Critical Insights on **Optimizing Performance for Mobile Client Connectivity** in Industrial Applications

Today, many private wireless networks are built with a combination of technologies, including Long Term Evolution (LTE), fixed wireless, and wireless mesh. Specific technologies are chosen to provide dedicated coverage and a desired quality of service (QoS). While LTE works well in many situations, the increasing demand for mobility introduces some challenges for LTE.

Rajant's Kinetic Mesh technology is specifically designed and engineered to address mobility requirements, including user mobility on the network as well as always-on communications to assets that are traversing that network. This paper specifically addresses the challenges and compares the capabilities of LTE and Kinetic Mesh wireless networking in mobile communications within industrial enterprises. The intent is to provide valuable insights that can help you select the best technology or combination of technologies for your requirements.

The communication requirements in the industrial marketplace are particularly unique in terms of the demands placed upon the network infrastructure. For purposes of this overview, we will focus on reliability, adaptability, mobility, bandwidth, scalability and redundancy. These features are critical driving factors for market segments such as open-pit mining, military, gas and oil, utilities, transportation, municipalities, and federal and state government.

Industrial Wireless Networks: Why Does Kinetic Mesh Have Advantages over LTE?

In industrial organizations, wireless networks must operate in landscapes that continually evolve and can inhibit the line of sight between the infrastructure and the client device. Poor line of sight translates to poor signal quality, and signal quality directly correlates to throughput. A network that continuously evolves with the topography can maintain good signal quality and high throughput. In such conditions, Kinetic Mesh is the only technology capable of achieving the reliability, mobility, and high performance needed to accomplish the connectivity objectives.

While LTE offers many network variations, there are basically two alternatives available to enterprises seeking to build or expand a private wireless network.

- **Purchase a data service plan from a wireless carrier:** This option gives you almost no control over coverage and capacity but offers minimal up-front capital investment and high usage rates.

- **Build your own infrastructure:** With this option, you build your own LTE cell sites using a commercially-licensed frequency or your own licensed frequency. This gives you the flexibility to add infrastructure as needed but requires a significant capital investment. With a commercially-licensed frequency, there will be usage costs in addition to infrastructure costs. If you have or obtain a licensed frequency, there are associated costs for the licensing, but there will be no usage costs.

With Rajant Kinetic Mesh technology, you also have two options:

- **Build your own stand-alone wireless network:** When you build a Rajant Kinetic Mesh network, you can configure and scale the network to virtually any enterprise and geography desired, and you maintain full control over network operations.

- **Integrate Kinetic Mesh with other networking technologies:** Kinetic Mesh networks are fully compatible with other wired and wireless infrastructure such as LTE, point-to-point wireless, and Wi-Fi. As a result, you can seamlessly integrate Kinetic Mesh with LTE to enhance mobile client connectivity.

The following information takes a closer look at some of the critical capabilities that industrial organizations need to handle their unique environmental and application requirements.

Reliability: Complete Reliability is Non-Negotiable

LTE provides reliable coverage where enough base stations exist. If an access point is in a location where no base station exists or the base station is too far away, your connections will be unreliable. As people, vehicles, and equipment roam across industrial sites, LTE connectivity can be lost, and temporary outages will occur when a client device is out of range or a tower is not available. While you can add towers and base stations to overcome this problem, the cost and time required is significant.

In operation, LTE communications are asymmetric with significantly more bandwidth allocated for downloads than for uploads. This is consistent with smart-phone communications which are geared toward the consumption and use of data rather than the production and dissemination of data. However, most business and government enterprises require equal or greater capacity to upload large amounts of video or sensor data, for example.

Machine-to-machine (M2M) and vehicle-to-vehicle (V2V) devices, pervasive in industrial enterprises, tend to randomly burst traffic onto the network. LTE networks have an assigned schedule specifying when data can be uploaded to the base station. As a result, random data bursts can be lost

if the scheduling algorithm cannot handle multiple sources transmitting to the base station at the same time.

With Rajant BreadCrumb® wireless nodes and patented InstaMesh® networking software, Rajant Kinetic Mesh networks are extremely reliable. InstaMesh, the mobility enabler in our solutions, is responsible for the continuous and virtually instantaneous transfer of all wired and wireless mesh communications. The software continuously determines the best action for each packet flowing through the network with no central management node or single of point of failure. Since each wireless node can be connected to hundreds of neighboring nodes, any node can transmit your data, voice, and video information across the fastest and most efficient means possible.

Kinetic Mesh connectivity is symmetric with equal bandwidth available for downloads and uploads, giving you high bandwidth in either direction. This allows you to connect your data-producing equipment and vehicles and efficiently upload any and all information at any time. In M2M and V2V operations, the network can easily transfer random bursts of information without losing packets.

Because Kinetic Mesh supports multiple frequencies, data can be sent and received simultaneously on different frequencies. Should interference occur, the system will simply redirect data packets over another frequency to keep the data flowing. Industrial organizations can further avoid interference by assigning specific frequencies to specific client devices and applications. These features greatly increase network availability while ensuring that large volumes of data can be transferred quickly and reliably.

Adaptability and Mobility: Industrial Networks Must Adapt to Constant Changes and Movement

LTE networks do not adjust easily to changing topographies. In mines, for example, ground elevations are constantly changing as drilling and excavation proceed. Oil and gas fields experience similar changes with excavating and blasting for well-pad sites, terrain grading, and construction of roads and facilities. Infrastructure adjustments are often required to adapt to such changes. However, moving LTE base stations and towers is neither easy nor inexpensive. When a base station or tower is added or moved, technical personnel must reconfigure neighboring routes to ensure clean handoffs. This leaves room for connectivity errors and conflicts. At a minimum, changes in topography require realigning antennas, which involves sending trained personnel to the site, and that can be costly.

Spectrum availability can be another concern for LTE communications due to different carriers having different licensed frequencies for customer use. If your organization wants a specific licensed frequency for a private LTE network, you have to obtain the license from the carrier of that particular licensed frequency. Depending on where you are in the world, the desired frequency may not be available for private use.

To have true adaptability and mobility within an industrial network, the network infrastructure has to accommodate physical changes, including supporting in-motion people and assets; adding, moving, or removing infrastructure nodes; and changing radio frequencies. Rajant Kinetic Mesh networks thrive in changing environments. You can easily install BreadCrumb nodes on portable towers, industrial equipment, drones, and other objects for quick and/or temporary connectivity. When terrain elevations change or you need to add equipment into the mesh, you can simply pick up light-weight BreadCrumb nodes, put them on portable trailers, and move them to the desired locations.

As you add, move, or remove nodes, InstaMesh automatically adapts to the changes. New links are established in real time while keeping the network available, intact, and secure with a make-before-break connection system. In fact, the more nodes you add, the more communication pathways you establish, and the more resilient your network becomes. Any maintenance person can be trained to install and move BreadCrumb nodes.

Spectrum availability is not an issue because our Kinetic Mesh networks use unlicensed and lightly-licensed frequencies which are readily available worldwide. Multi-transceiver and multi-frequency BreadCrumb configurations can support the simultaneous use of 900 MHz, 2.4 GHz and 5 GHz unlicensed frequencies as well as the 4.9 GHz licensed frequency. As a result, your people and assets can communicate in real time over the same frequencies, ensuring seamless integration of applications and data.

Bandwidth: Huge Volumes of Data, Voice, and Video Need Huge Bandwidth

Because LTE bandwidth is divided among clients, the per-client bandwidth is reduced. With licensed frequencies, licensees get a small slice of spectrum which can reduce data throughput when you need to move large amounts of data and video. Most of the new repeater towers are designed as wireless rather than fiber, which can also restrict per-client bandwidth. The only way to increase per-client bandwidth is to add more radios or towers.

4G capacity has been defined as 3.7bps/Hz/cell, and current LTE technology falls considerably short of that capacity. This means that uplink data rates are substantially reduced. To increase the data rates, it is necessary to increase channel transmission bandwidths. Carrier aggregation makes it possible to utilize more than one channel to increase the overall transmission bandwidth. However, carrier aggregation has not been fully implemented; so, when you need to upload high-bandwidth data such as video, you may not have enough bandwidth available.

BreadCrumb wireless nodes with InstaMesh are spectrally-efficient, high-bandwidth nodes with physical-layer data rates up to 270 Mbps. With multi-transceiver and multi-frequency BreadCrumb configurations, Kinetic Mesh networks can have multiple devices sending packets over multiple paths simultaneously. In addition, you can have multiple data drop-off points throughout the mesh, allowing you to get information from the client device to the network infrastructure quickly. These capabilities translate to high bandwidth and high throughput with fewer issues resulting from congestion.

Redundancy: Anytime, Anywhere Access to Data and Applications is Vital

Unreliable power sources and interrupted fiber connectivity are the two main causes of LTE communication outages. In remote and geographically-dispersed networks such as those deployed across oil fields, mines, and train and bus routes, power and fiber issues can be more prevalent. LTE private networks can have three to twelve regions of overlapping coverage which offers a level of redundancy protection by handing off or attaching to another coverage area. However, hand-offs are not always clean and efficient. And, maintaining spares for LTE networks is complicated and costly due to the number of different devices all having different functions.

When disasters occur, cellular coverage is one of the first services to go down. Typically, LTE networks are taken over or completely shut down during disasters, attacks, and other emergencies. Microwave radios and antennas can be torn off or knocked out of alignment, and fiber is often destroyed or ripped up. Replacing towers, antennas, radios, and fiber takes time and is costly. Any of these scenarios can leave public and private LTE networks out of service and organizations unreachable for some time.

Kinetic Mesh networks are fully redundant, self-healing, peer-to-peer networks you can depend on for continuous connectivity. Because they are not controller based, the networks have no single point of failure or the latency required to manage a controller. There is no difference in operation between a BreadCrumb infrastructure node and mobile node. So, you have any-node to any-node connectivity. Should a BreadCrumb experience an outage due to a power problem or a disaster knock out several nodes, InstaMesh would simply redirect traffic around the out-of-service or damaged nodes and continue operating.

Keeping spares on hand is very affordable since there is no difference between infrastructure and mobile nodes. In the event of catastrophic damage to the whole network, you could very quickly set up two or more nodes as a portable Kinetic Mesh network and reestablish communications. And, you can use your own maintenance personnel to establish a portable network and/or replace nodes as needed.

Scalability: Network Infrastructure Must Evolve as Requirements Evolve

A number of factors can determine LTE scalability, including the base station and tower placement, frequency availability, and the number of access points within the network. Each tower can support a finite number of clients. So, expanding density and coverage really means adding base stations, towers, and access points, which can be costly and time consuming. LTE towers that used to be placed 8 to 10 miles (13 to 16 kilometers) apart are now designed for three to six miles (5 to 10 kilometers) apart. This is especially important in rural areas where adding towers takes time. Frequency licensing also can limit expansion if the desired frequency is not available for private use in the region needed. These issues make it difficult to scale an LTE network affordably when you need to support new applications, expand coverage, and add vehicle and equipment connectivity.

Rajant networks evolve as your communication requirements evolve. We use unlicensed and lightly-licensed frequencies because those frequencies offer large amounts of bandwidth and are available globally to support a wide variety of applications. Expansion is accomplished by simply adding rugged BreadCrumb wireless nodes anywhere needed. Installation is easy and fast, and the cost is significantly less than adding towers or base stations. Anytime you add, remove, or relocate a node, the network will automatically adjust to the changes in topology, without dropping packets or incurring an outage. And, Kinetic Mesh networks can scale to thousands of high-bandwidth mobile nodes, with each node having multiple connections.

Summary

If you are looking to support the critical requirements of your industrial organization, Kinetic Mesh offers many networking advantages for increasing reliability, adaptability, mobility, bandwidth, redundancy, and scalability. LTE technology is primarily cellular technology that has been enhanced to handle data transfer over a cellular network with the emphasis on passing data from the infrastructure to the client. As a result, LTE cannot adequately handle many of the environmental, application, and data-transfer requirements inherent in industrial organizations. Conversely, Rajant Kinetic Mesh networks are specifically engineered to support industrial environments, applications, and video-voice-data requirements.

If you already have an LTE network, Rajant Kinetic Mesh can integrate with your existing infrastructure as it is an OSI Layer 2 distributed switch, provide added mobility for people and assets, and make your infrastructure mobile as well. If you are evaluating new networking options, our Kinetic Mesh technology may well be your best alternative for delivering continuous wireless connectivity and mobility within your industrial organization.

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 levels of governments. **For more information, visit www.rajant.com.**

POWERING THE LIVING NETWORK
RAJANT KINETIC MESH

Completely mobile and mobile-enabled, Rajant Kinetic Mesh powers the Living Network, an adaptable, productive, smart, and dynamic private wireless network with an inherent 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.

20+ Yrs OF GAME-CHANGING WIRELESS

RAJANT