



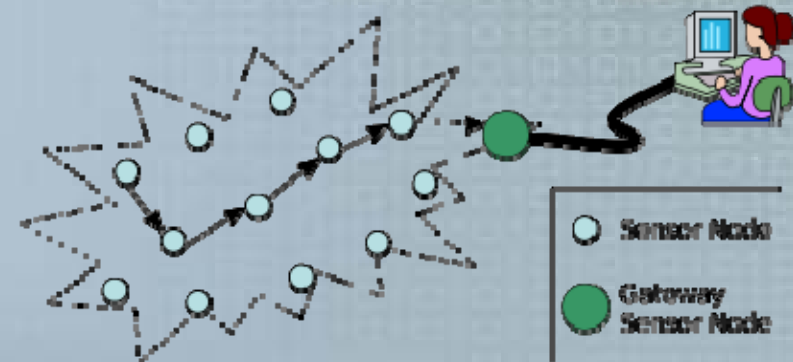
Wireless Sensor Networks for Healthcare Applications

Michelle L. Chen (FAS), Orlando Gutierrez, M.D. (MGH), Jonathan Wyler (HBS) December 2007
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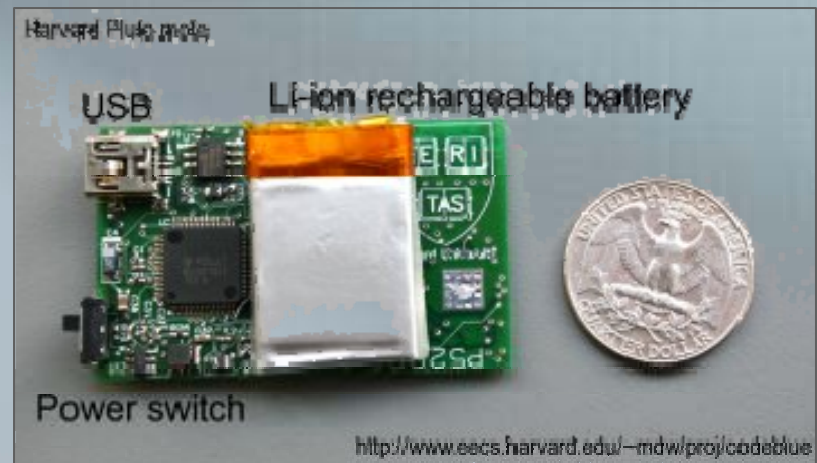
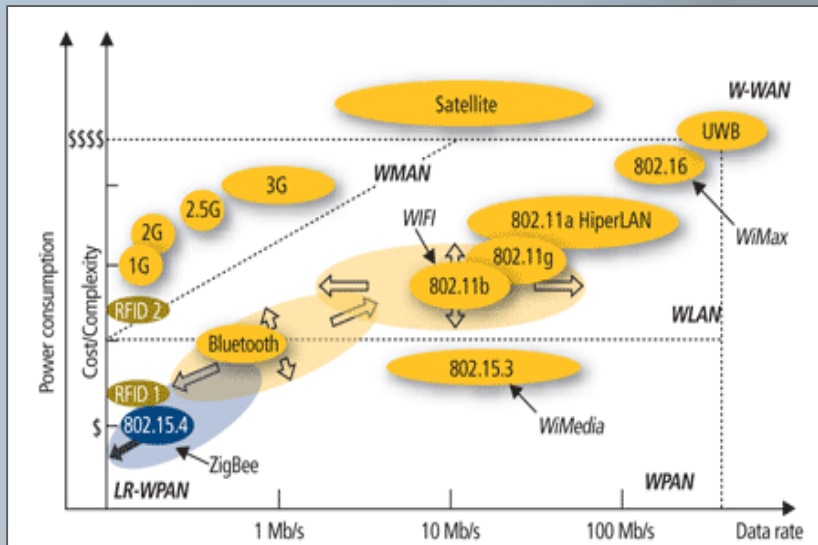
Wireless Sensor Networks

A high-tech solution for a broad range of applications

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions.



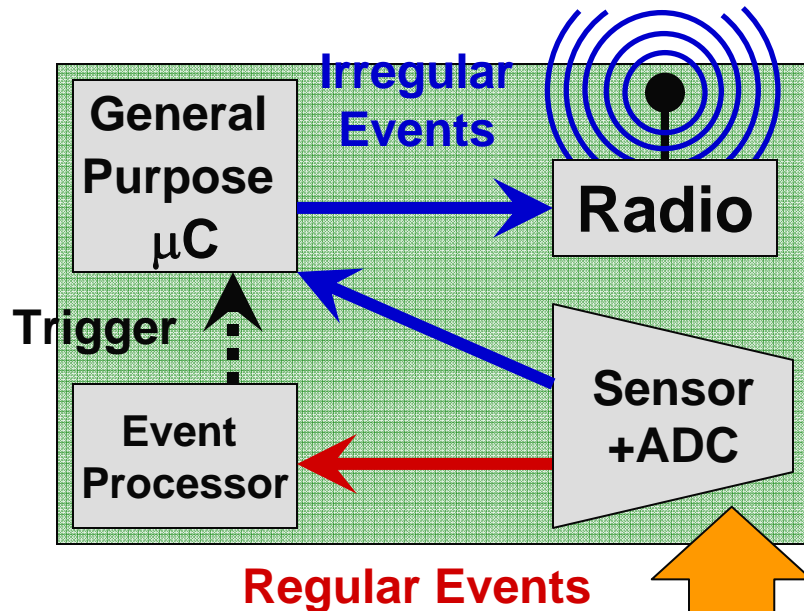
Nodes consist of: hardware (microprocessor, memory, battery, MEMS sensor, antenna, etc.), software, RF protocol, OS



The Cutting Edge of Wireless Sensor Technology

An application-specific, event-driven approach to optimize power management

U.S. Patent Application 2007/021434



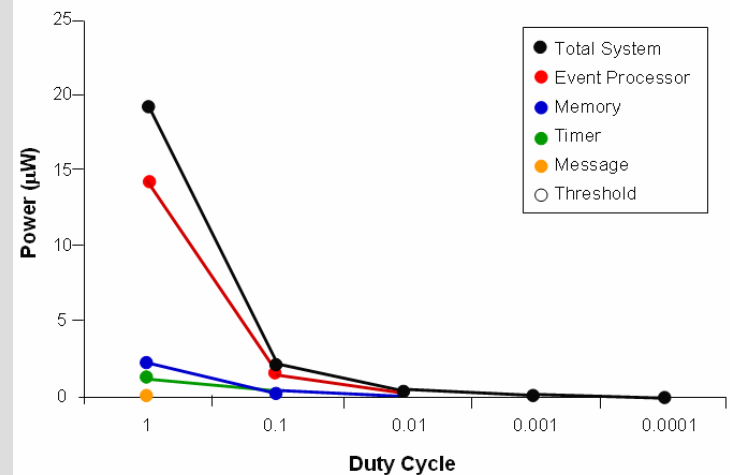
Stage of Development

- Prototypes of motes using this architecture have been created and low power consumption levels demonstrated
- However, the innovation is *architecture*, and not a specific design or product, so feasibility must demonstrated for specific application-specific embodiments

Prototypes have demonstrated ultra-low power performance

Comparison of cycle count for the test application written on our architecture and on TinyOS for the Mica Platform.

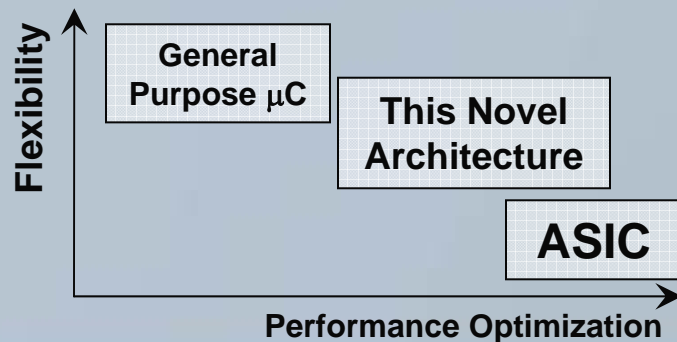
Measurement	Mica2	Our System	Speedup
Total send path w/out filter	1522	102	14.9
Total send path w/ filter	1532	127	12.1
Process regular message	429	165	2.6
Process irregular message			
Timer change	234	136	1.7
Threshold change	11	114	0.096
Units	Cycles	Cycles	%



Product and Market Space

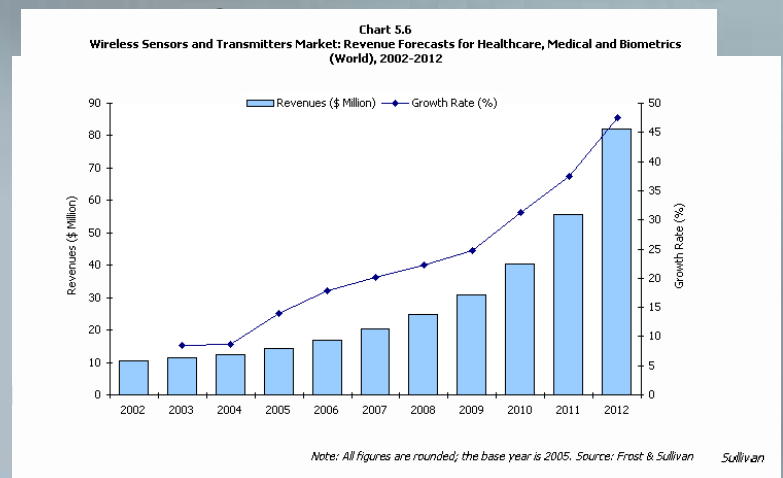
TECHNOLOGY BENEFITS

- **Event-driven computation:** eliminate unnecessary event-processing overhead with an event-driven hardware platform.
- **Hardware acceleration** – system that is optimized for specific tasks.
- Exploiting **regularity of operations** within an application
- **Optimization for particular applications** to reduce power, while enabling broad functionality.
- **Modularity** – architecture allows different hardware configurations for applications.
- **Power management** based on computational requirements. The power target is 100 μ W for normal workloads.



POTENTIAL USES/PORTFOLIOS

- **Industrial**
 - Asset tracking
 - Equipment condition monitoring
- **Home**
 - Electrocardiography (EKG)
 - Pulse oxymetry
 - Bedding automation
- **Agriculture**
 - Field activity monitoring
- **Mass-Escalators**
 - Escalator growth
- **Hospital equipment**
 - Hearing and tracking activity
- **Environmental**
 - Environmental motion analysis
- **Research**
 - Temp, humidity, weather



Commercial Opportunity Assessment

There are currently far more appealing and fitting applications than healthcare

HEALTHCARE

- There are potential opportunities for WSN in healthcare, but they are still in infancy
 - Need for wireless monitoring due to “monitoring gap” – can’t monitor all patients due to cost of wired diagnostic equipment
 - There are funded hospital and academic research projects in this area – but few companies have started or had success
- Healthcare applications generally use the “cell phone model” with different demands
 - No real need for ultra-low power because of opportunities for charging batteries
 - It is unclear who the customer is on many applications (e.g. mass casualty)
 - Many other challenges related to infrastructure, lack of standards, security, and data volume and integrity
- Equipment tracking has been mentioned a number of times as most relevant and least complex relative to technical, regulatory and market adoption challenges

OTHER



- **Asset tracking**
 - Active WSN systems can enable tracking over much larger areas with less expensive scanning systems versus passive RFID
- **Industrial automation**
 - Wireless systems now can provide financial benefit over previously wired systems
- **Environmental monitoring**
 - Very long-term application require ultra-low power, potentially with energy harvesting
 - However, this is primarily a research interest and a commercial market is yet to develop

Application Relevance Assessment

Appealing markets and need for benefits of this invention must align

Application	Customer	Low Power	Mod-ular	Irreg. Events	Market	'05 Rev (\$MM)	Est. '12 (\$MM)	Overall
Defense/security	DOD/DHS	●	⊙	●	●	49	676	●
Industrial equip.	Misc Mfg's	●	●	⊙	●	14	142	●
Asset tracking	Many	●	○	○	●	\$B	\$Bs	⊙
Automotive	Auto Mfg's	●	⊙	⊙	●	10	232	⊙
Building auto.	Many	●	⊙	●	⊙	6	26	⊙
Energy & power	Utilities	●	○	●	⊙	6	31	⊙
Environmental	NOAA?	●	⊙	⊙	○	~0	???	○
Healthcare	Hospitals	○	⊙	⊙	⊙	14	82	○
Mass Casualty	FEMA?	⊙	⊙	⊙	○	~0	???	○
Agriculture	Farmers	●	⊙	○	⊙	9	48	○

● Favorable / Needed

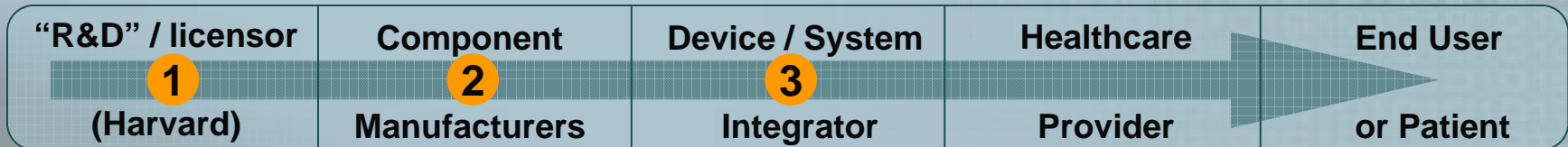
⊙ Neutral or Unclear

○ Unfavorable / Not Needed

Recommended Path to Market

License to WSN-focused chip makers, but consider application-specific venture

Value / Supply Chain (Healthcare Applications)



1 Technology licensing

- Capitalize on broad range of applications
- Candidate licensees: WSN-focused chip makers (*Ember Corp.*, *Crossbow Tech.*, *Freescale Semiconductor*, *Millennial Net*, *Dust Networks*)

2 Chip manufacturing venture

- Requires major capital investment and substantial process expertise
- Rapidly evolving technology space makes it unreasonable and risky on this single patent

3 Device/system development

- Could either contract out chip manufacture or integrate OTS components using architecture
- Will limit range of application of technology to selected product space, hence opportunity

Complementary Assets

		Low Need	High Need
IP	Strong	Start-Up	License
	Weak	Open	X

Recommendation

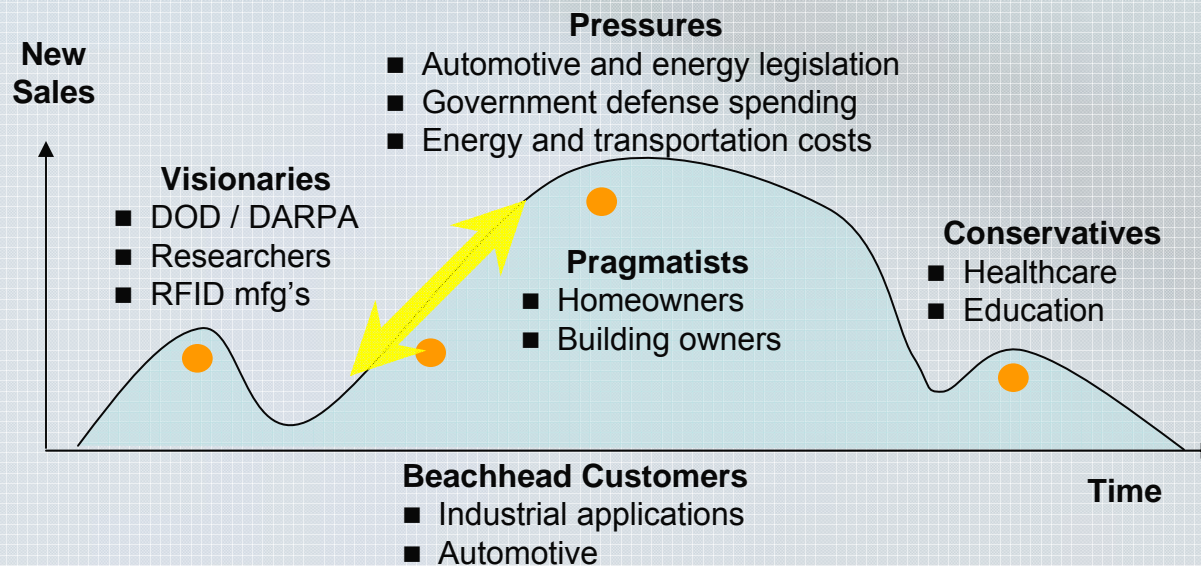
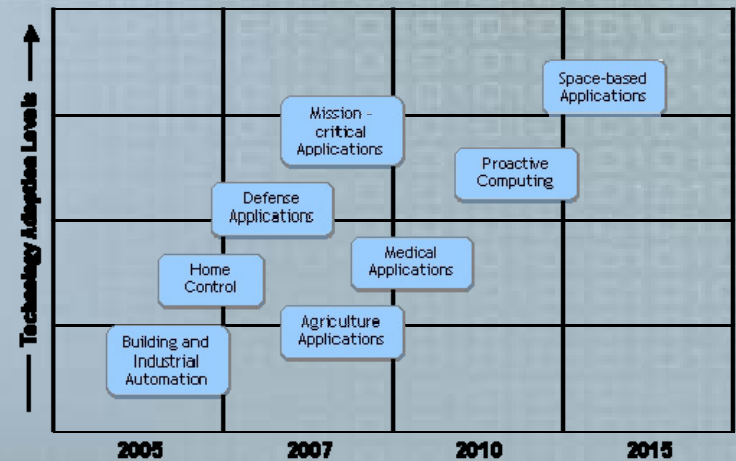
- Start wireless device company to develop a modular platform based on the technology
- Outsource chip manufacture
- Expand application roadmap

Go-to-Market Strategy

Customer and technology roadmap key to platform-business success

Business Model

- Develop device platform with broad applicability (like Millennial Net)
- Outsource chip manufacturing, engage consultative partners for system deployment
- Competitive advantage is better performance for a given level of system configurability



Marketing Strategy

1. Start with most visionary customers, not necessarily the largest markets, to establish platform and brand
2. Use success in niche applications to transition into large volume and high growth verticals

Interview Acknowledgements

Academic

- Professor Matt Welsh, Harvard University CSEE Department
- Assistant Professor Gu-Yeon Wei (PI), Harvard University CSEE Department
- Assistant Professor David Brooks (PI), Harvard University CSEE Department
- Alan Gordon, Director, Harvard University OTD

Clinical

- Dr. Thomas Stair, Brigham & Women's Hospital, Emergency Department
- Assistant Professor Mark Gaynor, Boston University, 10Blade

Industry

- Brent Hodges, VP of Business Development, Zigbee Alliance
- Robert G. Andosca, President & CEO, MicroGen Systems, LLC (*to be completed*)

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