Crossbow: MoteWorks Getting Started Guide

Presented by Catherine Greene, Bretny Khamphavong, Chloe Norris, and Nancy White

Sections 1-3

Presented by Catherine Greene

MoteWorks

- MoteWorks
  - end-to-end enabling platform for the creation of wireless sensor networks
  - easy-to-use wireless original equipment manufacturer
    - OEM refers to the company that originally manufactured the product (wikipedia)
    - Allows for more freedom
      - Unique differentiation to applications
      - Innovative solutions to the market quickly

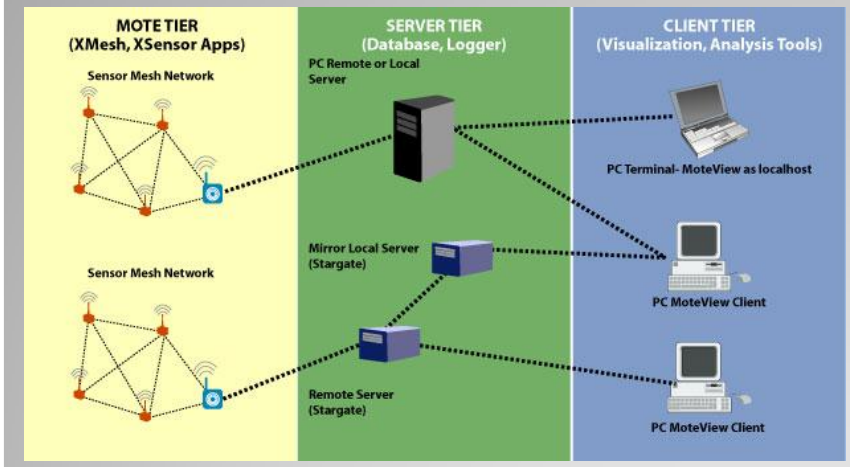
Information taken from: http://en.wikipedia.org/wiki/Original_equipment_manufacturer
MoteWorks Getting Started Guide

Software Tiers

- A wireless network deployment is composed of three distinct software tiers
  - Mote Tier
    - Xmesh located
      - The software that has the networking algorithms that form a reliable communication to connect all the nodes in the mesh cloud to the server
  - Server Tier
    - Always on
    - The facility that handles translation and buffering od data coming from the wireless network and provides the bridge between the wireless motes and the internet clients
  - Client Tier
    - Provides a graphical interface and software (MoteView) for managing the network
      - Software is made for low-power battery-operated networks and provides an end-to-end solution across all the tiers of the wireless sensor networking applications

Information and Images taken from: MoteWorks Getting Started Guide

SoftwareTiers



Xmesh Landscape

Information and Images taken from: MoteWorks Getting Started Guide

Un/Installing MoteWorks

- One needs
  - PC with Windows
  - 1 GB or more of free space in destination drive
  - 550 MB or more of space in C drive
- How to Install
  - Insert MoteWorks CD in CD-ROM drive
  - Double click on MoteWorks_<version>_Setup.exe
  - InstallShield Wizard will come up and guide you on what to do
- How to Uninstall
  - Can use the remove option for MoreWorks which can be found under *Start>Control Panel>Add/Remove Programs*
    - Removes *MoteWorks* Tree, Programmer's Notepad and MoteConfig
      - but other components like viz., *Graphviz*, *XSniffer*, PuTTY and TortoiseCVS have to be removed seperately from the add/remove programs wizard.

Information and Images taken from: MoteWorks Getting Started Guide

MoteWorks

- Comes with Programmer's Notepad
  - Simple IDE for NesC code
  - Start>Programs>Crossbow>PN
- Comes with Cygwin
  - Unix/Linux emulation
  - Optional interface for compiling and downloading Mote applications in MoteWorks
  - Double clicking the  icon on your desktop

Information and Images taken from: MoteWorks Getting Started Guide

Setting up Aliases

- It's recommended that you setup aliases
  - Commonly used commands
  - Aliases are to be edited at the bottom of the filed called profile which is located in <install dir>/cygwin/etc/
  - Useful for quickly changing to commonly used directories while in the *Cygwin* shell
  - some the aliases appear as two lines, all are written as one line

```
alias cdMoteWorks="cd <install dir>/cygwin/opt/MoteWorks"
alias cdtools="cd <install dir>/cygwin/opt/MoteWorks/tools"
alias cdapps="cd <install dir>/cygwin/opt/MoteWorks/apps"
```

Information and Images taken from: MoteWorks Getting Started Guide

Compiling and Platforms

- Compiling MoteWorks applications can be done in a Cygwin window
  - "make <platform>"

Processor/Radio Platform	For <platform> use
MICAz (MPR2400 series)	micaz
MICA2 (MPR4x0 series)	mica2
MICA2DOT (MPR5x0 series)	mica2dot
M2100 or XM2100	m2100
M2110 or XM2110	m2110
M9100 or XM9100	m9100

Information and Images taken from: MoteWorks Getting Started Guide

Programming

- Micro In-System Programmer (UISP)
  - Standard programming software
  - Takes various arguments according to the programmer (erase, verify, program, etc.).
    - You need to specify the type of device you are using and how to communicate with it
      - Done using environment variables

Information and Images taken from: MoteWorks Getting Started Guide

Installing MW Apps into a Mote

- Programming tools include a method of programming unique node addresses without having to edit source code
- To set the node address/ID during program load, the syntax for installing is "make <*platform*> re/install,<*n*> <*programmer*>,<*port*>"
  - <programmer> and <port> are the name of the programmer the port ID or address or number of the host PC to which the programmer is attached
  - <n> is an optional number (in decimal) to set the node ID or address
    - Assigning a node ID (", <n>") is optional
  - <platform> is the type of Mote processor/ radio hardware platform
  - "install,<n>" compiles the application for the target platform, sets the node ID/address and programs the Mote
  - "reinstall,<n>" sets the node ID/address and downloads the pre-compiled program (into the mote) and it does not recompile, using this option is a lot faster.

Information and Images taken from: MoteWorks Getting Started Guide

Automated Tools

- Build command filters out the compile output to highlight only error messages and warnings
- Buildall command performs an automated build of all applications under that application folder
- Flash command flashes an image onto the Mote
- Flashall command flashes an image onto a test bed of motes
- Fuses command allows the user to read or write the fuse settings of the mote on the programming interface board
- Motelist command lists MIB=520 and Telos devices that are attached to the USB port
- Gettos command allows the user to see how their current TinyOS environment is configured
- Settos command allows a user to switch to a new MotesWorks tree by changing the symbolic link
  - The first time this is run it renames your current MoteWorks tree to the specified version
- The usetos command allows a user to switch between MoteWorks and a legacy TinyOS envirnment
  - usetos switches to MoteWorks, usetos tinyos switches to TinyOS 1.x, etc..
- The make command (make <platform>) allows users to compile their nesC code with many options from the command line

Information and Images taken from: MoteWorks Getting Started Guide

Reviewing TinyOS and nesC Sections 4 and 5

Presented by Bretny Khamphavong

Primary Concepts of TinyOS

- Application: set of components linked together to form a run-time executable
- Component
  - Module - implements one or more interfaces
  - Configuration – “wires” other components together
- Interface
  - Bidirectional - specify both commands that a module must implement and events that modules must handle

Application Make Up: Makefiles

- *Makefiles* and nesC files that implement and wire up the application
- *Makefile* and *Makefile.component* define the dependencies for an application
  - *Makefile* tends to have the same contents across all applications
  - *Makefile.component* can be used to specify dependencies for this particular application

Application Make Up: nesC files

- nesC files can be identified because they use the extension ".nc" for all source files—interfaces, modules, and configurations
- Comments inside these files can either be single line "//" style comments, or multiline "/* */" style comments

nesC Example Code

- Modules are nesC files that perform two main functions:
  - Define the interfaces the module provides
  - Implement those interfaces with nesC code
- StdControl interface with implementation that returns SUCCESS when each function is called
- The interfaces provided and implementation are separated into a provides and implementation block respectively

```
module ModuleName {
        provides {
                interface StdControl;
        }
}
implementation {
        command result_t StdControl.init() {
                return SUCCESS;
        }
        command result_t StdControl.start() {
                return SUCCESS;
        }
        command result_t StdControl.stop() {
                return SUCCESS;
        } }
```

Wired Configurations

- A configuration can also provide interfaces by wiring components together into more complex interface providers, but it is not required to
- In the implementation section of an application configuration, the modules are wired together.
- For example:

```
Main.StdControl -> MyAppM.StdControl;
```

- Tells the compiler that the Main.StdControl interface is provided for by the StdControl interface in MyAppM

All Applications Must Have "Main" Component

- Referred to as the scheduler, or driver, of the application
- All nesC application execution starts in this component
- It must be properly wired into the application with the application configuration

Sensing Application and XMesh Sections 6 and 7

Presented by Chloe Norris

All Information and Images taken from: MoteWorks Getting Started Guide

Section 6

A Simple Sensing Application

All Information and Images taken from: MoteWorks Getting Started Guide

Hardware Requirements

- two standard edition Motes
  - of MICA2 (MPR4x0), MICAz (MPR2400), XM2100, XM2110 or XM9100 or OEM editions MPR600, MPR2400, M2100, M2110 or M9100
- one sensor or data acquisition board
  - MDA100, MTS300 or MTS310
- one gateway board
  - MIB510, MIB520, or MIB600 and the associated hardware (cables, power supply) for each
- Windows PC with *MoteWorks* installed.

All Information and Images taken from: MoteWorks Getting Started Guide

A Simplified Sensing Application

- Take light readings using one of the following sensors boards: MTS300/310 or MDA100
- Use the Mote serial port (UART) and radio to send sensor data to the base station
- Blink the yellow LED when the sensor is sampled
- Blink the green LED when the sensor data message is successfully sent to the base station
- Compile and debug if necessary

All Information and Images taken from: MoteWorks Getting Started Guide

Getting Started

- Application's configuration is located in the MyApp.nc file
- To create the applications configuration, the illustration to the left would be entered into the Programmers Notepad

```
includes sensorboardApp;

/**
 * This module shows how to use the Timer, LED, ADC and Messaging
components.
 * Sensor messages are sent to the serial port
 *
 * @author Crossbow Technology Inc.
 **/
configuration MyApp {
}
implementation {
  components Main, MyAppM, TimerC, LedsC, Photo, GenericComm as Comm;

  Main.StdControl -> TimerC.StdControl;
  Main.StdControl -> MyAppM.StdControl;
  Main.StdControl -> Comm.Control;

  MyAppM.Timer -> TimerC.Timer[unique("Timer")];
  MyAppM.Leds -> LedsC.Leds;
  MyAppM.PhotoControl -> Photo.PhotoStdControl;
  MyAppM.Light -> Photo.ExternalPhotoADC;

  MyAppM.SendMsg -> Comm.SendMsg[AM_XSXMSG];
}
```

All Information and Images taken from: MoteWorks Getting Started Guide

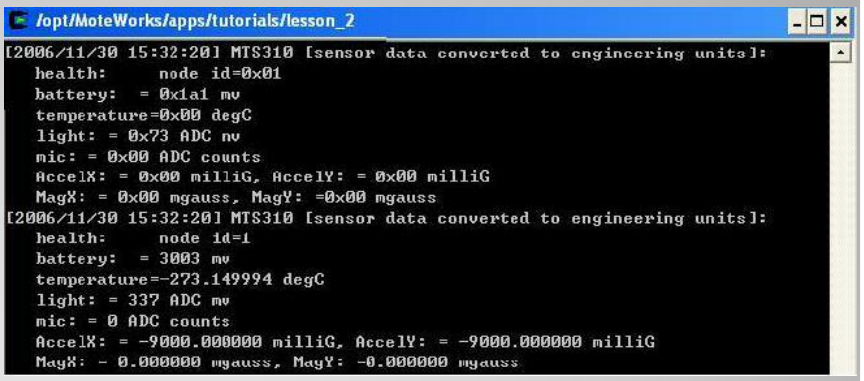
Getting Started Continued

- Blinking lights every seconds
  - Firing of the timer, sampling light sensor, and then sending message back to base station
  - Red: 1 second timer event fired
  - Yellow: light sensor has been sampled
  - Green: Sensor message has been sent back to base station

All Information and Images taken from: MoteWorks Getting Started Guide

XServe

- *XServe* is an application that installs with MoteWorks for the purpose of displaying sensor message packet contents as they arrive on the PC over serial port.



All Information and Images taken from: MoteWorks Getting Started Guide

Sending Sensor Data over the Radio

- One change needed in the code of the MyAppM.nc file
- SendMsg.send command decides where the message packet should be sent
- TOS_BCASE_ADDR tells the communications component to send the message through the radio.

From

```
if (call SendMsg.send(TOS_UART_ADDR,sizeof(XDataMsg),&msg_buffer) != SUCCESS)
```

To

```
if (call SendMsg.send(TOS_BCAST_ADDR,sizeof(XDataMsg),&msg_buffer) != SUCCESS)
```

All Information and Images taken from: MoteWorks Getting Started Guide

Using *Xsniffer to View Sensor Data Sent Over The Radio*

- *XSniffer used to eavesdrop on messages sent over the Mote radios.*
  - Monitor messages sent from modified sensing application
- Modify the sensing application in the ***/lesson_3*** folder onto a Mote.
- Tools>shell
- **make mica2 install, 1 mib510, com1**
- Remove the Mote from the programming board
- plug one of the sensorboards onto the Mote and turn it on

All Information and Images taken from: MoteWorks Getting Started Guide

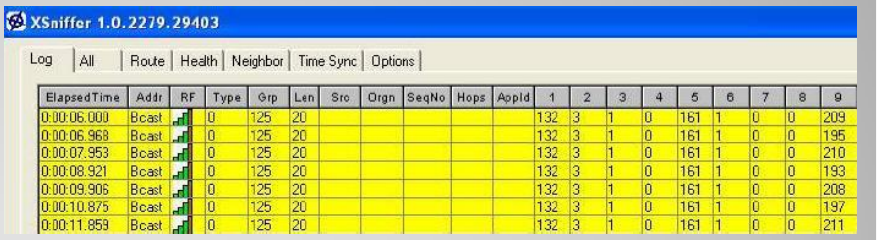
Using *Xsniffer* to View Sensor Data Sent Over The Radio Continued

- Install the *XSniffer* application onto another Mote
- Node id of 2
- Start *Xsniffer* by double clicking desktop icon
- Options>General Packet Type
- Go back to Log Tab
- Select COM port connected to programming board
- Click start to begin “Sniffing”

All Information and Images taken from: MoteWorks Getting Started Guide

Using *Xsniffer to View Sensor Data Sent Over The Radio Continued*

- Elapsed time the messages are begin sent about 1 second apart
- Each time the LEDs blink you should see a new message captured by *XSniffer.*



All Information and Images taken from: MoteWorks Getting Started Guide

Using a Sensorboard

- Specify the sensorboard
- Send a message containing the sensor data back to the base station
- GenericComm- used to send messages through the UTART port over to the radio

All Information and Images taken from: MoteWorks Getting Started Guide

XSensor Applications Supported in MoteWorks

- Crossbow's sensor and data acquisition boards supported with *XSensor enabled applications*
- *XSensor* applications are test applications for Crossbow's sensor data acquisition boards.
- Quickly and easily test sensor and data acquisition boards
- Send data over one hop

All Information and Images taken from: MoteWorks Getting Started Guide

Section 7

XMesh enabled Sensing Application

All Information and Images taken from: MoteWorks Getting Started Guide

Hardware Requirements

- Two Motes
  - standard editions of MICA2 (MPR4x0), MICAz (MPR2400), XM2100, XM2110 or XM9100 or OEM editions MPR600, MPR2400, M2100, M2110 or M9100.
- One sensor or data acquisition board
  - MDA100, MTS300 or MTS310
- One gateway board
  - MIB510, MIB520, or MIB600 and the associated hardware (cables, power supply) for each
- A Windows PC with *MoteWorks installed*

All Information and Images taken from: MoteWorks Getting Started Guide

A Simple Sensing Application

- Simple sensing application using the *XMesh* multi-hop networking service would
  - Take light readings
  - Use the Mote serial port (UART) and radio to send sensor data to the base station
  - Blink the yellow LED when the sensor is sampled
  - Blink the green LED when the sensor data message is successfully sent to the base station
  - Compile and debug if necessary

All Information and Images taken from: MoteWorks Getting Started Guide

Getting Started

- Create folder for code
- To create the application's configuration, enter the text shown on the right in the Programmer's Notepad
- Save File

```
includes sensorboardApp;

/**
 * This module shows how to use the Timer, LED, ADC and Messaging
components.
 * Sensor messages are sent to the serial port
 *
 * @author Crossbow Technology Inc.
 **/
configuration MyApp {
}
implementation {
  components Main, MyAppM, TimerC, LedsC, Photo, GenericComm as Comm;

  Main.StdControl -> TimerC.StdControl;
  Main.StdControl -> MyAppM.StdControl;
  Main.StdControl -> Comm.Control;

  MyAppM.Timer -> TimerC.Timer[unique("Timer")];
  MyAppM.Leds -> LedsC.Leds;
  MyAppM.PhotoControl -> Photo.PhotoStdControl;
  MyAppM.Light -> Photo.ExternalPhotoADC;

  MyAppM.SendMsg -> Comm.SendMsg[AM_XSXMSG];
}
```

All Information and Images taken from: MoteWorks Getting Started Guide

Using XSniffer to View Sensor Data Through the Network

- Monitor the messages being sent from the sensor node
- Remove the *XMeshBase* programmed Mote from the programming board
- Install the *XSniffer* application onto a third Mote that you will plug into your programming board (base station)
- Node id of 2
- Start the *XSniffer* application by double clicking on the icon on your desktop
- Options>*XMesh*>*Log tab*

All Information and Images taken from: MoteWorks Getting Started Guide

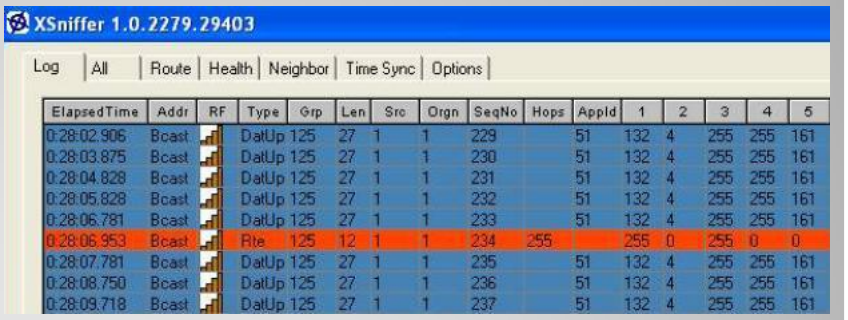
Using XSniffer to View Sensor Data Sent Over the Radio Continued

- Select COM port connected to programming board
- Click Start to begin “Sniffing”
- You should see message packets displayed in *Xsniffer*
- Remove the *XSniffer* Mote from the programming board and plug the *XMeshBase* Mote back into the programming board
- **File>Connect>Connect to Database**.
- **mts310_results** and click Apply
- MoteView main menu select **File>Connect>Connect to MIB510/MIB520/MIB600/Stargate**.

All Information and Images taken from: MoteWorks Getting Started Guide

Using XSniffer to View Sensor Data Sent through the Network

- Set the COM port value
- **XMTS310** application
- **Advanced** tab
- In **Data Logging Options** menu, check the box for **Spawn Separate Shell**
- Click Start to begin "Sniffing"
- All of Crosbow's sensor and data acquisition boards are supported with *XMesh* enabled applications.



All Information and Images taken from: MoteWorks Getting Started Guide

XMesh Advanced Features Sections 8 and 9

Presented by Nancy White

8.1 Hardware Requirements

- Two motes
- One gateway board
- A Windows PC with MoteWorks

End-to-End Acknowledgements

- In the MyApp subdirectory /lesson5 it shows how to use XMesh end-to-end acknowledgment, which have code to modify transport requests to the base station.
- A yellow LED light blinks when a message is received.

MyApp subdirectory /lesson5

- MyApp will need to be installed on two mote's, one of the mote's will be the sensor node while the other one will function as the base station.
- The mode you wish to use as the sensor node should be plugged into the programming board
- The red and green lights will flash until a network is formed, once the network is formed the yellow light will flash.

MyApp subdirectory /lesson5 con't

- ReceiveAck file allows for interface writing and requires a callback function that is generated by XMesh.
- MODE_UPSTREAM_ACK tells XMesh to send a message acknowledging that the message was received to the base station
- ReceiveAck.receive is another acknowledgment message that confirms a message has arrived from the base station and the LED light will flash green

MyApp subdirectory /lesson6

- Shows how to implement command processing
- requires 2 mote's, one will function as the sensor node, and the other as the base station, which is plugged into the programming board and connected to your PC.
- get_config, which will return the current configuration parameters for a mote

MyApp subdirectory /lesson6 cont'd

- set_rate and is used to change the motes sampling rate
- XCommandC component provides the functionality for processing downstream commands
- XCommand provides a single event name received which implements the application module and is signaled when a command arrives to the node.

Data Logging Application

Data Logging Application

- This section teaches you how to read and write data from external flash on a mote
- Requires a Windows PC with MoteWorks, two motes, and one gateway board
- allows the user to read and write operations at the external flash is ByteEEPROM

ByteEEPROM

- Allows you to log the number of light sensor readings in the external flash.
- When a new reading comes it over-writes the previous reading.
- Once the new reading is written to the external flash the logged data is read back from the flash and is placed in a data packet on the computer

ByteEEPROM Cont'd

- The node that has a node id of 0 will always be the base station
- Uses XServe to display the incoming packets on the computer
- ByteEEPROM component is required to request memory in the external flash and carry out read and write operations
- All changes that need to be made use the interface AllocationReq, ReadData, and WriteData of ByteEEPROM

To Sum it up…

- The MoteWorks Getting Started Guide is a very helpful reference when aid is needed with:
  - Uninstalling/reinstalling software
  - How-to's with commands and programming
  - TinyOS and NesC help
  - Running several different applications
  - Several different MoteWorks features