The Trillion Sensors (TSensors) Foundation for the IoT

Dr. Janusz Bryzek

Chairman and CEO, TSensors Summit

Outline

- Introductions to emerging sensor driven major economic tides and TSensors.
- Showcase of amazing sensor based products

Technical Revolutions Shifting Global GDP Leaders*

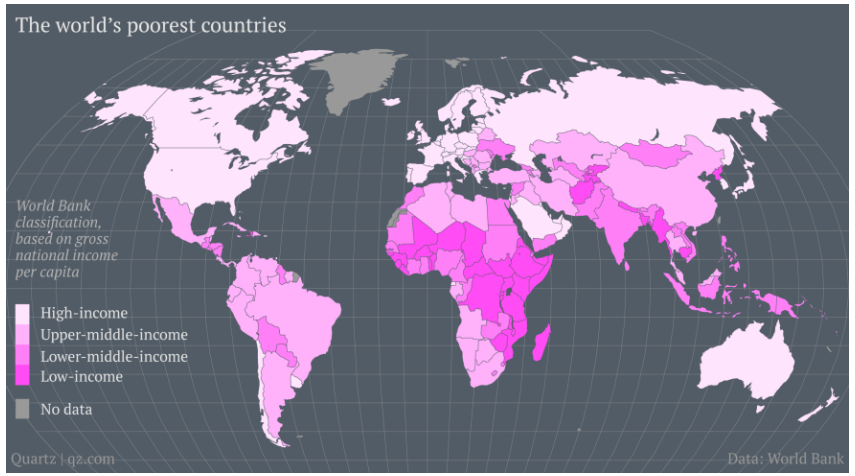
- In the 18th century, GDP depended on the size of population.
  - China and India dominated global DGP.
- 1st Technical Revolution brought steam, electricity, internal combustion, radio, aeronautics.
  - Europe started to dominate global GDP.
- 2nd Technical Revolution brought transistor, computer, internet.
  - US and Japan started to dominate global GDP.
- Emerging 3rd Technical Revolution fuses *computing*, *communication* and *sensing*.
  - Expected to free people from manual labor, leaving for them creative work.

- Expected 4th Technical Revolution: machines take over the world, leaving for humans enjoyment in a virtual world through a direct computer-brain communication.

* Concept of the first three Revolutions was introduced by Vijaj Ullal, President of Fairchild Semiconductor. Extrapolation to the 4th revolution by J. Bryzek..

Abundance is Enabled by the 3rd Technical Revolution

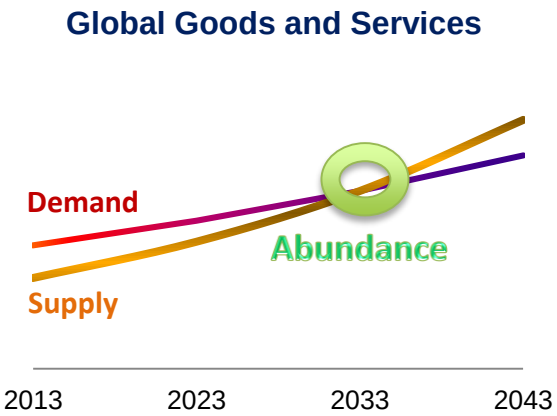
- Abundance is defined as the World:
  - Without hunger.
  - With medical care for all.
  - With clean water and air for all.
  - With clean energy for all.
- Abundance is expected to be reached in one generation (20 years) and will need (among others) 45 trillion sensors.
  - Many not yet developed.
- Historical sensor development cycles from prototypes to volume production were 30 years.
  - Left to historical cycles, slow *new* sensor commercialization would delay the Abundance.



Bill Gates: No Poor Countries by 2035 = Abundance

Abundance Enablers

1. Exponential technologies produce goods and services faster than growth of demand:
   - Biotechnology and bioinformatics
   - Medicine
   - Nanomaterials and nanotechnology
   - Networks and sensors
   - Digital manufacturing (3D printing) and infinite computing
   - Computational systems
   - Artificial intelligence
   - Robotics



2. Billionaire DIY (Do-it-Yourself) revolution:
   - Power of individual innovators capable of “impossible”.
   - E.g., flying into space (Burt Rattan) and sequencing human genome (Craig Venter), building electric car (Elon Musk), etc.
3. Unrivaled in history billionaire technophilanthropic force:
   - E.g., Gates, Zuckenberg, Omidyars, etc.
4. The rising billion:
   - Billion of the very poorest of the poor on earth is being plugged into global economy through a global transportation network, Internet, microfinance and wireless communication.

Abundance benefits from multiple emerging global economic tides, such as Exponential Organizations, IoT and Digital Health.

Exponential Organizations (ExO)

- Disruption cycle time for business has been shrinking:
  - 65 years for companies formed 100 years ago, to…
  - About 15 years currently.
- New breed of Exponential Organizations has emerged demonstrating exponential growth, such as:
  - Grand Theft Auto game: $800M in 72 hours.
  - Instagram: 2 years to $1B
  - Uber: 3 years to $1B
  - AirBnB: 3 years to $1B
  - Square: 2 years to $1B
  - DropBox: 4 years to $1B
- ExO's create new business models disrupting global economy.

6D Process for ExO's

- ExO's follow a 6D process that affects every product, service, company and industry:
  - Products or services are **D**igitized (information technology),
  - which leads to **D**eceptive phase (new technologies seem not good enough for key players),
  - which leads to **D**isruptive phase (new technologies improve and disrupt existing players),
  - which leads to **D**ematerialization: *physical products or service becomes digitized and distributed as bits* on the pre-existing ubiquitous platforms.
  - which leads to **D**emonetization: *dematerialized products (bits) can be freely distributed globally*,
  - which leads to **D**emocratization, with enables growth everywhere.

Example of 6D's for Semi and Sensor Industry

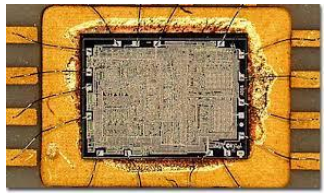
- **D**igitization
  - Designs are downloaded as bits to be printed on local 3D printers.
- **D**eceptive phase
  - Local 3D printers can't yet print transistors.
  - Existing 3D printed IC products serve niche markets.
- **D**isruptive phase
  - Large applications which can't afford to pay silicon create killer apps.
    - E.g., food quality sensors printed on food packages.
- **D**ematerialization
  - Large market segments stop using silicon VLSI, buying inks instead of silicon.
- **D**emonetization
  - New business models emerge, e.g., paying for service instead of hardware (such as US cellphone market).
- **D**emocratization
  - As hardware cost is irrelevant, global deployment follows.

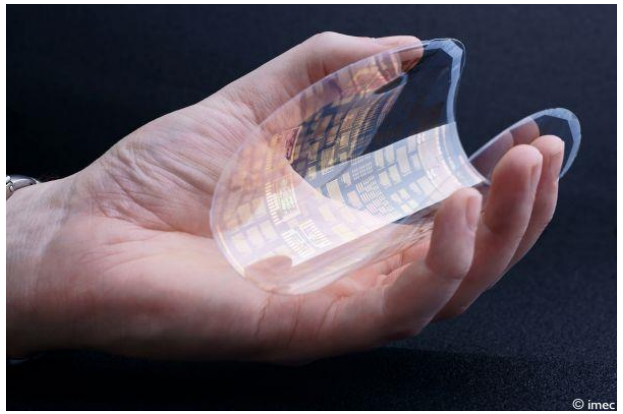
Deceptive Phase for SEMI Industry

IMEC have demonstrated in 2011 the first 3D printed 8-bit microprocessor with 2000 transistors.

- Gap between monolithic and printed transistors: 40 years.

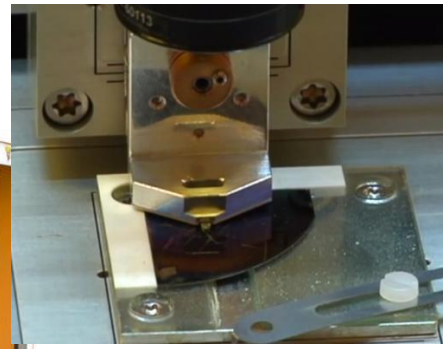
1971: Intel 4004	**2011: imec & Holst**
First Si µProc.	First plastic µProc.
10 µm	5 µm
4 bit	8 bit
pMOS	pMOS, dual Vt
-15V Vdd	-10V Vdd
2300 TOR	2000 TOR
108 KHz	6 Hz



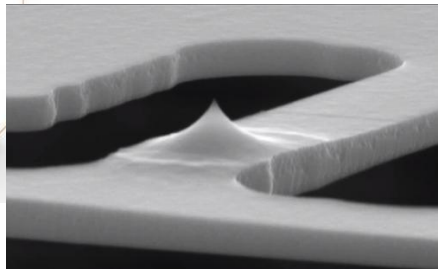


Disruptive Phase for Semiconductor Industry?

- IBM Research in Zurich unveiled in 2014 a 3D printer capable of writing 10 nm patterns.
  - Printer outperforms e-beams, but costs around $500k, as opposed to e-beams, $1.5M to $30M.
- IBM hopes to be prototyping tunneling FETs in GaAs and graphene by the end of 2014.



IBM's mechanism works like an atomic force microscope (AFM) but with a heated tip that can sculpt 3D nanometer resolution patterns. (Source: IBM)

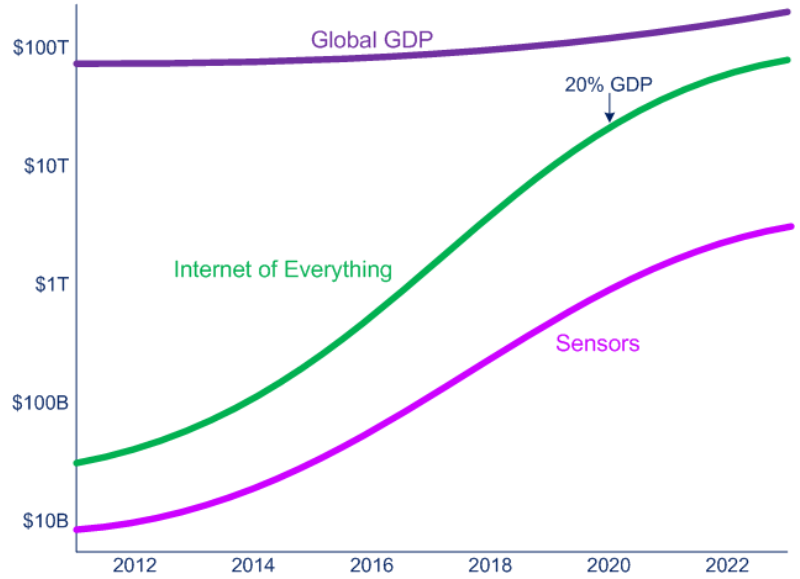


The heated tip of the 3D printing mechanism is 700 nanometers long but just 10 nanometers at its tip and can be positioned with nanometer resolution. (Source: IBM)

http://www.eetimes.com/document.asp?doc_id=1322091

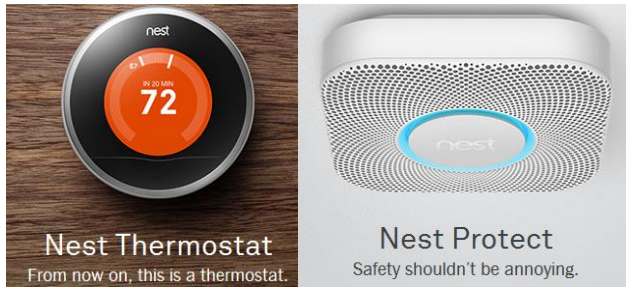
Internet of Things and Everything (IoT, IoE)

- World of connected <u>all things</u> around us.
- Enabled by:
  - IPv6 providing $3x10^{38}$ IP addresses, one for every “thing”.
  - Fog and Swarm connectivity/computing (below the Cloud).
  - Sensors.

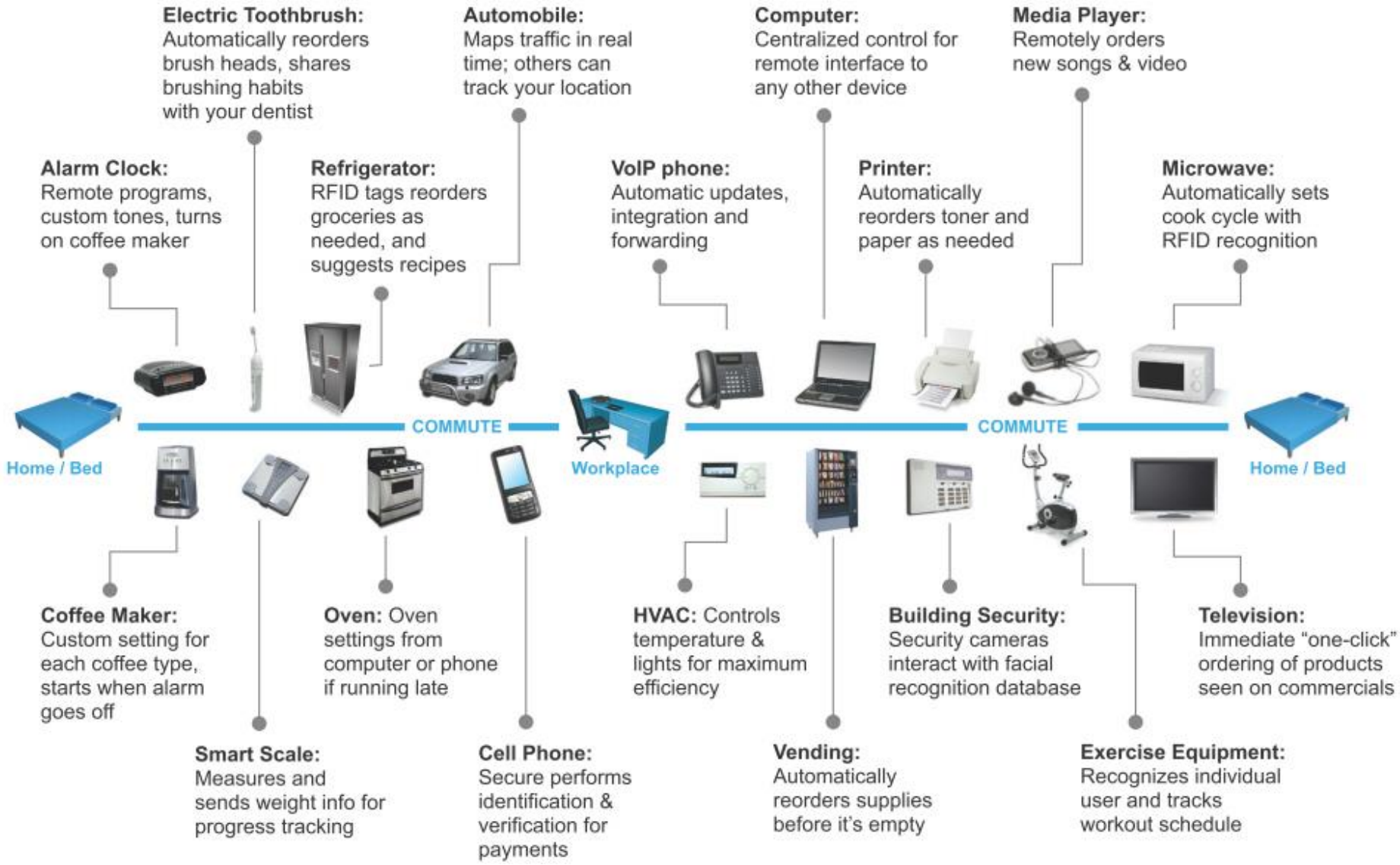


- Bold forecasts for IoX:
  - Cisco: $19 trillion by 2020, over 20% of the global 2020 GDP
  - GE: $15.5T by 2020.
- Networked sensors are expected to represent 5% of IoX, $1T by 2020.

- First major IoE startup: NEST.
  - Acquired for $3.2B by Google.
  - New Era for startups?

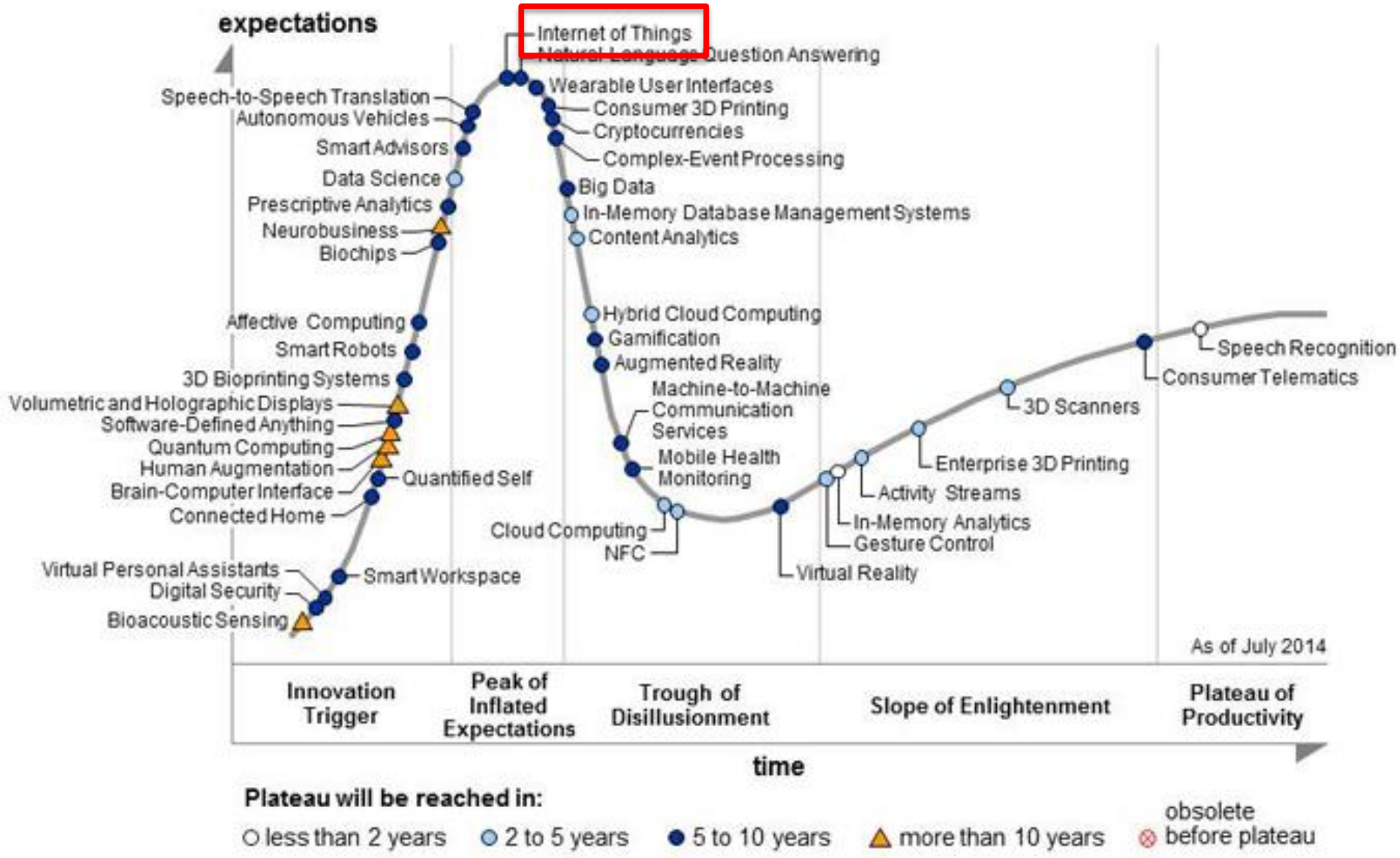


IoT: Not Your Father's Internet…



http://backwardstimemachine.wordpress.com/tag/the-internet-of-things/

The IoT Takes Over Big Data as the Most Hyped Technology



http://www.gartner.com/technology/research/hype-cycles/

Is it Going to Happen?

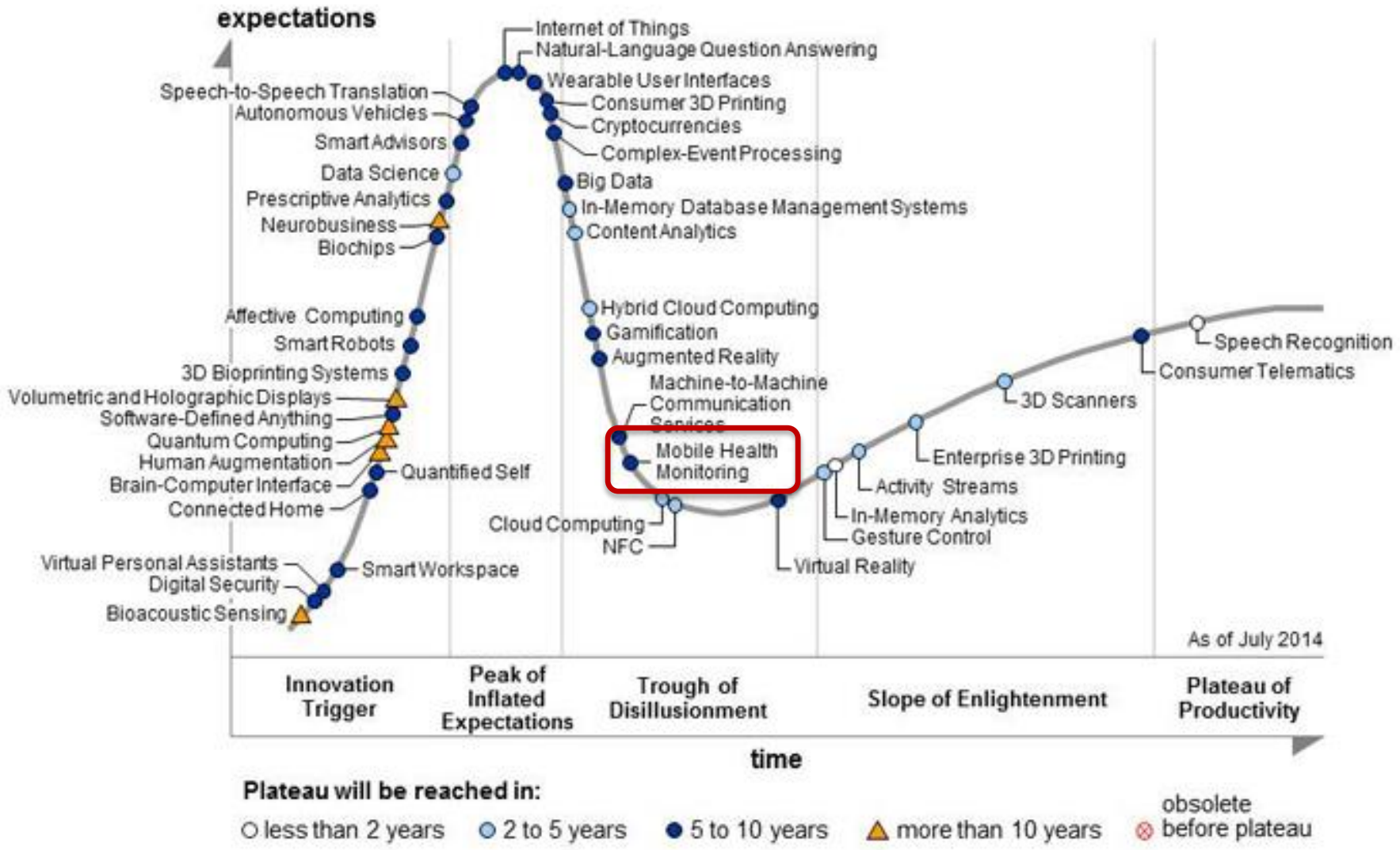
- **$3.4B** invested in IoT startups by the end of 2013
  - http://onworld.com/news/3.4-Billion-Invested-in-Wireless-Smart-Object-Startups.htm
- 153 VC firms invested into IoT startups **$1B** in 2013, 50% more than in 2012.
  - http://www.inc.com/jeremy-quittner/venture-capital-flows-to-gadget-and-hardware.html
- Cisco and IBM invest **$1B** each in IoE
  - http://venturebeat.com/2014/03/24/cisco-reveals-billion-dollar-plan-for-a-cloud-and-a-pack-of-partners-too/
- China incorporated IoT into the 12th Five Year Plan in June 2010 with the goal of creating an industry worth more than **$160B** by 2020.
  - http://www.hoganlovells.com/files/Publication/a80e769e-6a83-40bd-b967-efd63a2fad77/Presentation/PublicationAttachment/eac1127d-9aa8-40fc-af52-f91a27b6336d/13.09.12_China%20TMT%20Alert_IOT.pdf
- Cisco invests **$150M** in startups
  - http://www.cruxialcio.com/cisco-invests-150-million-disruptive-it-startups-7200
- Ag Tech Investment Tops **$100M** in the Last Year
  - https://www.cbinsights.com/blog/agriculture-tech-venture-capital-financing/
- Intel launches **$100M** fund for wearables in China
  - http://venturebeat.com/2014/04/02/intel-launches-100m-venture-fund-to-invest-in-smart-devices-and-wearables-in-china/
- Siemens launches **$100M** fund for manufacturing startups
  - http://techcrunch.com/2014/02/17/siemens-launches-100m-fund-to-back-software-startups-that-can-disrupt-manufacturing/

mHealth (eHealth, Digital Health)

- Represents the emerging market for mobile fitness, wellness and healthcare devices and services.
- Enabled by emergence of low cost sensors.
- Expected to save 35% of cost of treatment of chronic medical conditions in coming years, which represents vast majority of health care spending.
  - US Healthcare spending is about 19% of GDP.
- Expected to bring healthcare to everybody on Earth, thus creating healthcare abundance.
- Expected to dramatically redefine medical industry and the function and responsibility of doctors.
  - Large number of traditional medical equipment medical companies will cease to exist.
    - First “death sentence” was “issued” to $5B EKG industry.
  - Diagnostics will shift to AI computers (such as Dr. Watson funded by IBM at $1B).
  - Doctors will need to learn how to use Big Data generated by sensors and processed by supercomputers in patients’ hands.

Inc Magazine, February 2014

mHealth is More Mature than IoT



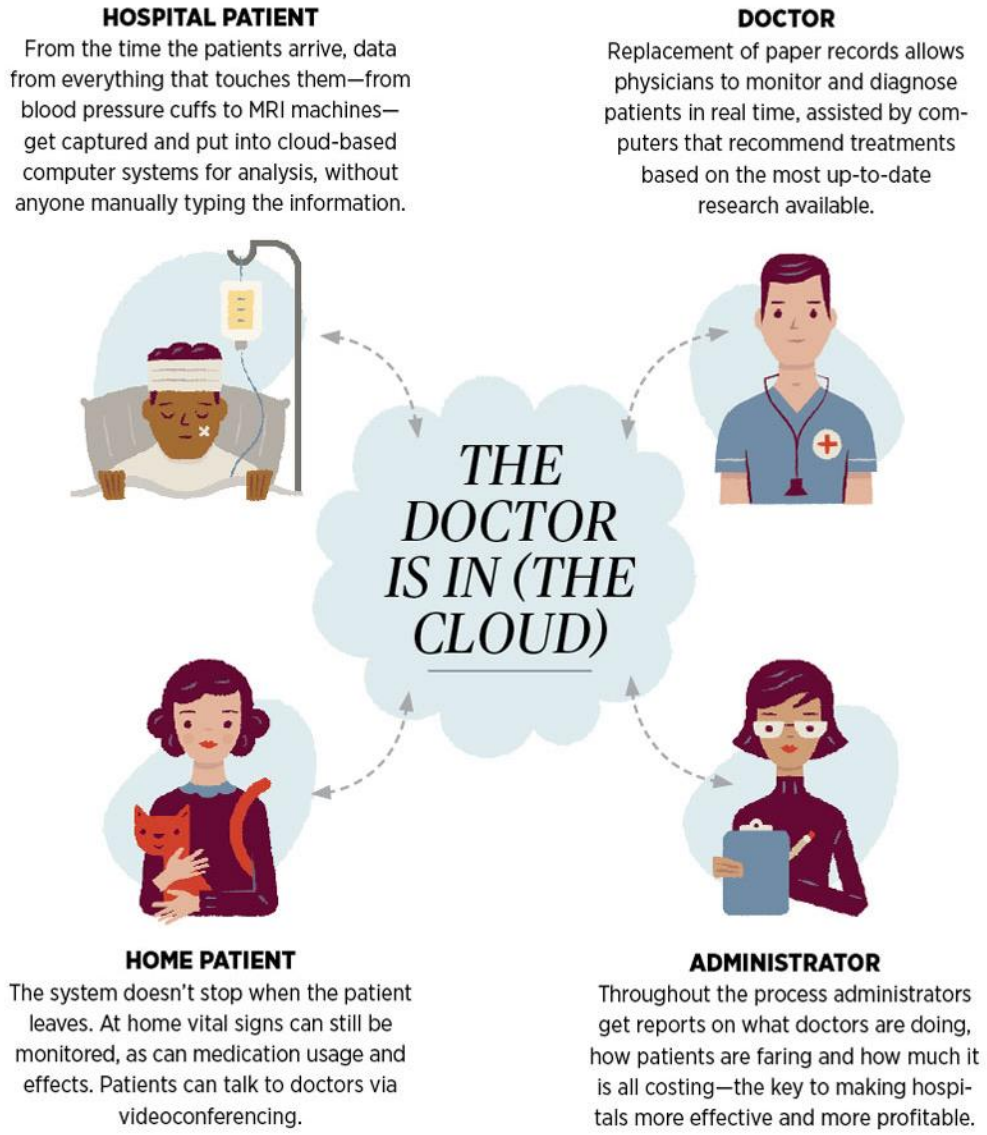
http://www.gartner.com/technology/research/hype-cycles/

mHealth: Not Your Mother's Healthcare…

http://www.inc.com/ss/ready-wear#0

Medicine's Manhattan Project

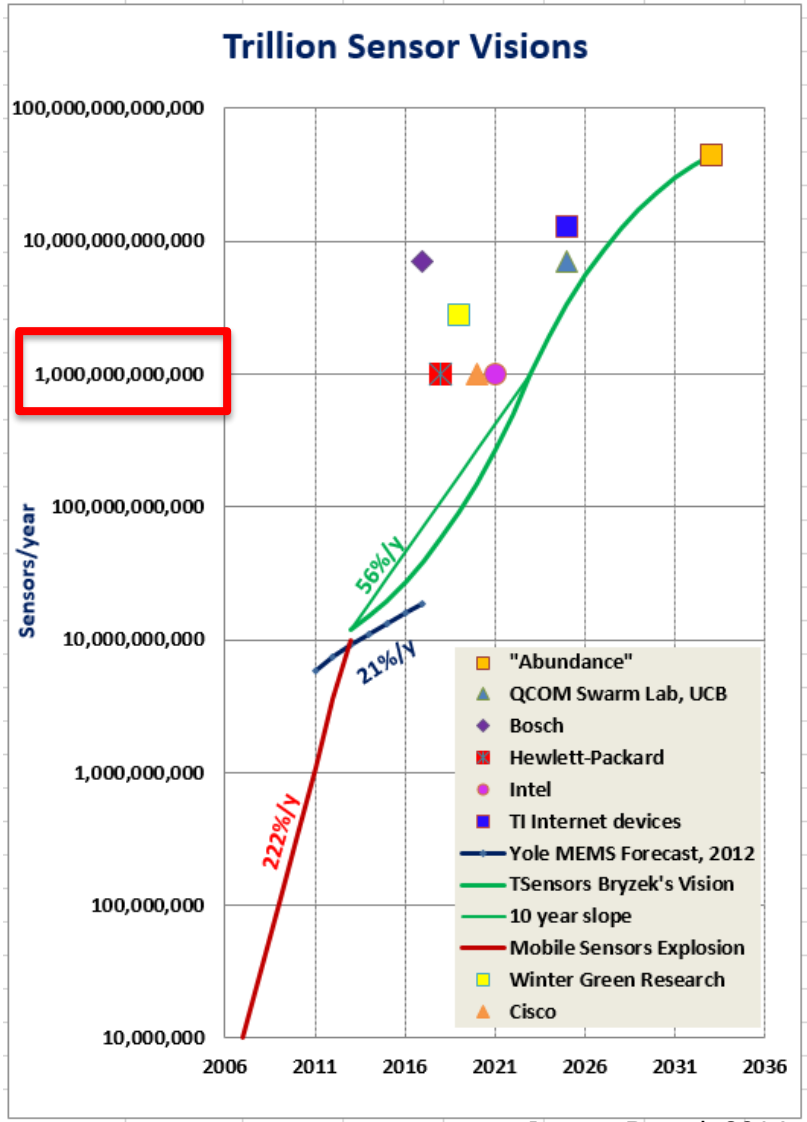
- Patrick Soon-Shiong, the world's richest doctor, launched the program to advance medical care.
- Patient's real time data generated by sensors (from DNA to the proteins in blood) will get instantly analyzed via a superfast network.
- In real time computers will recommend the treatment and follow up patients in real time.



http://www.forbes.com/sites/matthewherper/2014/09/10/medicines-manhattan-project-can-the-worlds-richest-doctor-fix-health-care/

Trillion Sensors (TSensors) Visions

- Mobile sensor market grew exponentially over 200%/y between 2007 and 2013.
- Several visionary organizations created trillions unit forecasts.
  - Explosion to trillion(s) is likely to be driven by new applications.



Janusz Bryzek 2014

Disruptive Impact of Mobile Market on Sensors between 2007 and 2014:

Item	Impact	Comments
Market size	Growth by $11B	From $2B to $13B
Shipments	**1000x increase**	From 10M to 10B
ASP	**1000x decrease**	E.g., from $250/axis for gyros to $0.75 for three axis
Power	**1000x decrease**	From W to mW and mW to µW, depending on sensor
Physical Volume	**1000x decrease**	E.g., gyro from 2000 mm^3 to 2 mm^3/axis
Transistors	**1000x increase**	From 1000s/sensor to 1,000,000s/sensor

Mobile sensor market explosion created a foundation for growth of IoT and mHealth to trillions!

TSensors Initiative

- Objective: acceleration of historically long new sensors development cycles for sensors supporting Abundance/Impacting the World.
- Strategy:
  - Collects visions for new ultrahigh volume sensor applications (TApps™) to create development targets reducing development cycle.
    - Implementation: TSensors Summits™ with talks by sensor visionaries.
      - 2013 Summits: UC Berkeley and Stanford University.
      - 2014 Summits: Tokyo (February), Munich (September), San Diego (November 12-13), Tokyo (December 8-9).
      - 2015 Summits: discussion started with Abu Dhabi, Korea, China and US.
  - Collect information about emerging sensor technologies and sensor infrastructure capable of supporting TApps™.
    - Implementation: TSensors Roadmap and TSensors System Roadmap.
  - Help Supply Chain to support development of TSensors through:
    - Restructuring of academic and R&D programs.
    - Increasing number of startups from leading research organization.
    - Promoting cooperation (Cooptition) between sensor suppliers, customers, infrastructure companies, academia and research organizations.
    - Governments and billionaires funding.
    - TSensors Challenge incentive competition.

Initial TSensors Roadmaps Targets

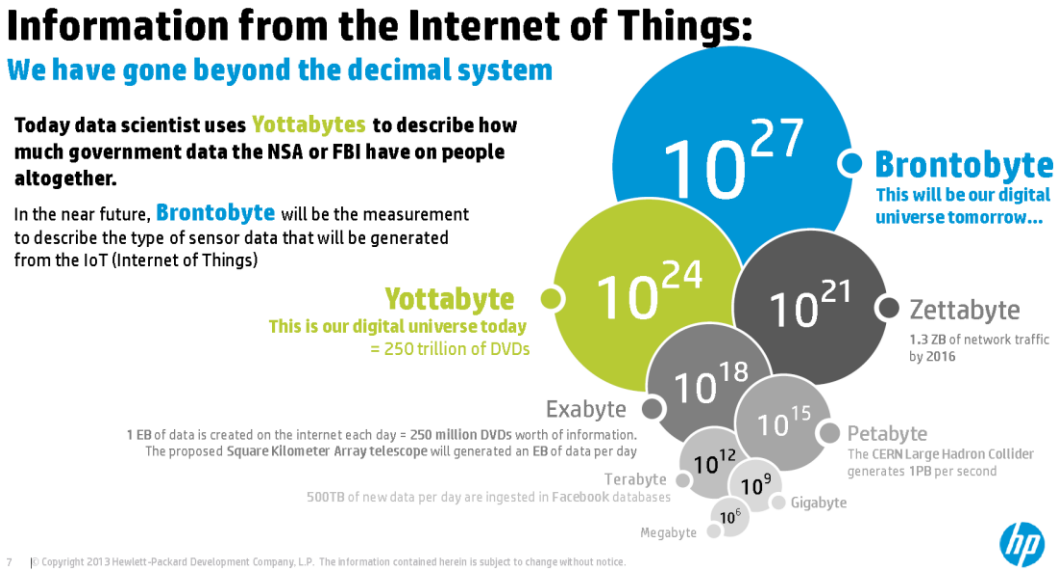
- TSensors Roadmap
  - TSensors Education and Retraining
  - TSensors for Feeding 9 Billion
  - TSensors for Healthcare Abundance
  - TSensors for Clean Environment
  - TSensors for Clean Energy
- TSensors System Roadmap (infrastructure for TSensors)
  - Networks
  - Wireless communication
  - Energy harvesters
  - Big data
  - Analytics
  - Security

Cost Driven TSensors Explosion?

- Trillion sensors/year translates to about 130 sensors/person/year.
  - We already are using up to about 200 sensors/car, 100 sensors/smart home, 15 sensors/cell phone, 10 sensors/wearables, etc.
  - Massive adoption of new sensors depends on cost, samples below.
- **$1/networked sensor**:
  - Should enable IoT application fighting global hunger, pollution, healthcare and energy.
- **$0.10/sensor**:
  - Should enable ultrahigh volume sensors applications for personal health, fitness and lifestyle.
  - 7 billion people collectively own about trillion things (clothing, shoes, jewelry, toothbrushes, pets, etc.).
  - Each of them will have an array of sensors, as evidenced by recently introduced products.
- **$0.01/sensor** (3D printed systems):
  - Should enable monitoring trillion shipped packages (UPS alone ships about 160 million/year).
  - Deployment may be based on smart 3D printed tags with sensor arrays (temperature, shock, location, etc.).
- **$0.001/sensor** (3D printed systems):
  - Should enable monitoring freshness and quantity of food in trillions of food packages sold every year.
  - Your refrigerator will have a Swarm Server collecting food status, and e.g.,
    - Alerting you while detecting your visit to a grocery store to buy needed food matching your diet stored in your profile.
    - Scheduling delivery by Google or Amazon
    - Looking for incentives to buy food early.
- **$0.0001/sensor** (3D printed systems):
  - Should enable planting sensor arrays with plant seeds to monitor health and nutrient needs of every plant to optimize the crop yield.

Challenges for TSensors

- Scaling network size enabling processing of sensor generated data at the level of Brontobytes.
- Cycle time for commercialization.
  - Bleeding edge technologies.
- Development of algorithms enabling derivation of useful information.
- Bandwidth sharing wireless communication.
- Battery/scavenger sources enabling power for life.
- Network architecture enabling low latency control.
- Standardization
- Available funding.



Jobs, Jobs, Jobs…

- Based on Peter Diamandis and Singularity University forecasts:
  - 40% of Fortune 500 (and similar large companies) will be replaced by new exponential organizations in 10 years.
    - Example: Kodak went bankrupt in 2012, while Instagram was acquired by Facebook for $1B.
  - 50% of US workforce will be displaced by robots in 10 years.
  - Both factors will dramatically reduce the workforce with current skill set.
- Based on Cisco forecast ($19T) IoE could create 170M global jobs by 2020.
  - Majority of new jobs will be for knowledge workers.
  - Major retraining will be needed.
- Location of jobs may mirror Apple's iPhone 4s breakdown of ASP:
  - 3% ($14): cost of assembly (China)
  - 32% ($178): cost of components (global)
  - 66% ($368): Apple's share (US)

    100% ($560)

Showcase: The Amazing World of Sensor Based Tornado for All of Us

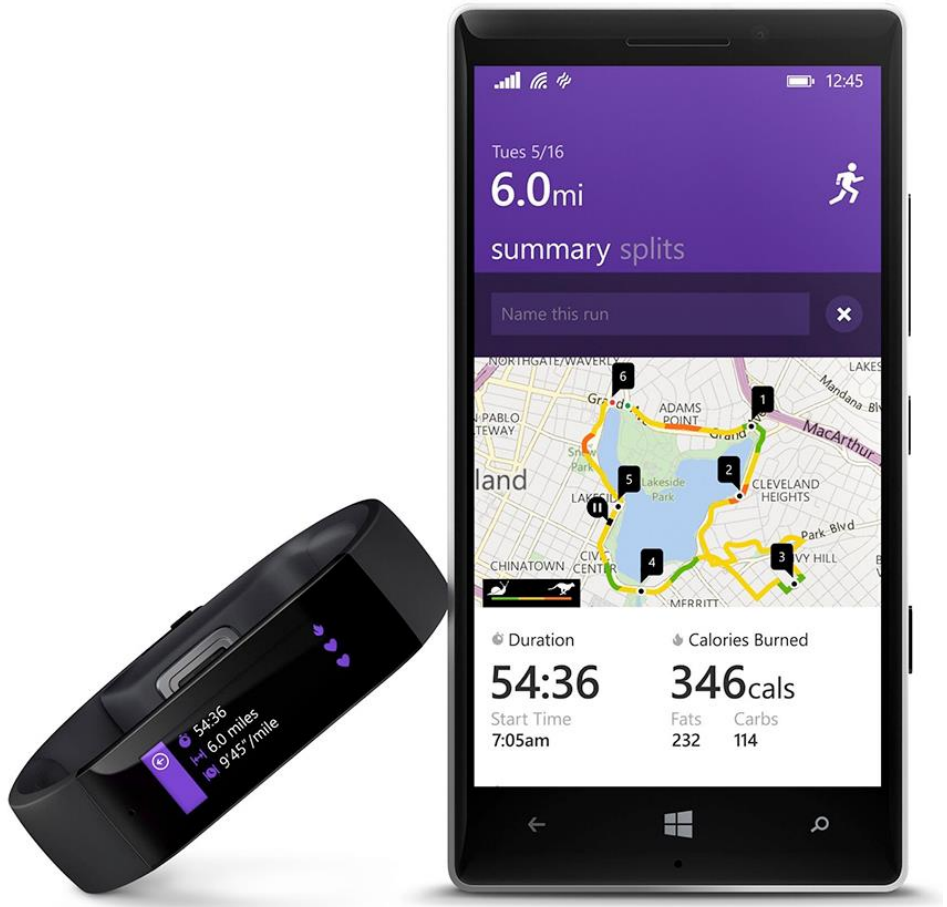
Sensor Studded Mobile Devices

AppleWatch

Microphone
Tri-Accel
Tri-Gyro
Dual-Pulse
11 sensors in
a band

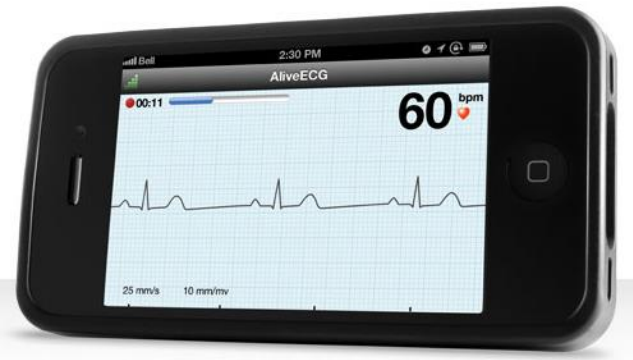
4 Microphones
Tri-Accel
Tri-Gyro
Tri-Mag
Pressure
Light
Proximity
32 SAW
Image stabilization
Fingerprint
2 Cameras

iPhone6



Microsoft's $199 Fitness Band Packs in 10 Sensors, Works with Windows Phone, iOS, and Android
http://www.dailytech.com/Microsofts+199+Fitness+Band+Packs+in+10+Sensors+Works+with+Windows+Phone+iOS+and+Android/article36803c.htm#sthash.2wDoqYux.dpuf

Sending Cellphone to Med School…



EKG monitor from AliveCor

http://www.alivecor.com/home

EKG monitor from Quardio

https://www.getqardio.com/qardiocore/

Preventice ‘s smart bandage constantly tracks cardiac ECG and rhythm monitoring

http://www.preventice.com/bodyguardian/howitworks/

Uchek (MIT) detects 25 diseases, such as diabetes, urinary tract infections, pre-clampsia, glucose, proteins, ketones, and more.

http://www.medgadget.com/2013/08/smartphone-based-urine-analysis-interview-with-ucheks-myshkin-ingawale.html

Fraunhofer’s glucose, lactate and cholesterol sensors, pulse oximeter, and a fluorescence sensor for detecting biomarkers

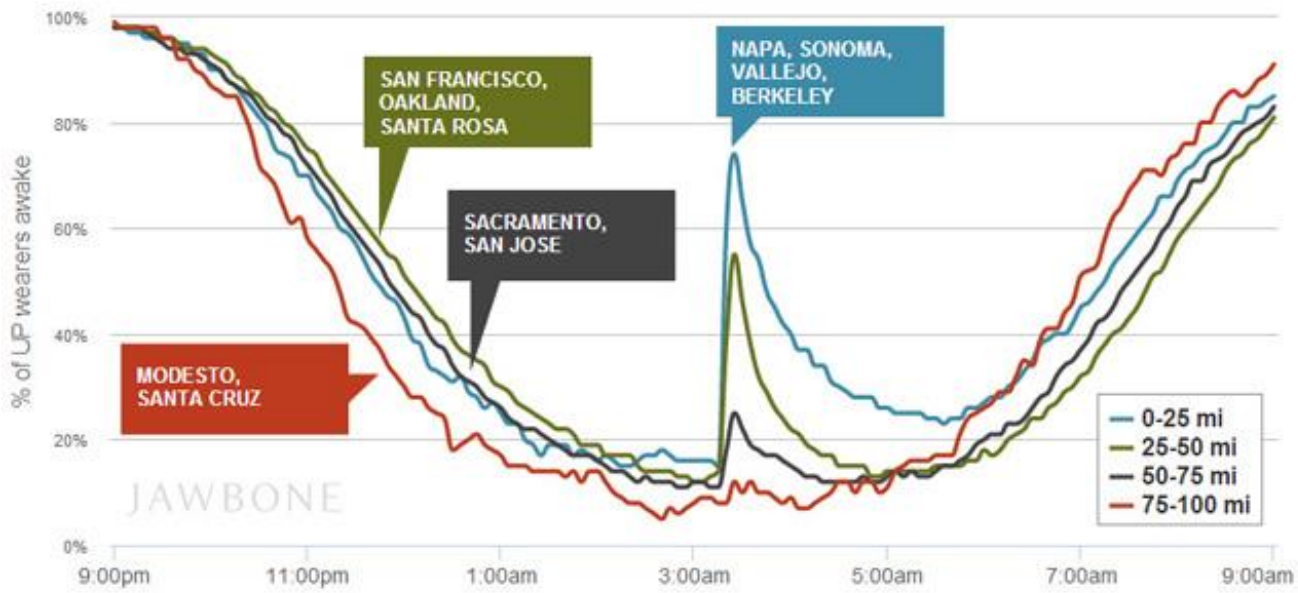
http://www.fit.fraunhofer.de/en/presse/13-09-12.html

Lapka can detect radiation and organicity of food.

https://mylapka.com/pem

The Power of Wearables and Big Data

The wristband tracks in the background your movement and sleep. The app displays your data, lets you add things like meals and mood, and delivers insights that keep you moving forward.

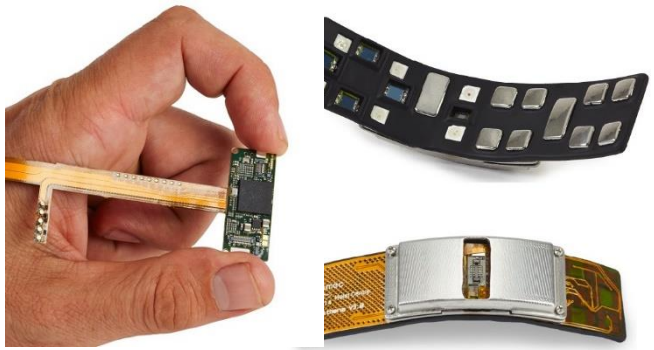


Big Data: 8/24/14 earthquake in Napa, CA, based on Jawbone users' data.

https://jawbone.com/up

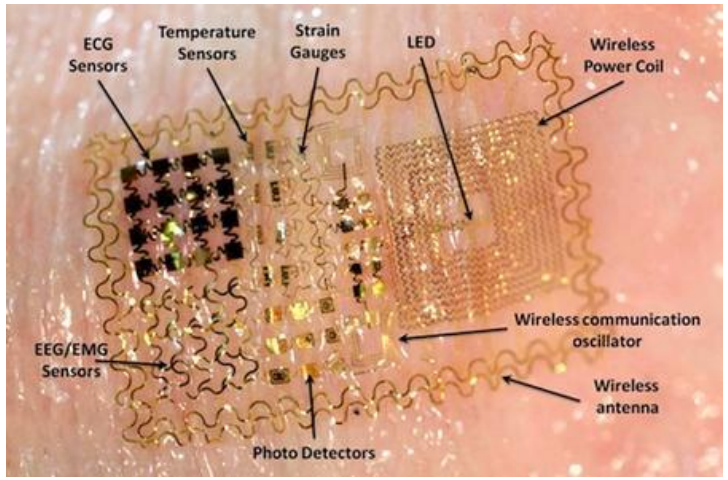
First Open Wearable Platform from Samsung

- Simband: modular wristband enabling plugging multiple sensors.
- First sensors developed by Imec:
  - PPG sensors that measure blood flow, heart rate, blood pressure, and other vital signs.
  - ECG sensor to measure the rate and regularity of a heartbeat.
  - Body temperature.
  - Galvanic skin response.
  - Bioimpedance sensor to monitor everything from blood flow to body fat.
- Samsung Architecture Multimodal Interactions (S.A.M.I.) is a data broker that enables wearable devices to upload information to the cloud.



http://www.samsung.com/us/globalinnovation/innovation_areas/

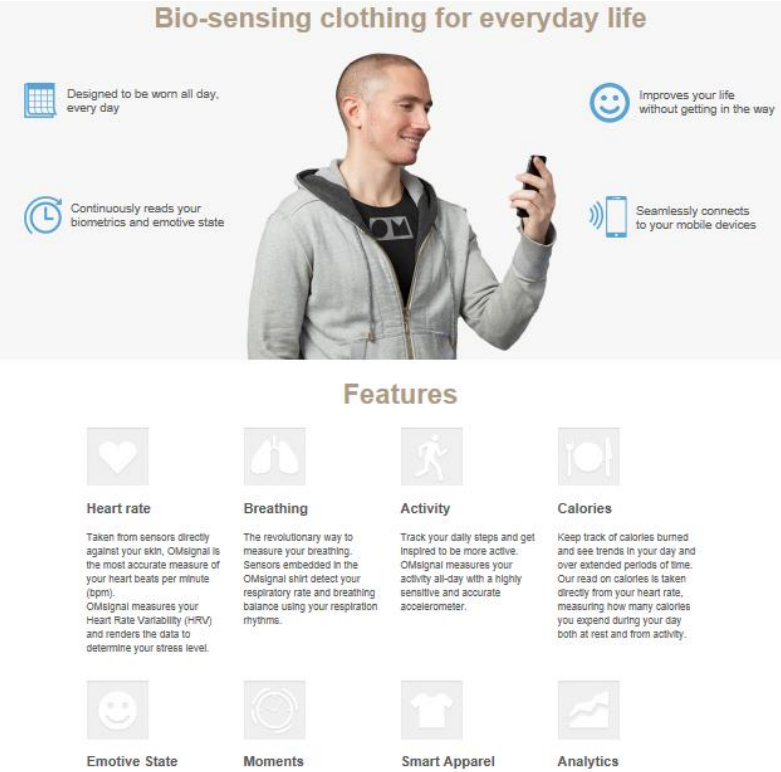
Wearable Tatooed Sensors



UC San Diego

MC10

Wearable Sensor based Clothing



http://www.omsignal.com/

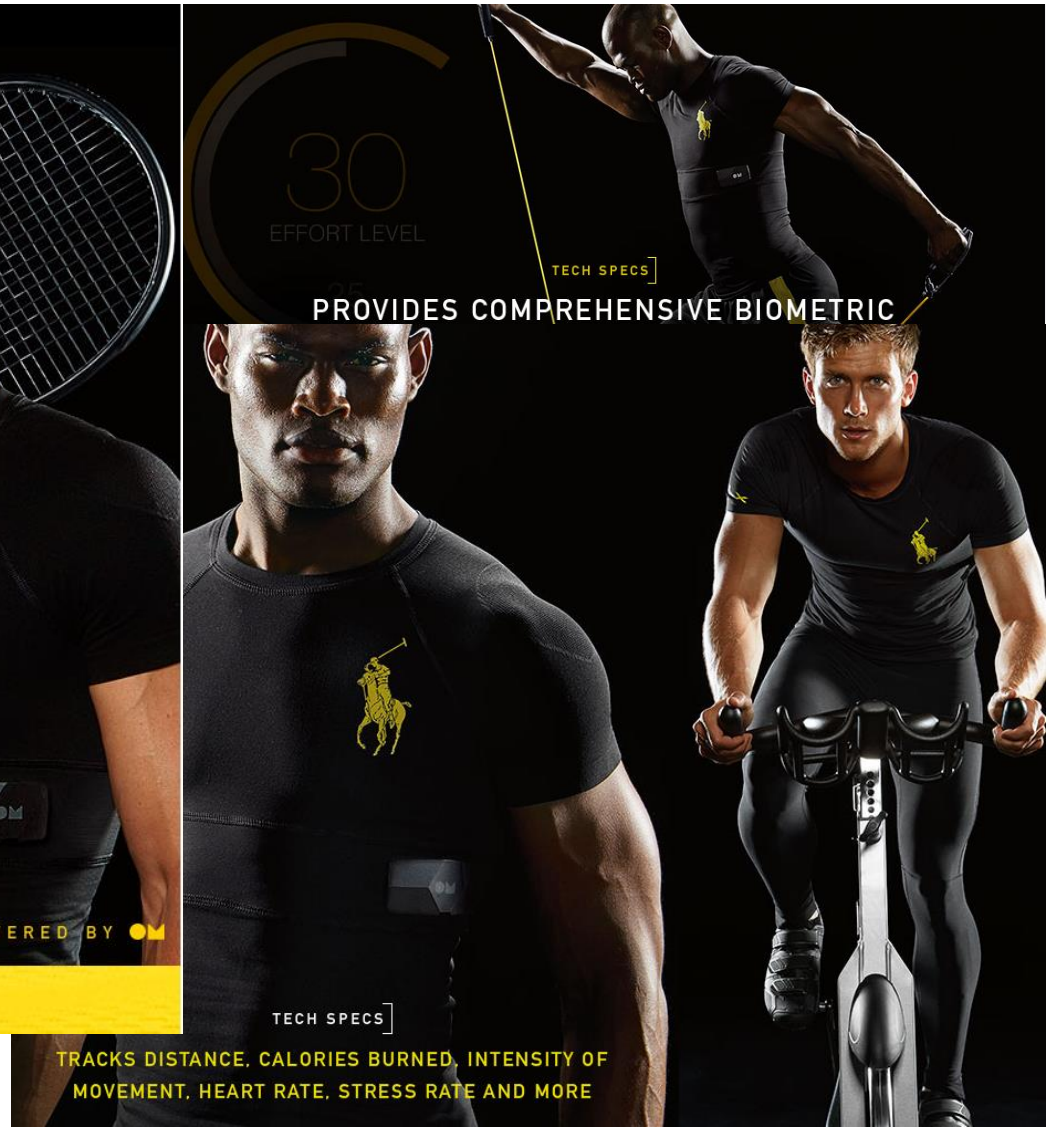
Washable T-shirt that can read a patient's heart rate, blood pressure, cardiac irregularities

http://www.timesofisrael.com/israeli-ecg-t-shirt-monitors-hearts-saves-lives/#ixzz3ATObYkf2

NTT Docomo and Toray announced Hitoe (Japanese for "one layer") cloth with coated nanofibers and a square patch that does the sensing, measuring heartbeat and even offering metrics resembling a cardiogram.

http://www.engadget.com/2014/01/30/ntt-docomo-toray-smart-cloth/

Wearable Luxury Brands…



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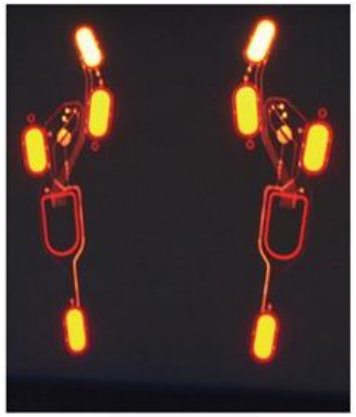
Wearable Jewelry

Wellograph Wellness Watch
9DOF + Heart monitor

Netatmo's June bracelet with UV sensor

Intel unveiled 3G snakeskin smart bracelet

Wearable Smart Shoes



8 sensors

Nike's smart shoe insert with 8 sensors measures jump height, speed, performance.

Fall-Prevention Motorized Shoe for elderly people based on pressure sensors detecting loss of balance.

http://nocamels.com/2014/05/israeli-fall-prevention-motorized-shoe-is-a-step-in-the-right-direction/

Wearable Smart Bra…

Bra with autolock. When True Love is detected, the bra unhooks automatically from the front to help save women from one-night stands with less-than-savory men.
The bra contains a heart-rate sensor. The app calculates the "true love rate," comparing the readings to activities like shopping, watching a horror movie, flirting, jogging, or receiving a surprise gift.

http://news.cnet.com/8301-17938_105-57617747-1/bust-lock-down-bra-only-unhooks-for-love-true-love/

Smart Bra concept is aimed at helping people ward off emotional eating (Image: Microsoft) using EKG and EDA, an electrodermal activity sensor measuring skin conductance (moisture) and movement (respiration rate).

http://www.telegraph.co.uk/technology/microsoft/10499811/Microsoft-developing-smart-bra.html

The sensor finds cancer by detecting tiny metabolic temperature changes caused by cancerous cells in a tumor. The temperature readings are sent to a global library where they're run through a proprietary algorithm. Then the results are sent back to a user's phone.

http://mobihealthnews.com/32250/breast-cancer-wearable-sensor-company-raises-560k-plans-asian-launch/

Breast Health Exams

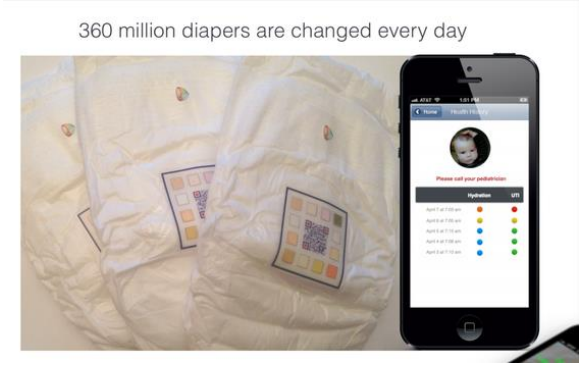
Breast lumps self-exams sensor (mammogram replacement)

https://www.indiegogo.com/projects/eclipse-the-first-smart-digital-self-breast-exam-device

Glove Tricorder with pressure feedback loops, temperature sensors, accelerometers and later ultrasound pads to the tips of the glove, allowing doctors to see inside the breast to diagnose breast cancer and enlarged kidneys and other sub-dermal issues.

http://medsensation.com/

Wearables for Babies



Smart diapers monitors urinary tract infection, prolonged dehydration, kidney problems.

http://www.indiegogo.com/projects/pixie-scientific-smart-diapers

The Mimo baby monitor has respiration sensors temperature sensors, the Mimo Kimono monitors baby movements and body position. Clinically validated sleep algorithms, you can know when your baby falls asleep, when they wake and how well they are sleeping.

http://mimobaby.com/

Smart sock from Owlet Baby Care monitors infant's quality of sleep, blood oxygenation levels, and skin temperature

https://www.owletcare.com/

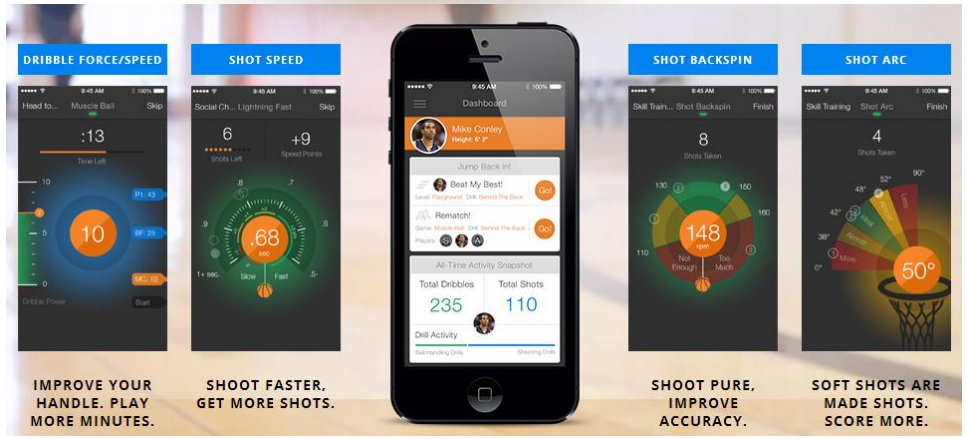
Teddy bear measures child's temperature, heart rate, and oxygen levels through his 'smart paws'. Bear's LED heart beats at the same rate as child's, creating a bond between child and bear.

http://blogs.plos.org/globalhealth/2014/05/wiredhealth/

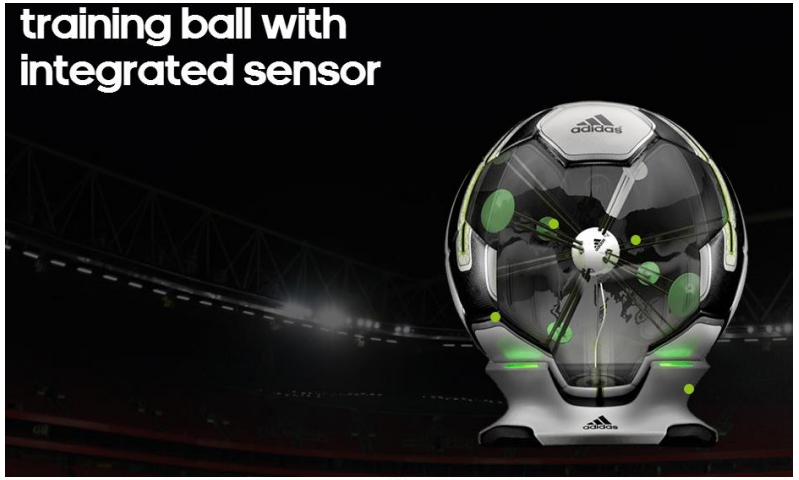
SmartOne infant monitor measures temperature, baby orientation and breathing

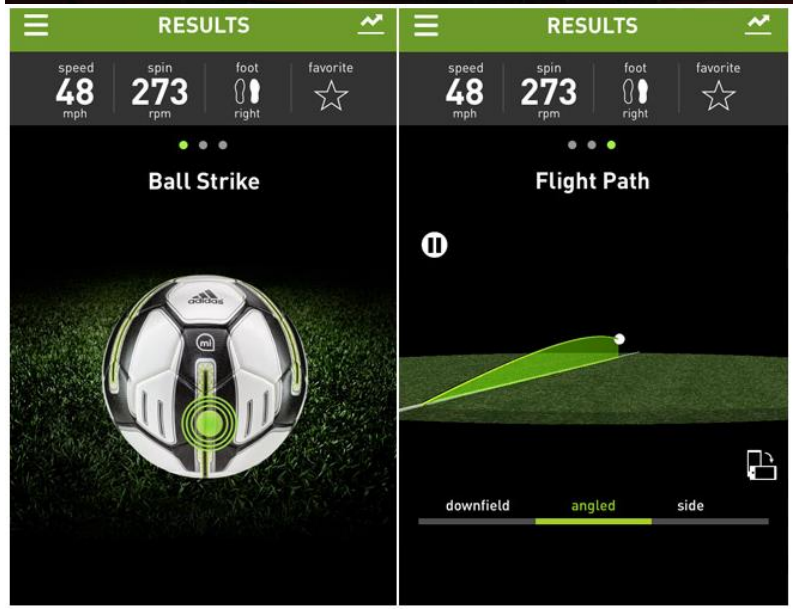
http://mysensiblebaby.com/

Smart Balls



http://www.94fifty.com/





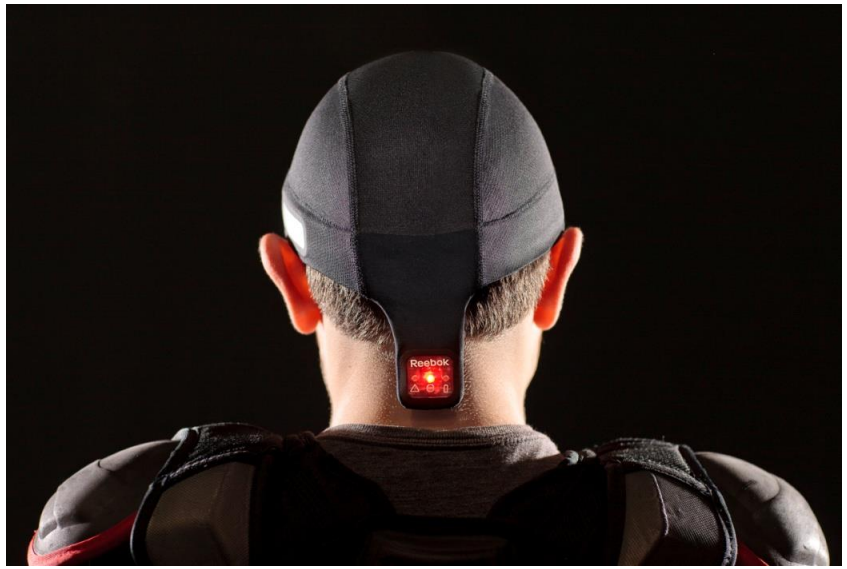
http://micoach.adidas.com/us/smartball/

Zone Cleat-based Power Meter

A sensor plate is sandwiched between a Speedplay cleat and the sole of the shoe, using the cleat force sensor and the motion sensor in the pod atop each shoe measuring the position and motion of the cranks and pedals and calculating power with 2% accuracy.

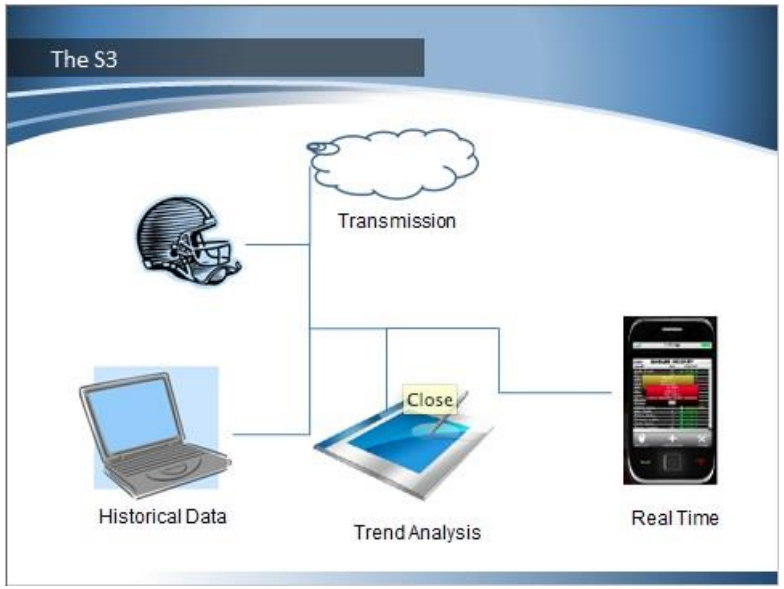
http://road.cc/content/news/130261-brim-brothers-finally-launch-zone-dpmx-cleat-based-power-meter

Detecting Players' Brain Injury



A green, yellow and red lights indicate moderate, medium and severe impacts, respectively, measured by acceleration sensors,.
The system also logs the total number of impacts.

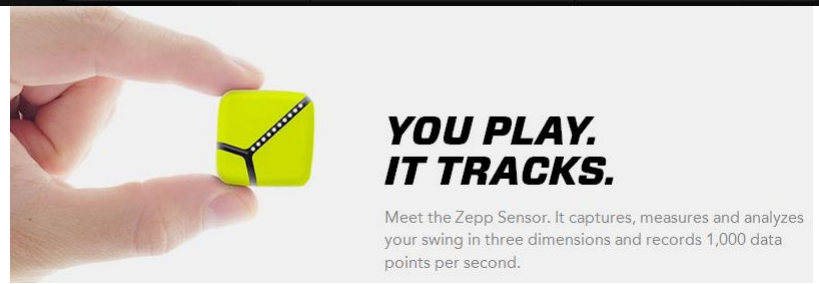
http://www.mc10inc.com/



S3 itself is a wireless helmet-mounted impact logger that transmits data to the Eurotech Everyware Cloud where it can be used to provide immediate information on the impact levels experienced by an athlete to coaches, doctors, and parents.

http://www.sensuss.com/news

Sporting Along



Zepp sensors create 3D representations of a player's swing

http://www.zepp.com/

Sensor based tennis racket from Babolat

http://www.babolat.com/product/tennis/racket/babolat-play-pure-drive-102188

Onewheel: the self-balancing electric skateboard that gives you the feeling of flying

http://rideonewheel.com/

Helping in Daily Life

Personal asthma wheeze monitor measures WheezeRATE™, or the percentage of breathing time a person spends wheezing, as a result of their airways narrowing, using Acoustic Respiratory Monitoring.
It enables measurement of the response allergens and medications.

http://isonea.com/

Shake stabilized spoon for Parkinson disease patients eliminates 70% of the tremor.

http://www.liftlabsdesign.com/

The first sonic connected toothbrush provides daily feedback on the quality of brushing and helps all the family to improve brushing habits.
The app analyses data and provides key feedback to improve over time through a new and fun experience

http://www.kolibree.com/en/

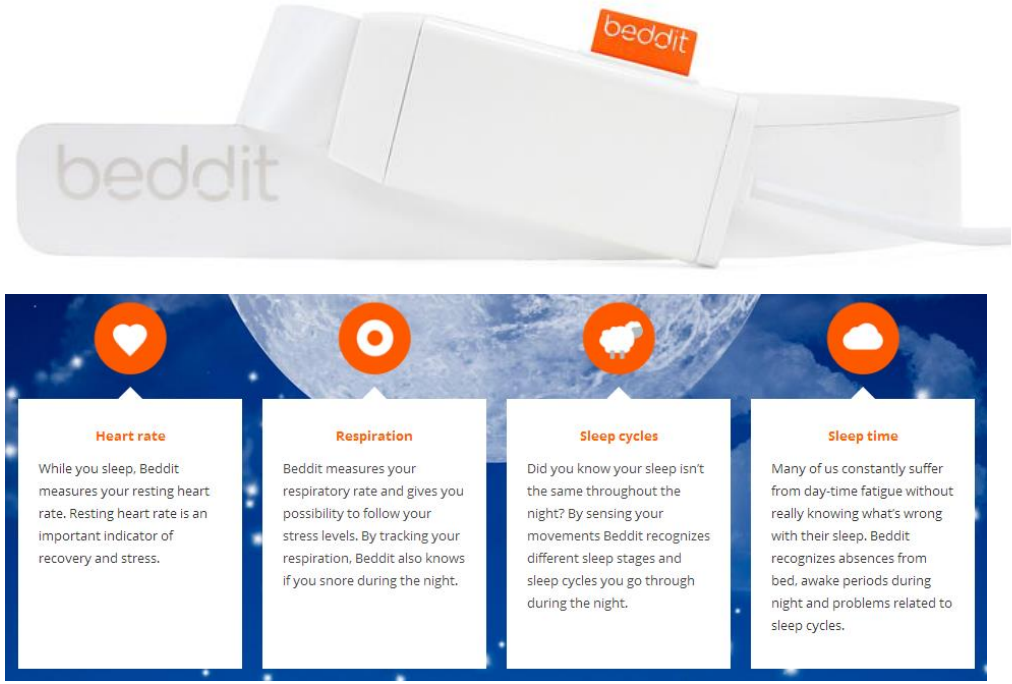
Monitoring Sleep

Sense system includes:

- Sense, a device that sits on nightstand monitoring the conditions in your bedroom and disturbances at night.
- Sleep Pill, sleep tracking sensor that clips invisibly to your pillow
- Mobile applications that bring it all together

The app tells you how well you slept, or didn't, by giving you a unique Sleep Score each night.

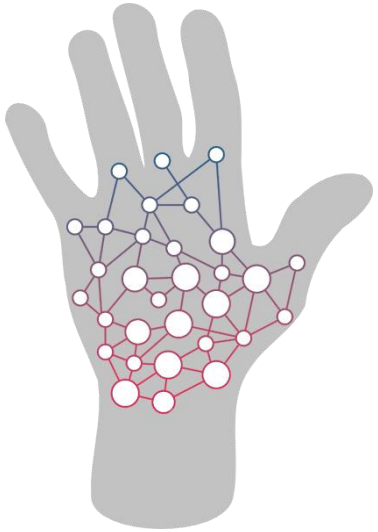
https://www.kickstarter.com/projects/hello/sense-know-more-sleep-better



Beddit is an ultra-thin film sensor that you place in your bed, under the bed sheet.
All you have to do is to sleep on it. Beddit connects wirelessly to your smartphone for a sleep analysis.

http://www.beddit.com/

Paying with Your Hand



SWIPE

Swipe your credit card as you normally would during payment at any Biyo merchant

ENROLL

Scan palm and enter your phone number to link it to your credit card for future cardless payments

FINISH

That's it! You can now scan your palm instead of swiping your card at ***any*** Biyo terminal.

Biyo senses the unique vein patterns in your palm to create the most secure and convenient password that you never have to remember.

http://biyowallet.com/

Brainwaves Driven Smart Toys

Brainwaves driven ears and tail from Necomimi ($69) express your emotional state before you start talking.

http://www.necomimi.com/

Sensing the Brain

Wireless neuroheadset based on 16 sensors detects:

- Thoughts
- Feelings
- Expressions
- Subconscious emotional states
- Facial expressions
- User-trained mental commands which can control existing and custom applications and games as if by magic.

http://www.emotiv.com/epoc/

ElMindA's Brain Network Activation Analysis System uses dozens sensors that measure and analyze neural activity during specific brain processes, measuring it against a database of over 7,000 brain functions to see how a patient's condition stacks up, to spot problems early, such as like Alzheimer's, Parkinson's and ADHD.

http://nocamels.com/2014/08/futuristic-eiminda-helmet-monitors-brain-health-like-never-before/

Cuffless Blood Pressure Measurement

Sotera Wireless' non-invasive measures continuous blood pressure, along with pulse rate, skin temperature, electrocardiogram, blood oxygenation and respiration rate and temperature.
FDA approved

Cnoga's device spectrometrically measures noninvasively blood pressure, blood oxygen, and pulse.

HealthStats watch measures blood pressure using applanation tonometry.

Noninvasive Glucose Monitoring

Integrity Applications' employs a combination of ultrasound, electromagnetic, and thermal technologies to obtain blood glucose readings

http://www.integrity-app.com/

Minimally-invasive continuous glucose monitoring system based on skin permeation

http://www.echotx.com/symphony-cgm-system.shtml

Biosensors ' approach is based on electromagnetic impedance spectroscopy (EIS) and electromagnetic impedance tomography (EIT).

http://www.biosensors-tech.com/#

Sensing glucose, heartbeat, skin resistance, quality of skin collagen, skin health and identifies nervous people based of color change of RGB lights passing through skin.

http://www.globes.co.il/en/article-1000877563

C8 MediSensors developed Raman spectroscopy based glucose sensor, raised $120M ($43M in 2012) and closed in 2013 after finding measurement instability. Apple hired several of former employees

Personal Glucose Monitors

Contact lens embedded glucose monitor in tears being developed at Google, wirelessly communicates with mobile devices. Google partnered with Novartis to bring it to market.

http://www.nytimes.com/2014/07/16/business/international/novartis-joins-with-google-to-develop-contact-lens-to-monitor-blood-sugar.html?_r=0

Toilet embedded sensors measure blood glucose and albumin, free protein, urea, bilrubin, and others, for tracking health condition for type 2 and pre-diabetes, based on mid-IR spectroscopy

http://www.pyreos.com/

Intelligent Pills

Digital Medicines

Tiny, Safe Ingestible Sensor
Grain-of-sand sized sensor made from dietary minerals, manufactured in drugs

Medicines Signal When Ingested
Unique, pill-specific signal inside body with no battery, radio or antenna

Monitor Therapy & Outcomes
Wearable patch measures ingestions & full panel of physiologic response metrics

Deliver Mobile User Experience
Applications translate data into knowledge, incentives and collaboration

FDA

CE

proteus DIGITAL HEALTH

Spectrometric Food Quality Measurement

Handheld spectrometric scanner SCIO enables scanning food to get calorie counts, scanning pills to see what chemical compounds they're made of, and scanning your household plants and flowers to see if they need more water.

http://www.thetechgets.com/2014/05/scio-handheld-spectrometer-kickstarter.html

Tellspec food quality monitor based on spectrometer processing sensor data in the Cloud.

http://www.indiegogo.com/projects/tellspec-what-s-in-your-food

Breath Diagnostics

- Dogs are trained to detect medical problems based on breath due to their extreme smell sensitivity:
  - Low sugar level in diabetics or cancer.
- What can be smelled with chemical sensors:
  - Cancer
  - Cholesterol
  - Asthma
  - Lipid peroxidation
  - Metabolism
  - Neonatal jaundice, intestinal distress
  - Cystic fibrosis/bronchitis
  - Periodontal disease
  - Infectious disease (flu)
  - Etc.
- Stony Brook University in New York have developed a breath analyzer (right)
  - Technology utilizes single crystal nanowires that are created by electrospinning.
  - Configuration of metal and oxygen atoms in the nanowires defines which molecules are captured by the chip

Source: Dr. J. Stetter, SRI

Sobriety Tester

$49 accessory plugs into the base of the iPhone and functions like a field sobriety test.

Shareable

Breathometer is designed so you can share it with your friends. No accessories or tubes needed for safe, sterile, accurate use. Breathometer is not just for you!

Portable

Breathometer is designed to be with you, so you can make more informed decisions wherever you are. Ideally, before you get back to your car!

Accurate

Breathometer is a FDA-registered device which boasts accuracy that compares favorably to other high-end breathalyzers.

Make more informed decisions

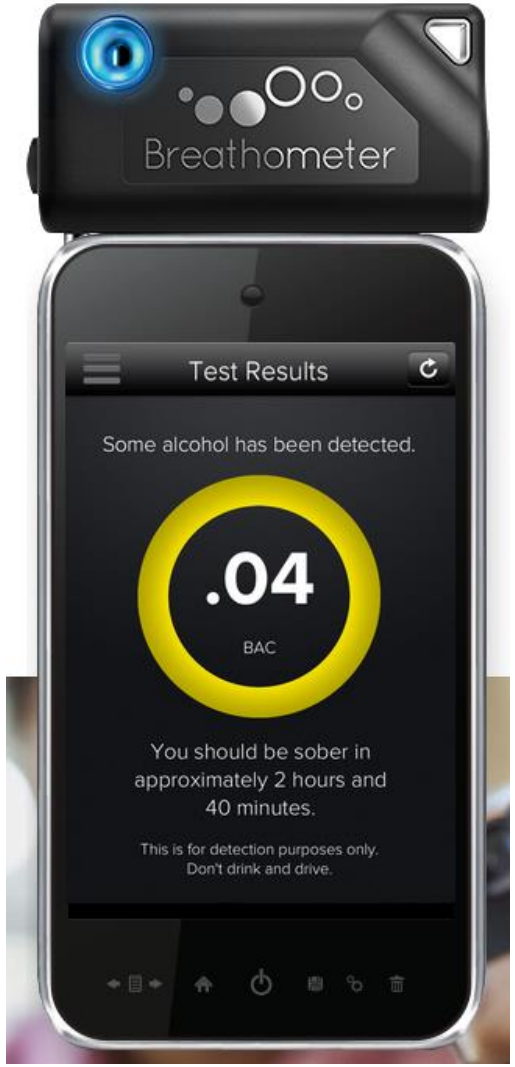
The Breathometer app provides more than just your current blood alcohol level — it allows you to make smarter decisions by giving you access to local cab services and providing guidance for how long until you'll be sober.

Back To Zero

Based on scientific research, Breathometer provides guidance on how long it will be before you are most likely "back to zero" blood alcohol level. This is an estimate, so please be sure to check again and always use your best judgement before driving!

Call a Cab

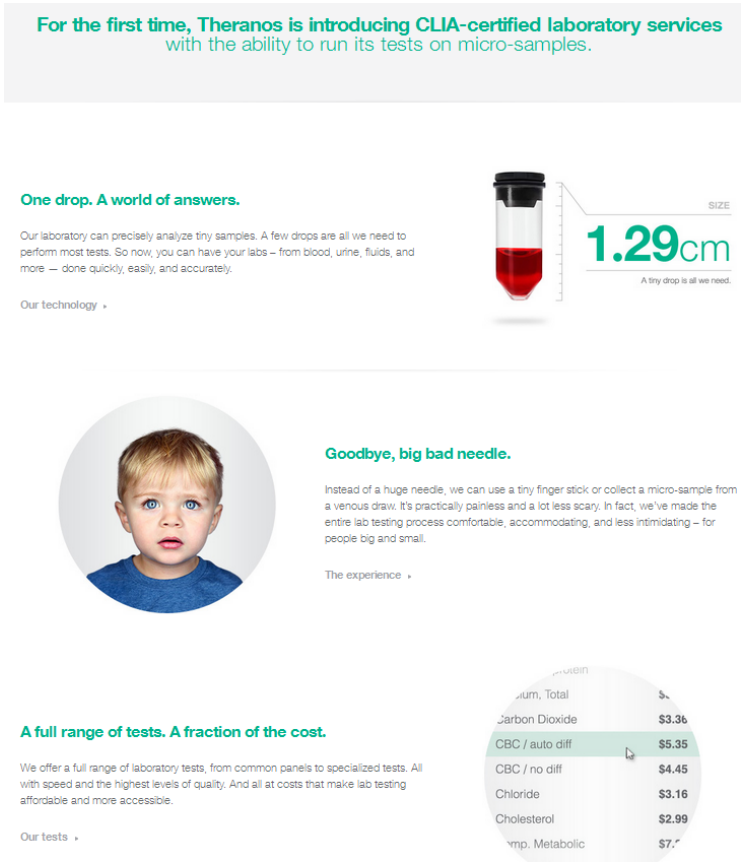
Push-button cab service for quick and easy access to a local cab service near you.



https://www.breathometer.com/

Blood Testing based on Lab on Chip

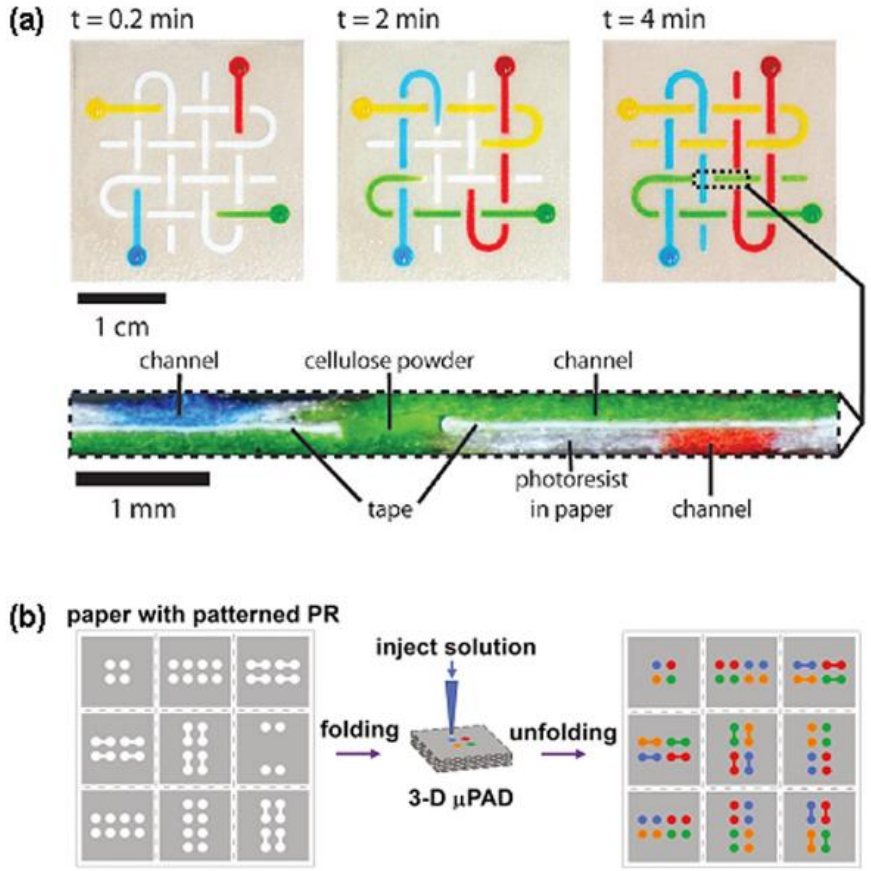
- Palo Alto startup Theranos rolled out blood testing system (starting with Walgreens in Palo Alto) after 10 year/$100M+ funding:
  - 1000x reduced blood volume for about 1000 blood tests.
    - Likely enabled by Lab on Chip with fluorescent tags.
  - Providing results in 4 hours
  - With increased accuracy.
  - At a fraction of lab cost.



Printed Paper Microfluidics

- Lab-on-Chip can be multilayer printed on paper.
- Low-cost, easy-to-use, disposable, and equipment-free.
- Promising technology particularly relevant to improving the healthcare and disease screening in the no- or low infrastructure developing world.
- Applications:

Health diagnostics (e.g., urinalysis, saliva analysis, sputum analysis, pregnancy test, blood type)
Biochemical analysis (e.g., enzyme activity)
Environment monitoring
Food quality control
Forensic (e.g., detection of blood)



http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3365319/#c19

Infrared Vision for iPhone

The FLIR One is a $349 iPhone accessory. It's a self-contained device with its own standard camera, infrared-based thermal imaging camera, its own SoC, and its own battery.

Increasing Imaging Sophistication Level…

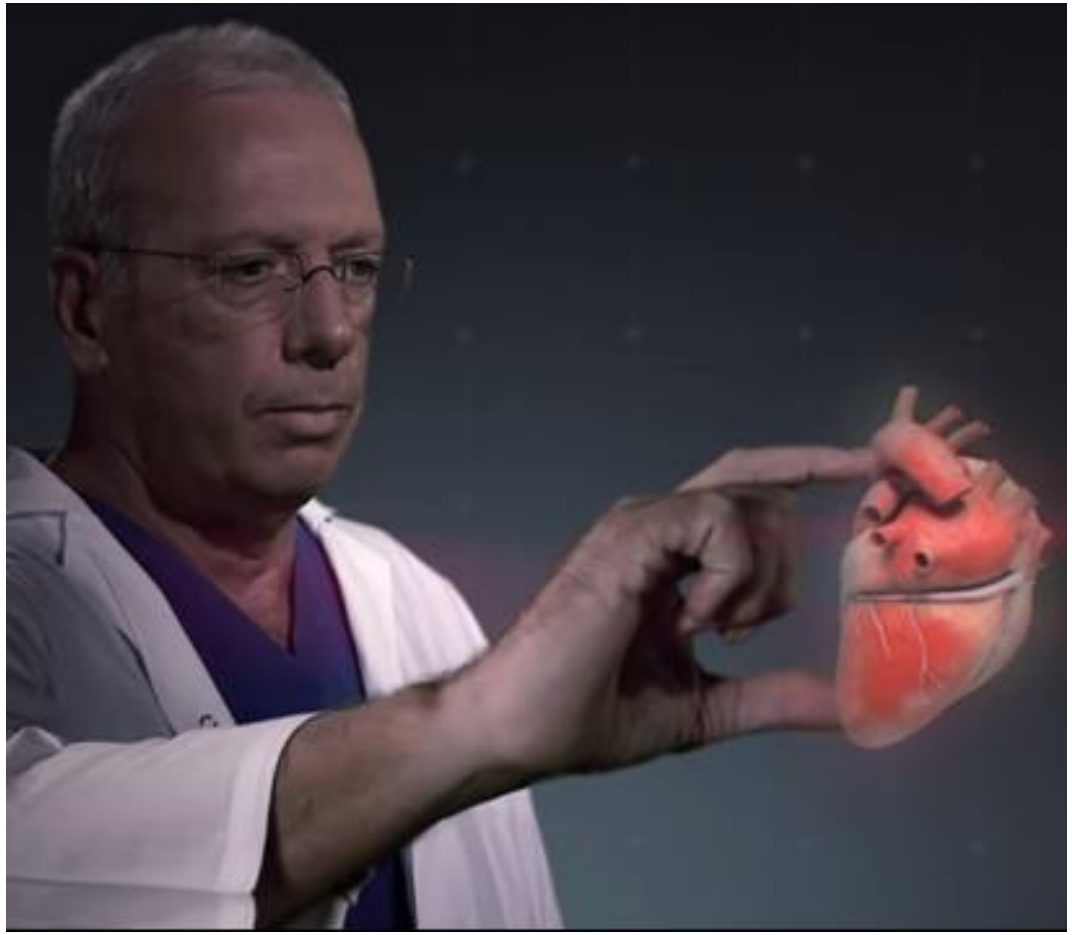
World's first cellphone based ultrasound imager.

World's first portable Xray imager.
25lbs, MODIS™ 810 from Tribogenics is the world's smallest self-contained imaging system.
Battery powered and solar rechargeable.
Unfolds in seconds to provide rapid imaging anywhere in the world for both diagnostic and industrial needs.

http://www.mobisante.com/

http://tribogenics.com/

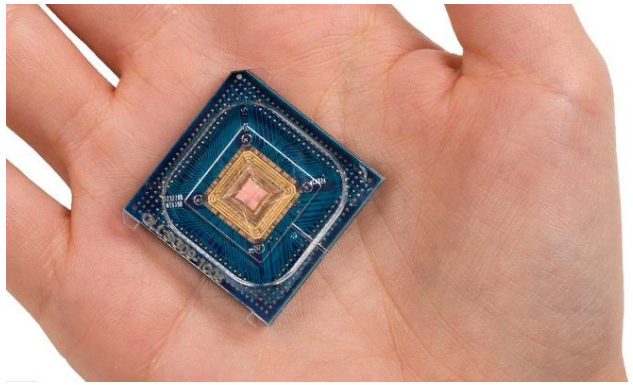
Holographic Ultrasound Imaging



http://nocamels.com/2013/10/israeli-tech-puts-3d-holographic-heart-in-the-doctors-hand-to-save-lives/

Personal iPad-Size DNA Sensor

- Breakthrough electronic DNA Sequencing.
- Instead of optical technologies, a pure electronic chips.
  - 1st will measure 1 gigabase of DNA
  - 2nd will measure 20 gigabases of DNA
  - 3rd will measure 100 gigabases
    - Amount of DNA code needed to accurately analyze a human genome.
- Machines will be sold for a few thousand dollars.
  - Cost of cartridges and chemicals is rumored at $10/sequence.



http://genapsys.com/

Increasing Our Lifespan by 25 years in Our Lifespan!

- Human Longevity Inc. (HLI) is building the world's most comprehensive database on human genotypes and phenotypes to tackle the diseases associated with aging-related human biological decline.
  - Using advances in genomic sequencing, the human microbiome, proteomics, informatics, computing, and cell therapy technologies,
- HLI is also leading the development of cell-based therapeutics to address age-related decline in endogenous stem cell function.
  - HLI is concentrating on cancer, diabetes and obesity, heart and liver diseases, and dementia.
- Using the combined power of HLI's core areas of expertise – genomics, informatics, and stem cell therapies, HLI is going to change the way medicine is practiced by furthering the shift to a preventive, genomic-based medicine.

http://www.humanlongevity.com/

Summary

- Global economic tides riding on TSensors are redefining global economies :
  - The Future will be more amazing than shown products sampler.
  - Multiple market Tornados are coming providing room for many new companies.
    - The 2020 room is expected to be $19T big…
  - New printed electronics industry is emerging
- Rapid market evolution is expected to require massive re-training.
- Byproducts of Sensor-based Revolution:
  - Abundance, eliminating major global problems.
  - All of us will live longer and healthier, in less polluted and more energy efficient world.
  - We will have more fun than ever.
  - We will enjoy the biggest bull market in history?
- The first MEMS/NEMS/Bio Billionaires may have emerged (Nest)…
  - One of you could be the next one…

We need Volunteers

to contribute white papers to the Roadmap on:

- Emerging ultrahigh volume applications
- Emerging sensor technologies supporting ultrahigh volume applications
- Emerging infrastructure for sensors
- Solutions for requested sensors

Next TSensors Summit:

December 8-9, Tokyo, Japan

Please contact: Janusz Bryzek

www.TSensorsSummit.org
jbryzek@TSensorsSummit.org

Thank you