제 2 부 [특강]

발 표 (1)

Wireless Sensor Networks

- 강남대학교 퓨터미디어공학부 조 승 호 -

Wireless Sensor Networks

2007.6.28(Thu.)

강남대학교 컴퓨터미디어공학부

조 승 호

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Why Wireless Sensors Now?

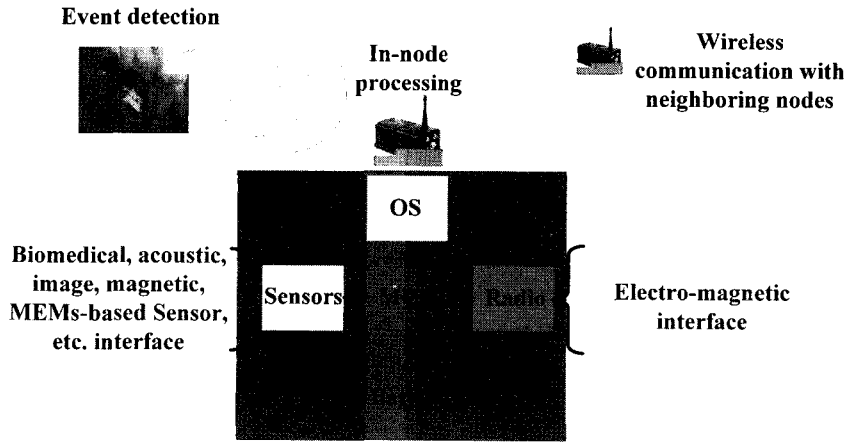
- Moore's Law is making sufficient CPU performance available with low power requirements in a small size.
- Research in Materials Science has resulted in novel sensing materials for many Chemical, Biological, and Physical sensing tasks.
- Transceivers for wireless devices are becoming smaller, less expensive, and less power hungry.
- Power source improvements in batteries, as well as passive power sources such as solar or vibration energy, are expanding application options.

Overview of a Sensor Node and Wireless Communications

Typical Sensor Node Features

- A sensor node has:
  - Sensing Material
    - **Physical** – Magnetic, Light, Sound
    - **Chemical** – CO, Chemical Weapons
    - **Biological** – Bacteria, Viruses, Proteins
  - Integrated Circuitry (VLSI)
    - A-to-D converter from sensor to circuitry
  - Packaging for environmental safety
  - Power Supply
    - **Passive** – Solar, Vibration
    - **Active** – Battery power, RF Inductance

Sensor Network Platform



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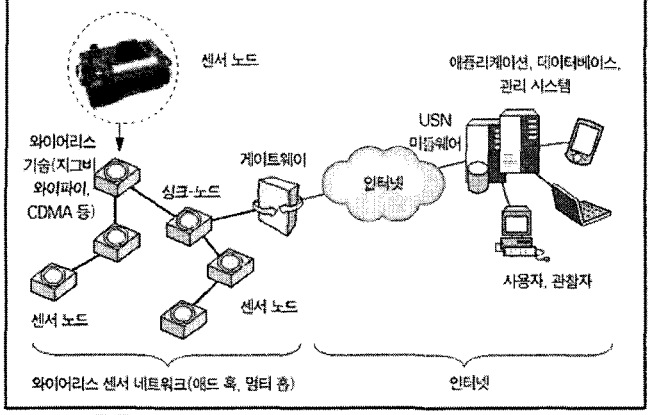
Sensor Network Outline

그림 1 | 무선 센서 네트워크의 기본 구조



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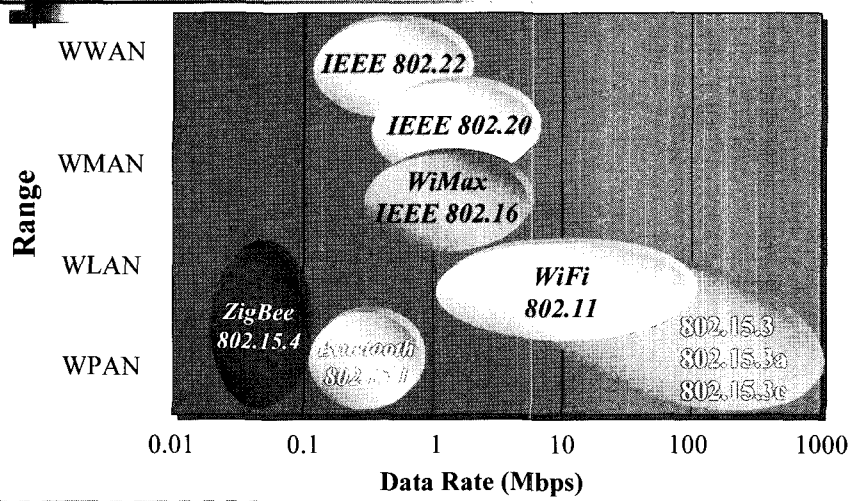
The 802 Wireless Space



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WLAN 802.11 & WPAN 802.15

Wi Fi Bluetooth

Market Name Standard	Wi-Fi™ 802.11b	Bluetooth™ 802.15.1	ZigBee™ 802.15.4
Application Focus	Web, Email, Video	Cable Replacement	Monitoring & Control
System Resources	1MB+	250KB+	25KB - 50KB
Battery Life (days)	.5 - 5	1 - 7	100 - 1,000+
Network Size	32	7	255 / 65,000
Bandwidth (Kb/s)	11,000+	720	20 - 250
Transmission Range (meters)	1 - 100	1 - 10+	1 - 100+
Success Metrics	Speed, Flexibility	Cost, Convenience	Reliability, Power, Cost

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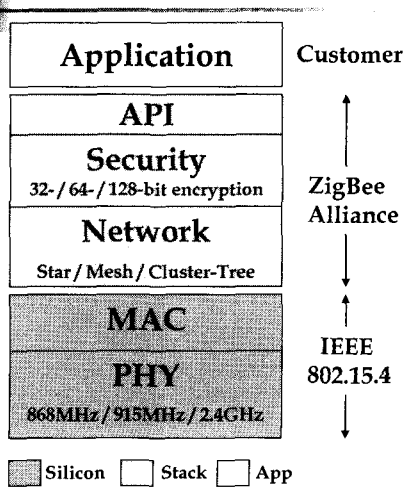
IEEE802.15.4 & ZigBee



ZigBee Alliance

- "the software"
- Network, Security & Application layers
- Brand management

IEEE 802.15.4

- "the hardware"
- Physical & Media Access Control layers

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Proposed Applications of Wireless Sensors

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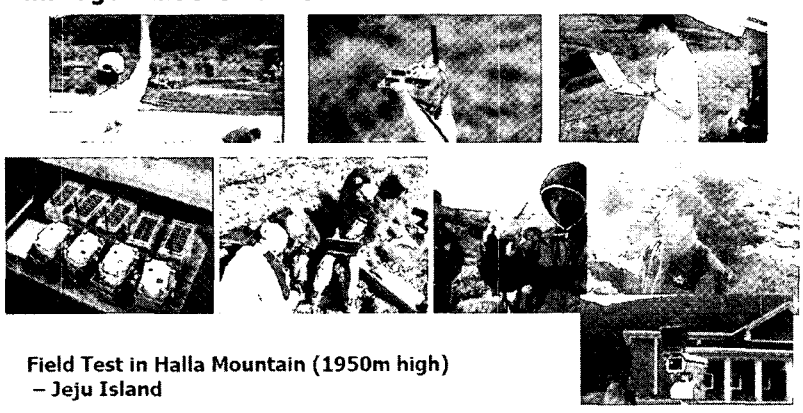
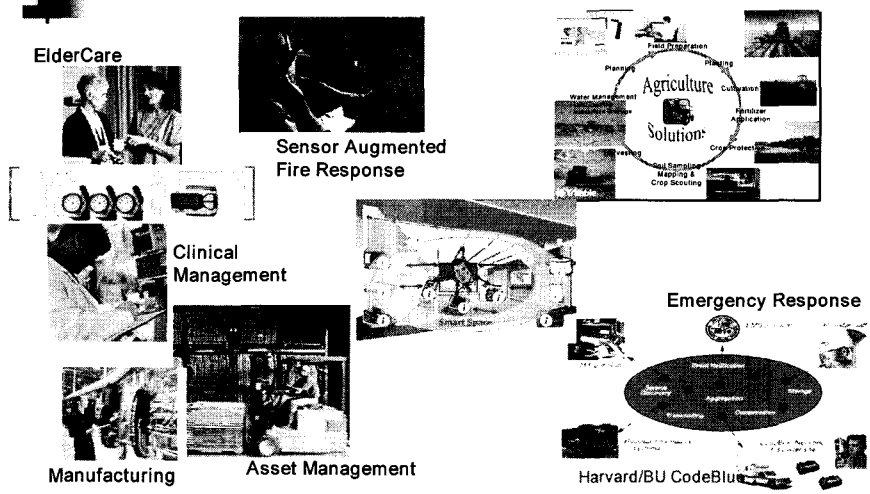
Research in Korea

*** ANTS Pilot Project – Haroobang for Disaster management & U-tourism**

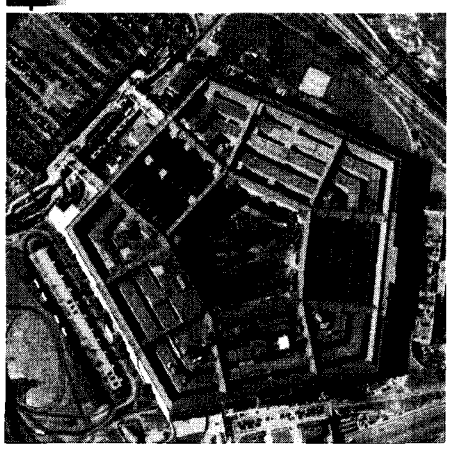


Field Test in Halla Mountain (1950m high) – Jeju Island

World-Wide Research



Smart Home / Smart Office



- Sensors controlling appliances and electrical devices in the house.
- Better lighting and heating in office buildings.
- The Pentagon building has used sensors extensively.

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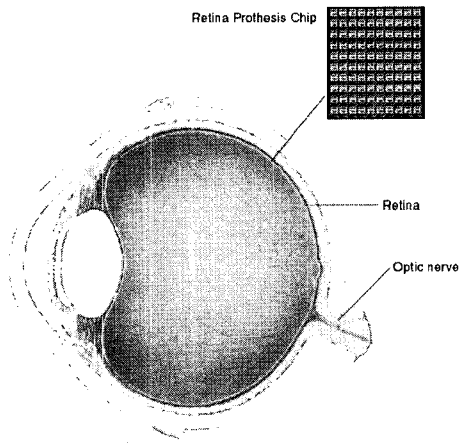
Biomedical / Medical



- Health Monitors
  - Glucose
  - Heart rate
  - Cancer detection
- Chronic Diseases
  - Artificial retina
  - Cochlear implants
- Hospital Sensors
  - Monitor vital signs
  - Record anomalies

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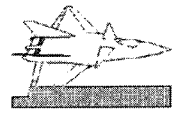
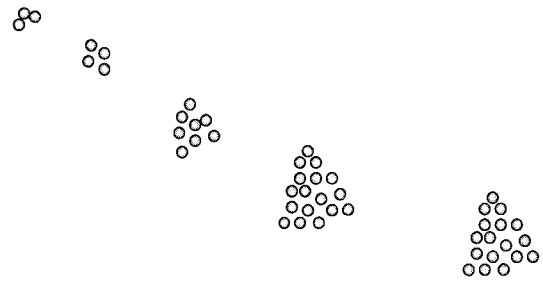
Military



Remote deployment of sensors for tactical monitoring of enemy troop movements.



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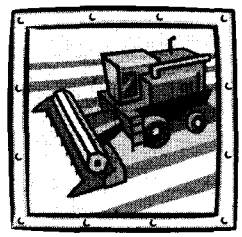
Industrial & Commercial

- Numerous industrial and commercial applications:
  - Agricultural Crop Conditions
  - Inventory Tracking
  - In-Process Parts Tracking
  - Automated Problem Reporting
  - RFID – Theft Deterrent and Customer Tracing
  - Plant Equipment Maintenance Monitoring



State of Art of a Sensor Node

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Current Microcontroller suitable for WSN

Manufacturer	Device	RAM (kB)	Flash (kB)	Active (mA)	Sleep (μA)	Release
Atmel	AT90LS8535	0.5	8	5	15	1998
	Mega128	4	128	8	20	2001
	Mega165/325/645	4	64	2.5	2	2004
General Instruments	PIC	0.025	0.5	19	1	1975
Microchip	PIC Modem	4	128	2.2	1	2002
Intel	4004 4-bit	0.625	4	30	N/A	1971
	8051 8-bit Classic	0.5	32	30	5	1995
	8051 16-bit	1	16	45	10	1996
Philips	80C51 16-bit	2	60	15	3	2000
Motorola	HC05	0.5	32	6.6	90	1988
	HC08	2	32	8	100	1993
	HCS08	4	60	6.5	1	2003
Texas Instruments	TSS400 4-bit	0.03	1	15	12	1974
	MSP430F14x 16-bit	2	60	1.5	1	2000
	MSP430F16x 16-bit	10	48	2	1	2004
Atmel	AT91 ARM Thumb	256	1024	38	160	2004
Intel	XScale PXA27X	256	N/A	39	574	2004

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Current Radio suitable for WSN

Type	Narrowband				Wideband		
Vendor Part no.	RFM TR1000	Chipcon CC1000	Chipcon CC2400	Nordic nRF2401	Chipcon CC2420	Motorola MC13191/92	Zeevo ZV4002
Max Data rate (kbps)	115.2	76.8	1000	1000	250	250	723.2
RX power (mA)	3.8	9.6	24	18 (25)	19.7	37(42)	65
TX power (mA/dBm)	12 / 1.5	16.5 / 10	19 / 0	13 / 0	17.4 / 0	34(30)/ 0	65 / 0
Powerdown power (μA)	1	1	1.5	0.4	1	1	140
Turn on time (ms)	0.02	2	1.13	3	0.58	20	*
Modulation	OOK/ASK	FSK	FSK,GFSK	GFSK	DSSS-O-QPSK	DSSS-O-QPSK	FHSS-GFSK
Packet detection	no	no	programmable	yes	yes	yes	yes
Address decoding	no	no	no	yes	yes	yes	yes
Encryption support	no	no	no	no	128-bit AES	no	128-bit SC
Error detection	no	no	yes	yes	yes	yes	yes
Error correction	no	no	no	no	yes	yes	yes
Acknowledgments	no	no	no	no	yes	yes	yes
Interface	bit	byte	packet/byte	packet/byte	packet/byte	packet/byte	packet
Buffering (bytes)	no	1	32	16	128	133	yes *
Time-sync	bit	SFD/byte	SFD/packet	packet	SFD	SFD	Bluetooth
Localization	RSSI	RSSI	RSSI	no	RSSI/LQI	RSSI/LQI	RSSI

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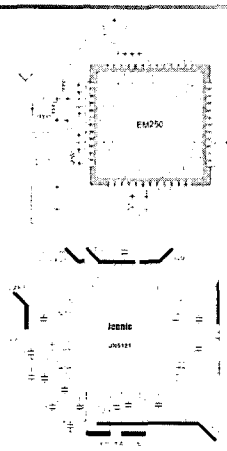
IC Development Roadmap

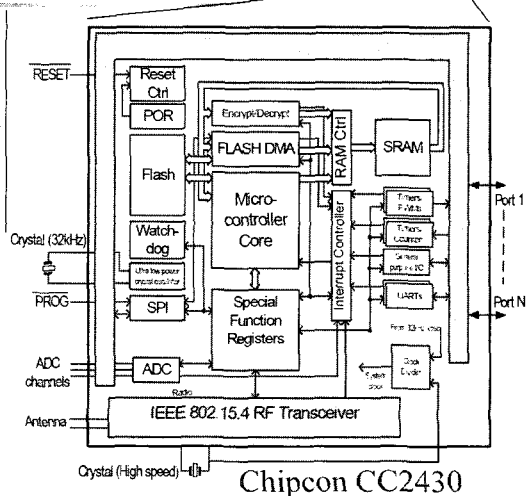
802.15.4 / ZigBee	1st Generation	2nd Generation	3rd Generation
Year of 1st IC	2003	2005	2007
	2 (or more) ICs	SoC solutions	Optimized SoC solutions
Examples	CC2420 + Atmega128 MC13192 + MC9S08GT	CC2430 EM250 (?) MC13213	CC2530 (8051,MSP430, other based???)
Typical BOM	$6 to $10	$4 to $5	$2 to $4
Power: Stand-by Tx / Rx	3uA 30mA / 32mA	0,6 / 0,9uA 25mA / 27mA	0,5 / 0,8uA 20mA / 22mA
Ref. design Area	4 – 8 cm²	2 – 5 cm²	1 – 3 cm²

Integrated Solution

Ember
EM250

Jennic
JN5121





Chipcon CC2430

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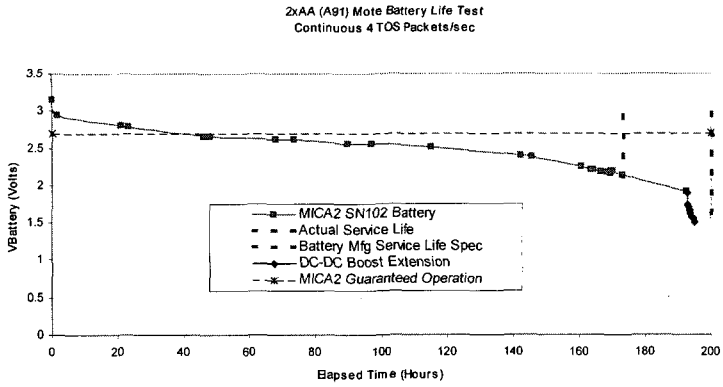
Battery Life on MICA2 at 100% Duty Cycle



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Operating System for Sensor Networks

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O/S for Sensor Networks

- 제한된 자원의 사용
  - 프로세싱, 저장, 대역폭, 전력 ...
- 수많은 노드에 뿌려진 Applications
  - 자가 수집
  - 변화하는 네트워크 환경에서의 적응
  - 통신은 기본적인 요소 (*ad-hoc , mesh*)
- 병목 현상 처리
  - 센싱 데이터와 네트워크 트래픽 등 (scheduling)
- 견고성
  - Critical 한 operation 에 대한 보장
- 응용 계층과 하위 레벨 계층간의 access가 용이성

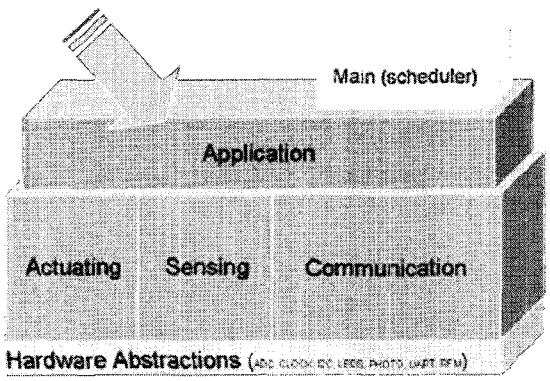
TinyOS

- UC 버클리 대학에서 고안
  - Prof. David Culler & Kris Pister
  - Prof. David Culler -> TinyOS & Intel Research Lab. @ Berkeley
  - Kris Pister -> Dust network (Smart Dust)
  - Key Engineer -> Jason Hill, etc.
- 300개가 넘는 대학 연구소와 산업체에서 사용
- 공개 소프트웨어
- 간단한 운영체제
- 프로그래밍 언어 및 모델 지원
- 서비스 정책

TinyOS

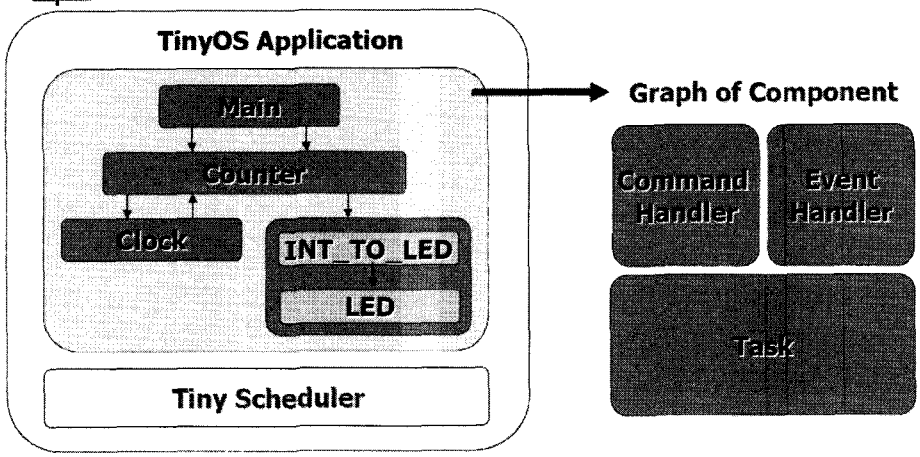
- 2-Level 구조
  - Task
    - 시간에 비종속
    - 오래 수행되는 operation
    - 선점할 수 없고, 선점 될 수 있다.
    - Background computation
  - Events
    - 시간에 종속
    - 짧게 수행되는 operation
    - 선점될 수 없다
    - Task가 수행 중에, interrupt 할 수 있다.

TinyOS Architecture



- Running One Application
- nesC : pre-processor
- ***nesC output is a c program file that is compiled and linked using gnu gcc tools***

TinyOS Architecture



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What will Wireless Sensor Networks Look Like in the Near Future?

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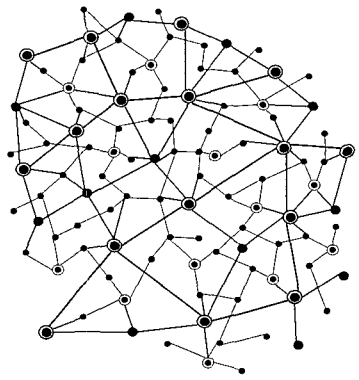
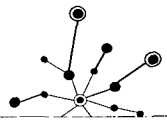
Large-Scale Deployments

- Sensor networks will grow in size because of:
  - Lower cost
  - Better protocols
  - Advantages of dense networks





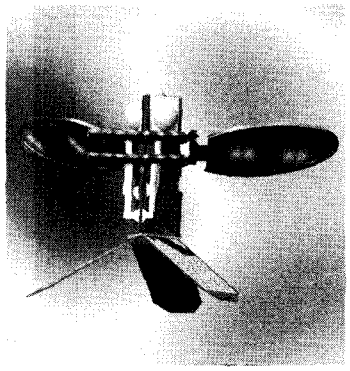
Sensing Zone with sensor-coordinator, sensing-collaborators, and backbone nodes

Heterogeneous Sensors

- Homogeneous network of sensors has been the typical assumption, but not the future!!
  - Combining sensors with different functions
  - Hierarchy of sensors – a few expensive powerful sensors with more cheap sensors
    - Useful for special communication nodes
  - A few sensor nodes with expensive sensors, such as GPS-equipped sensors

Mobile Sensors

- Sensors with Micromachines
- Low-Power Motors that Support Mobility



General Purpose Sensors

- Single-purpose network is the typical assumption, but the future!!
  - Sensors for evolving applications
  - Sensors that can adapt to changing objectives
  - More memory and CPU will allow more complex applications
  - Flexibility increases marketability

Overlapping Coverage Areas

- Sensors will be deployed for specific applications, but
  - These deployments will overlap physically
  - Sensors will have different properties
  - Users will want to combine these different sensors for new applications:
    - Temperature sensors for HVAC control
    - Location tracking of employees
    - Combine these for fire rescue operations

Mixture of Wired and Wireless

- Wireless sensors will become a seamless part of larger networks!
  - Combining wired sensors with wireless sensors
    - Wired sensors can have more power
    - Wired sensors can run TCP/IP
  - Accessing wireless sensors through the Internet
    - Need a gateway to translate requests
    - Uploading/downloading information remotely
    - Modifying wireless sensor tasks remotely
  - Increased direct user interaction

감사합니다

질의 및 응답?