Wireless Sensor Networks

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Outline

- Networked Embedded System
- Sensor Network : Introduction
- Applications
- Why need OS
- TinyOS
- Development at DA-IICT
- Summary

Networked Embedded Systems

- Most of the embedded system development – standalone device
- With the growth of networking and Internet possibility of group of embedded device communicating
- Wireless network and explosive growth in mobile phone technology has made this even more attractive
- Last 3-4 years technology development have opened the possibility of Sensor Networks

Technolgy Development

- Commercial demand (e.g. Mobile phone)
  - Integration of Sensing and Processing
  - Miniaturization
  - Low power consumption
  - Efficient wireless communication
- Sensor Network nodes combine
  - Microsensor
  - Low power computing
  - Wireless networking

Sensor Network

A sensor network is composed of a large number of sensor nodes, which are densely deployed either inside the phenomenon or very close to it.

- Random deployment
- Cooperative capabilities

Instead of low density highly sensitive sensors
-> high density, low cost sensor nodes

Wireless Communication Range

- Low range
  - Node to Node
  - Multi-hop
  - 50-100 meters
  - Few 100 MHz to few thousand MHz
  - No infrastructure needed to support communication

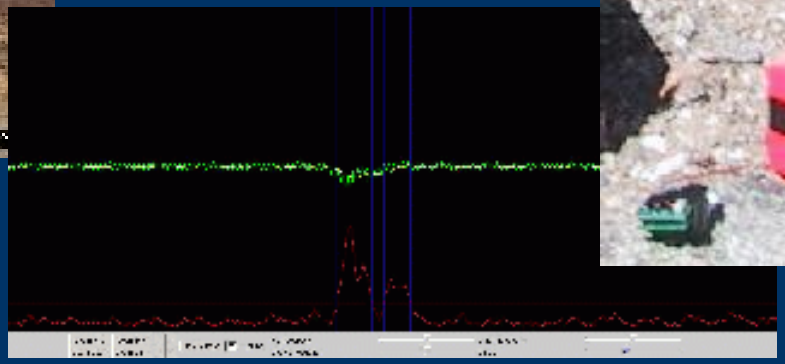
Applications

- Temperature
- Humidity
- Vehicular movement
- Lightning condition
- Pressure
- Soil property
- Noise levels
- The presence or absence of certain kinds of objects
- Mechanical stress levels on attached objects
- The current characteristics such as speed, direction, and size of an object

Military Applications

- Monitoring friendly forces, equipment and ammunition
- Battlefield surveillance
- Reconnaissance of opposing forces and terrain
- Battle damage assessment
- Nuclear, biological and chemical attack detection and reconnaissance

Vehicle Tracking



Environmental Applications

- Forest fire detection
- Bio-complexity mapping of the environment
- Flood detection
- Precision agriculture

Health Applications

- Tele-monitoring of human physiological data
- Tracking and monitoring patients and doctors inside a hospital
- Drug administration in hospitals

Animal Tracking : ZebraNet

Home Applications

- Home automation
- Smart environment

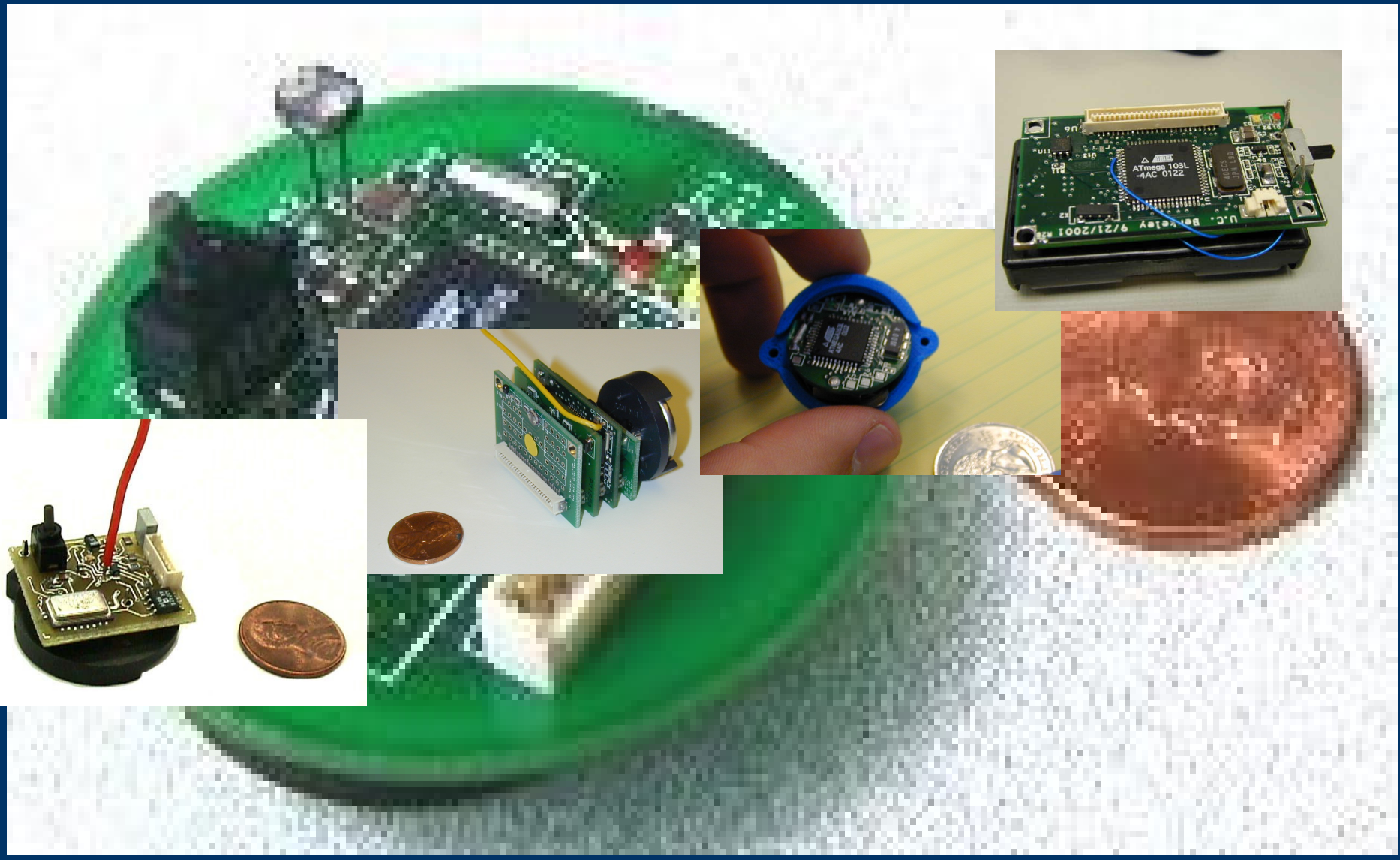
Other Commercial Applications

- Environmental control in office buildings
- Interactive museums
- Managing inventory control
- Vehicle tracking and detection
- Detecting and monitoring car thefts

Agricultural Application

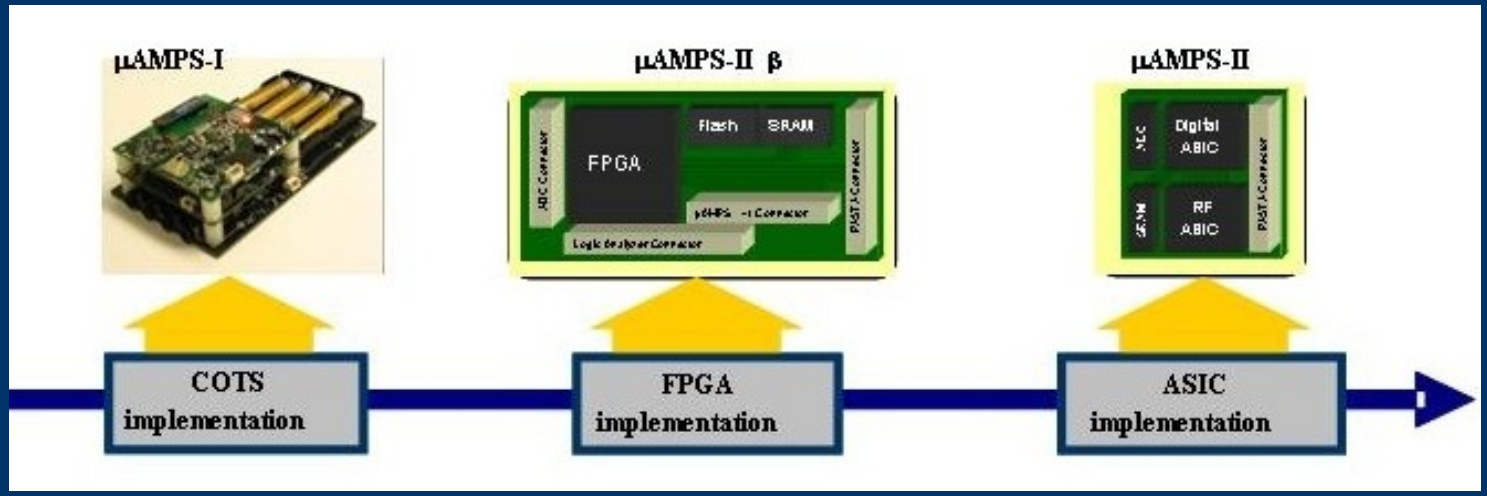
- Detailed local environment
  - Temperature
  - Humidity
  - Soil Moisture
  - Wind speed, direction
  - Rain Fall
  - Sunshine
  - CO_2

COTS MOTES



MIT µAMPS

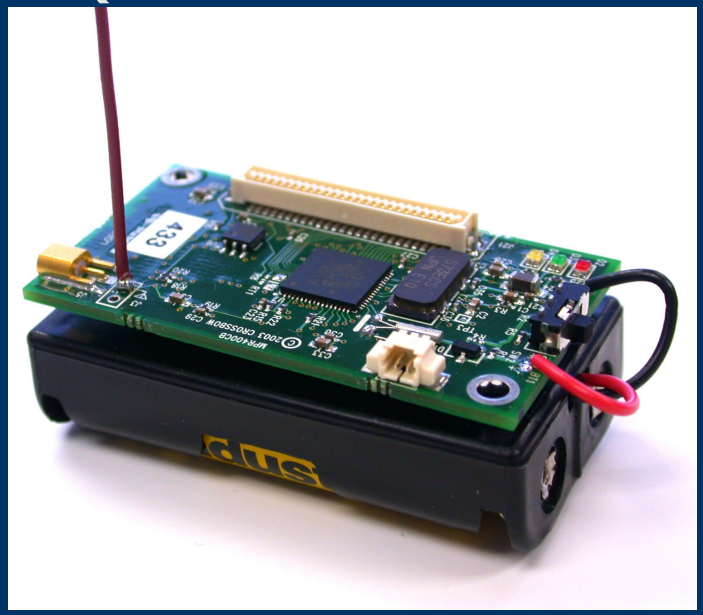
- 'highly integrated, yet flexible sensor node based on two dedicated chips' (off-the-shelf -> systems on chip)
- StrongARM SA1110 32-bit, 206MHz, RISC processor

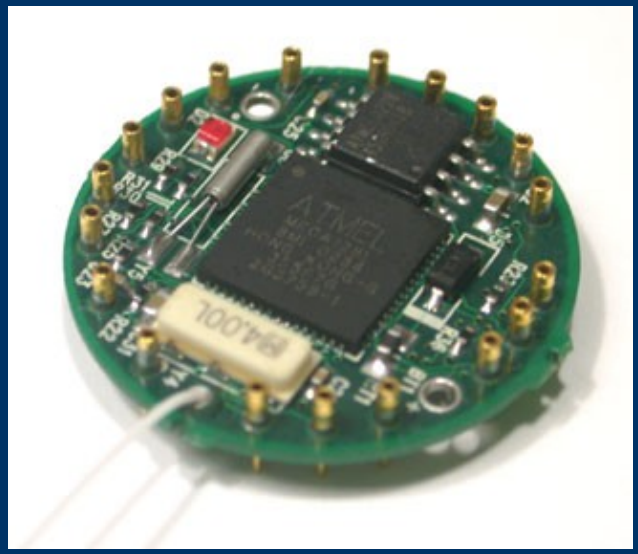


- 3 acoustic sensors attached to each node, for estimation of direction of target (µAMPS I)

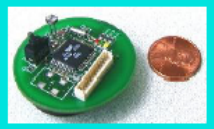
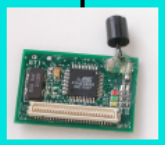
Berkeley Motes

- ATMega 128L 8-bit, 8MHz, 4KB EEPROM, 4KB RAM, 128KB flash
- Chipcon CC100 multichannel radio (Manchester encoding, FSK). Up to 500-

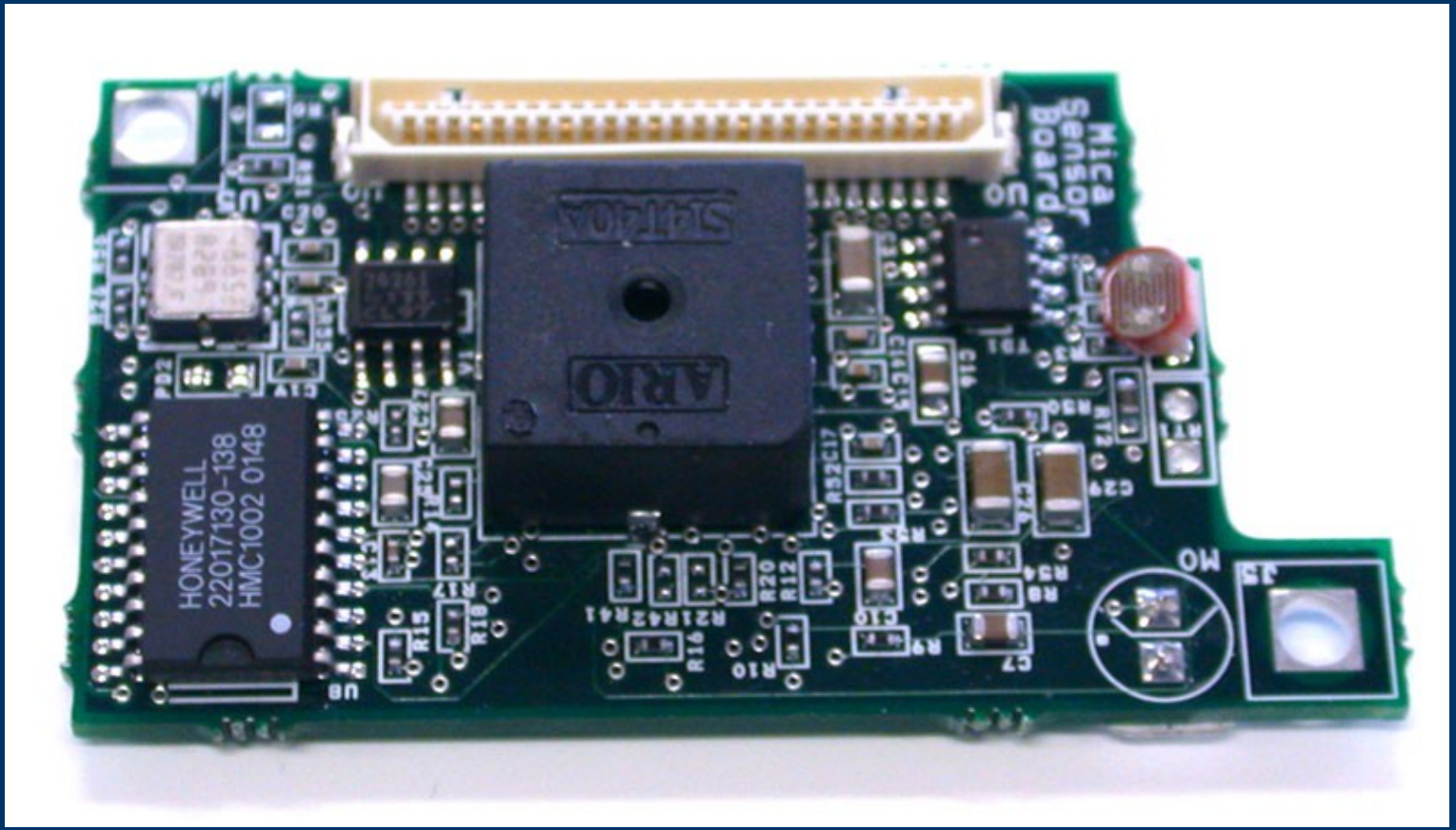




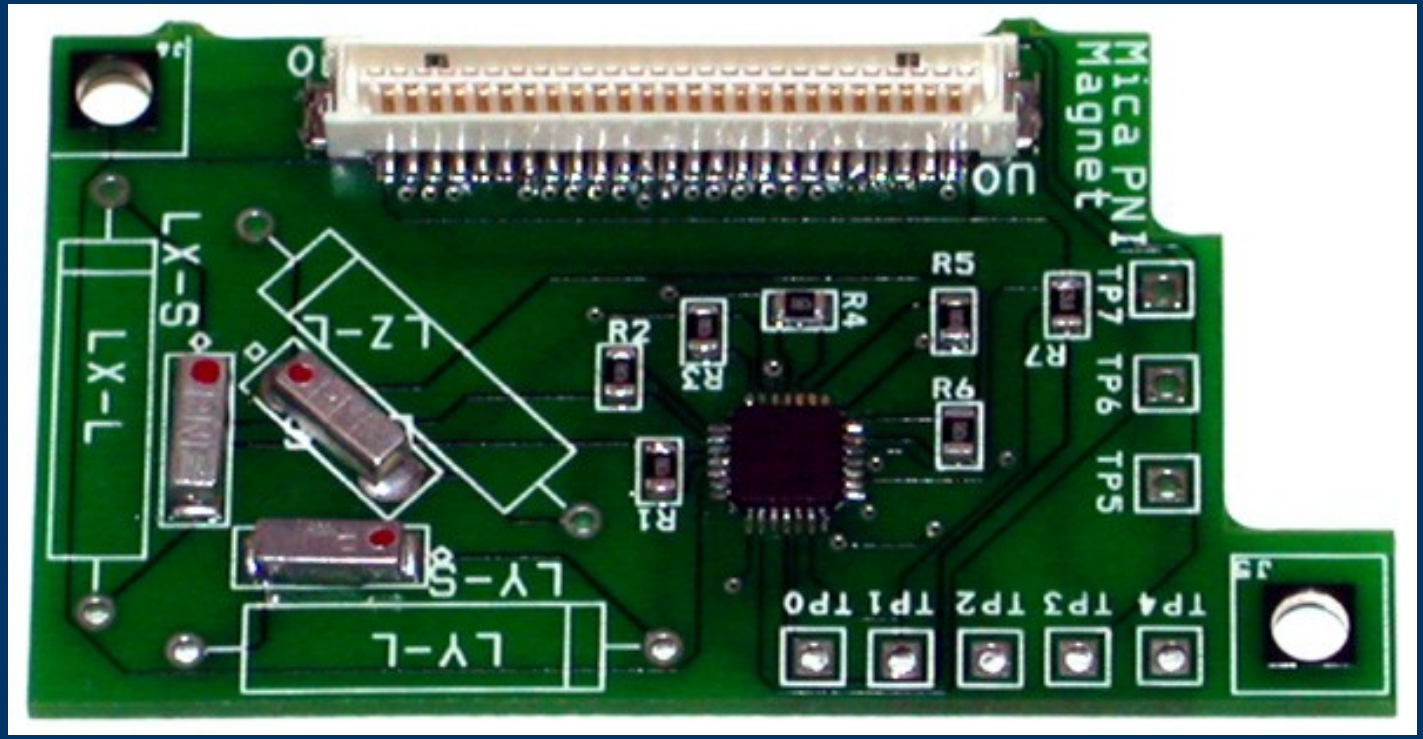
Berkeley Motes

Mote Type	*WeC*	*René*	*René 2*	*Dot*	*Mica*	*MicaDot*
						
Microcontroller						
Type	AT90LS8535		ATmega163		ATmega128	
Program memory (KB)	8		16		128	
RAM (KB)	0.5		1		4	
Nonvolatile storage						
Chip	24LC256				AT45DB041B	
Connection type	I^2C				SPI	
Size (KB)	32				512	
Default power source						
Type	Lithium	Alkaline	Alkaline	Lithium	Alkaline	Lithium
Size	CR2450	2 x AA	2 x AA	CR2032	2 x AA	3B45
Capacity (mAh)	575	2850	2850	225	2850	1000
Communication						
Radio	TR1000					CC1000
Radio speed (kbps)	10	10	10	10	40	38.4
Modulation type	OOK				ASK	FSK

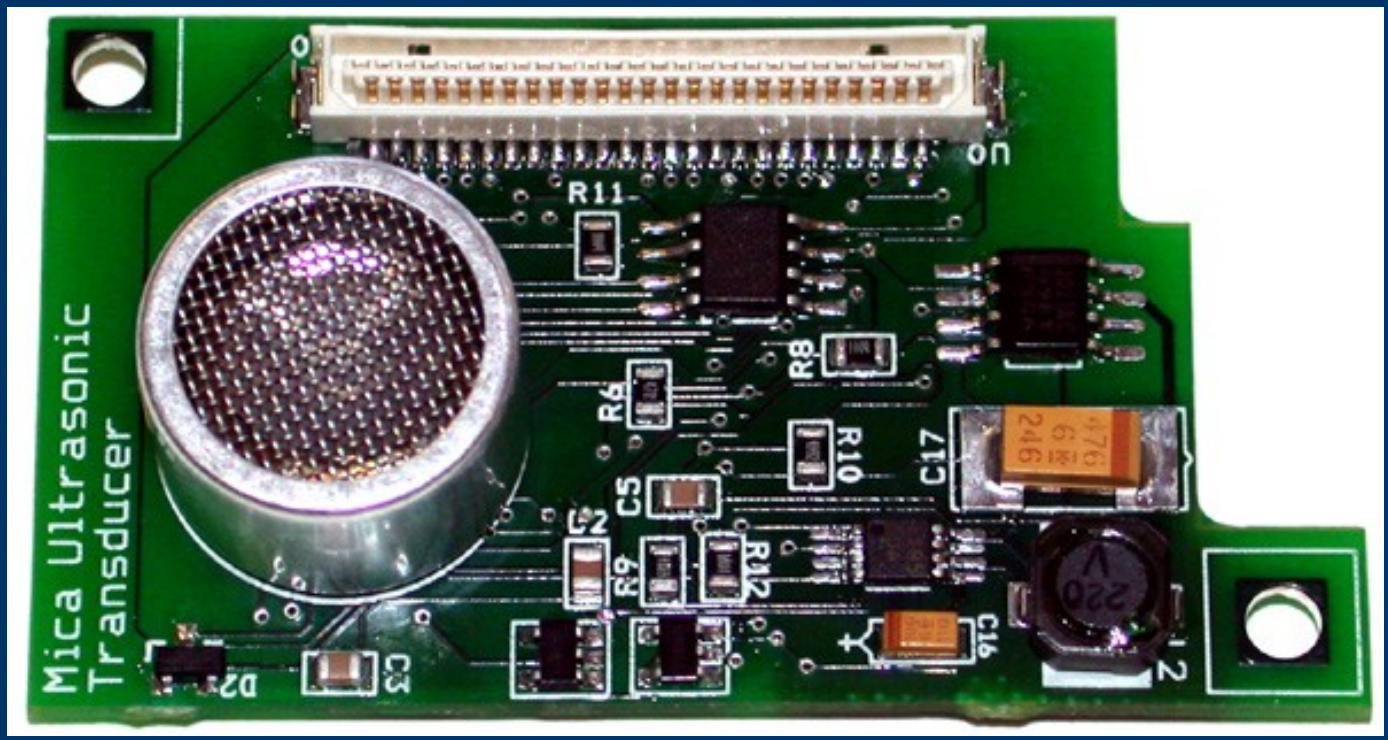
Sensor Board



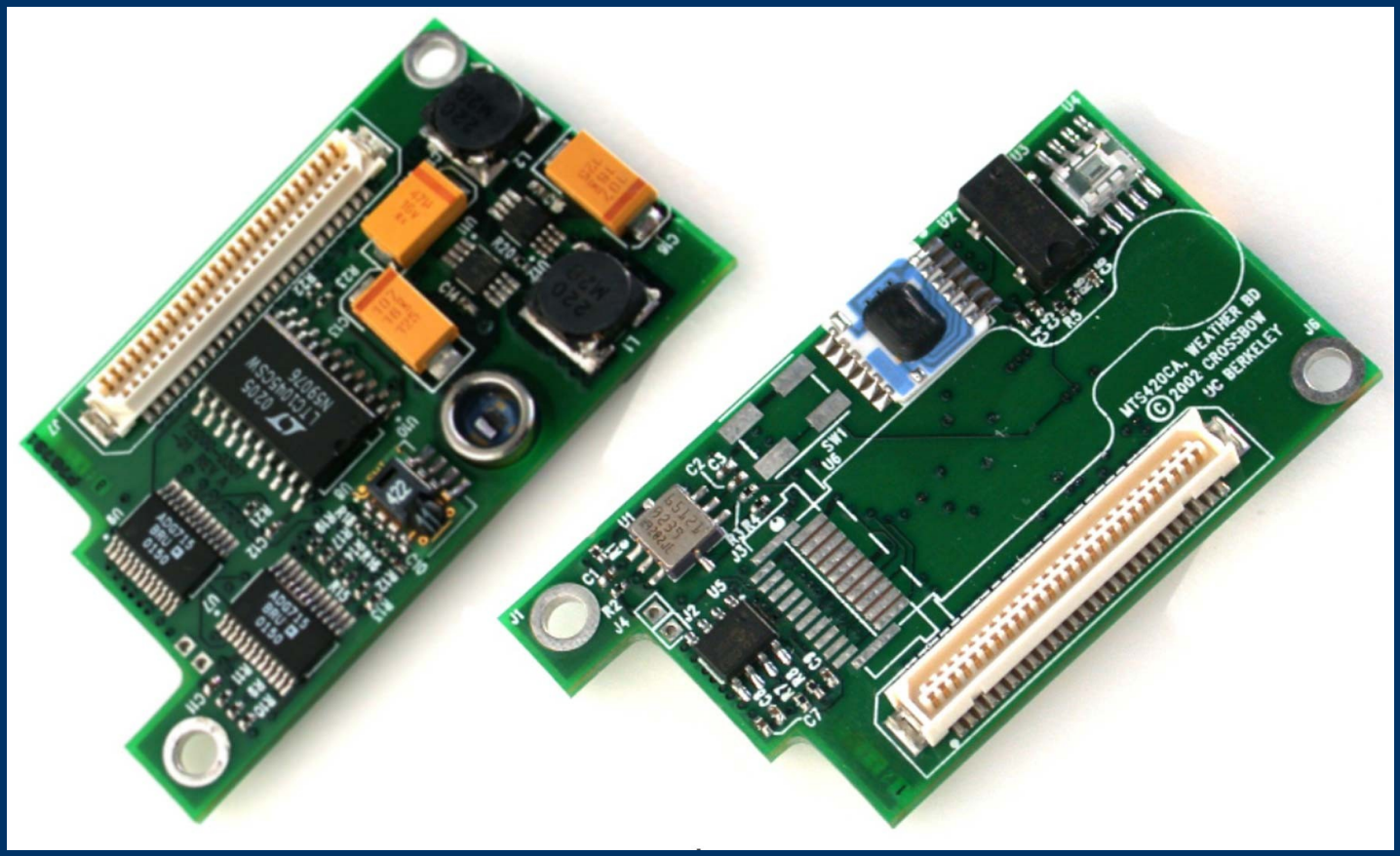
PNI Magnetometer Compass



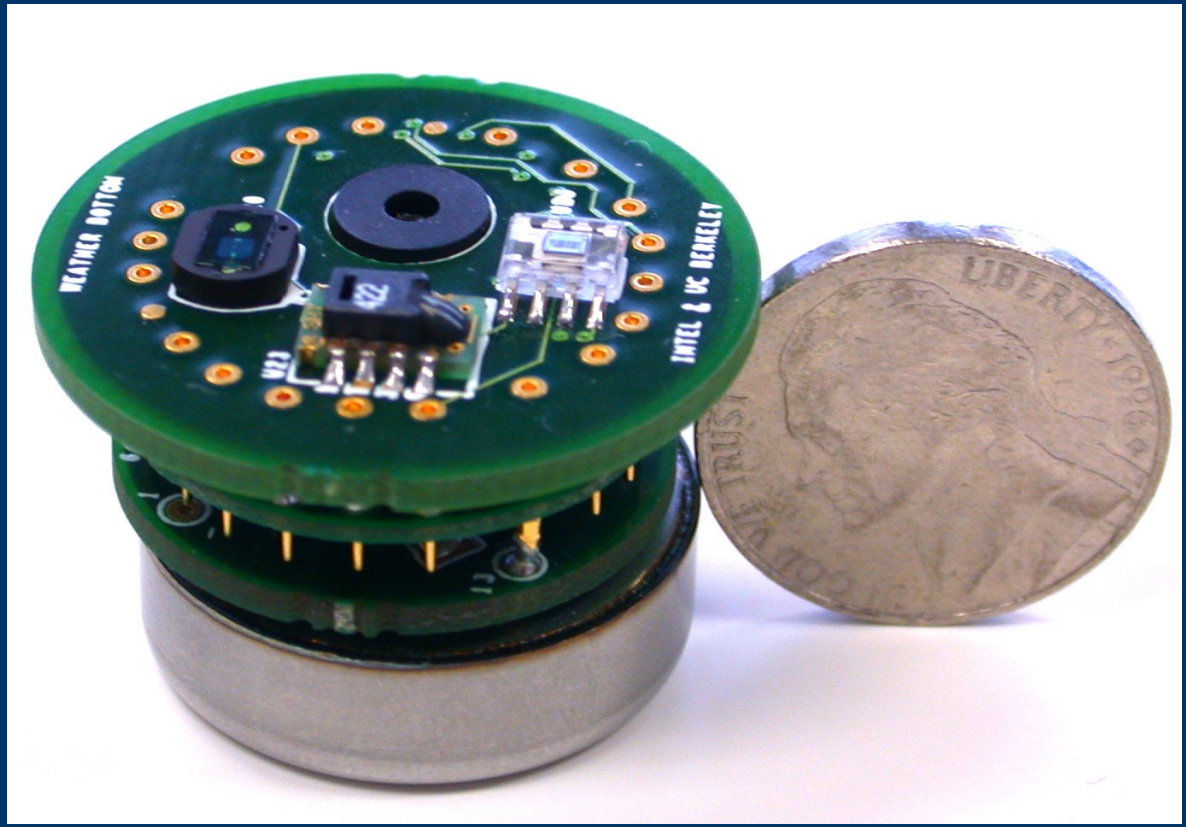
Ultrasonic Transceiver



Mica Weather Board



MicaDot Sensor Board



A typical implementation

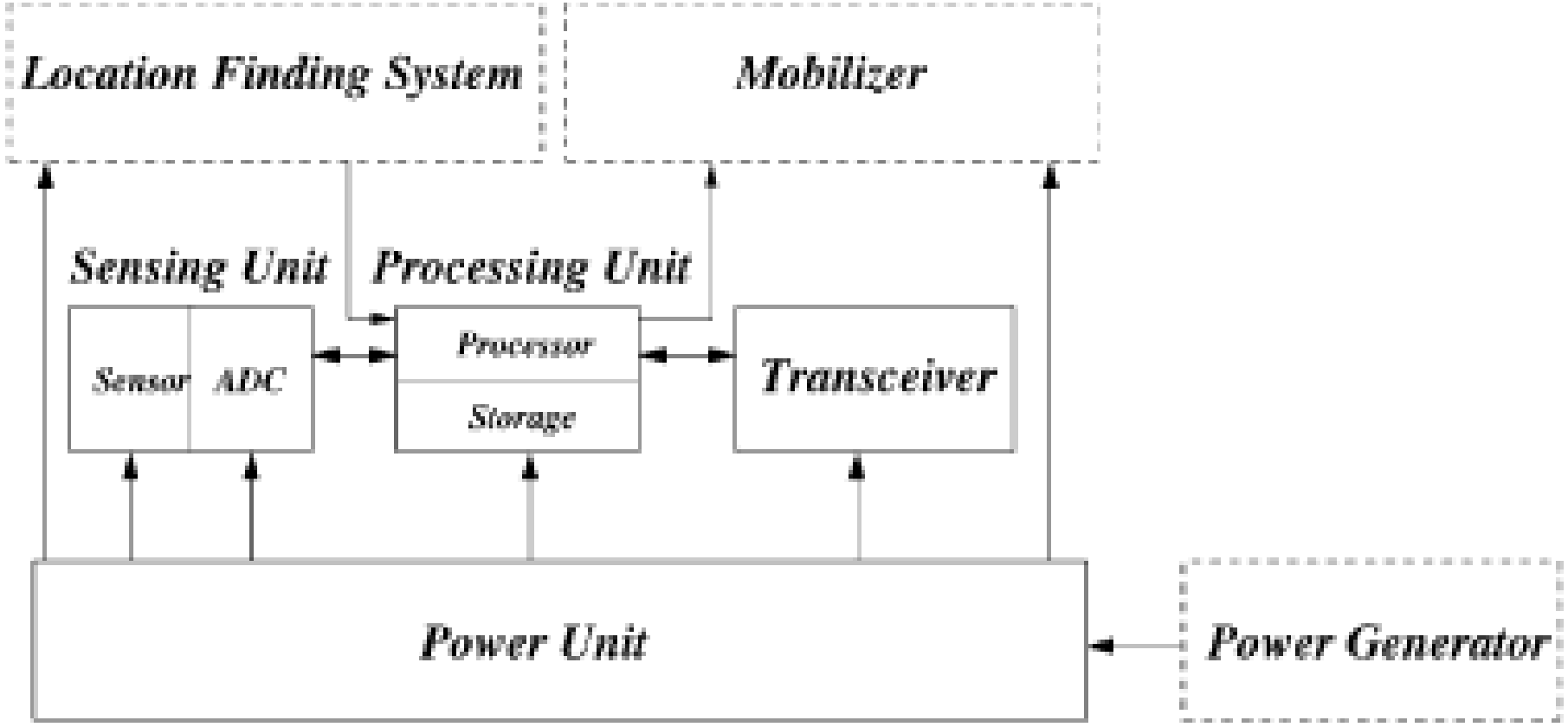
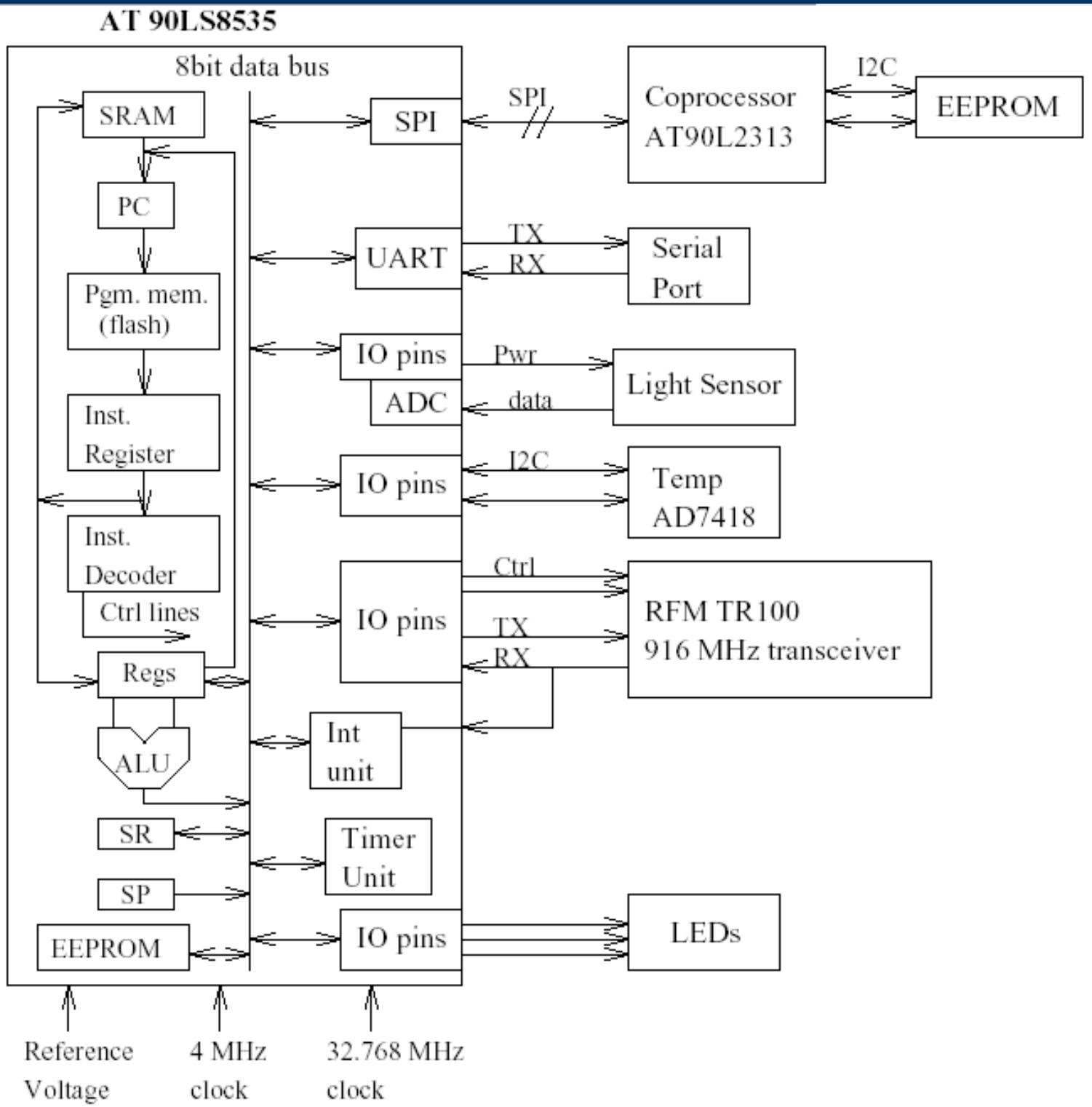


Fig. 1. The components of a sensor node.


AT 90LS8535
8bit data bus
SRAM
PC
Pgm. mem. (flash)
Inst. Register
Inst. Decoder
Ctrl lines
Regs
ALU
SR
SP
EEPROM
SPI
UART
IO pins
ADC
IO pins
IO pins
Int unit
Timer Unit
IO pins
SPI
Coprocessor AT90L2313
I2C
EEPROM
TX
RX
Serial Port
Pwr
data
Light Sensor
I2C
Temp AD7418
Ctrl
TX
RX
RFM TR100
916 MHz transceiver
LEDs
Reference Voltage
4 MHz clock
32.768 MHz clock

Tiny Micro-threading Operating System (TinyOS)

- Small physical size, modest active power load and tiny inactive load are provided by the hardware design.
- An operating system framework is needed that will retain these characteristics by managing the hardware capabilities effectively, while supporting concurrency-intensive operation in a manner that achieves efficient modularity and robustness.

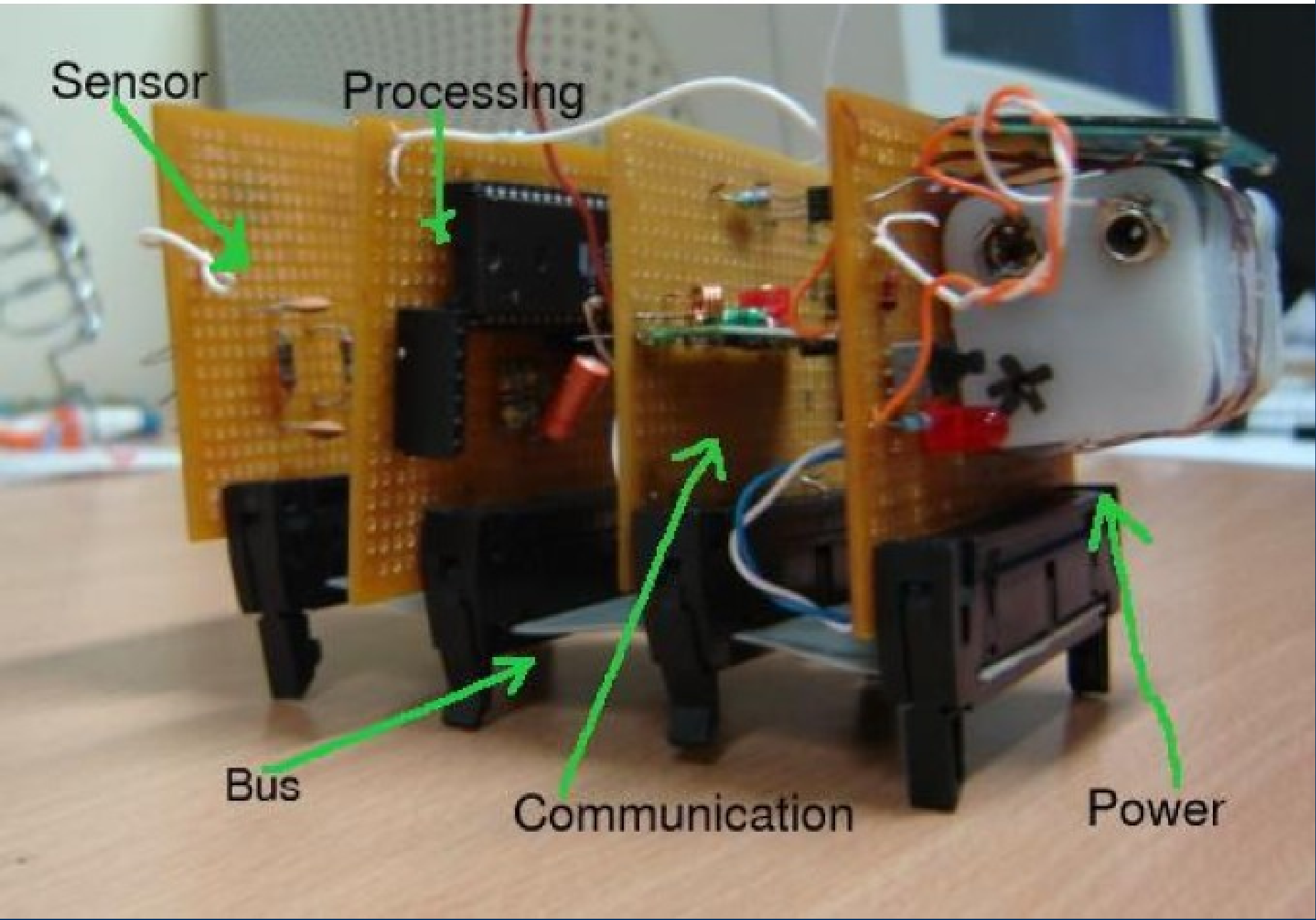
- Existing embedded device operating systems did not meet this challenge
- A clean open platform was desired to explore alternatives
- It was tackled by building an extremely efficient multi-threading engine
- It maintains a two-level scheduling structure, so a small amount of processing associated with hardware events can be performed immediately.

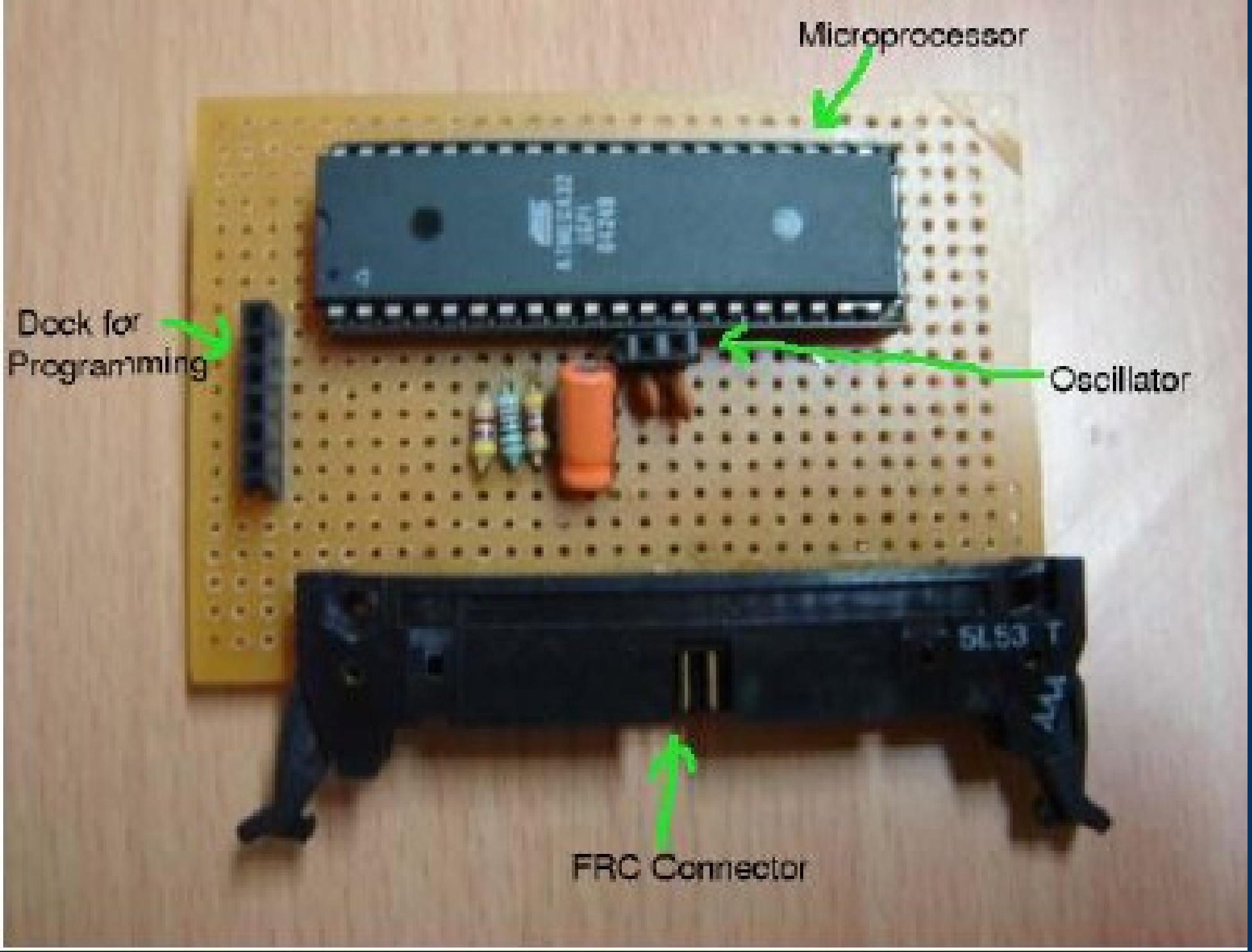
Component Name	Code Size (bytes)	Data Size (bytes)
Multihop router	88	0
AM_dispatch	40	0
AM_temperature	78	32
AM_light	146	8
AM	356	40
Packet	334	40
RADIO_byte	810	8
RFM	310	1
Photo	84	1
Temperature	64	1
UART	196	1
UART_packet	314	40
I2C_bus	198	8
Procesor_init	172	30
TinyOS scheduler	178	16
C runtime	82	0
Total	3450	226

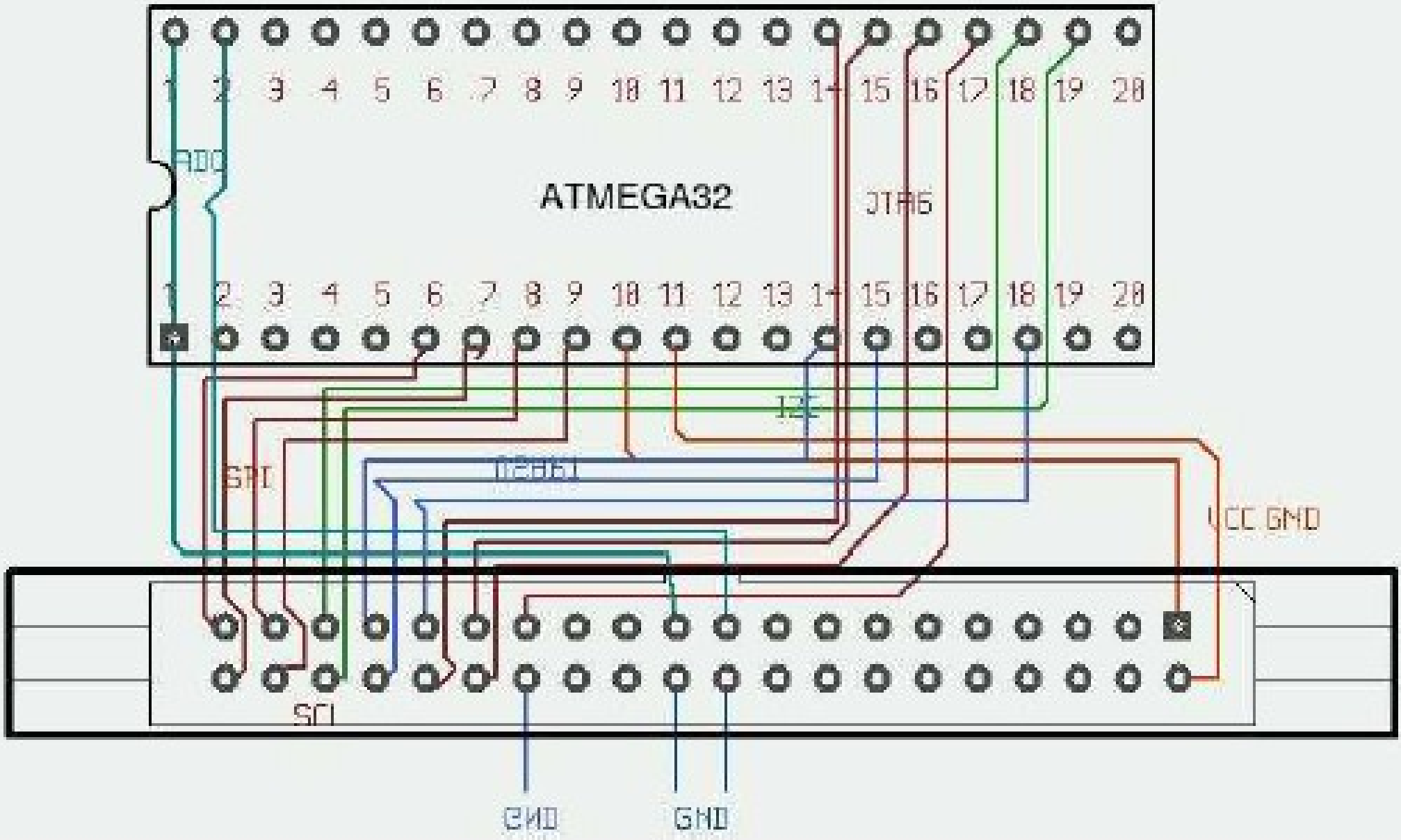
Table 2: Code and data size breakdown for our complete system. Only the processor init, the TinyOS scheduler, and the C runtime are required for every application, the other components are included as needed.

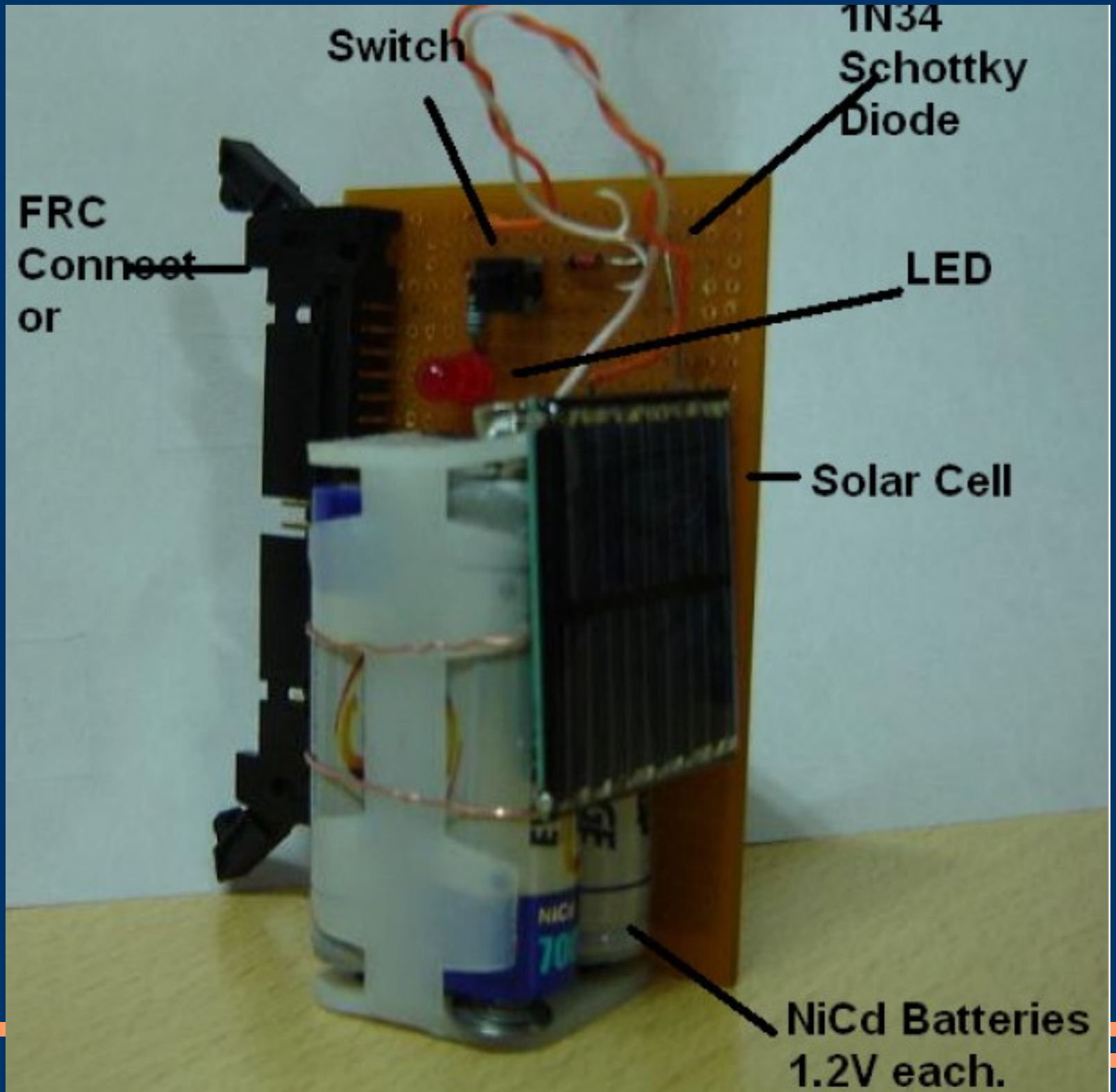
Development at DA-IICT

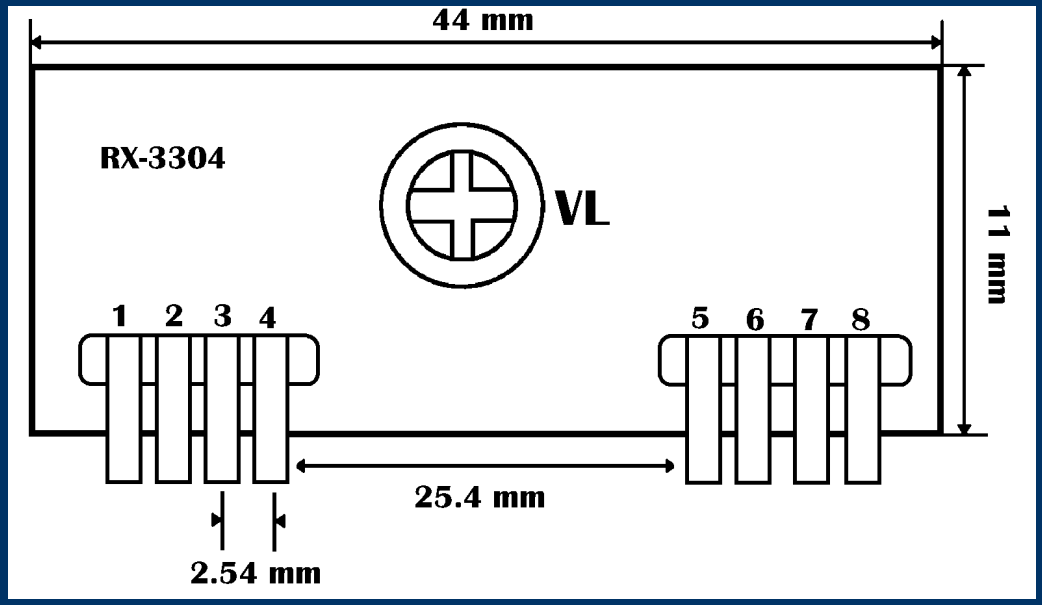
CENSE : A MODULAR SENSOR NETWORK TESTBED OF DA-IICT


Sensor
Processing
Bus
Communication
Power


Microprocessor
Dock for Programming
Oscillator
FRC Connector

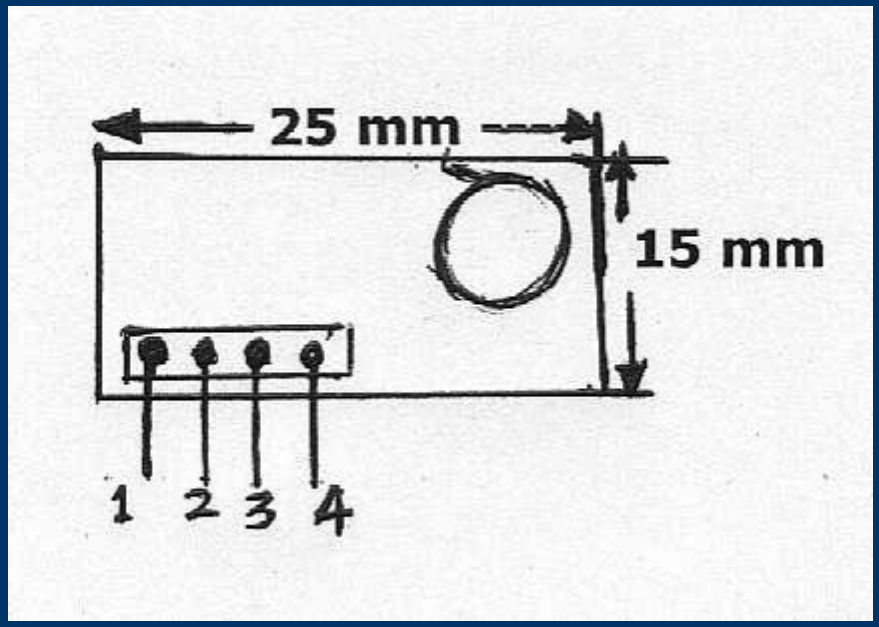

ATMEGA32
JTAG
I2C
SPI
PWM1
VCC GND
SCL
GND
GND

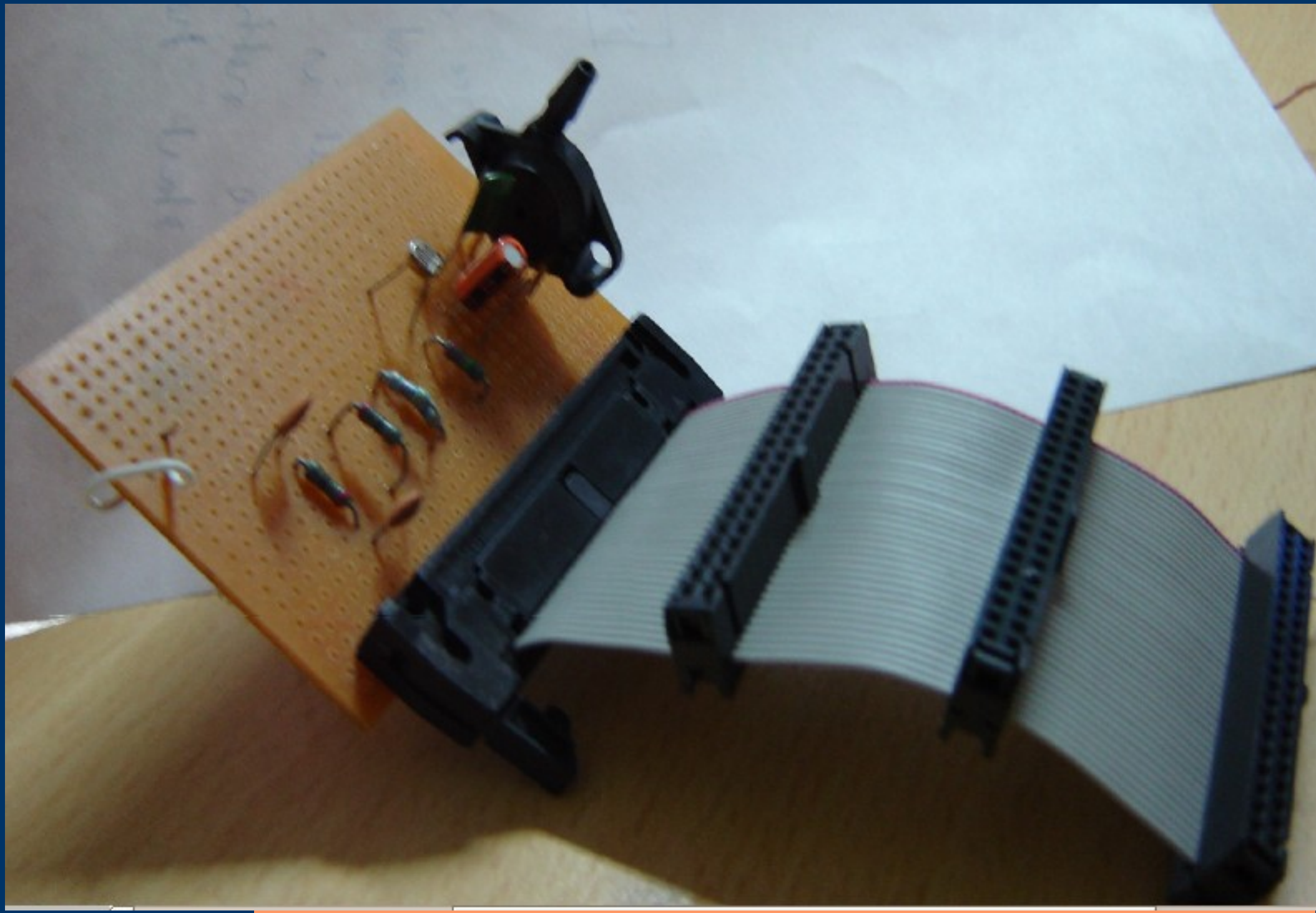

Switch
1N34
Schottky
Diode
FRC
Connector
LED
Solar Cell
NiCd Batteries
1.2V each.

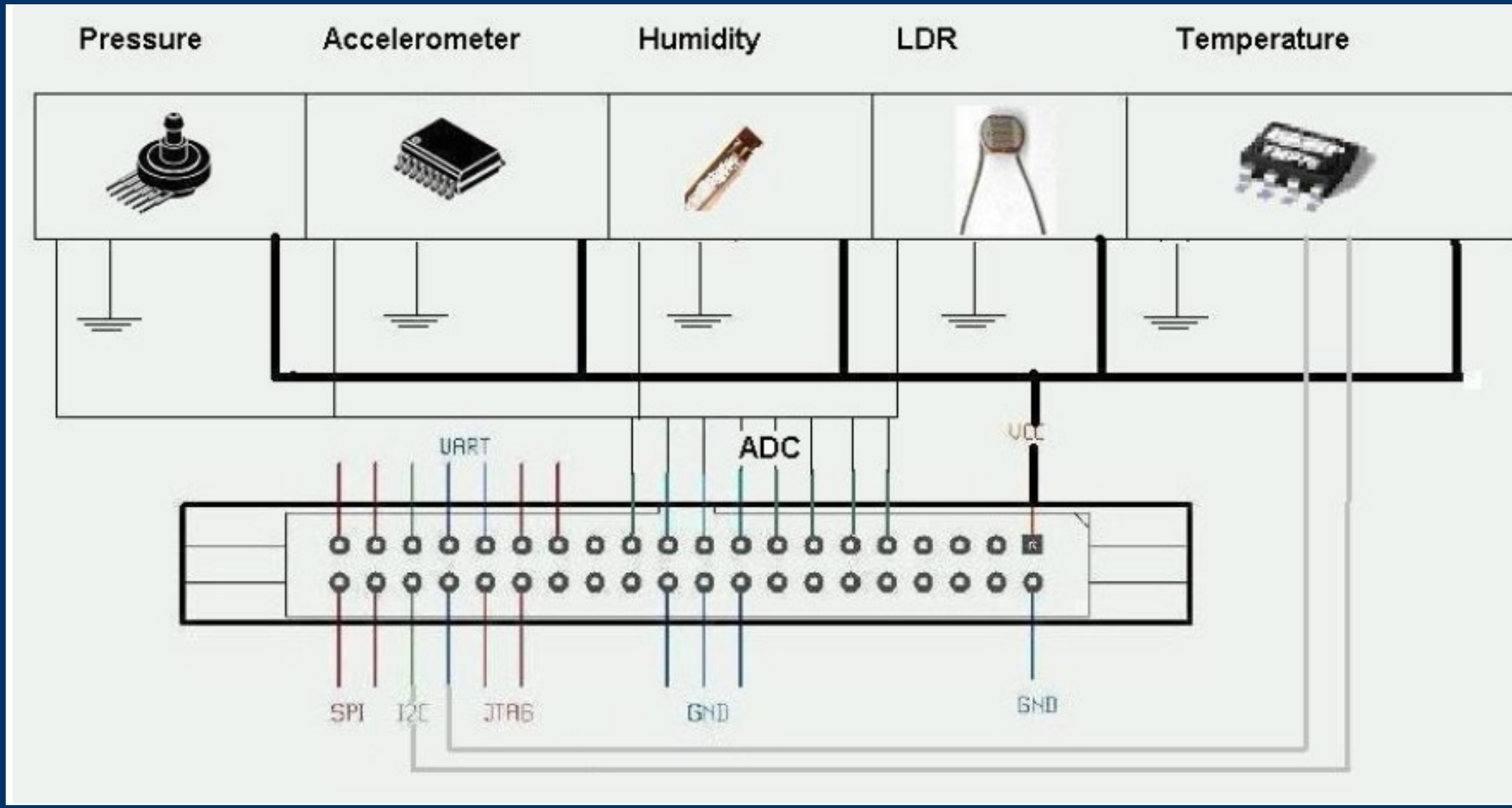


Futuretechniks

Rx/Tx 433 MHz






Pressure
Accelerometer
Humidity
LDR
Temperature
UART
ADC
VCC
SPI
I2C
JTAG
GND
GND

Summary

- Sensor Networks applications are becoming possible in a wide variety of situations
- Represents an excellent example of networked embedded device with tremendous resource constraints

Thank you!!!