# Powering a New Generation of Wireless Mesh Networks

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Wireless Mesh Networks (WMNs) are a rapidly emerging technology, forming the backbone of an increasingly interconnected world. Whereas traditional communication networks rely on a small number of wired access points or wireless hotspots to ensure robust connectivity, WMNs expand the network across a larger number of devices, with multiple mesh nodes “talking” to each other to create dynamically scalable routing paths for data to travel.



The greater the number of nodes, the broader the network becomes, essentially creating a “cloud” of wireless connectivity that can encompass a residence, warehouse, neighborhood, municipality or even an entire region.

WMNs are self-configuring, automatically accepting and incorporating new nodes into the community without the need for outside intervention. They are also self-healing, able to automatically identify a new path to communicate if individual nodes are blocked or lose their signal. These qualities make WMN networks inherently redundant and scalable.

**A Wide Range of Potential Applications**

The best-known WMN is the Internet, which creates billions of potential pathways for data to travel. WSNs are also playing a major role in the burgeoning Industrial Internet of Things (IIoT), enabling truly wireless connectivity and interoperability across a wide range of industrial applications, including government, military, transportation, utility metering, education, healthcare, hospitality, manufacturing, and distribution, to name a few.

For example, in the transportation field, Intelligent Transportation Systems (ITS) are being developed that use WMN technology to monitor traffic accidents and dangerous road conditions. Bridge abutments are also monitored with wireless networked sensors to warn of impending erosion, while bridges and tunnels are continuously monitored for structural stress and corrosion.

Long-life lithium batteries enable WMNs to reach remote, inaccessible locations where they can operate maintenance-free for decades, including certain low-power devices that can operate up to 40 years on a single battery.

WMNs are enabling factories and warehouses to modernize very cost-effectively, providing seamless connectivity between legacy manufacturing equipment that incorporate the original HART communications protocol and wireless sensors that communicate with WirelessHART or similar protocols. The U.S. military is even experimenting with microchip-sized mesh networks to improve surveillance and enhance communications between ground troops and command centers. The future of WMNs is practically limitless.

**Requirements Dictate Power**

WSNs can be developed using commercially available wireless technologies and IEEE standards 802.11, 802.15, and 802.60 or using proprietary RF networks or cellular technologies not restricted to any one technology or communications protocol.

Designing a WSN is a complex process that typically begins with a predictive site survey and physical site survey to determine the overall size and scope of the network and the predicted strength of RF signals throughout the operating environment. This knowledge is then used to assign a priority to the required applications and devices, taking into consideration key factors like network security, network infrastructure, system management, scalability, redundancy, and reliability.

If the device is easily accessible and batteries are easily replaceable, then the power supply solution may be relatively simple, especially for consumer devices. However, if the wireless device needs to operate maintenance-free for an extended period in a highly inaccessible location or extreme environment, then the choice of power supply becomes far more critical, as the labor expense to replace a battery far exceeds the cost of the battery itself.

For example, if the WMN is being used to provide long-term monitoring of stress and vibration in bridge trusses, then it could make sense to specify bobbin-type lithium thionyl chloride ($LiSOCl_2$) batteries that can operate for up to 40 years. This would eliminate the need for battery replacement, including the time-consuming task of erecting scaffolding and safety harnesses to protect workers. With a proven record for longevity, bobbin-type $LiSOCl_2$ batteries are the preferred choice for AMR/AMI utility metering applications. These ultra-long-life batteries help protect water and gas utilities against the possibility of a wide scale, system-wide battery failure, which would prove very costly, interrupting billing and reporting systems and forcing work crews to prematurely change-out thousands of batteries just to avoid potential chaos.

Numerous factors must be considered when deploying an energy harvesting device including: the reliability of the device and its energy source; the expected operating life of the device; environmental parameters; size and weight restrictions; and the total cost of ownership.

Consumer-grade rechargeable Lithium-ion (Li-ion) cells may work sufficiently if the device is easily accessible and must operate for no more than five years and 500 recharge cycles within a moderate temperature range (0 to 40°C). However, if the wireless device is intended for use in a remote location or in extreme temperatures, then an industrial-grade Li-ion battery may be required, capable of operating for up to 20 years and 5,000 full recharge cycles, and offering an expanded temperature range of -40 to 85°C. Industrial-grade rechargeable Li-ion cells can also deliver the high pulses (5 A for a AA-size cell) required for advanced, two-way communications and feature a hermetic seal whereas consumer-grade rechargeable batteries use crimped seals that may leak.

**Finding Ways to Extend Battery Life**

If the WMN is being designed for long-term deployment in a remote location or extreme environment, then every effort must be taken to extend battery life by reducing the device's average daily energy consumption.

Energy conservation starts by first choosing a low-power consuming communications protocol such as ZigBee, LoRa, WirelessHART or others. Reduced power consumption can also be achieved with low-power components, software solutions, and system architecture that maximize the amount of time spent in "standby mode" by periodically querying the data and then activating the device only if pre-programmed limits are exceeded. Intelligent product design can also limit the size and duration of the pulses required to initiate data interrogation and transmission.

High pulse requirements can also dictate the choice of power supply. For example, bobbin-type $LiSOCl_2$ batteries are ideally suited for long-term, low-power applications due to their low rate design. However, a standard $LiSOCl_2$ cell must be modified to handle high pulses with the addition of a patented hybrid layer capacitor (HLC). The standard $LiSOCl_2$ cell delivers the low background current needed during standby mode, while the HLC works like a rechargeable battery to store and deliver the high pulses required for data interrogation and transmission.

Alternatively, supercapacitors can be used to store high-pulse energy in an electrostatic field. Supercapacitors are found in many consumer products but are not generally recommended for use in industrial applications due to inherent performance limitations including: an inability to provide long-term power; linear discharge qualities that do not allow for use of all the available energy; low capacity; low energy density; and high annual self-discharge rates (up to 60 percent per year). Supercapacitors linked in series also require the use of cell-balancing circuits that draw additional current.

**Conclusion**

The demand for WMNs is growing with the emergence of the IIoT. This dynamic growth curve is creating exciting possibilities for battery-operated remote wireless devices that provide seamless integration, connectivity, and interoperability for a wide range of technologies.