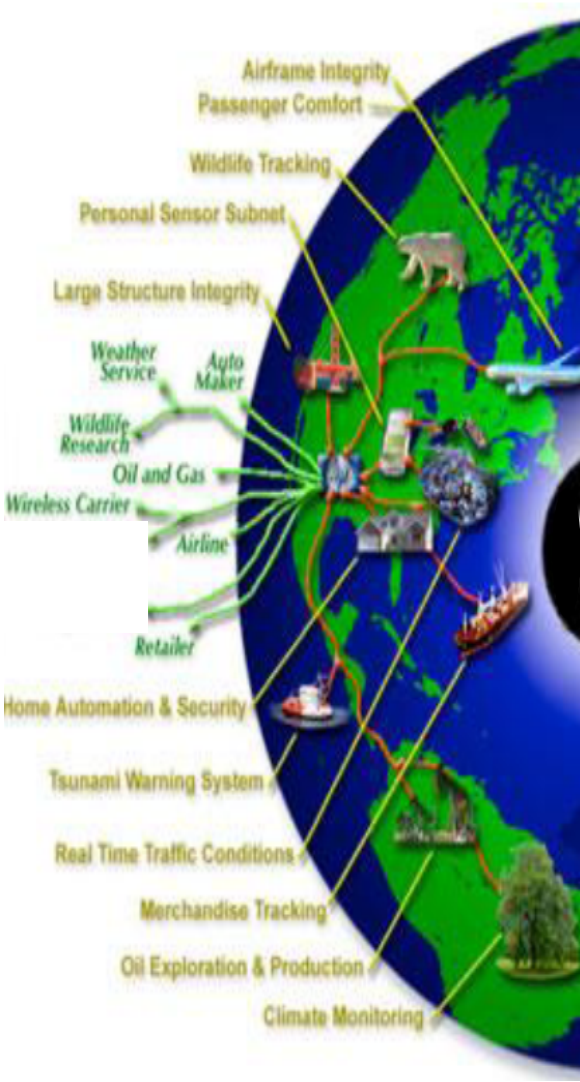
"The Real World is Analog"

and we'll have

a TRILLION Sensors

to monitor it



HP Labs

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Exponential Growth

- Combination of cheap computing, cheap sensors, and cheap connectivity is creating exponential growth
  - Are now shipping over 8 billion MCUs / year
    " " 3 billion Sensors / year
    and the pace and CAGR is accelerating
  - Rate of deployments of new types of Sensors (motion, inductive, fluidic, photonic, …) is growing exponentially
    - 2007 - 10 Million mobile Sensors shipped
    - 2012 - 3.5 Billion mobile Sensors shipped
- Sensor Gurus believe having 1 Trillion Sensors online within 10-15 years is a serious, feasible scenario

Effects of 1 Trillion Connected Sensors

- Current Internet would increase by a factor of 1000
- 1 Bronto-bytes of data (10 ** 27) (10 ** 12 PetaBytes)
- Sensors are proliferating everywhere:
  - 1000 sensors per engine (GEnx Jet engine - 787)
  - 6-20 MCUs, 30-80 Sensors, and 3 networks (Can/Lin/Wifi) in our new cars
  - 2+ MCUs and 4-8 Sensors in a Smartphone, 8 Sensors in Nike Shoe (Nike+)
- Even if we only reach 1/4 of the Trillion Sensor goal (250 billion is easily within reach), the numbers are still huge
- BUT: "We are swimming in sensors, and drowning in data" (IBM researcher)

Typical "Big Data" Sensor Based Apps

- Oil Exploration
- Electrical Grid / Power Generation
- Aviation
- Environment
- Healthcare

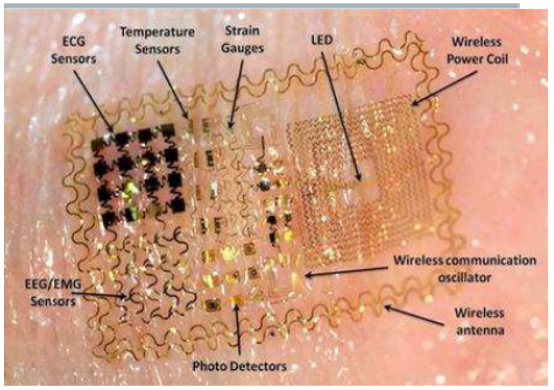
Next Gen Sensors Expanding Reach

- Huge increases in accuracy (100 - 1000x better)
  - Micro-fluidics: resolution down to pico-liters
  - Inductive sensing: resolution down to microns
  - Photonic sensing: resolution down to pico-meters

- Each increase in accuracy significantly expands the scope of problems areas that can be addressed and monitored

Major New Markets and Apps

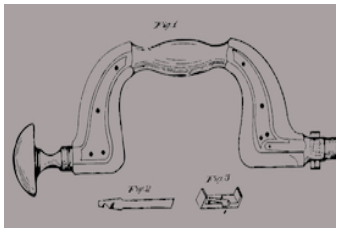
- Wearable and Disposable Sensors
  - Micro-fluidic devices printed on paper
  - Tattoo sensors printed on skin

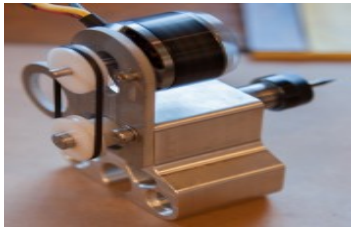


Tattoo sensors printed on skin UCSD

- Combine data from multiple sensors to provide more comprehensive view (Sensor Fusion / Sensor Hubs)

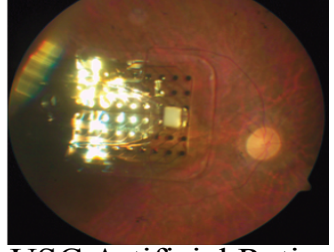
- 3-D Gestures / 3-D Printing / 3-D Milling (CNC)
  - Dramatically speed up and simplify manufacturing
  - Mass customization and low cost small production runs
  - "Programmable Matter" (DARPA/MIT/Harvard)





- Embedded Devices (not PCs) will dominant these spaces, and be the key driver of new apps

Medical



USC Artificial Retina

- Current Healthcare approach is a joke !
  - Go to doctor once or twice a year, and get 3-4 data points recorded.
  - In the industrial world, no one in their right mind would consider that level of data a useful trend analysis.

- 75% of Developed world's Medical problems are Chronic (heart, diabetes, …) ==> frequent periodic monitoring

- Better Approaches coming
  - Home-based "Health Hub" - record key vitals daily.
  - Micro-fluidic sensors plus silicon "Lab on a Chip" will eliminate the need for most clinical labs.
  - Testing can be done at home, and results sent periodically to Doctor.
  - Ultra-sound imaging in a Hand-Held

Summary

- Exponential growth in cheap sensors and cheap computers will hyper-charge new Application areas
- Analog (Sensor) derived data will begin to rule
  - Conventional "Structured Data" input's days are numbered (including HTML)
- The really large "Big Data" apps of the future will be Sensor driven.