

Rajant Kinetic Mesh:

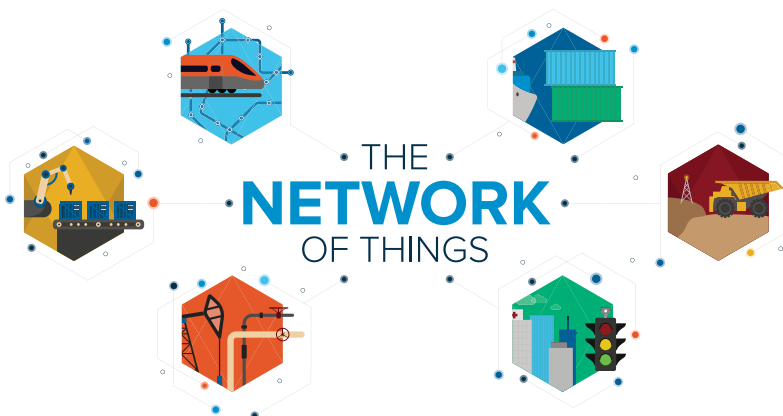
Get Your Network Rajant Ready
and Benefit from the ‘Network of Things’

Network Infrastructure for Today's Mobile World

Industry analysts agree that the Internet of Things (IoT), autonomy, and robotics are transformative productivity enablers that are quickly gaining market acceptance. With embedded intelligence, controls, and sensors, these rapidly evolving systems can generate and disseminate large volumes of valuable data, voice, and video over wired or wireless networks without human involvement. Now Industry 4.0 ushers in a new phase of manufacturing automation that promises to integrate operations and technology into an all-inclusive digital ecosystem.

As a result, industrial enterprises continue to experience ever-growing demands for anytime, anywhere access to information and applications through intelligent devices such as cameras, sensors, smart phones, tablets, and laptops. By providing connectivity over a web of interconnected wireless nodes, mesh networks can supply stationary and mobile workers, assets, and processes with real-time, continuous communications.

Rajant's Kinetic Mesh® networks help you bring these network-of-things technologies to life. Our networks can transform virtually any asset into network infrastructure, interconnecting diverse environments and all the things that move within them.



“Gartner forecasts **21 billion connected things by 2020.** IoT is proliferating across all sectors, creating opportunities for those who are actively exploring opportunities and risks for those who are passive.”

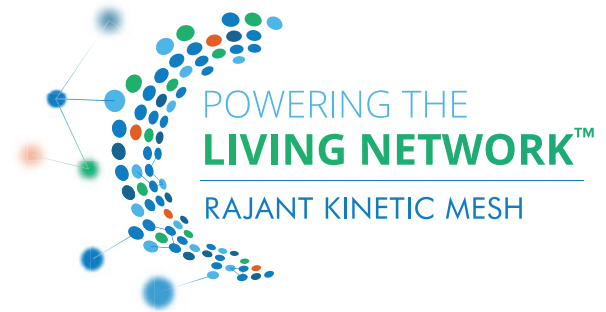
—Gartner, Inc., “Measuring the Strategic Value of the Internet of Things for Industries”

“Industrial sectors are planning to commit **US \$907 bn p.a. (per annum) to Industry 4.0—around 5% of revenue p.a.** A major focus of these investments will be on digital technologies like sensors or connectivity devices, and on software and applications like manufacturing execution systems.”

—PwC, 2016 Global Industry 4.0 Survey

Rajant Kinetic Mesh® Networks Live Up to Your Demands

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 private Kinetic Mesh solutions offer highly reliable, agile, and adaptable wireless mesh connectivity that survives and thrives in diverse and evolving mobility-driven environments—a “living” mesh network that moves with and adapts to your connectivity demands. Many competing solutions claim this level of performance. However, they consistently fall short because they cannot scale beyond a limited number of nodes and/or cannot handle multi-frequency hand-offs at packet levels without a controller which creates a potential bottleneck and point of failure.



Our self-healing, peer-to-peer wireless mesh networks consist of Rajant BreadCrumb® wireless nodes powered by our InstaMesh® networking protocol. Even where no communications infrastructure exists, you can quickly deploy a wireless mesh network with ad-hoc connectivity using multiple frequencies. If you require wide-area links, a Rajant network can easily transmit and receive data via satellite, point-to-point wireless, or wired link. Once deployed, 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.



Rajant Kinetic Mesh: Game Changing Wireless Networks

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The Power of InstaMesh

While Rajant networks offer many advantages, our patented¹ 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 continually discovers and updates BreadCrumb information with each packet to direct data quickly and reliably to its destination. While InstaMesh utilizes a proprietary routing algorithm, it is fully compatible with 802.11 standards. If your information can be sent over Ethernet, it can be sent over a Kinetic Mesh network.

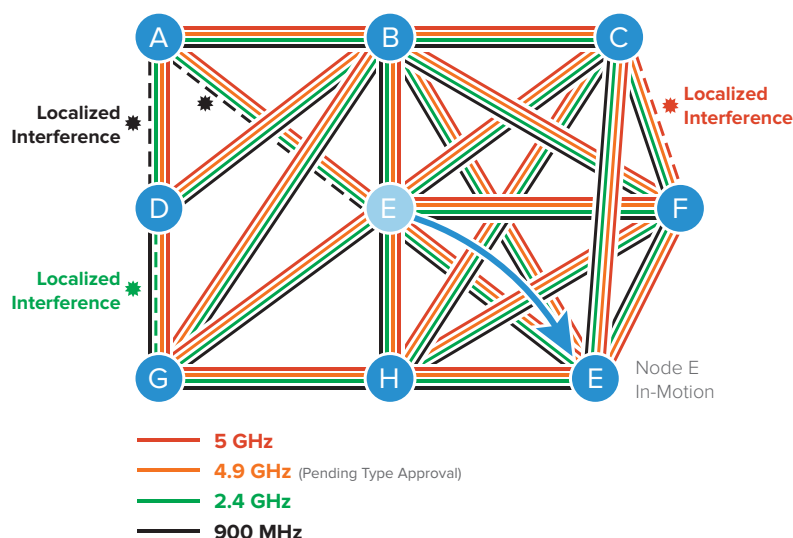
Our Automatic Protocol Tunneling (APT) feature enables reliable and fast off-loading into your wired Ethernet network

via multiple, simultaneous bridge-mode links, avoiding Spanning Tree Loops. In a large mesh network, establishing multiple ingress and egress points can increase usable bandwidth, deliver data to client devices faster, and further eliminate the possibility of a single point of failure.

As you add, move, or remove nodes, InstaMesh automatically adapts to the changes, establishing new links in real-time while keeping the network available, intact, and secure. In-motion BreadCrumbs remain connected to other nodes while forming new connections with approaching nodes. InstaMesh never has to break communications to form new connections as is the case with traditional wireless networks, and it maintains connections until they are no longer needed.

¹ U.S. Patent 8341289B2

Because BreadCrumbs® have multi-radio capabilities, InstaMesh® can dynamically redirect packets to mitigate the effects of interference or obstructions and always chooses the most efficient path to the destination. This diagram illustrates how a multi-frequency LX5 network adapts to changes caused by the movement of BreadCrumb node E. The dotted lines show locations where radio frequencies experience interference. In these situations, InstaMesh instantly reroutes traffic over a clear frequency. These capabilities greatly alleviate radio-frequency bottlenecks while maintaining robust fault tolerance, high throughput, and low latency.



Reliable, Easy-to-Deploy BreadCrumb Wireless Nodes

Rajant BreadCrumbs are rugged wireless nodes that create a mesh network when deployed with other neighboring BreadCrumbs. The industrial-strength, light-weight design of the nodes coupled with IP67-designed dust-tight and water-tight enclosures allow them to operate continuously in virtually any environment for years.

BreadCrumb networks can scale to hundreds of interconnected mobile nodes. In larger networks, a single node could have hundreds or even thousands of pathways over which data can be sent and received. In fact, the more nodes you add, the more resilient your network becomes. Since BreadCrumbs automatically form multiple connections with other nodes within the mesh, our networks are inherently redundant. To provide redundancy in traditional wireless networks, additional access points or infrastructure nodes must be purchased to serve as backups, inflating the overall deployment cost significantly. In Kinetic Mesh® networks, the mesh forms a fully redundant web of connectivity without the added cost of purchasing “backup nodes.”



BreadCrumb LX5



BreadCrumb ME4



SlipStream

Our LX5 and ME4 systems support the simultaneous use of 900 MHz, 2.4 GHz and 5 GHz license-free frequencies for communication redundancy and interference mitigation. The ME4 also supports the 4.9 GHz licensed frequency. 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.

LX and ME models also offer 2x2 MIMO (multiple-input, multiple-output), providing two transmit and two receive radio-frequency chains or antennas. As a result, BreadCrumbs can simultaneously send and receive information on different frequencies and can use any of the multiple frequencies to provide localized access for Wi-Fi clients. This feature significantly increases the capacity of a transceiver and translates to greater diversity with fewer issues due to interference, congestion, and equipment outages.

SlipStream is our indoor BreadCrumb® model that enables high-throughput connections between your wired and Kinetic Mesh® networks to help you meet increasing communication requirements. The high-speed processor allows data streams to traverse the wired-wireless boundary at rates of several hundred megabytes per second. SlipStream works in concert with other BreadCrumb models via APT and is designed to help you increase throughput and virtually eliminate potential ingress and egress bottlenecks in new or existing networks.

Many competing wireless solutions depend on controller nodes which result 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. Mesh clustering lets you designate per-BreadCrumb sub-meshes that will only mesh with a specified series of nodes. This allows you to operate two BreadCrumbs in a point-to-point (PTP) capacity, eliminating the need to purchase a third-party PTP backhaul link. You can also isolate one or more groups of BreadCrumbs to mesh with each other and no other nodes outside your defined clusters.

The Right BreadCrumb for the Right Function

LX5 and ME4 BreadCrumbs 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 transceivers and antenna ports. Our ME4 systems are ideal for adding wireless infrastructure and mobile nodes into an existing network. Both models integrate easily with each other, LTE networks, and third-party satellite, wired, point-to-point wireless, point-to-multipoint wireless, and Wi-Fi devices.



Key BreadCrumb Features

- Multiple transceivers and radio frequencies
- Multiple, 2x2 MIMO-enabled antenna ports
- Up to 300 Mbps physical-layer data rate
- Scalable to hundreds of high-bandwidth nodes
- Full redundancy—no single point of failure
- Self-configuring and self-healing operations
- Automatic interference avoidance
- Military-grade security

Dynamic Frequency Selection (DFS) and Dynamic Transmit Power (DTP)

Many countries require that wireless devices operating in the 5 GHz radio frequency (RF) band support DFS standards. The objective 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), and other countries. BreadCrumbs comply with these regulations.

Many of these same countries also require lower transmit power for nearby wireless connections. DTP enables BreadCrumbs to use less power when communicating with nearby peers while reaching distant peers with higher power. Once enabled, DTP 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 improves performance in dense networks by minimizing mesh self-interference.

Military-Grade Security to Guard Your Information

The ever-increasing number of interconnected devices such as smart phones, cameras, laptops, and sensors that traverse a network has placed great pressure on those responsible for ensuring the security and authenticity of the traffic moving in, out, and across the network. In addition, network users are placing greater demands on these infrastructures to support more mobility-enabled applications and services to employees and contractors. As network size and scope expands, network operators and security officers are tasked with the difficult job of assuring their enterprise communications remain protected and that their information systems are not compromised by a variety of attack vehicles.

The consequences of a network security breach can be severe, including everything from significant business and service disruption to financial system collapses and even catastrophic situations that impact human safety. Needless to say, security is a top priority for mission-critical networks. Recognizing this, we have invested significant time and effort to secure your mesh network and protect confidential information. The robust security features built into our BreadCrumb® nodes can provide reliable mesh network security without impacting the efficiency and performance of the network. Each node can be configured with robust encryption and authentication capabilities, including:

- Multiple cryptographic options
- Configurable data and MAC address encryption
- Configurable per-hop, per-packet authentication between BreadCrumbs

Rajant Active Security Certifications

- FIPS 140-2 Level 2
- Suite A—Classified
- AES Suite B—Secret and Below



Managing the Mesh for Optimal Performance

Wireless networks are dynamic, so it is common to have a variety of network changes over time which can result in immediate or eventual performance degradation. Changes can include soft changes such as mesh software configuration changes, unmanaged addition of applications on the mesh, and/or improper changes to the LAN segment. You can also experience physical changes such as operational expansion beyond the initial coverage area, layout or topographic changes to the mesh area, and/or changes in how BreadCrumbs are deployed on vehicles or infrastructure.

BCICommander® and BCIEnterprise are intuitive software applications designed to help you quickly and easily identify changes and keep your network operating at peak performance. Together they offer a comprehensive monitoring and management solution for your Kinetic Mesh® network, providing both historical and real-time data.

BCICommander

Many users of 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, and our authorized channel partners can assist with installation, configuration, operation, troubleshooting, and diagnostics.



Although BreadCrumbs® are simple to deploy and require minimal maintenance, you may want to exercise more administrative control over your Rajant network. To help you configure, monitor, and manage individual BreadCrumbs or groups of BreadCrumbs, our networks include BCICommander®. 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:

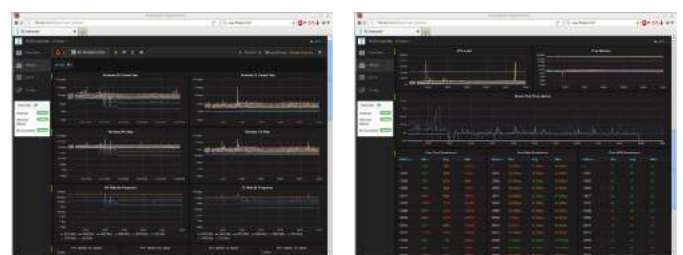
- Point-and-click configurations of multiple BreadCrumbs
- Real-time network views in tabular and topological formats
- Real-time map view of the network via GPS-enabled nodes
- Wireless client displays, network analysis, and configuration reporting
- Peer link information for GPS-enabled nodes
- Per-BreadCrumb alerts and warnings
- 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

Our BreadCrumb Application Programming Interface (BCAPI) lets design your own custom interface to integrate with current network monitoring systems and provide granular details of the mesh to replace day-to-day use of BCICommander. This lets you monitor and manage BreadCrumbs using your own software.

BCIEnterprise

BCIEnterprise delivers historical network performance data with live updates to complement the real-time, tactical network views available from BCICommander. The system allows you to view network conditions showing what has transpired on your Kinetic Mesh® network for any chosen time period. With fast access to performance, traffic, and configuration data, you can proactively identify and diagnose potential problems and obtain the insights needed to optimize network performance. Key features include:

- Low overhead, always-on monitoring and data gathering
- Installation on a locally-hosted web server to retain data on your network, requiring no Internet connection
- Network functionality spanning user-defined time slices
- Automatic alerts to identify and address network anomalies
- Analysis data for individual nodes or administratively-designated groups of nodes
- Remote or on-site monitoring and management
- Individual user accounts to access monitoring functions
- Customizable dashboards



Supporting Your Mission-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 functions. BreadCrumb®-based networks are proven to deliver continuous, high-bandwidth communications in some of the most demanding environments across the globe. For more than a dozen years, our wireless mesh networks have been operating successfully in industry-leading mining companies, top military agencies, and other notable industrial organizations. While each market has unique requirements and challenges, the following information describes some of the exacting markets we serve and how our networks can support their applications.

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. Terrain continually changes; the environment is dusty and noisy; and weather conditions run the gamut. The logistics involved to effectively orchestrate the people, processes, and machines are enormously challenging.

Every day, our dependable networks are 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, dispatch, and production control, our solutions are helping personnel work more efficiently and safely. As terrain changes and nodes are added or moved, their networks can adapt to 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.

A Kinetic Mesh® network can help your people and assets stay connected while working more safely. You can provide connectivity for process and production control, platform and well monitoring, video surveillance, vehicle routing and dispatch, and personnel and contractor communications. You can efficiently transmit critical SCADA (Supervisory Control and Data Acquisition) information, regardless of environmental conditions. And, when you need to shut down operations for inspection, testing, and maintenance, the network can supply critical wireless connectivity for roaming employees and contractors.

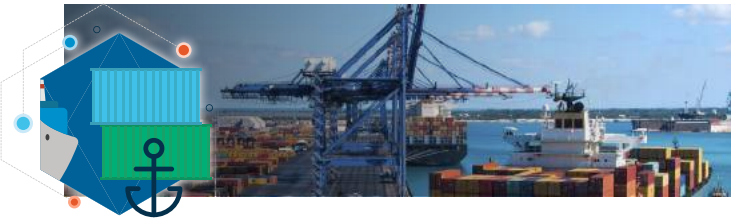
Transportation



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. 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 flow, and more. Our self-healing, wireless mesh networks can connect hundreds of moving assets and provide reliable, secure, broadband connectivity to keep vehicles in communication with command centers, stations, and each other.

Buses and trains often travel across vast, remote areas where no, or limited, cellular, 3G/4G/5G, or Wi-Fi infrastructure is available. In such locations, our networks can establish and maintain 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 networks can supply fully redundant connectivity to support communications-based train control (CBTC).

Ports



With the majority of the world's trade carried by the international shipping industry, ports are vital to the flow of commodities and capital worldwide. This puts immense pressure on port operators to optimize cargo movement and maintain tight security. Our Kinetic Mesh® networks allow workers, ships, containers, equipment, and vehicles to move and communicate simultaneously. With multi-transceiver capabilities, InstaMesh® can dynamically route traffic to handle interference and provide the fastest possible throughput. And, robust security helps protect against terrorist strikes and container theft or smuggling.

Municipalities



With pressure from taxpayers, state and federal agencies, and competing cities, municipalities are seeking new technologies to help them better engage with citizens, attract new residents and businesses, improve the quality of life, manage traffic flow, and maintain a healthy economic climate. Top of mind is the need to protect citizens and property. Although budgets are tight, forward-thinking municipalities are investing in innovative technologies to help them achieve these objectives.

Our high-bandwidth, secure networks can help your municipality improve video surveillance and first-responder communications, consolidate data access, increase online services, improve collaboration and resource utilization, and even increase revenue. With real-time, mobile access to vital voice, video, and data, police officers, firefighters, and emergency teams can respond more quickly and safely while enabling better on-scene decisions.

Industry 4.0



Massive increases in computing power, data volumes, advanced analytics, man-to-machine interfaces, and mobility come together in Industry 4.0 to create the “smart factory.” This next phase in manufacturing automation connects people, machines, processes, business intelligence, sensors, and computers to form a complete digital ecosystem. Typical goals are to manage the value chain, produce superior products, and gain a commanding competitive edge. Technologies such as the Internet of Things (IoT), autonomy, and robotics are included in the digital product footprint from design through the life cycle. Our Kinetic Mesh networks are uniquely qualified to provide the ubiquitous connectivity required to support Industry 4.0 applications.

Military



Military and defense personnel frequently need to establish and maintain tactical communications for domestic and battlefield applications—often in hostile terrain and extreme weather conditions. Security is vital to protect highly sensitive information and ensure personnel safety. Our Kinetic Mesh® networks are providing mission-critical communications for a variety of military applications, including convoy communications, surveillance, man-portable and personal-area networks, sensor aggregation, training, and TROIP (Tactical Radio Over Internet Protocol).

Our networks are ideal for tactical communications due to their rugged construction, fast deployment, robust security, superb reliability, and high-bandwidth connectivity. They can complement existing satellite or microwave links and provide broadband communications that help to ensure safety in remote theaters of operation. In a convoy, the mesh technology linking vehicles can keep communications on the localized network even if some of the satellite-equipped vehicles are compromised.

Autonomy

The use of autonomous vehicles such as unmanned ground vehicles (UGVs) and small unmanned aerial vehicles (sUAVs) is rapidly gaining acceptance across virtually all industrial organizations. Our Kinetic Mesh® networks can provide the continuous communications needed to support efficient and safe operations for autonomous and semi-autonomous vehicles and equipment.



Sharp Intellos™ UGV with an integrated BreadCrumb wireless node



Rajant BreadCrumb®-enabled drone

Federal and State Government



As government has become more mobile, agencies such as the Departments of Energy, Agriculture, and Interior have a growing number of on-the-move personnel. Whether protecting wildlife, measuring seismic activity, or analyzing water samples, workers are performing duties remotely. During emergencies, officials have to coordinate activities to rescue and house survivors and distribute emergency aid. Border control officials are tasked with monitoring people, vessels, and goods as they cross boundaries. These are just a few examples government applications that require real-time mobile communications.

Our wireless communication networks can support a wide variety of mobile government applications. BreadCrumbs® can be deployed quickly and easily to support disaster recovery. For long-term projects, fully redundant networks can provide high-performance communications across hundreds of mesh nodes—all of which can be in motion at the same time.

Summary

When it comes to mobile communications, a “living” Kinetic Mesh network is your best alternative. Our industry-leading InstaMesh® technology is unequalled in delivering continuous wireless connectivity to support a wide variety of industries and applications. Our networks have been thoroughly tested in real-world scenarios and are proven to provide exceptional reliability, performance, security, and scalability in the most stringent circumstances imaginable. And, many of our customers have Rajant networks that have been operating for years without system failure.

Let us show you how a Rajant Kinetic Mesh network can provide the mobile communications network you need to support your game-changing business enablers.