Enhancing **Battlefield Communications**

Through the Use of Dynamic Best-Path Selection

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Introduction

Battlefield communication systems are hampered by inadequate capacity, flexibility, security and access. Over time, a broad range of performance and operational requirements has resulted in the use of **numerous incompatible communications systems and waveforms.**

Furthermore, transition to more capable systems is made more complicated by the need to remain inter-operable with aging legacy platforms. Although the JTRS program and Software Defined Radio was envisioned as a solution to the difficulties of systematic technology insertion, it has yet to meet operational expectations.

Network resiliency and operational complexity urgently need addressing. Until networks are fully capable of fast self-healing, skilled human operators and analysts will remain necessary to interact with equipment and link protection systems, interpreting their results and taking corrective restorative actions based on the indications. Operator familiarity with these systems and the threats to them will continue to dictate how quickly and correctly problems can be identified and resolved.

The JTRS mobile ad hoc waveforms were expected to provide less complexity through self-healing capabilities. However, their reliance on complex protocols and algorithms has limited the ability to build scalable networks with these waveforms. This problem is directly attributable to the rapid decrease in network efficiency as the size of the network increases, which is a result of the overhead burden associated with maintaining and disseminating routing information to a large number of nodes.

The integration of dynamic best-path selection technology with existing and emerging communications systems offers a practical means for addressing these issues. The best-path selection system operates above the physical and data link layers and is capable of reacting appropriately using multiple, dynamic links. In this scenario, the radio systems provide transport while the dynamic best-path selection system handles directing and de-duplicating traffic.

In fact, the best-path algorithm does not require radios at all but rather network interfaces that might be based on radio, copper, fiber, or other mechanisms.

Only minimal metadata is required from interfaces in order to support the best-path algorithm. In the absence of this data, the best-path algorithm would fall back to a “good enough” approach that gathers its own metadata for the interface. Certain commercial Mesh networking systems have used this technique for over a decade in situations where reliability of overall communications is of paramount concern, but availability of any given node or communications channel cannot be relied upon.

Use Case Scenario

Of a Large Above-Ground Mine

The Rajant Breadcrumb system is arguably the best example of a communications system developed to eliminate the need for performance compromises between mobility, scalability, reliability and capacity. Breadcrumb systems provide mission critical communications in hundreds of oil and gas fields, ports and mines. At the technology core of these systems is the networking protocol, Instamesh, which operates on top of the transmission medium to provide self-healing best-path selection capabilities independent of the radio and waveform attributes.

A commercial use case example is that of a large above-ground mine covering more than 100 square kilometers. Between 200 and 800 vehicles operate in the mine, each requiring constant reliable communications to other vehicles, remote application hosts, and stationary assets. Haul trucks, capable of carrying over 400 tons, must communicate location data to a centralized dispatch system and inform the shovels when they are in position for loading. Up to 400 sensors on each vehicle provide continuous analytical data for condition monitoring. Autonomous rail and conveyor systems are remotely monitored. Augmented GPS information is distributed for precision positioning. Water pumps, fuel tanks and other infrastructure systems are remotely managed. Operational information and files are distributed to mobile computing devices. Reliance on fixed infrastructure in the mine is undesirable due to constantly changing topography. Mobility and vastness makes network planning for density and congestion difficult. Finally, the costliness of taking equipment offline for maintenance of communications systems makes it undesirable to require servicing. Mobility requires seamless and transparent self-healing without the need for direct management intervention.

The commercial Breadcrumb implementation of Instamesh technology uses multiple IEEE 802.11 based radios in each node. Each radio operates independently of the other radios in the node and is configured to utilize different frequency, modulation and other radio parameters. The radios, each independently manage their connections to the radios at other nodes. For two nodes to connect, they need only share a single radio in common.

Rajant Kinetic Mesh® networks are battle-proven to support mission-critical communications needed to overcome environmental adversity.

Rajant BreadCrumbs operate reliably in the harshest conditions and provide configurable per-hop, per-packet data authentication to ensure security.

The Army RAM WARN program is another use case example where multiple independent radios are used at each node to provide redundant connections to similarly equipped nodes. The program provides a Warn capability to BCTs for detection of threat indirect fire (IDF) rounds, transmission of the detection data to the C2 element for correlation and determination of a predicted point of impact (POI), and passage of the POI information to audio and visual alarms for localized or full area warning over the defended area. In addition to providing automatic connection switching protection in the case of interference or jamming, the separate radios provide best-path selection at each node when impacted by traffic congestion, intermittent faults, and other factors reducing but not eliminating a connection.

Instamesh Technology

Maximizing Uptime in Extreme Conditions

Contrary to the methods used by other networking protocols, Instamesh does not have requirements to calculate, store or communicate source-to-destination routes. All Instamesh path selection decisions are made locally at each node, for each packet. This results in low administrative overhead, the ability to utilize any available connection, and adaptation to change and interference even while packets are in route to their destination.

Route costing is an important factor in best-path performance. Costing algorithms are typically complex, involving the collection and analysis of multiple factors such as hop counts, link utilization, latency, packet loss, energy usage, throughput, and interference. The attributes are then applied to a weighted factor algorithm which may need periodic adjusting for environmental parameters such as node density. Instamesh is unique in its use of a temporal costing methodology. This involves using the total elapsed time observed from received packets to determine which local connection represents the first leg of the fastest total path for each transmitted packet. Ideally, the radio or other transmission system is capable of supplying additional information regarding delivery failure and transmit queue time. However, Instamesh can supply its own information in its absence.

The ability to select and utilize multiple discrete radio and network transport systems enables the Instamesh protocol to choose the best path under constantly changing conditions and to operate under relative immunity to certain interference and link failures. Additionally, because Instamesh path selection decisions are independent of the physical transport layer, it can introduce multi-hop forwarding capabilities regardless of the actual services provided by a given network topology. Lastly, as indicated by the network scalability, Instamesh imposes minimal cost on the network in terms of per hop latency, maximum throughput handling and traffic overhead.

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