CeNSE :
Central Nervous System for the Earth

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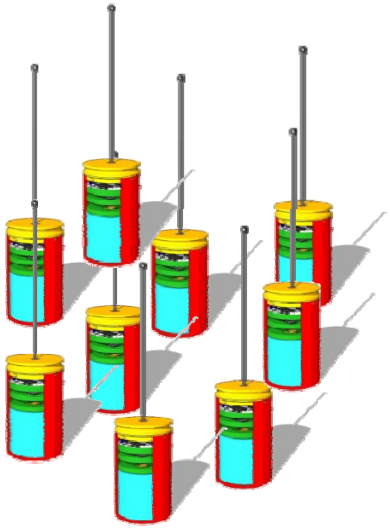
Sensors

will impact human interaction with the earth as profoundly as the internet has revolutionized communication

GROWTH OF IT AND THE NEXT WAVE

- Integrated circuits and Moore's Law enabled computing everywhere
- Integration = low cost, small size, low power
- From 1 computer to computer labs to networked computers to cloud computing
- This "brain" for processing information is "blind, deaf and numb" to its surroundings
- Sensors begins an era of aware computing
- An example is the modern car: a closed system of networked sensors and microcontrollers greatly increasing occupants safety, sustainability, and security

SENSING SYSTEM CREATION



Nodes

Network

Big. Black Boxes: HP's new BladeSystem Matrix.

Analysis

Action

DATA → INFORMATION

A network of sensors produces data that is turned into information

CeNSE

Central Nervous System for the Earth

– Awareness of planet

– Measurement of impact

– Taste/Smell/Touch/Sound/Sight

– Safety

– Sustainability

– Security

~1 trillion sensor network

Quantity of data creates quality of data

MEMS TECHNOLOGY MAKES SENSORS

– 1 trillion sensors
  - Need to push integration to lower cost, size, power

– MEMS – micro – electro - mechanical systems
  - uses IC fab techniques to make mechanical elements
  - HP is #1 MEMS company

INK CARTRIDGE = SENSOR NODE

MEMS chip

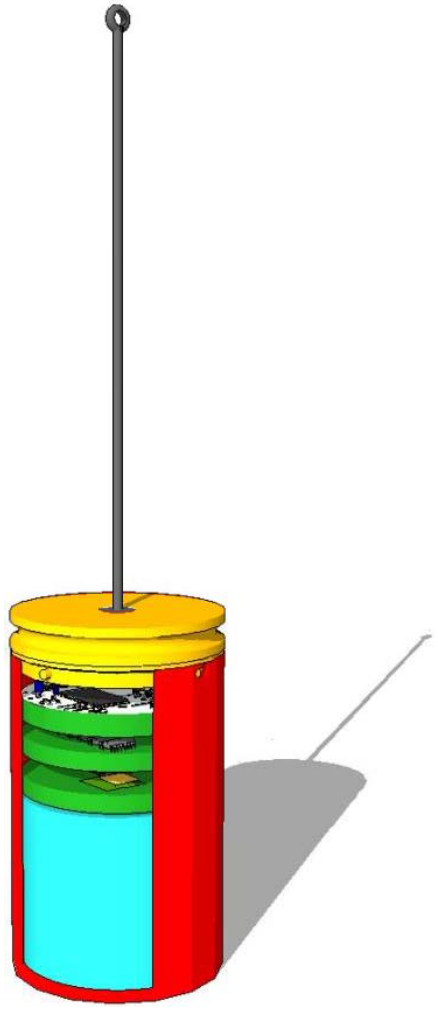
Harsh environment

Custom package

Interface

Reservoir

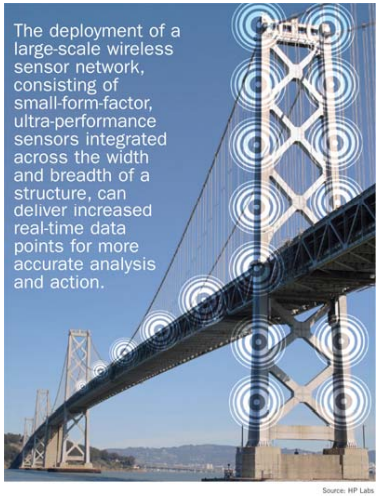
Millions produced



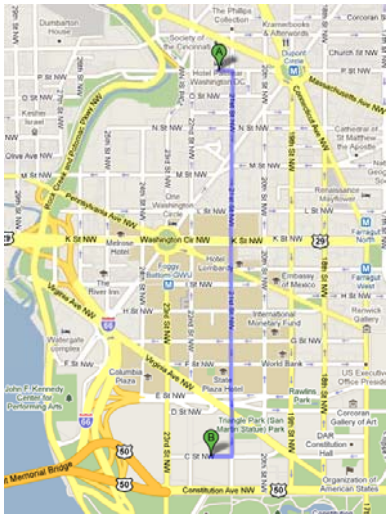
"FEEL" – INERTIAL SENSORS

– Consumer revolution
  • Game Controller / Smart Phone

– Vibrations
  • Seismic detection
  • Security at borders
  • Structural health monitoring



– Navigation
  • Add gyroscopes
  • GPS denied, dead reckoning



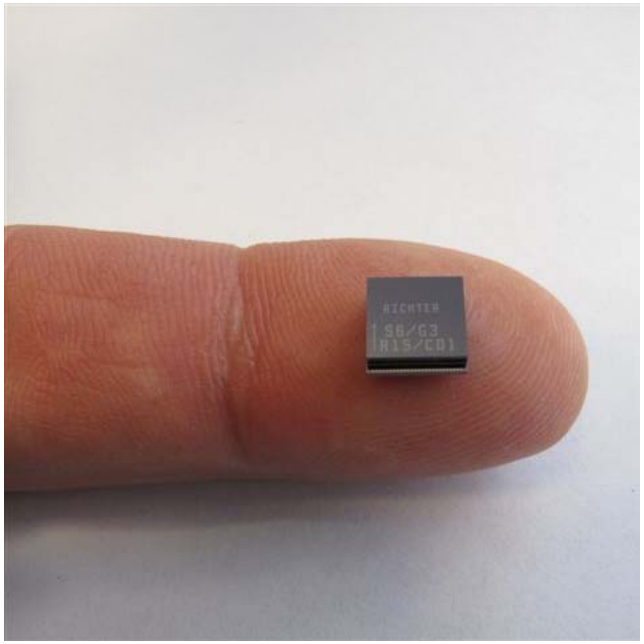
NEXT GENERATION INERTIAL SENSORS

HP's platform for high performance inertial sensors

- Silicon based MEMS
- Accelerometers, Gyroscopes

- 1000x more sensitive than current MEMS
- < 1 micro-g to > 10 g

- Built in our 200mm inkjet fab
- High performance meets low cost



HP Inertial MEMS Technology

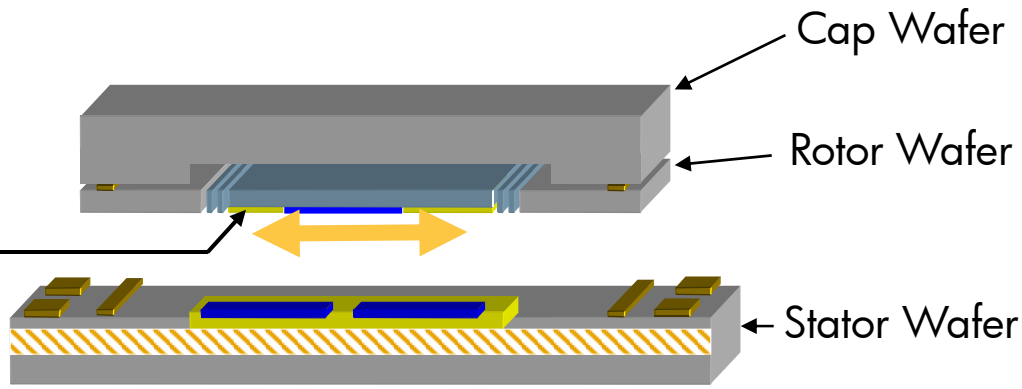
Next-Generation MEMS Inertial Sensors

Device Innovations

3 Wafer (Single Crystal Si) Const.

Large Proof Mass

Novel Electrode Design –
Constant Gap Sensing Surface Electrodes



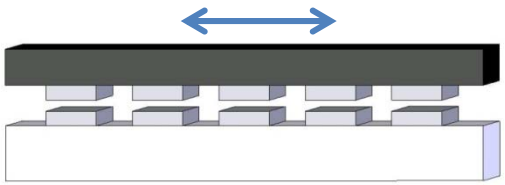
$$C \propto \frac{Area}{Gap}$$

Linear ΔC

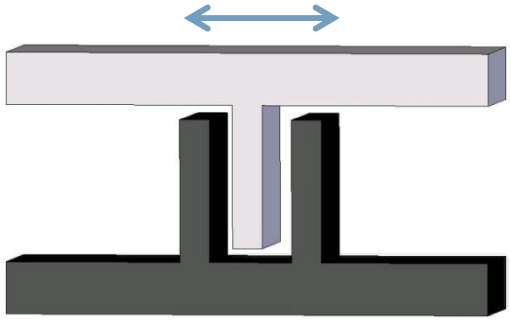
Large dC/dx

Low N_t (total noise)

HP Area Change

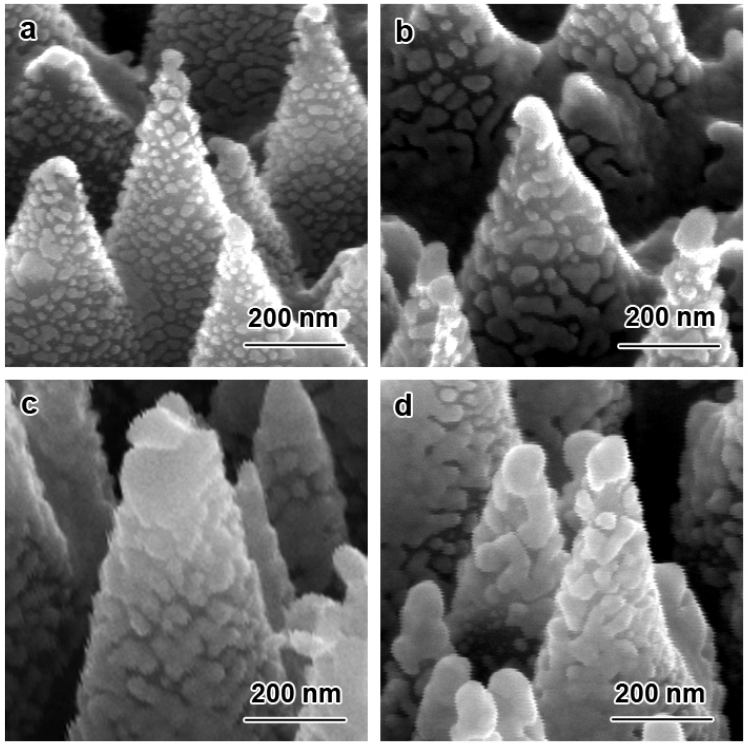


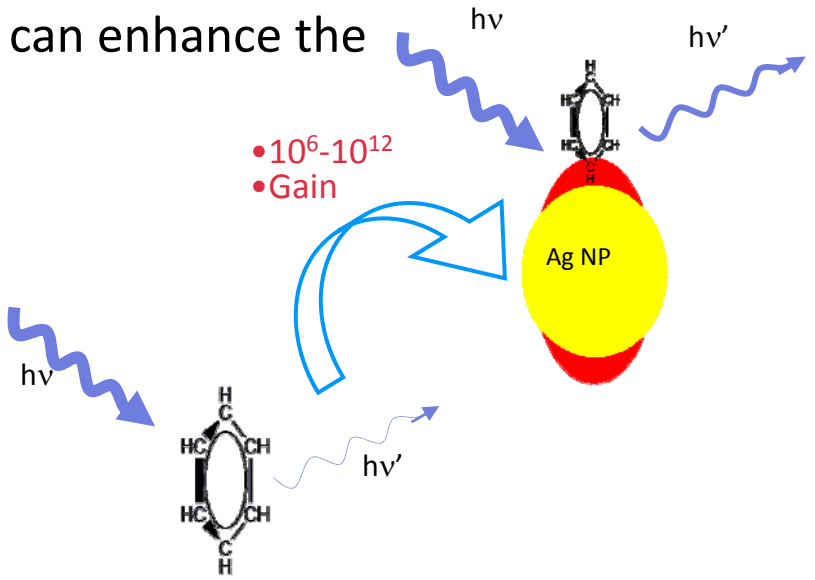
Competition Gap Change

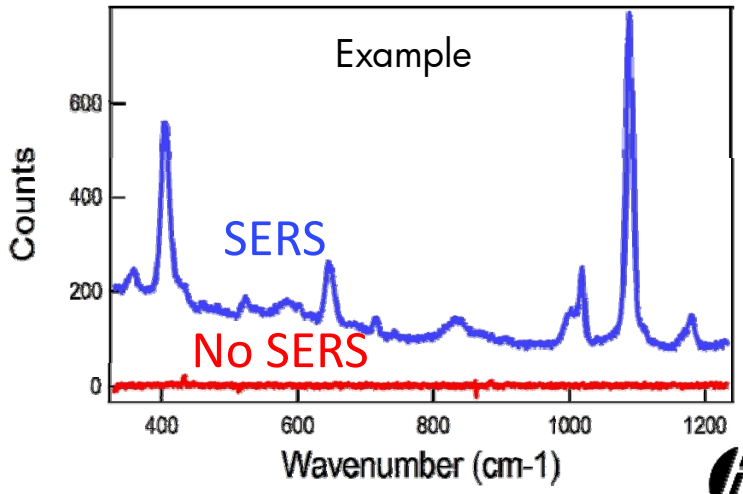


"TASTE AND SMELL" –
NANO-OPTICAL ANTENNA FOR SERS SENSOR

Localized surface plasmon on nanostructure can enhance the Raman scattering process -- SERS



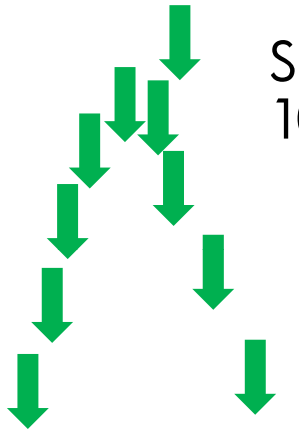




Electromagnetic field induced EF: 10^6 - 10^{12}

SMART HIGHWAY

SAME DATA, MANY USERS



Sensor node every
10m along roadway

Sensor

Vibration	Tilt	**Air Flow**	**Light**
Biological	Rotation	Navigation	**Temperature**
Chemical	**Humidity**	**Sound**	**Pressure**

Time, frequency, number

Cloud Services

Data Center

5pm
30 mph (-50%)
1000 veh/hr (-60%)
Temp, baro, humid

Highway Patrol
Accident
Send response

Dept of Transportation
Occurs on weekdays
Study improvement

Street light outage

Automaker
Wireless Carrier
Traffic Advice

Weather service
News outlet
Climatologist
Local conditions

NETWORK AND CLOUD

Data rate gets HUGE!

- Bandwidth for transfer (6kbps * 1e6) = 6 Gbps
- Spindles for storage (> 50)

Information Theory

- Applications where you want 100% of data
- Applications where you want “just enough for records”
- Applications where you must have “that” 30 seconds

VISUALIZATION

Combine data

- Smart freeway AND information from vehicles

How to turn data into information

- Decisions **in machine**
  - Adjust HVAC unit 2 and dampers 34, 35, and 64
- Decisions **for humans**
  - Take this freeway to the airport
- Decisions **by humans**
  - Warehouse resource management

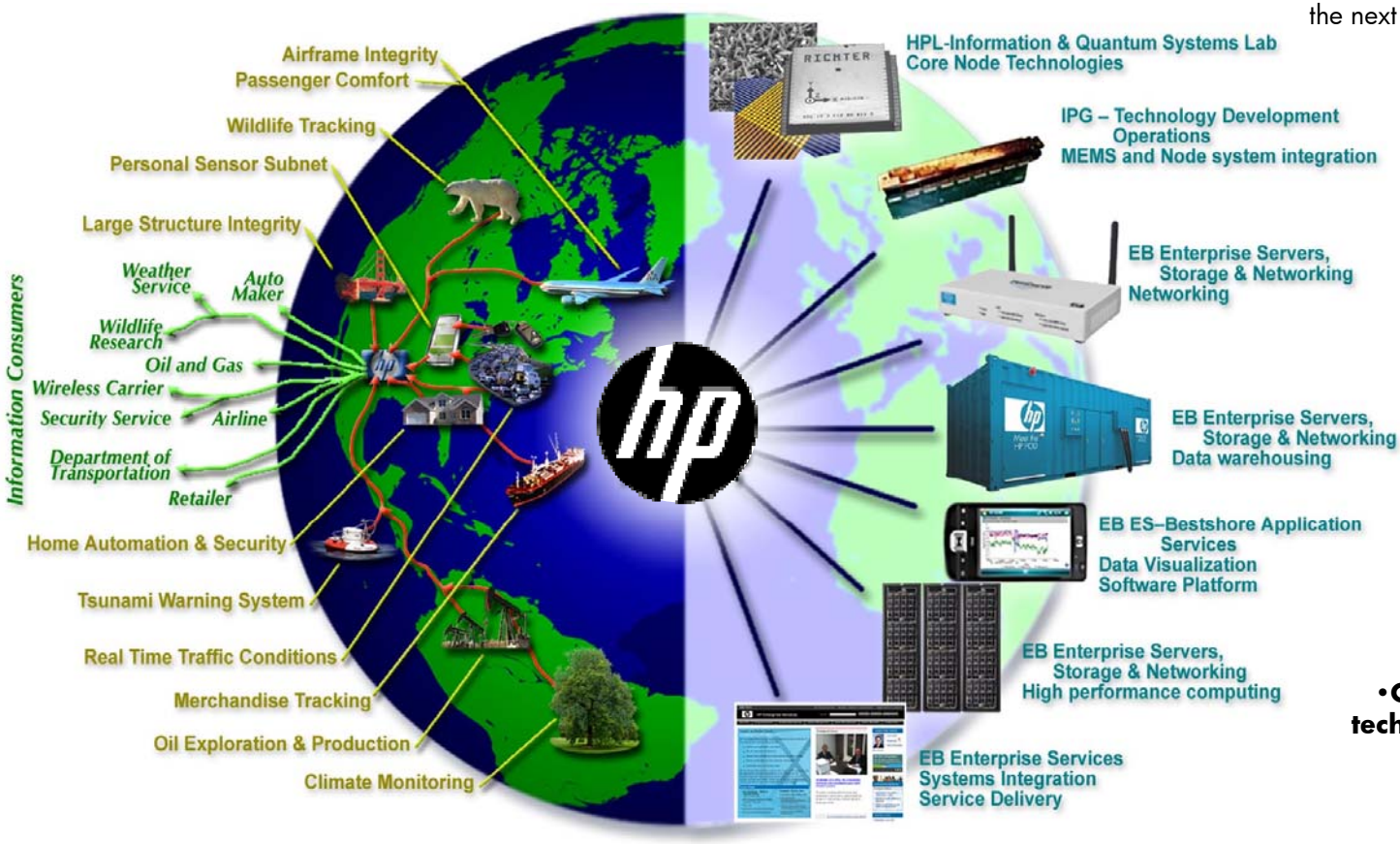
EVERYTHING AS A SERVICE

- Bridge owner doesn't want to be in IT space
- Sensing solution:
  - Sensor node design
  - Network hardware selection (wireless/cabled)
  - Management of system and equipment
  - Data collection / storage / retrieval
  - Quality control of system / data
  - Visualization and dashboard creation
  - Information supply

CeNSE – CENTRAL NERVOUS SYSTEM FOR THE EARTH

Revolutionize human interaction with the earth as profoundly as the internet has revolutionized personal and business interactions

One trillion nanoscale sensors and actuators
will need the equivalent of 1000 internets:
the next huge demand for computing!



Sensing systems:
$70 B global market by 2013
Source: Frost & Sullivan

Value Added Sensing Services:
$290B global market by 2013
Source: Harbour Research

Why HP?

- **Only company with the technical breadth and depth**
- **Uniquely positioned core competencies: hardware and IT**
- **Pull through for computing**
- **New information services**

IMPACT ON SOCIETY

- Privacy
  - Want to know how many cars
  - Don't care who's car
- Security
  - Trusted data
  - Secure network
- Open Data Source
  - If private and secure, let people compete on analysis
  - New business models we can only imagine
  - Use the cloud to access and analyze data

MOVING CENSE FORWARD

- 5 year program at HP Labs
  - Sensing: Richter – feel SERS – taste, smell
- Seeking strategic partner with real application
  - Distributed sensing need, integration
  - Large node count 1e4 -> 1e6
  - Work with partner to spec system
- Service creation: develop, deploy, collect, analyze
- Real world trial, real hardware, real data
- Real results

FIRST CENSE PARTNER, FEB 2010

http://www.np.com/go/sensingsolutions

- Exploration survey network
- Up to 1M wireless sensor nodes
- Complete sensing solution
- Increase efficiency of extraction
- Reduce impact to environment