CeNSE: Awareness through A Trillion MEMS Sensors

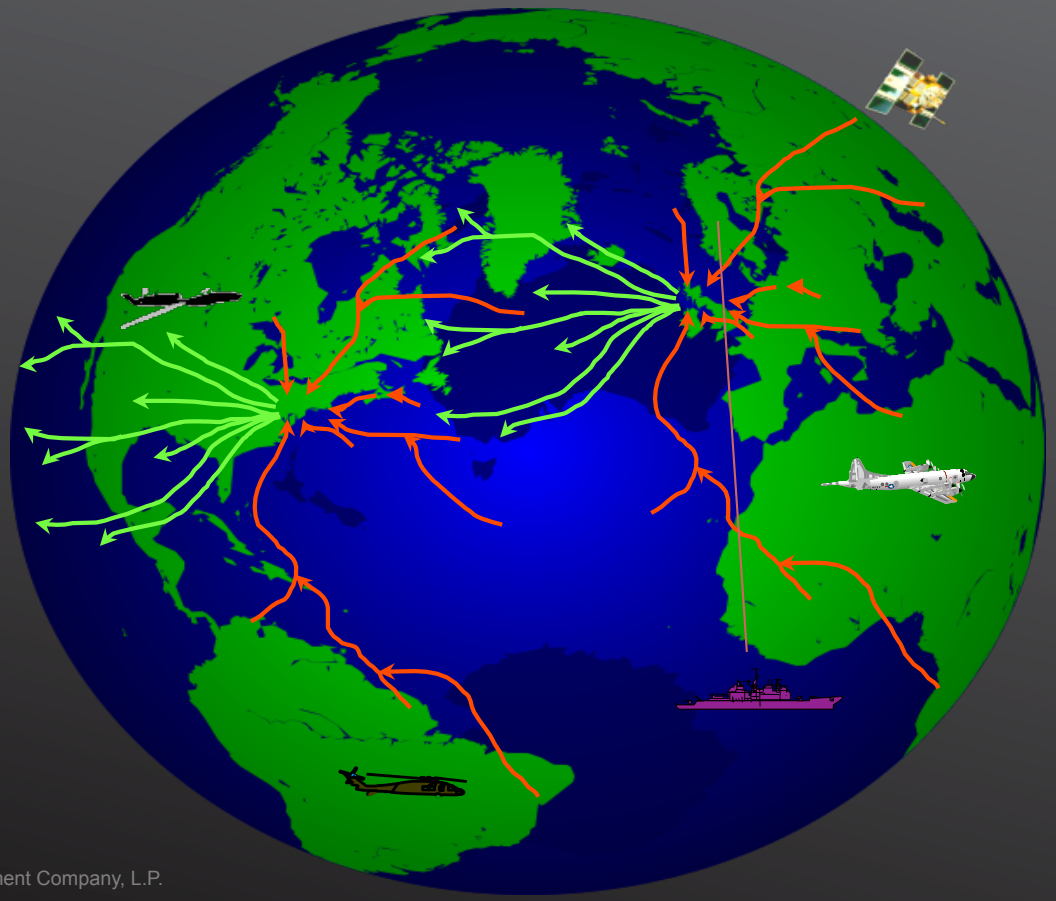
the decade of sensing

and sense-making

Richard J Friedrich
HP Labs
April 2012

FUSION OF MAN, MACHINE, VIRTUAL, PHYSICAL

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



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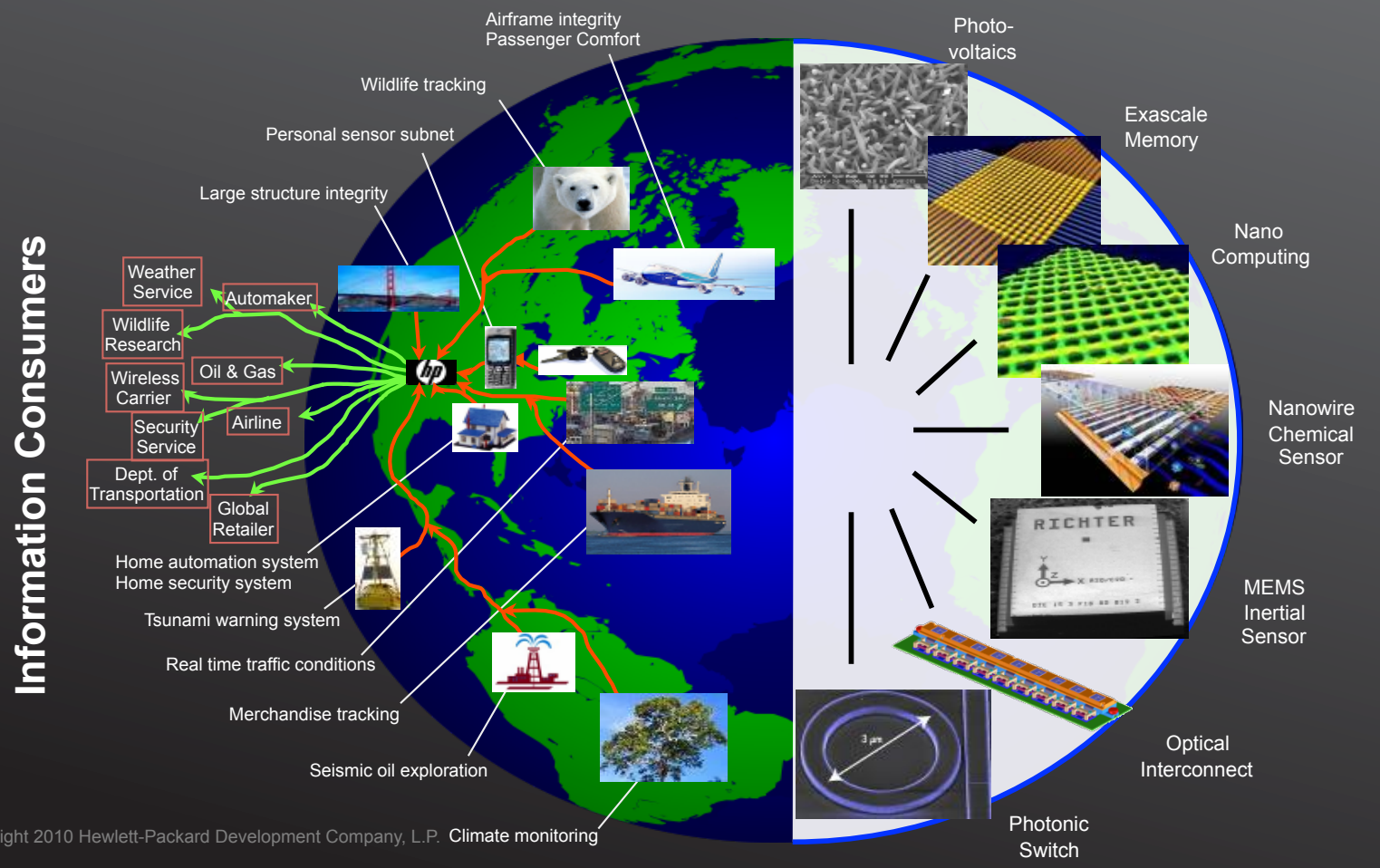
CeNSE : The Central Nervous System for the Earth



One trillion nanoscale sensors and actuators will need the equivalent of 1000 internets

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A Trillion Sensor Market

- A trillion sensors equals
  - one sensor every 10 square feet covering the US
  - 150 sensors per person on the planet

- Revenues
  - sensor devices
    - US $76.7 Billion by 2017, According to Global Industry Analysts, Inc. (October 2011)
  - big data analytics
    - IDC expects the Big Data technology and services market to grow from $3.2 billion in 2010 to $16.9 billion in 2015. a compound annual growth rate of 39.4% (March 2012)

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Sensing

physical, chemical, biological

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Sensor Capabilities & Sensor Densities

better sensors

more sensors

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CeNSE

Central Nervous System for the Earth

- RESEARCH CONTRIBUTION
- Networks of billions of low-cost, self-powered, nano-scale sensors
  - Acute sensitivity of minute changes
- Dynamically provision resources in real time
  - Seismic oil exploration
  - Structural integrity
  - Merchandise tracking
  - Energy use
  - Climate monitoring

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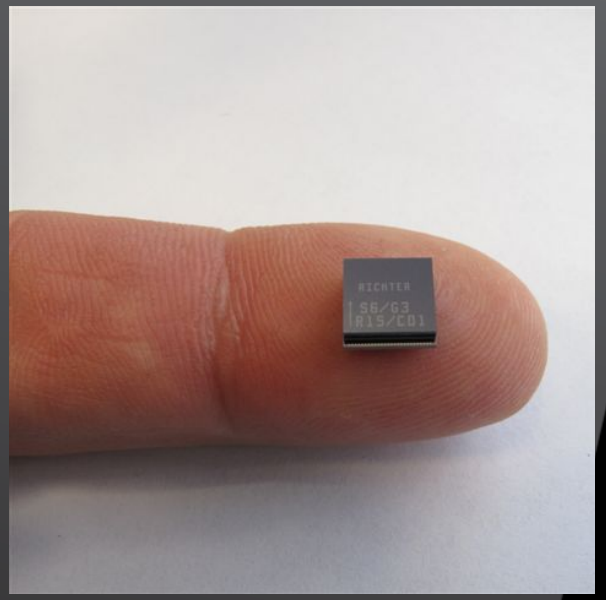
Feel: Next Generation Inertial Sensors

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



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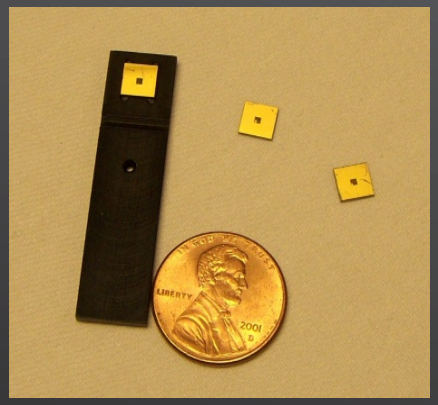
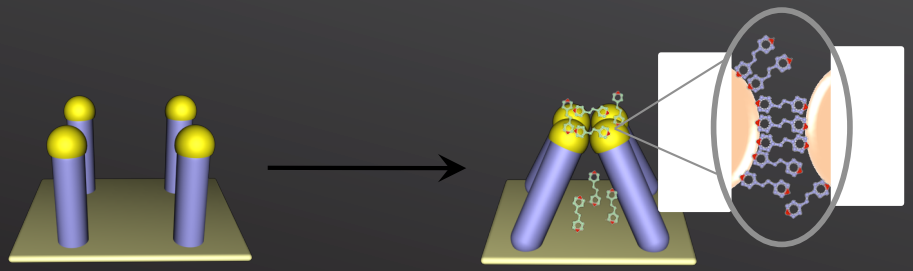
Taste and Smell: Nanofinger sensor chips



- Surface Enhanced Raman Scattering (SERS)
- Rational engineered nano-structures for active molecule capture and detection
- Reliable SERS Enhancement Factor > 10^{11}
- Scalable fabrication based on nanoimprinting



Molecule trapped gold nano-fingers

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Sense Making

big data analytics

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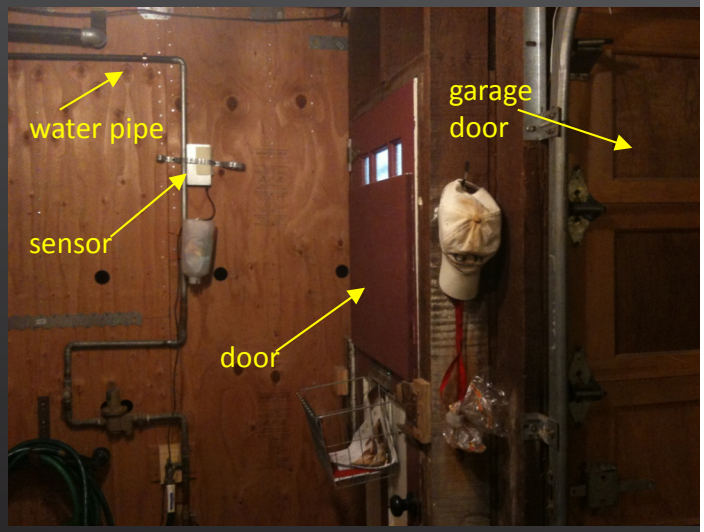
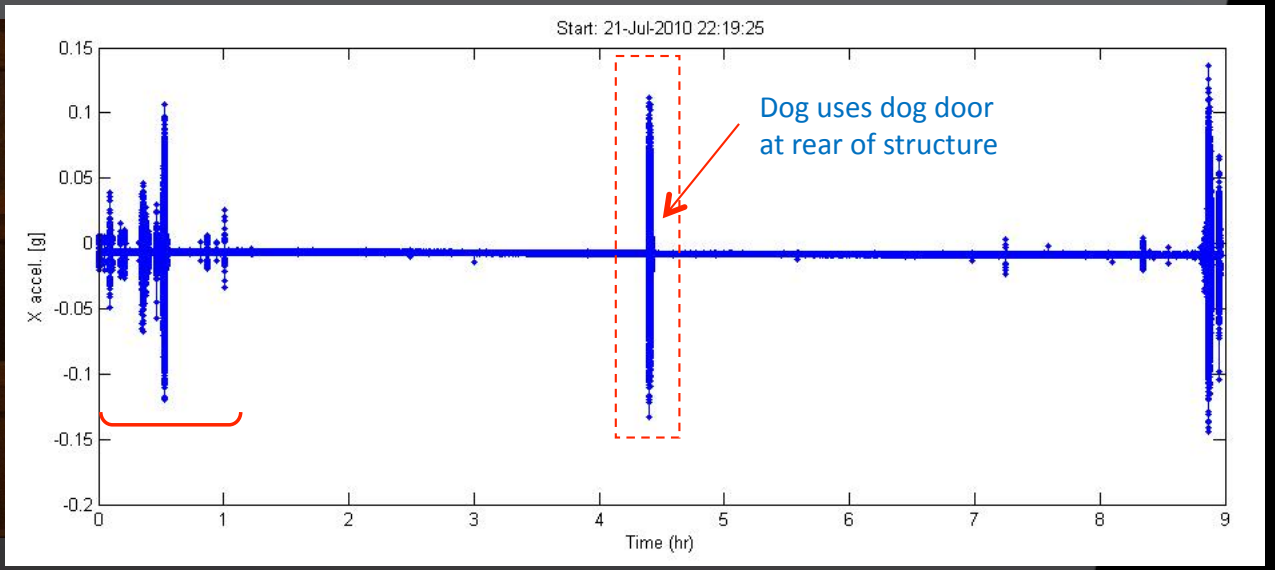
Signal processing





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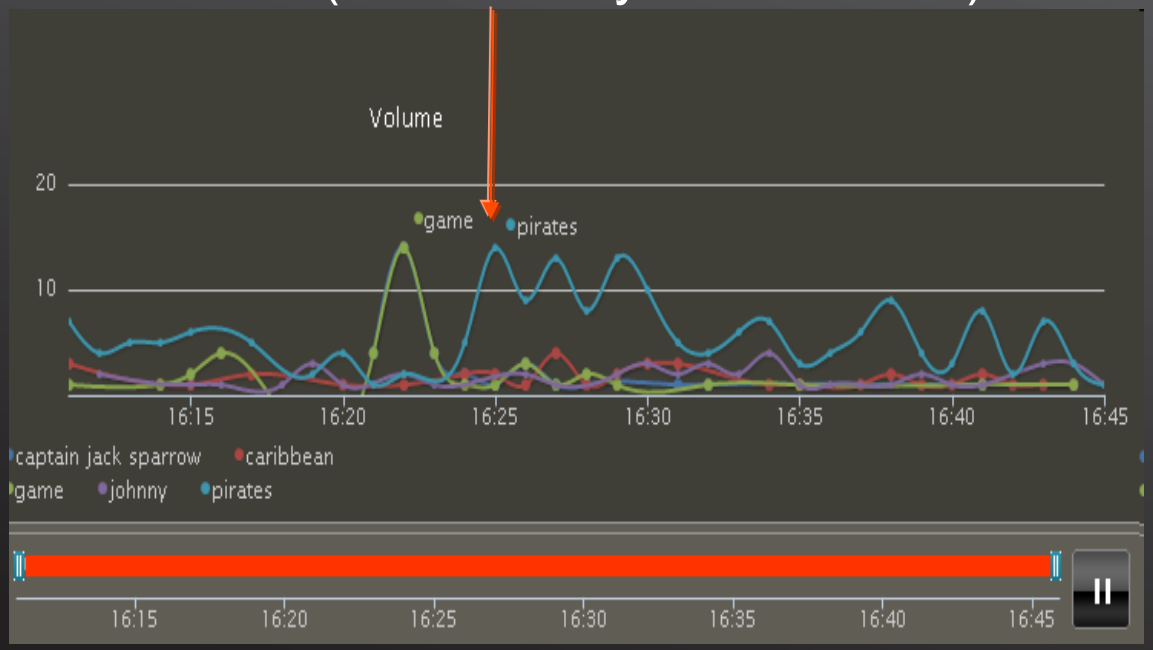
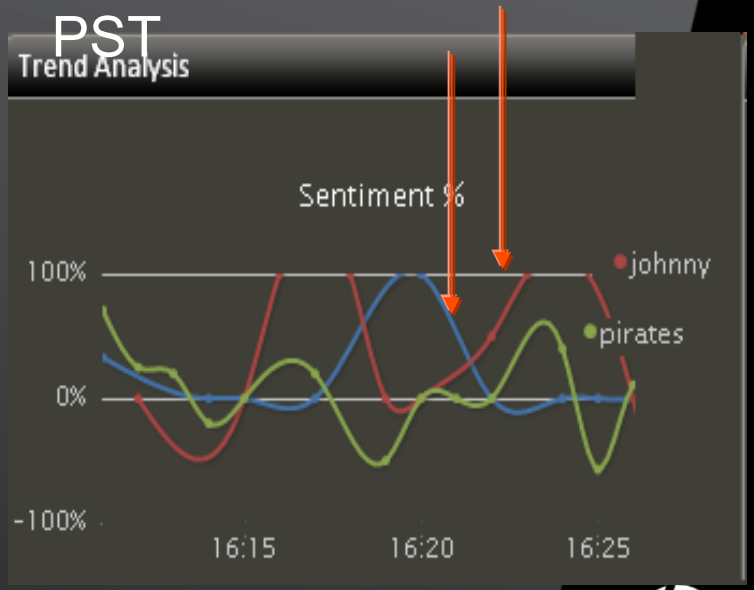
Real time analytics

Pirates of the Caribbean tweets

- Spike in tweet volume on Pirates of the Caribbean (after Disney teaser tweet) around



- Spike in positive tweet sentiment on ‘Pirates of the Caribbean’ and ‘Johnny Depp’ around same time PST



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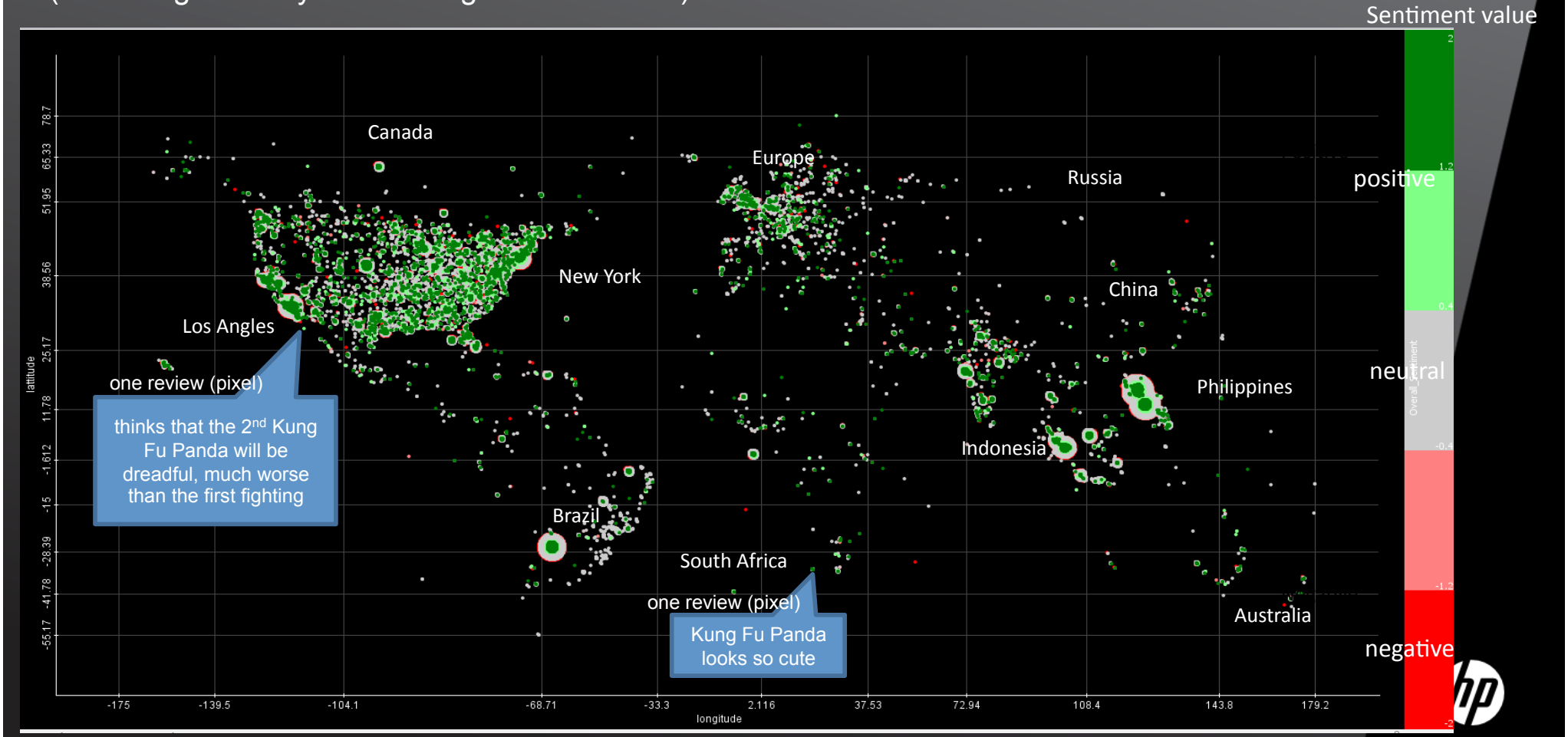
Visualization: Pixel Feedback Geo-Map

(distort high density areas using colored circles)

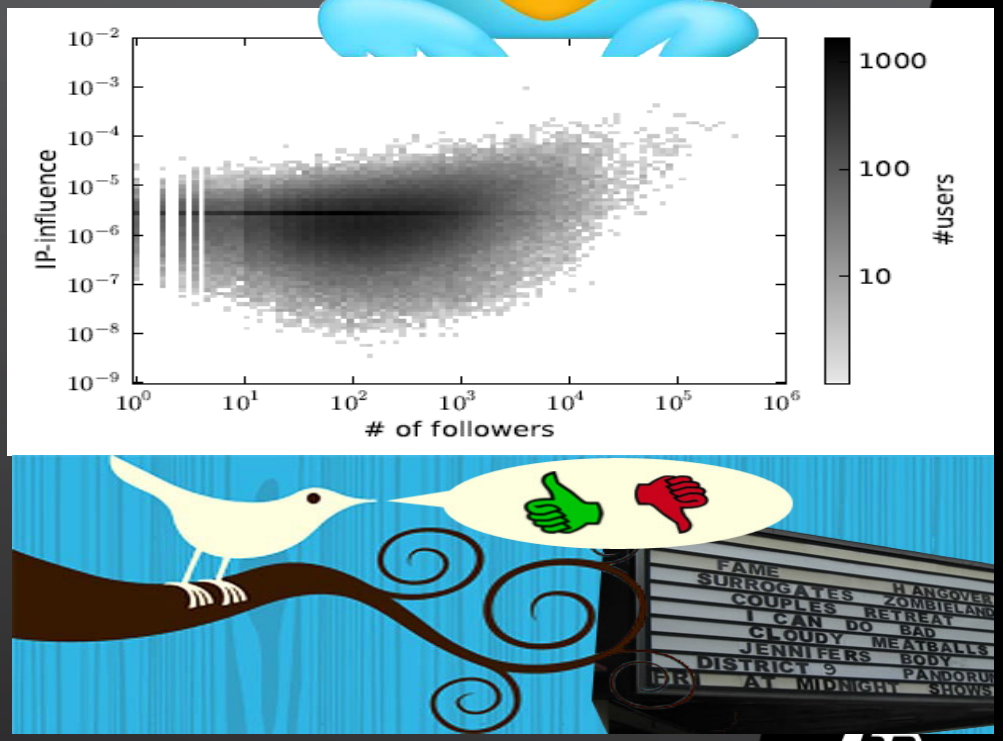


Predictive analytics

– Predicting movie succes with HP Social Web Analytics

HP Social Computing Lab:
"*High popularity numbers does not necessarily add up to high influence and vice versa.*"

HP Labs uses Twitter to predict how well a movie will do in the first two weekends of release. What's more, the method works even better than the most accurate method currently in use, the "Hollywood Stock Exchange" (HSX). HP Labs demonstrated 97.3% accuracy.



- A new source to predict market behavior
- A tool to do influential CRM much more effectively

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HP Customer Co-Innovation

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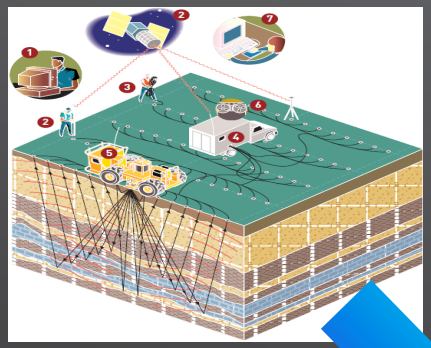
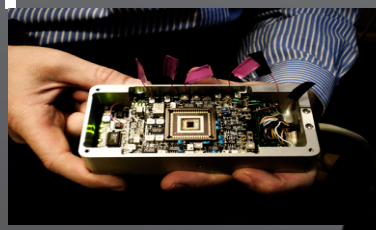
HP Seismic Sensing Solution

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

- Exploration survey network
- Up to 1M wireless sensor nodes
  - **New HP seismic sensor technology**
- Complete sensing solution
  - Sensors, network, storage, quality control, deployment/recovery
- Efficiency of extraction – more from existing fields
- Reduced impact to environment
  - fewer new wells, in best locations
  - Less equipment into field, no cables
  - Energy reduction of system

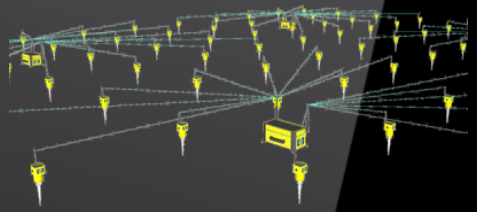


HP Accelerometer



PRESENT
10km x 10km survey
10,000 nodes
300km cables

FUTURE
10km x 10km survey
Up to 1,000,000 nodes
NO cables



Courtesy: http://www.ainc-inac.gc.ca/ai/scr/nt/ntr/pubs/og-eng.asp

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Sensors in a System– Major Airline

Sensors on:
- Airplanes
- Baggage
- Tugs, Carts, etc.
- Crew
- Parking Lots
- Cargo
- Equipment
- Spares & Inventory

Sensed Data from:
- Weather
- Traffic
- Terminal flow
- Airport
- Other Airports

Information from:
- Other airline systems
- Passengers
- Suppliers
- Unions
- Road Departments
- Weather Bureaus
- CNN/FOX/etc.
- FAA
- Etc. Etc. Etc.

To achieve:
- Optimum economics
- Optimum compliance
- Optimum passenger satisfaction
- Optimum employee satisfaction
- Optimum whatever you tune it to

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Innovation Invents the Future

HP-DreamWorks collaboration on the film *Real Steel*

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Awareness of the World

Our Vision for the Future

- Internet of things – not conscious
- Deploying and training sensors to be aware
- Seamless integration of virtual and physical
- Sense, Communicate, Analyze, Insight, **Act**
- Improve Safety, Sustainability, Security
- *The next technology age*

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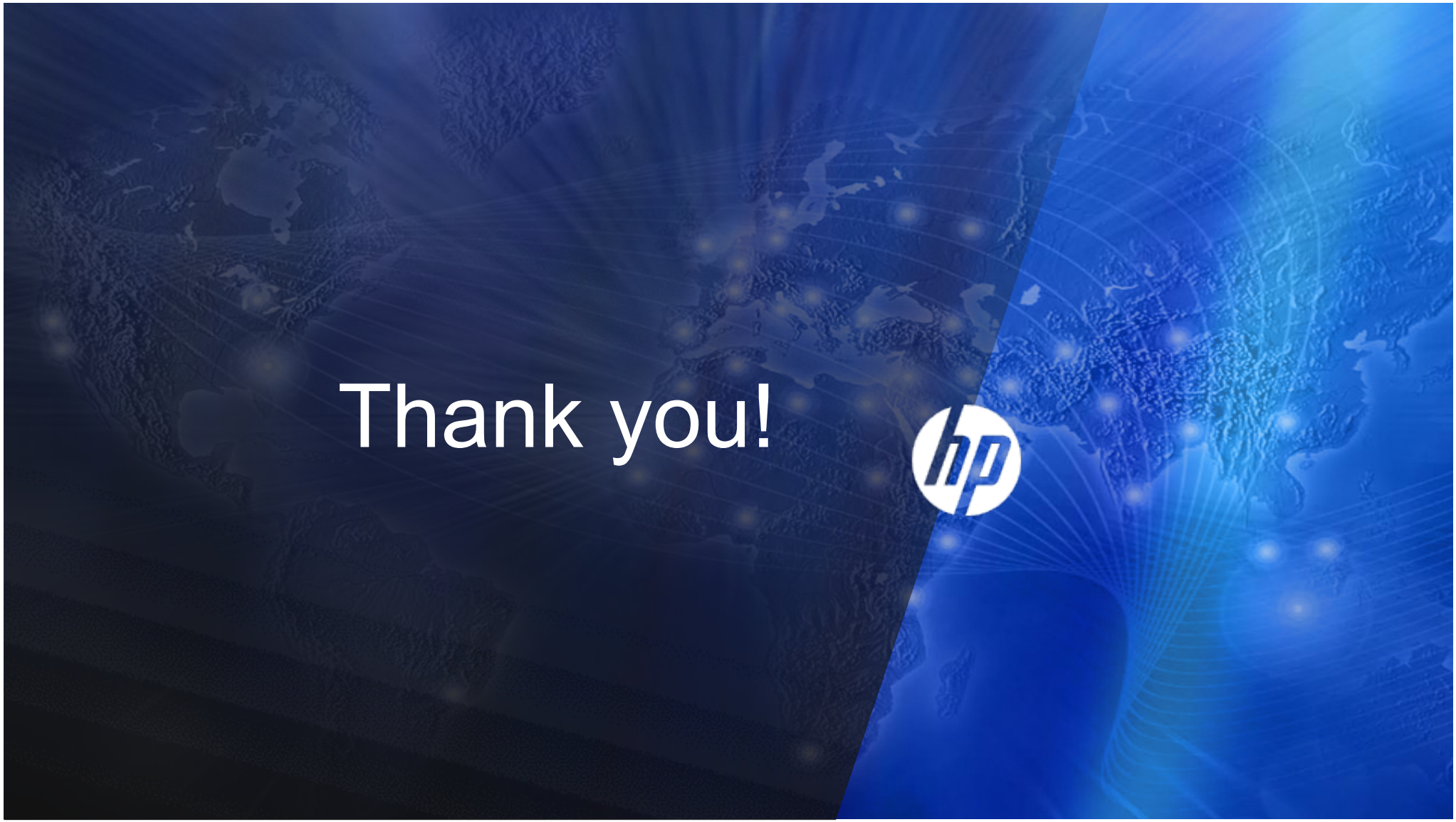
Thank you!