Rajant Kinetic Mesh:

Secure, Private Wireless Networks
When Mobility and Productivity Matter Most

Network Infrastructure
for Today's Mobile Ecosystem

Enterprises continue to experience ever-growing demands for anytime, anywhere access to business information and applications through intelligent devices such as smart phones, tablets, laptops, cameras, and sensors. This demand is driving organizations to broaden their enhanced mobility and productivity capabilities.

Industry analysts agree Internet-of-Things (IoT) and machine-to-machine (M2M) connectivity are transformative productivity enablers which are quickly gaining market acceptance. With embedded intelligence, controls, and sensors, IoT and M2M devices generate and disseminate data, voice, and video information over wired or wireless networks without human involvement.

As organizations seek easily deployable and robust connectivity solutions to enable mobility and support IoT and M2M, wireless mesh networks are quickly becoming the preferred communications method. By providing connectivity over a web of interconnected wireless nodes, wireless mesh networks can enable communications between stationary and mobile assets while providing real-time access to critical data and applications. Our proven Rajant Kinetic Mesh networking solutions deliver the exceptional reliability, performance, scalability, and flexibility needed to realize the full benefits of IoT, M2M, and mobility.

Gartner, Inc. forecasts that **4.9 billion connected things will be in use in 2015,** up 30% from 2014, and will **reach 25 billion by 2020.**

— Gartner.com, *"Gartner Says 4.9 Billion Connected 'Things' Will Be in Use in 2015,"* 11/11/2014

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The market for wireless mesh networking has seen rapid growth in recent years by proliferation of wireless broadband and Wi-Fi.

— LinkedIn, *"Wireless Mesh Network Market – 2013-2019,"* Smita Deshmukh, Transparency Market Research, 8/20/2014

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Providing people, machines, and equipment the ability to simultaneously move and communicate requires a wireless communications network that is smart enough to adapt quickly to changing topographies and conditions without dropping communications. Our Kinetic Mesh networking technology delivers highly reliable, agile, and adaptable wireless mesh connectivity that will survive and thrive in diverse, evolving, and mobility-driven environments. While many competing solutions claim this level of reliability, agility, and adaptability, they consistently fall short because they cannot scale beyond a limited number of nodes and cannot handle multi-frequency hand-offs at network packet levels without a controller which creates a potential bottleneck and point of failure.

Our private, wireless mesh networking solutions consist of Rajant BreadCrumb® wireless nodes combined with our InstaMesh® networking protocol. Even where no communications infrastructure exists, you can quickly deploy a self-healing, peer-to-peer wireless mesh network with ad-hoc connectivity using multiple frequencies. If you require wide-area network links, a Rajant network can easily transmit and receive data via satellite, point-to-point wireless, or wired links. Once deployed, our Kinetic Mesh networks provide extremely flexible, reliable, wide-range communications that allow all nodes and clients to be in motion all the time. In operation, our mesh networks act as distributed Layer-2 switches with proprietary forwarding capabilities and as-needed Wi-Fi access-point service.

The Power of InstaMesh®

While Rajant solutions offer many advantages, our patented[1] InstaMesh technology is the most noteworthy. It is the mobility enabler in our solutions and responsible for the continuous and virtually instantaneous forwarding of all wired and wireless connections within the network. This groundbreaking software orchestrates all network traffic across our Kinetic Mesh networks. InstaMesh continuously discovers and updates BreadCrumb information with each packet to direct data quickly and reliably to the destination.

[1] U.S. Patent 9,001,645

Each BreadCrumb can have multiple connections, ensuring there will always be a viable pathway to deliver your information. As you add, move, or remove nodes, InstaMesh automatically adapts to the changes. New links are established in real-time, keeping the network available, intact, and secure. Any BreadCrumb network can scale to thousands of high-bandwidth mobile nodes. In fact, the more nodes you add, the more communication pathways you establish, and the more resilient your network becomes.

Regardless of how you design your mesh network, InstaMesh will optimize pathways to determine the most reliable and efficient paths between any two points. The software will dynamically redirect packets over multiple frequencies to avoid interference or obstructions. For example, if an LX5 BreadCrumb, offering up to four transceivers, encounters interference on 2.4 GHz, it can immediately redirect the packet from 2.4 GHz to 5 GHz to deliver the information at the fastest possible throughput. These capabilities greatly mitigate radio-frequency bottlenecks while delivering robust fault tolerance, high throughput, and low latency.

The diagram below illustrates how a Rajant LX5 mesh network supports multi-frequency communications and adapts to changes caused by the movement of BreadCrumb node E and how InstaMesh can redirect packets over multiple radio frequencies in the event of interference.

Localized Interference

Localized Interference

Localized Interference

Node E In-Motion

—— 5 GHz
—— 4.9 GHz (Pending Type Approval)
—— 2.4 GHz
—— 900 MHz
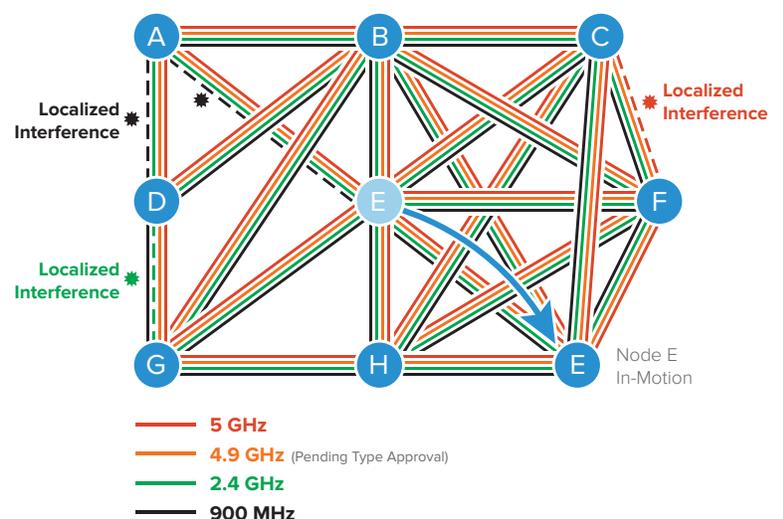
Reliable, Easy-to-Deploy BreadCrumb® Wireless Nodes

The industrial-strength, light-weight design of our BreadCrumbs coupled with IP67-rated sealing against dust and water intrusion allow them to operate continuously in virtually any environment for years. BreadCrumb devices are rugged, multi-frequency wireless nodes that create a Rajant mesh network when deployed with other neighboring BreadCrumb systems. The systems use our InstaMesh networking software to efficiently direct data, voice, and video over the mesh.

BreadCrumb LX5   **BreadCrumb ME4**   **BreadCrumb JR2**

Our BreadCrumb solutions portfolio serves a wide variety of application, connectivity, and environmental requirements. Although the LX, ME, and JR series share many features, there are differences between them as shown below.

Rajant BreadCrumb Models — Comparison of Key Features			
Feature	**LX5**	**ME4**	**JR2**
Radio Frequencies[2]	900 MHz; 2.4 and 5 GHz	900 MHz; 2.4, 4.9 and 5 GHz	2.4 and 5 GHz
Transceivers	Up to 4	Up to 2	1
Antenna Ports	Up to 6	Up to 4	1
Max. Physical Layer Data Rate (Throughputs Vary)	Up to 270 Mbps	Up to 270 Mbps	Up to 135 Mbps
Ethernet Ports	Up to 2 @ 1000 Mbps	1 @ 1000 Mbps and 1 @ 100 Mbps	1 @ 100 Mbps
Network Functionality	VLAN and QoS support; Access Point; Bridge; Gateway; DHCP; NAT and Port Forwarding; Automatic Protocol Tunneling (APT)		
Dimensions	197 mm x 220 mm x 29 mm (7.75" x 8.665" x 1.125")	189 mm x 95 mm x 51 mm (7.46" x 3.75" x 2.00")	216 mm x 60 mm x 38 mm (8.49" x 2.36" x 1.50")
Weight	1945 g (4 lbs 6 oz)	1250 g (2 lbs 12 oz)	310 g (11 oz)
Operating Temperatures	-30 °C[3] to 80 °C (-22 °F to 176 °F)	-30 °C[3] to 80 °C (-22 °F to 176 °F)	-30 °C[3] to 70 °C (-22 °F to 158 °F)
Humidity	95% (non-condensing)		
Enclosure	IP67 (6 — Dust-tight; 7 — Waterproof)		
Warranty	1 Year	1 Year	90 Days

[2] Custom frequencies from 350 MHz to 6 GHz are available for development upon request.

[3] Rajant provides warranty coverage to -40° C (-40° F).

Currently, BreadCrumbs can include up to four transceivers and radio frequencies. The LX5 and ME4 systems support the simultaneous use of 900 MHz, 2.4 GHz and 5GHz license-free frequencies for communication redundancy and interference mitigation. The ME4 also supports the 4.9 GHz licensed frequency. In addition, custom transceiver configurations and frequencies from 350 MHz to 6 GHz are available for development upon request, and may include a mix of licensed, military, or unlicensed frequencies. Our LX and ME BreadCrumbs offer 2x2 MIMO (multiple-input, multiple-output), or two transmit and two receive radio-frequency chains or antennas. This feature significantly increases the capacity of a transceiver. Having multiple transceivers also translates to more redundancy and diversity with fewer network issues due to interference, congestion, and equipment outages.

Using our InstaMesh software, BreadCrumbs will simultaneously send and receive information on different frequencies. If there is interference or congestion on one frequency, the system will intelligently redirect data over another frequency. In addition, our BreadCrumbs can use any of the multiple radio frequencies to provide localized access for Wi-Fi clients. This multi-frequency functionality greatly increases network availability.

Many competing solutions depend on controller nodes, resulting in higher latencies and service interruptions when there is a change in network characteristics or physical configuration. In contrast, our networks do not use a controller node, and have no single point of failure. Our Automatic Protocol Tunneling (APT) feature enables reliable and fast off-loading into your wired Ethernet network via multiple, simultaneous bridge-mode links, avoiding Spanning Tree Loops. In a large mesh network, having multiple ingress and egress points increases your usable bandwidth and delivers data to client devices faster. These capabilities further eliminate the possibility of a single point of failure.

Robust Security to Guard Your Information

Recognizing the critical nature of security, we have invested significant time and effort to ensure network security and protect confidential information. Each node can be configured with robust encryption and authentication capabilities, including:

- Multiple cryptographic options, including NSA Suite B algorithms; however, this does not designate the Rajant BreadCrumb LX5, ME4, and JR2 as NSA Suite B certified systems. Contact Rajant or your authorized Rajant partner if you require a system that is Suite B certified by the NSA.
- Configurable data and MAC address encryption via 128/192/256-bit Advanced Encryption Standard (AES), XSalsa20, XSalsa20/12, and XSalsa20/8
- Configurable per-hop, per-packet authentication between BreadCrumbs via 128/192/256-bit AES and HMAC-SHA 512/384/256/224/1
- Support for IEEE 802.11i, AES-CCMP and TKIP encryption, WPA/WPA2 Personal/Enterprise, 802.1x, 64/128-bit WEP, Access Control Lists
- Layer-2 and Layer-3 client/server and peer-to-peer security solutions compatibility
- Harris SecNet 54® encryption compatibility

Dynamic Frequency Selection (DFS) and Dynamic Transmit Power

Many countries require that 5 GHz wireless devices operating in the 5 GHz radio frequency (RF) band support DFS standards. The objective of these DFS regulations is to prevent interference with military and civilian radars by removing RF communications from the channels used by radars whenever radar transmissions are present. DFS is mandatory for certification of 5 GHz wireless devices in Europe (ETSI), the U.S. (FCC), Japan (based on FCC rules with some differences), and other countries. Rajant BreadCrumb devices comply with these regulations.

In addition to DFS, many of these same countries also require lower transmit power for nearby wireless connections. Dynamic transmit power enables BreadCrumbs to use less power when communicating with nearby peers while reaching distant peers with higher power. Once enabled, dynamic transmit power will automatically adjust the per-peer transmit power based on the distance required to send information and optimize the signal-to-noise ratio (SNR). This typically provides higher performance in very dense networks by minimizing mesh self-interference.

BC|Commander®
Intuitive Network Management Tool

Typically, users of highly mobile, private wireless networks do not have the time or resources to devote valuable man-hours to network-device set up and configuration. So, we offer virtually one-button set-up. In addition, our authorized channel partners can assist with installation, configuration, operation, troubleshooting, and diagnostics.

Although BreadCrumbs are simple to deploy and require minimal maintenance and administration, you may want to exercise more administrative control over your Rajant network. To give you that capability, Rajant wireless networks include our intuitive BC|Commander management and monitoring software. This application gives you many standard and advanced network-control capabilities for BreadCrumb-based wireless mesh networks. Available for both Microsoft® Windows® and Linux®, the system provides a global view of your network through an easy-to-use graphical interface. Key features include:

- Point-and-click, multiple BreadCrumb configurations
- Secure, encrypted links to each BreadCrumb in the network
- Real-time network views in table and topographic formats
- Real-time map view of the network via GPS-enabled nodes
- Wireless client display
- Peer link information for GPS-enabled nodes
- Network analysis and configuration reporting
- Control of configurable features such as transceiver settings, mesh encryption and authentication, VLANs, DFS, dynamic transmit power, and InstaMesh settings
- InstaMesh trace displaying paths taken through the mesh network
- Ability to perform firmware updates remotely
- Customizable task-oriented screen layouts

With our BreadCrumb Application Programming Interface (BCAPI), you can design your own custom interface to integrate with current network monitoring systems and provide granular details of the mesh for end users to replace day-to-day use of BC|Commander. This allows you to monitor and manage Rajant BreadCrumbs using your own software.

Supporting Your Critical Applications

A wireless mesh network is only as valuable as the information it delivers, the applications it supports, and the environments in which it can function. Rajant BreadCrumb-based networks have been deployed and proven to deliver continuous, high-performance communications in some of the most demanding environments across the globe. For more than a decade, our private, wireless mesh networks have been successfully installed in many industry-leading mining companies and top military agencies as well as other industrial organizations.

While each market has unique requirements and challenges, our wireless mesh networks have consistently met or exceeded our customers' requirements and overcome their challenges. The following pages describe some of the exacting markets we serve and how our networks support their applications.
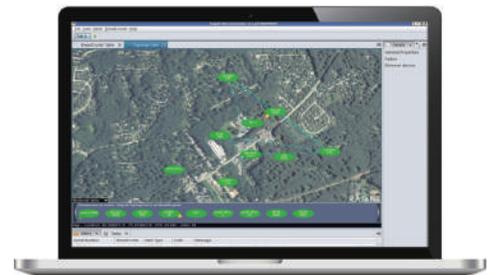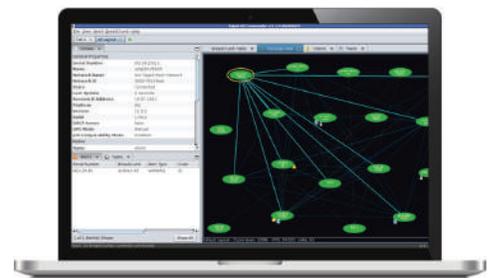
The Right BreadCrumb for the Right Function

While all BreadCrumb systems can function as infrastructure or mobile nodes, our premier LX5 systems are recommended for building and expanding your core mesh infrastructure since they offer the most power and flexibility with multiple transceivers and up to two 2x2 MIMO antenna ports per transceiver. Our ME4 systems are ideal for adding wireless infrastructure and mobile nodes into an existing network. The JR2, our single-transceiver model, is typically used for on-body and on-vehicle communications and remote connectivity for a small number of people or assets. All BreadCrumbs integrate easily with each other, LTE networks, and third-party satellite, wired, point-to-point wireless, and Wi-Fi devices to form a complete wireless networking solution.

Key BreadCrumb Features

- Multiple transceivers and radio frequencies
- Simultaneous send and receive operations
- Multiple, 2x2 MIMO-enabled antenna ports
- Up to 270 Mbps physical-layer data rate
- Scalable to thousands of high-bandwidth nodes
- Full redundancy – no single point of failure
- Self-configuring and self-healing operations
- Automatic interference avoidance
- Robust security
- Sealed enclosures

Open-Pit Mining

Typically, mines span large geographic areas where fleets of high-cost, high-tech vehicles and equipment are dispatched, managed, and monitored using sophisticated hardware and software systems – all of which must operate 24x7x365. On-site personnel are constantly on the move. The terrain continually changes; the environment is dusty and noisy; and weather conditions run the gamut. The logistics involved to efficiently orchestrate the people, processes, and machinery are enormously challenging.

Rajant's dependable, self-healing wireless mesh networks are designed and engineered for just such conditions. Every day, our patented Kinetic Mesh networking technology is helping mine operators increase productivity, reduce costs, and improve safety. From vehicle and equipment health monitoring, fleet management, and miner tracking, to drilling and blasting management, dispatch, and production control, our solutions are helping mine operators and personnel work more efficiently and safely. As terrain changes and nodes are added or moved, their networks are adapting to the new conditions without disrupting service or operations.

Oil and Gas

Oil and gas complexes also cover large geographic areas which are dusty, noisy, and subject to weather extremes; plus, these environments can be potentially hazardous. Every aspect of exploration, extraction, and production has to be carefully monitored and managed to ensure continuous operations and cost containment. Rajant private wireless mesh networks deliver the high reliability, performance, agility, and security needed to keep your people and assets continuously communicating while working more safely.

With a Kinetic Mesh networking infrastructure, you can depend on always-on connectivity for your process and production control, platform and well monitoring, video surveillance, vehicle routing and dispatch, and personnel and contractor communications. Fully redundant, wireless networks can efficiently and reliably send and receive critical SCADA (Supervisory Control and Data Acquisition) information, regardless of environmental and weather challenges. When you need to shut down operations for inspection, testing, and maintenance, the network can supply critical wireless connectivity for roaming employees and contractors.

Transportation

In response to demands for enhanced passenger experiences, improved safety, and increased profits, transportation operators are tasked with deterring crime, increasing productivity, and reducing costs. Today, sensors, cameras, and handheld devices on smart buses and trains monitor and report passenger behavior, vehicle and equipment health, vehicle speeds and locations, freight status, weather reports, fuel consumption, traffic optimization, and more. Effective information utilization depends on having a communications network that can connect hundreds of moving assets simultaneously. Our self-healing, wireless mesh networks can provide reliable, secure, high-bandwidth connectivity to keep buses and trains communicating with command centers, stations, and each other.

Buses and trains often travel across vast, remote areas where no, or limited, cellular, 3G/4G, or Wi-Fi infrastructure is available. In such locations, our Kinetic Mesh technology can establish and maintain a resilient wireless mesh network capable of any-node to any-node connectivity. Where a wide area link is required, BreadCrumbs can effortlessly transmit and receive information through satellite, point-to-point wireless, or wired links.

In addition, our mesh networks can supply critical redundant connectivity to support positive train control (PTC). Mandated by U.S. Congress in the Rail Safety Improvement Act of 2008 (RSIA), PTC is GPS-based technology designed to prevent train-to-train collisions, over-speed derailments, unauthorized incursion into work zones, and train movement through switches left in the wrong position. A Rajant wireless mesh networking solution can keep trains connected to provide continuous, real-time access to critical information and applications while helping operators comply with regulatory requirements.

Military

Military and defense personnel frequently need to establish and maintain tactical communications for both domestic and battlefield applications. Often these communications must operate in hostile terrain and extreme weather conditions. Security is extremely important to protect highly sensitive information and ensure personnel safety. Rajant private wireless mesh networks are providing mission-critical communications for a variety of military applications, including convoy communications, surveillance, man-portable and personal-area networks, high-bandwidth connectivity, sensor aggregation, training, and TROIP (Tactical Radio Over Internet Protocol).

Even in the most challenging conditions, our wireless mesh solutions are ideal for tactical communications due to their rugged construction, fast deployment, robust security, superb reliability, and high-bandwidth connectivity. In a convoy scenario, for example, the Kinetic Mesh technology linking vehicles ensures that the data, voice, and video communications remain on the localized network – even if some of the satellite-equipped vehicles are compromised. The wireless mesh network complements existing satellite or microwave links and provides resilient, self-healing broadband connectivity that helps to ensure safety in remote theatres of operation.

Municipalities

With pressure from taxpayers, state and federal agencies, and competing cities, municipalities are seeking new technologies to help them transform their systems, operations, and services. The objectives are to engage with citizens, attract new residents and businesses, improve the quality of life, improve service-delivery efficiencies, and maintain a healthy economic climate. Perhaps most pressing is the need to protect citizens and property by enhancing emergency response systems and complying with Homeland Security initiatives. Although budgets are tight, forward-thinking municipalities realize that innovative technologies can help them achieve these objectives.

Our reliable, high-bandwidth, secure, and flexible wireless mesh networks can help municipalities improve first-responder and emergency-response communications, consolidate data access, increase online citizen services, improve intra- and inter-agency collaboration, improve resource utilization, and even provide opportunities to increase revenue. With an easy-to-install BreadCrumb-based network, on-the-move police officers, firefighters, and other first responders can have real-time access to vital information which can help them respond more quickly and safely while enabling better on-scene decisions.

Federal and State Government

As government has become more mobile, agencies such as the Departments of Energy, Agriculture, and Interior have more in-field, in-motion personnel than ever before. Whether protecting wildlife in Alaska, measuring seismic activity in California, or analyzing water samples in the Mississippi river, personnel are performing duties remotely. During emergencies federal and state officials need to coordinate activities to rescue and house survivors and distribute emergency aid. Border control officials are tasked with monitoring people, vehicles, vessels, and goods as they cross borders. These are just a few examples of the many government applications which require real-time access to vital information and anytime, anywhere communications.

Rajant private wireless mesh networks can provide continuous, reliable, high-bandwidth, secure connectivity for all these situations and many more. With easy and fast deployment, BreadCrumb wireless nodes can form a mesh network to support disaster recovery. For long-term projects, our fully redundant wireless mesh networks can provide always available communications across thousands of high-bandwidth wireless nodes — all of which can be in motion.

Summary

If you are evaluating or building a network infrastructure or looking to extend or augment your existing network to enhance productivity and mobility, you want to make the right choice to address your specific objectives. When it comes to private wireless mesh networking, a Rajant mesh network is your best alternative. Our Kinetic Mesh technology is unequalled in delivering continuous wireless connectivity to support a wide variety of customers and applications.

And, we have a long history of delivering on our promises! In fact, our wireless mesh networks have become the standard for mining. Mining is clearly one of the most challenging and

demanding environments in which to perform, and we have performed flawlessly. Many of our customers have Rajant networks which have been in operation for years without system failure.

When evaluating wireless communication networks for your organization, you can be assured our networks have been thoroughly tested in real-world scenarios and are proven to provide exceptional reliability and performance in the most stringent circumstances imaginable. So let us show you how a Rajant private wireless mesh network can meet and even exceed your individual requirements.

RAJANT