

# MOTWORKS™

## SOFTWARE PLATFORM

MoteWorks™ 2.0 provides a complete software development environment for wireless sensor network applications. Included is a collection of flexible software packages that enables both quick-and-easy out-of-the-box deployment of sensor systems for monitoring and alerting, to powerful tools to empower custom development of pervasive sensory networks.

## Key Features

- Supports all Crossbow MICA and IRIS series Mote hardware and sensor boards:
  - **Motes:** IRIS, MICAz, MICA2, MICA2DOT
  - **Sensors:** MDA100/300/320, MTS300/310/400/410/420, MEP410/510
- Simple one-click installation and upgrade
- Based on TinyOS 1.1, a popular Open Source embedded operating system
- Source level access for modification and custom development
- **MoteView:** Rich interface for visualization and analysis of sensor data streams
- **MoteConfig:** Simple graphical interface to program flash and configure firmware images
- **XMesh:** Reliable mesh networking stack
- **XOtap:** Over-the-air firmware reprogramming
- **XRadio:** Low power radio protocol for battery powered devices
- **XServe:** Powerful utilities for data logging, parsing, conversions, and alerts
- **XSniffer:** Displays radio communication for protocol debugging
- **XSensor:** Complete set of example sensor applications
- **Cygwin:** Command line shell and development environment
- **Programmers Notepad:** Rich text editor and compilation front-end
- **nesC:** Pre-compiler language for generating ultra-efficient embedded software
- **gcc:** Industry standard C language cross-compiler
- **TortoiseCVS:** File Manager integrated revision control interface
- **WinMerge:** Graphical source revision differencing tool

## Overview

A wireless network deployment is composed of the three distinct software tiers:

1. The **Mote Tier**, where XMesh resides, is the software that runs on the cloud of sensor nodes forming a mesh network. The XMesh software provides the networking algorithms required to form a reliable communication backbone that connects all the nodes within the mesh cloud to the server.
2. The **Server Tier** is an always-on facility that handles translation and buffering of data coming from the wireless network and provides the bridge between the wireless Motes and the internet clients. XServe is the primary server tier application, and can run on a PC or Gateway.
3. The **Client Tier** provides the user visualization software and graphical interface for managing the network. Crossbow provides an analysis and monitoring package called MoteView for the client tier, but XMesh can be interfaced to custom 3<sup>rd</sup> party client software as well.

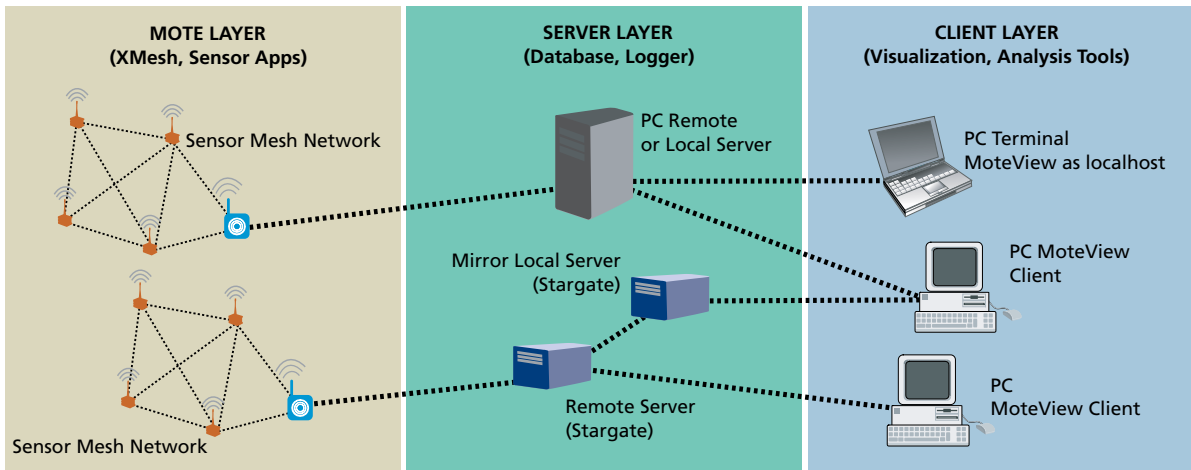


Figure 1.1  
Software Framework  
for a Wireless Sensor  
Network

## XMesh

XMesh is a reliable, low power, mesh networking library included in the MoteWorks package. XMesh provides higher reliability and lower power operation than other packages available in Open Source.

Package	Module	Reliability
MoteWorks 2.0	XMesh	95 - 99.9%
TinyOS 1.1	MintRoute	65 - 70%

## Key Features of XMesh 2.0 Include

- **Fast Formation** – Network forms in seconds compared to hours with other solutions.
- **Responsiveness** – Supports low-latency, sub-second alarm delivery across multiple hops.
- **Self-healing** – Network continuously assesses link quality and adjusts accordingly.
- **Reliability** – Over 95% reliability without any end-to-end retries.
- **Guaranteed Delivery** – Achieve 99.9% reliability by enabling end-to-end acknowledgement.
- **Bi-directional Delivery** – Send commands to any node using directed downstream service.
- **Scalability** – Supports clusters of 100+ nodes.
- **Proven Low Power** – LP and ELP topologies with known characterized battery life.
- **Low Power Router** – Supports full mesh topology with all nodes powered by battery.
- **End Node Support** – ELP service provides ultra low power hybrid-star end nodes.
- **Full Range** – Low power protocol provides Uncompromised full radio range.
- **Documented API** – Extensive manual describing services and development model.

## XOTAP

Crossbow provides a unique OTAP (Over-the-air Programming) capability that is superior to Open Source solutions such as Deluge for the following reasons:

- **Highly Reliable** – Directed dissemination with acknowledgement of completion and success.
- **Heterogeneous** – Allows programming of different firmware to different nodes in the network.

(Deluge propagates the same image to all devices.)

Feature	Module XOTap	Deluge
Images per node	4	2
Over-the-air programming	XMesh	X
Command-line tool	X	X
Management GUI tool	X	
Heterogeneous network	X	

## XServe

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MoteWorks includes a powerful connectivity solution between wireless sensor networks and Enterprise networks in the form of XServe. Open source has no middleware for connecting a sensor network to an IT network or a legacy process control / industrial automation network. In addition, the MoteWorks Base station software has been stress tested for long term stability, and includes reliability extensions.

- **Database Logging** – Logs data into an SQL database (PostgreSQL).
- **File Logging** – Logs data into a CSV file format.
- **Modbus Support** – Bridges a WSN to a legacy network through Modbus interface.
- **TCP/IP Support** – Bridges WSN data into standard IP communication protocol.
- **XML-RPC Support** – Configures WSN nodes through standard distributed object protocols.
- **Flexible Parsing** – Supports custom packet formats with auto-generated XML configuration.
- **Unit Conversions** – Seamlessly Converts raw ADC sensor values to final engineering units.

## Developer Tools

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MoteWorks provides a complete Windows based development environment through a simple single-click installer. MoteWorks also provides a simple Windows interface for viewing, editing, compiling, and downloading code. For the open source developer, familiar tools like 'vi' and 'cmacs' and command-line driver development is supported.

## MoteView

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MoteView provides visualization and analysis of multiple sensor data streams. MoteView comes with pre-compiled firmware for simple deployment of periodic sensing applications.

### Key Features of MoteView 2.0 Include

- **Simple Out-of-Box Experience** – Get your WSN kit up and running fast.
- **Charting** – Graph sensor data over time with zoom/pan tools for detailed analysis.
- **Topology** – Overlay network linkage on custom bitmap with isobar display of sensor data.
- **Data Grid** – Tabular display of sensor data across all nodes.
- **Time Bar** – Scroll backward and forward in time, and playback sensor data as movie.
- **Health** – Quickly view node outages, and detailed link quality information.
- **Export** – Manage database with import / export from SQL to CSV formats.
- **Commands** – Simple interface to control and actuate individual nodes.
- **Alerts** – Send an email or text page when a sensor value crosses a critical threshold.

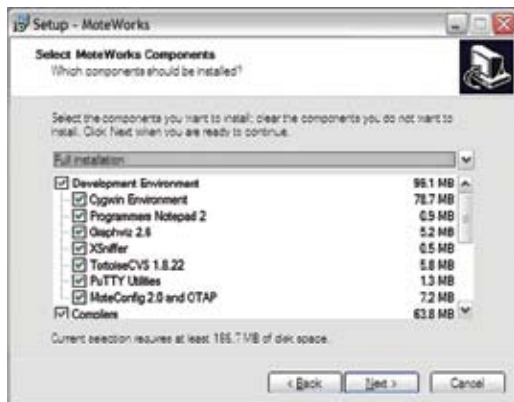
## Why MoteWorks?

MoteWorks provides the following benefits over TinyOS 1.x or TinyOS 2.x:

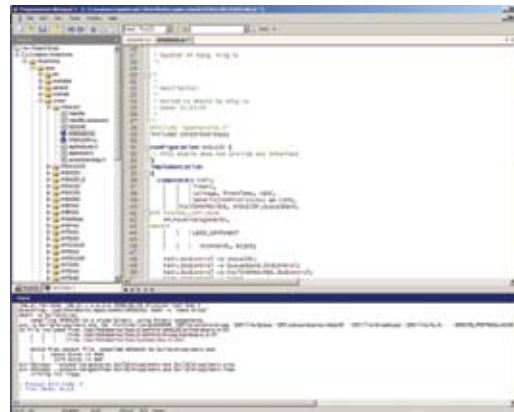
1. Faster network formation time (5x improvement)
2. Enhanced data transfer success rate (success rate went up from <70% to >95%)
3. API interface to proven XMesh routing stack (upstream and downstream)
4. Multiple topology support (Star, TrueMesh and Hybrid-Star)
5. Reliable and targeted XOtap (vs. dangerous viral propagation with Deluge)
6. IDE-like interface for compiling/debugging (vs. vi editor) and GUI interface for programming.
7. XML/Web interface via XServe for enterprise connectivity
8. One-click installer for quick start (vs. multiple install steps)
9. Plug and Play support for entire Crossbow hardware suite
10. Crossbow's professional support for bug fixes and potential custom enhancement requests (vs cry for help at TinyOS forum).

## MoteWorks Walk-through

1. Simple single-click installer will equip your machine with all the tools and configuration needed.



2. Programmers Notepad provides code highlighting and points out errors in the code to the user.



3. MoteView provides visualization and analysis of multiple sensor data streams. MoteView comes with pre-compiled firmware for simple deployment of periodic sensing applications.



Figure 1. MoteView – Topology

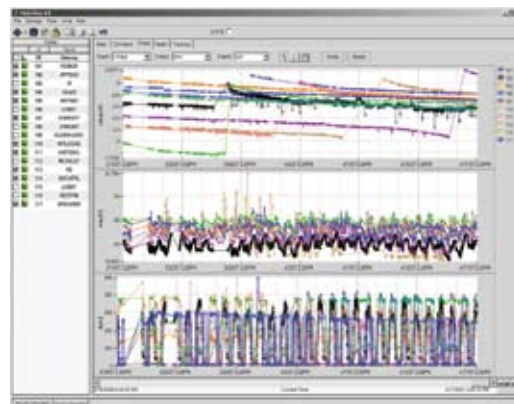


Figure 2. MoteView – Charts

# MoteWorks Walk-through

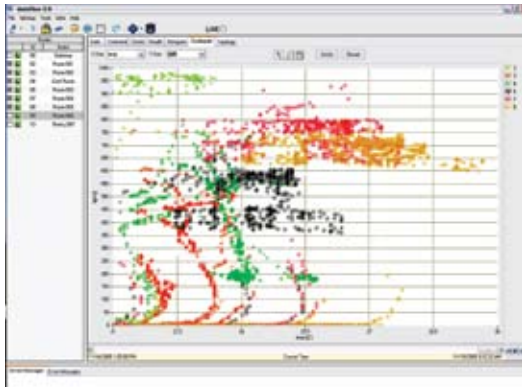


Figure 3. MoteView – Scatterplot

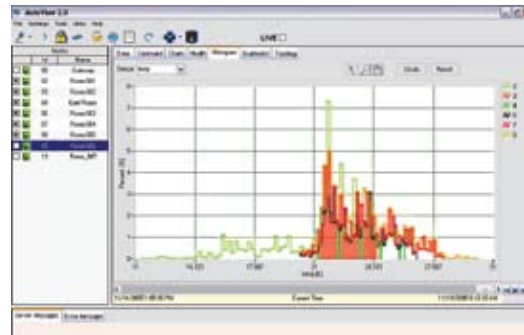
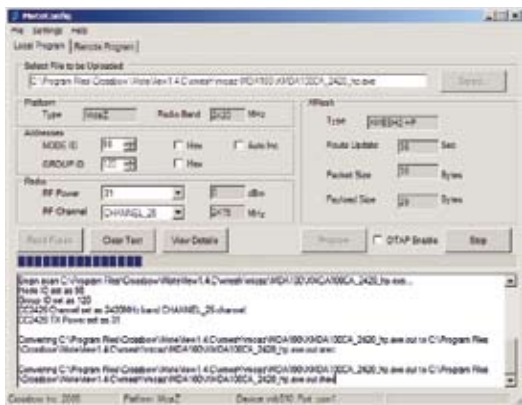
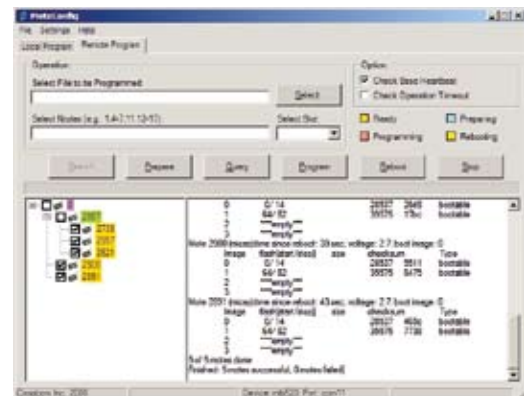


Figure 4. MoteView – Histogram

4. MoteConfig enables both local and remote (over-the-air) programming of firmware to the wireless sensor devices.



MoteConfig – Local Programming



MoteConfig – Remote Programming (OTAP)

5. XSniffer network radio protocol analyzer.



Figure 8 4. Screenshot displaying XSniffer Output†

## License Terms

The entire suite of MoteWorks software is, or will soon be available, for free download from Crossbow’s website, <http://www.xbow.com>. All binaries and substantial source code are included as part of these free distributions. The end-user license agreement provides for redistribution and use, for an unlimited time and at no cost, for most uses that are academic, research, personal, evaluative, or non-profit in nature. Licenses for commercial use without geographic or time limitation are available from Crossbow, and may include certain source code that is not included in the standard release. Please contact [sales@xbow.com](mailto:sales@xbow.com) for more information.