Basic Anatomy

- Node = Processor + Sensors/Data Acquisition Boards

- Network = Node* [+ Gateway]

Source: Crossbow Inc
**Anatomy: Processor Board**
- Small, energy-efficient processor
- Small amount of memory
- Radio for wireless communication
- Small amount of flash memory for storage
- Wide range of options
  - Mica, Mica2, MicaZ, Telos, Tmote Sky …

**Anatomy: Sensor Board**
- Light
- Humidity
- Barometric pressure
- GPS
- Accelerometer
- Magnetometer
- …
**Gateway Nodes**

- Just the network alone is not enough
- Gateway nodes interface with the “Internet world”
- More capable: ethernet, longer radio range, powered

**MicaZ (Crossbow)**

- **Microprocessor**: Atmel ATmega128L
  - 7.3728 MHz clock
  - 128 kB of Flash for program memory
  - 4 kB of SRAM for data and variables
  - 2 UARTs (Universal Asynchronous Receive and Transmit)
  - Serial Port Interface (SPI) bus
  - Dedicated hardware I2C bus
- **Radio**: Chipcon’s CC2420
- **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 programmable LEDs
- JTAG port
- **Powered** by two AA batteries
  - 1850 mAh capacity
Tmote Sky (Moteiv)

- Microprocessor: TI MSP430
  - 8 MHz clock
  - 48 kB of Flash for program memory
  - 10 kB of SRAM for data and variables
  - USB interface
  - Integrated antenna
- Radio: Chipcon's CC2420
- External flash memory: 1MB
- User interface: 3 programmable LEDs
- JTAG-capable
- Powered by two AA batteries
  - 1850 mAh capacity

Source: Moteiv
Tmote Sky (back)

Intelligently manages energy for perpetual operation without human intervention or servicing.

Implementation uses a two-stage storage system consisting of supercapacitors (primary buffer) and a lithium rechargeable battery (secondary buffer).

Prometheus: Perpetual Self-Sustaining Telos Mote

- Intelligently manages energy for perpetual operation without human intervention or servicing.
- Implementation uses a two-stage storage system consisting of supercapacitors (primary buffer) and a lithium rechargeable battery (secondary buffer).

<table>
<thead>
<tr>
<th>Duty Cycle</th>
<th>Required Light</th>
<th>Life Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>3%</td>
<td>5hrs / month</td>
<td>43yrs</td>
</tr>
<tr>
<td>10%</td>
<td>5hrs / 4days</td>
<td>4yrs</td>
</tr>
<tr>
<td>100%</td>
<td>10hrs / 1day</td>
<td>1yrs</td>
</tr>
</tbody>
</table>

**eXtreme Scale Mote**

- Platform: Mica2/CC1000
- Sensors & Actuators:
  - Magnetometer
  - Microphone
  - four passive infrared
  - Photocell
  - Sounder
  - Feedback LEDs

Source: Exscal group, OSU
**Unique Advantages**

- Sensing accuracy – dense deployment
- Coverage – large number of nodes
- Fault tolerance – redundant nodes
- Minimal human interaction – self-organizing
- Operability in harsh environments
- Enables a whole range of applications that were previously not feasible
**Unique Constraints**

- Continuously varying network topologies
- Resource optimization
- Limitations
  - power, memory, processing power, life-time
- Failure-prone
  - Individual nodes are cheap, so dispensable
- Dense network => Network congestion => lost packets
- Security – everyone around is anonymous

**Characteristics of Network Sensors**

- Small physical size and low power consumption
- Concurrency-intensive operation
  - Multiple flows, not wait-command-respond
- Limited Physical Parallelism and Controller Hierarchy
  - Primitive direct-to-device interface
  - Asynchronous and synchronous devices
- Diversity in Design and Usage
- Application-specific, not general purpose
- Huge device variation
- Efficient modularity
- Migration across HW/SW boundary
- Robust Operation
  - Numerous, unattended, critical
  - Narrow interfaces