Overview

J-DSP

- A Web-based DSP Simulation Tool
- Universally accessible DSP functions
- Embeds Interactive Simulations in Web pages
- Seamlessly Integrates Animated Demos

Wireless Sensor Motes

- Seamless Integration with J-DSP enables real-time sensor signal analysis
- Java interface natural for remote sensing
- User-friendly GUI for computation/graphics using the J-DSP-Mote interface
- Hardware: *Mica2* from *Crossbow*

Motivation

- Wireless sensor networks have gained popularity in a number of applications
- Simplify control of *Mica2* platform through the object-oriented, platform independent structure of Java-DSP
- Connectivity with the signal processing environment of Java-DSP allows for real-time sensor data analysis
- Remote sensing possibilities
- Control by Java based handheld devices (i.e. PDAs)

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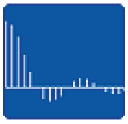
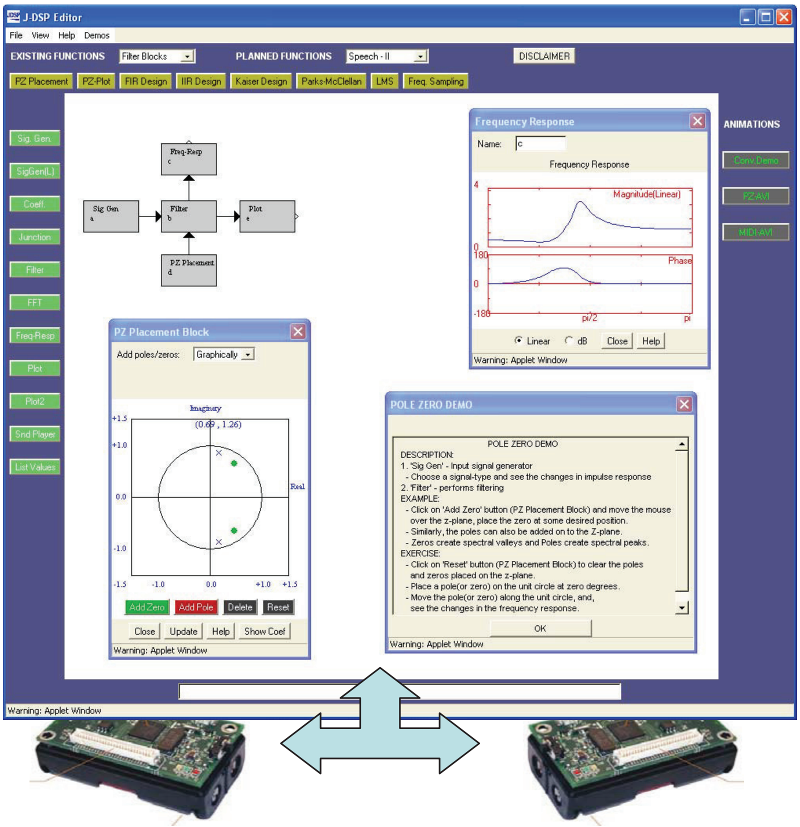
J-DSP: Background



J-DSP Editor

BASIC FUNCTIONALITY IN J-DSP

- Fundamental DSP functions (FFT, IFFT, Windowing, etc.)
- Arithmetic Functionality
- Digital Filtering
- FIR/IIR Filter Design
- Spectral Estimation
- Multi-rate DSP
- Visualization Blocks
- Pole-Zero Demo
- Frequency Response
- **Sensor Networks**



POLE ZERO DEMO

DESCRIPTION:

1. 'Sig Gen' - Input signal generator
   - Choose a signal-type and see the changes in impulse response
2. 'Filter' - performs filtering

EXAMPLE:

- Click on 'Add Zero' button (PZ Placement Block) and move the mouse over the z-plane, place the zero at some desired position.
- Similarly, the poles can also be added on to the Z-plane.
- Zeros create spectral valleys and Poles create spectral peaks.

EXERCISE:

- Click on 'Reset' button (PZ Placement Block) to clear the poles and zeros placed on the z-plane.
- Place a pole(or zero) on the unit circle at zero degrees.
- Move the pole(or zero) along the unit circle, and, see the changes in the frequency response.

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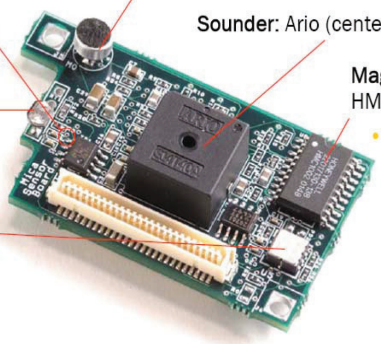
Hardware Platform



Temperature: Panasonic ERT-J1VR103J

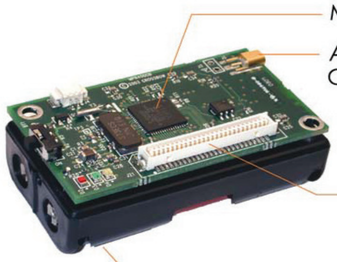
Microphone / Tone Detector

Sounder: Ario (centered at 4.5 kHz)

Light (Photoresistor): Clairex CL94L

Magnetometer: Honeywell HMC1002 (MTS310CA only)
- Resolution: 134 mGauss

Accelerometer: ADI ADXL202 (MTS310CA only)
- 2 axis
- Resolution: ± 2mG

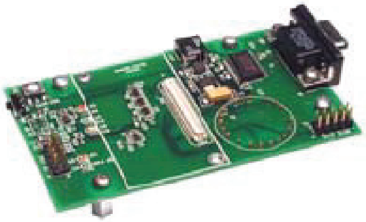


Microprocessor

Antenna Connector

Expansion Connector

Battery Pack

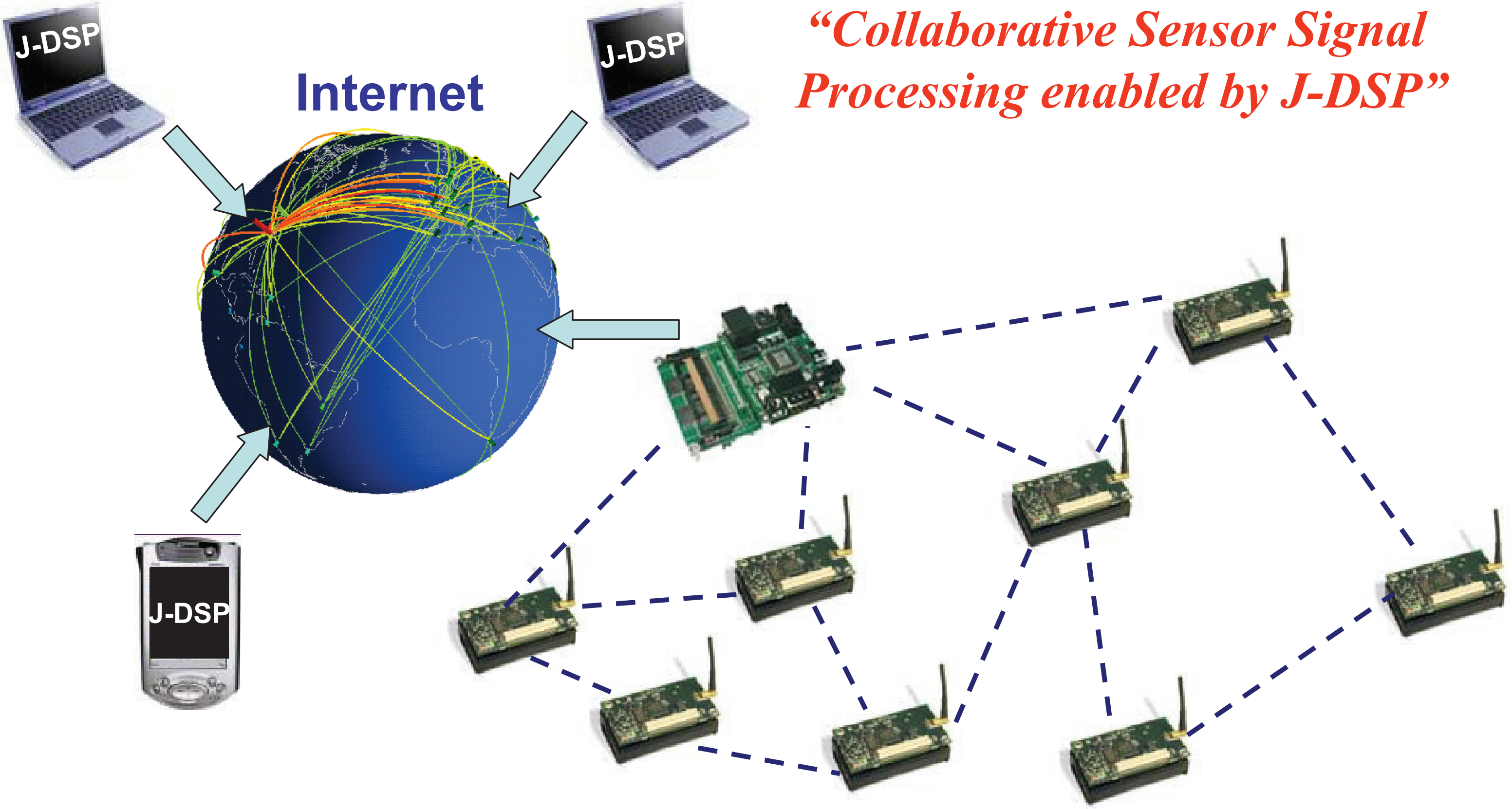


MIB(510) Gateway
: serial port programmer

- **Targeted Applications:** Environmental Monitoring, Security, Source Localization, Tracking, Biological Applications

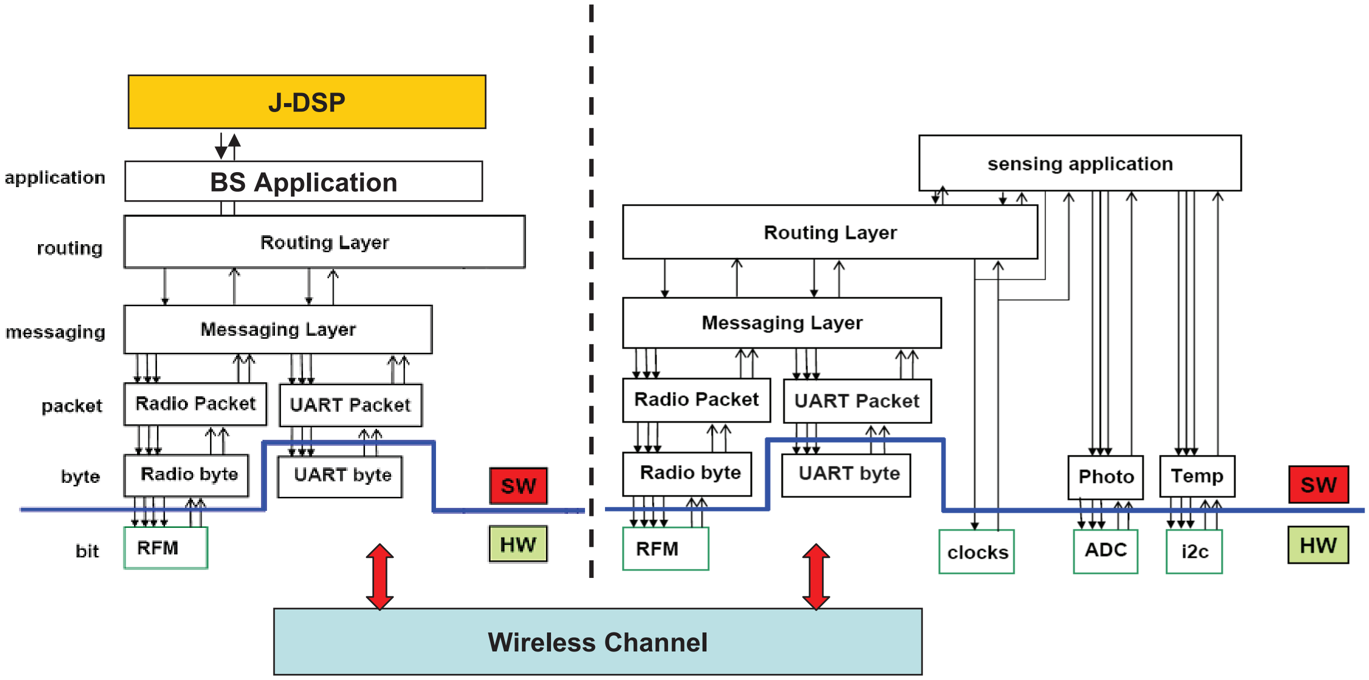
Java-DSP and the Motes

"Collaborative Sensor Signal Processing enabled by J-DSP"



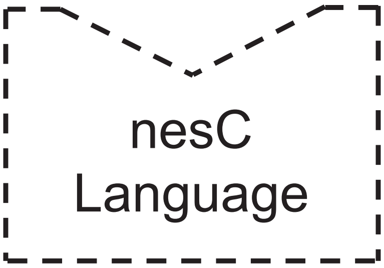
Tiny OS and Java-DSP

- Java-DSP acts as an additional layer at the base station
- Lower layer processing is seamless to the user



Tiny OS & nesC

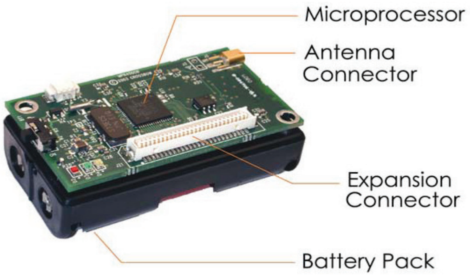
- Simple and powerful OS for low power
- Re-use of component
- “Hurry up and sleep”
- Scheduling based on events and tasks
- FIFO structure

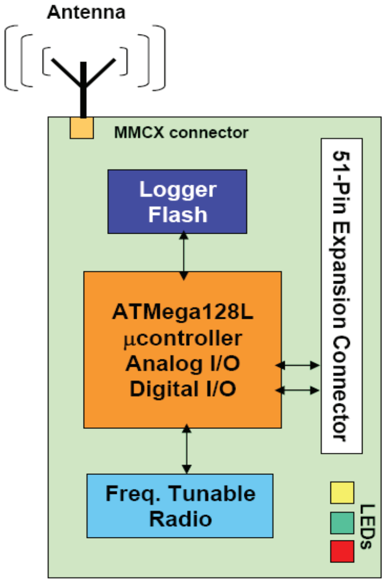


- TinyOS syntax and structure
- Dialect of C language
- A pre-processor
  - Converts wiring of high level modules into efficient code
  - nesC output is a c program file that is compiled and linked using gnu-gcc tools for a specific Mote

The Motes (MICA2 Platform)

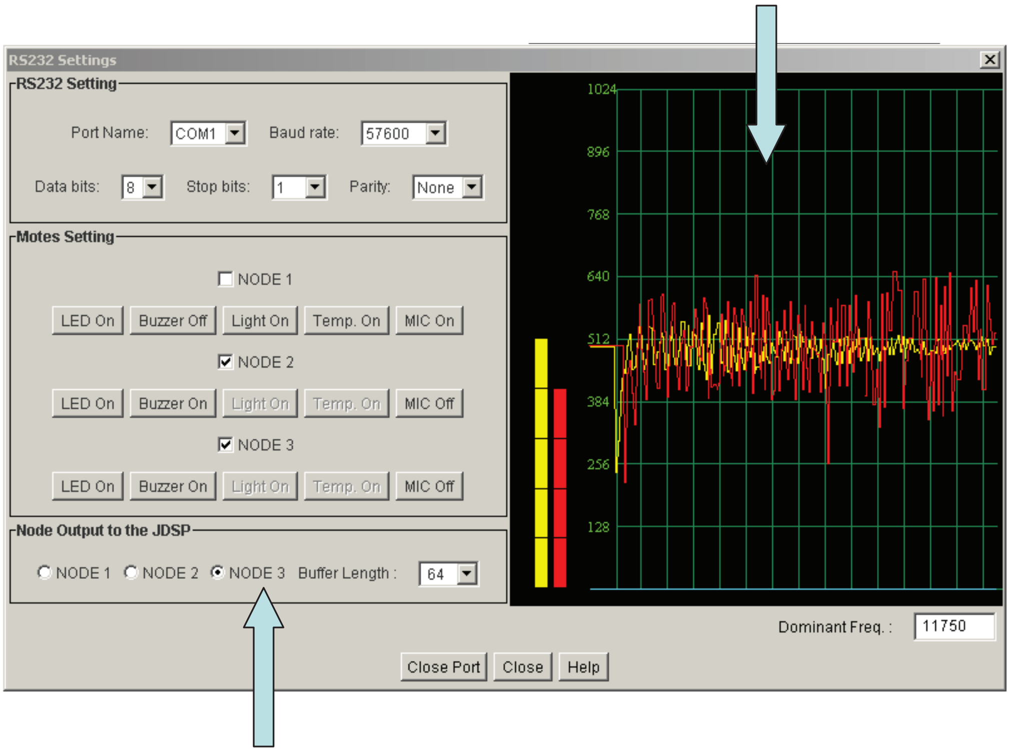
- **Microprocessor:** Atmel ATmega 128L
  - 7.3728 MHz clock
  - 128 kB of Flash for program memory
  - 4 kB of SRAM for data and variables
  - 2 UARTs
  - Serial Pot Interface (SPI) bus
  - Inter IC (I2C) bus
- **Radio:** Chipcon’s CC1000
- **External serial flash memory:** 512 kB
- **51-pin expansion connector**
  - Eight 10-bit analog I/O
  - 21 general purpose digital I/O
- **User interface:** 3 LEDs
- **JTAG port**
- **Powered by two AA batteries**
  - 1850 mAh capacity




Antenna
MMCX connector
Logger Flash
ATMega128L µcontroller Analog I/O Digital I/O
Freq. Tunable Radio
51-Pin Expansion Connector
LEDs

The MOTE Block

- GUI for the motes
- Control panel is used to control the individual motes and the RS232 settings
- MOTE block in J-DSP allows users to control individual motes
- Real-time graph plots data as it comes



Plot Area

RS232 Settings

RS232 Setting

Port Name: COM1 Baud rate: 57600

Data bits: 8 Stop bits: 1 Parity: None

Motes Setting

□ NODE 1

LED On | Buzzer Off | Light On | Temp. On | MIC On

☑ NODE 2

LED On | Buzzer On | Light On | Temp. On | MIC Off

☑ NODE 3

LED On | Buzzer On | Light On | Temp. On | MIC Off

Node Output to the JDSP

○ NODE 1 ○ NODE 2 ● NODE 3 Buffer Length : 64

Dominant Freq. : 11750

Control Panel

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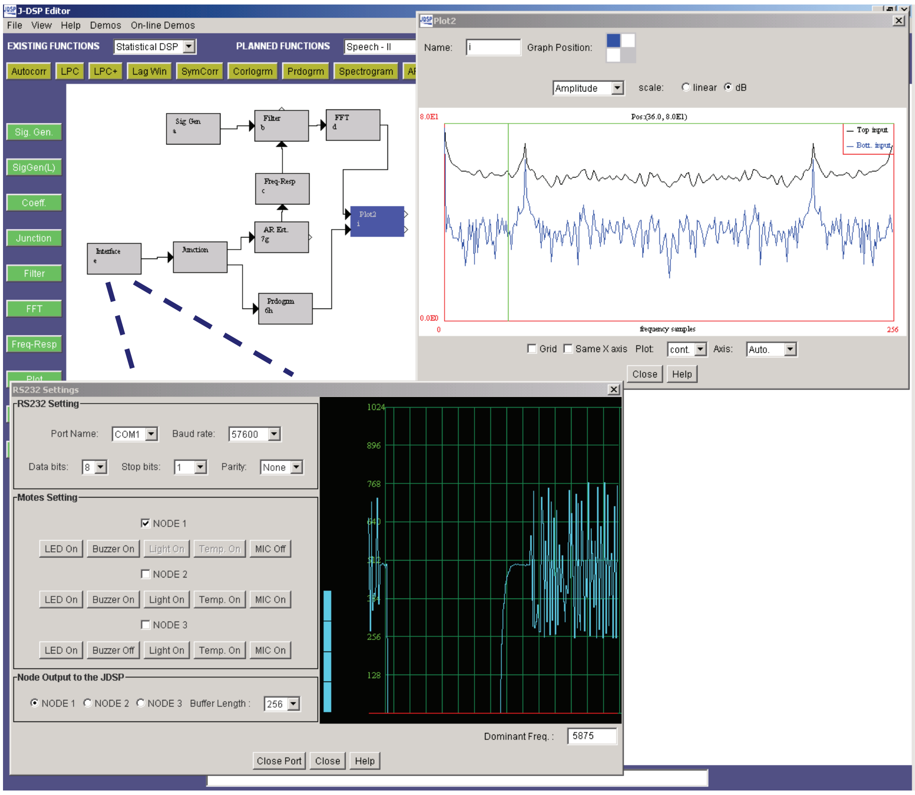
Sensor Network Signal Processing with J-DSP

J-DSP
Editor

- A number of advanced signal processing features available in J-DSP
- You can connect the incoming data to existing blocks to create DSP systems
- Example: Fitting incoming data to an auto-regressive model



EXISTING FUNCTIONS: Statistical DSP
PLANNED FUNCTIONS: Speech - II

Name: i
Amplitude scale: ○ linear ● dB
☐ Grid ☐ Same X axis Plot: cont. Axis: Auto.

Port Name: COM1 Baud rate: 57600
Data bits: 8 Stop bits: 1 Parity: None

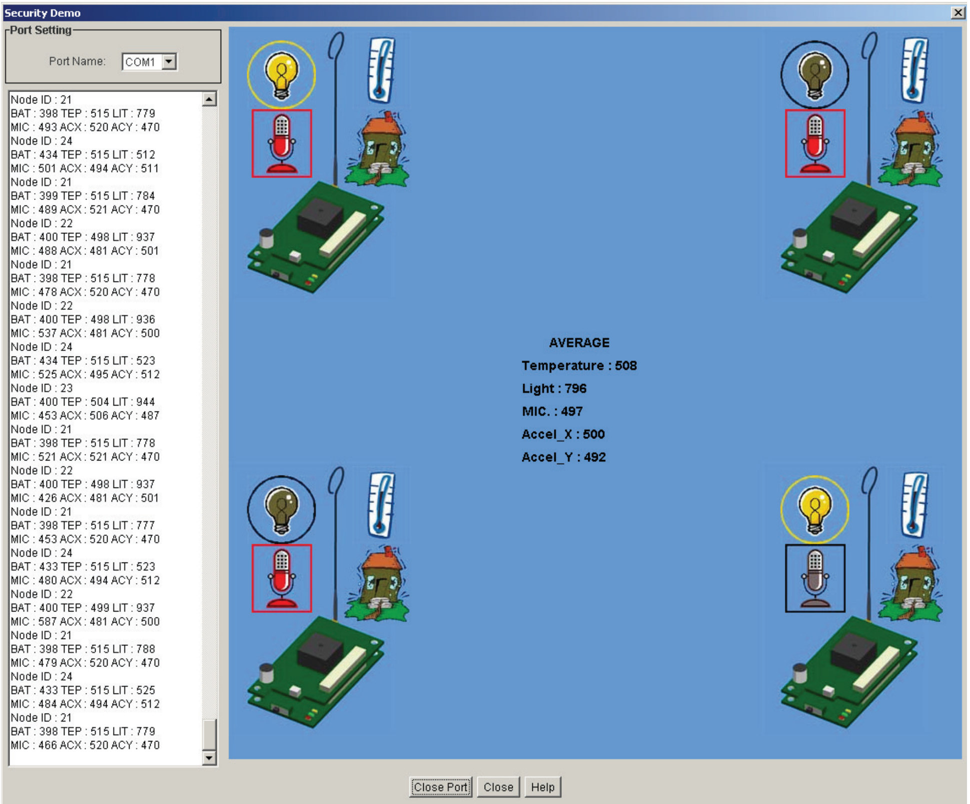
☑ NODE 1
☐ NODE 2
☐ NODE 3

● NODE 1 ○ NODE 2 ○ NODE 3 Buffer Length : 256

Dominant Freq. : 5875

Remote Sensing with J-DSP

- Preliminary example shows possibilities for sensing and security applications
- Display panel shows which sensors are active
- Active Sensors:
  - Light
  - Sound
  - Temperature
  - Accelerometer



Port Name: COM1

```
Node ID : 21
BAT : 398 TEP : 515 LIT : 779
MIC : 493 ACX : 520 ACY : 470
Node ID : 24
BAT : 434 TEP : 515 LIT : 512
MIC : 501 ACX : 494 ACY : 511
Node ID : 21
BAT : 399 TEP : 515 LIT : 784
MIC : 489 ACX : 521 ACY : 470
Node ID : 22
BAT : 400 TEP : 498 LIT : 937
MIC : 488 ACX : 481 ACY : 501
Node ID : 21
BAT : 398 TEP : 515 LIT : 778
MIC : 478 ACX : 520 ACY : 470
Node ID : 22
BAT : 400 TEP : 498 LIT : 936
MIC : 537 ACX : 481 ACY : 500
Node ID : 24
BAT : 434 TEP : 515 LIT : 523
MIC : 525 ACX : 495 ACY : 512
Node ID : 23
BAT : 400 TEP : 504 LIT : 944
MIC : 453 ACX : 506 ACY : 487
Node ID : 21
BAT : 398 TEP : 515 LIT : 778
MIC : 521 ACX : 521 ACY : 470
Node ID : 22
BAT : 400 TEP : 498 LIT : 937
MIC : 426 ACX : 481 ACY : 501
Node ID : 21
BAT : 398 TEP : 515 LIT : 777
MIC : 453 ACX : 520 ACY : 470
Node ID : 24
BAT : 433 TEP : 515 LIT : 523
MIC : 480 ACX : 494 ACY : 512
Node ID : 22
BAT : 400 TEP : 499 LIT : 937
MIC : 587 ACX : 481 ACY : 500
Node ID : 21
BAT : 398 TEP : 515 LIT : 788
MIC : 479 ACX : 520 ACY : 470
Node ID : 24
BAT : 433 TEP : 515 LIT : 525
MIC : 484 ACX : 494 ACY : 512
Node ID : 21
BAT : 398 TEP : 515 LIT : 779
MIC : 466 ACX : 520 ACY : 470
```

AVERAGE
Temperature : 508
Light : 796
MIC. : 497
Accel_X : 500
Accel_Y : 492

Future Directions

- J-DSP and Motes for Research
  - Source localization using the Motes
  - Target tracking
  - Interfacing with advanced J-DSP features (i.e. HMM)
  - Collaborative remote sensing using J-DSP
  - Implement sensor networks using J-DSP/Motes for smart home and security applications

- J-DSP and Motes for Education
  - Train UG and grad. students the basics of working with wireless Motes using the J-DSP GUI
  - Train engineers and practitioners in real-time analysis of sensor data
  - Use hands-on hardware/ software approach to create a workforce trained in using sensors for security and other applications

Summary

- Simulation modules and blocks in J-DSP have been developed to control the *Crossbow* Motes
- Object-oriented structure of J-DSP allows for easy manipulation of the Motes
- Please visit http://jdsp.asu.edu for more information on J-DSP
- J-DSP also supports: Statistical DSP simulations, Communications, Speech analysis-synthesis, 2D and Image processing, Spectrogram/time-frequency experiments, and Controls simulations

Some figures taken from http://www.xbow.com