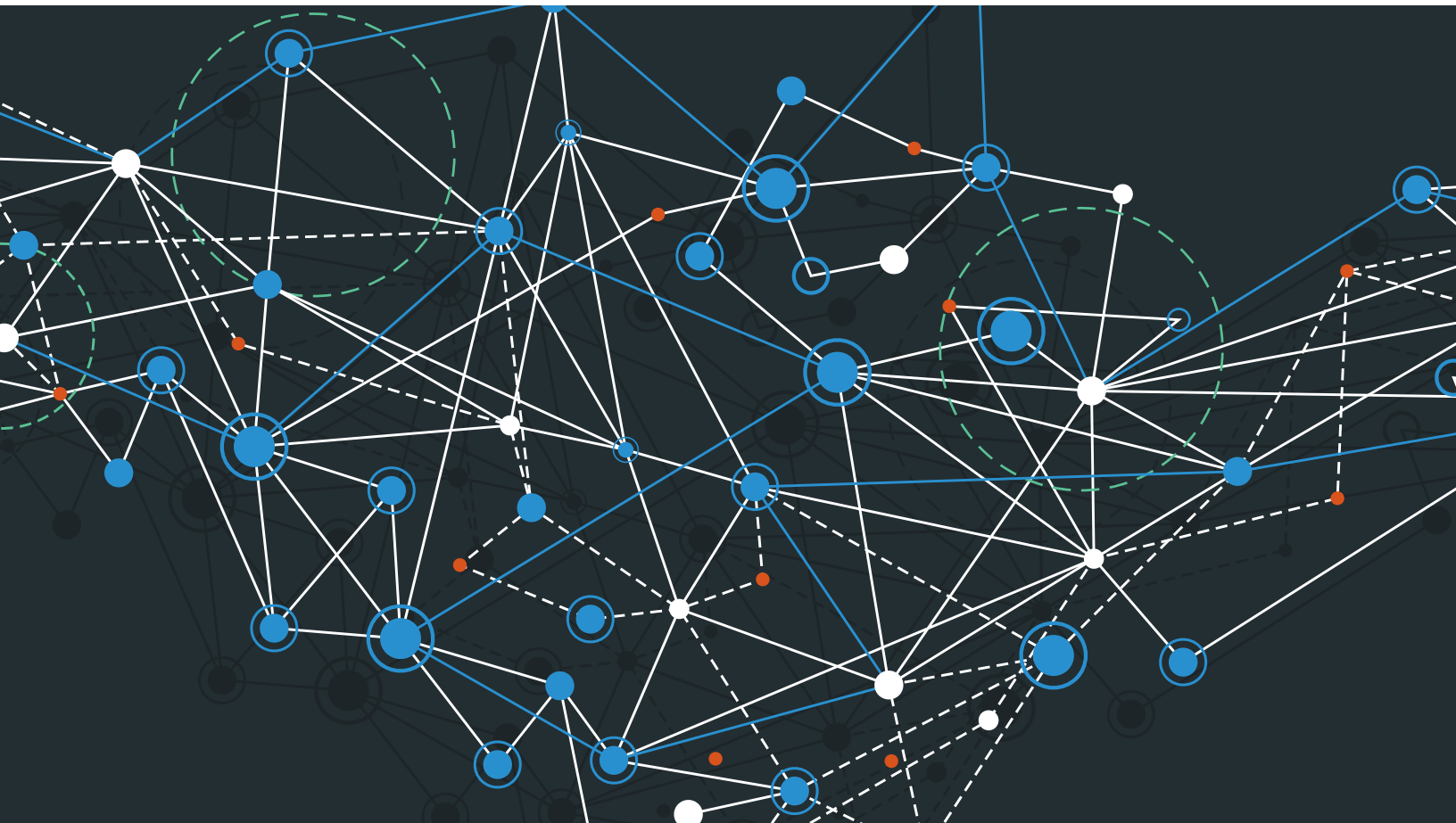
RAJANT

Rajant Kinetic Mesh Networks: **Untraditional for Good Reason**

Rajant InstaMesh® Brilliantly Orchestrates Kinetic Mesh Traffic Across the Network



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Executive **Summary**

Anyone who has tried to build a secure, reliable, high-performance wireless network — one in which devices are mobile and can move freely — knows how difficult this is to accomplish. Making a wireless network secure, or making it reliable, or making it high performance is hard enough, but achieving all of these objectives at the same time is an extremely difficult undertaking.

More often than not, traditional wireless networks fail to achieve these goals, earning them a reputation for being unreliable, slow, and not very secure.

Rajant wireless mesh networks are not traditional mesh networks. We call our networks *Kinetic Mesh networks*, and they are uniquely designed for environments and applications where client devices and even the network itself are in a state of constant change and motion.

This white paper explores the challenges of traditional wireless networks, particularly when it comes to mobility, and how Rajant Kinetic Mesh networks overcome those issues by employing InstaMesh® networking software to orchestrate traffic via the fastest pathways between any wired, wireless, or in-motion points.

Market Insight

A "Mobility at Work" report by CDW revealed that 39% of IT professionals surveyed have already seen the growth of mobility create serious issues tied to their existing network performance.[1]

Part I: **What is a Kinetic Mesh Network?**

Kinetic Mesh networks consist of Rajant BreadCrumb® wireless nodes running Rajant InstaMesh® networking software. When you turn on more than one BreadCrumb, they find each other automatically and talk to and through each other to deliver data packets wherever they need to go. BreadCrumbs can form very large and very dense wireless networks in which everything can move.

Granting all devices and infrastructure complete freedom of movement while maintaining continuous connectivity is extremely powerful. Nodes can be added or removed at any time, the radio frequency (RF) environment can change, and InstaMesh will automatically ensure that data is delivered where it is needed. Together, BreadCrumb nodes and InstaMesh software achieve the three elusive goals of security, reliability, and high performance at the same time.

This is well-proven in the field. For more than a decade, Rajant Kinetic Mesh networks have been providing anytime, anywhere wireless communications for a variety of military applications and industrial enterprises such mine operators, gas and oil companies, utilities, transportation agencies, municipalities, and a variety of state and federal agencies.

BreadCrumb Nodes: Tough Hardware for Tough Conditions

If you want your applications and data to be available when you need them, you need a reliable network. And if you want a reliable network, you have to start with reliable hardware.

Rajant's extensive experience with military and industrial customers is reflected in our hardware. Rated to IP67 Ingress Protection, BreadCrumbs are dust-tight and waterproof when immersed up to 1m. They are also protected from vibration, shock, and heat, and have operated for years in extreme environments. For example, fielded BreadCrumbs have operated in temperatures ranging from -40˚ F to 115˚ F (-40˚ C to 46˚ C). Our customers have even had BreadCrumbs encased in ice that continued to operate and provide applications and data to their users.

Rajant BreadCrumb wireless nodes are suitable for installation on trucks, shovels, aircraft, convoys, drones, and other moving equipment in addition to traditional fixed locations.

BreadCrumb LX5

BreadCrumb ME4

BreadCrumb JR2

Figure 1. *BreadCrumb Wireless Mesh Nodes*

Multiple Transceivers Are Key to a Reliable, High-Performance Network

Rajant BreadCrumbs are available with multiple radio transceivers operating on multiple radio frequencies. Current models can include up to four 802.11 transceivers and up to four frequencies in a wide variety of combinations. Available unlicensed frequencies include 900 MHz, 2.4 GHz, and 5.8 GHz. Rajant has a soft license for 3.65 GHz in the U.S., and we have deployed radios in the 4.9 GHz licensed band for law enforcement, first responders, and public safety networks. We also offer military configurations designed to meet other specific frequency requirements. Upon request, we can provide custom configurations that operate over frequencies from 350 MHz to 6 GHz and can include a mix of licensed and unlicensed frequencies.

Because they support multiple transceivers and frequencies, BreadCrumbs can tolerate interference and network congestion and still continue to operate. Having multiple radio frequencies opens up redundant traffic pathways, and using all available frequencies and paths for all network functions, gives Kinetic Mesh networks very high performance and reliability and allows networks to adapt to changes immediately. Moreover, all this happens automatically, requiring no administrative intervention.

Additionally, any BreadCrumb can receive data from one peer and forward it to another on a different frequency at the same time. This results in extremely low latency – on the order of 0.5ms per hop – and is only possible with multiple transceivers.

InstaMesh: Unparalleled Mobility, Scalability, and Availability

In addition to rugged, reliable hardware, Kinetic Mesh networks use Rajant's robust, responsive networking software called InstaMesh. InstaMesh is a proprietary, peer-to-peer networking protocol and the key mobility enabler in our Kinetic Mesh networks. It continuously directs all wired and wireless communications within the Kinetic Mesh network and allows BreadCrumbs to react immediately to changes in network topology, network load, and external environmental conditions. InstaMesh runs on every BreadCrumb node and has continued to evolve for over ten years as we continuously enhance the software with new technologies.

Although InstaMesh is proprietary software, it supports all of the important industry standards. InstaMesh uses 802.11 standards for the physical layer and makes its packet-directing decisions at OSI Layer 2. In short, if your data can be sent over Ethernet, it can be sent over a Rajant KineticMesh Network.

The diagram in Figure 2 shows how a Kinetic Mesh network can adapt to the changes caused by the movement of Node E. New links are established in real time by InstaMesh, keeping the network available, intact and secure.

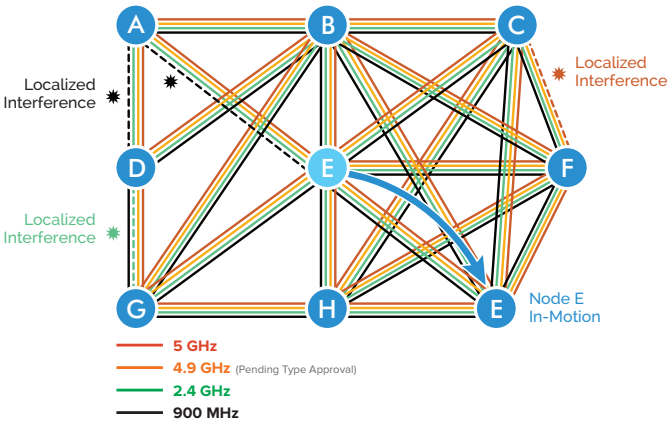

Figure 2. *Kinetic Mesh Networks Maintain Connectivity While Nodes Are in Motion*

Part II: **How InstaMesh Works**

InstaMesh is a completely distributed protocol. A Kinetic Mesh network has no central controller, no central decision-maker, and no single point of failure to take down the entire network – something that can easily occur with traditional networks. Every BreadCrumb makes its own local decisions independent of any other nodes on a packet-by-packet basis in real time.

In a highly mobile network, traditional networks that rely on a "big picture" view of the network base their decisions on constantly out-of-date information, while transmitting a great deal of data to the device tasked with maintaining this obsolete view. Not only is InstaMesh always up-to-date, but it also eliminates that network overhead, further enhancing its performance compared to alternatives.

InstaMesh always chooses the fastest, most reliable path to the destination. In a Kinetic Mesh Network, InstaMesh constantly deduces and maintains network information at each BreadCrumb node via a low-overhead InstaMesh packet header. This allows each BreadCrumb to react immediately to changing network conditions and determine the best direction possible for each packet.

There is no managed "tree" laid on top of potentially usable connections from which InstaMesh chooses "upstream" or "downstream" links as in traditional networks. Instead, InstaMesh considers all links to be usable and simply determines which are best for each packet. If network or link conditions change (for example, a peer node is turned off or local RF interference is impacting performance), InstaMesh will immediately choose a different link for a given data stream.

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Part II: **How InstaMesh Works**

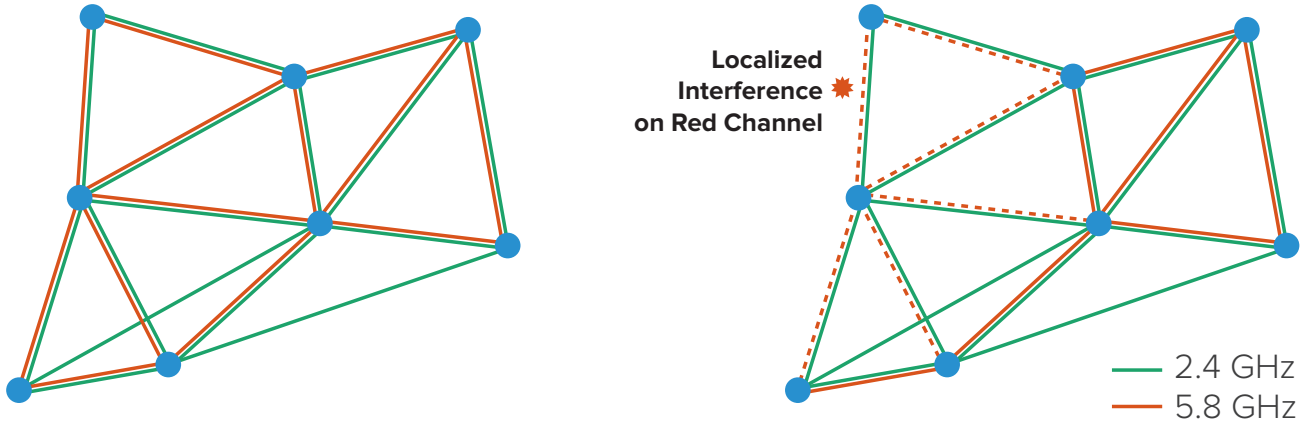


Figure 3. *Multi-Frequency, Multi-Transceiver BreadCrumbs Keep Communications Flowing*

The diagram on the left side of Figure 3 shows a well-connected Rajant Kinetic Mesh network with a high degree of redundancy. Each circle in the diagram represents a BreadCrumb node in a Kinetic Mesh network. Each line between nodes represents a radio connection. The different line colors between nodes represent links on two different frequencies. (For simplicity, these illustrations show two frequencies per node. In reality, each BreadCrumb can support up to four frequencies, and an entire network can support far more.)

The diagram on the right side of Figure 3 shows what might happen if a local interference source, represented by the star, interferes with part of the network. In this example, there is interference on the red frequency, rendering it unusable near that interference source. As you can see, the green frequency is still usable in that area. Away from the interference source, both frequencies are usable.

Having multiple frequencies also increases the usable spectrum and gives the Kinetic Mesh network more bandwidth to access applications. Figure 4 shows two network diagrams. Although the two diagrams are very similar, the one on the left is a two-frequency network, while the one on the right is a one-frequency network. The one on the left has approximately twice the available bandwidth.

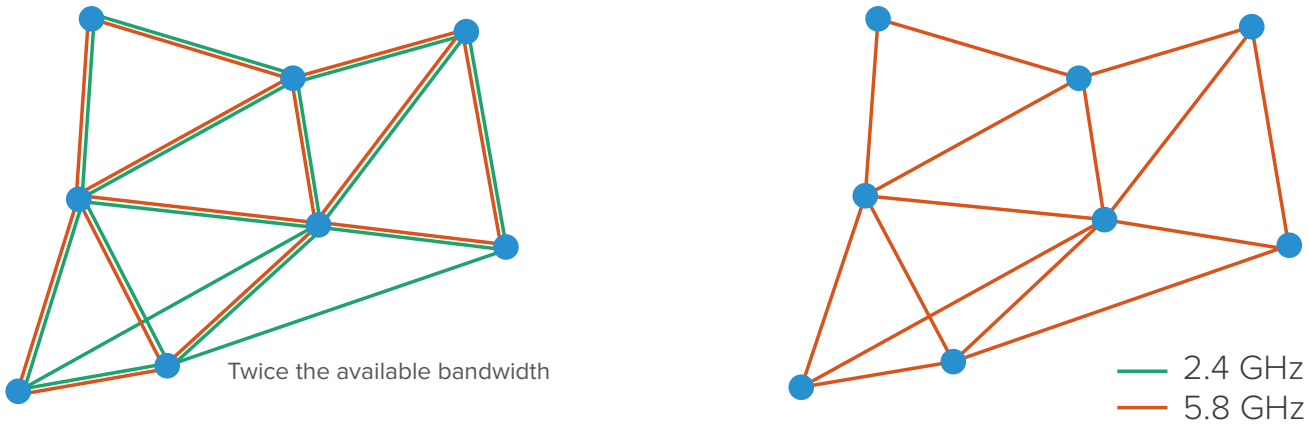


Figure 4. *Rajant Kinetic Mesh Networks Can Deliver More Bandwidth When Needed*

Part II: **How InstaMesh Works**

Compare this to the traditional wireless network shown in Figure 5. Traditional wireless networks have two kinds of nodes, infrastructure nodes, shown by the orange circles, and mobile nodes, shown by the blue circles. These two different types of nodes function differently.

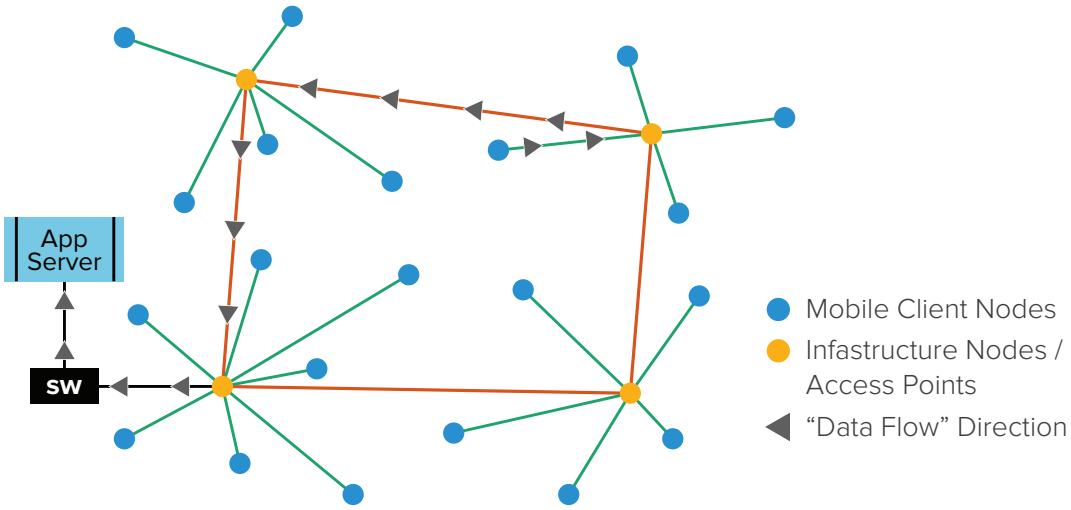


Figure 5. *Less Efficient Traditional Mesh Networks Have Different Types of Nodes Performing Different Functions*

In this type of network, mobile nodes never communicate directly with one another. They can only roam among and communicate with infrastructure nodes that operate as access points. Each mobile node passes data to its infrastructure node, which may forward data to one or more other infrastructure nodes, ultimately reaching its destination. Even if the network uses multiple frequencies – like this one does – the frequencies are not used efficiently: mobile nodes use one frequency to talk to the infrastructure nodes, and the infrastructure nodes use a different frequency to talk to each other.

This type of traditional wireless network offers far fewer routes than a Kinetic Mesh. As shown by the black arrows in Figure 5, there are only two paths from a mobile node to the application server on the left side of the diagram. First, the mobile node transmits to its infrastructure node. Then the data has to travel either clockwise or counter-clockwise to get to the switch and application server. This requires frequency re-use at each infrastructure node, slowing traffic and increasing interference and congestion.

Dedicating frequencies to a single purpose always reduces performance dramatically. By not using the available frequencies as efficiently as possible, the network bandwidth is not as high as it could be.

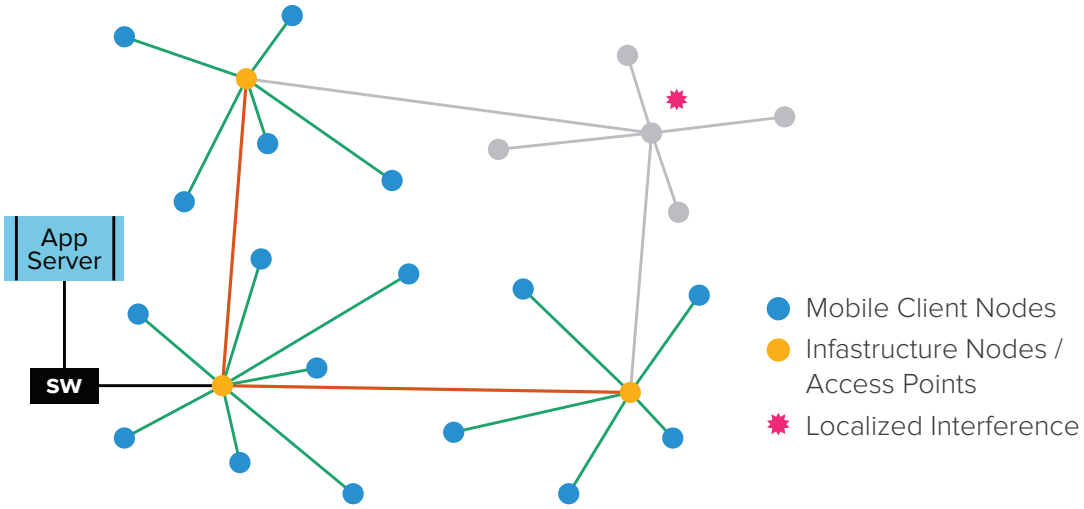


Figure 6. *Outages Due to Interference in a Traditional Mesh Network*

Reliability is another major difference between traditional wireless and Kinetic Mesh networks As shown in Figure 6, if an infrastructure node becomes unavailable then none of its mobile clients can access the network.

Contrast this with the two-frequency Kinetic Mesh network having the same number of nodes as the above traditional network. As shown in Figure 7, if interference occurs on one frequency, the network still has another frequency available over which information can be forwarded. Although this example shows nodes with one or two frequencies, each BreadCrumb can support up to four frequencies, offering a huge list of possible paths. Because there are a great number of potential paths from the data source to the application server, the network can bypass bottlenecks while maximizing throughput.

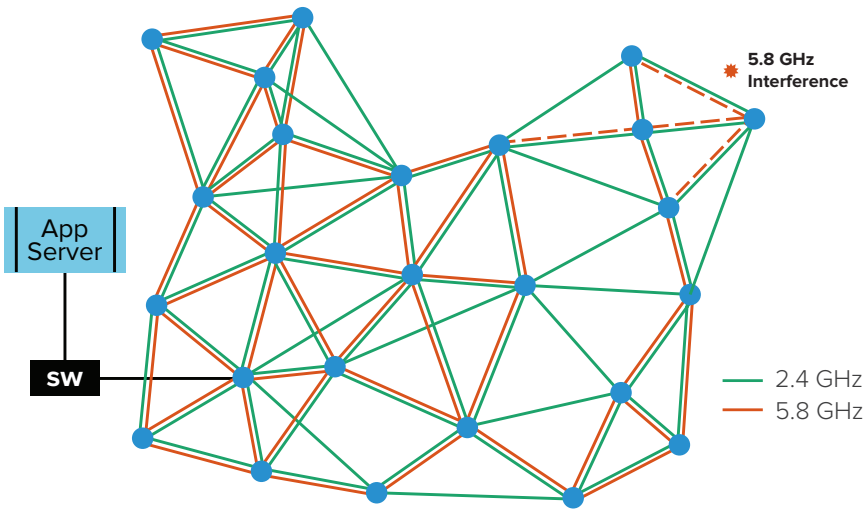


Figure 7. *In a Multi-Frequency Kinetic Mesh Network, Communications Remain Fast and Continuous Even in the Presence of Interference*

Part III: **Orchestrating Your Competitive Advantage**

In a traditional wireless network, throughput drops significantly as the number of clients increases. There are two primary reasons for this. First, all clients share a single frequency, and data to and from the clients is routed through a single infrastructure node. Secondly, all backhaul traffic is communicated over one frequency all the way back to the application server.

As a result, there can be potential bottlenecks on both frequencies and underutilized infrastructure.

Timely Access to Critical Data Makes All the Difference

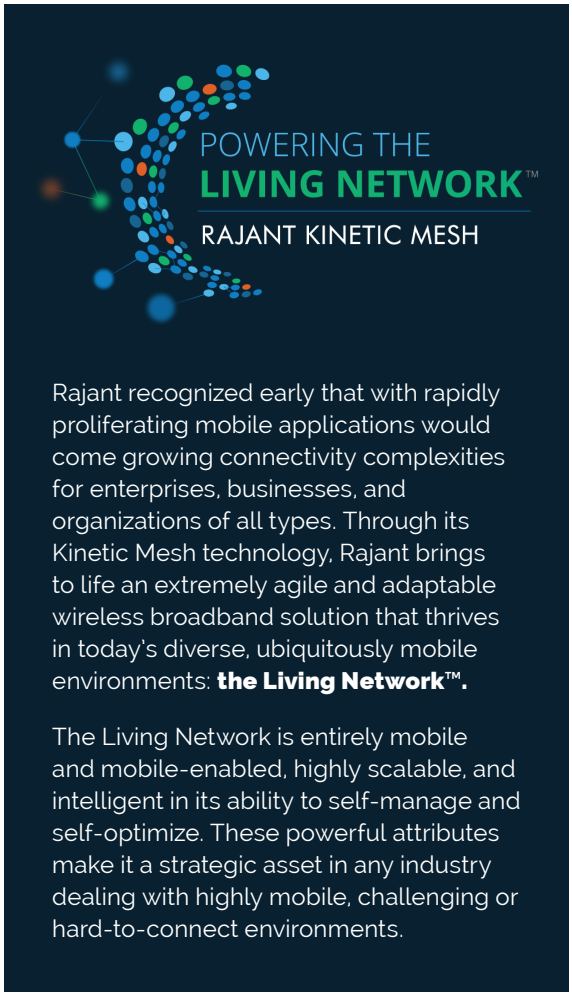
InstaMesh Moves Data Fast

In a Kinetic Mesh network, there are no specific bottlenecks. There are more available pathways and more available frequencies, and each data stream is using the best or fastest path available for each packet. Because it makes intelligent use of its allocated radio spectrum, a Kinetic Mesh network offers high bandwidth and low latency for all of your applications.

Enterprise Mobility Is Key to Maintaining a Competitive Edge

InstaMesh Embraces Mobility

Embracing mobility is the key to a successful wireless network. When we say "mobility" we are not only referring to people, vehicles, and equipment that are literally in motion, but also changes to the network that are equivalent to motion.



Rajant recognized early that with rapidly proliferating mobile applications would come growing connectivity complexities for enterprises, businesses, and organizations of all types. Through its Kinetic Mesh technology, Rajant brings to life an extremely agile and adaptable wireless broadband solution that thrives in today's diverse, ubiquitously mobile environments: **the Living Network™.**

The Living Network is entirely mobile and mobile-enabled, highly scalable, and intelligent in its ability to self-manage and self-optimize. These powerful attributes make it a strategic asset in any industry dealing with highly mobile, challenging or hard-to-connect environments.

For example, nodes can be added, removed, or relocated to accommodate changing application and data requirements, or the RF environment or even the physical landscape can change. In all these scenarios, InstaMesh will keep your data moving and automatically adapt to the changes without dropping packets or incurring an outage.

When an infrastructure node fails in a traditional wireless network, communication is lost to every node in that region of the network. This is known as a single point of failure and is a big problem for business-critical applications. When a node is powered off or removed in a Kinetic Mesh network, it is the only node that is unavailable to the network. Normally, there is no perceivable impact on the network if this happens because InstaMesh will simply redirect the data packets over another path. For example, one of our customers lost several infrastructure nodes at the same time due to a power issue, and there was no operational impact on the network at all. In fact, it took some time to realize that a good portion of their network was off-line.

When coverage requirements change, it can be difficult to modify a traditional wireless network. If you need coverage in a different area, you generally have to reposition your infrastructure nodes or add new infrastructure nodes. In a Kinetic Mesh network, adapting to changing coverage requirements is trivial. Generally, you can use your mobile nodes as infrastructure without having to worry about adding or repositioning infrastructure nodes.

TRADITIONAL WIRELESS NETWORK

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VS.

RAJANT KINETIC MESH NETWORK

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Part III: **Orchestrating Your Competitive Advantage**

Make-Before-Break

When a node moves out of range of its current access point in a traditional wireless network, it loses connectivity, and then tries to connect with another access point. This is standard Wi-Fi behavior known as "break-before-make," meaning that a connection has to be broken before a new one is formed, inherently resulting in a temporary loss of communications.

As a BreadCrumb node moves in a Kinetic Mesh network, InstaMesh makes multiple connections simultaneously, directing data packets through those connections if, and only if, they are the best choice for any given packet. No connections need to be broken for new connections to be used, allowing for seamless roaming via the much more reliable BreadCrumb-based "Make-Before-Break" approach.

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APT: InstaMesh over Ethernet

With Rajant's Automatic Protocol Tunneling (APT) feature, InstaMesh can further enhance performance by getting packets out of the air and onto a wired connection, freeing up spectrum for other traffic. BreadCrumb nodes can automatically form mesh connections over Ethernet links and treat wired connections as high-performing mesh links. As a result, a Kinetic Mesh network can have multiple ingress and egress points. This is useful for reaching wired devices such as application servers and can be used to get traffic from one side of the mesh to the other while bypassing several wireless hops. Meshing over Ethernet improves performance, eliminates potential bottlenecks, adds redundancy and reliability, and makes it easy to extend the network.

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Conclusion

To thrive in today's global economy, organizations must be highly agile and dynamic. As a result, their private wireless networks must also be agile and dynamic to support new and changing applications, programs, and procedures. Highly-adaptable wireless networks help organizations reduce costs, capitalize on opportunities, and maintain a competitive edge.

That is why we describe Rajant Kinetic Mesh networks as Living Networks. Living Networks are dynamic, adaptable, smart, and productive. InstaMesh software infuses Rajant Kinetic Mesh networks with unmatched mobile wireless connectivity. It enables Kinetic Mesh networks to deliver the high level of reliability, throughput, mobility, scalability, and adaptability you need to support your dynamic enterprise. And, because we are constantly updating the software to take advantage of new technologies, you can have the confidence to know that a Rajant Kinetic Mesh network will evolve as your communication needs evolve.

References

1. "Growing Number of Mobile Devices in the Workplace Placing a Strain on IT", http://www.biztechmagazine.com/article/2013/09/growing-number-mobile-devices-workplace-placing-strain-it-infographic, BizTech, 2013

About Rajant Corporation

Rajant Corporation is the exclusive provider of private wireless networks powered by patented Kinetic Mesh technology, BreadCrumb® network nodes, and 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 from the field. 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, industrial, transportation, utilities, telecommunications, and all level of governments. For more information, visit www.rajant.com.

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