Advances in Sensors Networks and Services

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SENSORCOMM 2012

Advances in Sensor Networks and Services

Simulation and design frameworks for WSN.
Energy harvesting : best supply source for WSNs?

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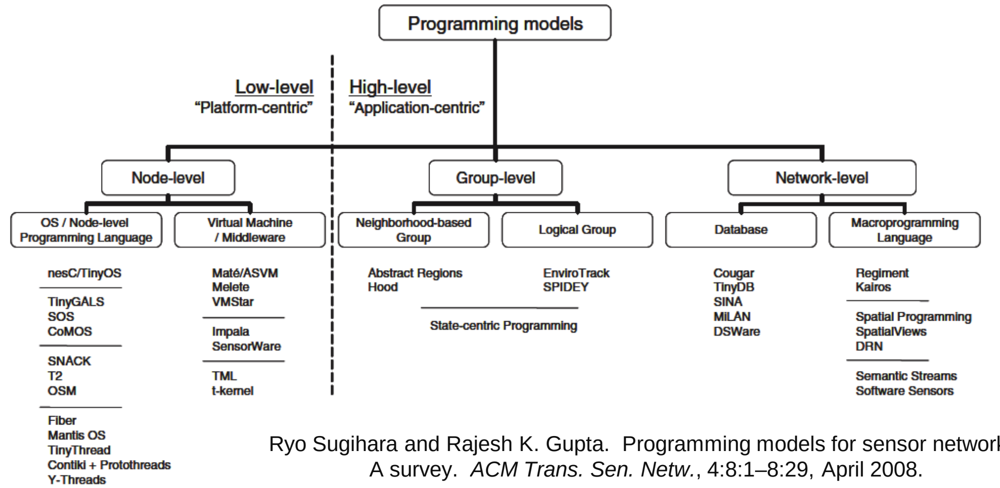
AK Dwivedi and OP Vyas. An exploratory study of experimental tools for wireless sensor networks. *Wireless Sensor Network*, 32011.



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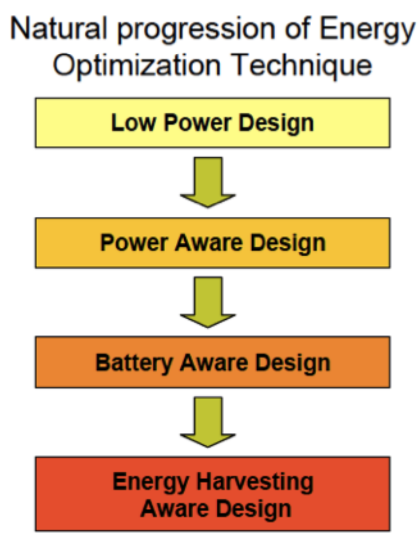
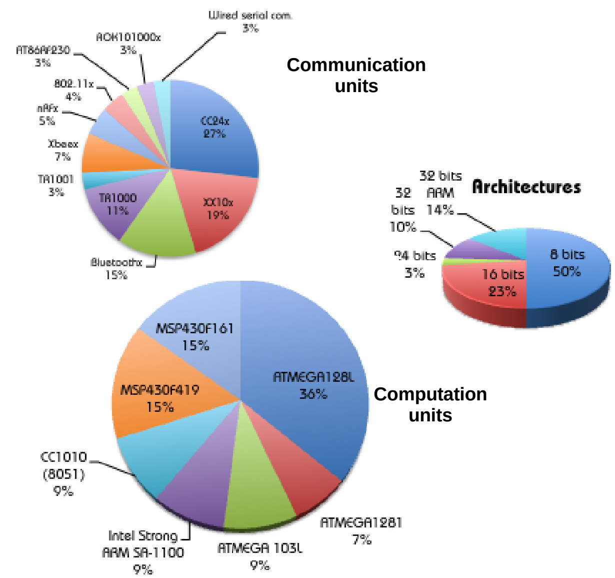
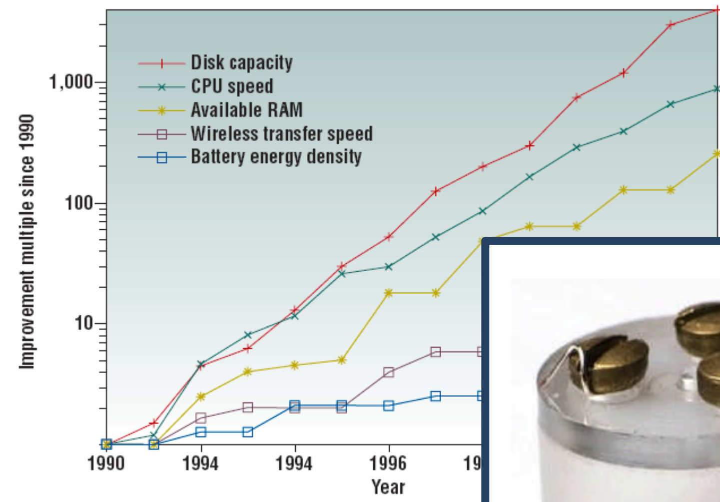
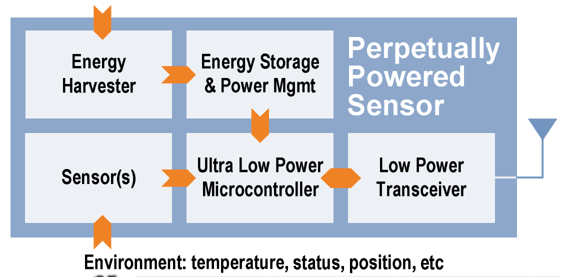


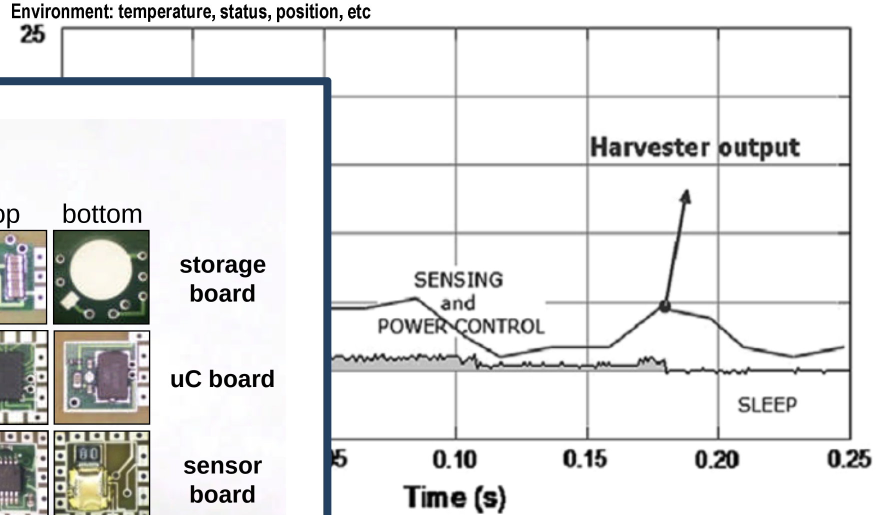


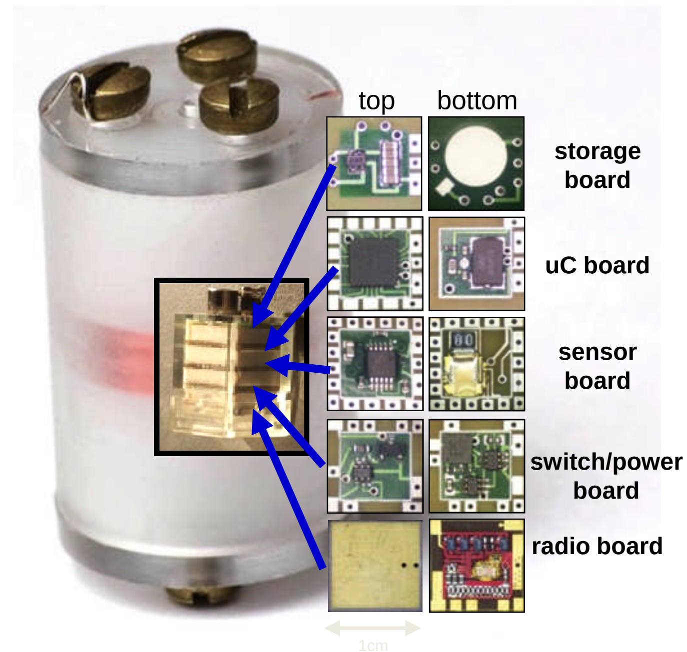
Carolina Fortuna. Why is sensor data hard to get?. COIN-ACTIVE Summer School on Advanced Technologies for Knowledge Intensive Networked Organizations in Aachen, 2010.

Paradiso 2005







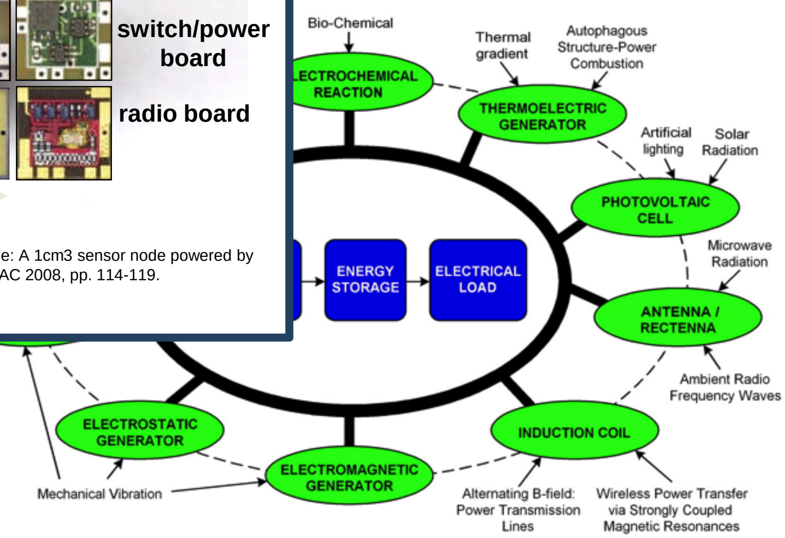


Yuen-Hui Chee, et. al., "PicoCube: A 1cm3 sensor node powered by harvested energy," ACM/IEEE DAC 2008, pp. 114-119.

Power Source	P/cm³ (µW/cm³)	E/cm³ (J/cm³)	P/cm³/yr (µW/cm³/Yr)	S… St… N…		
Primary Battery	-	2880	90			
Secondary Battery	-	1080	34			
Micro-Fuel Cell	-	3500	110	M…		
Heat engine	-	3346	106			
Radioactive(63Ni)	0.52	1640	0.52			
Solar (outside)	15000 *	-	-	U…		
Solar (inside)	10 *	-	-	U…		
Temperature	40 * †	-	-	U…		
Human Power	330	-	-	Yes	Yes	No
Air flow	*380 ††*	-	-	Yes	Yes	No
Vibrations	200	-	-	Yes	Yes	No

* Denotes sources whose fundamental metric is power per **square** centimeter rather than power per **cubic** centimeter.
† Demonstrated from a 5 ºC temperature differential.
†† Assumes air velocity of 5 m/s and 5 % conversion efficiency.

Power Sources for Wireless Sensor Networks, Shad Roundy, Dan Steingart, Luc Frechette, Paul Wright and Jan Rabaey, Wireless Sensor Networks, Lecture Notes in Computer Science, 2004, Volume 2920/2004, 1-17



Yen Kheng Tan and Sanjib Kumar Panda (2010). Review of Energy Harvesting Technologies for Sustainable WSN, Sustainable Wireless Sensor Network, Winston Seah (Editor) and Yen Kheng Tan (Editor-in-Chief), ISBN 978-953-307-297-5, INTECH

Sensor Networks Quo Vadis (… or yet another Playground for Researchers)

Horst Hellbrück
Lübeck University of Applied Sciences, Germany

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Some Facts (Incomplete List)

- More than 10 years of intensive research
  - International Symposium on Low Power Electronics and Design started 1995.
  - ACM MobiCom started 1995.
  - J. M. Kahn, R. H. Katz, and K. S. J. Pister. "Next Century Challenges: Mobile Networking for "Smart Dust" ACM MobiCom 1999.
  - Akyildiz, I.F., Su, W., Sankarasubramaniam, Y., and Cayirci, E., "A Survey on Sensor Networks, IEEE Communications Magazine," vol. 40, no. 8, August 2002.
  - IEEE SenSys has started 2003 (SENSORCOMM in 2007).
- Problems:
  - Scalability, Resources (Energy/CPU), Robustness, Security, Platforms (HW/SW), Engineering, QoS, Applications?
- Achievements:
  - Thousands of algorithms/protocols in papers - some tens of applications!?
  - Some tens of HW/SW platforms - for educational purpose!?
- Downside
  - Are Sensor Networks needed? Is there a market? Gartner Hype Cycle?
  - Producer of WSN (Wireless Sensor Network) hardware and software are "garage companies" and remember me to the situation in the 70s for home computing. Do you remember Commodore?

Overview of publicly available WSN Testbeds

- Simulations & emulations NOT sufficient for deployment of new technologies
  =>Testbeds gain attention (Experimental research)
- Deployment of testbeds is challenging
  =>Design architecture
  =>Provide solutions

	# of nodes	Heterogeneity	Federation	SW-Reuse
DES-Testbed	95			
FRONTS	21			
Kansei	260	✓		
KanseiGeni	576	✓	✓	
MIRAGE/Intel	100			
MoteLab	190			✓
NetEye	130			
Senslab	1024	✓	✓	
TutorNet	104			
TWIST	204	✓		✓
VineLab	48			
WISEBED	750	✓	✓	✓
w-iLab.t Testbed	200			

=> Testbeds do not (really) take-off either

[1] **Using and Operating Wireless Sensor Network Testbeds with WISEBED** Horst Hellbrück et. al., *In MediHocNet*, 2011

Smart Cities

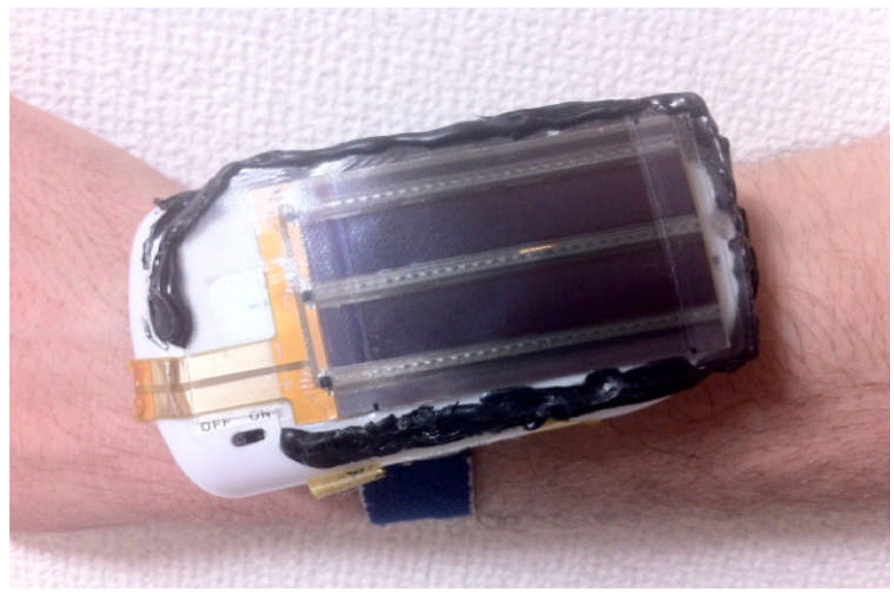
- Finally the Killer Application?

- SmartSantander, (probably) the biggest Wireless Sensor Network in the world.
  - 1100 wireless sensor devices are installed,
    - 400 for parking slots
    - 700 environmental measurements like noise, carbon monoxide, temperature or sunlight.

=> Or does Energy Harvesting push the deployment of Sensor Networks?

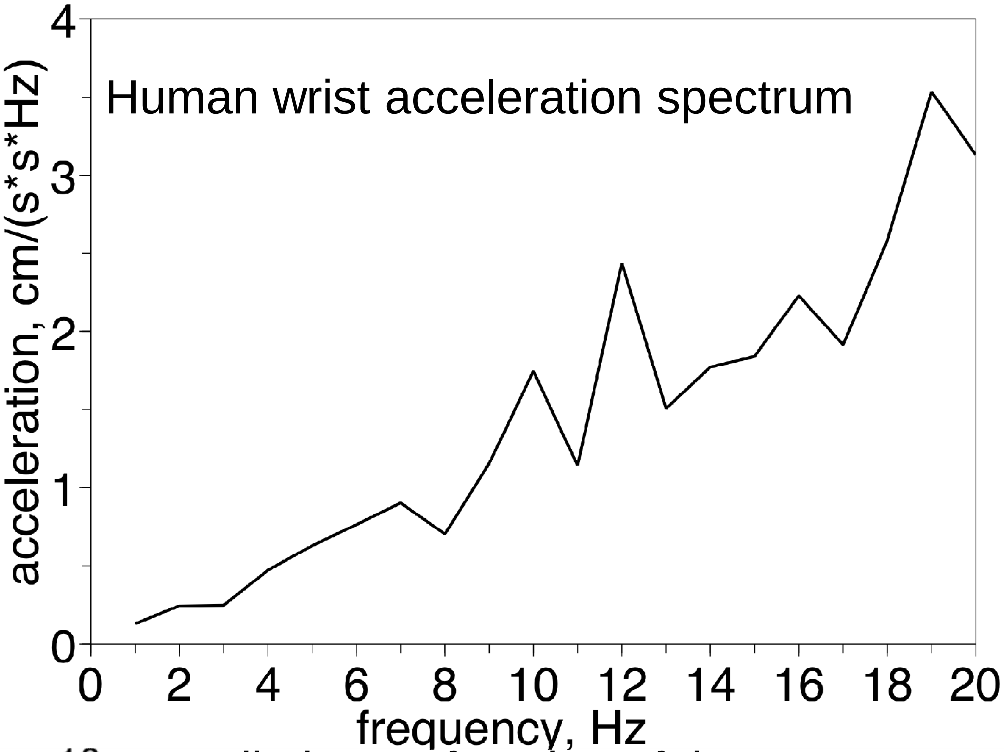
Oleg Nizhnik
Maenaka Human-sensing Fusion Project
(Japan Science and Technology Agency)

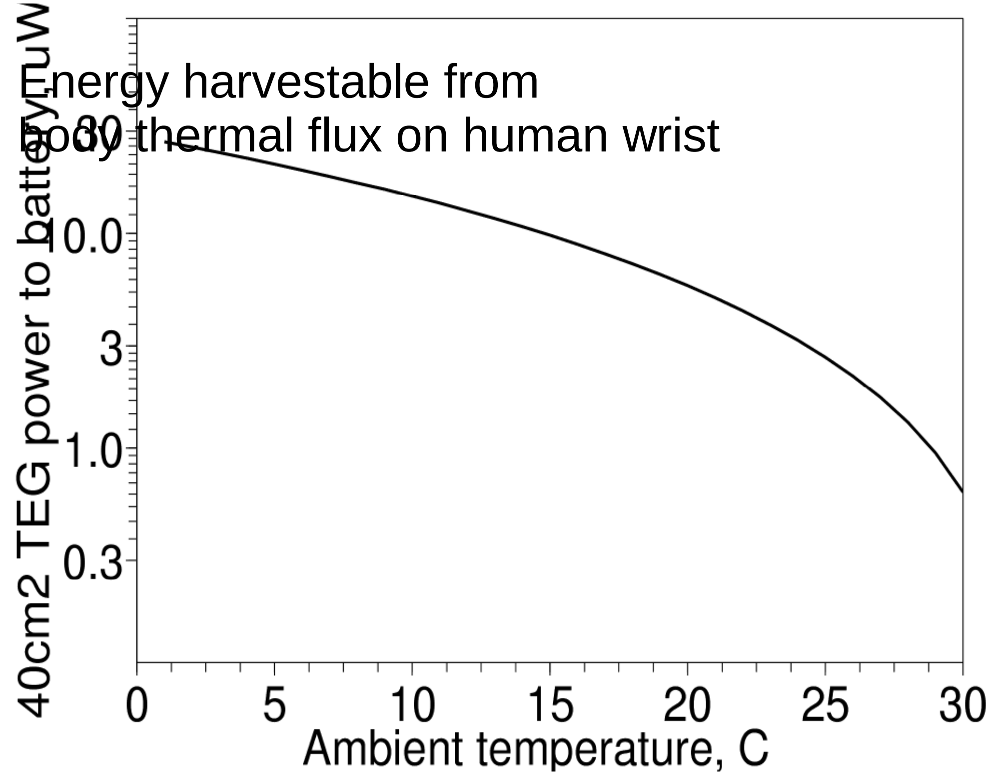
The numerical comparison of the light, thermal and vibration energy harvesting for the wireless sensor node

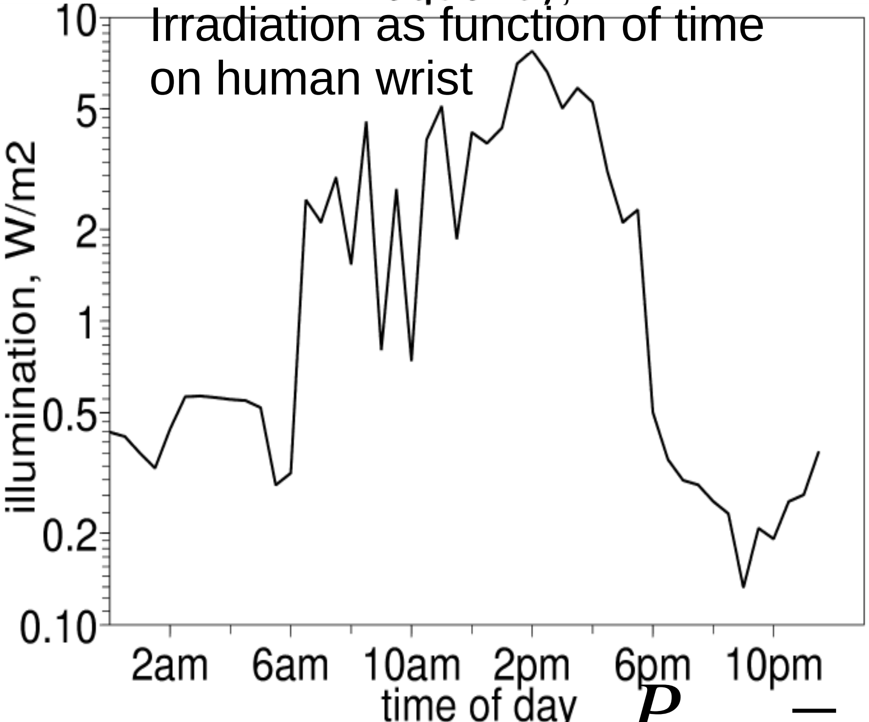


70x70x3.6mm TEG
human body heat
harvester with 4uW
output power at 27C

50x35x0.8mm flexible DSSC cell
Attached to evaluation wireless sensor node
Harvesting average 38uW





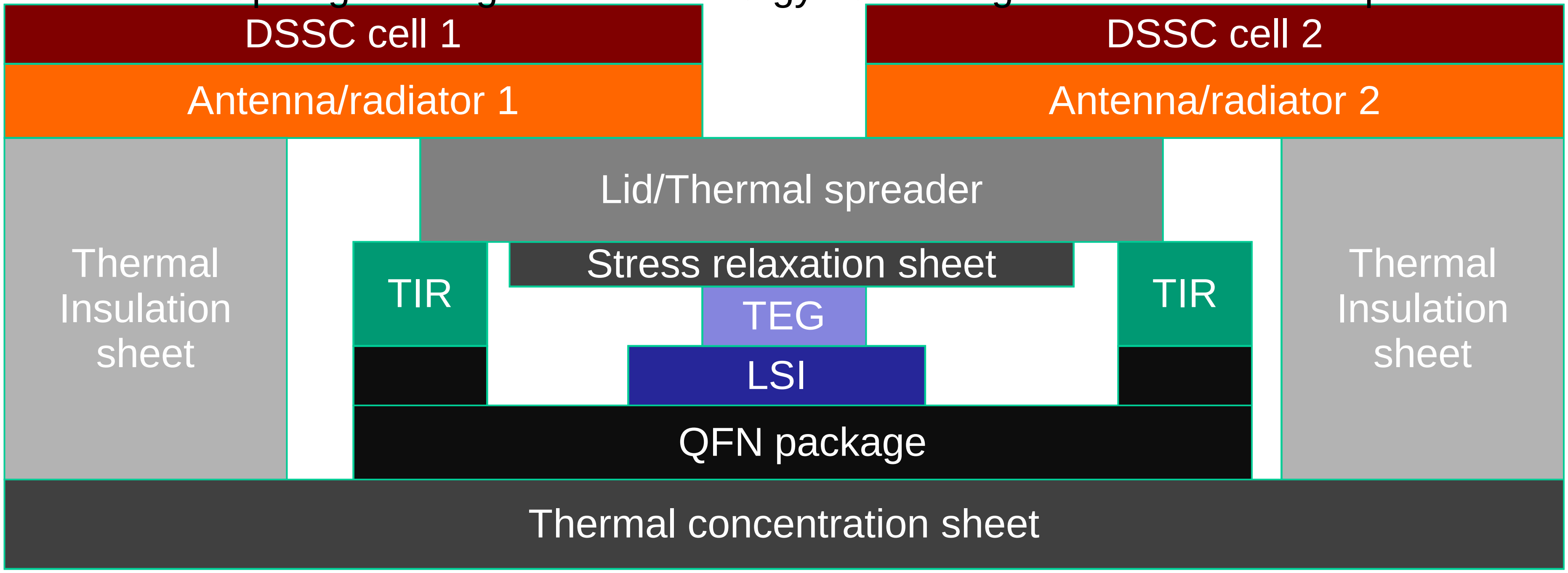


$$P_{vibration} = M_{harv} \cdot \int_{f_{\min}}^{f_{\max}} \frac{a^2(f)}{2\pi f} \eta(f,a)\, df$$

$$P_{light} = S_{harv} \cdot \int_{t_{start}}^{t_{end}} I(t)\eta_{fill}\eta(I)\eta_{\max}\, dt$$

$$P_{heat} = S_{harv} \cdot \int_{t_{start}}^{t_{end}} \phi_{q@1K}\eta_{DC-DC}\eta_{TEG@1K}(\Delta T)^2\, dt$$

Topological diagram of the energy-harvesting WSN under development



A comparison of the energy harvesting methods for the 40 cm^2, 23g weight conformal wearable sensor node prototype

Harvester	Electrical efficiency of DC-DC	Power output	Harvester operational efficiency	Component efficiency	Energy flux
TEG	41%	3.9 uW raw 1.7uW at bat.	56 %	0.012 % (Bi_2Te_3 TEG)	25 W/m^2 (worst case)
Solar	100%	38.4 uW raw	12.6 %	2.6 % (flexible DSSC cell)	2.96 W/m^2
Vibration	~ 50%	0.04 uW raw 0.02 uW at bat.	~10 %	~25 %	67 uW/kg

Sensor Networks and Technology

- Advances in Nano Technology and MEMS technology has aided development of novel applications
  - Multi-species chemical sensing
  - Multipurpose transducer
  - Active devices
  - Novel sensing and response applications

Wireless Network Improvements

- Technology advances have led to reductions in space, weight and power (SWaP) required for network operations.
  - Offer possibility to apply sensors to wider range of applications
    - Environmental
    - Industrial
    - Medical
    - Military
    - Transportation
    - Space

Sensor and network Standards

- Standards result in stable environment
- Foster third party development of applications
- Sensor Web Enablement (SWE) has led to many new services and applications
  - Sensor Discovery
  - Sensor plug and play capability
  - Sensor tasking
  - Subscription services
  - Sensor re-purposing

THE NEED OF SENSOR NETWORKS IN YARN PARAMETERIZATION

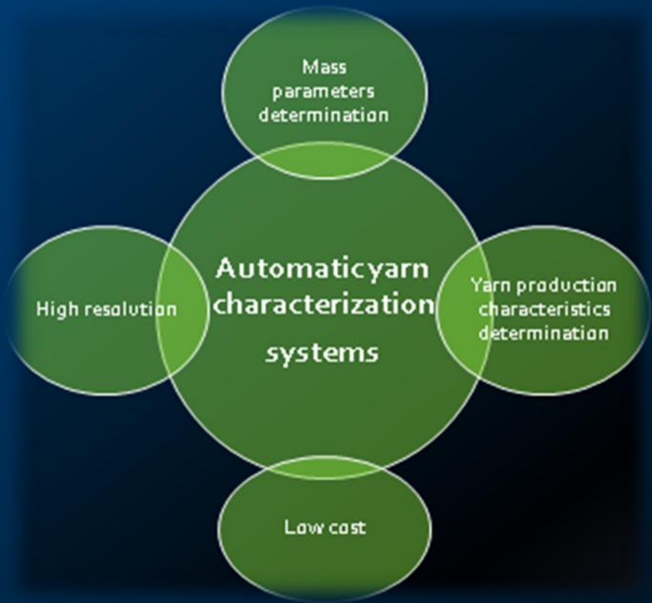
image source:

http://en.daewootextile.com

Vítor H. Carvalho

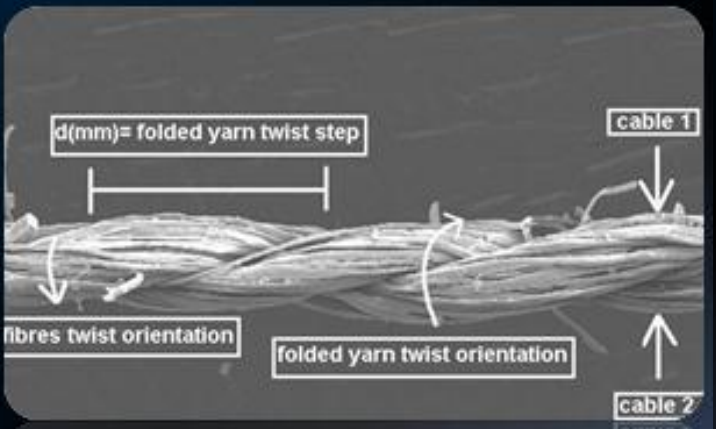
UNIVERSITY OF MINHO (UM)/ IPCA – PORTUGAL

Industry Necessities



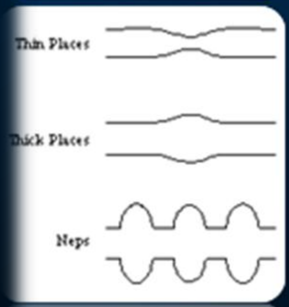
Production Characteristics

Twist step, orientation, number of cables



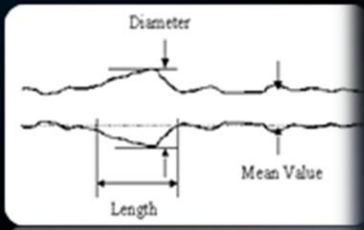
Mass Parameters

Irregularities

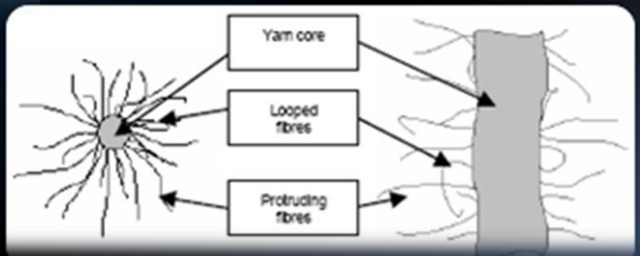


d(mm) = 0.060sqrt(g/km)

Diameter/Mass



Hairiness



Yarn Parameterization Equipament

- Uster Tester 5

Image source: www.uster.com

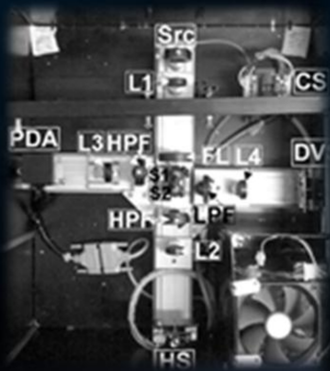
Limited resolution and precision

High cost, volume and weight

Complex measurement hardware

- YSQ

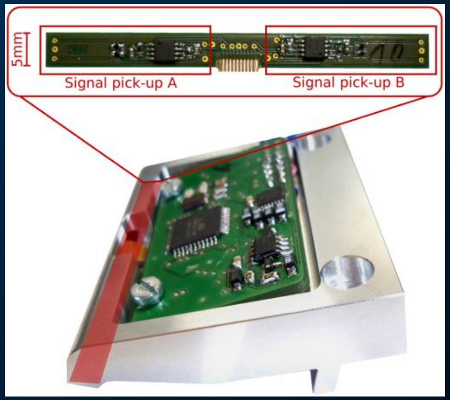
Supress the drawbacks of the comercial equipment



The YSQ and the Commercial Equipment **can not** be used in a sensor network of production systems:

- Offline use/laboratory use
- High cost/ dimension

A Partial Approach – Sensor Network



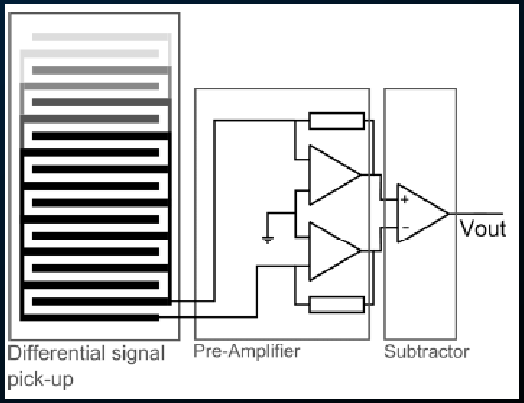


Image sources: Yarn Presence, Speed and Dust (Steffen Heinz et al. (2008))

The Full Approach Challenge/Motivation – Sensor Network

Integrate YSQ/Other in a miniaturized sensor

Able to be placed in **every single** yarn of a textile production system

Build a **sensor network** of these devices

Individual Yarn Online Analysis

Superior Production Quality Control

Increase of Production Efficiency

High Market Prospectives

Economic World Crisis Contribution

THE NEED OF SENSOR NETWORKS IN YARN PARAMETERIZATION

Thank you!

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