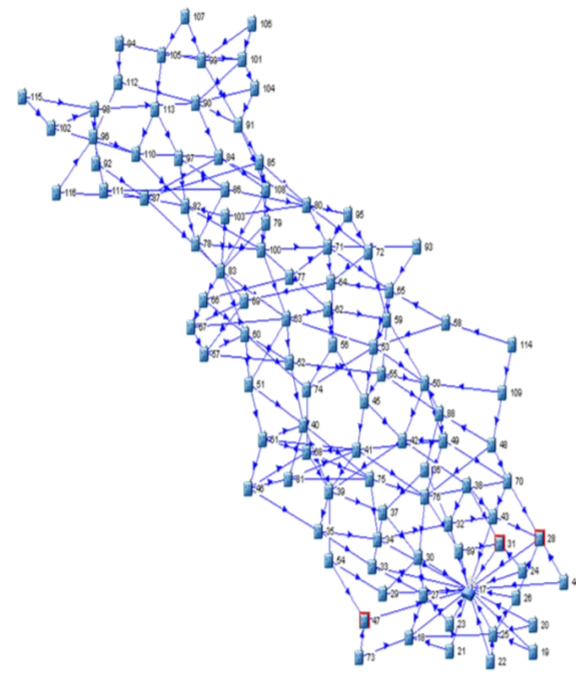


# Dust Networks SmartMesh™ Wireless RF Networking System

## Introduction

Industrial wireless is not new but has been in use in the industry for multiple decades. Legacy wireless systems were used in niche applications but did not have broad applications and hence have not been adopted more widely. However, the recent developments of low-cost, low-power radios and self-organizing, self healing wireless Smart-Mesh™ networking software have ignited interest in industrial wireless standardization.

In a GMP environment, anything which cannot be validated cannot be used. The new technologies have led to reliability, security & ease of usage.



Smart Mesh Formation: Each sensor node can act as a router and optimize data routing..

## Smart Mesh™ Network

### The Technology

Redundant routing is a must have in a real world RF application. A full mesh topology with automatic node joining and healing lets the network maintain long-term reliability. It works without special-purpose routers. Its implementation in the Kaye product line allows up to 100 sensor nodes to be connected in a seamless, reliable and self forming mesh network.

The mesh technology permits nodes to communicate with the base station and each other, correcting for weak RF links and automatically adjusting to dynamic RF environment, e.g. a forklift

truck driving into a warehouse blocking a signal. No special knowledge or expertise is required to install or operate the Kaye RF ValProbe.

### Smart-Mesh™ Network—Key Features

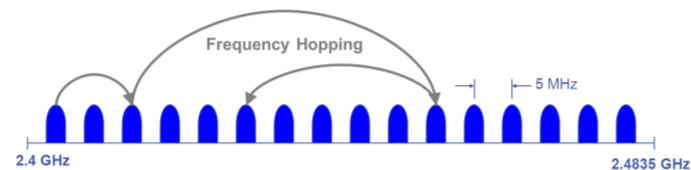
- **Transmission Reliability:** RF Mesh can provide up to 99.9% transmission reliability. Redundancy introduced through data-storage eliminates risks of data loss.
- **Dynamic Network Formation:** No RF Site surveys required. System works out of the box and is fully validatable.
- **Low Energy Consumption**
- **Data Security:** Immune to RF interference, snooping, insertion of invalid data.

## Transmission Reliability

For the application in a GMP environment a wireless sensor network needs to deliver wire-like transmission reliability.

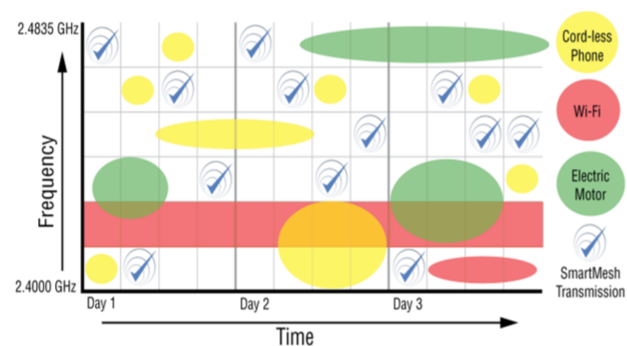
The Dust Networks SmartMesh™ is based on a Time Slotted channel hopping protocol (TSCH). The IEEE 802.15.4 provides 16 wireless transmission channels which are divided into different time slots. Each channel and each timeslot can be used for data packet transmission. Because of the manager coordinated network synchronization each sensor nodes always listens, talks or goes into sleep mode in time and always uses the best possible available channel for data transmission avoiding any possible interference.

Even pair wise channel hopping is possible enabling multiple simultaneous transmissions and



further increasing reliability by increasing the available channels for each sensor node.

Basically the time slotted channel hopping technique renders the transmission quite robust to interferences from other wireless device transmissions like cordless phones or WLAN connections and electric fields created by electric motors.



## Low Energy Consumption

In monitoring or mapping applications the possibility to place a sensor in a remote and difficult to reach location is a benefit of wireless sensor networks. Often a power line is not available.

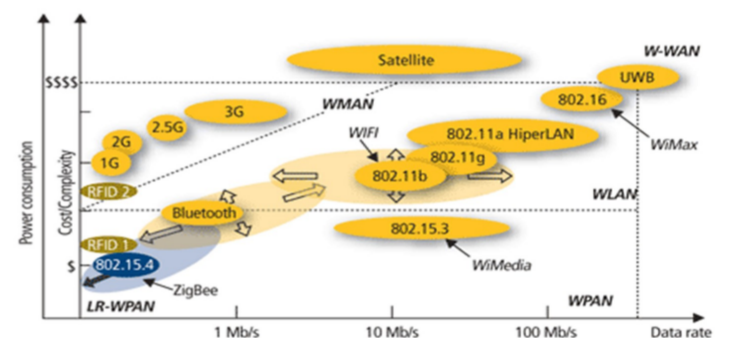
For a wireless sensor node most power is required by the data transmission. Common wireless transmission protocols require either a connection to the power line or frequent exchange of the batteries.

In a Dust Networks SmartMesh™ the communication of the sensor nodes is reduced to a minimum using the time synchronized protocol advantages. In addition Dust Networks has developed a very low power consuming IEEE 802.15.4 compliant hardware.

The combination of the low power optimized communication and the low power consuming

hardware leads to sensor nodes that can run easily a year or longer on battery power while continuously monitoring the environment.

The power consumption of the sensor node is monitored, too. Therefore the managing system can dynamically optimize the battery life by re-routing data transmission through neighbor sensor nodes if available, and the system will report the end of lifetime for a battery for duly replacement..

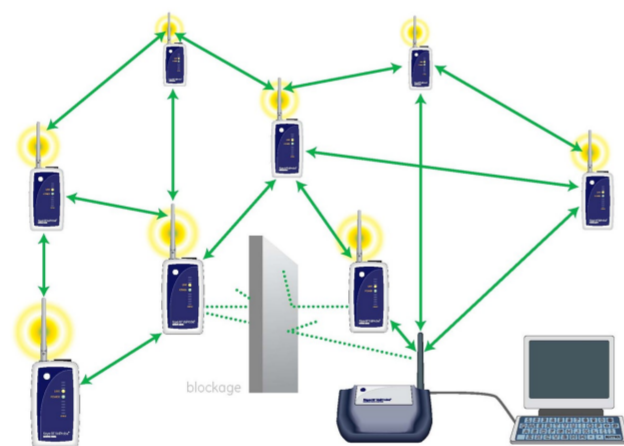


## Dynamic Network formation

The Dust Networks SmartMesh™ network is self forming and self-optimizing. Each of the nodes discover neighbors, measure RF signal strength, optimize signal pathways, dynamically optimize signal routing and route signal traffic from neighbors.

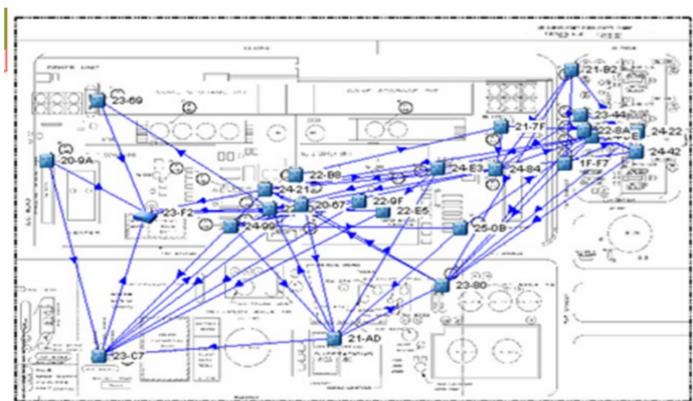
A node may also join as an end node, become a routing node due to changing RF conditions and later revert back to an end node.

The SmartMesh™ network manager performs a



continuous optimization of the transmission routing and changes the data pathways and allocate bandwidth in response of the dynamic changes in the RF environment.

The extension of a SmartMesh™ sensor network is simple. The manager automatically discovers new sensor nodes and implement them into the existing network. Extending the network increases the optimization possibilities and actually improves reliability and data latency times.



## Data Security

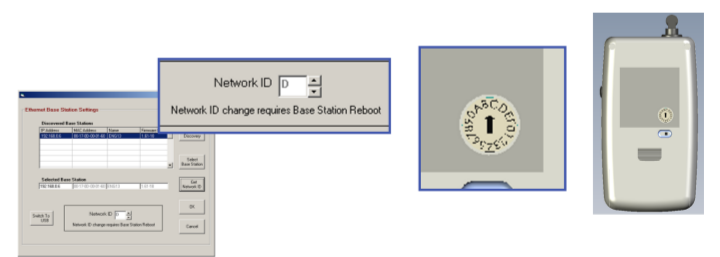
The Dust SmartMesh™ network provides full end to end data encryption (128bit XTEA) with pre-shared keys on RF level while checking data message integrity and authentication. Each sensor node is handled like an independent network device with a MAC address. The data inside the loggers and the basestation is encrypted and all files that are transferred to a PC is CFR 21 part 11 compliant hashed and digitally signed. All RF data is encrypted using a join key and a network key.

These security features render the Dust Smart-Mesh™ network to one of the most secure networks available with following features:

- **Data integrity:** Data transmitted within the packets is protected by message integrity codes to ensure that it has not been tampered with and that it originated from a known source.
- **Replay protection:** Replay attacks are prevented

on both the link layer and the network layer by using nonrepeating replay counters.

- **Denial-of-service (DoS) protection:** DoS attacks are mitigated with a combination of all of the above. In addition, the time-slotted channel hopping protocol diminishes the risks of a DoS attack by using the entire radio space.
- **Access control:** The source address of a joining mote is verified with a secure key to prevent device spoofing.



## Application example:

### Validation and Mapping



The Kaye RF ValProbe system is a wireless thermal validation system that collects temperature and humidity data. The Kaye RF ValProbe system is designed for accurate, convenient, and reliable process validation of environmental chambers and storage areas. These applications include

stability chambers, freezers, refrigerators and warehouses. A 2.4-GHz RF mesh network and multiple-redundant data storage support communications and storage of critical validation data, while safeguards guarantee data integrity, storage and compliance with regulatory requirements. The system consists of Kaye RF ValProbe Loggers, a Kaye RF ValProbe Base Station, and Windows-based software for programming and reading the Loggers, calibrating Loggers, verifying their calibration, and generating reports.

Data from multiple wireless Loggers is combined in a single file from which reports are generated. These reports are designed for implementation of 21 CFR Part 11 requirements for electronic records. Users can customize the reports by defining process cycles and specifying cycle-based calculations.

## Application Example:

### Monitoring—LabWatch Pro

The Kaye LabWatch Pro system is built as an Enterprise Architecture Model encompassing intelligence and redundancy at multiple levels in the system. At the primary input of the system lie the extremely accurate calibrated sensor modules. These sensor elements feed into the RF Valprobe sensor nodes or the Netpac modules. The RF sensor nodes store and forward the real time data from the sensor elements to the RF Base Stations. Up to 30000 samples can be stored on these loggers and can be retrieved in case of a power failure or RF transmission issues. The RF Base stations communicate the server via the industry standard OPC Server. With sophisticated monitoring and reporting features, Kaye LabWatch proves to be an effective turnkey solution for your laboratory, warehouse and stability monitoring

needs. Critical environmental information is provided to assure that your equipment is operating within defined parameters.

Integrating high quality sensors, latest wireless and wired technologies for communication and networking abilities into an easy-to-use Information Management Solution, LabWatch Pro combines precision monitoring with effective alarming, hassle-free reporting, and secure data archiving.

