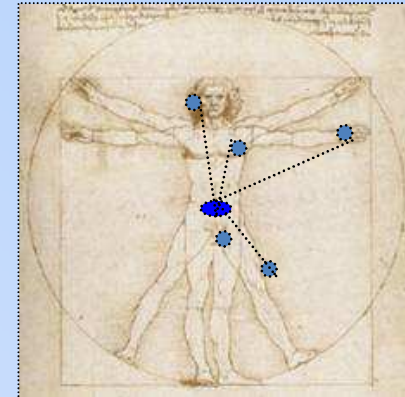




1st Invitational Workshop on
Body Area Network Technology and Applications
Future Directions, Technologies, Standards and Applications
June 19-20, 2011
Worcester Polytechnic Institute

Body Area Network (BAN) Standardization and future applications



**1st Invitational Workshop on
Body Area Network Technology and Applications
20 July, 2011, Worcester Polytechnic Institute**



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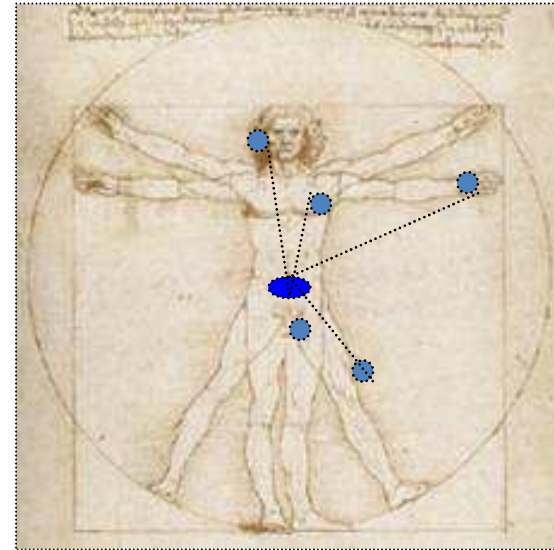
Agenda



- What is BAN?
- IEEE standardization progress
- Examples of BAN implementations
- Summary

What is BAN?

- Provides communication links in and around the body
- Allows communications between sensors, actuators and processing elements
- Hub allows nodes to be simpler, have a longer life and be less costly



IEEE Standards



- IEEE Standards are used around the world to help industries and companies open business opportunities, maximize research efforts, generate public and customer trust, build order in the marketplace and enhance safety.
- The IEEE Standards Association (IEEE-SA) is a leading developer of industry standards in a broad-range of industries. Globally recognized, the IEEE-SA has strategic relationships with the IEC, ISO, and the ITU and satisfies all SDO requirements set by the World Trade Organization, offering more paths to international standardization.

Purpose of IEEE802.15.6 Standard



The purpose of the proposed standard is to provide an international standard for a short range (i.e. about human body range), low power and highly reliable wireless communication for use in close proximity to, or inside, a human body.

(PAR 07-0575)

TG6 Proposal Level Membership



Broadcom Corporation
Casuh Corp
CEA-Leti
Chung-Ang University
City University of New York
CSEM
DecaWave Ltd.
ETRI
France Telecom
Fujitsu
Hitachi
Huawei
IMEC-NL
Inha University, Korea
Kairos Microsystems
KORPA
Kwangwoon University
LG Electronics

Meiji University
Micro Systems Engineering, Inc.
Motorola
NewLANS
NICT
NICTA
NIST
NXP
Panasonic Singapore Lab
Philips
Qualcomm
Samsung
Tensorcom
Texas Instruments
THALES Communications
Toumaz
University of Rochester
Yokohama National University
Zarlink

Liaisons: Medical ICT Consortium, eHealth, IEEE 802.15.4, IEEE1073

What was accomplished in TG6



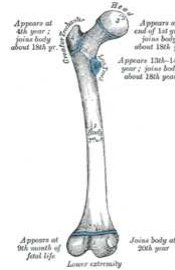
- 1/2008 TG6 formed in Taipei, Taiwan
- 5/2008 Call for Applications issued
- 11/2008 Call for Proposals issued
 - Application Summary Document
 - Technical Requirement Document
 - Channel Model Document
- 7/2009 Received 30 Proposals, begun merging process
- 3/2010 Merged to single proposal
- 7/2010 passed Letter Ballot 55 of Draft 01 76.73%
- 1/2011 passed Letter Ballot 66 of Draft 02 84.76%
- 5/2011 passed Letter Ballot 71 of Draft 03 87.88%

Body Tissue Types



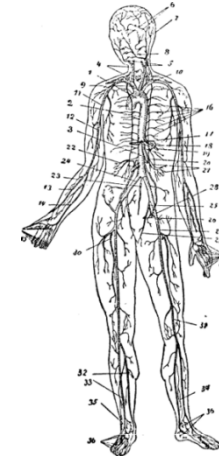
- **Connective tissue**

- Bone
- Blood



- **Muscle tissue**

- visceral or smooth muscle, inner linings of organs
- skeletal muscle, attached to bone for mobility
- cardiac muscle

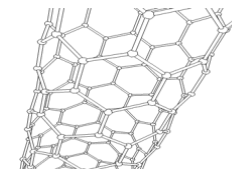


- **Nervous tissue**

- brain
- spinal cord
- peripheral nervous system

- **Epithelium**

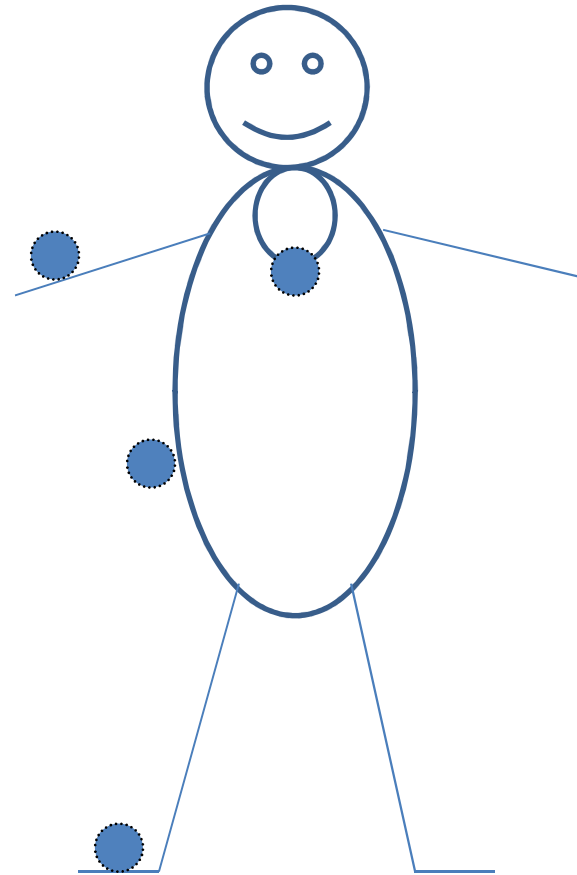
- surface of the skin
- inner lining of digestive tract: protection, secretion and absorption.



Possible hub locations

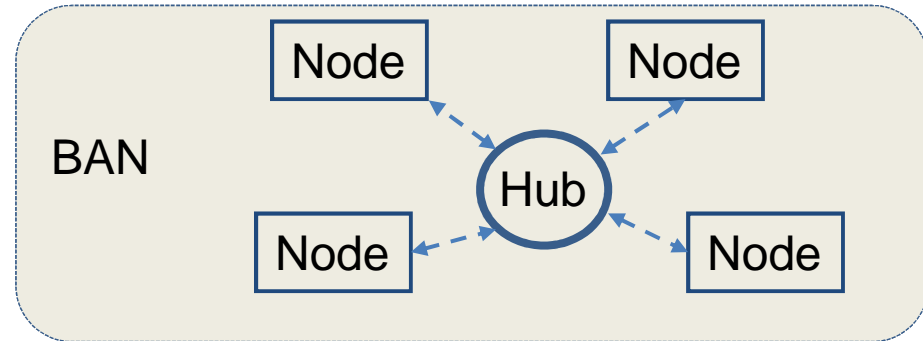


- Wrist
- Necklace
- Belt
- Shoe

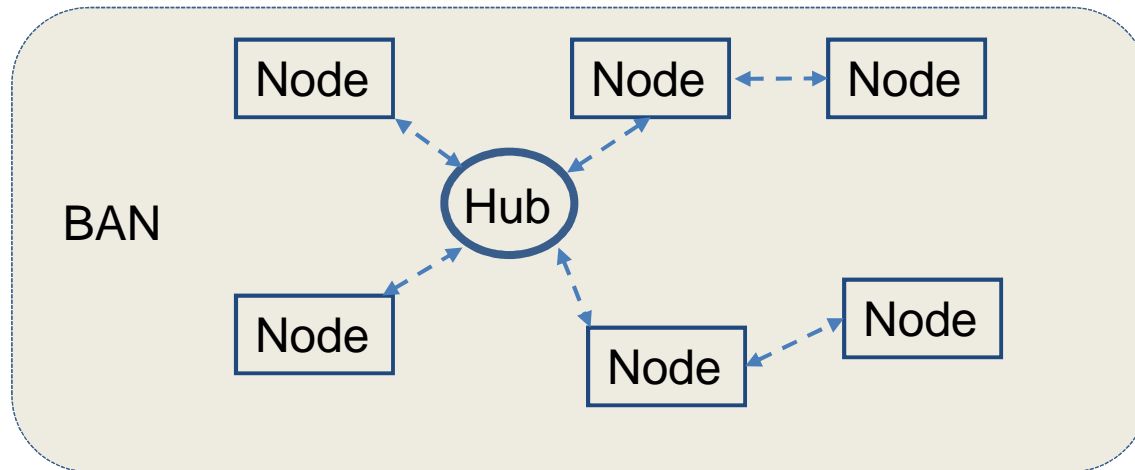


BAN Architecture

- Hub/Node



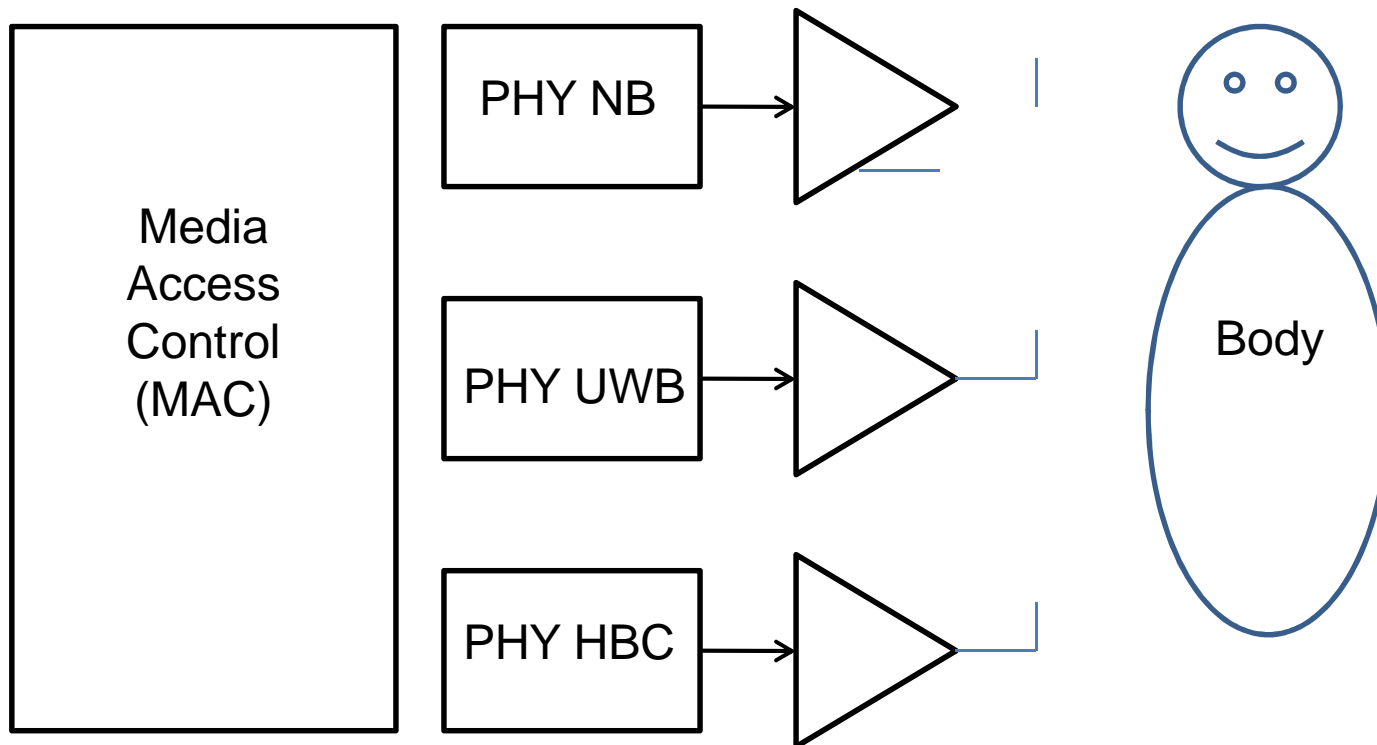
- Hub/Node with extension



806.15.6 Architecture



3 PHYs



Narrowband Channels



Frequency Band (MHz)	Number of Channels	Channel bandwidth
402 – 405	10	300 kHz
420 – 450	12	320 kHz
863 – 870	14	400 kHz
902 – 928	60	400 kHz
950 – 958	16	400 kHz
2360 – 2400	39	1 MHz
2400 – 2483.5	79	1 MHz

Narrowband Data Rates



Frequency Band (MHz)	Information Data Rate (kbps)
402 – 405	75.9
	151.8
	303.6
	455.4
420 – 450	75.9
	151.8
	187.5
863 – 870 902 – 928 950 – 958	101.2
	202.4
	404.8
	607.1
2360 – 2400 2400 – 2483.5	121.4
	242.9
	485.7
	971.4

Ultra wideband (UWB) bands



Band group	Channel number	Central frequency (MHz)	Bandwidth (MHz)	Channel attribute
Low band	1	3494.4	499.2	Optional
	2	3993.6	499.2	Mandatory
	3	4492.8	499.2	Optional
High band	4	6489.6	499.2	Optional
	5	6988.8	499.2	Optional
	6	7488.0	499.2	Optional
	7	7987.2	499.2	Mandatory
	8	8486.4	499.2	Optional
	9	8985.6	499.2	Optional
	10	9484.8	499.2	Optional
	11	9984.0	499.2	Optional

Ultra wideband (UWB) Data rates

- Impulse Radio (IR)

On-Off signaling

Uncoded bit rate (Mbps)	FEC rate	Coded bit rate (kbps)
0.487	0.81	394.8
0.975	0.81	789.7
1.950	0.81	1,579.0
3.900	0.81	3,159.0
7.800	0.81	6,318.0
15.600	0.81	12,636.0

DBPSK/DQPSK modulations

Mod	Uncoded bit rate (Mbps)	FEC rate	Coded bit rate (kbps)
DBPSK	0.487	0.5	243.0
DBPSK	0.975	0.5	457.0
DBPSK	1.950	0.5	975.0
DBPSK	3.900	0.5	1,950.0
DBPSK	7.800	0.5	3,900.0
DQPSK	15.600	0.5	7,800.0
DBPSK	0.557	0.5	278.0
DQPSK	1.114	0.5	557.0

- FM (optional)

FM-UWB data rate

Uncoded bit rate (kbps)	FEC rate	Coded bit rate (kbps)
250	0.81	202.5

Human Body Communication (HBC)



- The electrode in contact with the body is used for transmitting or receiving an electrical signal through the body.
- HBC uses 2 bands at 21MHz and 32MHz

Data Rate (21MHz)	Data Rate (32MHz)
164 kbps	250 kbps
328 kbps	500 kbps
656 kbps	1 Mbps
1.3125 Mbps	2 Mbps

MAC Features



- Supports Quality of Service (QoS)
- Supports MICS band communication support
- Supports Emergency Communications
- Supports hub to node as well as hub to node to node
- Strong Security
- Macroscopic and microscopic power management
- Coexistence and interference mitigation

MAC support of Priority



BAN Priority field encoding

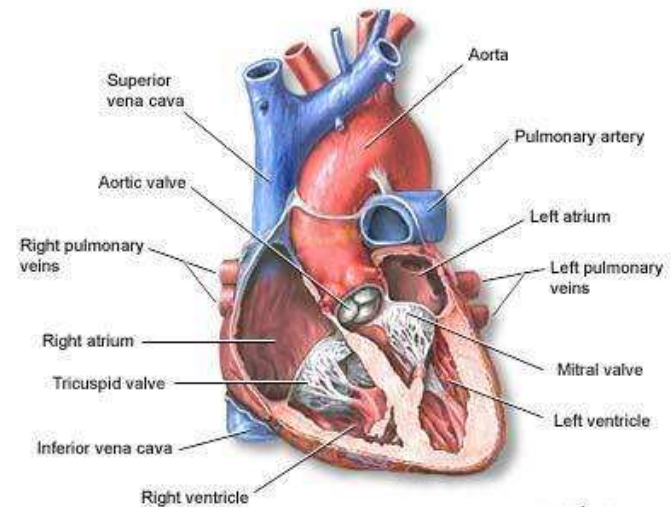
Field value in decimal	BAN services
0	Non-medical services
1	Mixed medical and non-medical services
2	General health services
3	Highest priority medical services

User priority mapping

Priority	User Priority	Traffic designation	Frame type
Lowest	0	Background (BK)	Data
	1	Best effort (BE)	Data
	2	Excellent effort (EE)	Data
	3	Video (VI)	Data
	4	Voice (VO)	Data
	5	Medical data or network control	Data or management
Highest	6	High priority medical data or network control	Data or management
	7	Emergency or medical event report	Data

BAN in Diagnostic Medical Devices

- **Heart Failure (congestive)**
- **Heart Rhythm Management**
 - *Bradycardia* - beating too fast
 - *Tachycardia* - too slow
 - Atrial Fibrillation or AFib - irregularly.
- **Hypertension**
- **Diabetes**
- **Parkinson's Disease**
- **Epilepsy**
- **Mood detection / Depression**
- **Pain Management**



ADAM

BAN definition of therapy

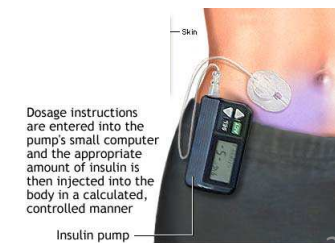


- Sense (mechanical, electrical, chemical)
- Process with therapy software
- Present to doctor (with alternatives)
- Allow doctor to stimulate (mechanical, electrical, chemical, pharmacological) remedies

Medical devices



- Pacemaker
- Implantable Cardioverter Defibrillator (ICD)
- Spinal Actuators
- Insulin pump
- Continuous Glucose Monitoring
- Deep brain stimulator
- External & Implantable Hearing Aids - cochlear implant
- Retina implants
- Muscular signal replacement



Clinical Applications: Sensors



- Temperature monitor
- Blood pressure sensor
- Mechanical motion sensors
- Respiratory monitor
- Saturation of Peripheral Oxygen (SpO2) - pulse oximeter
- Heart rate monitor
- Electro Cardiogram (ECG)
- pH value sensor
- Glucose sensor
- Electro Encephalography (EEG)
- Electromyography (EMG) (muscular)
- Brain liquid pressure sensor
- Fertility Monitor
- Endoscope (gastrointestinal)
- Temperature Modulation Therapy (TMT)

Physiological and vital signals monitoring

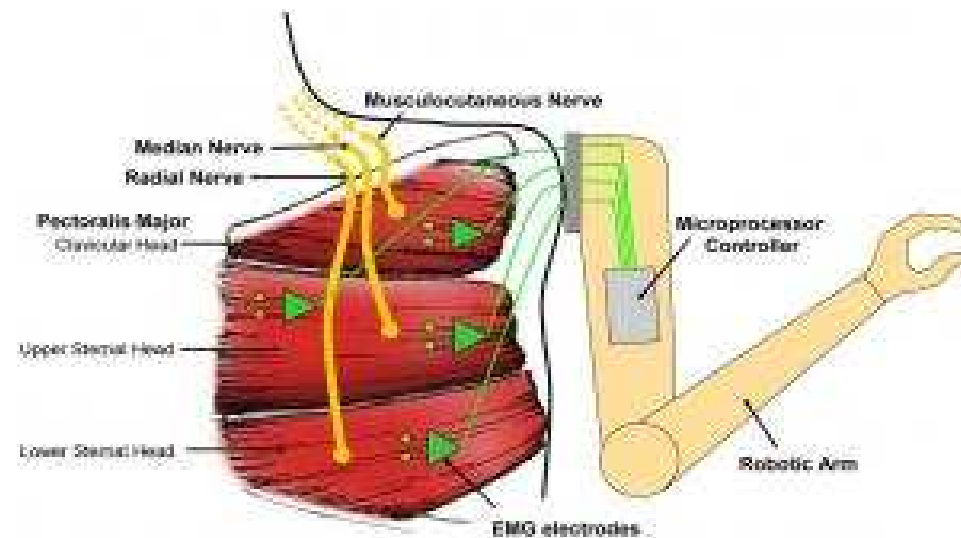
Clinical Applications: Actuators



- Deep brain stimulator - Parkinson's disease
- Cortical stimulator
- Epilepsy Stimulator
- Visual neuro stimulator
- Audio neuro stimulator
- Muscular stimulator
- Insulin pump
- Internal cooling -Temperature Modulation Therapy
- Wireless capsule for drug delivery

BAN and Prostheses

- BAN prosthesis status sensing
- BAN prosthesis control
- Prosthesis failure diagnostic



Summary



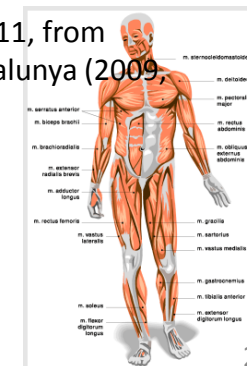
- BAN standard will allow medical device intercommunications
- Experiments with BAN enabled diagnostics are proving to have high therapeutic value.
- There are many worthwhile applications that need to bridge the biological sensors and actuators on and in body to the world of computers and devices
- Some will provide better healthcare, quicker patient recovery and new therapies.
- Some will greatly increase convenience of users
- Some critical apps like the war fighter require physiological monitoring
- Physicians wish for less wires in patient diagnosis environment, especially in critical care
- The body channel model is challenging, had a lot of contributions from many organizations
- Status: became 802.15 Task Group 6 in Jan 2008, had 30 proposals in 2009, merged to single on March 2010.
- Currently preparing for ballot process to finish by July 18, 2011 meeting in San Francisco



Thank You
Dankeschön
Merci
どうもありがとう。
謝謝!!
Bedankt

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The HP Garage



The HP Garage is California Historic Landmark No. 976 —
Birthplace of Silicon Valley. (1939 photo)

Role of smart phone



- “There is an app for this...”
- “A cell phone becomes an integral part of a medical device”.
- “A cell phone can cut the cost of almost every [diagnostic] device.”

Role of smart phone



- Despite all the advances in medical diagnostics, two-thirds of the world's population has no access to imaging technologies. Worse, about half of the imaging equipment sent to developing countries goes unused because local technicians aren't trained to operate it or lack spare parts, according to the World Health Organization. But thanks to the proliferation of cellular and other wireless networks, researchers are stepping up efforts to deliver crucial medical services from afar. [9]
- The University of California Bioengineering professor, says that by reducing a complex electromagnetic imaging machine to a portable electromagnetic scanner that can work in tandem with a regular cell phone and a computer, he has essentially replicated a \$10,000 piece of equipment for just hundreds of dollars. The mobile scanner plugs into the phone, which beams the data to the computer, generating an image that can be transmitted to a doctor or hospital far away.

Microsoft Research's in biomedical computing.



Some 30 health-care-related projects at various universities recently funded by Microsoft Research, 17 involve cell phones. One team, at Washington University in St. Louis, is attempting to take ultrasound readings using a cell phone and a TV. Scientists at the University of Pittsburgh are working to create a heart monitor that relies on a cell phone to analyze the readings and dial 911 whenever a person's cardiac activity careens into dangerous territory, providing emergency responders with a location and a preliminary diagnosis. "The cell phone is going to solve rural health-care problems, whether it's rural India or rural Indiana," says Kristin Tolle, Microsoft Research's program manager for external research in biomedical computing.

CardioMEMS EndoSure



CardioMEMS EndoSure
Wireless Pressure Sensor

- The EndoSure Wireless Pressure Measurement System is composed of two components: a miniaturized, wireless implantable sensor and an external electronics module. The external electronics module wirelessly communicates with our sensors to deliver vital patient data. Wireless sensors are powered by RF energy delivered by an external electronics module and transmit real-time data without batteries.
- The EndoSure sensor is designed and manufactured using micro-electromechanical systems, or MEMS, technology, which enables the fabrication of millimeter-scale devices with internal features in the nanometer to micrometer range. MEMS technology allows the creation of sensors with measurement stability and energy efficiency.
- The EndoSure sensor is approximately the size of a paperclip. It is a hermetically sealed circuit, encapsulated in fused silica and silicone, and is surrounded by a PTFE-coated nickel-titanium wire. Inside the fused silica is a micron scale cavity. Changes to the membrane of this cavity result in changes to the sensor's resonant frequency. These changes correlate to pressure changes. The sensor contains no batteries or internal power source, but is instead powered by RF-energy provided by a proprietary electronic antenna. [9]

<http://www.cardiomems.com/content.asp?display=medical+mb&expand=ess>

Gentag



Gentag also embeds a tiny sensor into the bandage that can continuously take a patient's temperature and notify a nurse if the person is running a fever



Gentag's technology can also be used to relay results from a urine test used to determine a patient's prostate health

Life Record

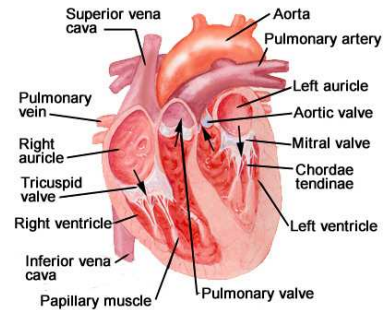


A software company called Life Record is using the iPhone to help physicians view patients' medical records, including electrocardiograms and brain scans, on the go.

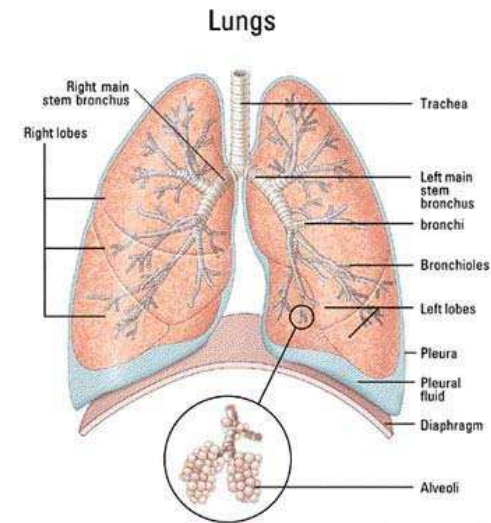
Life Record has developed software that lets doctors use an Apple iPhone to retrieve patients' records, including X-ray images and lab results. Doctors can also use the software to prescribe medicines. In June, Life Record plans to release a version of the software that makes it easy for people to keep tabs on their own health information—say, to transfer medical records to a new physician or share an ultrasound image of an unborn baby with loved ones. [9]

Organs in focus

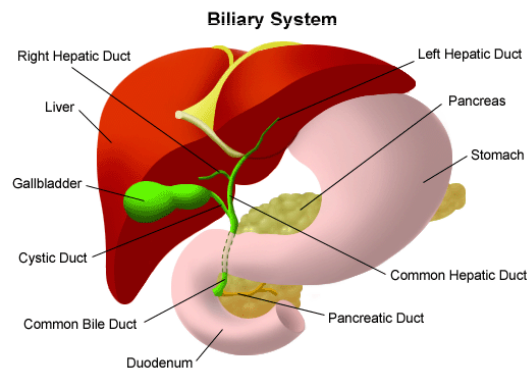
- Heart



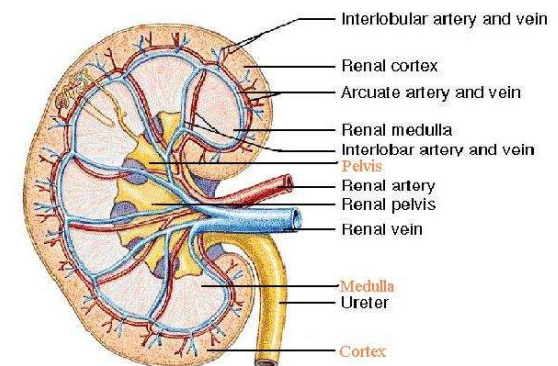
- Lungs



- Liver



- Kidneys



Cancer treatment



- Diagnosed with metastatic melanoma 6/2010
- Surgery 7/2011 remove lymph nodes
- Signed up for trial: Ipilimumab (“ipi”) 11/2011
- Side effects: colitis, digestive track, pneumonia, afibrillation, congestive heart failure, diabetes
- Aggressive treatment with MICT
- FDA approval for “ipi” on 25 March 2011