KNO.E.SIS

COLLECTING THE DOTS | CONNECTING THE DOTS

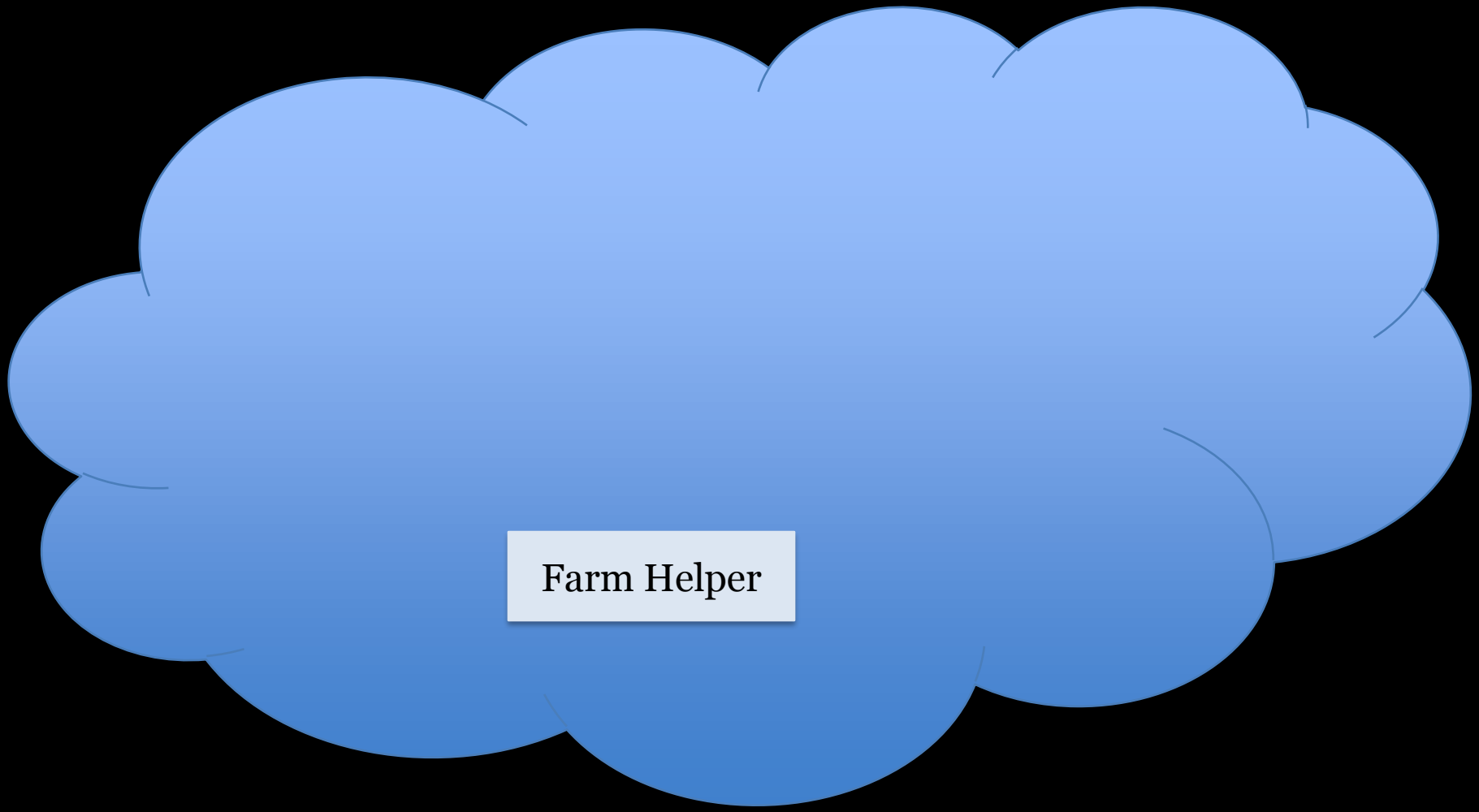
Joshi Research Center

A New Frontier in Innovation

imagine

imagine when

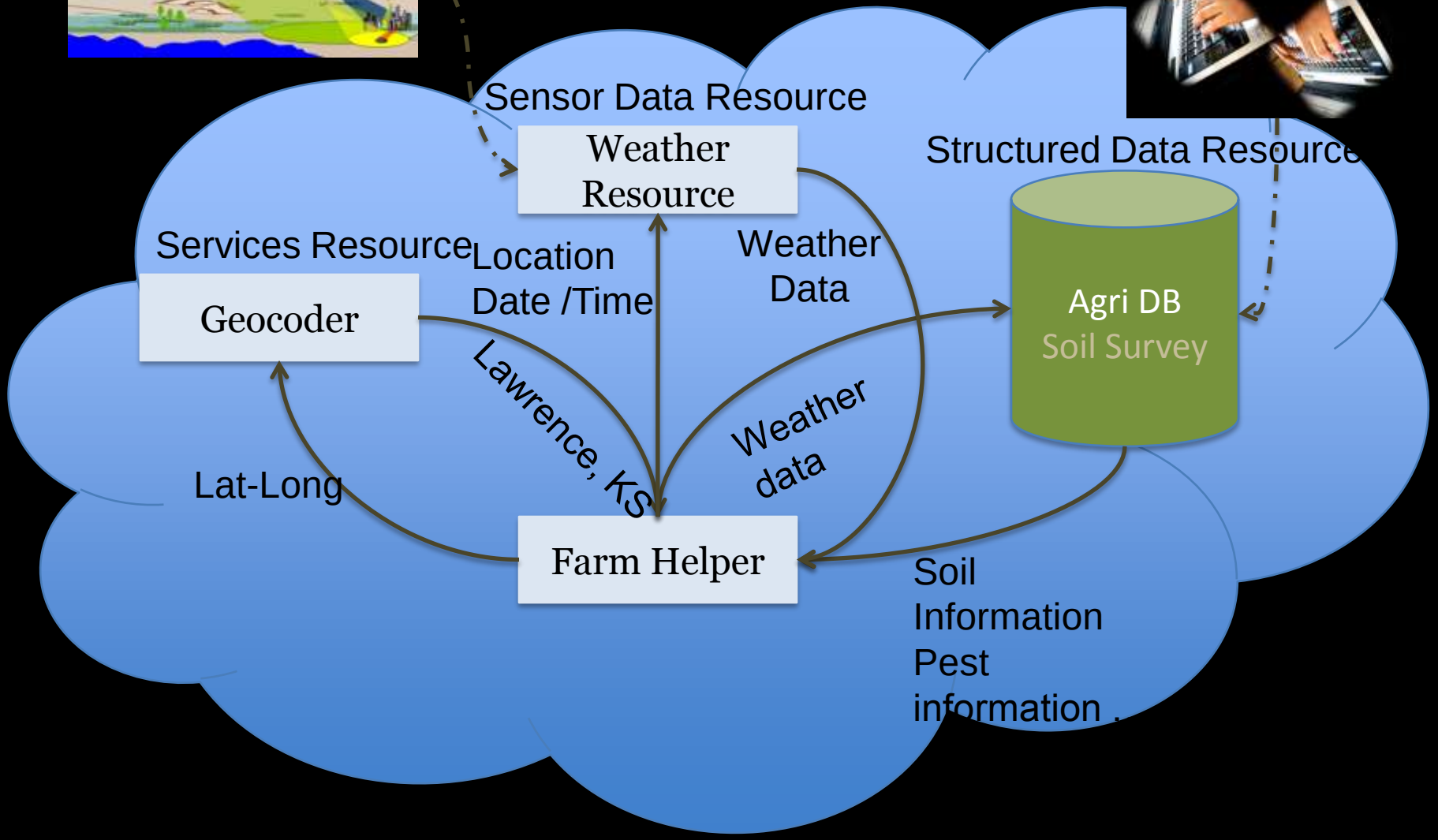
meets



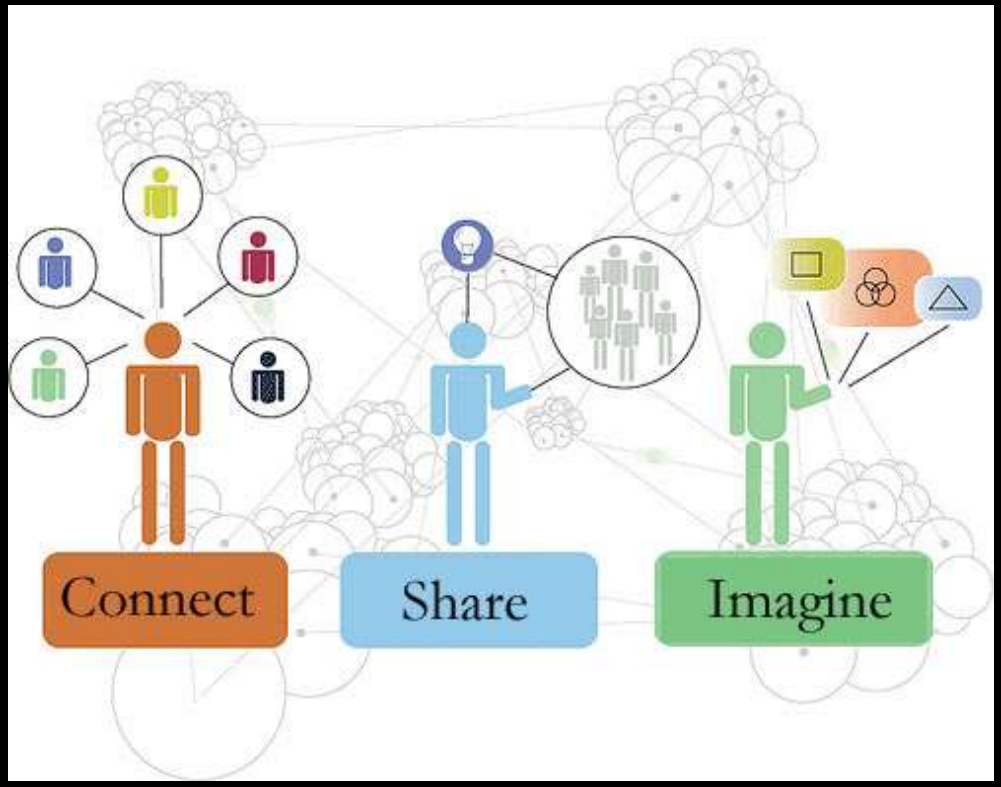
with this

- Latitude: 38° 57’36” N
- Longitude: 95° 15’12” W
- Date: 10-9-2007
- Time: 1345h

that is sent to



and



Six billion brains

imagination today

impacts our experience tomorrow


COMPUTING
FOR
HUMAN EXPERIENCE

Computing For Human Experience:

Sensing, Perception, Semantics, Social Computing, Web 3.0 and beyond

Keynote @ Workshop on Emerging Topics in Engineering, DAIICT, July 2009

Amit P. Sheth,

LexisNexis Ohio Eminent Scholar

Director, Kno.e.sis center, Wright State University

knoesis.org

Thanks: K. Gomadam, M. Nagarajan, C. Thomas, C. Henson and Kno.e.sis Researchers

Technology that fits right in

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

Machines that fit the human environment instead of forcing humans to enter theirs will make using a computer as refreshing as a walk in the woods."

Mark Weiser, The Computer for the 21st Century (Ubicomp vision)

"We're crying out for technology that will allow us to combine what we can do on the Internet with what we do in the physical world."

Ian Pearson in Big data: The next Google

But we are not just talking about

Ubicomp: Mark Wisner and others

Intelligence @ Interface: Gruber –
"the system knows about us, our information, and our physical environment.
With knowledge about our context, an intelligent system can make recommendations and act on our behalf."

What is CHE? Beyond better human interaction

- Focus in the past (egUbicomp): How humans interact with the system (computer, Internet)
- Our focus—almost the reverse of the past (and both are needed)
- Computing for Human Experience is about:
  How computing serves, assists and collaborates with humans to complement and enrich their normal activities
  - nondestructively and unobtrusively, with minimal explicit concern or effort on part of humans
  - anticipatory, knowledgeable, intelligent, implicit, ubiquitous
  - Computing that encompasses semantic, social, service, sensor and mobile Web

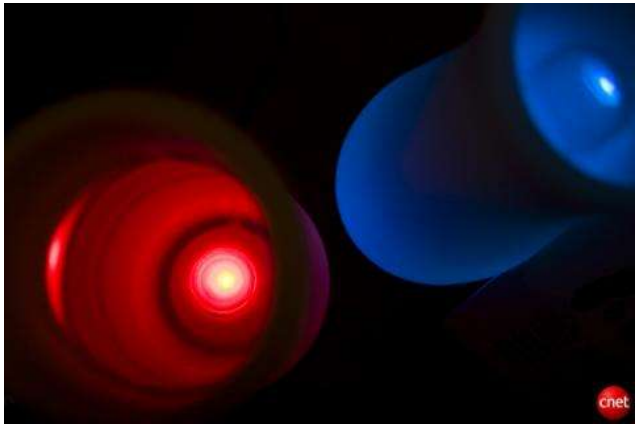
Principals of CHE

- Human is the master, system is the slave
- Human sees minimal changes to normal behavior and activity, system is there to serve/assist/support in human's natural condition
  - Search, browsing, etc are not primary; HCI is not the focus
  - Getting the assistance and answers are important, improving experience is key
- Multimodal, multisensory and participatory environment
- Integrated and contextual application of (not just access to) sensor data, databases, collective intelligence, wisdom of the crowd, conceptual models, reasoning

Learning from a number of exciting visions

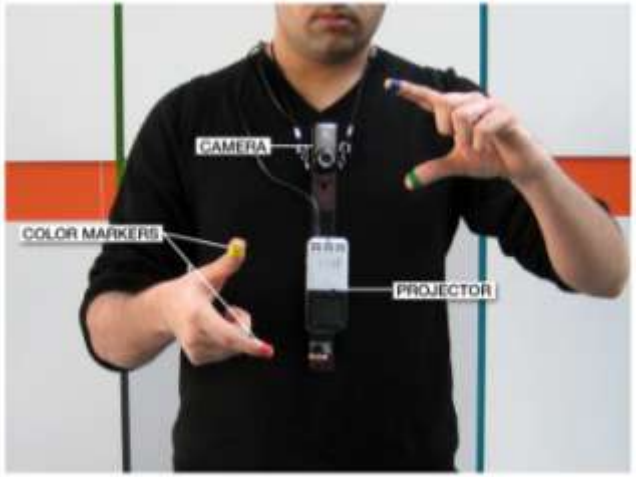
Vannevar Bush	Trailblazing, Memex (As We May Think)	1945
Mark Weisner	Ubicomp (The Computer for 21st Century)	1991
A. Sheth, V. Kashyap, et al	Semantic Information Brokering/ Metadata Reference Link	1994 - 2000
Zelkha, Epstein	Ambient Intelligence	1998 -
Tim Berners-Lee	Semantic Web	1999 -
Gordon Bell et al	MyLifeBits	2002
Jonathan Rossiter	Humanist Computing	2003
Ramesh Jain	Experiential Computing	2003
ITU	The Internet of Things	2005
Ramesh Jain	Event Web	2006-2008
A. Sheth et al	Relationship Web (also, Spatio-temporal-thematic analysis, Semantic Sensor Web)	2006-2008
Tom Gruber	Intelligence @Interface	2008

Physical-Cyber divide is narrowing



Psyleron's Mind-Lamp (Princeton U), connections between the mind and the physical world.

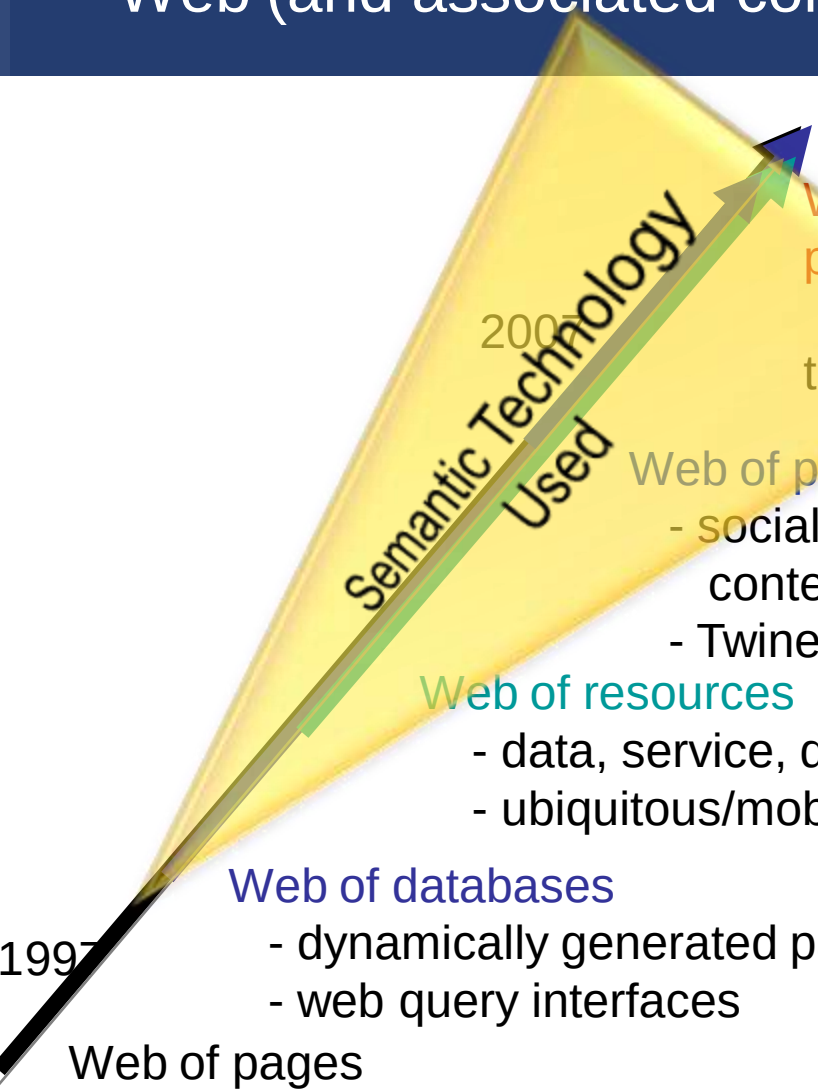
Neuro Sky's mind-controlled headset to play a video game.



MIT's Fluid Interface Group: wearable device with a projector for deep interactions with the environment

Sensing emotion is increasingly possible and sensors are being developed to capture Emotions.

Web (and associated computing) is evolving



Computing for Human Experience

Web as an oracle / assistant / partner
- "ask the Web": using semantics to leverage text + data + services
- Powerset

Web of people
- social networks, user-created casual content
- Twine, GeneRIF, Connotea

Web of resources
- data, service, data, mashups
- ubiquitous/mobile computing

Web of databases
- dynamically generated pages
- web query interfaces

Web of pages
- text, manually created links
- extensive navigation

Sensing, Observing, Perceptual, Semantic, Social & Participatory, Experiential

also everyone, anytime, anywhere

Consider

- that all objects, events and activities in the physical world have a counterpart in the Cyberworld(IoT)
- multi-facted context of real world is captured in the cyberworld(multilevel & citizen sensors/participatory sensing)
- each object, event and activity is represented
  - with semantic annotations (semantic sensor web)
- for a chosen context, with an ability to explicate and associate variety of relationships and events (Relationship Web, EventWeb)
- appropriate reasoning and human/social interaction are available and applied, insights extracted (semantic web, social semantic web, experiential computing)
- Activity anticipated/answers obtained/ decisions reached/communicated/applied

Paradigm shift …participatory sensing

- Where humans act as sensors or observers
- Around them is a network of sensors, computing and communicating with each other
  - Processing and delivering multi-modal information
  - Collective Intelligence
- Information-centric to Experience-centric era
  - Modeling, processing, retrieving event level information
- Use of domain knowledge
  - ….
- Understanding of casual text

Today's Sensor Network Types

- Inert, fixed sensors

- Carried on moving objects
  - Vehicles, pedestrians (asthma research)
  - anonymous data from GPS-enabled vehicles, toll tags, and cellular signaling to mark how fast objects are moving – and overlaying that information with location data and maps (traffic.com, Nokia experiment, …)

Text from http://www.geog.ucsb.edu/~good/presentations/icsc.pdf

Images credit – flickr.com, cnet.com

Today's Network of Sensors

- Are sensing, computing, transmitting
- Are acting in concert
  - Sharing data
  - Processing them into meaningful digital representations of the world
- Researchers using 'sensor webs' to ask new questions or test hypotheses
- 2009: 1.1 billion PCs, 4 billion mobile devices, 40+ billion mobile sensors (Nokia: Sensing the World with Mobile Devices)

Citizen Sensors

- Human beings
  - 6 billion intelligent sensors
  - informed observers
  - rich local knowledge
  - uplink technology
    - broadband Internet
    - mobile phone

Christmas Bird Count

Citizen Science

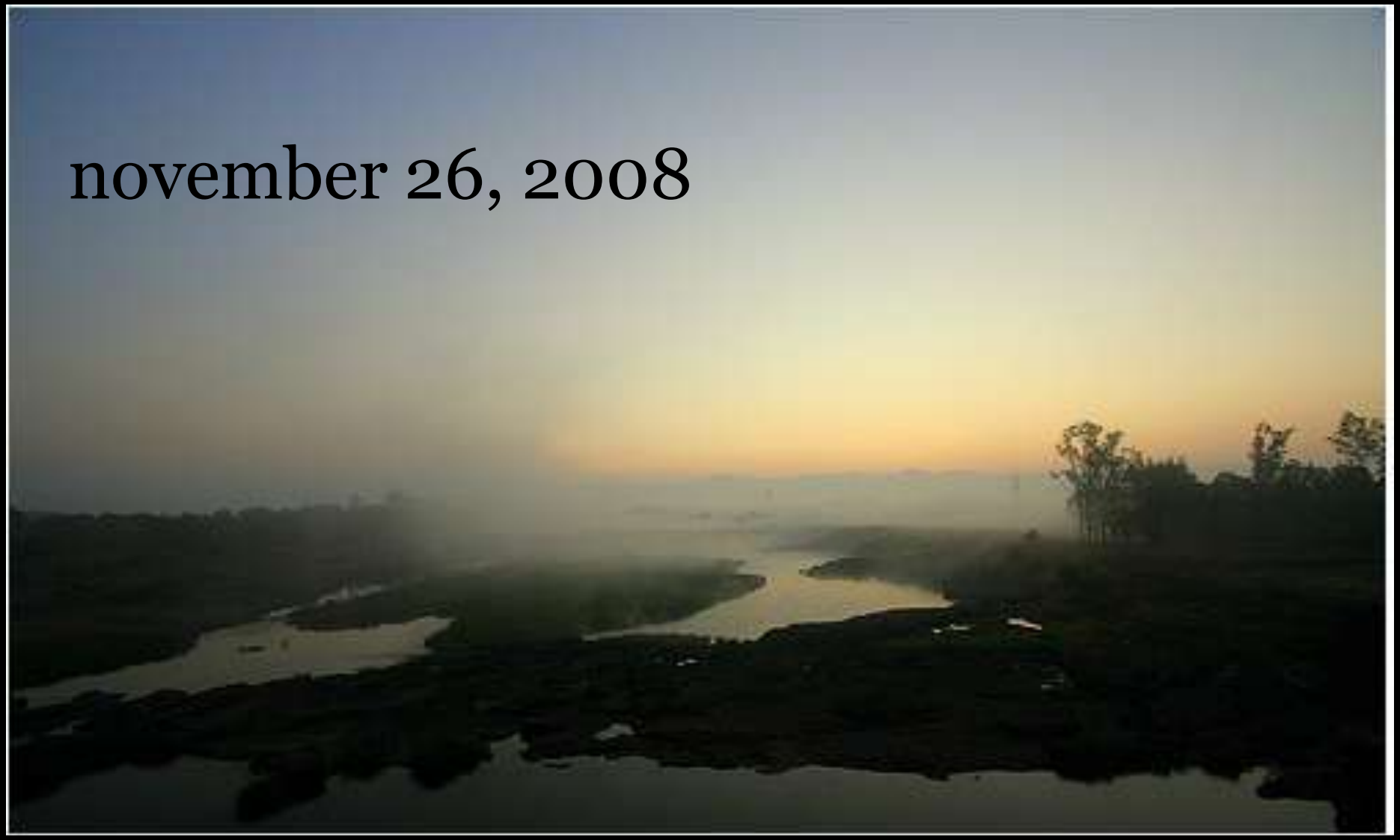
- Networks of amateur observers
  - possibly trained, skilled
- Christmas Bird Count http://www.audubon.org/bird/citizen/index.html , http://www.audubon.org/bird/cbc/index.html
  - thousands of volunteer participants
  - Protocols
- Project GLOBE
  - an international network of school children
  - reporting environmental conditions
  - central integration and redistribution

Citizen Sensor – Humans Actively Engage

- In connecting, searching, processing, stitching together information
- Asks, gets.. Asks again, gets again…

Images credit – flickr.com


mumbai, india


november 26, 2008

another chapter in the war against civilization

and

flickr

Home The Tour Sign Up Explore

Bombay Blast by Vinu

ALL SIZES

Nov 27, 2008 11:59 PM GMT · Reply · View Tweet

sameer_gupta: Why is Australian government issuing advisory to not to visit **Mumbai**? The govt. is nuts cos it gives more confidence to ppl spreading terror

Mumbai, India

Nov 27, 2008 11:55 PM GMT · Reply · View Tweet

sameer_gupta: CNBC is reporting that so far 7 terrorists have been killed in Taj Mahal. **#mumbai**

Mumbai, India

Nov 27, 2008 11:46 PM GMT · Reply · View Tweet

Mumbai: **#mumbai** Situation Report: mostly static. Cleanup operations at Taj, Oberoi and Nariman still in flux. Other reported attacks are rumors.

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Nov 27, 2008 11:33 PM GMT · Reply · View Tweet

the world saw it

Through the eyes of the people

the world read it
Through the words of the people

PEOPLE told their stories to PEOPLE

A powerful new era in Information dissemination had taken firm ground

Making it possible for us to

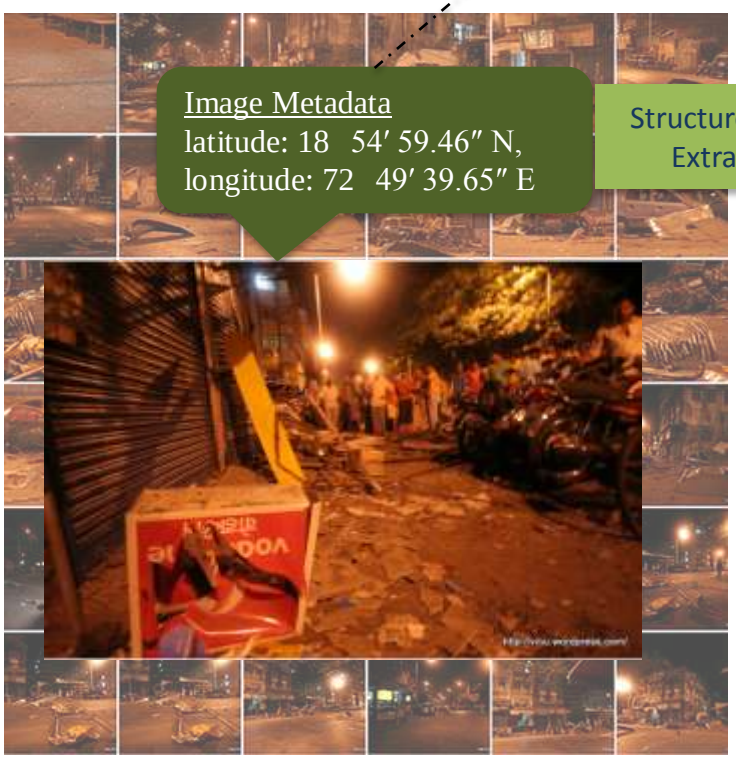
create a global network of citizens

Citizen Sensors –
Citizens observing, processing,
transmitting, reporting

Geocoder
(Reverse Geo-coding)

18 Hormusji Street, Colaba

Address to location database



Structured Meta Extraction

VasantVihar

Nariman House

Income Tax Office

Spatio-Temporal Analysis

Identify and extract information from tweets

Mumbai: #mumbai Situation Report: mostly static. Cleanup operations at Taj, Oberoi and Nariman still in flux. Other reported attacks are rumors.
Mumbai, India
Nov 27, 2008 11:37 PM GMT · Reply · View Tweet

sameer_gupta: Atleast 5-6 people held hostage in Nariman House. More than 50 NSG men surrounding the building. #mumbai
Mumbai, India
Nov 27, 2008 11:59 PM GMT · Reply · View Tweet

Research Challenge #1

- Spatio Temporal and Thematic analysis
  - What else happened “near” this event location?
  - What events occurred “before” and “after” this event?
  - Any message about “causes” for this event?

Spatial Analysis….

Which tweets originated from an address *near* 18.916517° N 72.827682° E?

sameer_gupta: Atleast 5-6 people held hostage in Nariman House. More than 50 NSG men surrounding the building. #mumbai
Mumbai, India
Nov 27, 2008 11:59 PM GMT · Reply · View Tweet

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Mumbai, India
Nov 27, 2008 11:33 PM GMT · Reply · View Tweet

Which tweets originated during Nov 27th 2008,from 11PM to 12 PM

sameer_gupta: Atleast 5-6 people held hostage in Nariman House. More than 50 NSG men surrounding the building. #mumbai
Mumbai, India
Nov 27, 2008 11:59 PM GMT · Reply · View Tweet

sameer_gupta: Why is Australian government issuing advisory to not to visit **Mumbai**? The govt. is nuts cos it gives more confidence to ppl spreading terror
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Mumbai, India
Nov 27, 2008 11:33 PM GMT · Reply · View Tweet

Giving us

Tweets originated from an address near 18.916517°N, 72.827682°E during time interval27th Nov 2008 between 11PM to 12PM?

Research Challenge #2: Understanding and Analyzing Casual Text

- Casual text
  - Microblogs are often written in SMS style language
  - Slangs, abbreviations

Understanding Casual Text

- Not the same as news articles or scientific literature
  - Grammatical errors
    - Implications on NL parser results
  - Inconsistent writing style
    - Implications on learning algorithms that generalize from corpus

Nature of Microblogs

- Additional constraint of limited context
  - Max. of **x** chars in a microblog
  - Context often provided by the discourse
- Entity identification and disambiguation
- Pre-requisite to other sophisticated information analytics

NL understanding is hard to begin with..

- Not so hard
  - "commando raid appears to be nigh at Oberoinow"
    - Oberoi = Oberoi Hotel, Nigh = high
- Challenging
  - new wing, live fire @ taj 2nd floor on iDesi TV stream
    - Fire on the second floor of the Taj hotel, not on iDesi TV

Social Context surrounding content

- Social context in which a message appears is also an added valuable resource
- Post 1:
  - "Hareemane Househostages said by eyewitnesses to be Jews. 7 Gunshots heard by reporters at Taj"
- Follow up post
  - that is Nariman House, not (Hareemane)

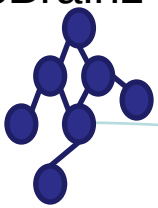
Understanding content … informal text

- I say: “Your music is *wicked*”
- What I really mean: “Your music is *good*”

Sentiment expression: Rocks
Transliterates to: cool, good

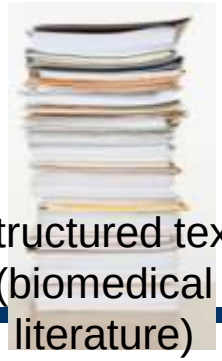
Semantic Metadata: Smile is a Track
Lil transliterates to Lilly Allen
Lilly Allen is an Artist

MusicBrainz Taxonomy



Artist: Lilly Allen
Track: Smile

Your smile rocks Lil



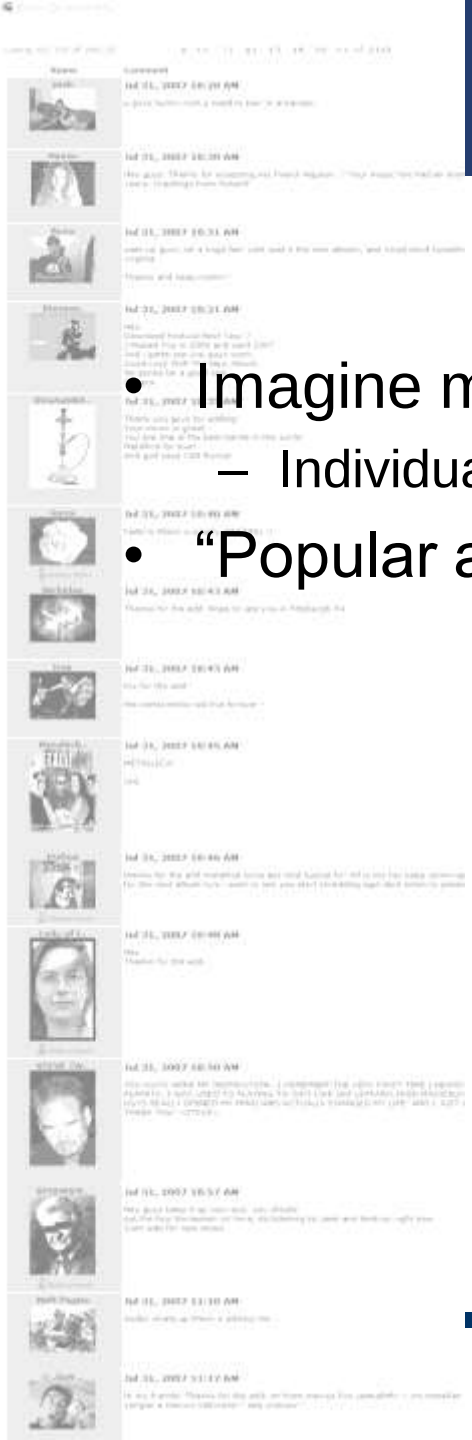
Structured text (biomedical literature)

Informal Text (Social Network chatter)

Multimedia Content and Web data

Web Services

Example: Pulse of a Community



- Imagine millions of such informal opinions
  - Individual expressions to mass opinions
- “Popular artists” lists from MySpace comments

Lilly Allen

Lady Sovereign

Amy Winehouse

Gorillaz

Coldplay

Placebo

Sting

Kean

Joss Stone

What Drives the Spatio-Temporal-Thematic Analysis and Casual Text Understanding

Semantics with the help of

1. Domain Models
2. Domain Models
3. Domain Models

(ontologies, folksonomies)

Domain Knowledge: A key driver

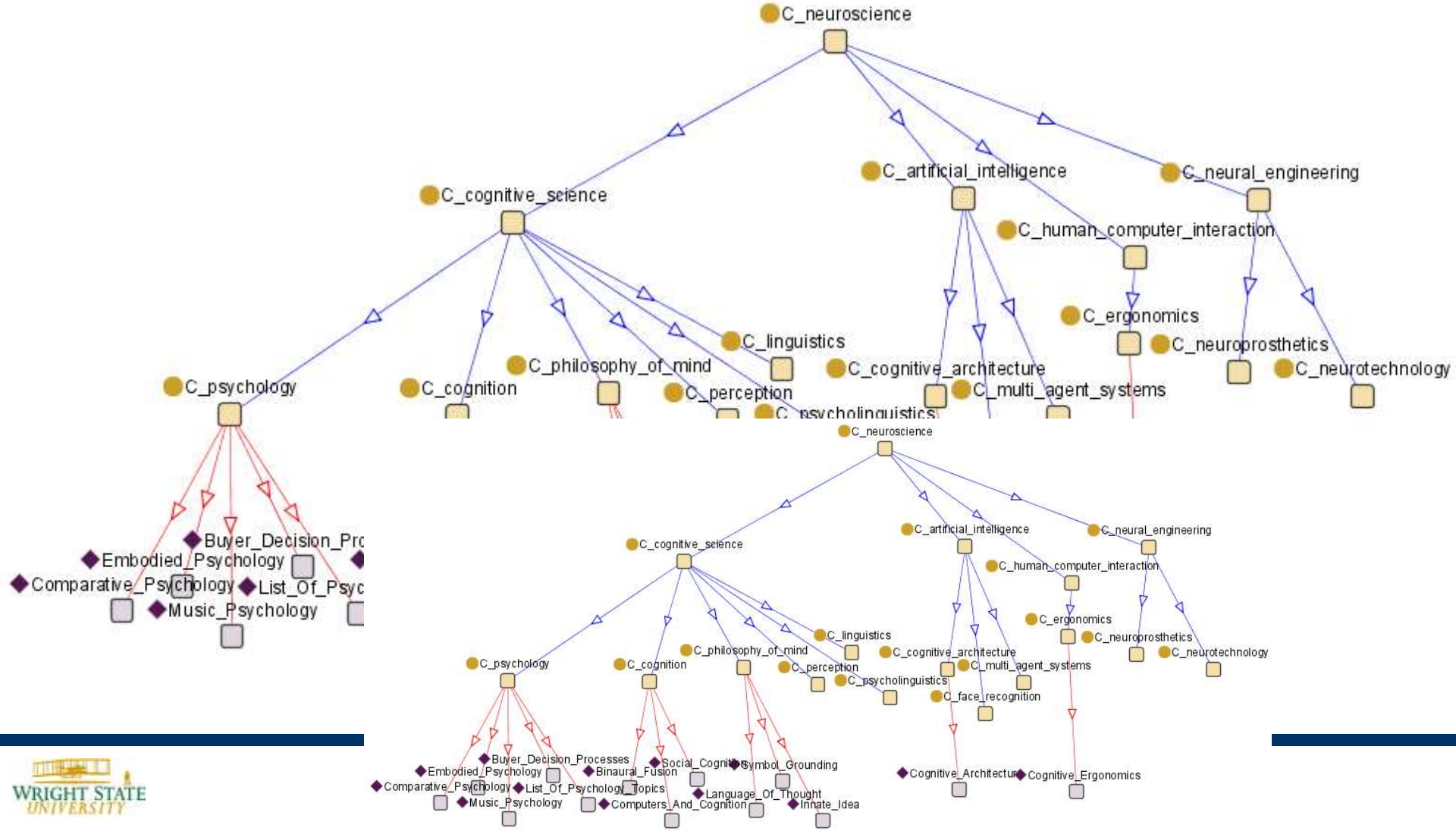
- Places that are nearby ‘Nariman house’
  - Spatial query
- Messages originated around this place
  - Temporal analysis
- Messages about related events / places
  - Thematic analysis

Research Challenge #3

But Where does the Domain Knowledge come from?

- Expert and committee based ontology creation … works in some domains (e.g., biomedicine, health care,…)
- Community driven knowledge extraction
  - How to create models that are “socially scalable”?
  - How to organically grow and maintain this model?

Building models…seed word to hierarchy creation using WIKIPEDIA



Identifying relationships: Hard, harder than many hard things

But NOT that Hard, When WE do it

Games with a purpose

- Get humans to give their solitaire time
  - Solve real hard computational problems
  - Image tagging, Identifying part of an image
  - Tag a tune, Squigl, Verbosity, and Matchin
  - Pioneered by Luis Von Ahn

OntoLablr

- Relationship Identification Game

- leads to
- causes

Explosion

Traffic congestion

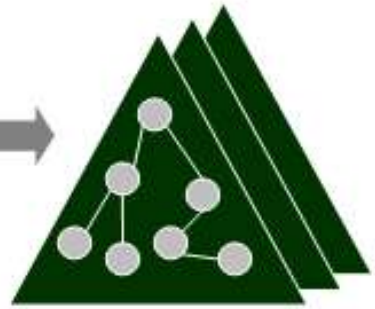
- How do you get comprehensive situational awareness by merging “human sensing” and “machine sensing”?

Research Challenge #4: Semantic Sensor Web

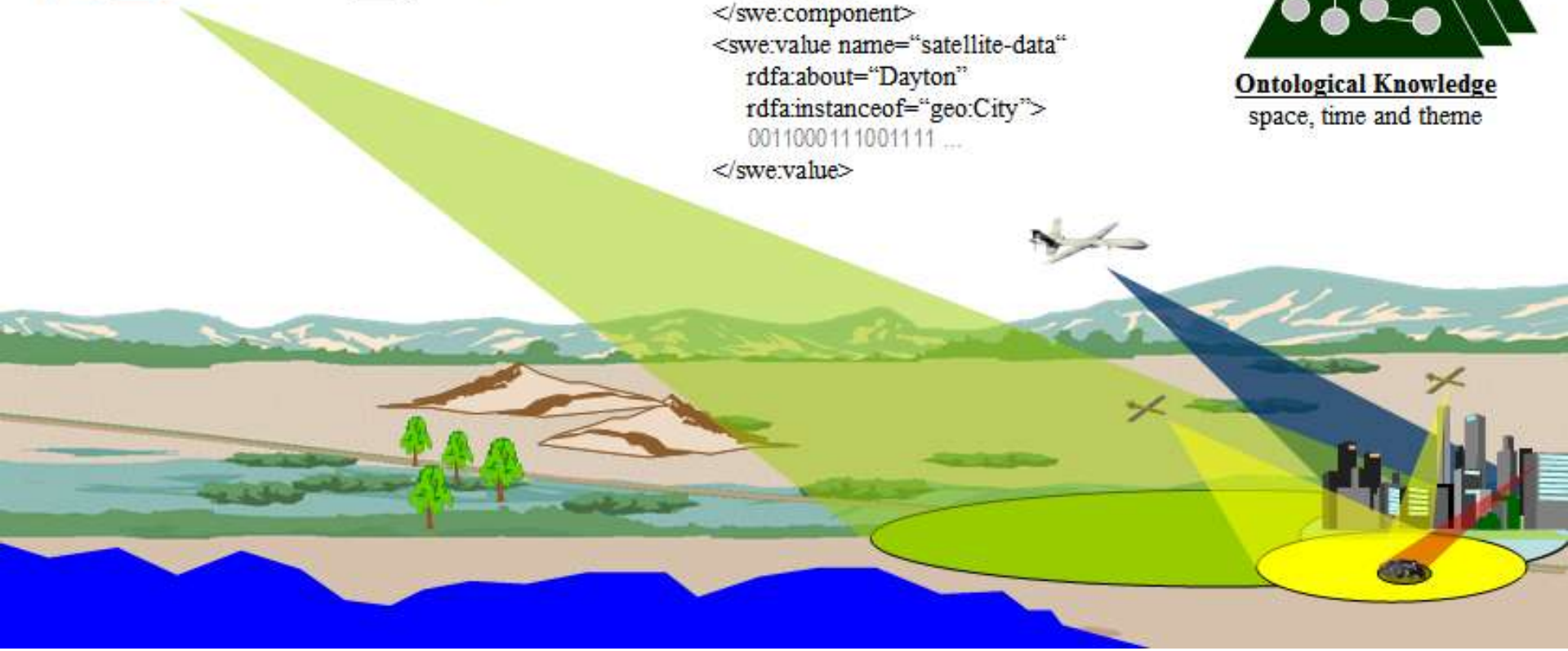
001100011
100111100
0111010...

Semantic annotation of SWE

```
<swe:component rdfa:about="time_1"
    rdfa:intanceof="time:Instant">
    <swe:Time rdfa:property="xs:date-time">
        2008-03-08T05:00:00
    </swe:Time>
</swe:component>
<swe:value name="satellite-data"
    rdfa:about="Dayton"
    rdfa:instanceof="geo:City">
    0011000111001111 ...
</swe:value>
```



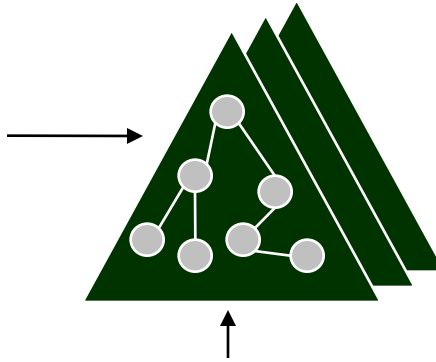
Ontological Knowledge
space, time and theme



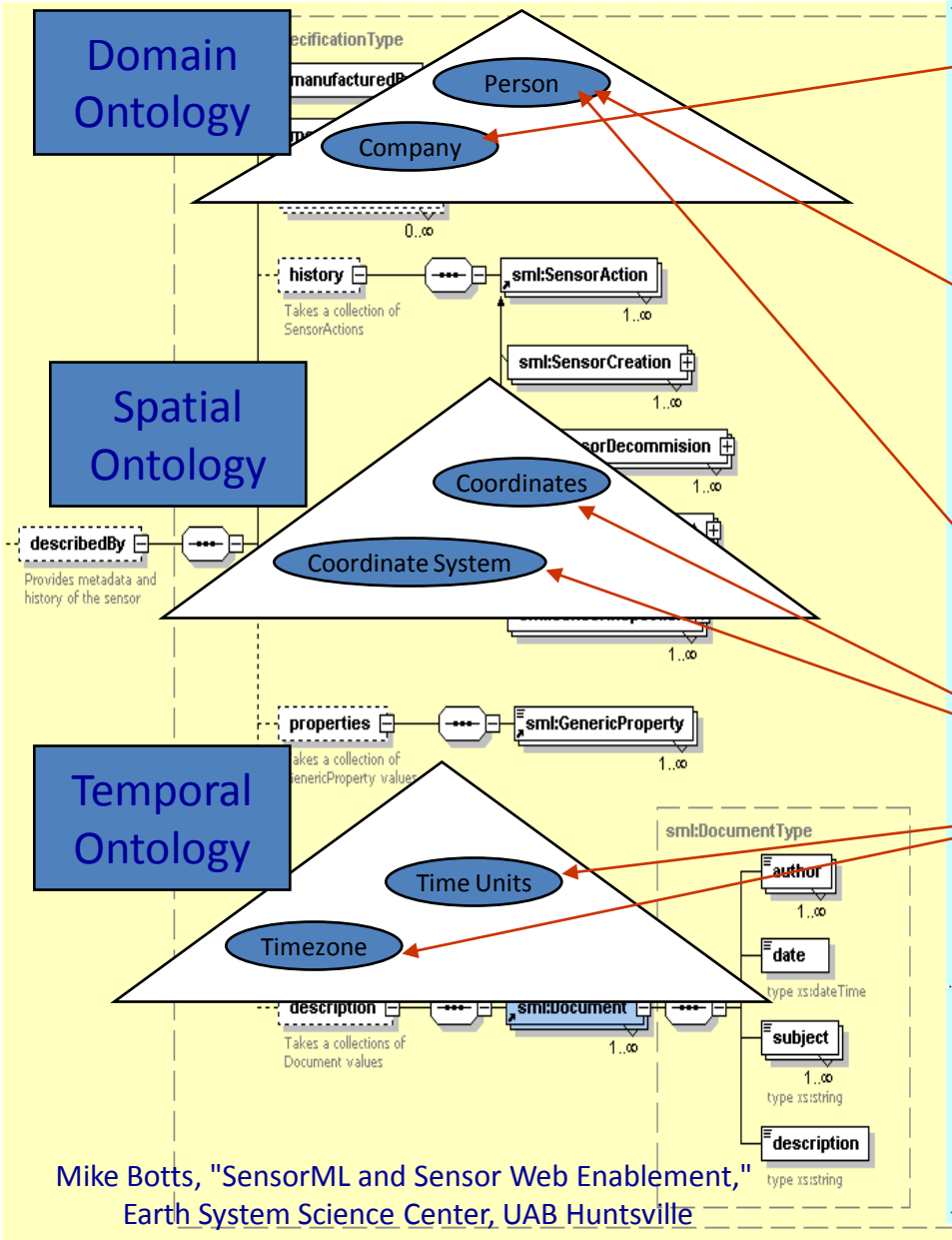
Semantically Annotated O&M

```
<swe:component name="time">
<swe:Time definition="urn:ogc:def:phenomenon:time" uom="urn:ogc:def:unit:date-time">
<sa:swe rdfa:about="?time" rdfa:instanceof="time:Instant">
<sa:sml rdfa:property="xs:date-time"/>
</sa:swe>
</swe:Time>
</swe:component>
<swe:component name="measured_air_temperature">
<swe:Quantity definition="urn:ogc:def:phenomenon:temperature“
              uom="urn:ogc:def:unit:fahrenheit">
<sa:swe rdfa:about="?measured_air_temperature“
rdfa:instanceof=“senso:TemperatureObservation">
<sa:swe rdfa:property="weather:fahrenheit"/>
<sa:swe rdfa:rel="senso:occurred_when" resource="?time"/>
<sa:swe rdfa:rel="senso:observed_by" resource="senso:buckeye_sensor"/>
</sa:sml>
</swe:Quantity>
</swe:component>

<swe:value name=“weather-data">
2008-03-08T05:00:00,29.1
</swe:value>
```



Semantic Sensor ML – Adding Ontological Metadata




```
<describedBy>
    <SensorSpecification>
        <manufacturedBy> YSI </manufacturedBy>
        <model> 58 </model>
        <identifyingNumber type="serialNumber"> s454165 </identifyingNumber>
        <history>
            <SensorCreation>
                <byWhom>
                    <Person>
                        <fullName> Some Guy </fullName>
                    </Person>
                </byWhom>
                <when> 2001-12-04 </when>
                <supportingDocuments>
                    <Reference id="YSI-12">
                        <authors>
                            <Person>
                                <fullName> Some Author </fullName>
                            </Person>
                        </authors>
                        <publishingDate> 2001-01-01 </publishingDate>
                        <documentTitle> Blueprints for This Sensor </documentTitle>
                        <documentNumber> YSI-12345-678 </documentNumber>
                    </Reference>
                </supportingDocuments>
            </SensorCreation>
            <SensorDeployment>
                <byWhom>
                    <Person>
                        <fullName>SomeOther Guy</fullName>
                    </Person>
                </byWhom>
                <where> Someplace, Somewhere </where>
                <when> 2001-12-04 </when>
                <description> Attached to northern most footing on Some Bridge at a depth
                    of 5 meters </description>
            </SensorDeployment>
        </history>
        <properties>
            <genericProperty name="sensorTechnology" dataType="xs:string"> rapid
                pulse </genericProperty>
            <genericProperty name="measurementMethod" dataType="xs:string"> EPA
                accepted </genericProperty>
            <genericProperty name="membraneThickness" dataType="xs:double"
                uom="#mil"> 1.0 </genericProperty>
            <genericProperty name="membraneType" dataType="xs:string"> Teflon
                </genericProperty>
            <genericProperty name="probeSolutionType" dataType="xs:string"> Na2SO4
                </genericProperty>
        </properties>
    </SensorSpecification>
</describedBy>
```

Mike Botts, "SensorML and Sensor Web Enablement," Earth System Science Center, UAB Huntsville

Semantic Query

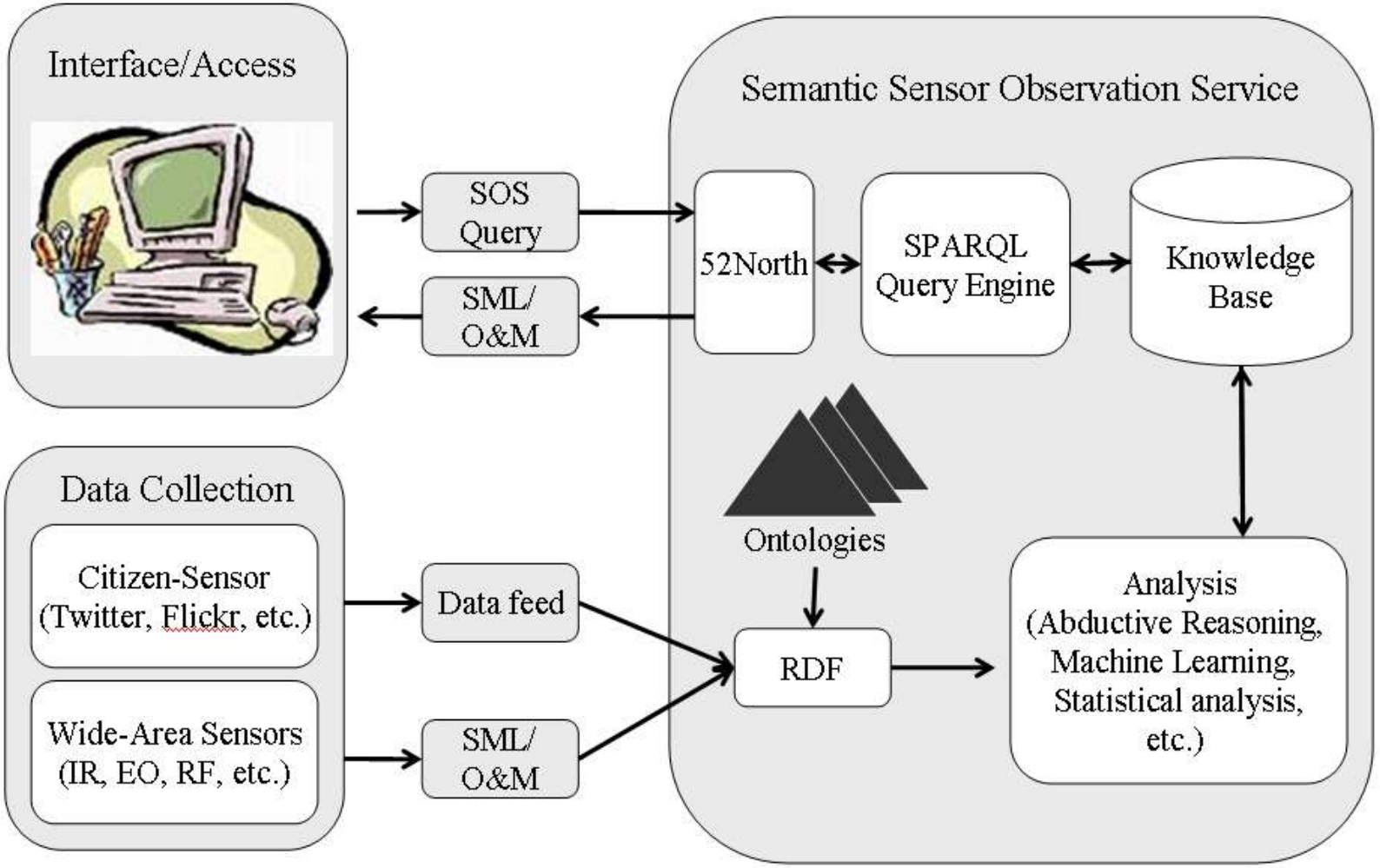
- **Semantic Temporal Query**

- Model-references from SML to OWL-Time ontology concepts provides the ability to perform semantic temporal queries
- Supported semantic query operators include:
  - **contains**: user-specified interval falls wholly within a sensor reading interval (also called *inside*)
  - **within**: sensor reading interval falls wholly within the user-specified interval (inverse of *contains* or *inside*)
  - **overlaps**: user-specified interval overlaps the sensor reading interval
- Example SPARQL query defining the temporal operator 'within'

```
SELECT ?interval
WHERE {
  ?interval time-entry:begins ?b .
  ?interval time-entry:ends   ?e .
  ?b time-entry:inXSDDateTime ?b_datetime .
  ?e time-entry:inXSDDateTime ?e_datetime .

  FILTER (
    xsd:dateTime("2005-11-10T01:00:00.00") < xsd:dateTime(?b_datetime) &&
    xsd:dateTime("2008-11-10T01:00:00.00") > xsd:dateTime(?e_datetime)
  ) .
}
ORDER BY ASC(?b_datetime)
```

Kno.e.sis' Semantic Sensor Web



Synthetic but realistic scenario

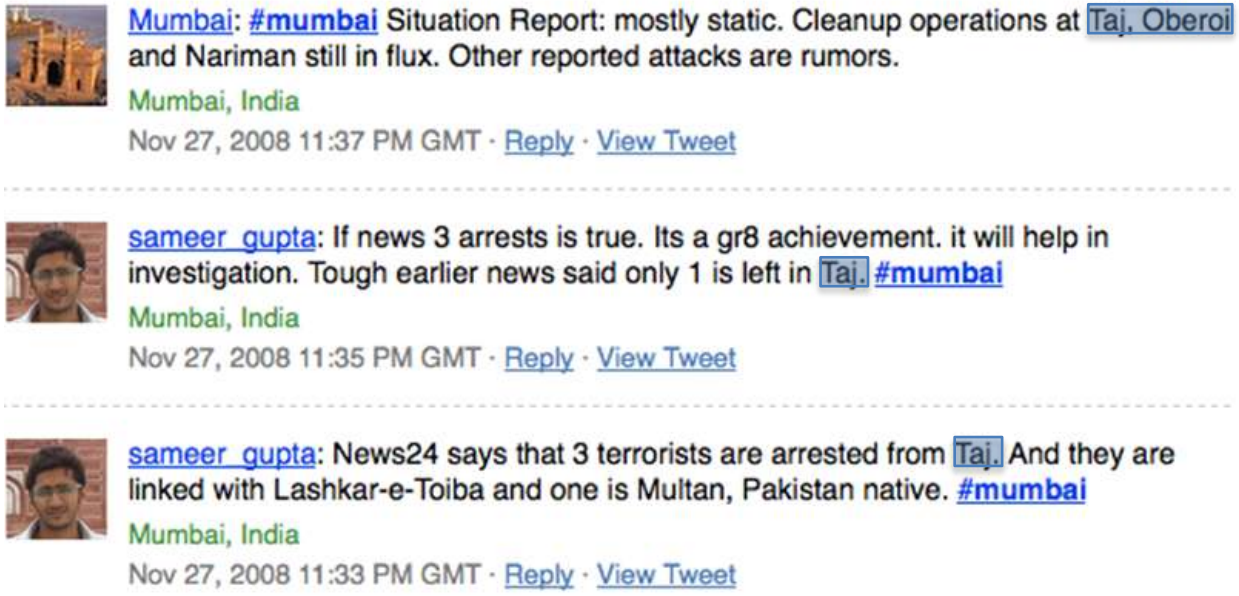
- an image taken from a raw satellite feed

Synthetic but realistic scenario

- an image taken by a camera phone with an associated label, “explosion.”

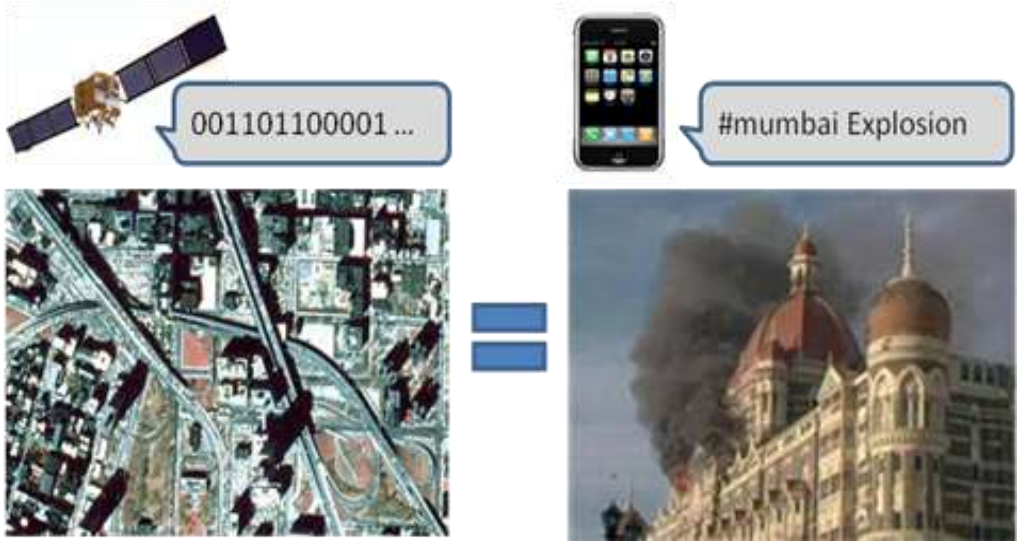
Synthetic but realistic scenario

- Textual messages (such as tweets) using STT analysis

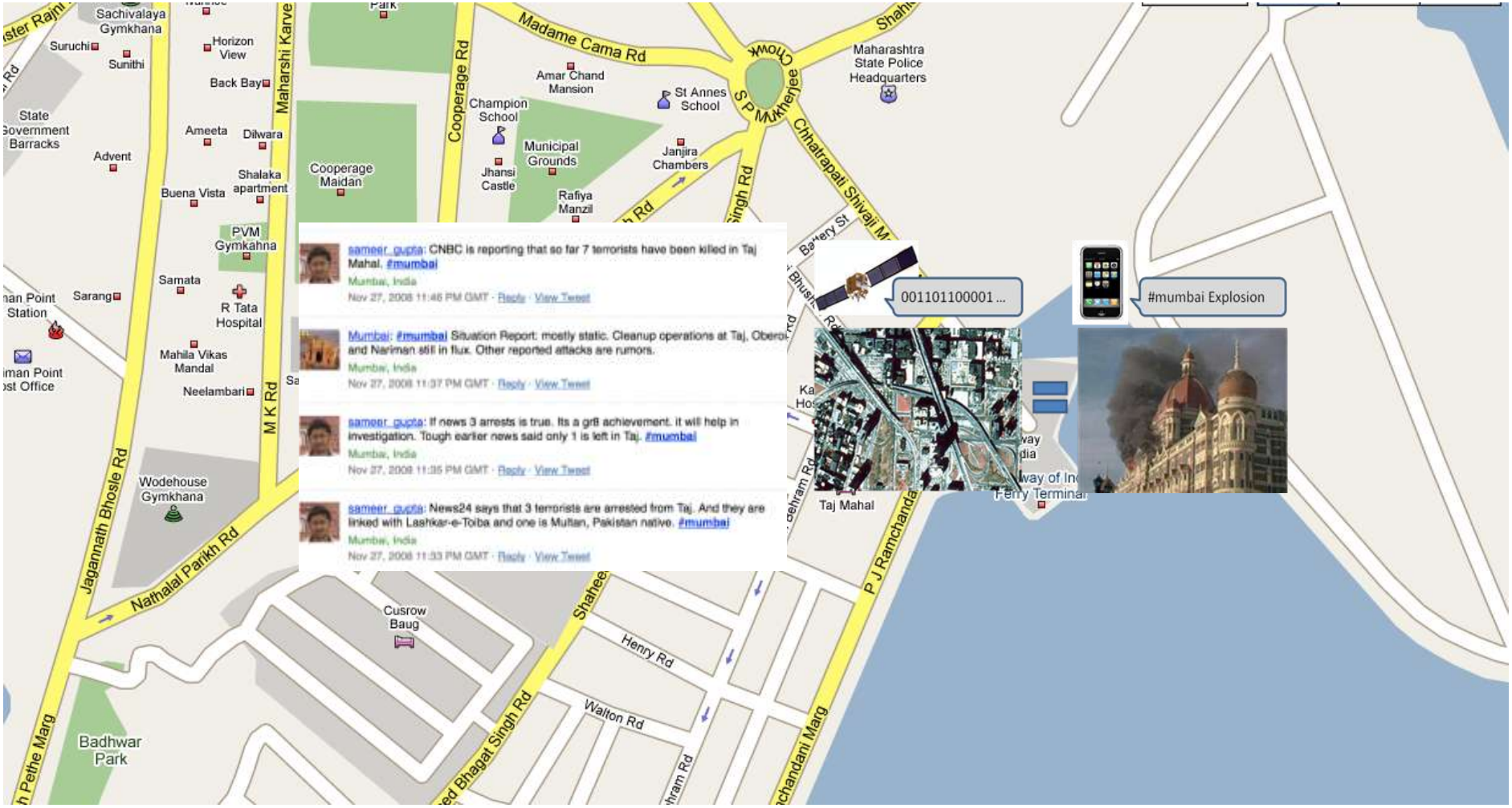


Synthetic but realistic scenario

- Correlating to get



Create better views (smart mashups)



A few more things

- Use of background knowledge
- Event extraction from text
  - time and location extraction
    - Such information may not be present
    - Someone from Washington DC can tweet about Mumbai
- Scalable semantic analytics
  - Subgraph and pattern discovery
    - Meaningful subgraphs like relevant and interesting paths
    - Ranking paths

The Sum of the Parts

Spatio-Temporal analysis
- Find out where and when

+ Thematic
- What and how

+ Semantic Extraction from text, multimedia and sensor data
- tags, time, location, concepts, events

+ Semantic models & background knowledge
- Making better sense of STT
- Integration

+ Semantic Sensor Web
- The platform

= Situational Awareness

Domain Models

Relationship Web

Search
Integration
Analysis
Discovery
Question Answering
Situational Awareness

Patterns / Inference / Reasoning

Meta data / Semantic Annotations

Metadata Extraction

Structured and Semi-structured data

Text

Multimedia Content and Web data

Sensor Data

Enriching Human Experience

- Recognition of objects (IOT) and models of object
- Understanding of objects and content
- Multimodal interfaces
- Multi(level) sensing and perception
- From keywords and entities to events and rich sets of relationships; spatio-temporal-thematic computing
- Models (ontologies, folkonomies, taxonomies, classification, nomenclature)– time, location, sensors, domain
- More powerful reasoning: paths, patterns, subgraphs that connect related things; deductive and abductive reasoning, ….

Online and offline worlds

- Computational abstractions to represent the physical world's dynamic nature
- Merging online and offline activities
  - Connecting the physical world naturally with the online world
- What are natural operations on these abstractions?
- How do we detect these abstractions based on other abstractions and multimodal data sources?

Experience

Direct Observation of
or Participation in
Events
as a basis of knowledge

Objects to Events

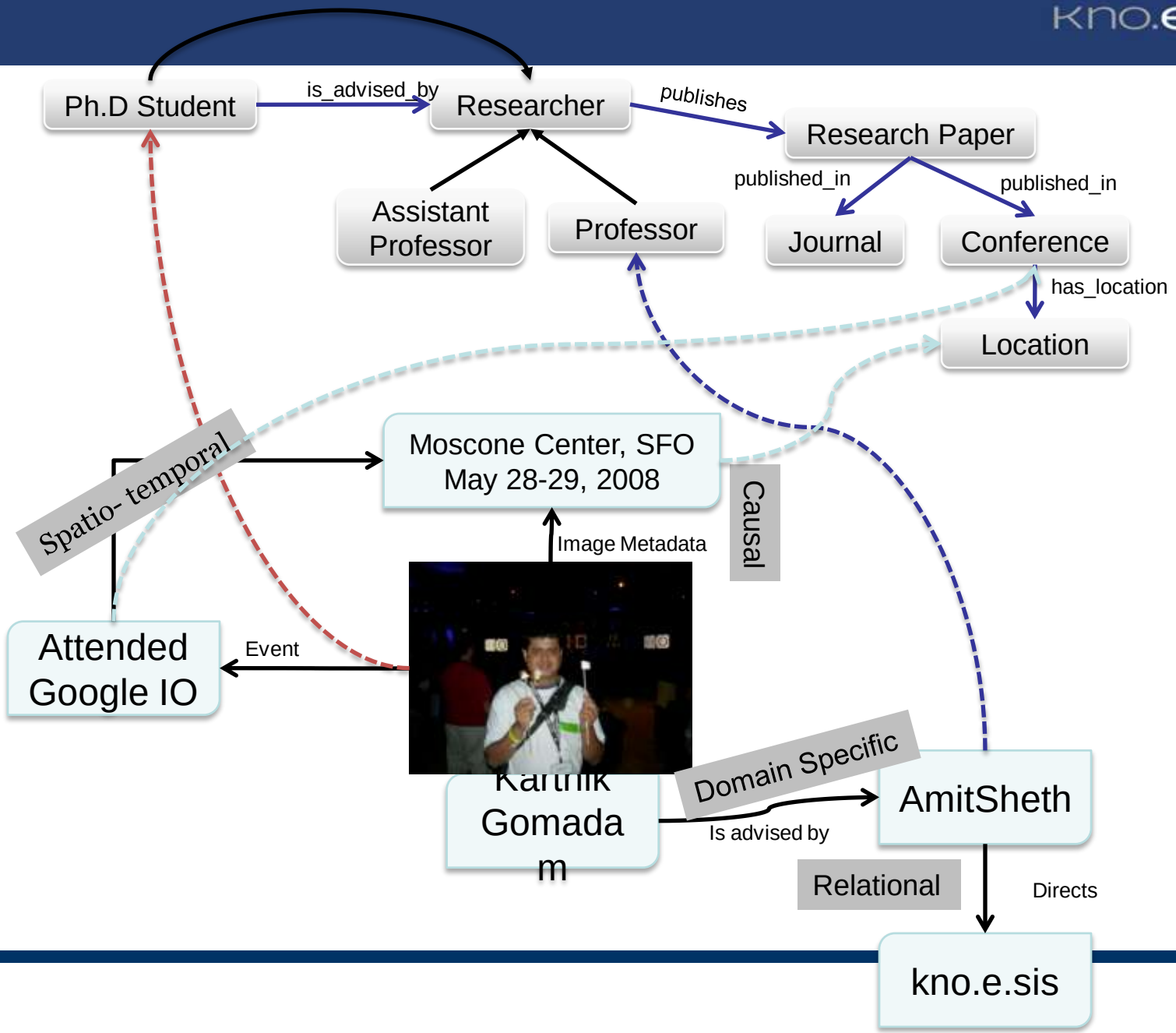
- If we move from this object mode to an event mode
  - A single user action or request or sensory observation could act as a cue for getting all (multi-modal) information associated with an event
  - If conditions change, systems could even modify their behavior to suit their changing view of the world

Today text is most prevalent, with increasing but disparate (non-integrated) image and video data, but human experience is event based (at higher levels of abstractions) formed based on multi-sensory, multi-perception (at lower level of abstraction) observations

EventWeb [Jain], RelationshipWeb [Sheth]

Suppose that we create a Web in which

- Each node is an event or object
- Each node may be connected to other nodes using
  - Referential: similar to common links that refer to other related information.
  - Spatial and temporal relationships.
  - Causal: establishing causality among relationships.
  - Relational: giving similarity or any other relationship.
  - Semantic or Domain specific:
    - Familial
    - Professional
    - Genetics,…


Ph.D Student
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Assistant Professor
Professor
Journal
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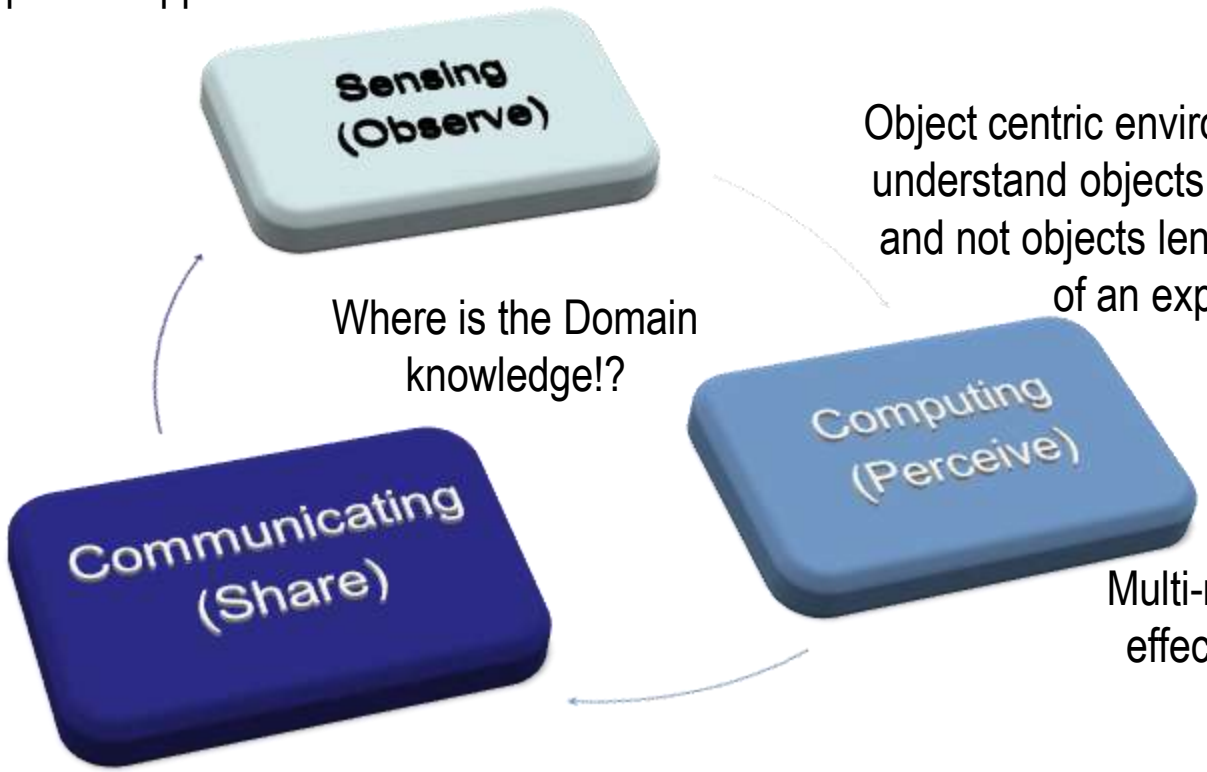
Location
Spatio- temporal
Moscone Center, SFO
May 28-29, 2008
Causal
Image Metadata
Attended Google IO
Event
Karthik Gomadam
Domain Specific
Is advised by
AmitSheth
Relational
Directs
kno.e.sis

However, today

Sensors capture and process uni-modal information. Bringing multiple modalities together is up to an application



Object centric environments – sensors understand objects from data. Events and not objects lend to holistic views of an experience

Where is the Domain knowledge!?

Multi-modal information effectively represents events

Human to machine to human to machine..

THE SEMANTICS OF OBSERVATION

- **Observation** is about capturing (or measuring) phenomena.
- **Perception** is about explaining the observations.
- When the human mind perceives what it observes
  - It uses what it already knows in addition to the context surrounding the observation
  - Cause-effect relationships play a vital role in how we reach conclusions

People Web

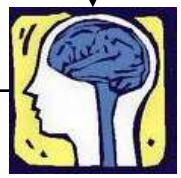
(human-centric)

Observation

(senses)

Communication

(language)



Perception

(cognition)

Sensor Web

(machine-centric)

Observation

(sensors)

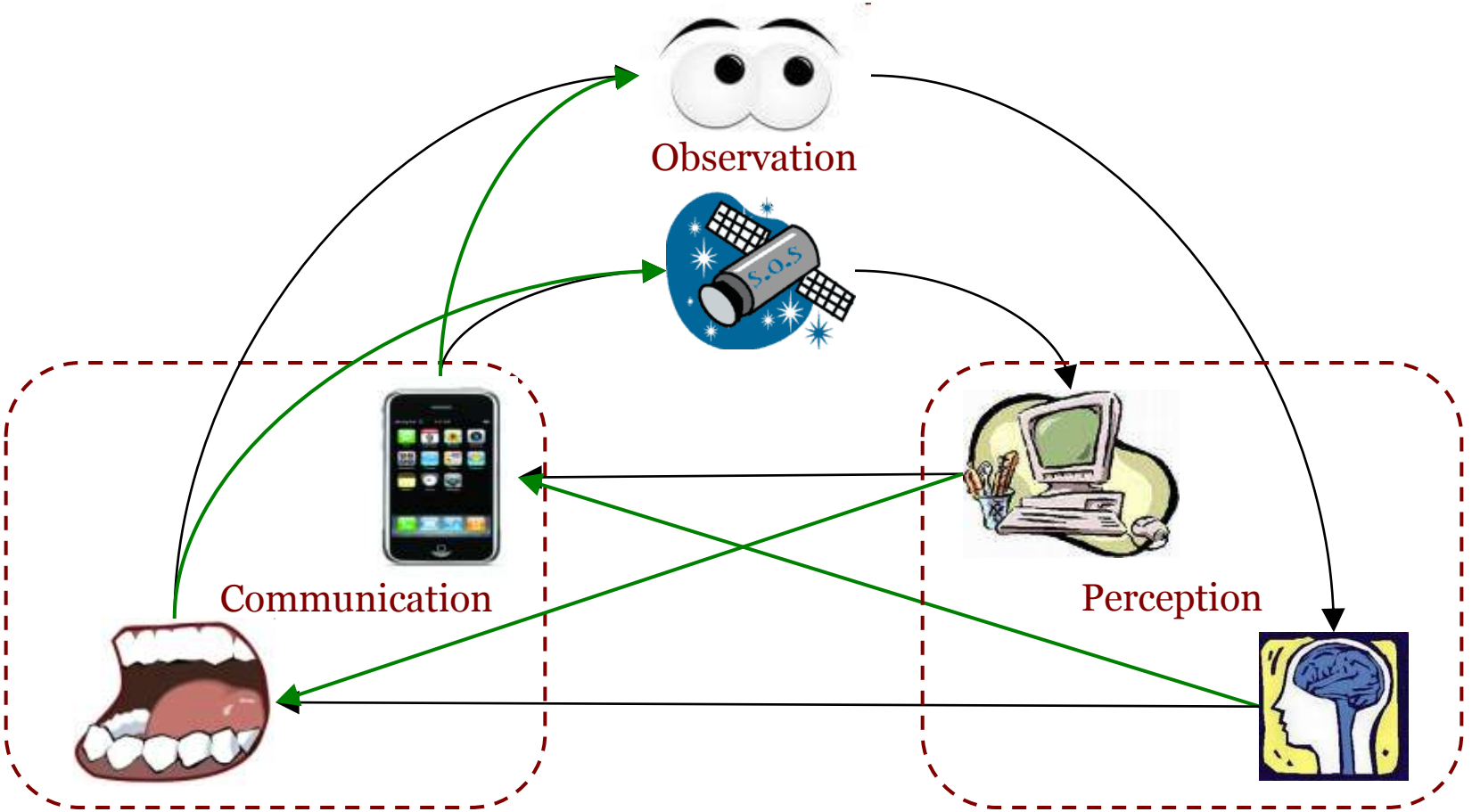
Communication

(services)

Perception

(analysis)

= Enhanced Experience (humans & machines working in harmony)



Ability to share common communication

Semantics for shared conceptualization and interoperability between machine and human

Example

1. Sensors observe environmental phenomena and nearby vegetation.

2. Observation analysis determines potential situation and effects.

- Through abductive reasoning, observation analysis perceives a possible storm as the best explanation hypothesis for observed phenomena.
- Through predictive deductive reasoning, observation analysis determines the effect on the crops, including the potential for the poisoning of the soil from salt carried from the ocean in the wind.
- Through query against a knowledge base of the agriculture domain, observation analysis determines that the best remedy
  - for saline soil is to “leach” the soil with excess irrigation water in order to ‘push’ the salts below the crop root zone,
  - for sodic soil is to add gypsum before leaching.

Example

1. Sensors observe environmental phenomena and nearby vegetation.

2. Observation analysis determines potential situation and effects.

3. System alerts nearby farmers of situation and possible remedy.

4. Farmer goes outside and looks at the sky and crops.

5. Farmer perceives high-winds and dark rain clouds over the ocean view and agrees with system perception.


6. Farmer calls children and neighbors to help take the necessary precautions to save the vegetables.

Sensing, Observation, Perception, Semantic, Social Experiential

Influential Works

- V Bush, As We May Think, The Atlantic, July 1945. [*Memex, trail blazing*]
- Mark *Weiser, The Computer* for the Twenty-First *Century*, *Scientific American*, Sept 1991, 94-10. [*The original vision paper on ubicomp*. Expansive vision albeit technical aspects focused on HCI with networked tabs, pads and boards.]
- V. Kashyap and A. Sheth, Semantics-based information brokering. Third ACM Intl Conf on Information and Knowledge Management (CIKM94), Nov 29 - Dec 02, 1994. ACM, New York, NY. [semantics based query processing (involving multiple ontologies, context, semantic proximity) across a federated information sources across the Web]
- Abowd, Mynatt, Rodden, The Human Experience, Pervasive computing, 2002. [*explores Mark Wisner's original ubicomp vision*]
- Jonathan Rossiter , Humanist Computing: Modelling with Words, Concepts, and Behaviours, in Modelling with Words, Springer, 2003, pp. 124-152 [*modelling with words, concepts and behaviours defines a hierarchy of methods which extends from the low level data-driven modelling with words to the high level fusion of knowledge in the context of human behaviours*]
- Ramesh Jain, Experiential computing. *Commun. ACM* 46, 7, Jul. 2003, 48-55.
- AmitSheth, Sanjeev Thacker, and Shuchi Patel, Complex Relationship and Knowledge Discovery Support in the InfoQuilt System, VLDB Journal, 12 (1), May 2003, 2–27. [complex semantic inter-domain (multi-ontology) relationships including causal relationships to enable human-assisted knowledge discovery and hypothesis testing over Web-accessible heterogeneous data]

KNO.E.SIS as a case study of world class research based higher education environment

http://knoesis.org

Kno.e.sis Center Labs (3rd Floor, Joshi)

Amit Sheth

- Semantic Science Lab
- Semantic Web Lab
- Service Research Lab

TK Prasad

- Metadata and Languages Lab

Shaojun Wang

- Statistical Machine Learning

Pascal Hitzler

- Formal Semantics & Reasoning lab

Michael Raymer

- Bioinformatics Lab

Guozhu Dong

- Data Mining Lab

Keke Chen

- Data Intensive Analysis and Computing Lab

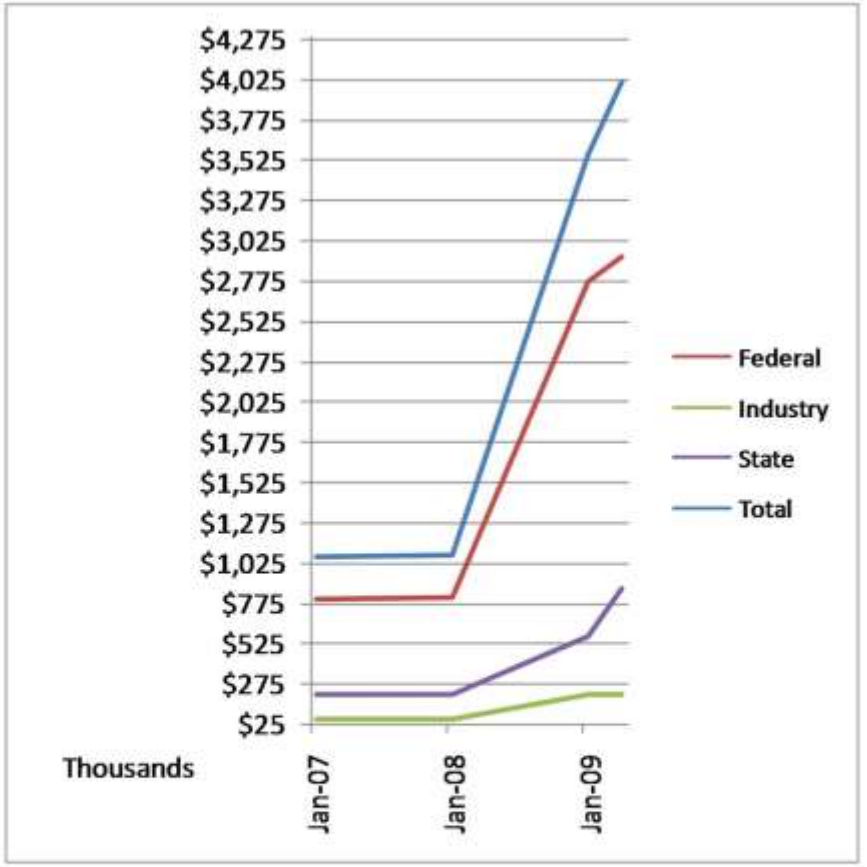
KNO.E.SIS MEMBERS – A SUBSET

Exceptional students

- Six of the senior PhD students: 84 papers, 43 program committees, contributed to winning NIH and NSF grants.
- Successfully competed with two Stanford PhDs, 1000+ citations in 2 years of his graduation.
- "BTW, Meena is an absolute find. If all of your other students are as talented, you are very lucky. … I'd definitely like to work with more interns of her caliber, … "[Dr. Kevin Haas, Director of Search at Yahoo!]
- "It has been a few years since I visited Dayton (Wright AFB). However, it is clear that Wright State has transformed itself. Congratulations on your success with the KnoesisCenter." [Dr. AlpersCaglayan – looking to hire Kno.e.sis grads]

Funding, Collaboration, etc

- UGA, Stanford, CCHMC, SAIC, HP, IBM, Yahoo!
- NIH, NSF, AFRL-HE, AFRL-Sensor, HP, IBM, Microsoft, Google
- 70% Federal, 19% State, 11% Industry
- Students intern at the best Industry labs & national labs
- Graduates very successful



- AmbjörnNaeve: The Human Semantic Web: Shifting from Knowledge Push to Knowledge Pull. Int. J. Semantic Web Inf. Syst. 1(3): 1-30 (2005) [*discusses conceptual interface providing human-understandable semantics on top of the ordinary (machine) Semantic Web*]
- Ramesh Jain, Toward EventWeb. *IEEE Distributed Systems Online* 8, 9, Sep. 2007. [a web of temporally related events… informational attributes such as experiential data in the form of audio, images, and video can be associated with the events]
- The Internet of Things, International Telecommunication Union, Nov 2005.

Other Closely Related publications

- AmitSheth and MeenaNagarajan, Semantics empowered Social Computing, IEEE Internet Computing, Jan-Feb 2009.
- AmitSheth, Cory Henson, and SatyaSahoo, "Semantic Sensor Web," IEEE Internet Computing, July/August 2008, p. 78-83.
- AmitSheth and Matthew Perry, "Traveling the Semantic Web through Space, Time and Theme," *IEEE Internet Computing,* 12, (no.2), February/March 2008, pp.81-86.
- AmitSheth and CarticRamakrishnan, "Relationship Web: Blazing Semantic Trails between Web Resources," IEEE Internet Computing, July–August 2007, pp. 84–88.

Interested in more background?

- Semantics-Empowered Social Computing
- Semantic Sensor Web
- Traveling the Semantic Web through Space, Theme and Time
- Relationship Web: Blazing Semantic Trails between Web Resources
- Text Mining, Workflow Management, Semantic Web Services, Cloud Computing with application to healthcare, biomedicine, energy

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Significant Infrastructure