Wireless Sensor Networks: Platforms and Applications
Introduction

- A new generation of massive-scale sensor networks suitable for a range of commercial and military applications is brought forth by
  - Advances in MEMS (micro-electromechanical system technology)
  - Embedded microprocessors
Introduction

- Tiny, cheap sensors may deploy onto roads, walls, or machines, creating a digital skin that senses a variety of physical phenomena of interest
  - Monitor pedestrian or vehicular traffic and intelligent transportation grids in human-aware environments
  - Report wildlife habitat conditions for environmental conservation
  - Detect forest fires to aid rapid emergency responses
  - Track job flows and supply chains in smart factories
Wireless Sensor Networks
Applications

- **Wildlife Monitor**
  - Observe wildlife
  - Wildlife habitat monitor
  - Plant accretion monitor
  - Ecosystem record

- **Dangerous Environment Monitor**
  - Environment information
  - Volcano detection
  - Danger detection
Applications

- Traffic Monitor (VANET)
  - Traffic jam detection
  - Parking space information
  - Shopping information
  - Vehicle tracking

- Building Monitor
  - Fire detection
  - Poison gas detection
  - Guide to exit
  - Safety assurance
  - E-home
Applications

- Health Monitor
  - Heartbeat
  - Blood pressure
  - Body temperature
  - Behavior of patient
Research Issues in WSNs

- Localization and Tracking
- Time Synchronization
- Routing Protocols
- Topology Control
- Coverage Problems
- Databases, Platforms, and Tools
Sensor Node Platforms

- Mote modules were developed by U.C. Berkeley
  - **MICA2:**
    - 8-bit AVR microcontroller (4 KB SRAM + 128 KB Flash)
    - RF: CC1000 (data rate: 38.4kbits/s)
  - **MICAz (Zigbee):**
    - 8-bit AVR microcontroller
    - RF: CC2420 (data rate: 250kbits/s)
  - **Tmote Sky/TelosB (Zigbee):**
    - 16-bit MSP430 microcontroller (10 KB RAM + 48KB Flash) + 1MB Flash
    - RF: CC2420 (data rate: 250kbits/s)
  - **OS: TinyOS**
    - NesC
Sensor Node Platforms

- Octopus modules were developed by NTHU and NCU
  - **Octopus X:**
    - CC2430 (or CC2431): 8-bit 8051 + CC2420
    - 8 KB RAM + 128 KB Flash
  - **Octopus I:** Compatible with MICAz
  - **Octopus II:** Compatible with Tmote Sky
Octopus X Platforms (Simple Node)

Octopus X-A (28mm*28mm)

Octopus X-B (28mm*28mm)

Octopus X-C (57mm*31mm)

USB Dongle
Simple Node Kernel – CC2431

- 8051 MCU core
- 128KB in-system programmable flash, 8KB RAM, 4KB with data retention
- Powerful DMA
- One IEEE 802.15.4 MAC timer
- 2.4GHz IEEE 802.15.4 compliant RF
- RX (27mA), TX (27mA)
- 0.5uA current consumption in power down mode
- CSMA/CA hardware support
- 12-bit ADC with up to eight inputs and configuration resolution
- Two USARTs with support for several serial protocols
Octopus X-A Features

Size: 28mm*28mm

- MCU (CC2431)
- Directional antenna
- RF range ~ 100m
- External crystal (32MHz+32.768KHz)
- 30-Pin expansion connector
- Polymer battery (3.7V 300mAh)

Height: 7mm
Octopus X-B Features

Size: 28mm*28mm

- MCU (CC2431)
- Omnidirectional antenna
- RF range ~150m
- External crystal (32MHz + 32.768KHz)
- 30-Pin expansion connector
- Polymer battery (3.7V 300mAh)

Polymer battery

CC2431(MCU+RF)

Omnidirectional Antenna

30-Pin expansion connector
Octopus X-C Features

- MCU (CC2431)
- Directional & Omnidirectional antenna
- Humidity & Temperature sensor
- External flash memory (2 MB)
- Micro SD socket (up to 8 GB)
- USB Interface
- Battery: 2 x AA (3.3 V 2700 mAh)

Size: 57mm*31mm
Octopus X-USB Dongle

- Octopus X-USB dongle provides an easy-to-use USB protocol for programming, debugging, and data collections.
Octopus X-Sensor Boards

Size: 28mm*18mm

Temperature sensor

Back of the Octopus X-sensor board

Sensor board (Gyroscope+ Three axis accelerometer )

Front of the Octopus X-sensor board

Compass
Summary of Octopus X

- Octopus X can use Zigbee Stack for programming
- Octopus X is of 2-Layer design to reduce production cost
- Octopus X can be not only programmed from USB interface but also TI programming board.
- RF range of Octopus X is up to 150 m
- Expansion connector design on Octopus X provides a user interface for sensor boards and dock
Octopus II Platforms (Super Node)

Super node (65mm*31mm)

Sensor board (50mm*31mm)

Super node Block Diagram
Super Node Kernel – MSP430

16-bit MSP430 microcontroller core @8MHz
{48KB in-system programmable flash
10KB RAM
ADC 12-Bit 8 Channels}
Octopus II-A Features

**Size:** 65mm*31mm

- **MCU (MSP430F1611)**
  - Flash Memory (48KB+256B)
  - RAM (10KB)
  - External Flash (1MB)
  - Five Power-Saving Modes

- **Radio (CC2420)**
  - 2.4GHz IEEE 802.15.4 compliant RF
  - Data rate (250Kbps)
  - RX (18.8mA), TX (17.4mA)
  - Programmable output power
  - RF range ~250m

- **Sensors**
  - Humidity & Temperature sensor
  - Light sensors

- **50-Pin expansion connector**
- **External DC power connector**
Octopus II-B Features

- CC2420 with external power amplifier
- RF range ~ 450m
- Maximum output power: ~10dBm
- Compliance with IEEE 802.15.4 (ZigBee)
- Battery: 2 x AA (3.3 V 2700 mAh)

Size: 80mm*31mm
Octopus II-Sensor Board

- **Sensors**
  - Humidity & Temperature sensor
  - Light sensors
  - Gyroscope
    - Integrated X- and Y- axis gyro
    - Three axis accelerometer
      - Selectable sensitivity (1.5g/2g/4g/6g)
      - Low current consumption (600uA)
      - Sleep mode (3uA)
      - Low voltage operation (2.2V-3.6V)
      - High sensitivity (800mV/g @ 1.5g)

- **Size**: 50mm*31mm
Summary of Octopus II

- Octopus II is fully compatible with Tmote Sky and can execute TinyOS applications
- Octopus II is of 2-Layer design to reduce production cost
- Octopus II can be programmed from USB interface
- Octopus II has two kinds of antennas, SMA type and inverted F type
- RF range of Octopus II is up to 500 m
- Expansion connector design on Octopus II provides a user interface for sensor boards and dock
Summary of Octopus II

- CC2420 RF Chip – compliant with IEEE 802.15.4 low power protocol
- MSP430 microcontroller – the most power saving micro-controller
- Expandable flash memory – 1 Mbytes
- External oscillator – support accurate timer
- Fully support TinyOS (an open source embedded system widely used in the world)
## Comparison of Octopus II and Tmote Sky

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<thead>
<tr>
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<th>Octopus II</th>
<th>Tmote Sky</th>
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<tr>
<td>PCB</td>
<td>雙層板</td>
<td>四層板</td>
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<tr>
<td>免抗干擾金屬蓋</td>
<td>需抗干擾金屬蓋</td>
<td></td>
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<tr>
<td>外接50-pin腳位</td>
<td>外接16-pin隻腳位</td>
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<tr>
<td>無Interface IC即可燒錄程式</td>
<td>需配置Interface IC以燒錄程式</td>
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Comparison of Octopus II and Tmote Sky

- **接收訊號強度RSSI比較**
  - 有放大電路之Octopus II具有最佳的RSSI值，無放大電路之Octopus II以雙層板之設計，其RSSI值即逼近四層板設計之Tmote。

![Graph showing RSSI comparison between Octopus II and Tmote Sky](image-url)
Wireless Sensor Network Testbed

- 模擬上的限制
  - 硬體的時序(Timing)和中斷(Interrupts)
  - 環境影響與即時事件
  - 難以模擬MAC層
  - 難以估計Power consumption

- 實驗上的資源問題
  - 龐大數量的實驗
  - 異質性的實驗

- 由於有上述兩種主要的問題，因此需使用真實的實驗平台來實驗
無線感測器測試平台-無線感測器之部署位置圖

- National Central University
  - Engineering Building 5, 3rd floor
無線感測器測試平台
無線感測器之部署位置圖

- National Tsing Hua University
  - EECS Building, 7th floor
無線感測器測試平台-3-Tier式的系統架構

3-Tier Hardware Infrastructure
結合自走車巡邏與定點監視器之遠端監控系統

- 設計與實作出利用無線感測器、智慧型自走車與嵌入式作業系統，並結合智慧型視訊監控之系統，提供遠端監控之功能
- 目的應用於居家保全與即時監控
應用場景
無線導航智慧型機械人 Pioneer 3DX

- 6具聲納感測器
- Wireless及TCP/IP架構
- 完整高階C/C++程式設計環境，可用在Linux/Win32 OS
- 可擴充各種感測器/視訊CCD/GPS/電子羅盤等
適用於復健運動之生理資訊追蹤及肢體互動系統

目的
• 復健的病患對例行性的復健練習動作有所倦怠
• 復健的病患通常會無法正確的執行復健動作

解決方法
• 結合各種感測器，利用無線感測網路開發一套可以輔助復健病患，和提供病患自我復健資訊給醫療人員的互動式肢體感測系統系統
系統設計

無線感測網路動作資料蒐集系統

- 利用微型化無線感測器 (sensor node) 蒐集動作資料，病患動作執行無負擔
- 高取樣頻率之無線感測網路，提高動作還原之正確性
復健醫師專業診斷

應用情境示範

情境：爬樓梯
動作：訓練重心往前並跨步100次
右腳上升正確次數：86次
左腳上升正確次數：15次
腳部最大彎曲角度
左腳：10度 右腳：35度
步態之腳底承受壓力圖表
左腳 右腳

病患在家進行自主復健

復健遊

ECO Sensor

Internet

Remote assisted physical rehabilitation

復健練習時間:2008/02/01
情境:爬樓梯
動作：訓練重心往前並跨步100次
右腳上升正確次數：86次
左腳上升正確次數：15次
腳部最大彎曲角度
左腳：10度 右腳：35度
步態之腳底承受壓力圖表
左腳 右腳

測驗總積分：
右腳上升:正確 左腳上升:不正確

60分

復健遊戲
姿勢辨認

- Game-based rehabilitation