

Wireless Sensor Networks: Platforms and Applications

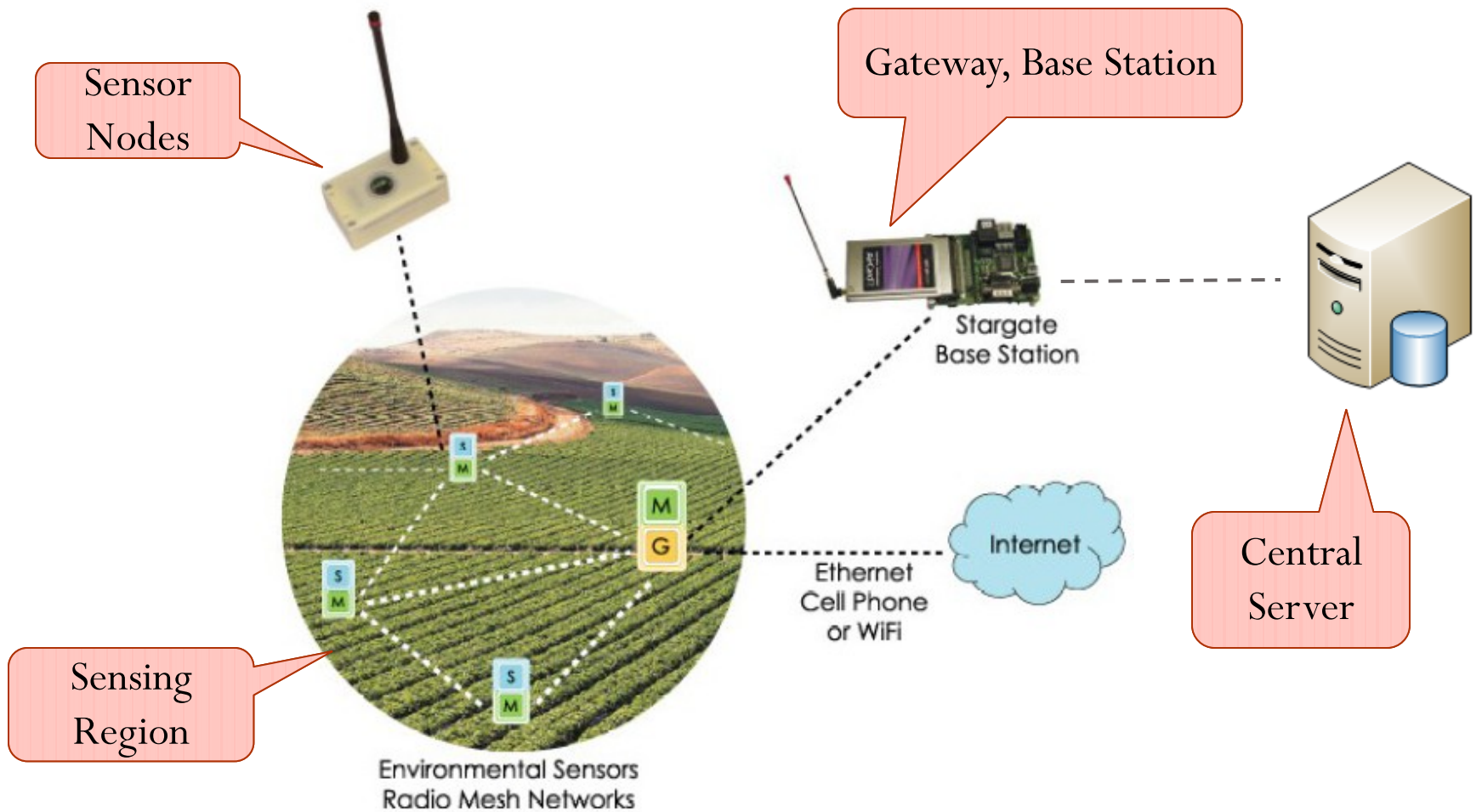
Introduction

- 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

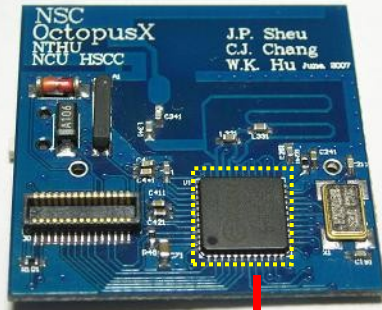


Sensor Node Platforms

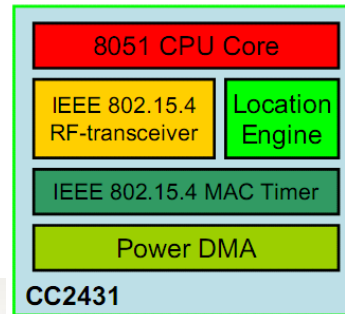
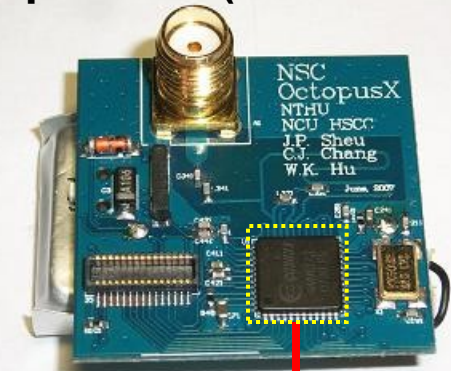
- **Octopus modules were developed by NTHU and NCU**
 - **Octopus X:**
 - CC2430 (or CC2431): 8-bit 8051 + CC2420
 - 8 KB RAM + 128 KB Flash
 - **Octopus I: Compatible with MICAz**
 - **Octopus II: Compatible with Tmote Sky**

Octopus X Platforms (Simple Node)

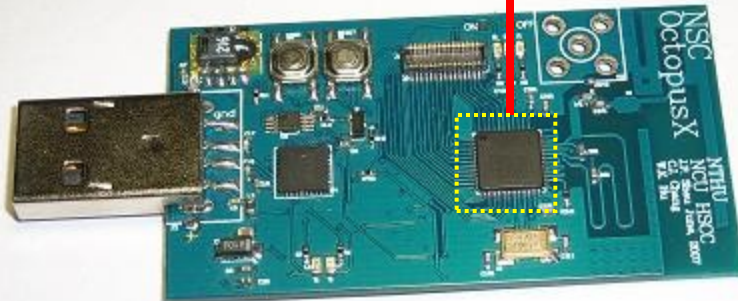
Octopus X-A (28mm*28mm)



Octopus X-B (28mm*28mm)



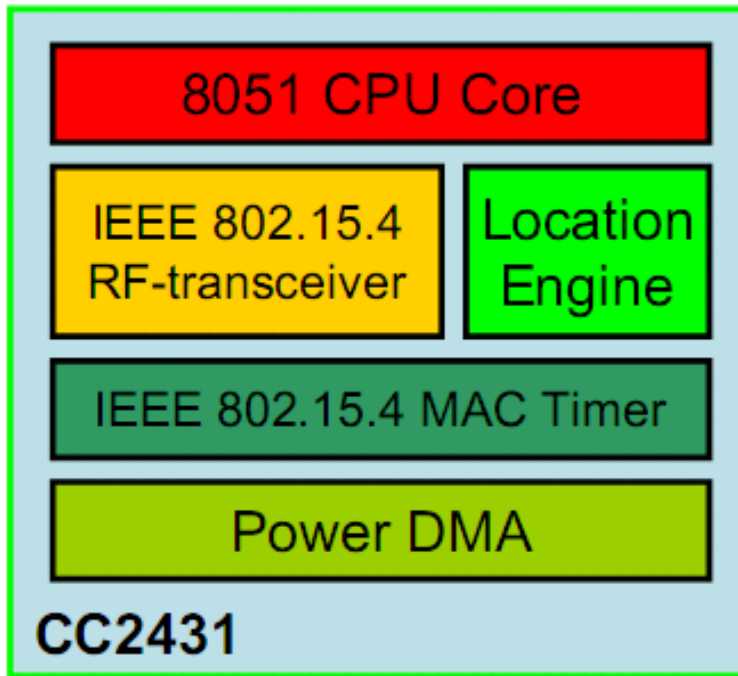
Octopus X-C (57mm*31mm)



USB Dongle



Simple Node Kernel – CC2431

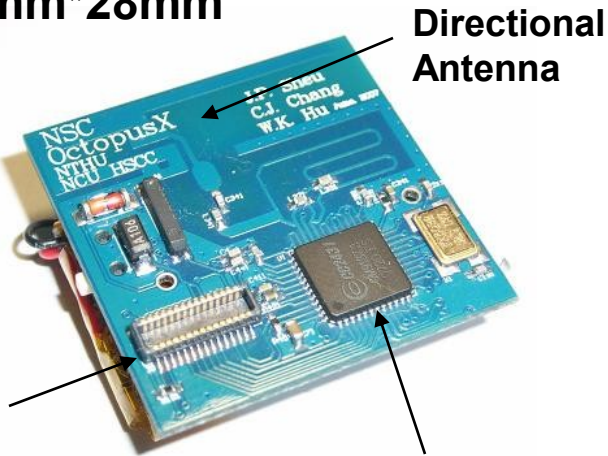


CC2431 Block diagram

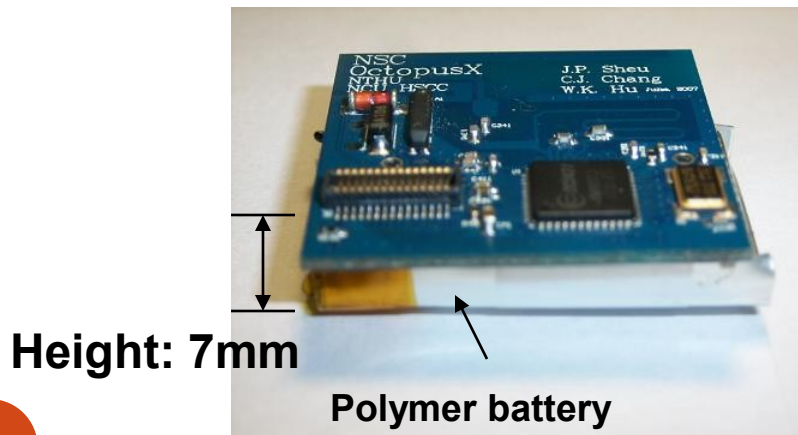
- 8051 MCU core
- 128KB in-system programmable flash, 8KB RAM, 4KB with data retention
- Powerful DMA
- One IEEE 802.15.4 MAC timer
- 2.4GHz IEEE 802.15.4 compliant RF
- RX (27mA), TX (27mA)
- 0.5uA current consumption in power down mode
- CSMA/CA hardware support
- 12-bit ADC with up to eight inputs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

Octopus X-A Features

Size: 28mm*28mm

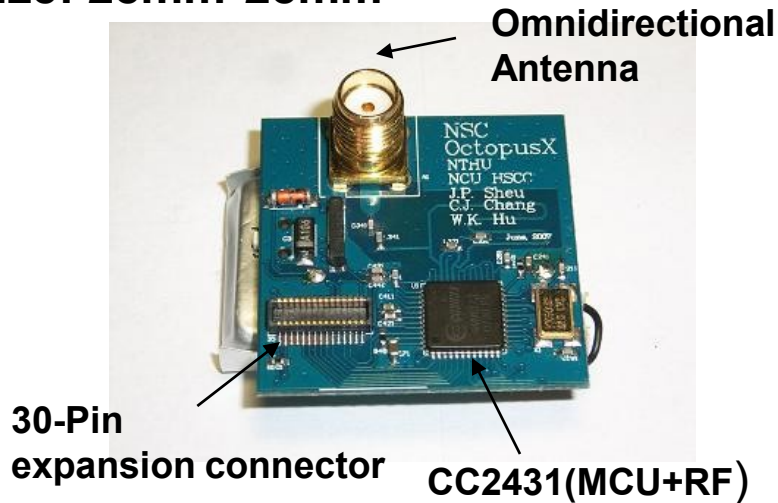


- MCU (CC2431)
- Directional antenna
- RF range ~ 100m
- External crystal (32MHz+32.768KHz)
- 30-Pin expansion connector
- Polymer batter (3.7V 300mAh)

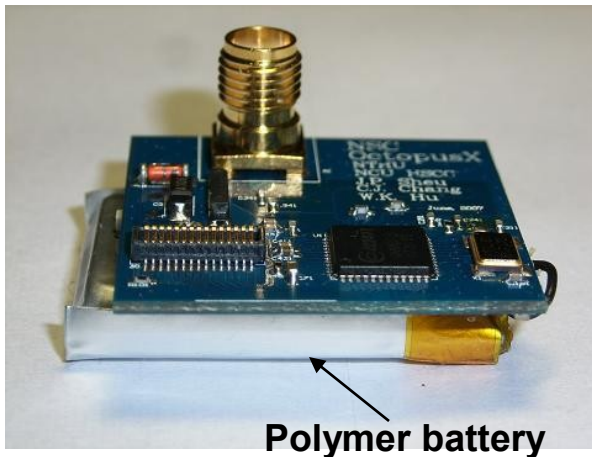


Octopus X-B Features

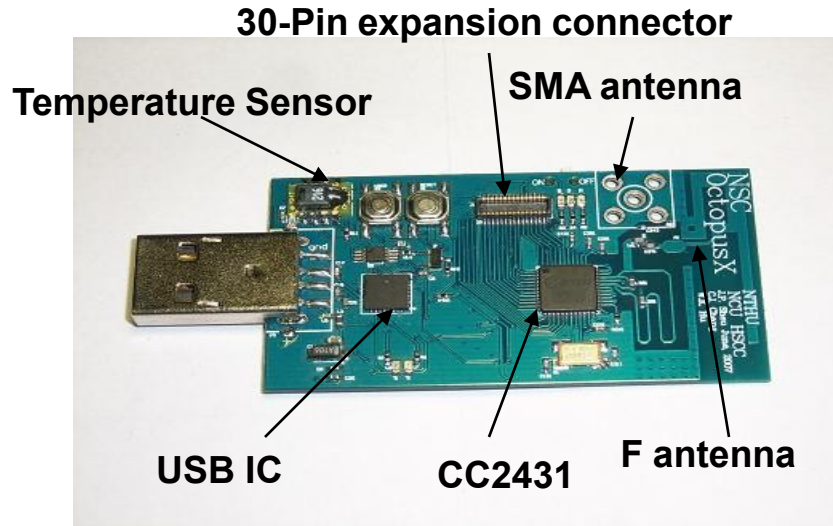
Size: 28mm*28mm



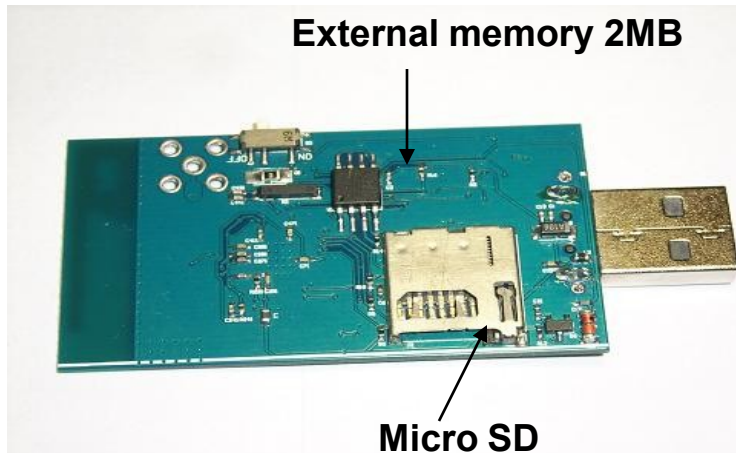
- MCU (CC2431)
- Omnidirectional antenna
- RF range ~150m
- External crystal (32MHz+32.768KHz)
- 30-Pin expansion connector
- Polymer battery (3.7V 300mAh)



Octopus X-C Features

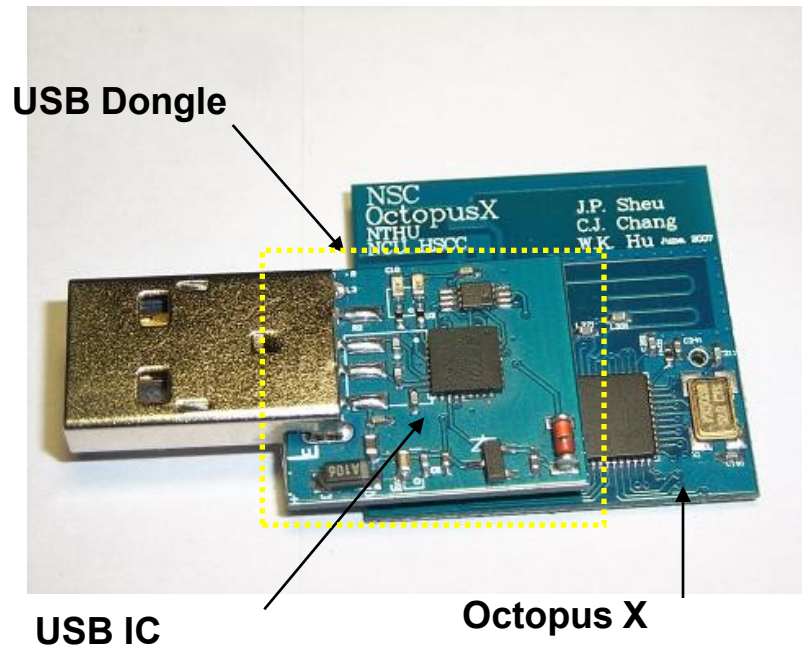


- MCU (CC2431)
- Directional & Omnidirectional antenna
- Humidity & Temperature sensor
- External flash memory (2 MB)
- Micro SD socket (up to 8 GB)
- USB Interface
- Battery: 2 x AA (3.3 V 2700 mAh)



Size: 57mm*31mm

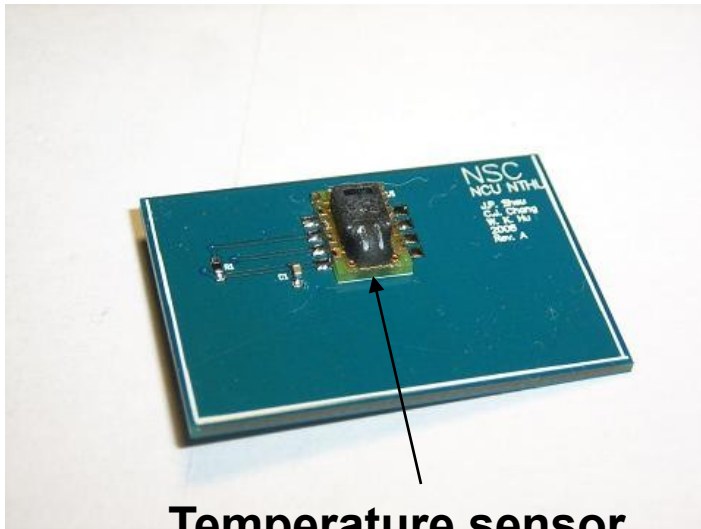
Octopus X-USB Dongle



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

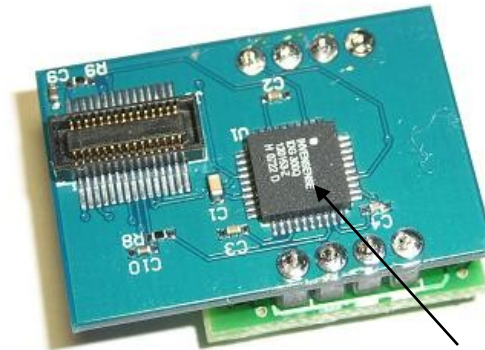
Octopus X-Sensor Boards

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



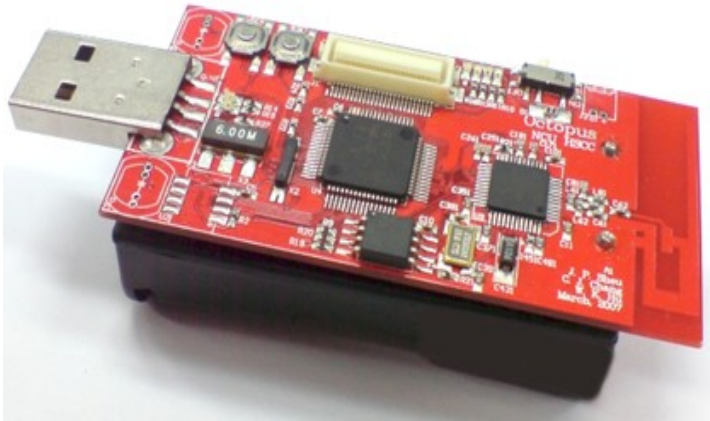
Compass

Summary of Octopus X

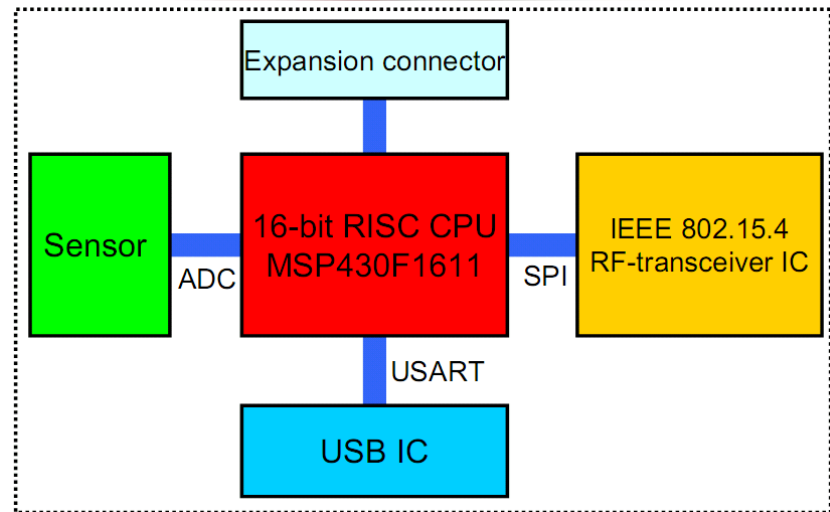
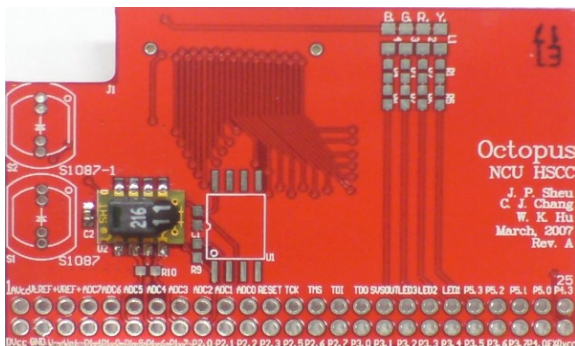
- Octopus X can use Zigbee Stack for programming
- Octopus X is of 2-Layer design to reduce production cost
- Octopus X can be not only programmed from USB interface but also TI programming board.
- RF range of Octopus X is up to 150 m
- Expansion connector design on Octopus X provides a user interface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

Octopus II Platforms (Super Node)

Super node (65mm*31mm)

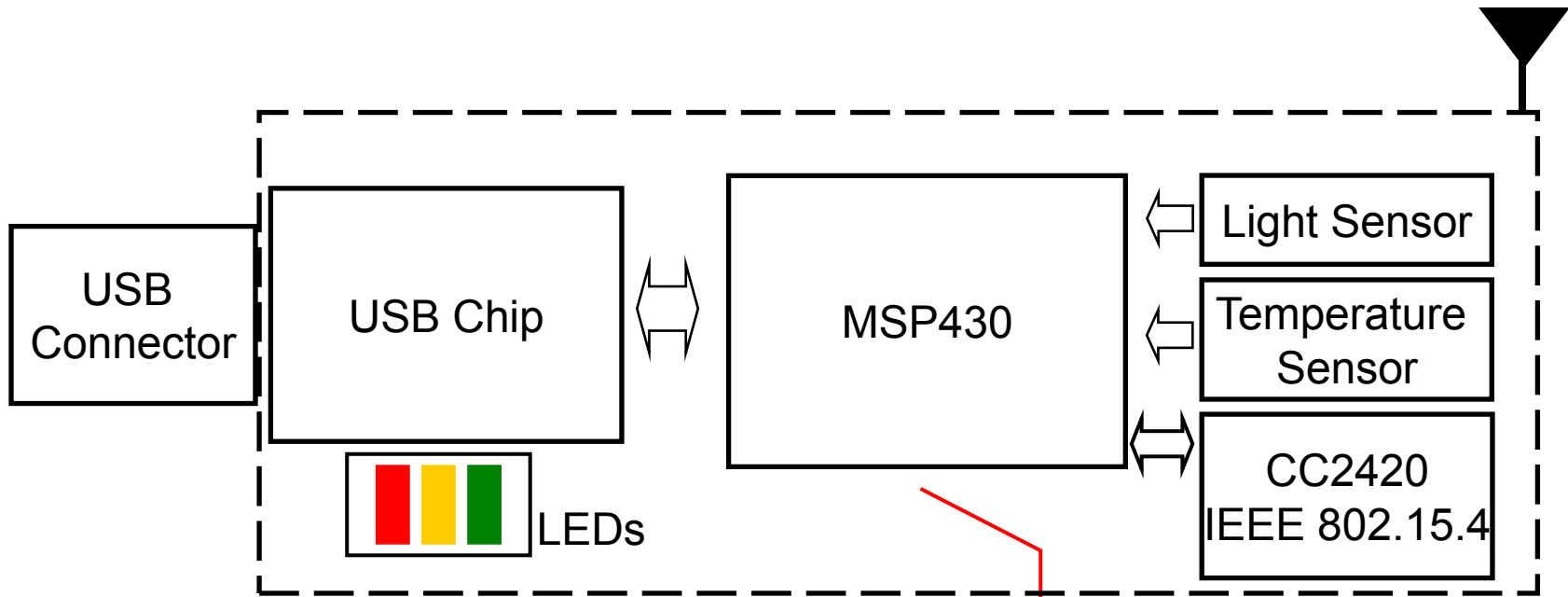


Sensor board (50mm*31mm)



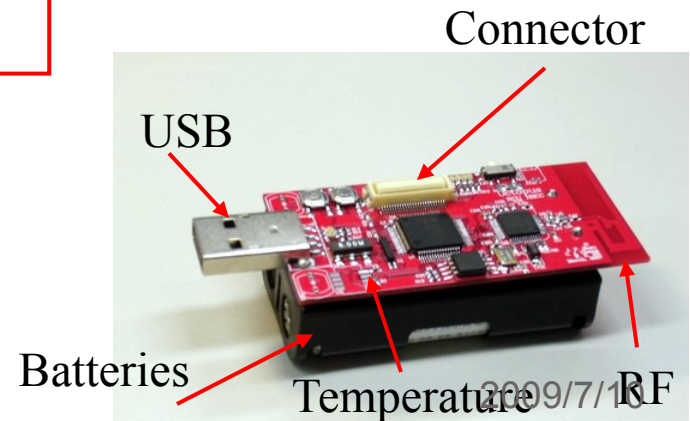
Super node Block Diagram

Super Node Kernel – MSP430



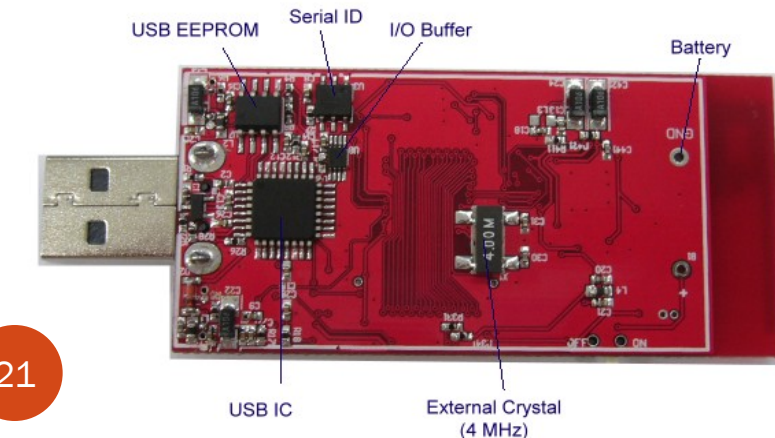
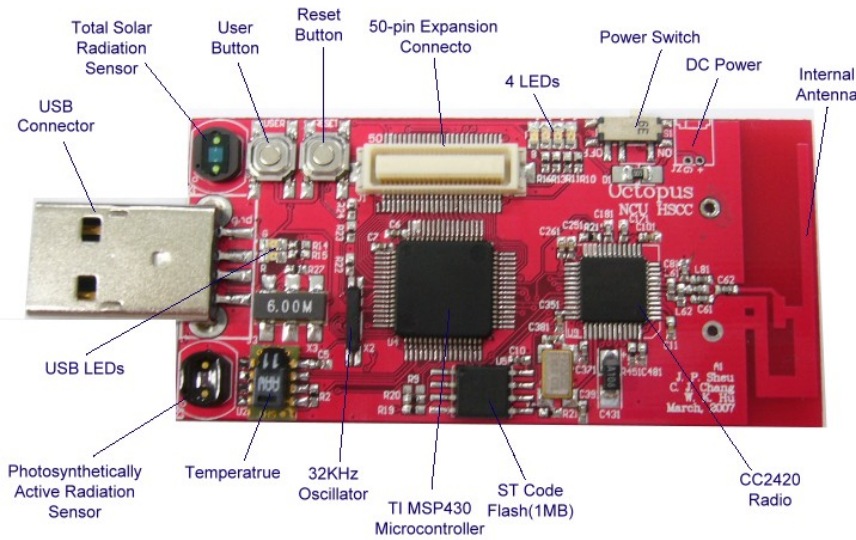
Size: 55*30 (mm)

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



Octopus II-A Features

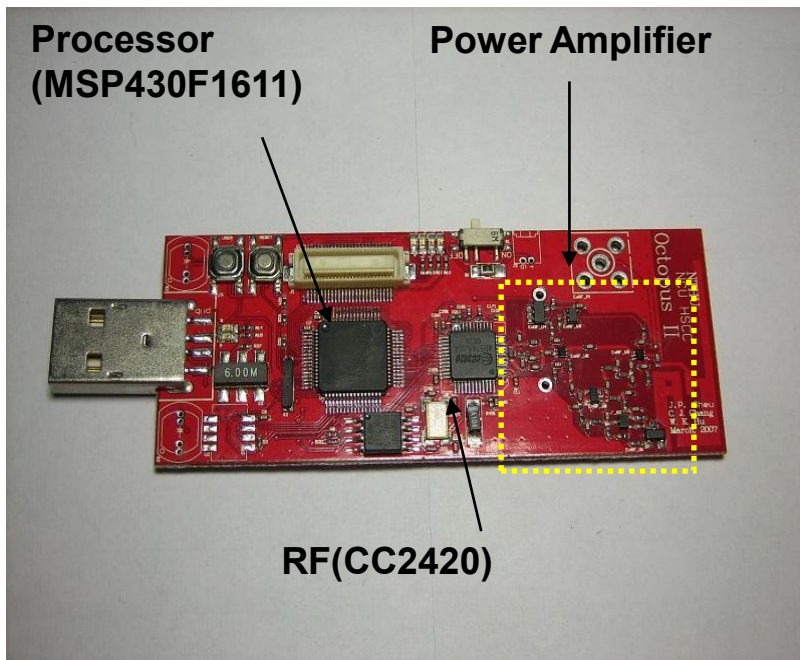
Size: 65mm*31mm



- **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

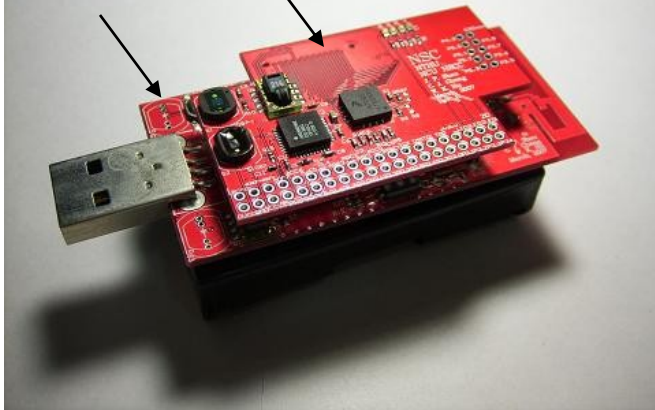
Size: 80mm*31mm



- 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)

Octopus II-Sensor Board

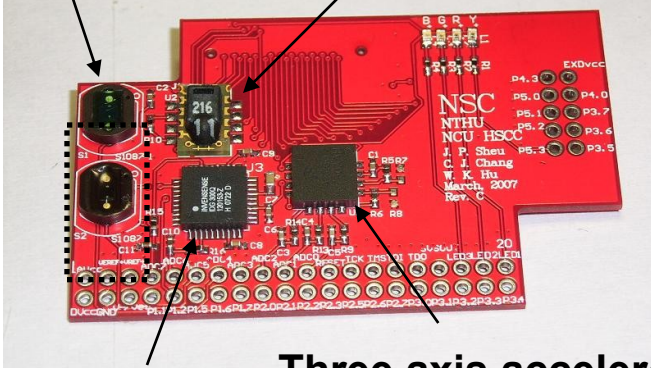
Octopus II Sensor board



■ 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)**

Light sensors Temperature sensor



Gyroscope

Three axis accelerometer

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)**

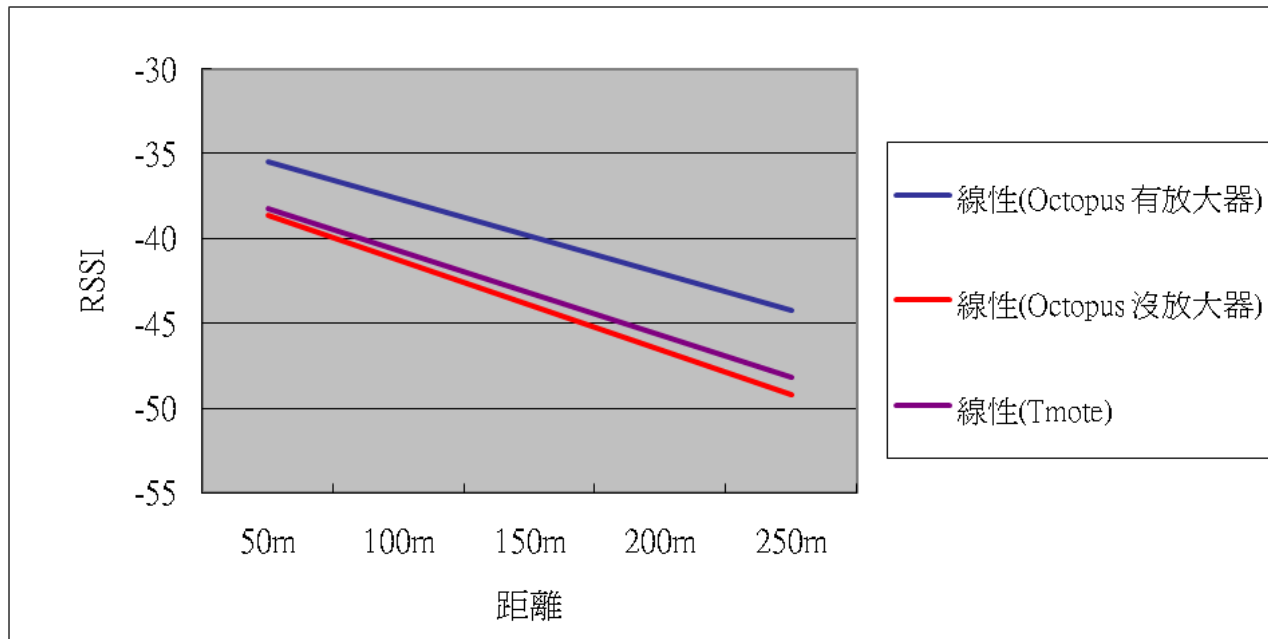
Comparison of Octopus II and Tmote Sky

Octopus II	Tmote Sky
PCB雙層板	PCB四層板
免抗干擾金屬蓋	需抗干擾金屬蓋
外接50-pin腳位	外接16-pin隻腳位
無Interface IC即可燒錄程式	需配置Interface IC以燒錄程式

Comparison of Octopus II and Tmote Sky

■ 接收訊號強度RSSI比較

- 有放大電路之OctopusII具有最佳的RSSI值，無放大電路之OctopusII以雙層板之設計，其RSSI值即逼近四層板設計之Tmote。



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

Wireless Sensor Network Testbed

<http://wsn.tw>



Heterogeneous
Wireless Sensor Networks Testbed



testbed.wsn.tw

Ver 1.1 Release

[Click to Login](#)

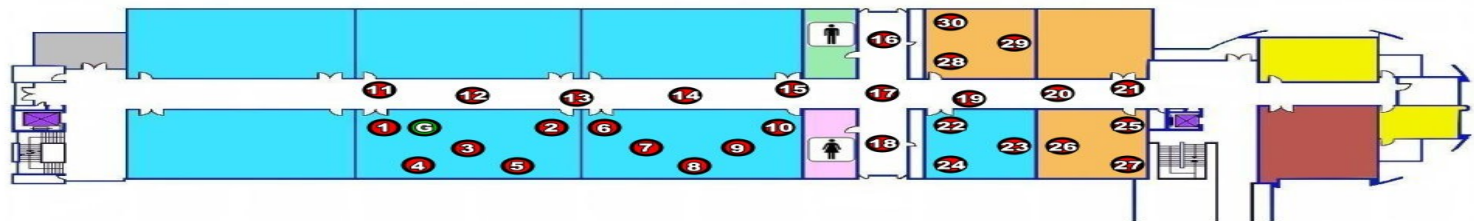
- Home
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 - Introduction
 - Hardware
 - Software
 - Map
 - Node Status
- Documents
 - Development Setup I
 - Development Setup II
 - Testbed Usage
- Information
 - References
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 - Q & A
 - E-letter

■ Announce

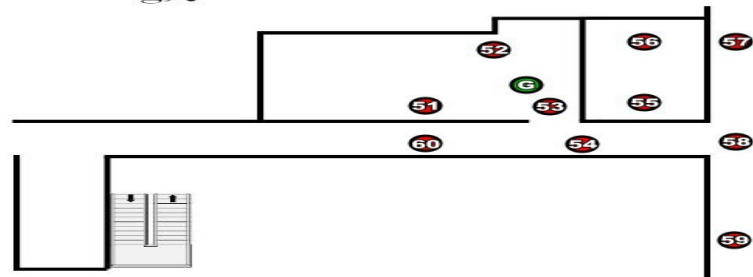
Title	[Date]
▶ Testbed uses and attention	[2008-05-13]
▶ Testbed 維護公告	[2008-04-25]
▶ Testbed 使用注意事項	[2008-04-22]

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National Central University Engineering Building 5, 3rd floor



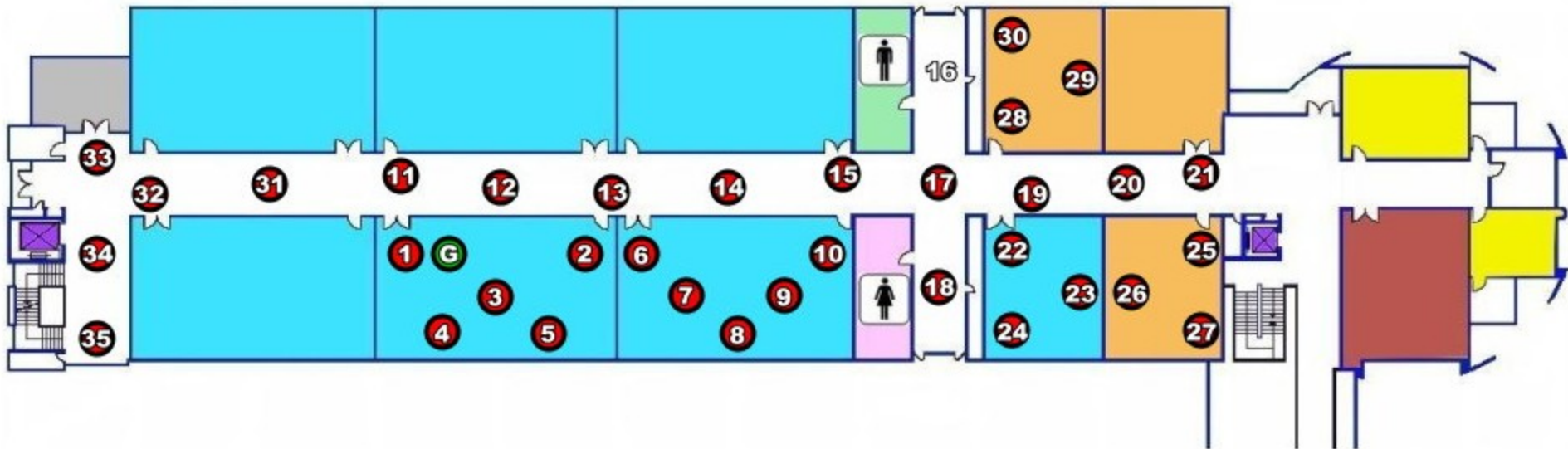
National Tsing Hua University EECS Building, 7th floor



無線感測器測試平台-

無線感測器之部署位置圖

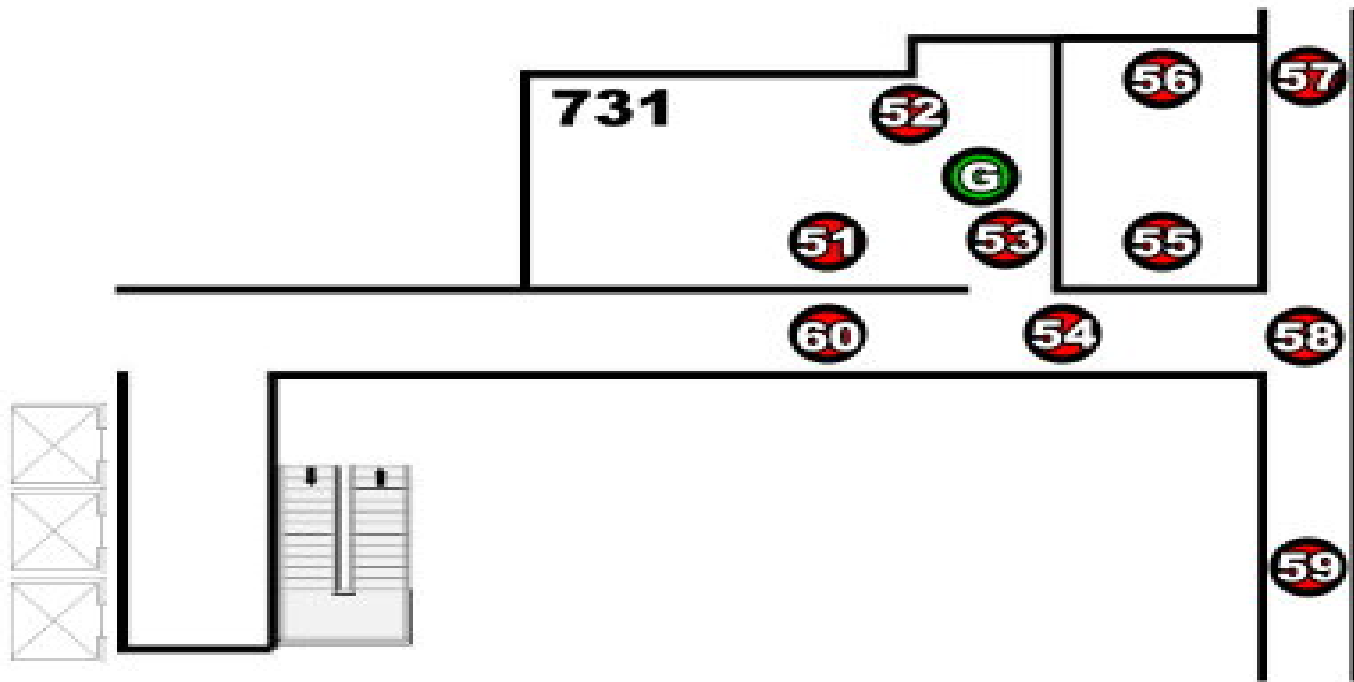
- National Central University
 - Engineering Building 5, 3rd floor



無線感測器測試平台-

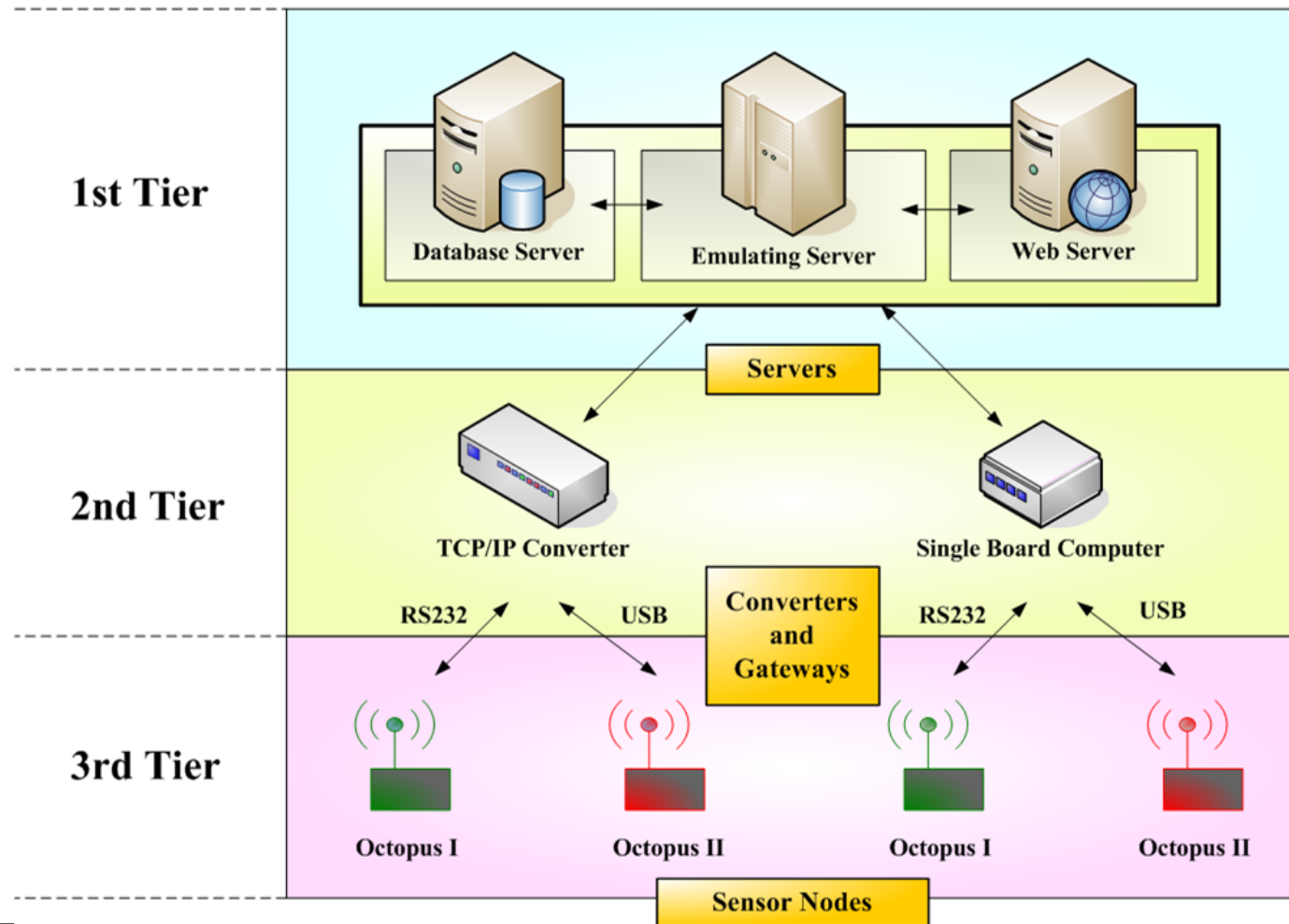
無線感測器之部署位置圖

- National Tsing Hua University
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無線感測器測試平台- 3-Tier式的系統架構

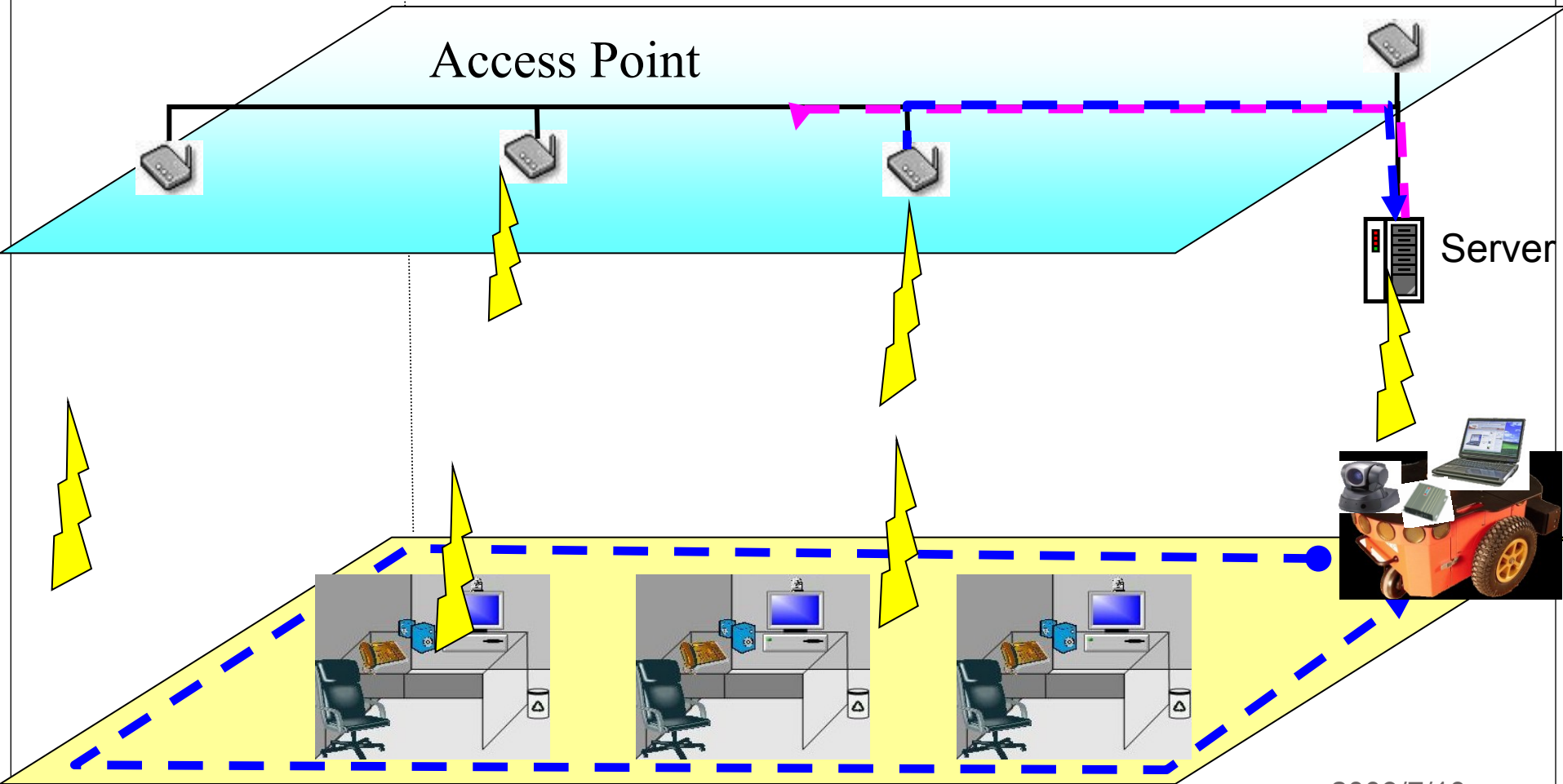
■ 3-Tier Hardware Infrastructure



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



2009/7/10

成果展示

- 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

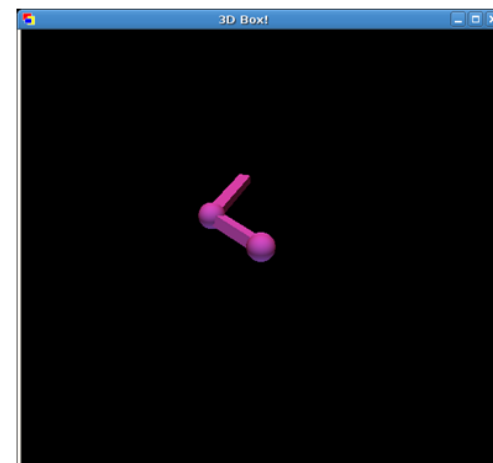
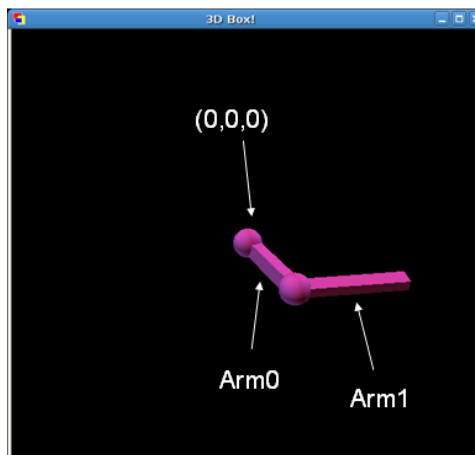
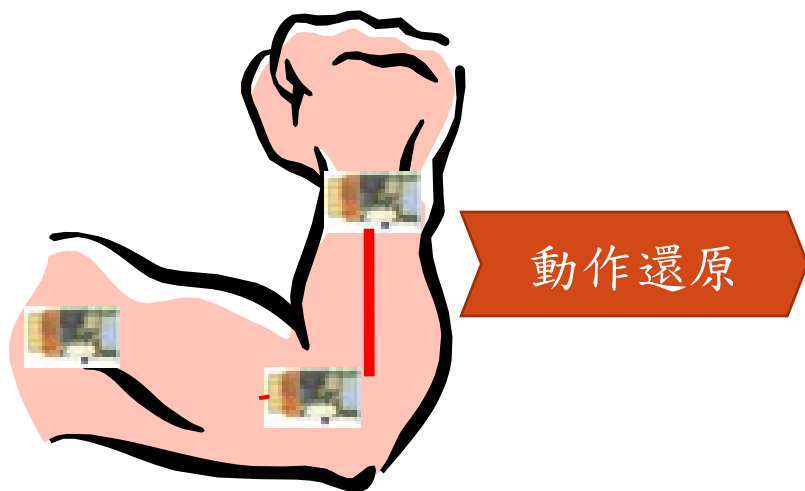
■ 解決方法

- 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



應用情境示範

病患在家進行自主復健

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

左腳上升正確次數:15次

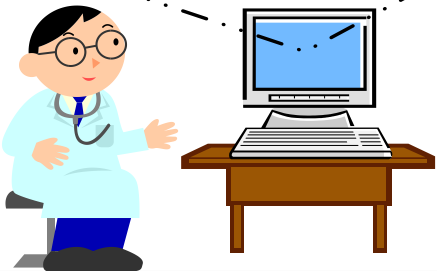
右腳上升正確次數:86次

腳部最大彎曲角度

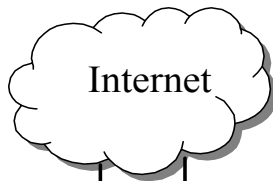
左腳:10度 右腳:35度

步態之腳底承受壓力圖表

左腳 右腳

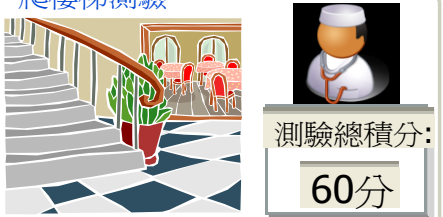


The doctor's workstation displays a computer monitor with a blue screen, a keyboard, and a mouse on a wooden desk. Dotted lines connect the workstation to the data panel above.



Self-physical-rehabilitation System

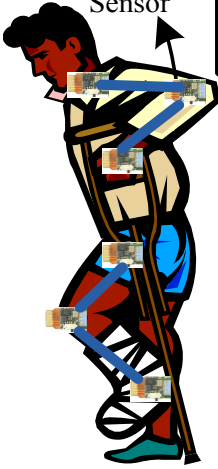
爬樓梯測驗



測驗總積分:
60分

右腳上升:正確 左腳上升:不正確

ECO Sensor



The patient is shown in profile, wearing a blue and red striped shirt and blue pants. An ECO Sensor is attached to their back, with a yellow lightning bolt indicating data transmission to a laptop on a table. The patient's legs are also equipped with sensors.

復健遊戲

復健醫師專業診斷

姿勢辨認

■ Game-based rehabilitation

