply installing these applications does not automatically ensure the expected ROI. Plus, deploying drones and robots, sensors, and autonomous vehicles and equipment imposes added communication requirements on existing networks and requires continuous, ultra-reliable connectivity to operate effectively.

Organizations seeking to achieve maximum benefits from technology investments can rely on Rajant's field-proven networks to help drive ROI.

- **Continuous Communications:** Having reliable, anytime, anywhere connectivity enables access to strategic decision-making insights that help operators optimize all aspects of exploration, extraction, and production. The resulting productivity and cost savings can improve bottom-line profits.
- **Well-Site and Platform Monitoring:** Well and platform cameras, smart meters, and sensors allow operators to monitor conditions as they occur and instantly spot problematic issues, often before they cause downtime or production delays.
- **Site-Wide Mobility:** Having site-wide communications allows personnel and contractors to access vital information and applications, maintain communications with command and/or dispatch, and perform operations more efficiently. And, autonomous vehicles and equipment can be monitored and controlled effectively, even at the network edge.
- **Safety:** Since the mesh network can provide GPS-based locations and status tracking, operators can maintain communications with people and assets for greater safety.
- **Investment Protection:** BreadCrumbs® are built to withstand the extreme conditions present in petrochemical, oil, and gas locations. As a result, a Kinetic Mesh® network investment is protected for the long term. Many Rajant customers have had networks that operated for several years without environmentally-induced failure.
- **Vehicle and Equipment Health:** A Kinetic Mesh network and predictive maintenance system can help keep vehicles and equipment operating at peak efficiency, reduce downtime, and extend the service life of such assets.
- **Big Data and Predictive Analysis:** Advances in meters, sensors, and other digital tools are delivering volumes of valuable decision-making data. A Rajant network can provide the high capacity required to support current and future Big Data demands and supply needed intelligence to help achieve operational objectives.
- **Surveillance:** To protect facilities and operations from malicious attack, video surveillance is a mission-critical application requiring high-bandwidth connectivity. With a Rajant network, operators can view site-wide video in real time.

Powerful, User-Friendly **Network Management**

While Rajant BreadCrumbs® offer virtually one-button set-up, many operators prefer to exercise more administrative control over their networks. To help configure, monitor, and manage individual BreadCrumbs or groups of BreadCrumbs, Rajant networks include BC|Commander®. Available for both Microsoft® Windows® and Linux®, this software provides a global view of the Kinetic Mesh® network through an easy-to-use graphical interface. Key features include point-and-click configurations of multiple BreadCrumbs, real-time network views in tabular and topological formats, wireless client displays, configuration reporting, ability to perform firmware updates remotely, and per-BreadCrumb alerts and warnings.

Rajant's BC|Enterprise application provides historical network performance data with live updates to complement the real-time, tactical network views available from BC|Commander. BC|Enterprise displays network conditions showing what has transpired on the mesh for any chosen time period. The system also provides automatic alerts to identify and address network anomalies. Alerts can be delivered via email or text message. Plus, BC|Enterprise can also send alerts via an API to a business chat network. With fast access to performance, traffic, and configuration data, users can obtain valuable insights to optimize Kinetic Mesh network performance.

While operators of smaller networks may prefer to monitor and manage their Kinetic Mesh networks using BC|Commander alone, larger enterprise networks will find BC|Enterprise indispensable to reduce troubleshooting manhours and increase network management productivity.

Global **Service and Support**

Rajant's trained and authorized Kinetic Mesh Partners are available to assist customers with a wide range of network and application requirements globally. They have extensive experience in transitioning customers to private Kinetic Mesh networks and can provide site surveys and analysis, site design, installation, configuration, operations, troubleshooting, diagnostics, and technical support.

Summary

The information network is the backbone of any complex gas, oil, and petrochemical operations. It is the linchpin on which the productivity, safety, and profitability of the organization relies. Bandwidth and availability are precious. Downtime is unacceptable. Application data, voice, and video flowing over the network are as essential to operations and efficiency as the fuel in vehicles. To realize peak productivity and savings, mission-critical applications need to run on a communications network that offers highly reliable, agile, and adaptable connectivity that survives and thrives in diverse and evolving mobility-driven environments—a "living" mesh network that moves with and adapts to ongoing connectivity demands. Rajant Kinetic Mesh networks are the industry leader in meeting these demanding requirements.

> The proliferation of increasingly lower-cost digital technology is already unleashing innovative ideas across the oil and gas value chain. From how we develop a field, procure goods and services, and move product to all the HR and back-office services to support the core businesses, digital technologies could change everything, resulting in radical efficiency gains and improvements of both top and bottom lines… **companies that are willing to innovate and invest can unlock tremendous value and may remain financially strong regardless of what happens to global supply and demand trends."**
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> —**"Deloitt 2018 Outlook on Oil and Gas, My take: John England," John England,** Vice Chairman, US Energy & Resources Leader and US and Americas Oil & Gas Leader, Deloitte LLP

About Rajant Corporation

Rajant Corporation is the exclusive provider of private Kinetic Mesh® wireless networks, consisting of BreadCrumb® network nodes powered by InstaMesh® networking software. With Rajant, customers can rapidly deploy a highly adaptable and scalable network that leverages the power of real-time data to deliver on-demand, critical business intelligence. Rajant BreadCrumbs can seamlessly integrate with any Wi-Fi or Ethernet-connected device to deliver low-latency, high-throughput data, voice and video applications across the meshed, self-healing network. With the ability to take private network applications and data everywhere, Rajant networks are used across a broad array of industries, including military, mining, oil and gas, transportation, municipalities, agriculture, ports, manufacturing, and all levels of government. For more information, visit **www.rajant.com.**

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20+ OF GAME-CHANGING WIRELESS

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