Implantable Telemetry

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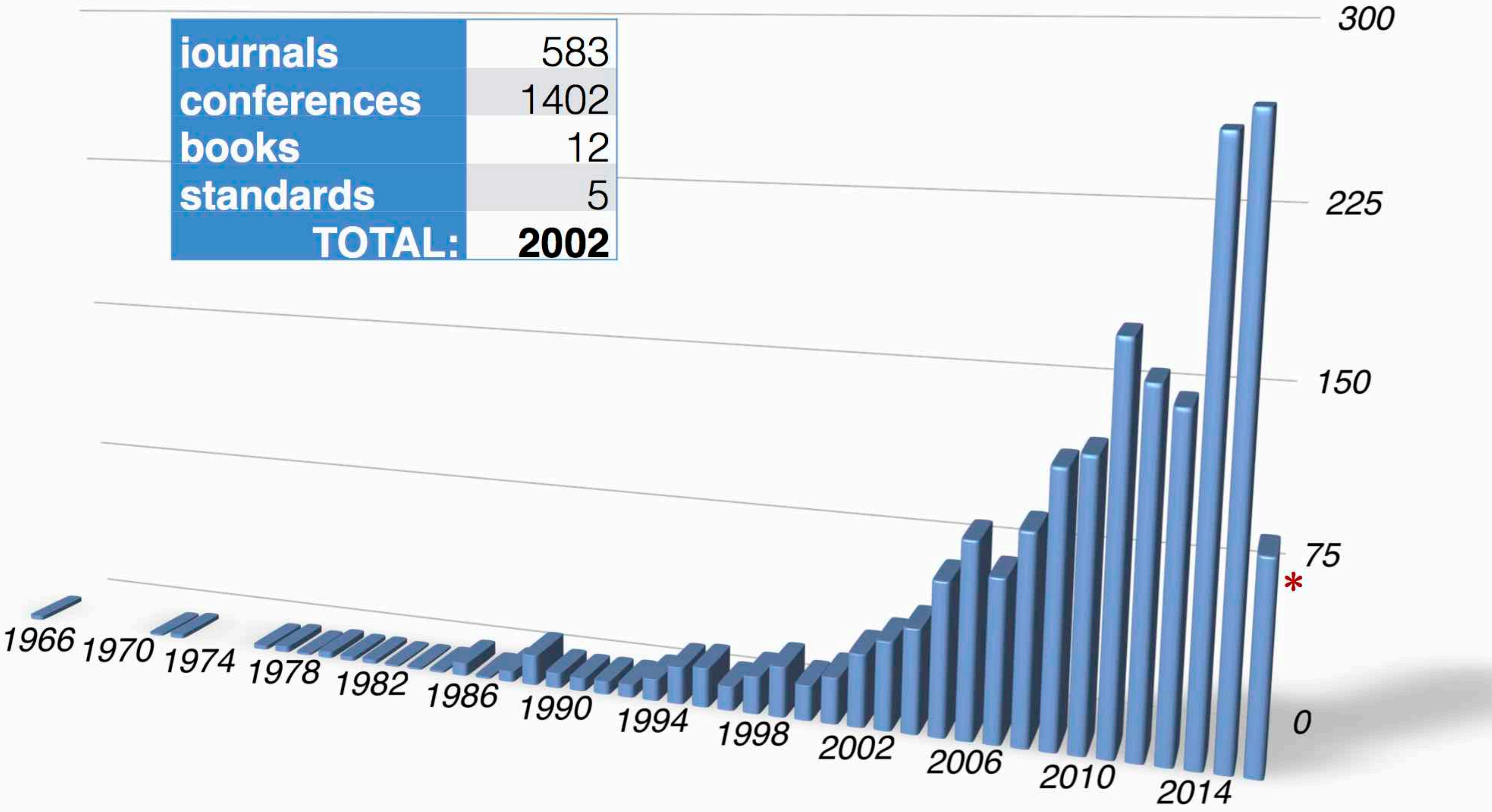
Synopsis

- Short history of technology
- Implantable devices
- Design case : PV cardiac monitoring system

Implantable biomedical devices

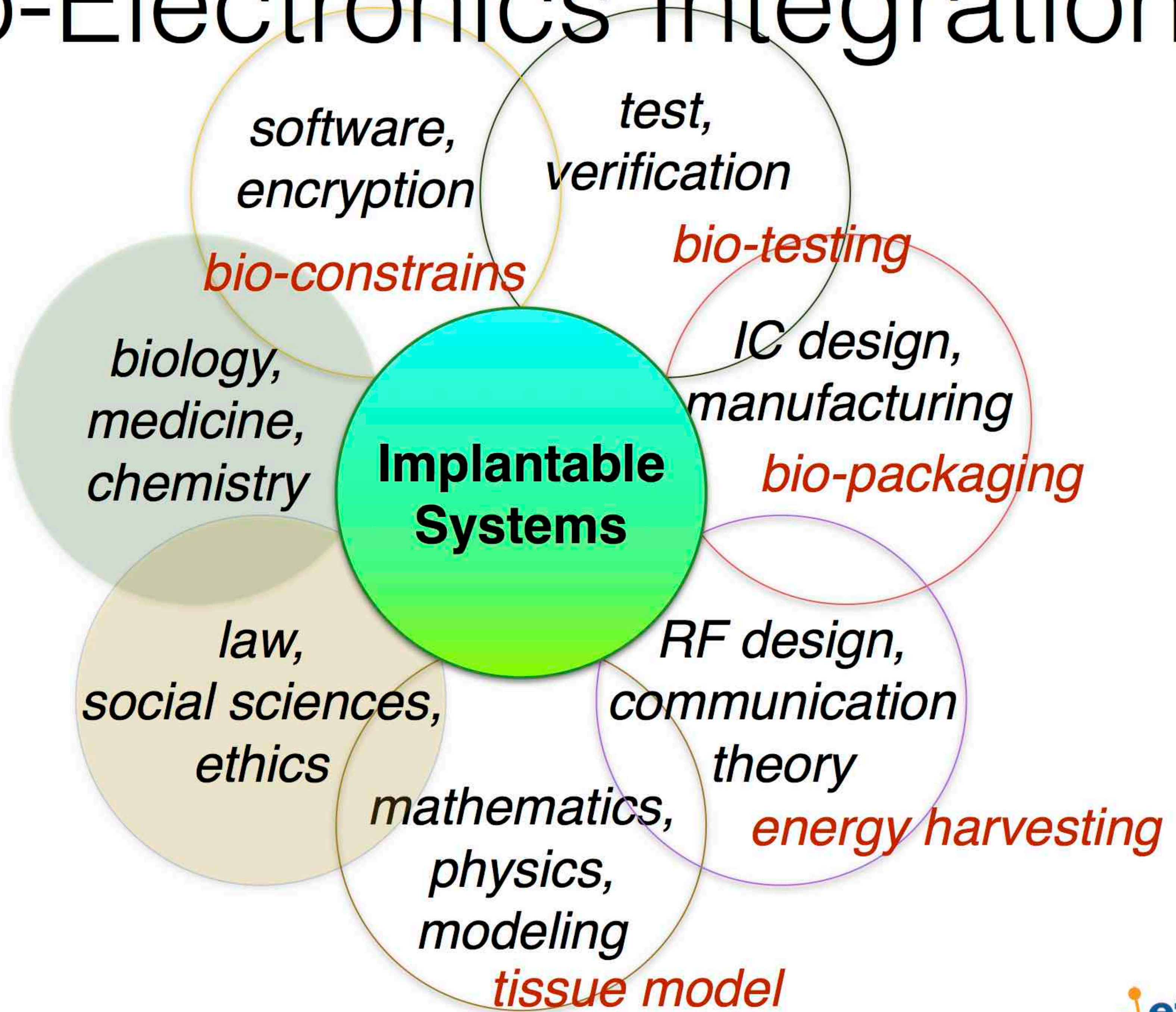
iournals	583
conferences	1402
books	12
standards	5
TOTAL:	**2002**



Source: IEEE Xplore - search on "implantable devices" (july 01, 2016)

* *2016 (partial data)*

Bio-Electronics Integration



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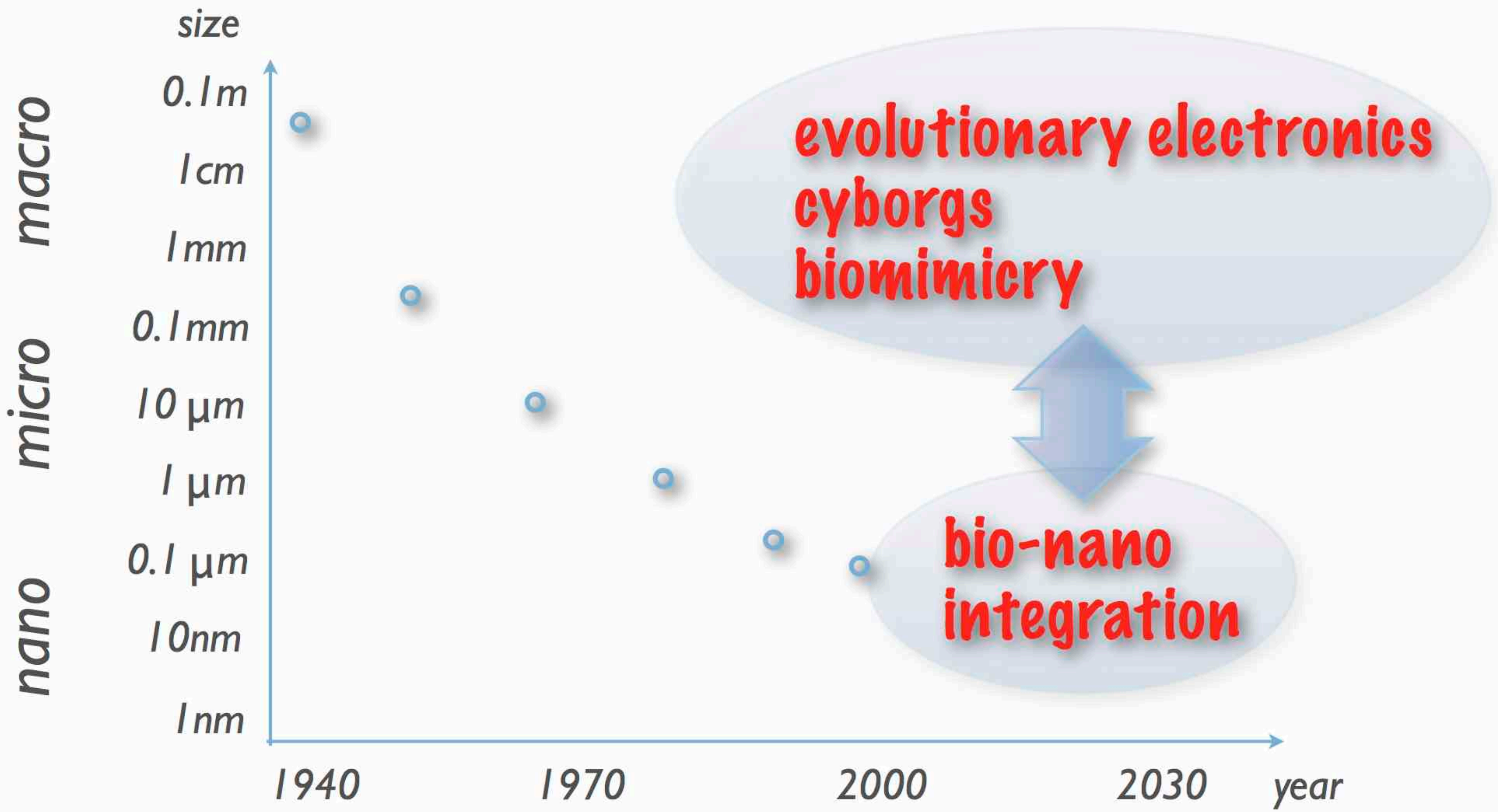
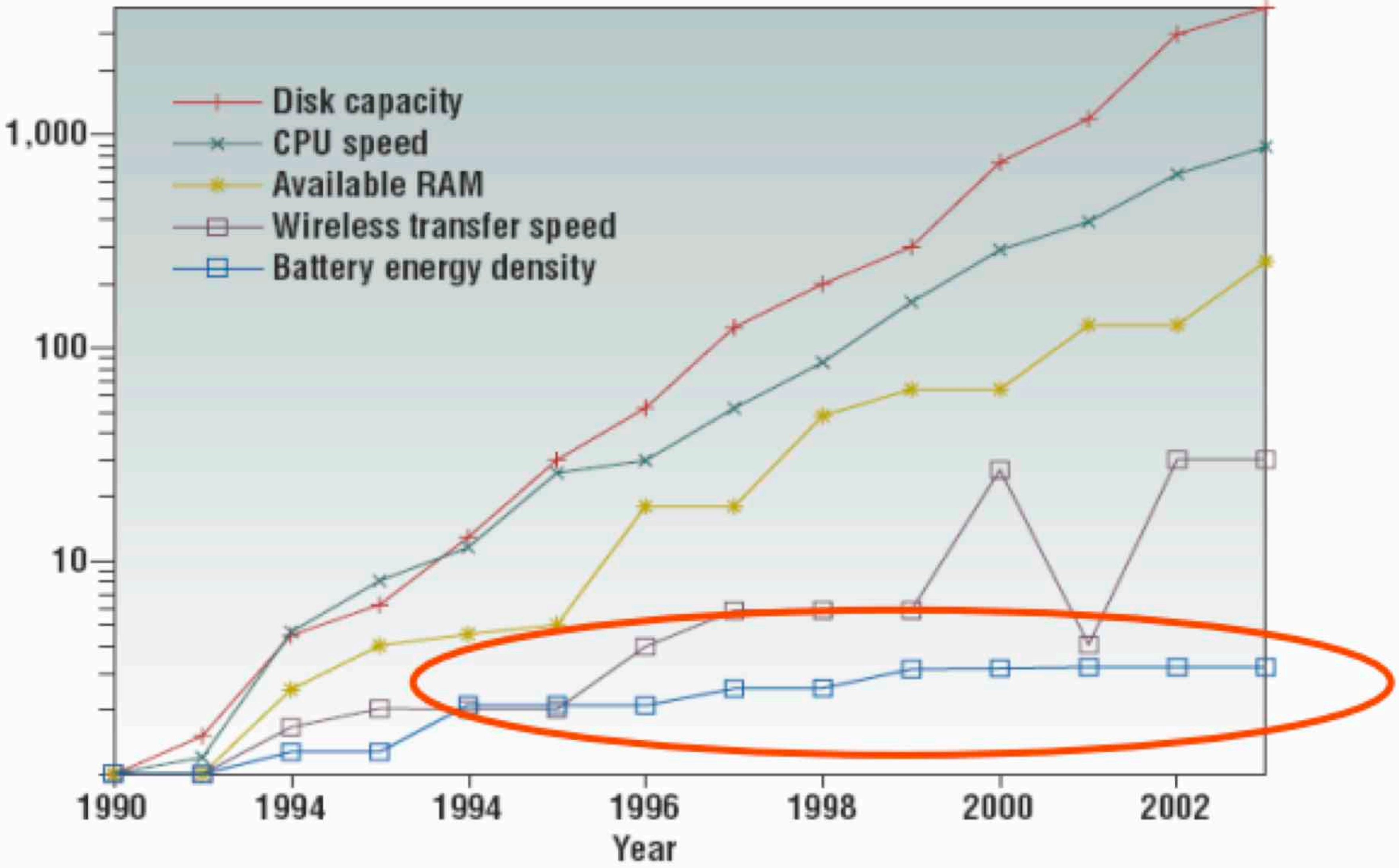
Bio-Electronics Integration

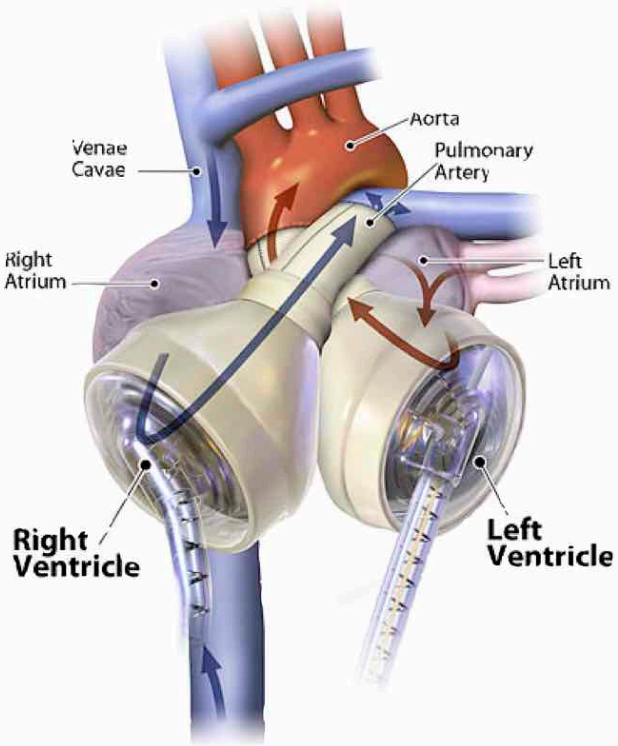


Moore's Law

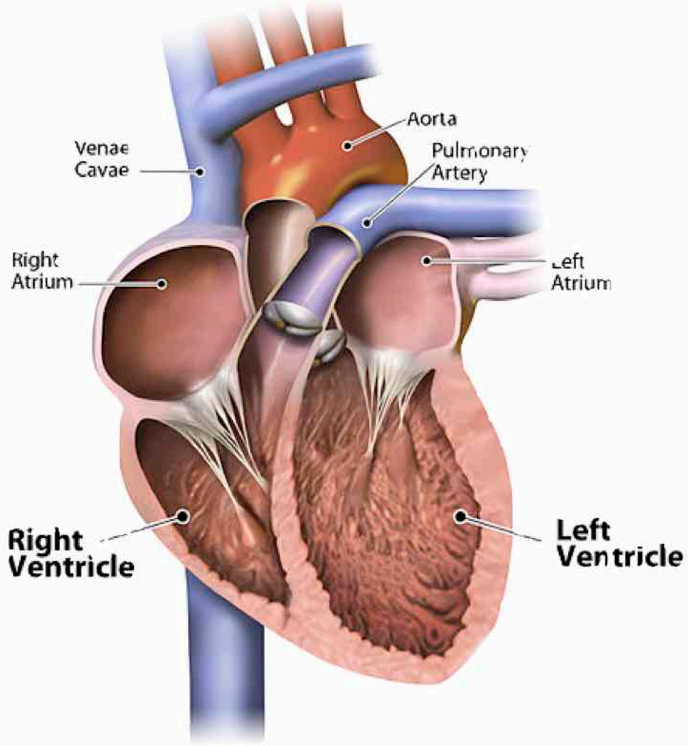


Mobile Computing Improvement – Paradiso, *et al.* Pervasive Computing, IEEE, 2005.

Why bio-nano integration ?



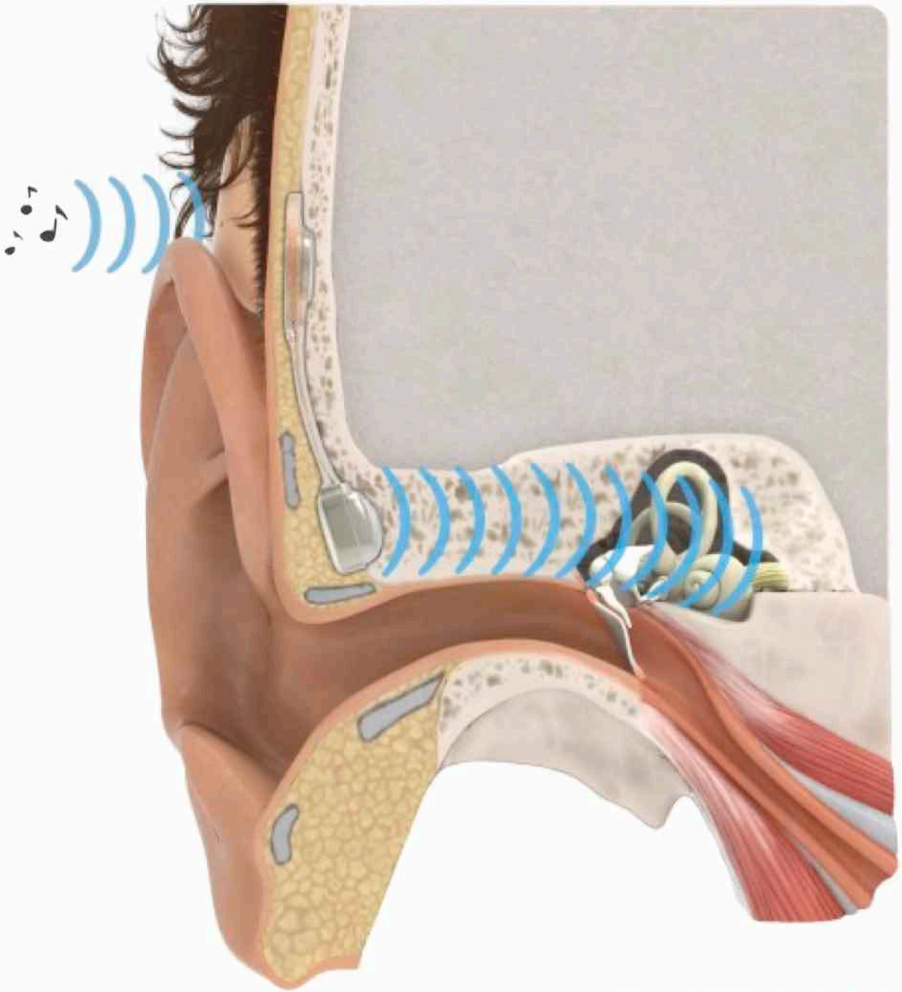
Total Artificial Heart



Human Heart

File source: wikipedia.org

Why bio-nano integration ?



File source: wikipedia.org

Artificial Hearing

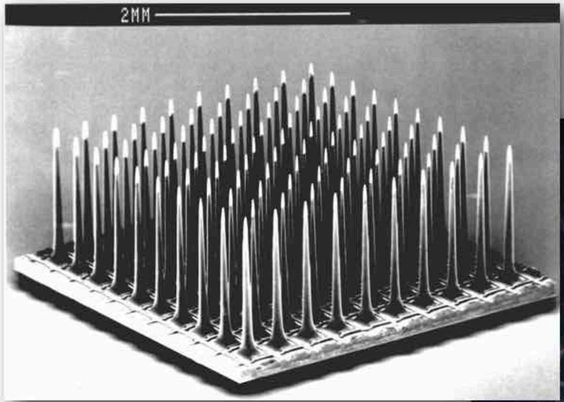
- Humans are living longer
- We need medical care
- Technology integration with the human body is inevitable (maybe only as a transition phase, but still…)

Living to non-living interface

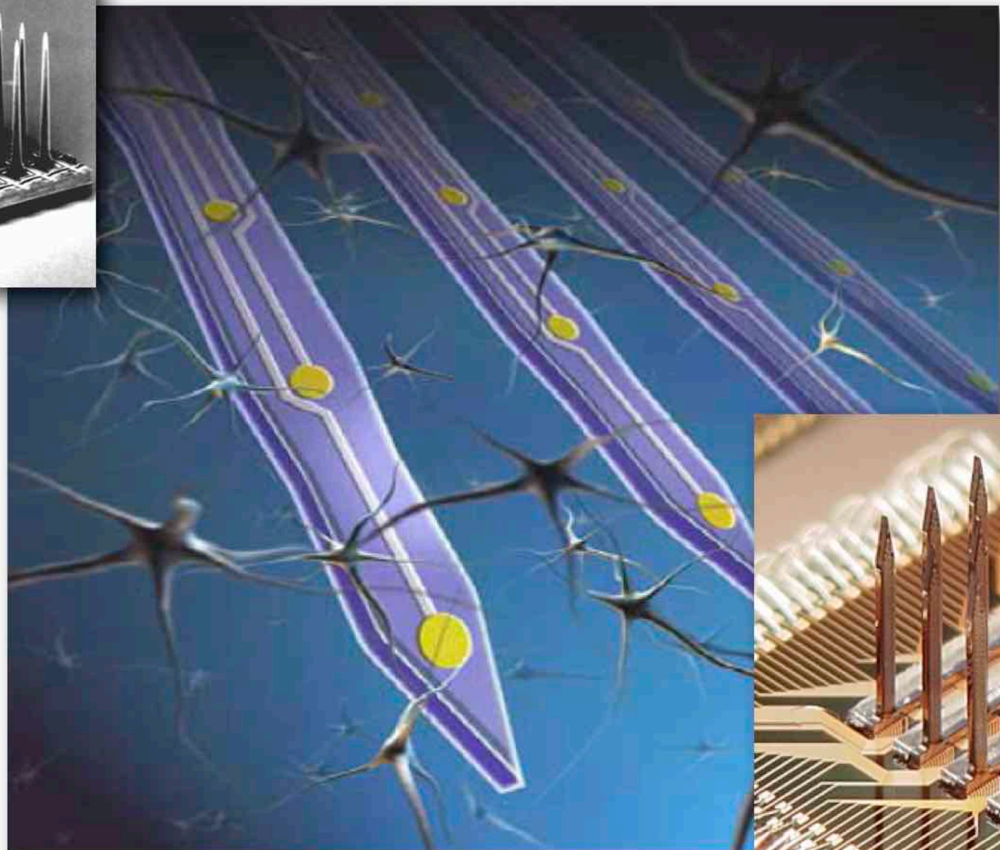
Body to technology distance :

- infinite
- external (shared)
- external (personal)
- internal (temporary)
- internal (permanent)
- iCyborg ?

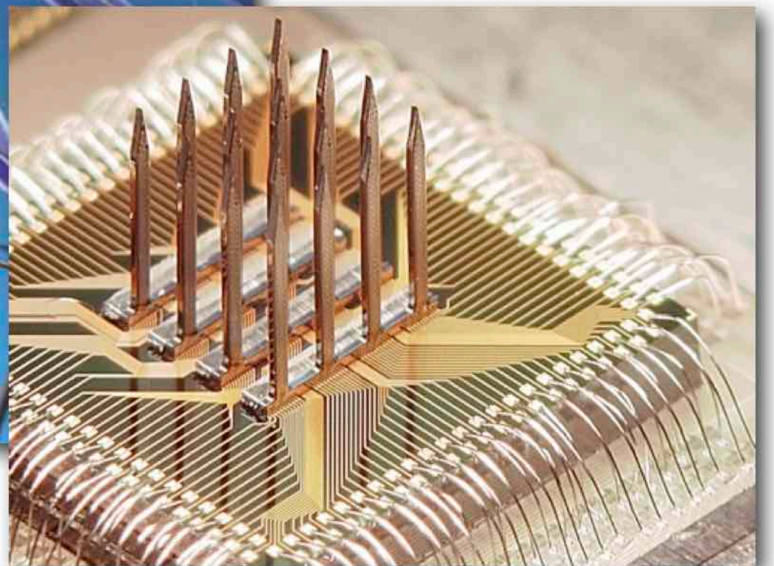

Living to non-living interface



Utah microarray



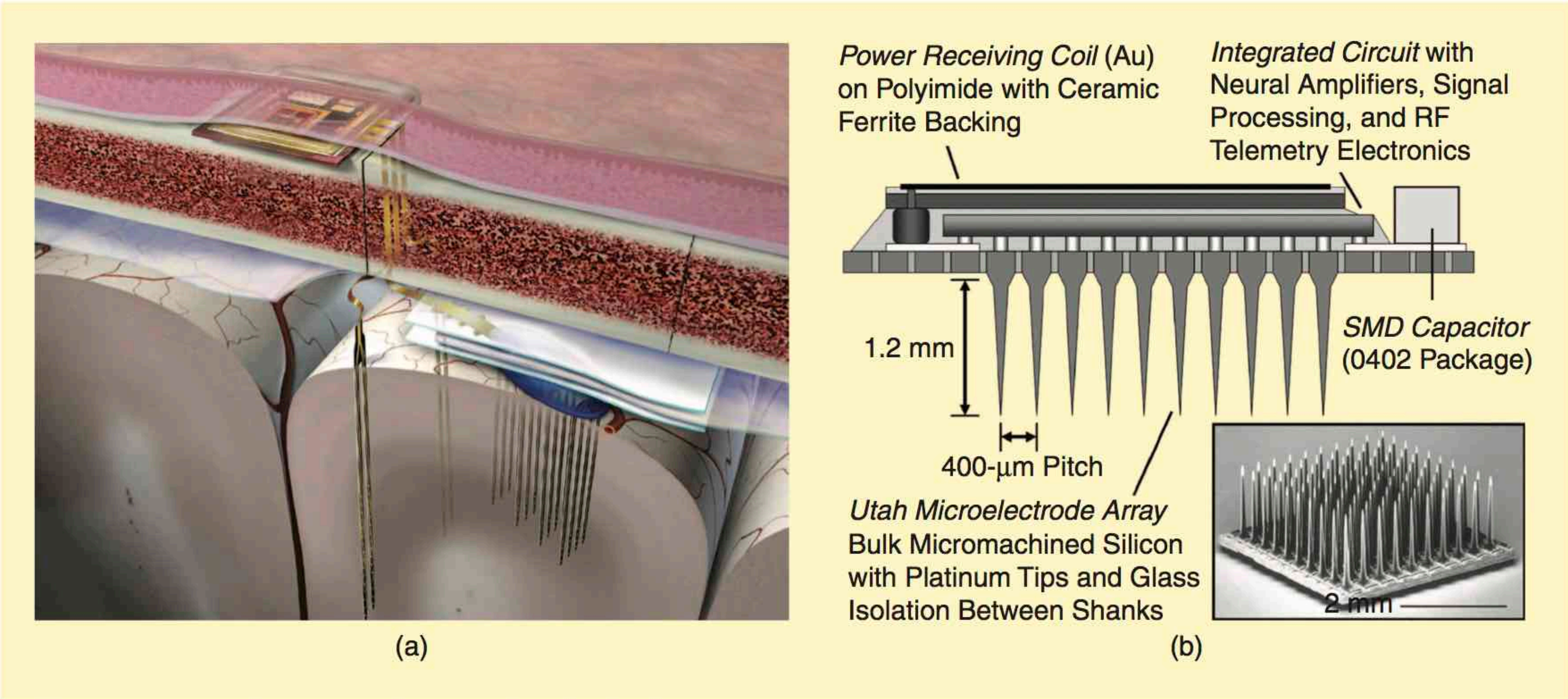
NeuroNexus Technologies



Living to non-living interface

Brain Computer Interface (BMI)

- 256 micro-electrodes interface, ~ 15mW, ~ 30mm^2 IC
- 4-8MHz inductive power link, 70-200MHz data link, 2Mb/s data rate

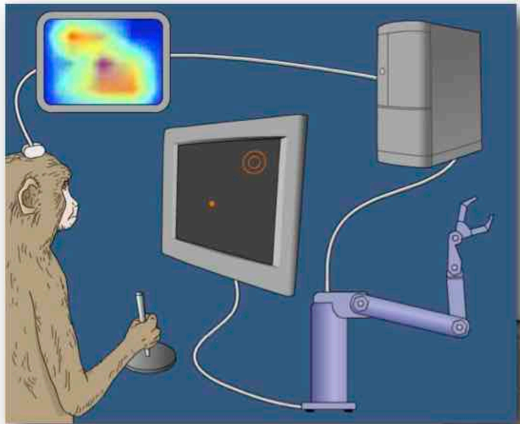


R. Bashirullah, Wireless Implants,IEEE Microwave Magazien, December 2010

Living to non-living interface

Brain Computer Interface (BMI) :

Magic of "mind control"

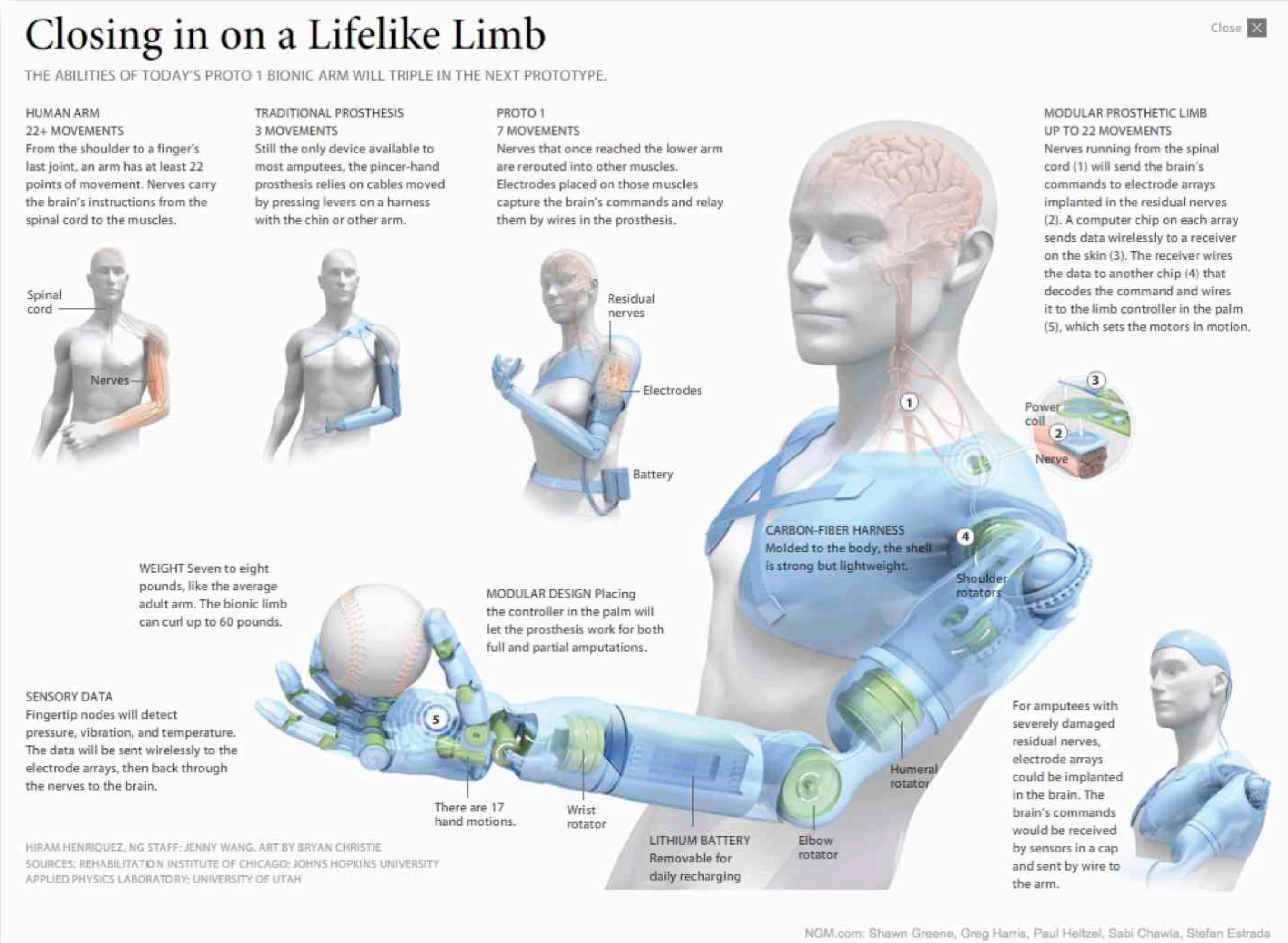


Prof. Miguel Nicolelis, Duke University

Mr. Jessie Sullivan, Prof. Todd Kuiken, Northwestern Medical School, Chicago

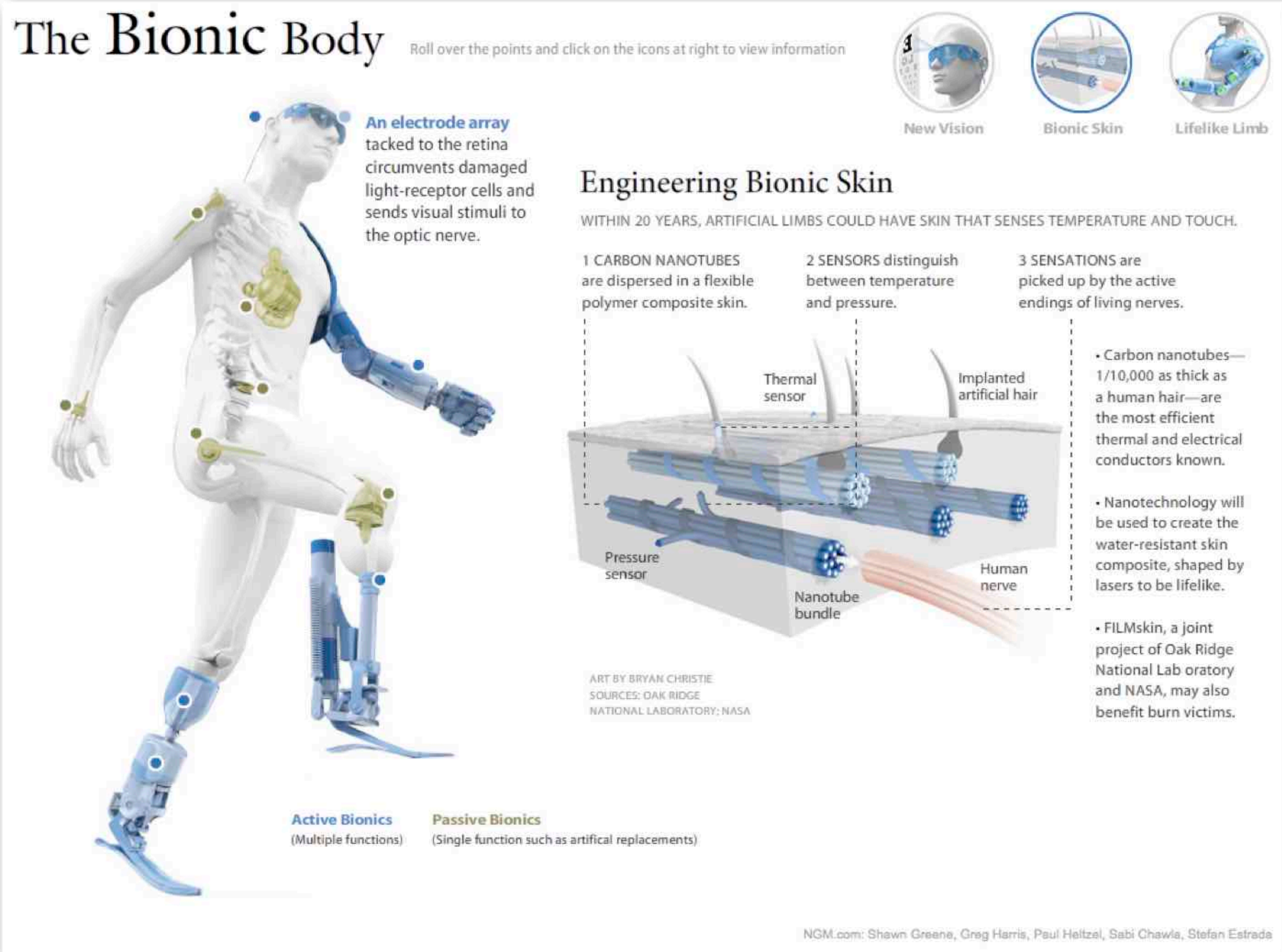
Bionic idea

"Enhanced human"



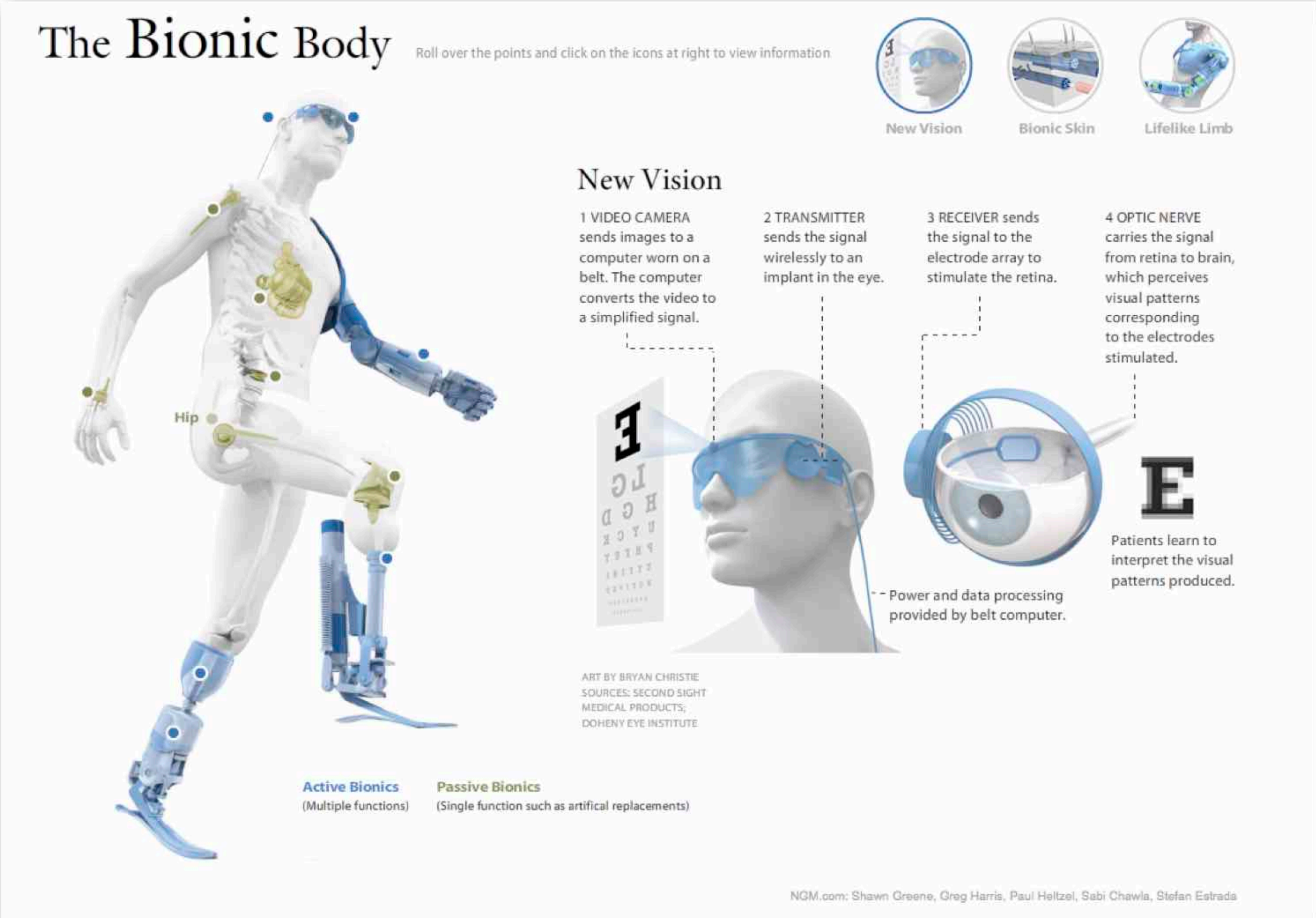
Bionic idea

"Enhanced human"



Bionic idea

"Enhanced human"



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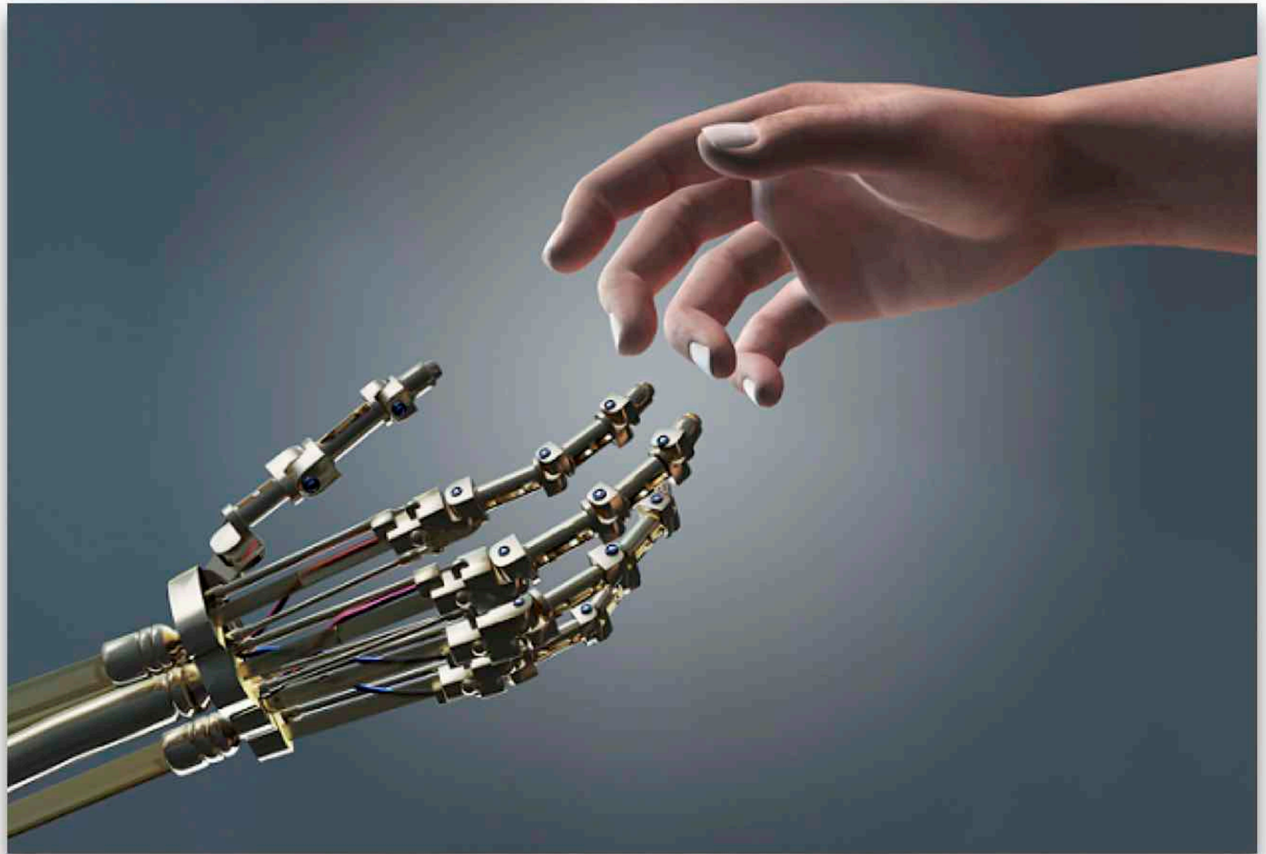
Living to non-living interface

"Missing links" : where is the border between the human and the machine ?



http://www.watchdocumentary.tv/future-human-2-the-cyborg-revolution-documentary/

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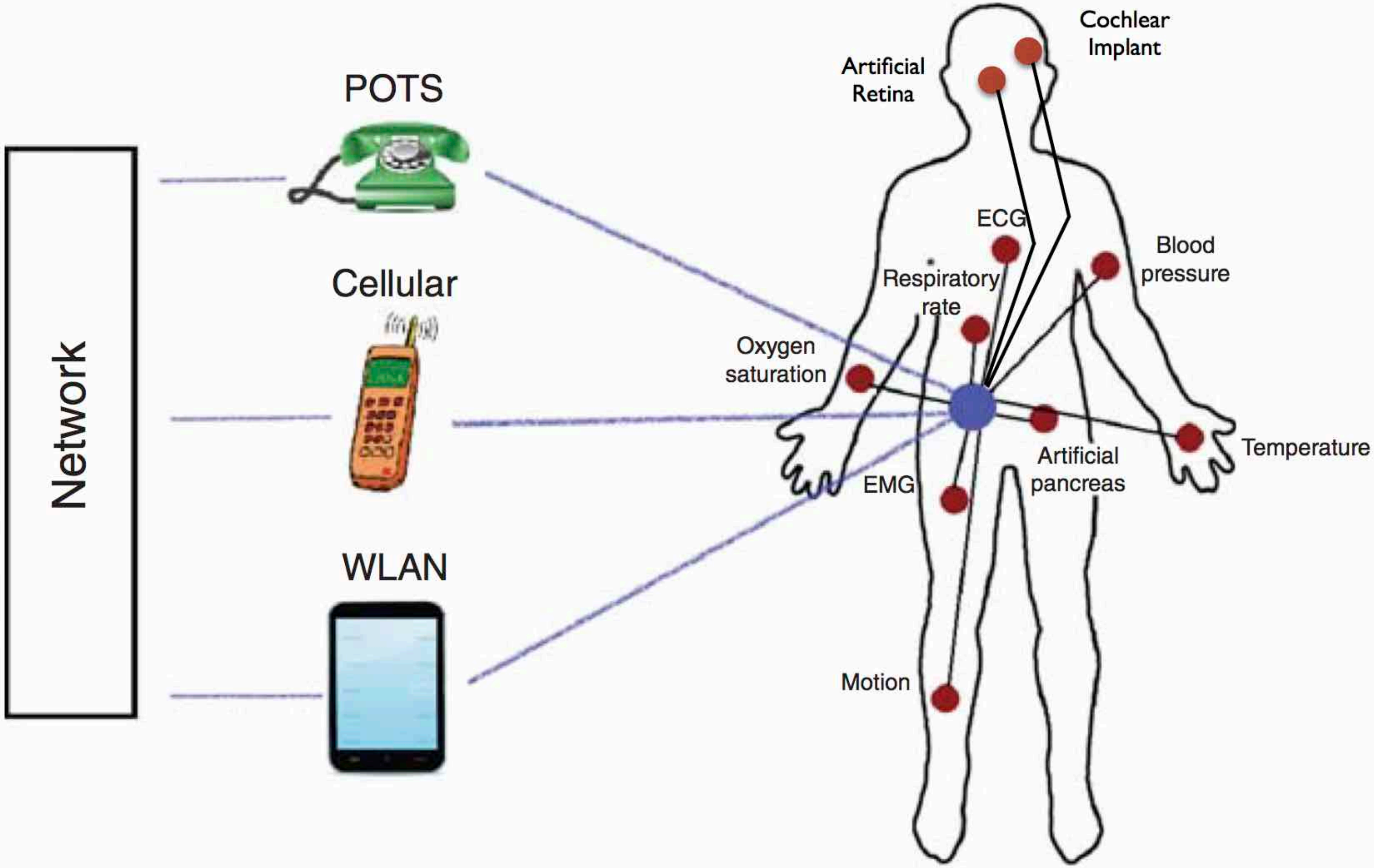
Implantable Technology Today

Telemetry systems :



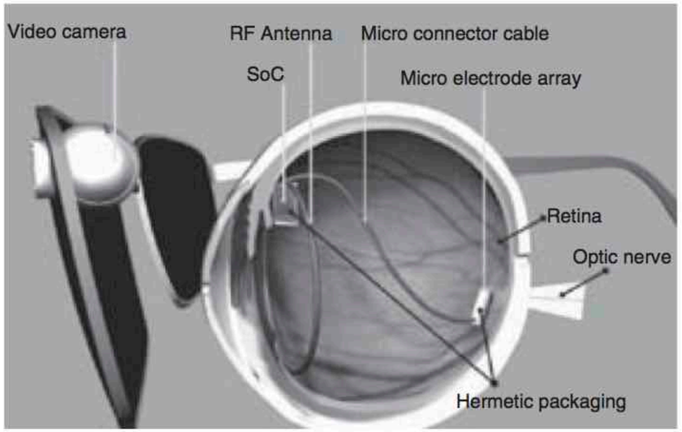
K.S. Nikita, ed.

Handbook of Biomedical Telemetry, First Edition © 2014 John Wiley & Sons, Inc.

Implantable biomedical devices

Categories :

- Wearable devices
- Implantable devices
- Ingestible devices



K.S. Nikita, ed.
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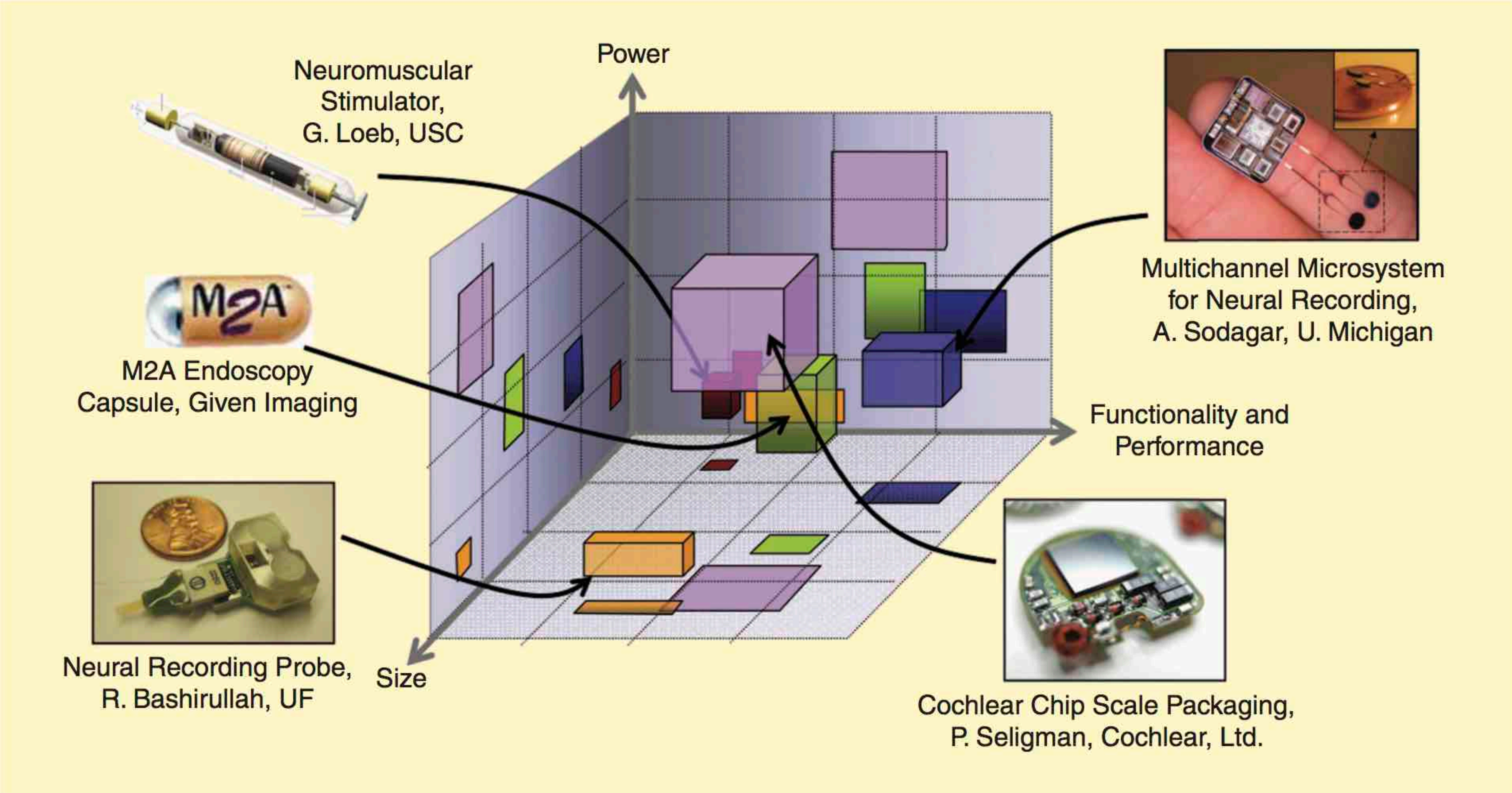
Implantable biomedical devices

System's parameter space :



R. Bashirullah, Wireless Implants,IEEE Microwave Magazien, December 2010

Implantable biomedical devices

Applications and power requirements :

Device	Power	Life-Time	Energy Source
Biomonitoring System	<100 μW	NA	Primary Battery
Pacemaker	<100 μW	10 Years	Primary Battery
Cardioverter-Defibrilator	Cont: <100 μW Peak: 5–10 W	10 Years	Primary Battery
Cochlear Processor	200 μW	1 Week	Rechargeable Battery
Hearing Aid	100–2,000 μW	1 Week	Rechargeable Battery
Retinal Implant	**40–250 mW**	NA	Inductive Power
Neural Recorder/Stimulator	**1–100 mW**	NA	Inductive Power
Artificial Heart	10–100 W	NA	Inductive Power

R. Ritter, J. Handwerker, T. Liu, M. Ortmanns

Telemetry for Implantable Medical Devices : Part 1—Media Properties and Standards

IEEE SOLID-STATE CIRCUITS MAGAZINE, Spring 2014, p.47-51

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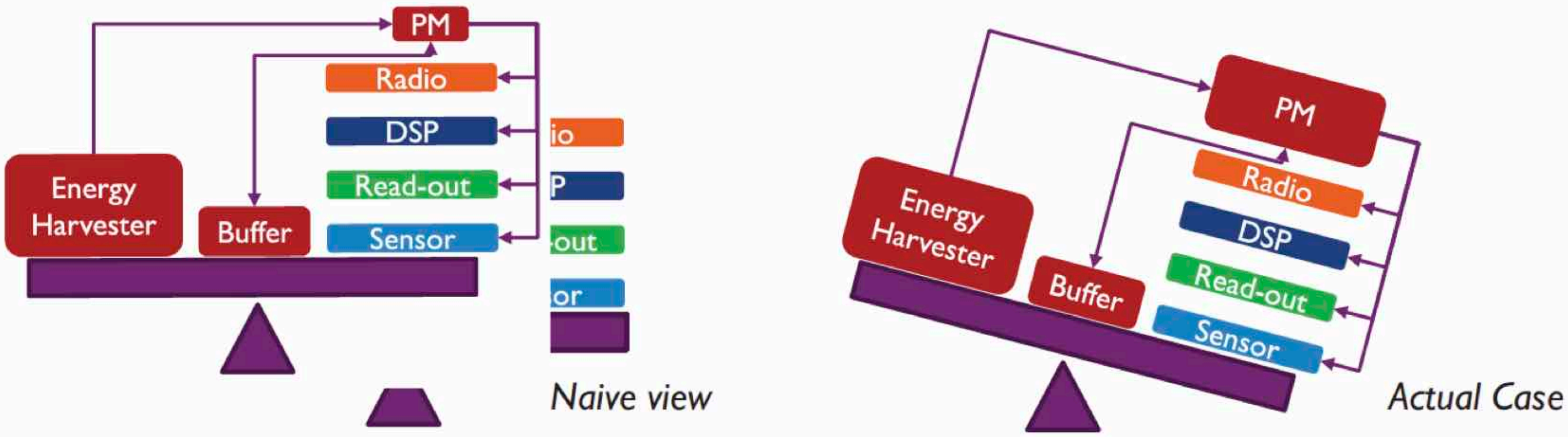
Implantable biomedical devices

Power management

- power usage must be minimized
- application specific IC design
- must increase the overall efficiency

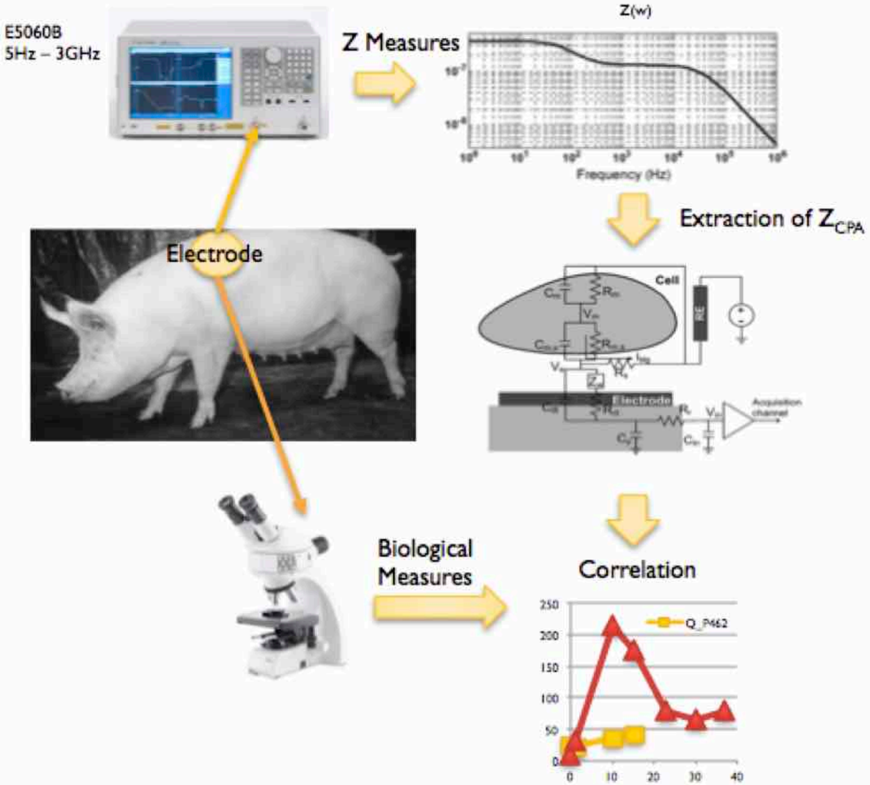


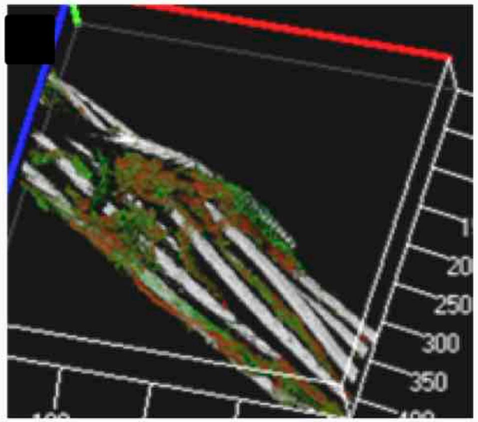
R. Vullers, Smart Systems for Healthcare and Wellness
BioCAS 2013 Tutorials

Implantable biomedical devices

Fibrosis issues :

- long term implantable devices induce fibrosis





N. Lewis at al. Study of fibrosis induced by an implanted medical device

IFRATH 2014

Implantable biomedical devices

Possible attacks :

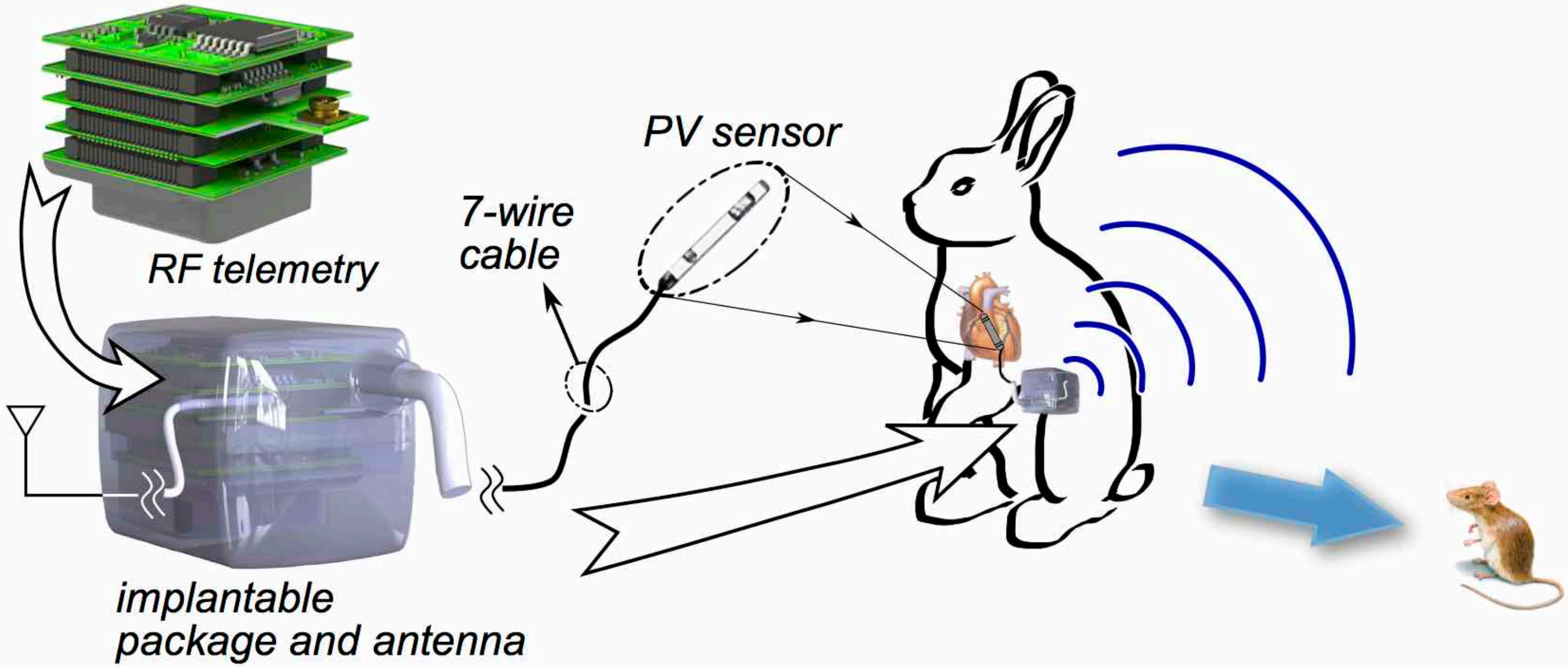
- Data harvesting
- Cloning
- Relay attack
- Physical compromise

Countermeasures :

- Limit the amount of data
- Distance measurement
- Blocking (using second tag)
- Authenticate readers
- Minimalistic cryptography

Implantable telemetry

Design case : PV cardiac monitoring



Implantable telemetry

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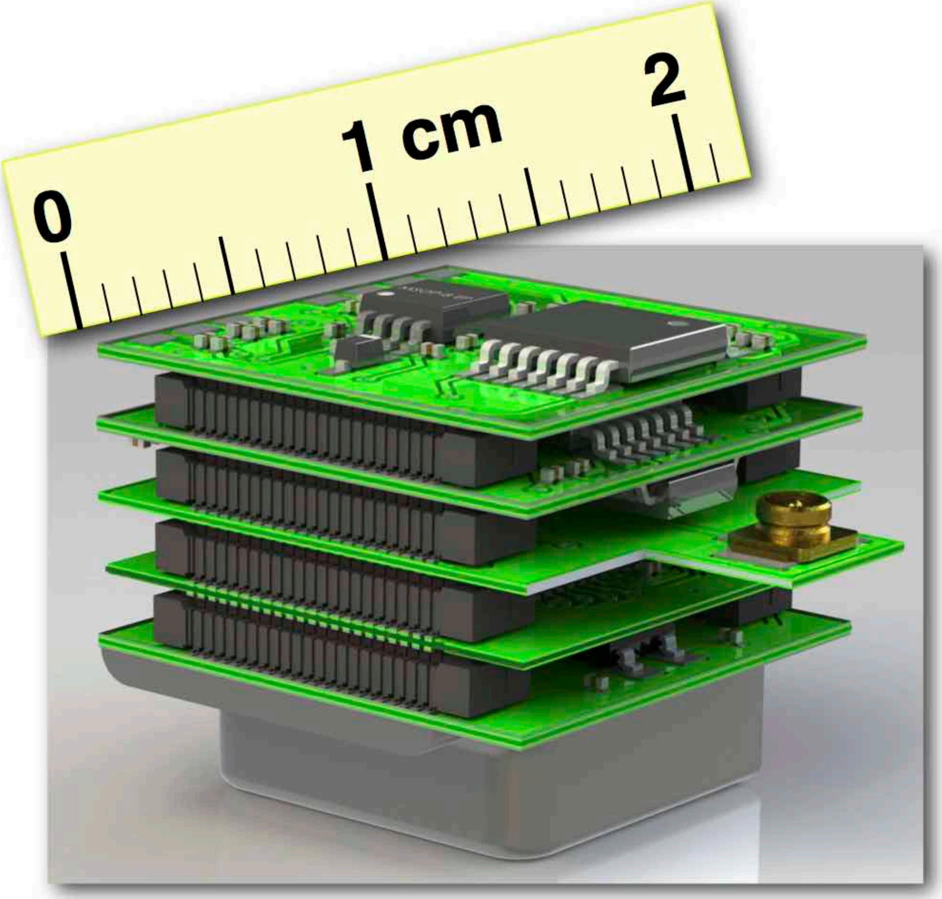

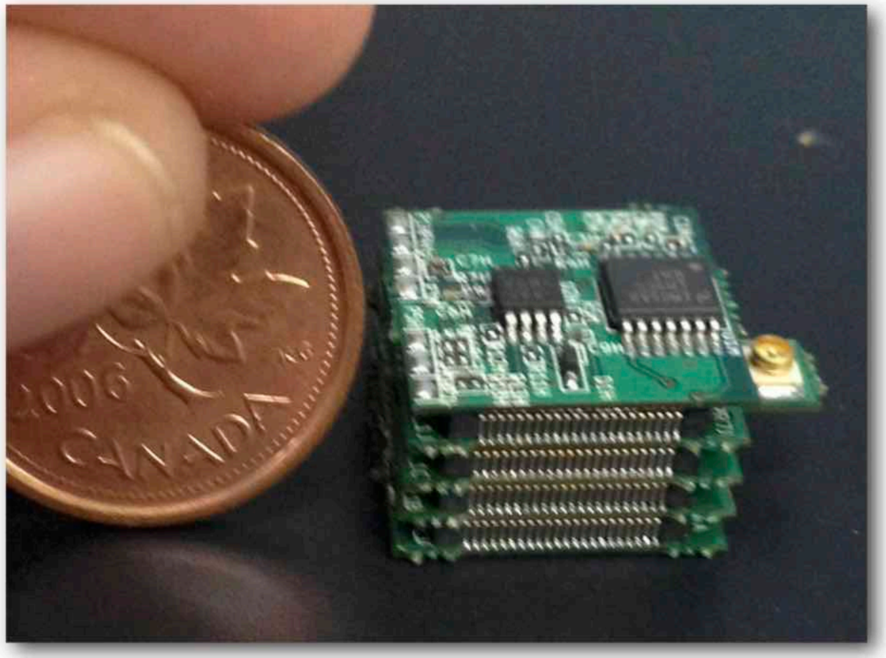

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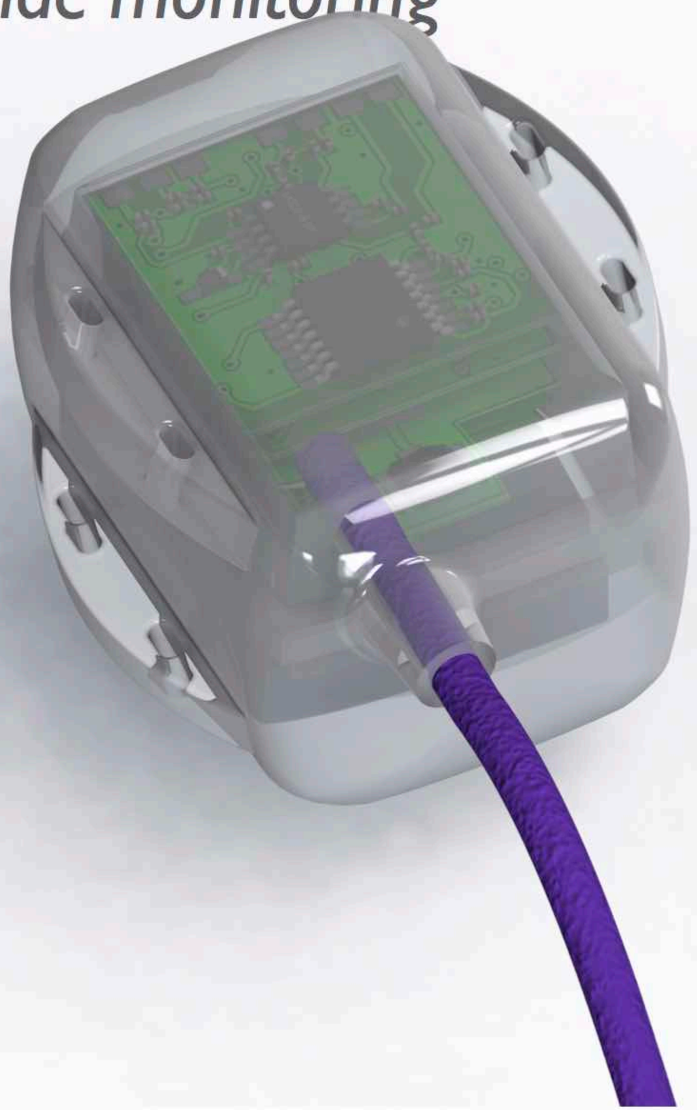
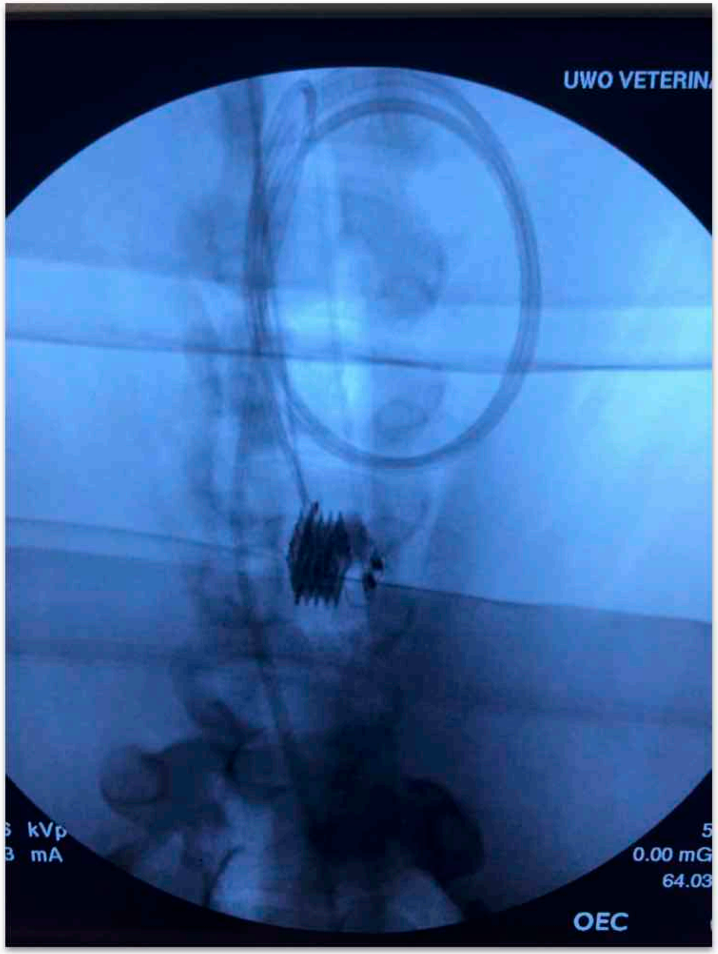
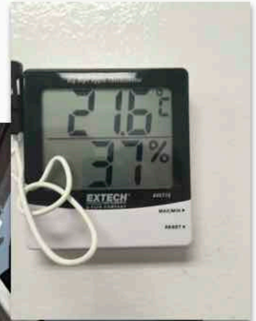
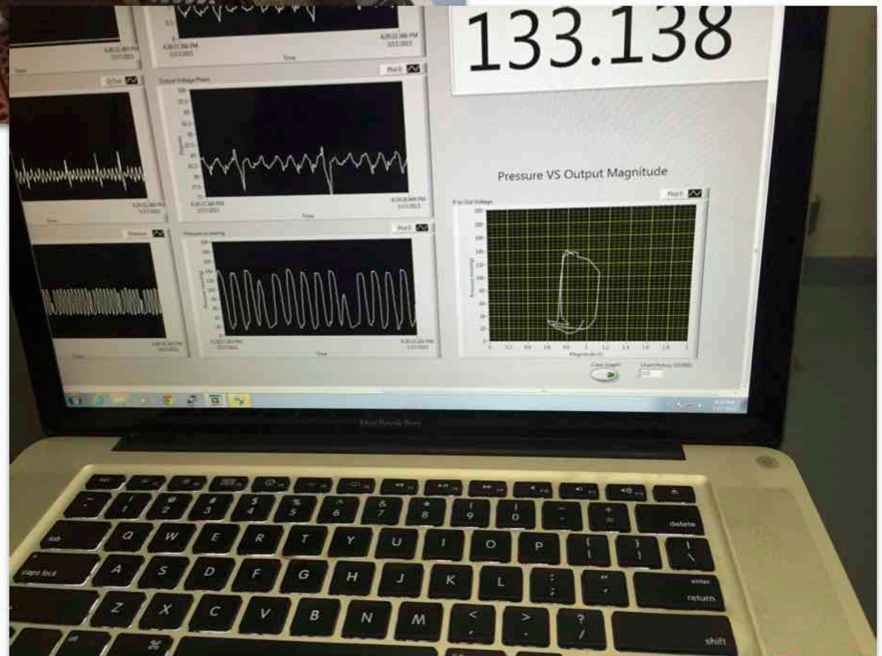


Implantable telemetry

Design case : PV cardiac monitoring







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Multidisciplinary research

- medicine: cardiology, genetics, …
- physics: biophysics, sensors…
- mixed-signal processing
- electronics, analog IC design
- communication theory, RF circuits
- semiconductor technology and manufacturing
- IC and biomedical test and characterization
- software tools IT support: Cadence, EM solvers,…
- … and, of course, …