

MoteWorks™

Wireless sensor network devices that integrate sensors, processor/radio hardware and wireless networking capabilities are commonly referred to as “Motes”.

MoteWorks™ is the industry’s first, open, integrated, standards-based platform for the development of wireless sensor network OEM devices and systems. It is the result of numerous wireless sensor network deployments across a variety of different applications including, industrial monitoring, building automation and control, supply chain management and location tracking. MoteWorks™ is the reliable OEM platform from Crossbow that offers users the comprehensive benefits of proven wireless technology in any given sensor application.

The software platform provided with MoteWorks™ is optimized for low-power battery-operated networks and provides an end-to-end solution across all tiers of wireless sensor networking applications, including:

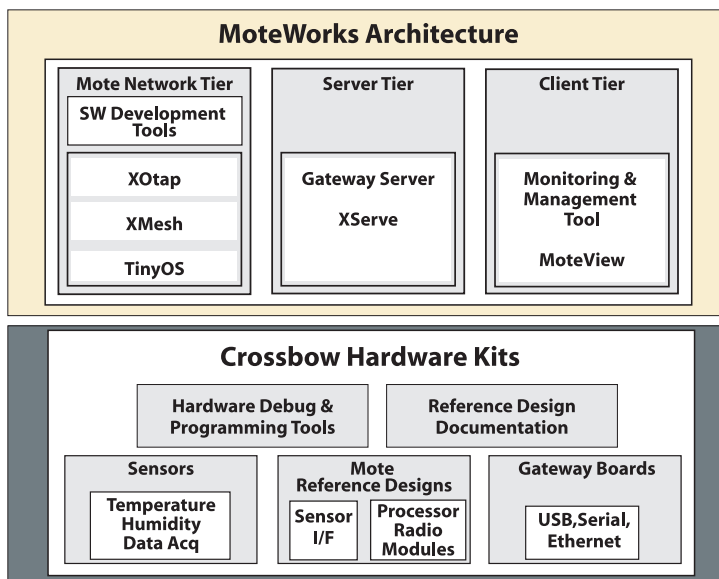
- Mote Network tier: Network stack and operating system including ZigBee standard support for mote devices
- Server tier: Middleware for connecting wireless sensor networks to the IT infrastructure and to the internet
- Client tier: User interface application for remote monitoring of the sensor network

MoteWorks™ also supports complete hardware reference and development platforms for rapid integration of wireless mesh communication hardware into custom OEM products providing:

- Pre-programmed, 802.15.4 /Zigbee compliant hardware reference design for out-of-the-box development
- OEM processor/radio modules and debugging tools for custom hardware development
- Documentation for hardware design and integration

Mesh Network Stack – XMesh

The XMesh networking stack is at the heart of enabling motes for reliable, wireless communication. To optimize



support for mass application requirements, different network topologies including star, hybrid and mesh are supported. XMesh provides dual support for the ZigBee standard and advanced mesh networking. The ZigBee standard defines star and hybrid star topologies for battery-powered end-nodes and a line-powered wireless backbone. XMesh also provides support for entirely battery-powered, multi-hop net-


works with extended year operation. The technology uses network-wide time synchronization to enable very low power operation. In this topology, every node acts as a router, providing easy network extensibility without requiring any line power. XMesh includes support for self-forming, self-healing networks and is optimized for dynamic routing. Based on the RF link characteristics, XMesh automatically determines the optimal route through the network to the gateway, minimizing the power requirements throughout the network. When an RF link degrades in quality or becomes unavailable, XMesh automatically re-routes messages through other nodes in the network. Combined with the ability to select the optimal radio channel, this dynamic routing capability provides for self-healing, reliable communication even in environments with heavy interference, including WiFi communication in the 2.4GHz band.

XMesh fully supports bi-directional message communication throughout the network with fast alert/alarm propagation to support safety and security applications with stringent, response time requirements.

Over-the-air-programming & Remote Update – XOtap

Over-the-air-programming and updating of sensor nodes is provided through MoteWorks™ XOtap capability. This over-the-air-programming system allows motes to be programmed reliably, peer-to-peer or via multicast over a low data rate wireless network. Over-the-air-programming facilitates the development of sensor network applications by eliminating a physical connection with the programmed node. During installation of the wireless sensor network, XOtap allows for rapid provisioning and configuring of the

XMesh Network Stack

- ▶ **Reliable, Multi-hop Mesh Networking with Support for Entirely Battery Powered Network**
- ▶ **Over-the-Air Programming (XOtap)**
- ▶ **Self-Forming and Self-Healing Networks**
- ▶ **Dynamically Optimized Routing**
- ▶ **Fully Bi-Directional Communication with Fast Response Times**
- ▶ **802.15.4 /ZigBee Support**  **ZigBee™ Alliance**

network. Maintenance of installed networks is also significantly reduced as upgrading the firmware of the network nodes is easily performed, especially for nodes that are difficult or impossible to reach.

Low-Power Operating System – TinyOS

MoteWorks™ includes TinyOS, the open-source operating system originally developed by University of California, Berkeley. TinyOS has developed a broad user community with thousands of developers, making it the standard operating system for wireless sensor networking in the research community. It is also the most widely-deployed wireless sensor network operating system for commercial applications. TinyOS is an object-oriented, event-driven operating system designed from the ground up for low-power devices with small memory footprint requirements. TinyOS supports microprocessors ranging from 8-bit architectures with as little as 2 KB of RAM to 32-bit processors with 32 MB of RAM or more. It provides a well-defined set of APIs for application programming. These APIs provide access to the computing capabilities of the sensor node, allowing for intelligence within the network. Using these capabilities, sensor data can be preprocessed on the node, optimizing both network throughput and battery life by avoiding unnecessary send and receive messages.

Software Development Tools

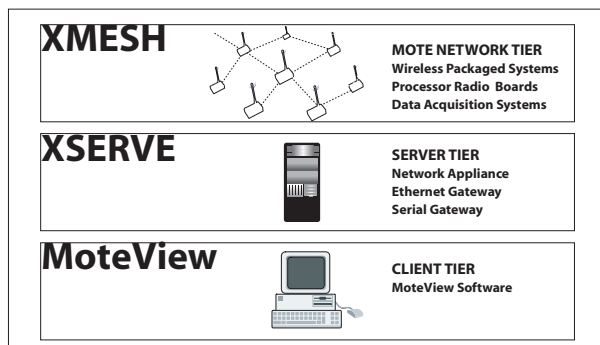
MoteWorks™ comes with a set of software development tools for custom mote applications, including custom sensor board drivers, sensor signal conditioning and processing and message handlers. MoteWorks™ includes an optimized cross-compiler for the target mote platform and an advanced editor for TinyOS application development. MoteWorks™ automatically installs and configures these development tools for quick set-up and rapid start of development.

Gateway Server Middleware – XServe

MoteWorks™ XServe is the software component that provides a simple, yet powerful API from the Intra/Internet to the wireless sensor network. Due to the low power and memory footprint requirements in wireless sensor networks, communication is streamlined through message formats and network protocols. This differs from the IP protocols used in IT back-end systems for Intra/Internet applications. XServe stands as the gateway between the wireless sensor network and IP-based applications, effectively bridging these different worlds. Integration with back-end monitoring, control and management systems delivers the full value of wireless sensor networks to enterprises and makes the connection of the physical world with the internet a reality.

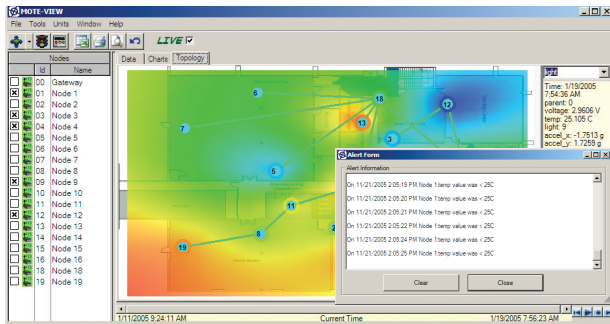
XServe's architecture provides reliable translation of sensor network data into XML messages for rapid integration into enterprise applications. The XML interface is integrated with MoteWorks™ gateway server, providing a standard web service interface.

XServe includes local database capabilities for logging and analysis of messages received from the network. Through standard SQL database interfaces, applications perform spatial analysis of the sensor network either locally or remotely, turning raw sensor data into valuable knowledge about the environment and the network. XServe can be deployed running on dedicated hardware such as a network appliance or on standard enterprise server hardware.



MoteWorks™ components

Crossbow MoteWorks™ is the industry's first, open, integrated, standards based software platform for the rapid development of wireless sensor network OEM devices and systems.



MoteView screen shot

Remote Monitoring and Management – MoteView

MoteView is the client user interface that enables MoteWorks™ to deliver an end-to-end solution across all tiers of wireless sensor networks.

MoteView displays the information from the network to developers or end-users. The entire network or individual nodes can be displayed and analyzed in graphical charting or textual format. MoteView's playback capability allows historical viewing of network status and sensor readings over time, and is based on the logging information stored in XServe.

MoteView's analysis capabilities allow automatic e-mail alerts when user-definable conditions are met. For example, if RF links are re-routed because of changes in the environment or sensor readings exceed a specified threshold, an e-mail will alert an operator or field technician via PDA or mobile phone.

MoteView enables end-users to optimize network layout and configuration, analyze sensor information interactively and then take corrective action.

MoteView provides an interface to remotely configure motes in the wireless network. Each node can be individually updated with configuration parameters provided by the mote. This makes it transparent for the user of an installed wireless sensor network to configure motes, e.g. change frequency of sensor readings, without requiring any programming knowledge.

MoteView also has built-in support for Crossbow's entire range of sensor boards, enabling very fast prototyping. If custom sensor boards are required for an application, these boards can be integrated for management in MoteView as well.

Hardware Reference Design – MICAz/MICA2 OEM Development Kits

MoteWorks™ supports a range of hardware platforms, from demonstration, software development to OEM development kits. The OEM development kit includes a complete hardware reference design consisting of fully manufactured, pre-programmed MICAz or MICA2 motes to set up a prototype wireless sensor network out of the box. These motes are fully-functional, battery-

MoteView Visualization Software

- ▶ Historical and Real-time charting
- ▶ Topology Map and Network Visualization
- ▶ Data Export capability
- ▶ Print Graph Results
- ▶ Mote Programming with MoteConfig
- ▶ Command Interface to Sensor Networks
- ▶ E-mail Alerts Service

powered wireless network nodes with the MoteWorks™ software stack pre-installed in flash memory. The MICAz mote is 802.15.4/Zigbee compliant, supporting the 2.4GHz frequency band. The MICA2 mote is based on a multi-channel transceiver with extended range support in the 868/916MHz bands. Both reference designs are based on Crossbow's OEM processor/radio modules (MICAz/MICA2 OEM Edition).



The MICAz and the MICA2 OEM Edition

The MICAz and MICA2 designs provide an expansion dual interface, supporting analog inputs, digital I/O, I2C and UART interfaces. This expansion connector allows a wide variety of external peripherals and sensor boards to be easily connected with the mote reference designs, offering a complete wireless sensor node for rapid prototyping and application development. The OEM development kit includes basic sensor boards with humidity, temperature sensors and an interface for external analog sensor inputs. A broad range of additional sensor boards with sensing capabilities for temperature, humidity, light, pressure, sound, magnetic field, acceleration and others are available from Crossbow. Each sensor board is supported with drivers for the MICAz or MICA2 reference designs. For connecting the wireless sensor network to a local PC or the Intra/Internet, Crossbow's ethernet gateway, the MIB600, is included to allow for easy connection to the network.

The MoteWorks™ OEM development includes a complete hardware reference design consisting of fully manufactured, pre-programmed MICAz or MICA2 motes to set up a wireless sensor network out of the box.

OEM processor/radio module - MICAz/MICA2 OEM Edition

The MICAz and MICA2 OEM Editions are surface-mount hardware modules, providing high-level functional integration designed to simplify the integration of wireless mesh networking technology for a wide variety of sensing applications. OEM Edition modules deliver optimized processor/radio module integration based on Crossbow's extensive experience in real-world mote development and deployment.

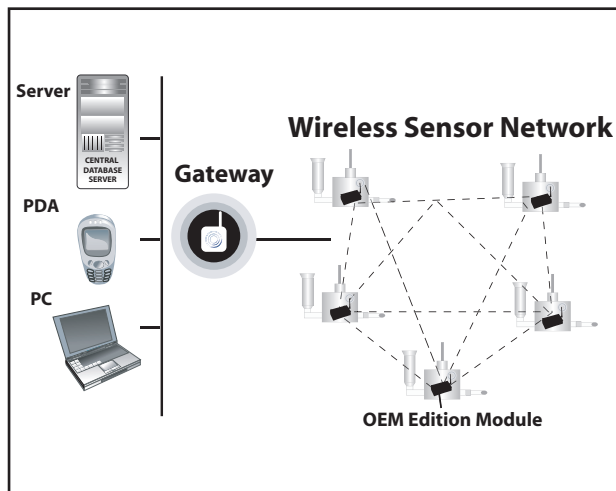
The MICAz OEM Edition module is IEEE 802.15.4/ZigBee compliant with a RF transceiver in the 2.4 to 2.4835GHz, globally compatible ISM band, providing 250 kbps data rate bandwidth. The MICA2 OEM Edition is configurable for

868/916 MHz frequency support and provides up to 38.4 kbps data rate bandwidth with a communication range of nearly twice the MICAz OEM edition.

Both modules include a fully programmable 8-bit microcontroller with 128kB of flash programming memory and I2C bus interfaces. Both modules are enhanced for low-power operation, enabling applications with multi-year battery life on two AA batteries.

To support easy integration of the OEM Edition surface mount modules in custom hardware designs, MoteWorks™ includes a full set of hardware documentation, Gerber files of the reference designs, OEM module pin-specifications and guidelines for achieving FCC certification of the end product. A hardware debug unit provides fast debugging and programming of custom hardware designs.

The OEM processor/radio modules can be quickly integrated into custom hardware reducing the effort needed to design wireless communication for specialized sensor applications.



Summary

MoteWorks™ is the end-to-end enabling platform for the creation of wireless sensor networks. The optimized processor/radio hardware, industry-leading mesh networking software, gateway server middleware and client monitoring and management tools support the creation of reliable, easy-to-use wireless OEM solutions. OEMs are freed from the detailed complexities of designing wireless hardware and software enabling them to focus on adding unique differentiation to their applications while bringing innovative solutions to market quickly.

Ordering Information

Description

MoteWorks Software Platform - Standard Edition
MoteWorks Software Platform - Academic Edition
MoteWorks Software Platform - Enterprise Edition with Full Source & CVS Access