Microsoft

Microsoft Research

Faculty Summit 2012

ADVANCING THE STATE OF THE ART

Predictions, Decisions, and Intelligence in the Open World

Eric Horvitz
Distinguished Scientist

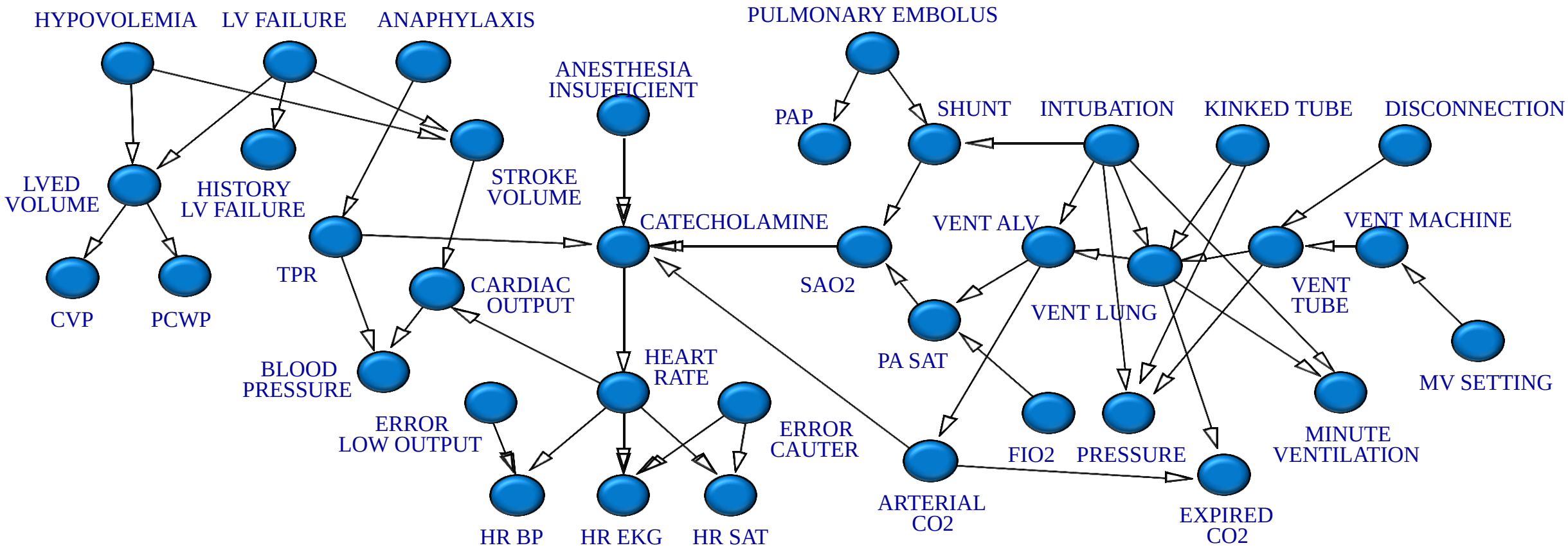
July 16, 2012

Exciting Times

- Computation & memory
- Connectivity & data
- Learning & reasoning prowess

Opportunities & directions

Advances in Capturing Expertise

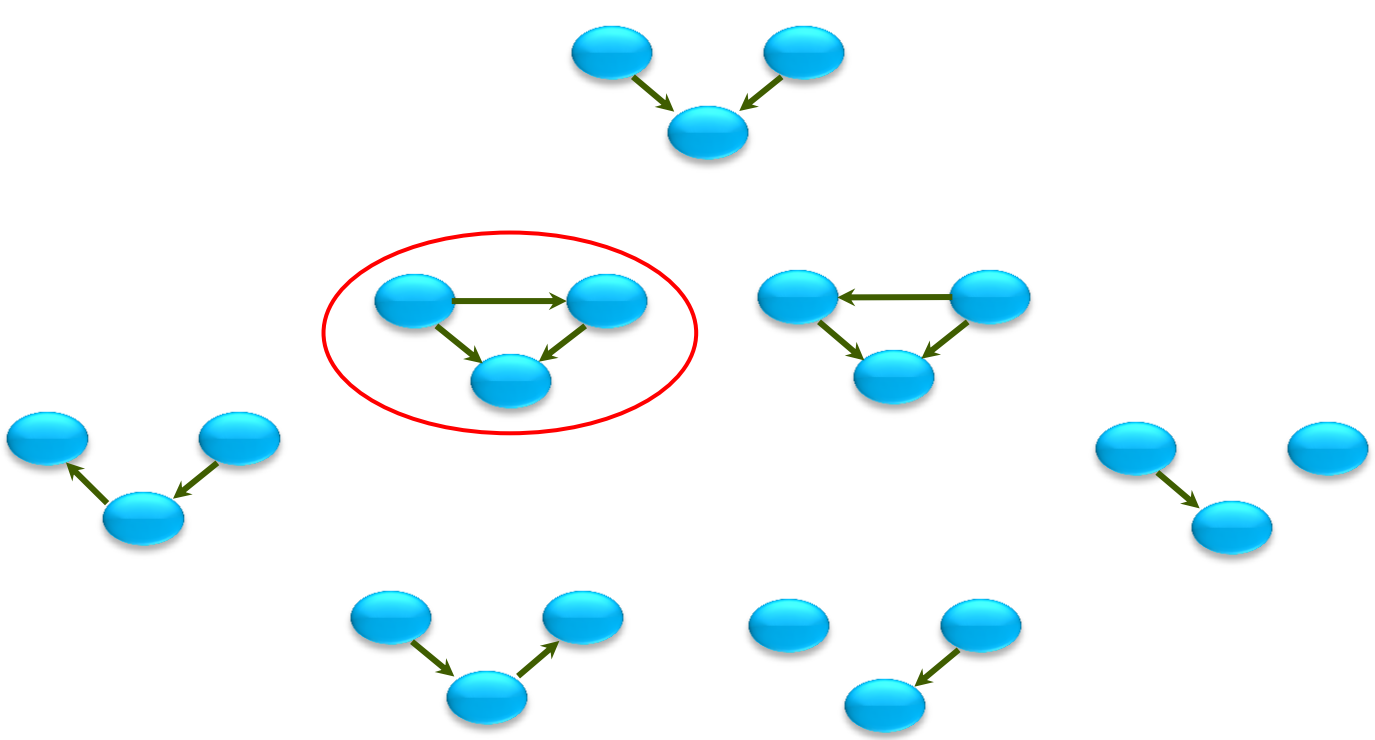


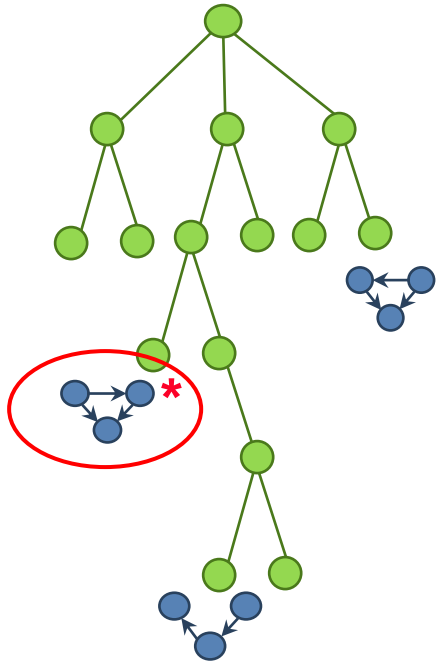
(I. Beinlich, et al)

Learning Predictive Models from Data

New access to large amounts of data

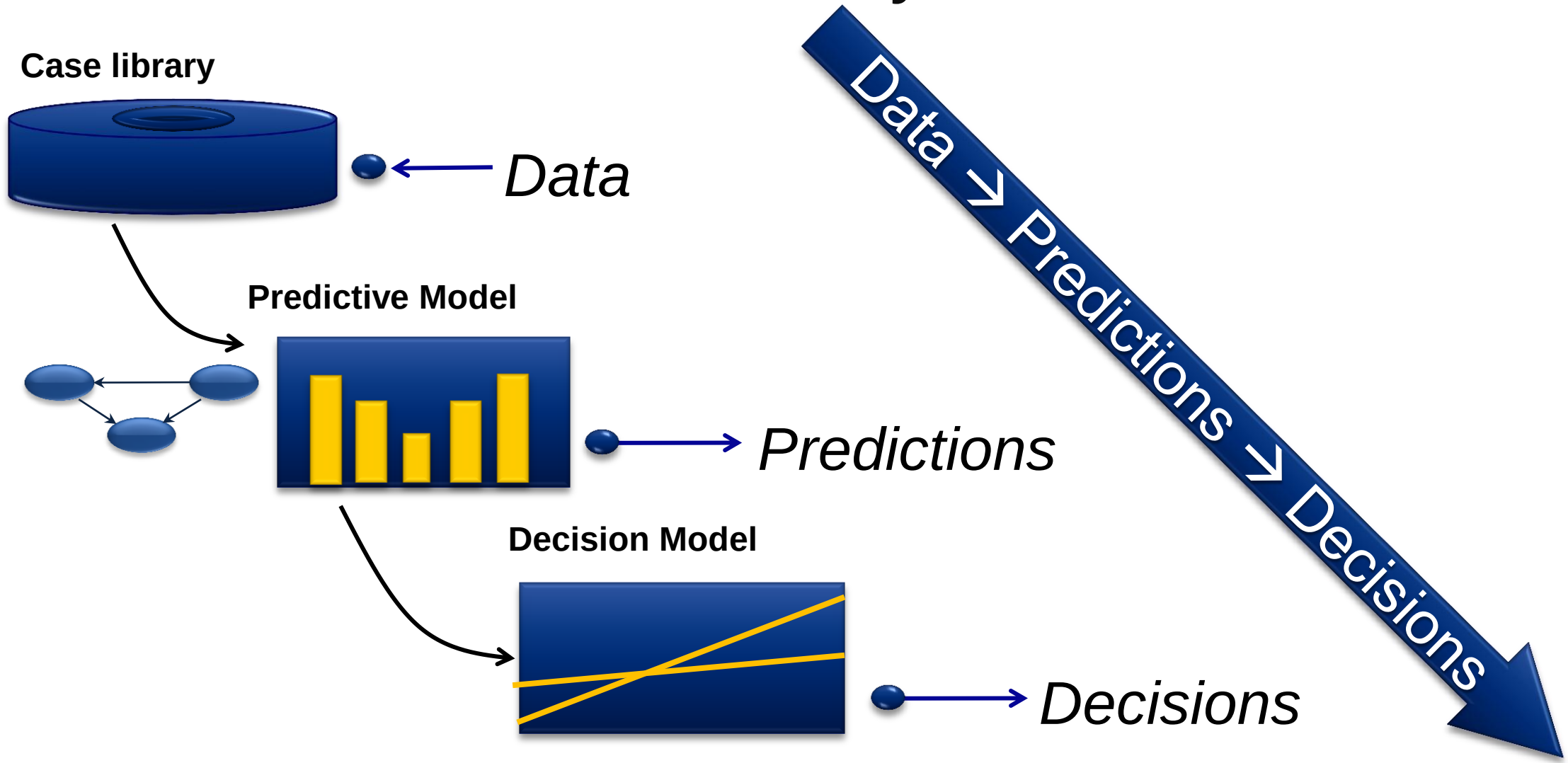
Procedures for learning predictive models





Data → Prediction → Decisions

Best actions under uncertainty

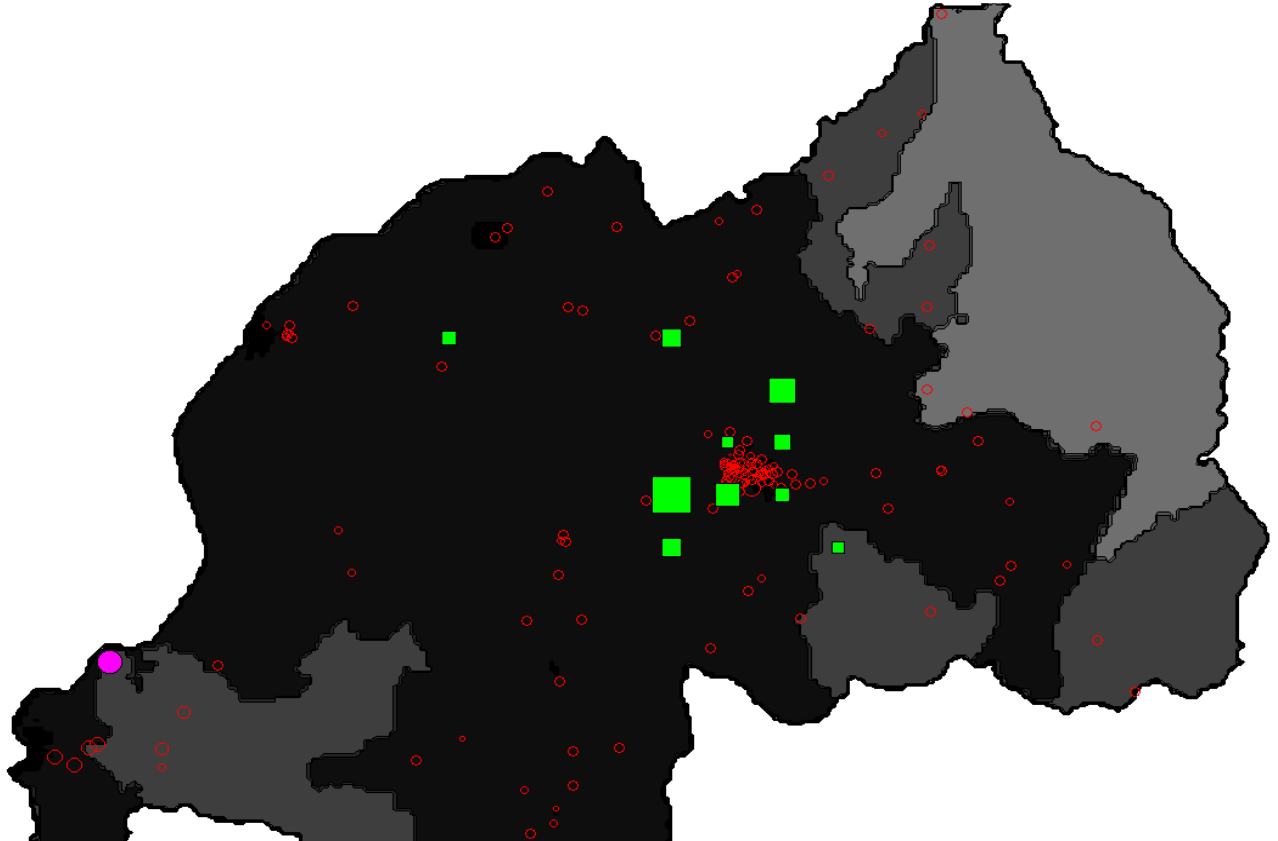


Exciting Directions

Ambient, "in-stream" data resources

Example: *Lac Kivu* earthquake, Congo

Rwandan call densities: 6 days, 140 cell towers, 10.5m calls



with A. Kapoor, N. Eagle

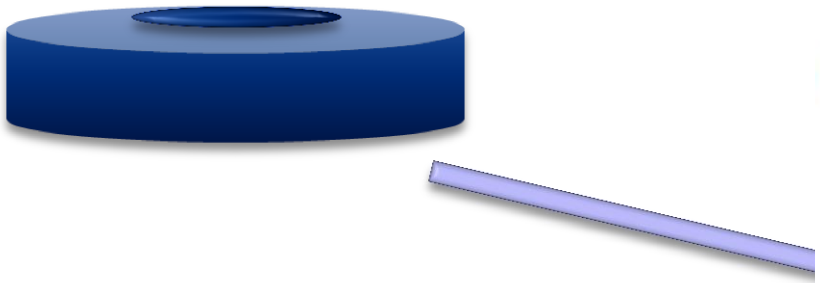
Exciting Directions

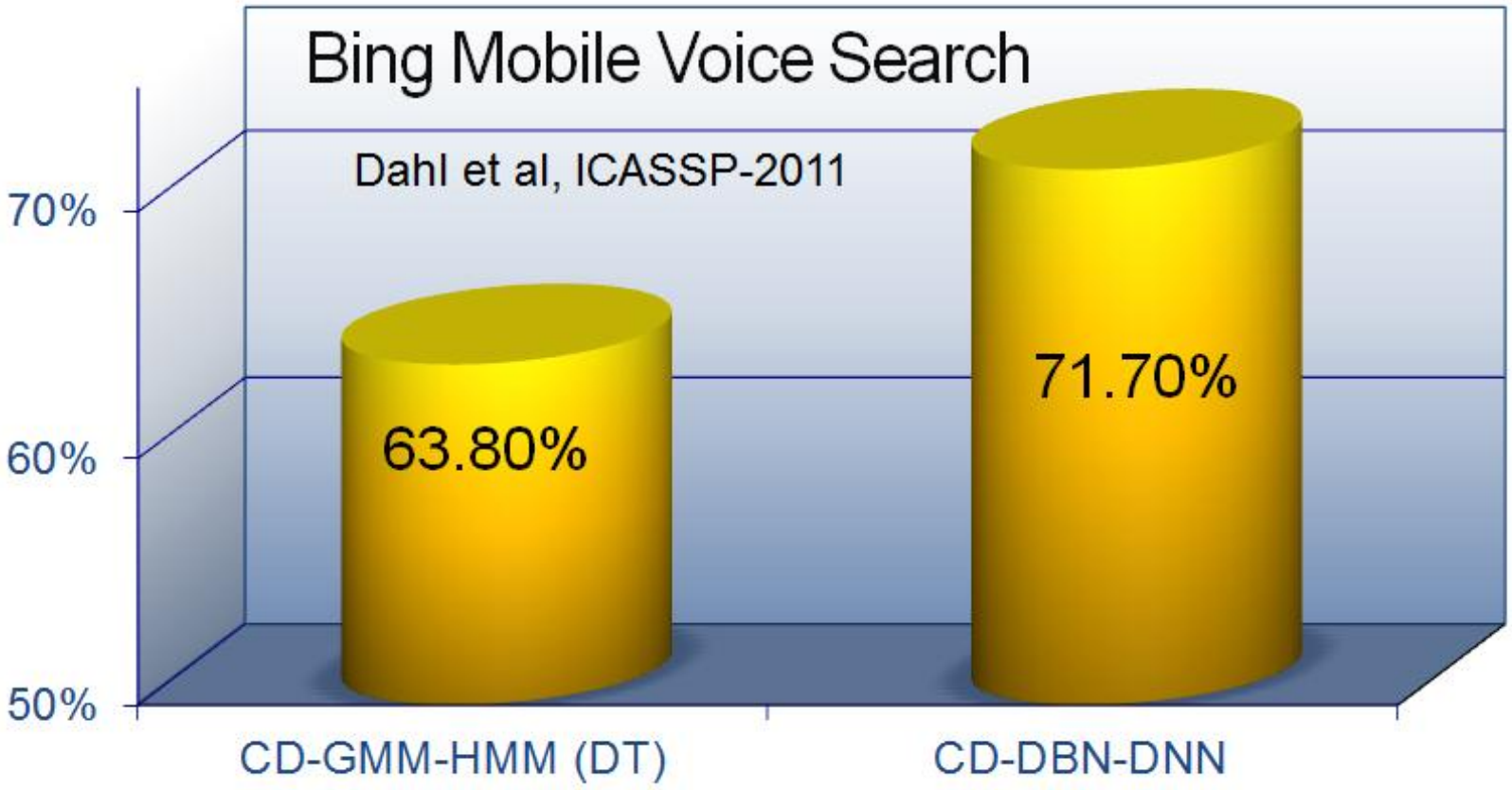
Causality

Active learning

Lifelong learning

Deep learning





Learning & Inference in the World

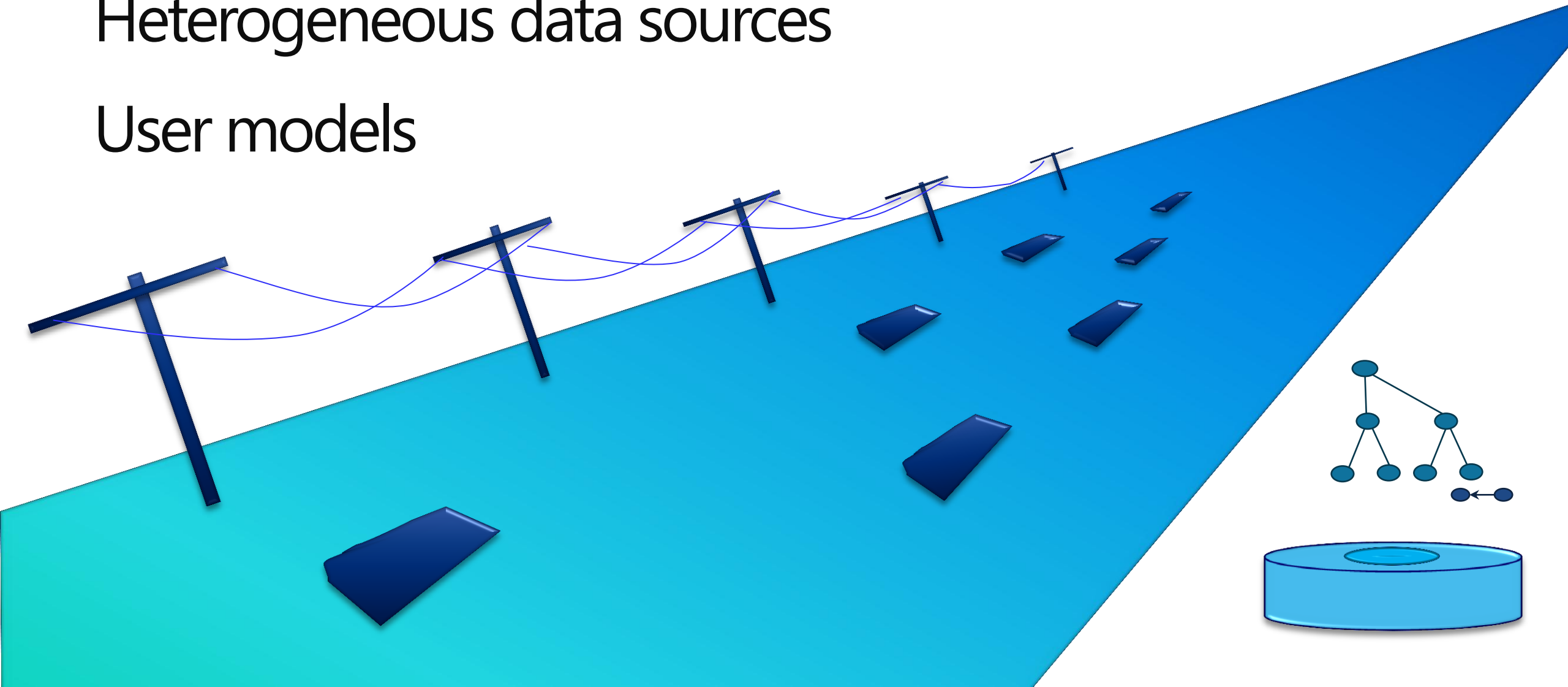
Four efforts

- Transportation
- Healthcare
- Citizen science
- Integrative AI

Transportation

Heterogeneous data sources

User models



Fusion of Heterogeneous Evidence

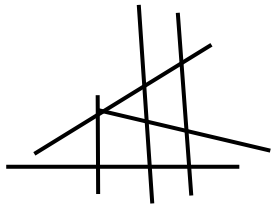
Multiple views on traffic

Incident reports

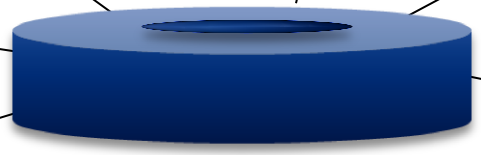
```
Operator ID: Nick
Heading: INCIDENT
Message: INCIDENT
INFORMATION
Cleared 1637: I-405 SB
JS I-90 ACC BLK RL CCTV
1623 - WSP, FIR ON SCENE
```

Weather

Road properties & topology



Day & time



Event store

Major events

with J. Apacible, P. Koch, J. Krumm, P. Newson, R. Sarin, S. Srinivasan, M. Subramani,

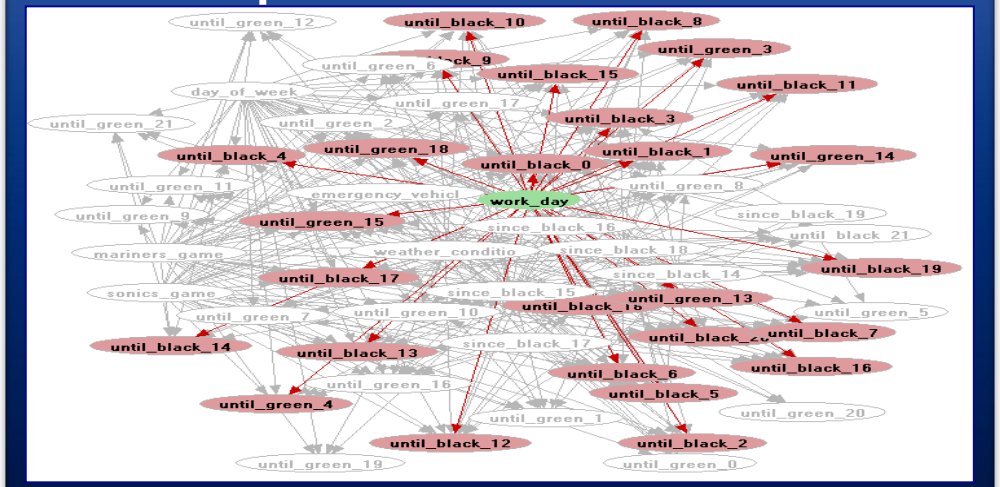
Predicting Future Flows

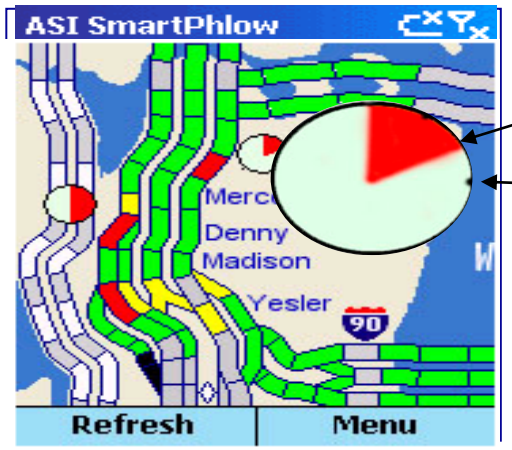
- System-wide status & dynamics
- Incident reports
- Major events
- Weather
- Day & time
- Road properties & topology
- Holiday status

Traffic prediction service

- Event store
- Learning
- Inference

Core predictions



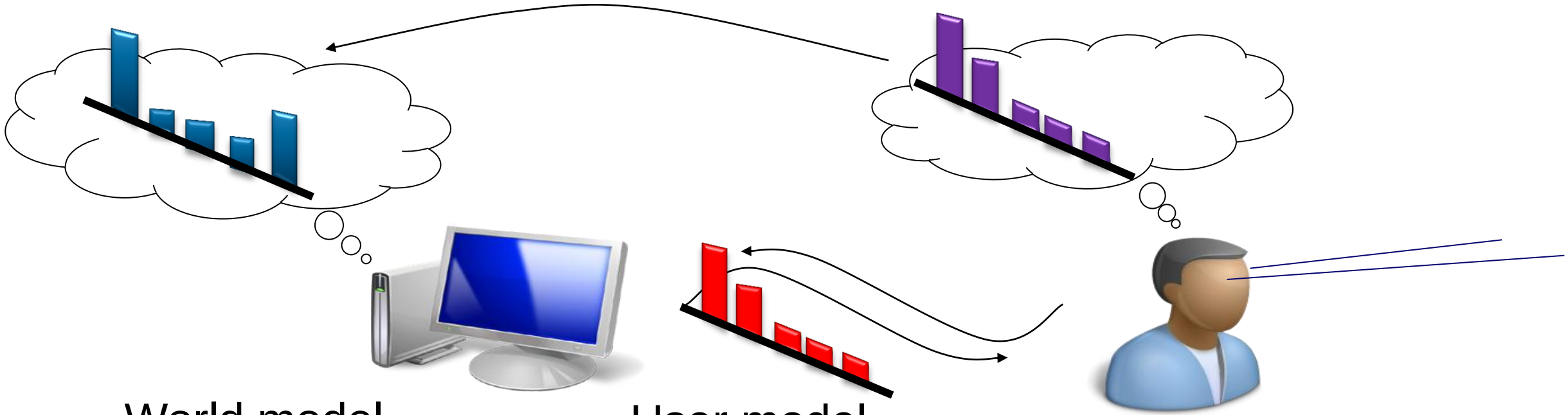


Max likely time jam will last

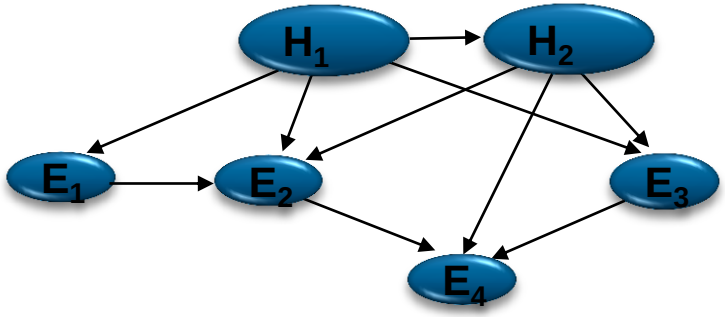
System's confidence

Beyond Domain Focus: Models of User

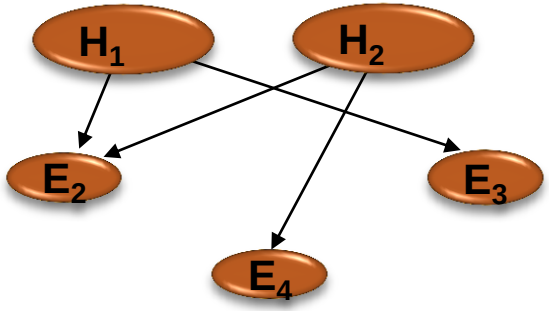
Extend system with model of user's knowledge



World model



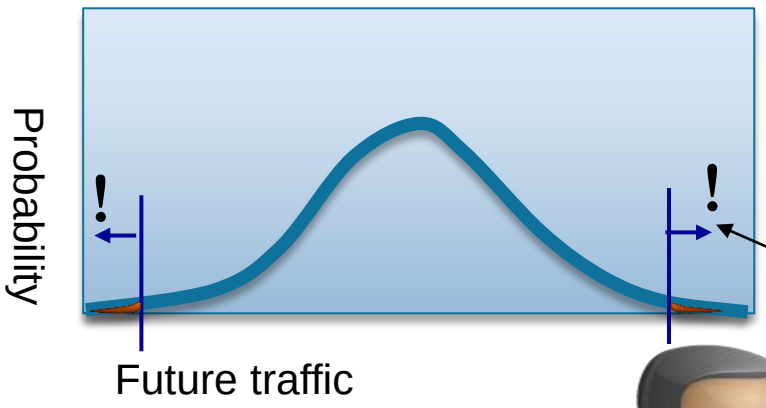
User model



Models of Surprise

Learn what surprises people

…now and in the future



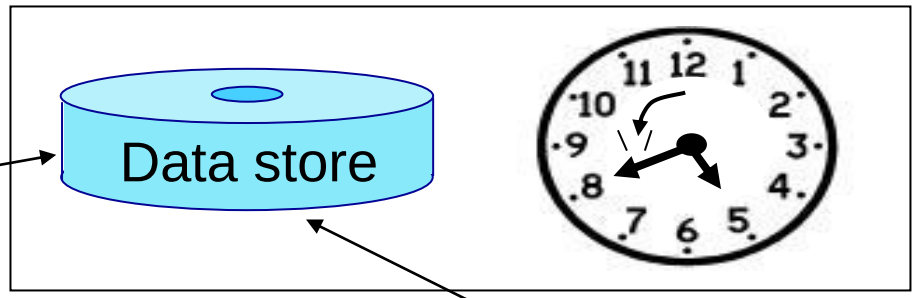
- Major events
- Weather
- Time and day
- Holiday status

Human Forecaster

Real World Outcome

Machine learning

Database of *surprising* events



Events at *t-T*

- System-wide status & dynamics
- Incident reports
- Sporting events
- Weather
- Time and day
- Topology
- Road properties
- Holiday status

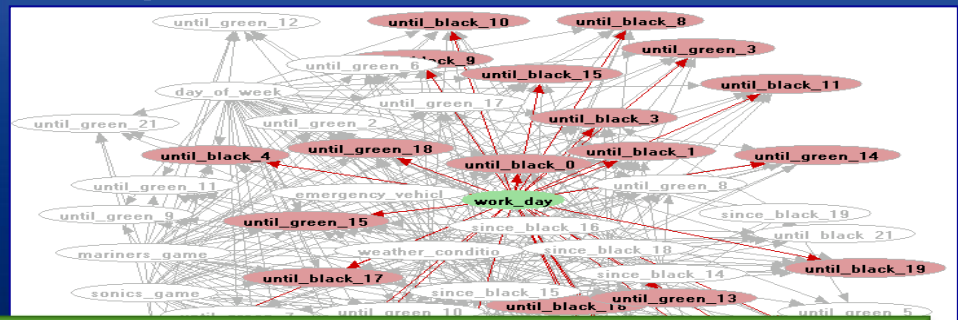
Integrating Surprise Forecasting

- System-wide status & dynamics
- Incident reports
- Major events
- Weather
- Day & time
- Road properties & topology
- Holiday status

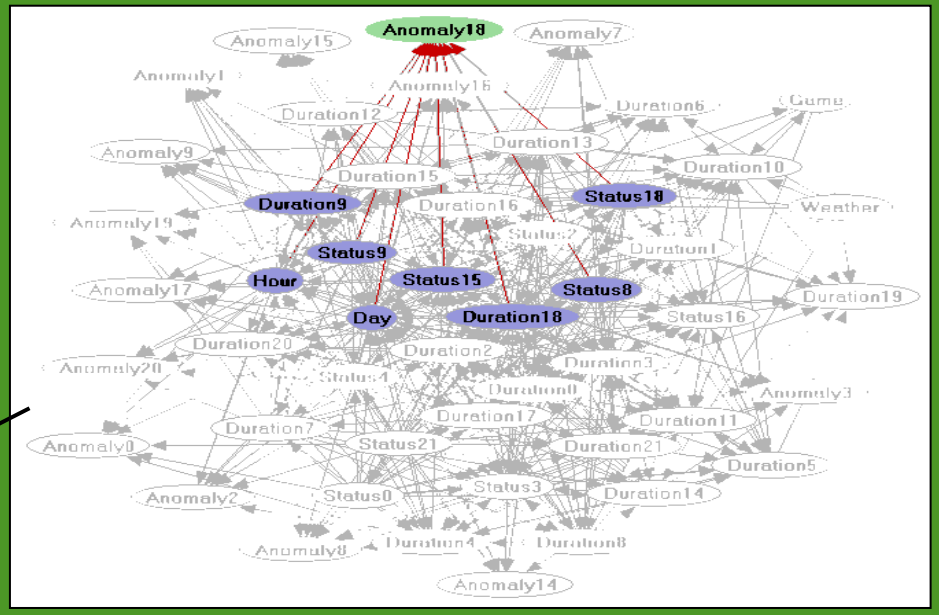
Traffic prediction service

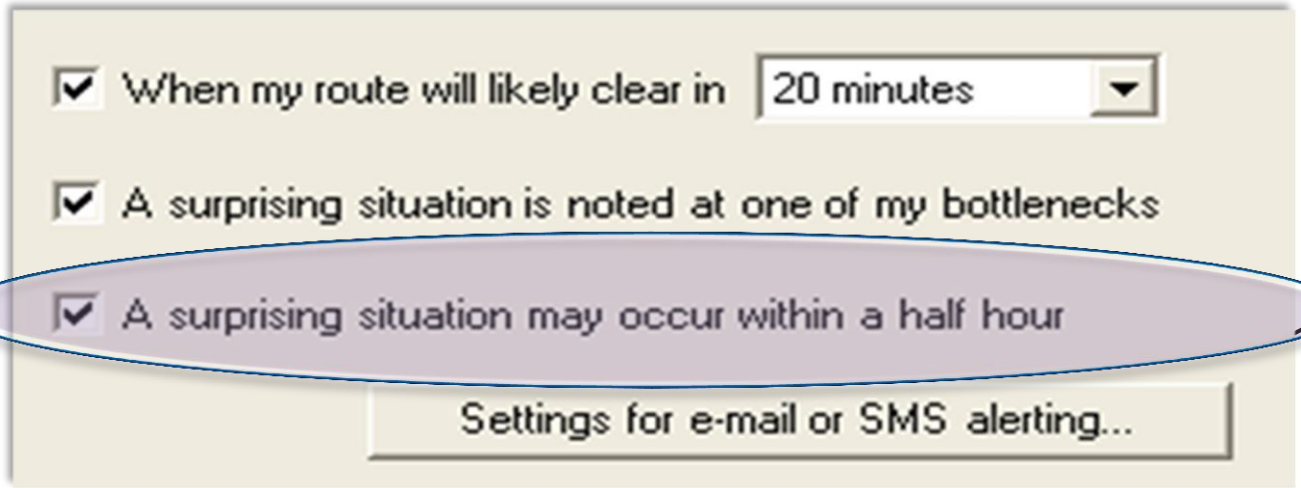
- Event store
- Learning
- Inference

Core predictions

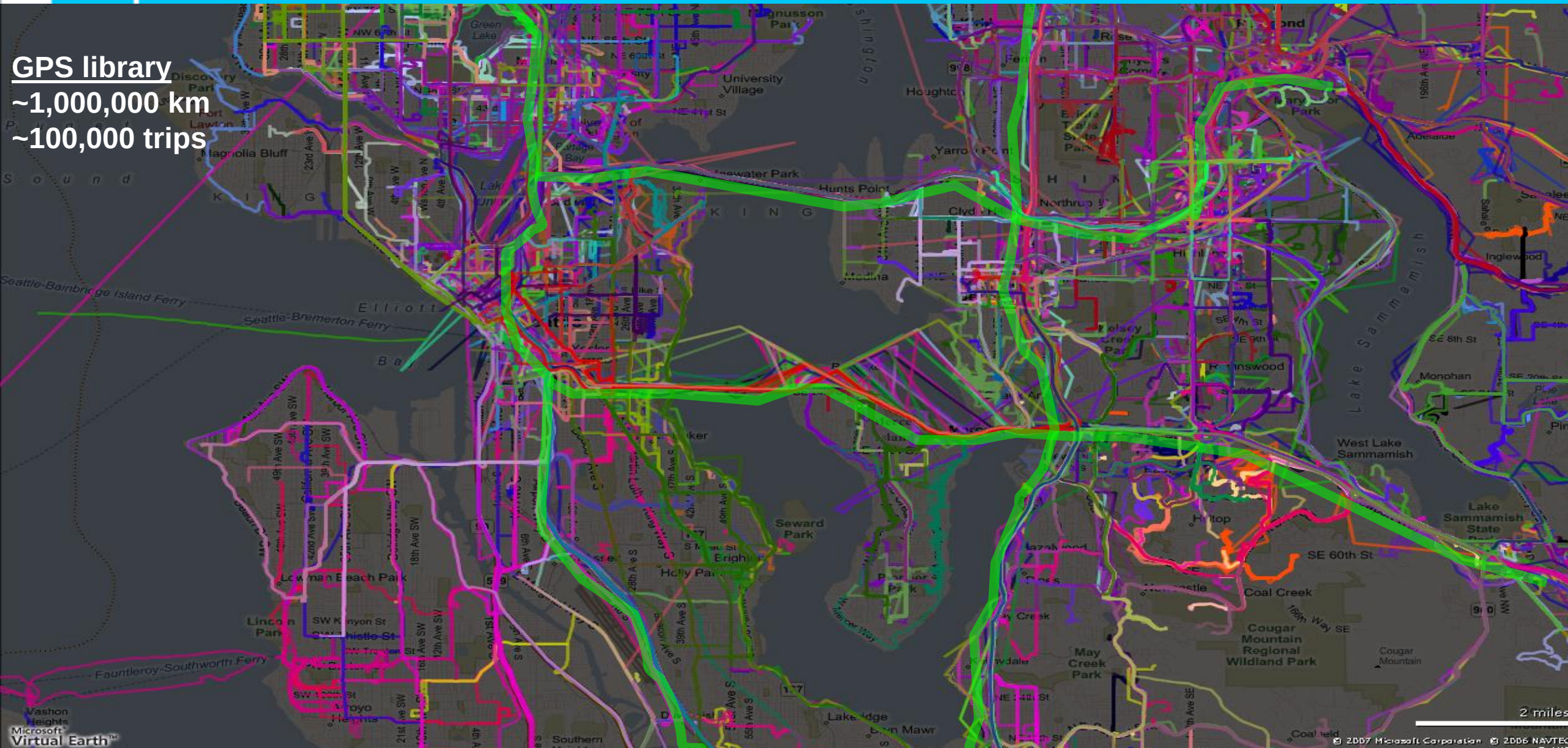


Surprise forecasting models





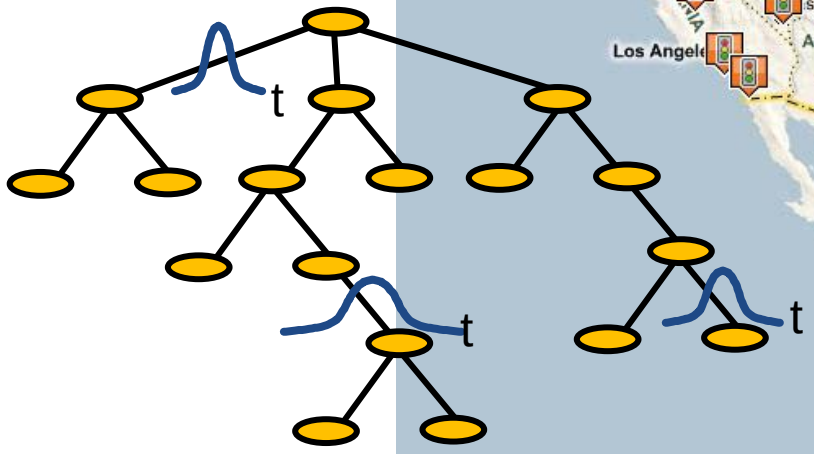
Extend Predictions to Unsensed Roads



Clearflow

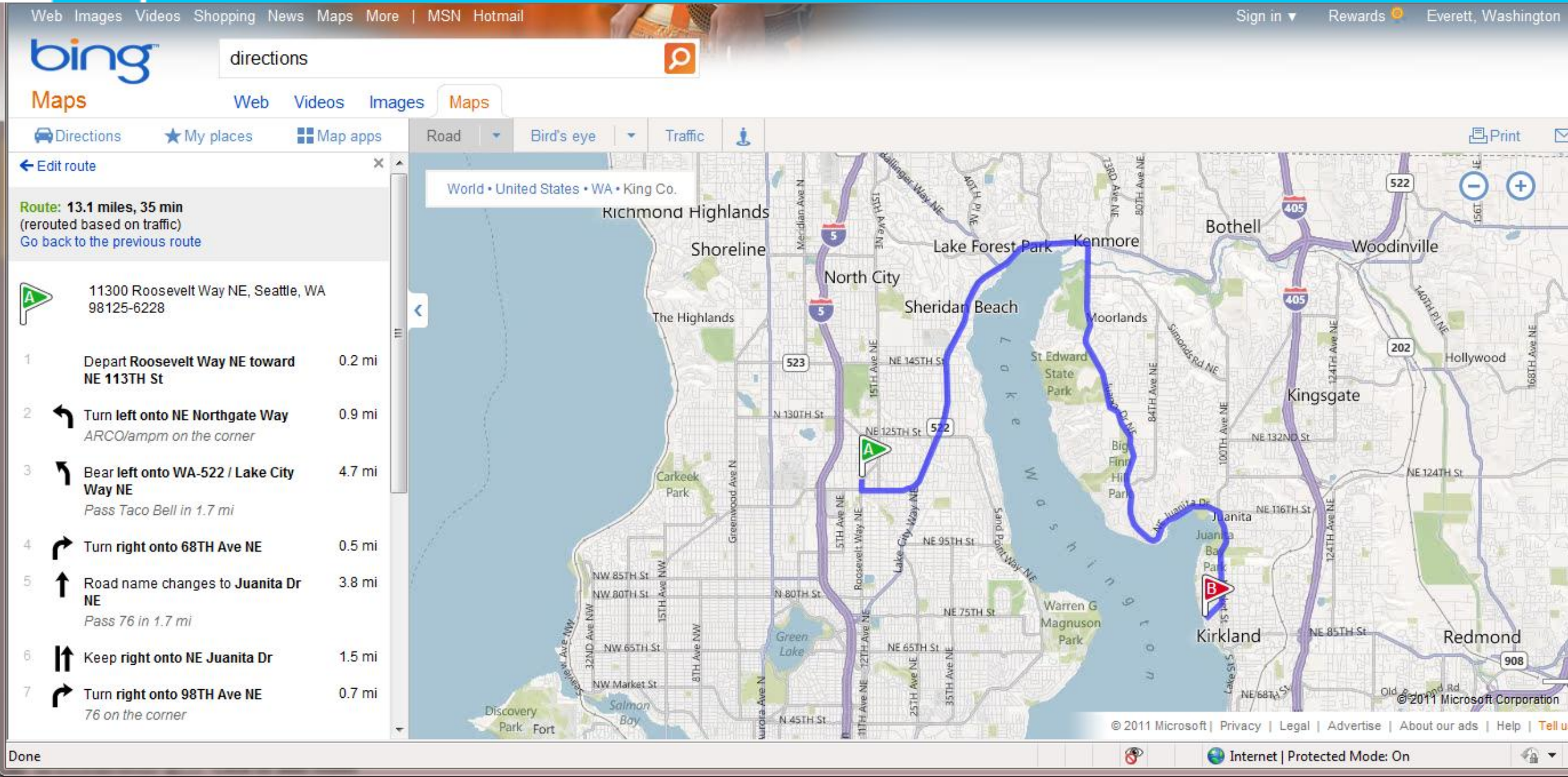
maps.bing.com * Windows phone

- 72 cities across North America
- Flows assigned to ~60 million streets *every few minutes*



Clearflow

maps.bing.com * Windows phone

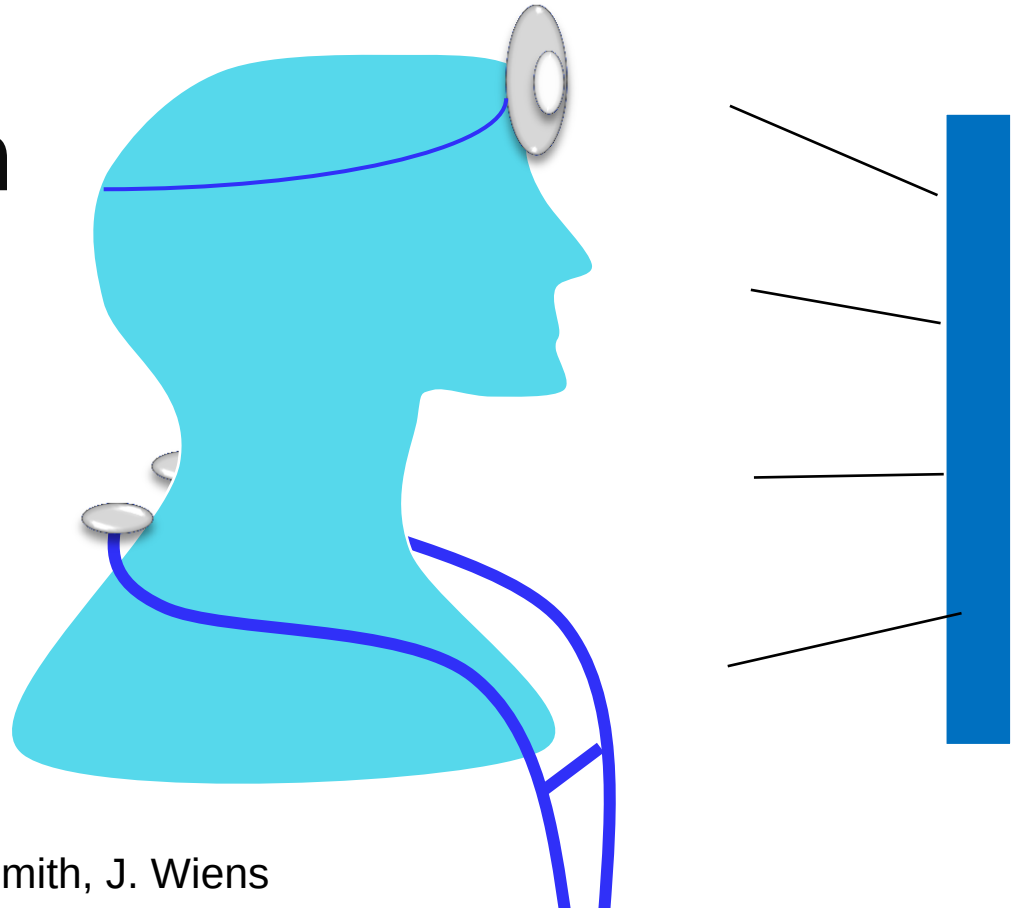


Healthcare

High-stakes challenges

Working across cultures

Coupling prediction & decision



with M. Bayati, M. Braverman, R. Caruana, J. Gatewood, P. Koch, M. Smith, J. Wiens

Costly Challenge

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SPECIAL ARTICLE

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Rehospitalizations among Patients in the Medicare Fee-for-Service Program

Stephen F. Jencks, M.D., M.P.H., Mark V. Williams, M.D., and Eric A. Coleman, M.D., M.P.H.

ABSTRACT

Background Reducing rates of rehospitalization has attracted attention from policymakers as a way to improve quality of care and reduce costs. We have limited information on the frequency and patterns of rehospitalization in the United States to aid in planning the necessary changes.

Methods We analyzed Medicare claims data from 2003–2004 to describe the patterns of

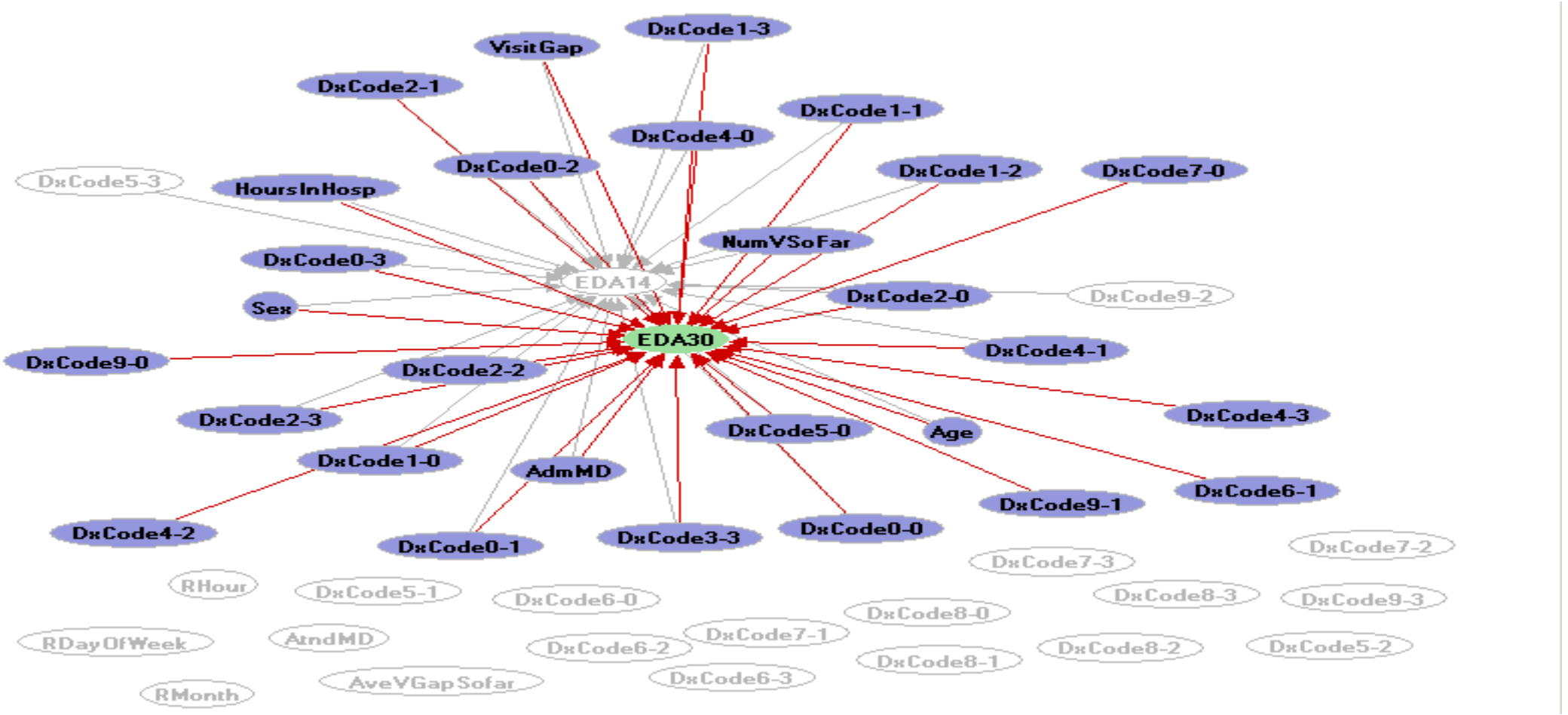
- **~20% within 30 days**
- **~35% in 90 days**
- ***Estimated cost to Medicare in 2004: $17.4 billion***

Learning from a Case Library

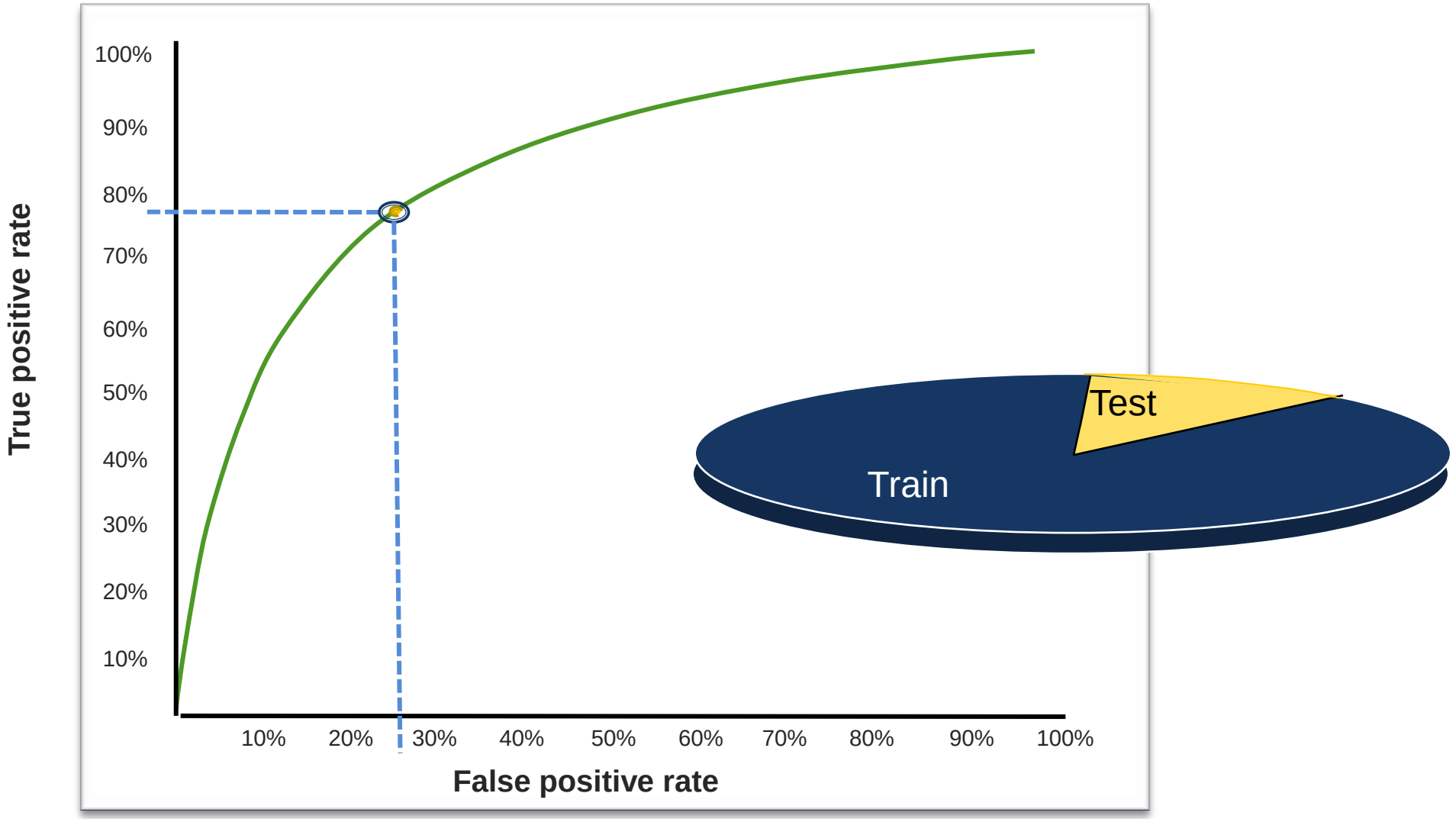
- Large hospital in Wash DC
- All visits during the years 2001 to 2009
  (e.g., ~300,000 ED visits)
  - Admissions, discharge, transfer (ADT)
  - Chief complaint in free text
  - Age, gender, demographics
  - Diagnosis codes (ICD-9)
  - Lab results and studies
  - Medications
  - Vital signs
  - Procedures
  - Admitting and attending MD codes
  - Fees and billing

~25,000 variables considered in dataset

Graphical Model for Readmission



Performance of Classifier



Identifying Discriminatory Evidence

Weight	Feature description	Frequency
0.68398	Dx0->2 = Excessive vomiting in pregnancy	0.31%
0.61306	Dx3->2 = Personal history of malignant neoplasm	0.28%
0.58281	Dx0->2 = Heart failure	0.30%
0.56708	Dx0->1 = Nephritis, nephrotic syndrome, and nephrosis	0.09%
0.56649	Dx3->2 = Heart failure	0.28%
0.54663	Complaint sentence contains ''suicidal''	0.17%
0.48415	Dx1->2 = Disorders of function of stomach	0.07%
0.47257	Dx5->0 = Diseases Of The Genitourinary System	0.15%
0.46136	Dx0->2 = Chronic airway obstruction, not elsewhere classified	0.10%
0.44555	Dx4->2 = Depressive disorder, not elsewhere classified	0.10%
0.44257	Stayed 14 hours in the ER	0.10%
0.43890	Dx0->1 = Other psychoses	0.32%
0.43513	Dx0->0 = Diseases Of The Blood And Blood-Forming Organs	0.46%
0.42582	Complaint sentence contains ''dialysis''	0.19%
0.41888	Dx0->2 = Depressive disorder, not elsewhere classified	0.27%
0.41302	Dx1->1 = Nephritis, nephrotic syndrome, and nephrosis	0.29%
0.38506	Complaint sentence contains ''fluid''	0.10%
0.37474	69 < Age	9.22%

Multiple Predictions

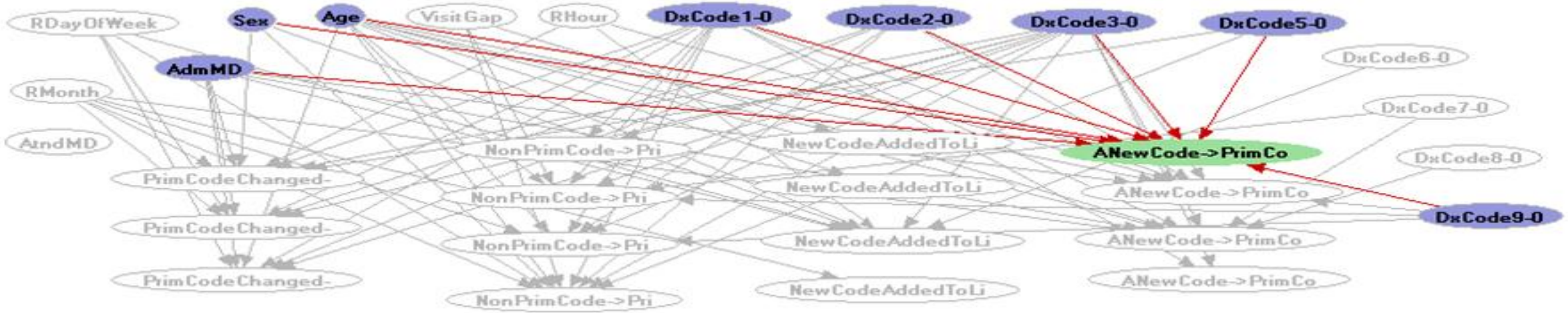
- ED discharge → Inpatient within 72 hours
- Inpatient discharge → Inpatient within 30 days
- CHF discharge → CHF inpatient within 30 days
- Death within 30 days
- Inpatient → infection within 48hrs, 72hrs, stay
  - *C.Difficile, MRSA, VRE*

Team
M. Bayati, M. Braverman, E. Horvitz, P. Koch, P. Oka, J. Wiens , N. Donegan, L. Pic-Aluas, G. Ruiz, M. Smith

New Kinds of Models: Predict Surprises

Predict readmission surprises:

"The patient you're discharging will likely return within 3 days with a 1^0 diagnosis that is not currently on the chart."



Translation: Research → Open World

Readmissions Manager for Microsoft Amalga

Reducing Hospital Readmissions is an Impending Priority

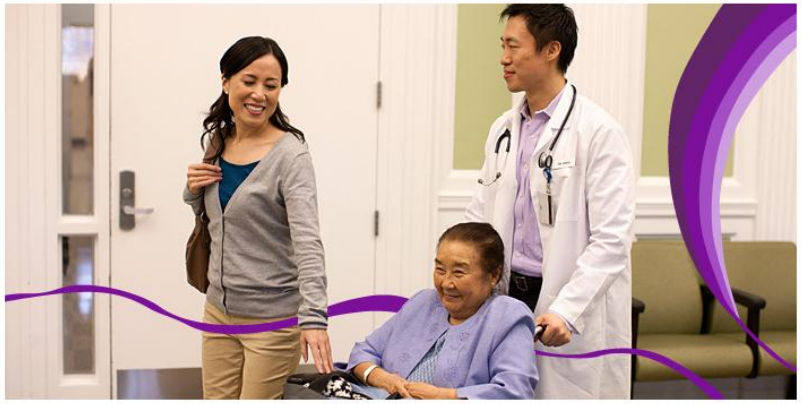
Overview

One in five Medicare inpatients is readmitted within 30 days. The Centers for Medicare and Medicaid Services (CMS) considers 40%-75% of these readmissions to be preventable.

In October 2012, CMS will begin to track readmission and impose financial penalties on hospitals with higher–than–expected readmission rates for certain conditions. Other payers will certainly follow.

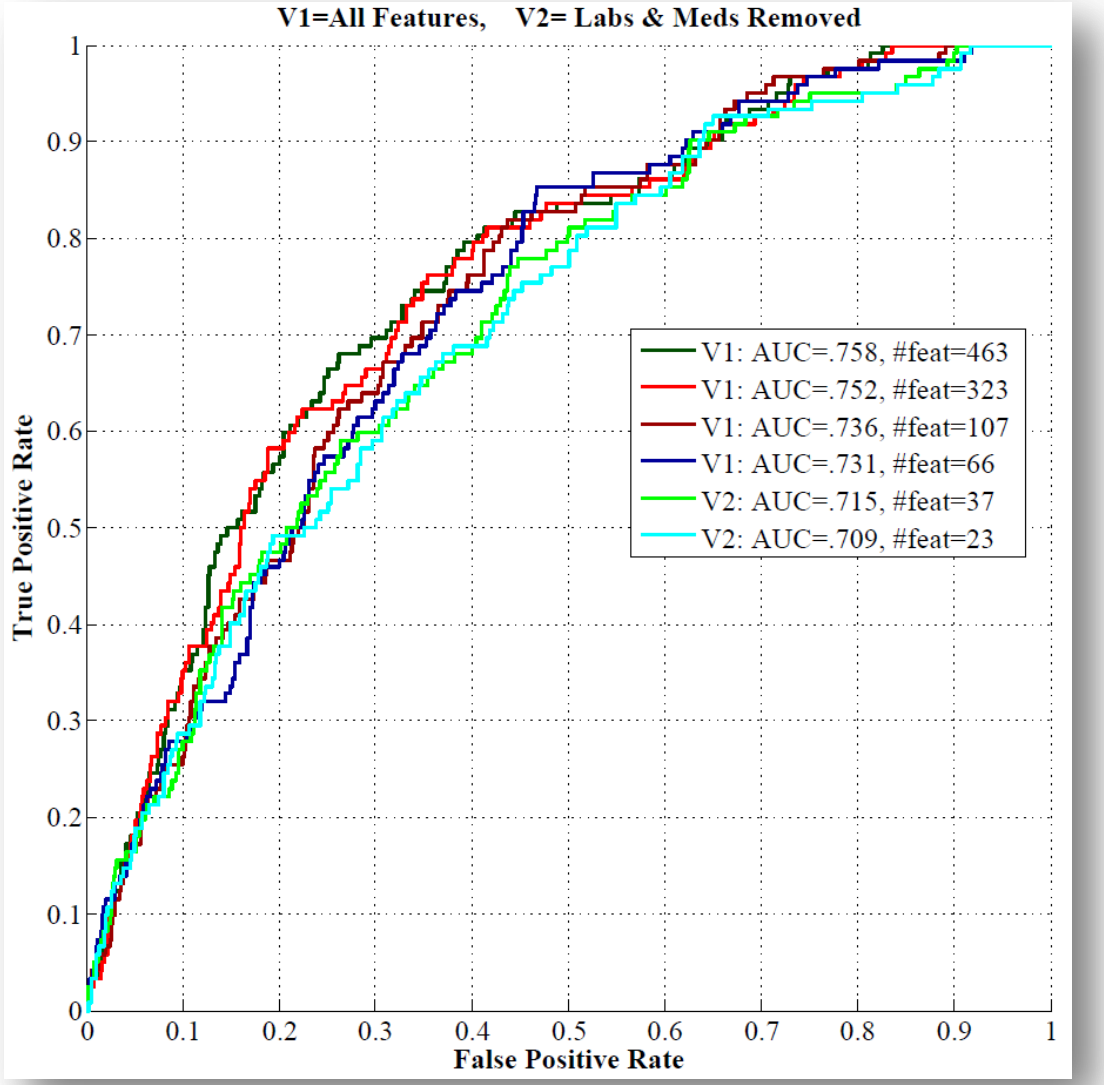
It is clear that hospital admissions and readmissions are becoming a critical parameter for tracking care delivery from both a financial and quality perspective.

Readmissions Manager for Microsoft Amalga is an innovative solution to help organizations address this very important business need.

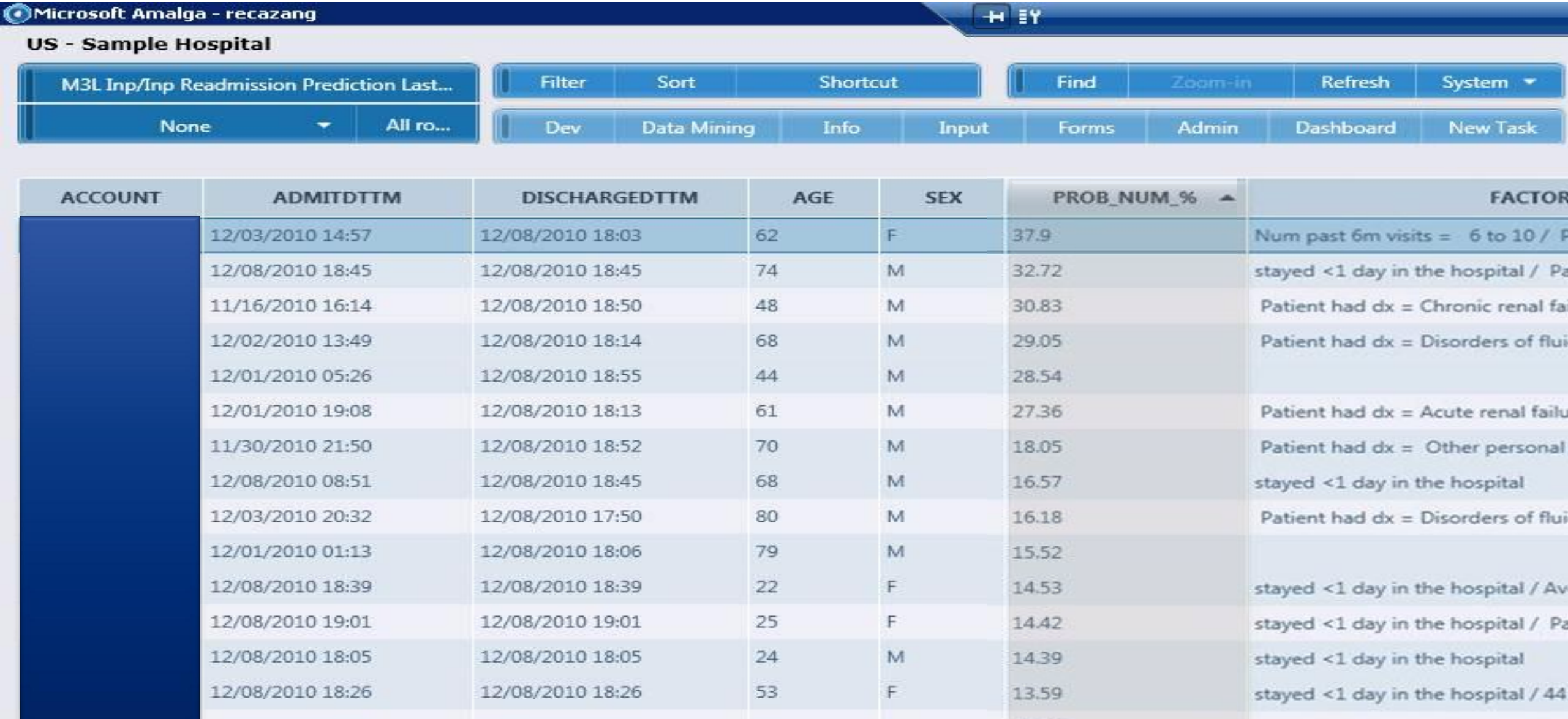


Readmissions Manager Targets Avoidable Hospital Readmissions

Engineering for Tractability and Availability

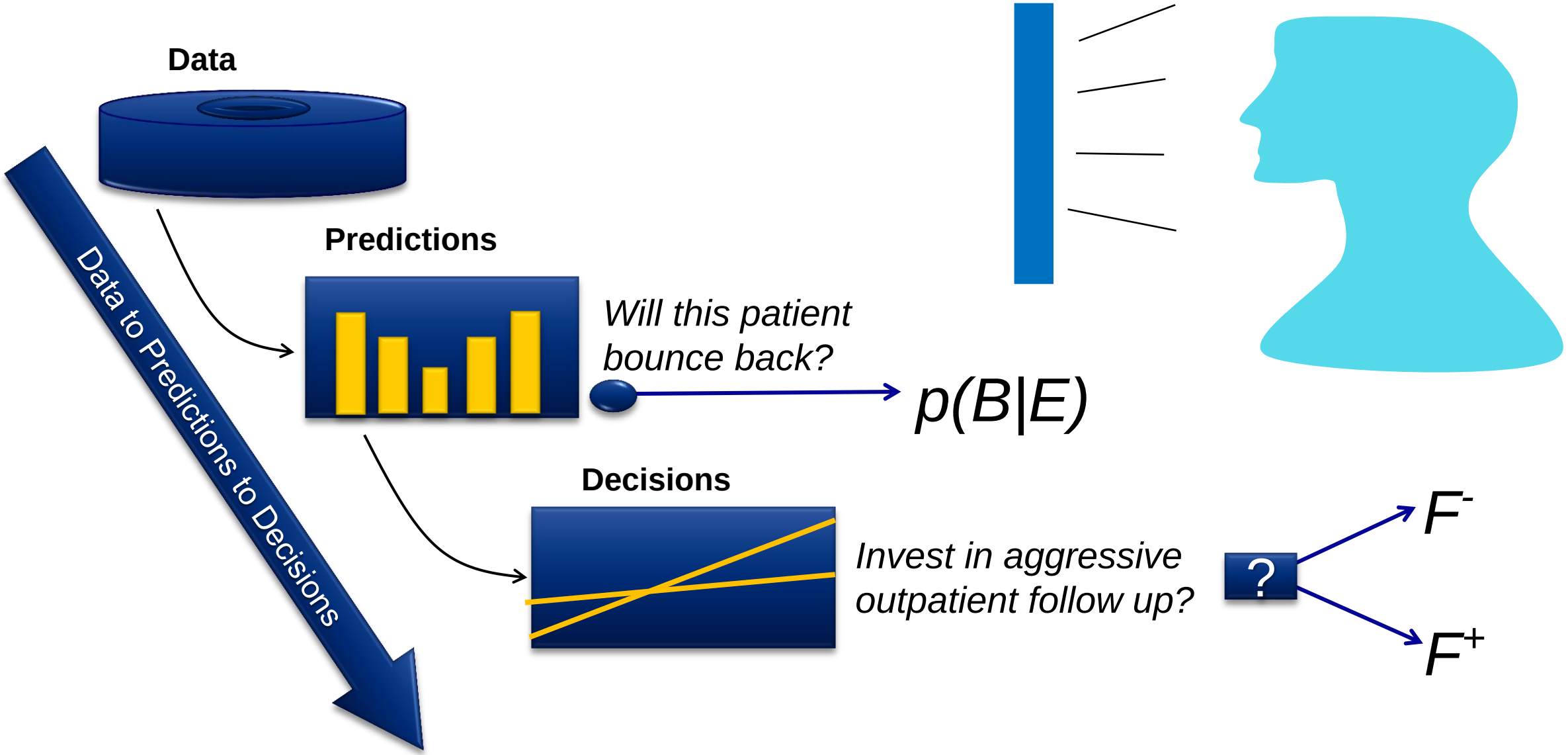


Predictive platform goes live…

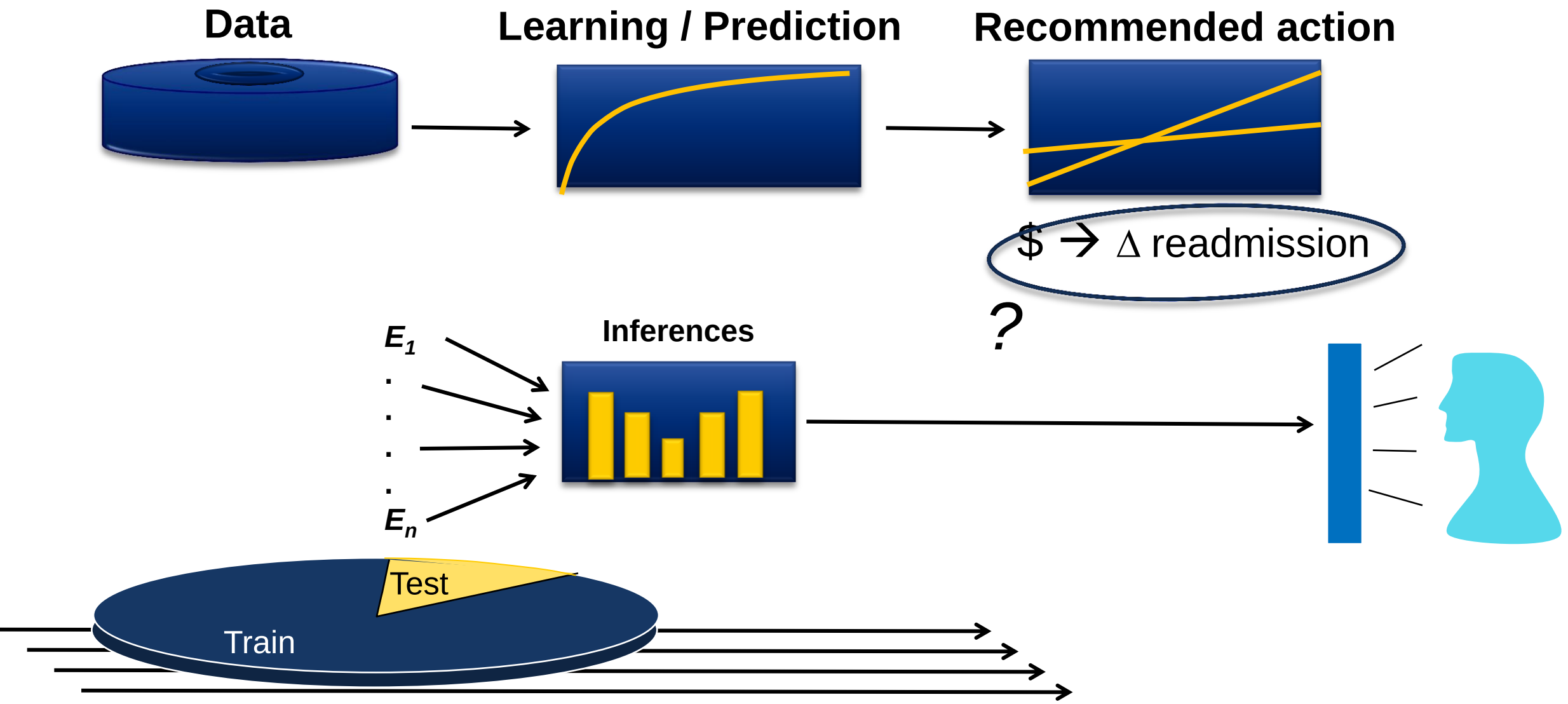


ACCOUNT	ADMITDTTM	DISCHARGEDTTM	AGE	SEX	PROB_NUM_%	FACTOR
	12/03/2010 14:57	12/08/2010 18:03	62	F	37.9	Num past 6m visits = 6 to 10 / P
	12/08/2010 18:45	12/08/2010 18:45	74	M	32.72	stayed <1 day in the hospital / Pa
	11/16/2010 16:14	12/08/2010 18:50	48	M	30.83	Patient had dx = Chronic renal fa
	12/02/2010 13:49	12/08/2010 18:14	68	M	29.05	Patient had dx = Disorders of flui
	12/01/2010 05:26	12/08/2010 18:55	44	M	28.54	
	12/01/2010 19:08	12/08/2010 18:13	61	M	27.36	Patient had dx = Acute renal failu
	11/30/2010 21:50	12/08/2010 18:52	70	M	18.05	Patient had dx = Other personal
	12/08/2010 08:51	12/08/2010 18:45	68	M	16.57	stayed <1 day in the hospital
	12/03/2010 20:32	12/08/2010 17:50	80	M	16.18	Patient had dx = Disorders of flui
	12/01/2010 01:13	12/08/2010 18:06	79	M	15.52	
	12/08/2010 18:39	12/08/2010 18:39	22	F	14.53	stayed <1 day in the hospital / Av
	12/08/2010 19:01	12/08/2010 19:01	25	F	14.42	stayed <1 day in the hospital / Pa
	12/08/2010 18:05	12/08/2010 18:05	24	M	14.39	stayed <1 day in the hospital
	12/08/2010 18:26	12/08/2010 18:26	53	F	13.59	stayed <1 day in the hospital / 44

Data → Predictions → Decisions

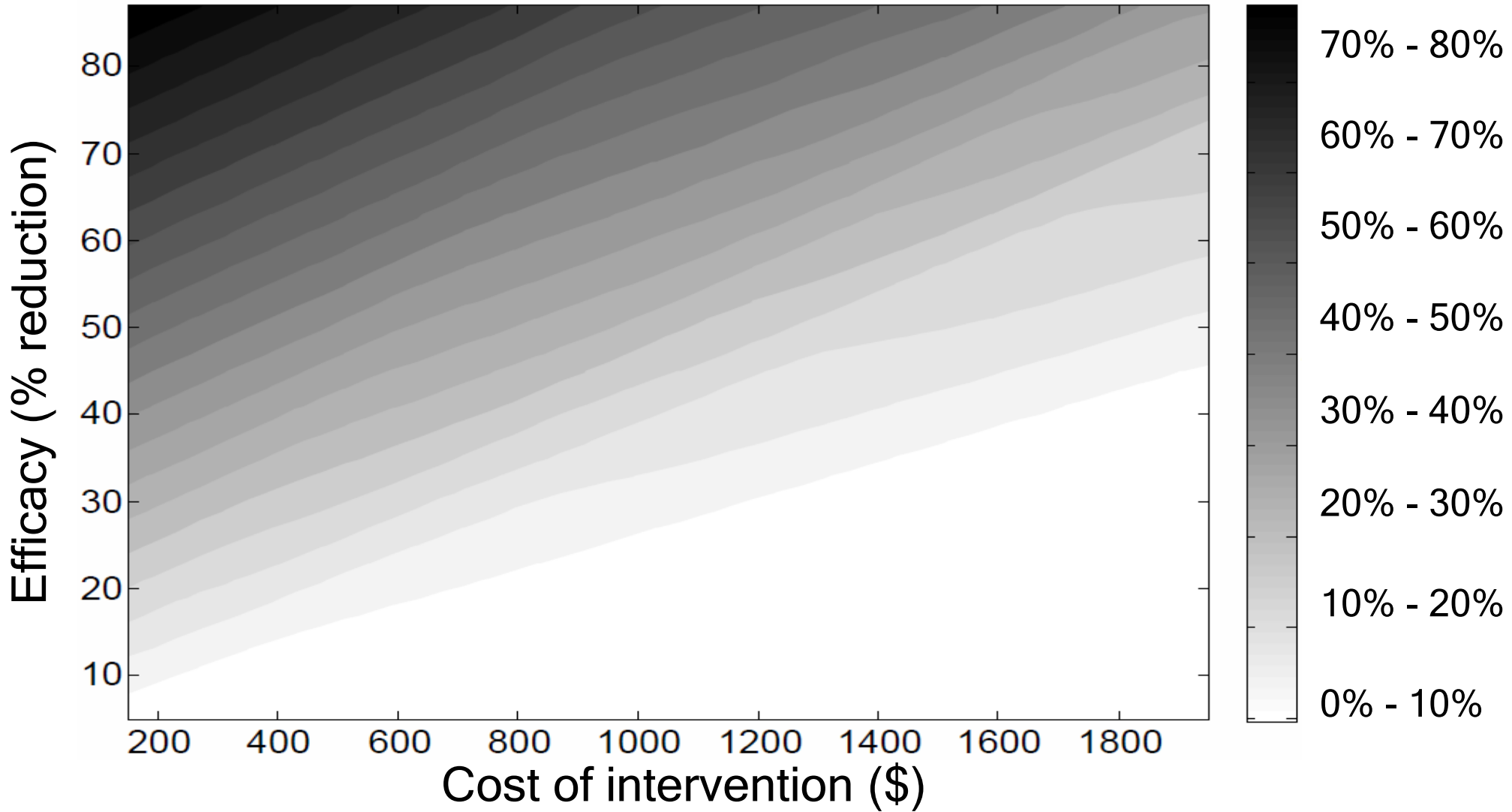


Expected Value of Fielding System for Population



Expected Value of Fielding System for Population

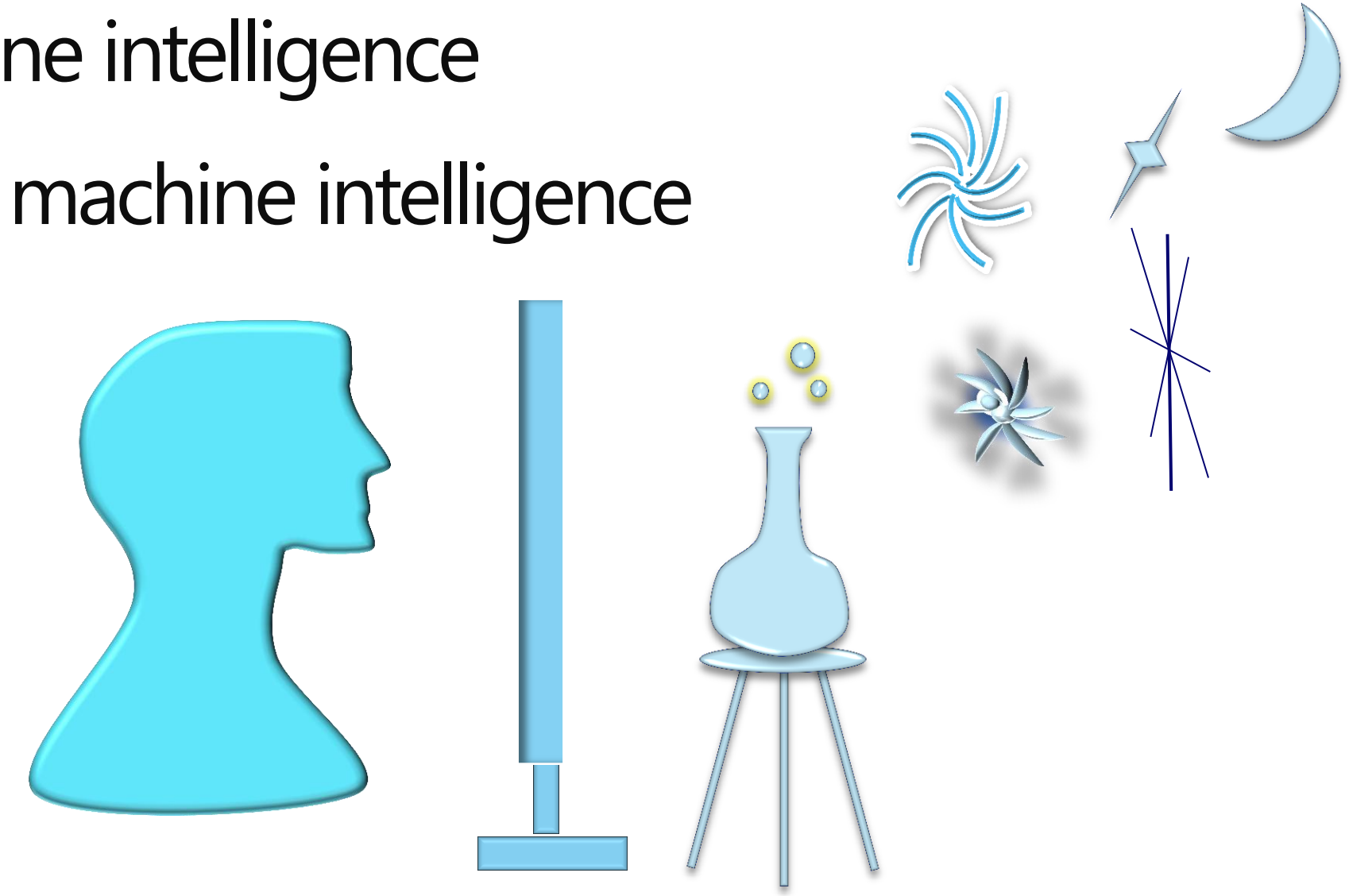
Congestive Heart Failure: Train: 2004-2007 / Test: 2008



Citizen Science

Human + machine intelligence

Multiple roles of machine intelligence



Citizen Science

Zooniverse: Classification & discovery in astronomy

Sloan Digital Sky Survey:

~10^6 galaxies, ~120k quasars, ~225k stars

Galaxy Zoo

View & classify galaxies online

886k galaxies, 34m votes, 100k participants

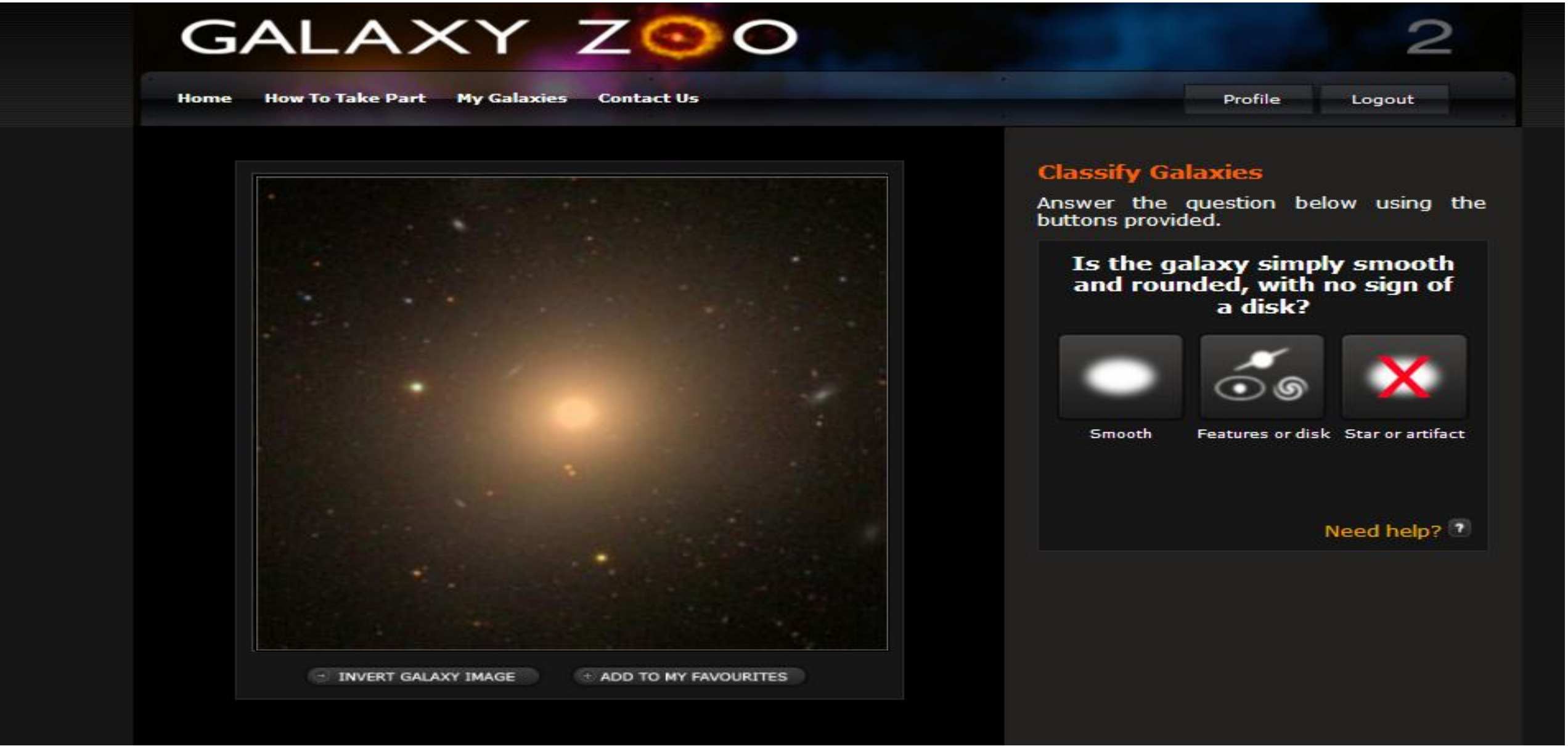
with E. Kamar, S. Hacker, P. Koch, C. Lintott, A. Smith

Classification & Discovery in Astronomy

Classification & Discovery in Astronomy

Classification & Discovery in Astronomy

Classification & Discovery in Astronomy



Sloan Digital Sky Survey: Image Analysis

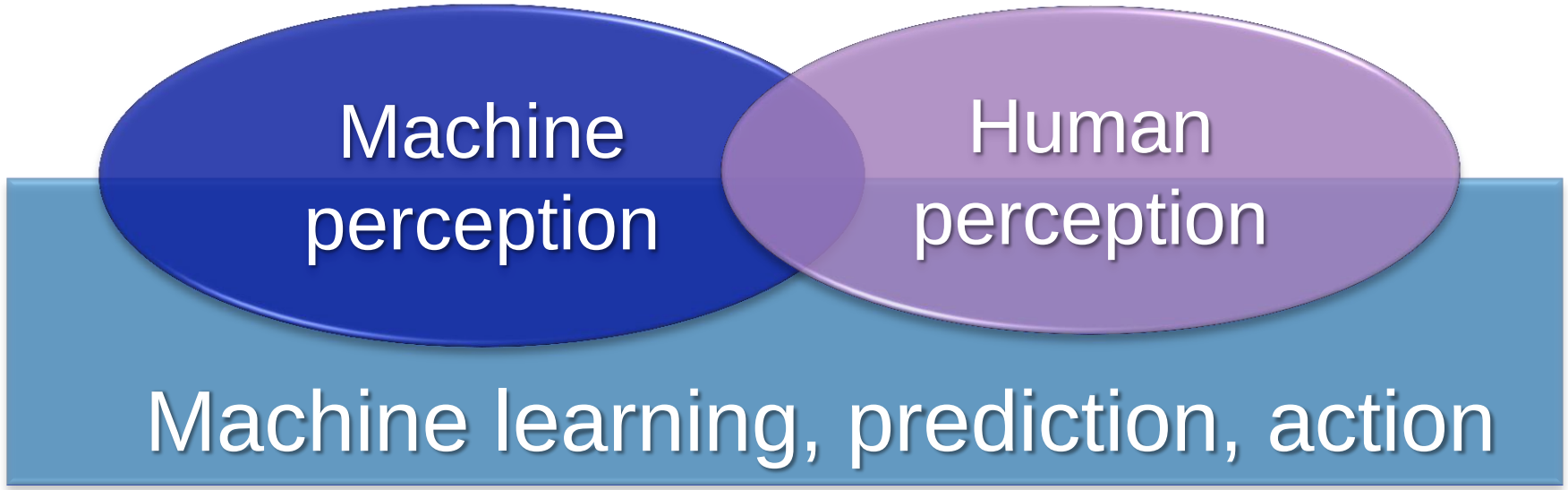
453 features

Attribute	Description
$petroMag_{ug}$	Petrosian magnitude colors. A color was calculated for four independent pairs of bands in SDSS (u, g, r, i, z).
$petroRad_u * z$	Petrosian radius, transformed with redshift to be distance-independent.
$invConIndx_u$	Inverse concentration index. The ratio of the 50% Petrosian magnitude to the 90% Petrosian magnitude.
$isoRowcGrad\_u * z$	Gradient of the isophotal row centroid, transformed with redshift to be distance-independent.
$isoColcGrad_u * z$	Gradient of the isophotal column centroid, transformed with redshift to be distance-independent.
$isoA_u * z$	Isophotal major axis, transformed with redshift to be distance-independent.
$isoB_u * z$	Isophotal minor axis, transformed with redshift to be distance-independent.
$isoAGrad_u * z$	Gradient of the isophotal major axis, transformed with redshift to be distance-independent.
$isoBGrad_u * z$	Gradient of the isophotal minor axis, transformed with redshift to be distance-independent.
$isoPhiGrad_u * z$	Gradient of the isophotal orientation, transformed with redshift to be distance-independent.
$texture_u$	Measurement of surface texture.
$lnLExp_u$	Log-likelihood of exponential profile fit.
$lnLDeV_u$	Log-likelihood of De Vaucouleurs profile fit.
$fracDev_u$	Fraction of the brightness profile explained by the De Vaucouleurs profile.

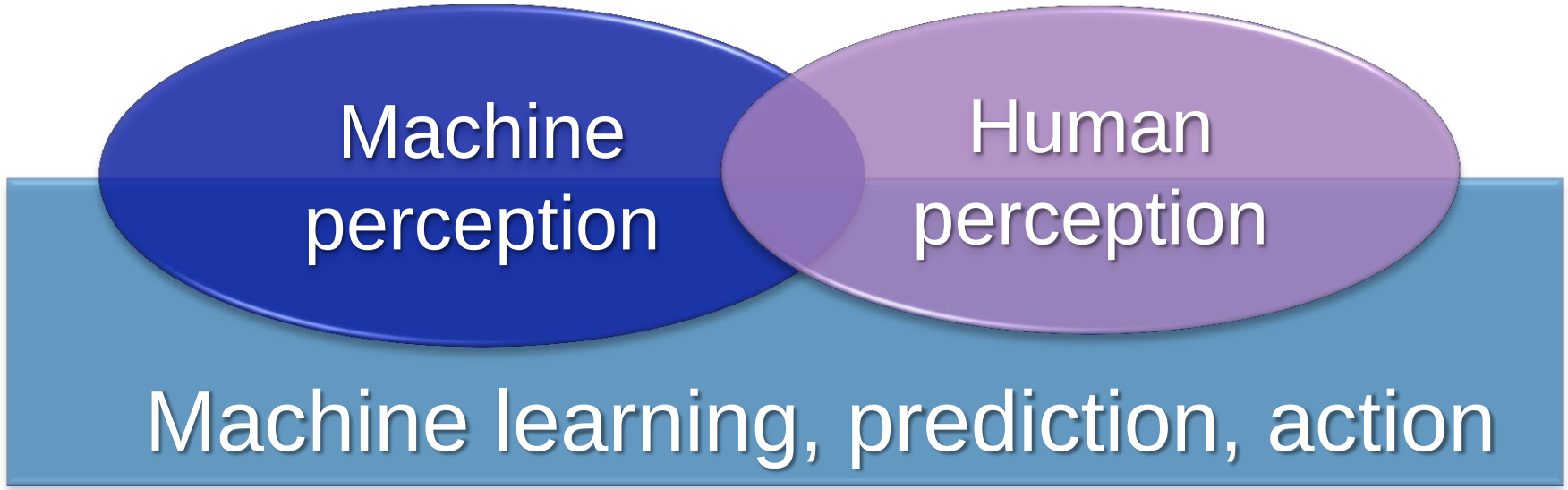
Mesh Human & Machine Intelligence

Fuse human & machine perceptual effort

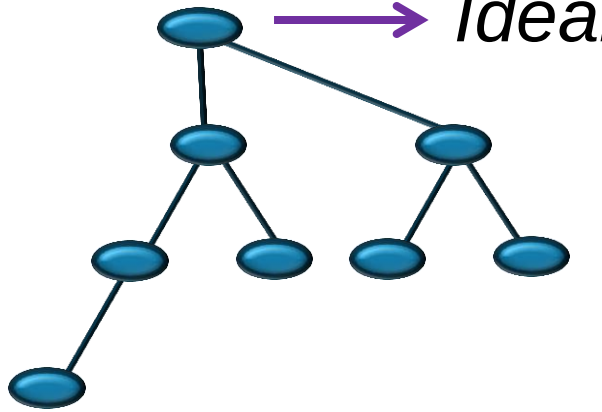
Optimize task routing & stopping



CrowdSynth & Zcion



CrowdSynth & Zcion



Ideal fusion, routing, stopping

~450 features

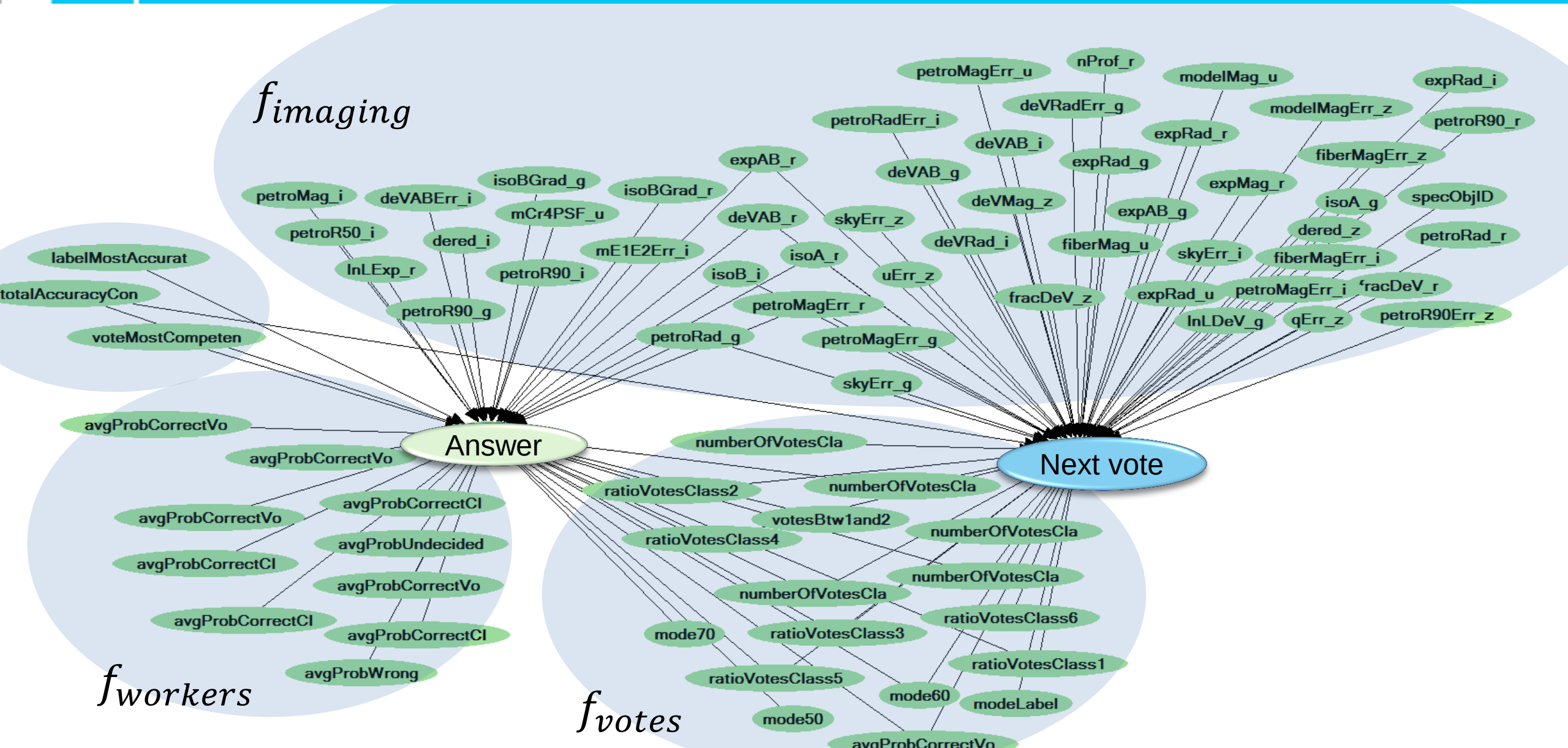
Machine perception

Human perception

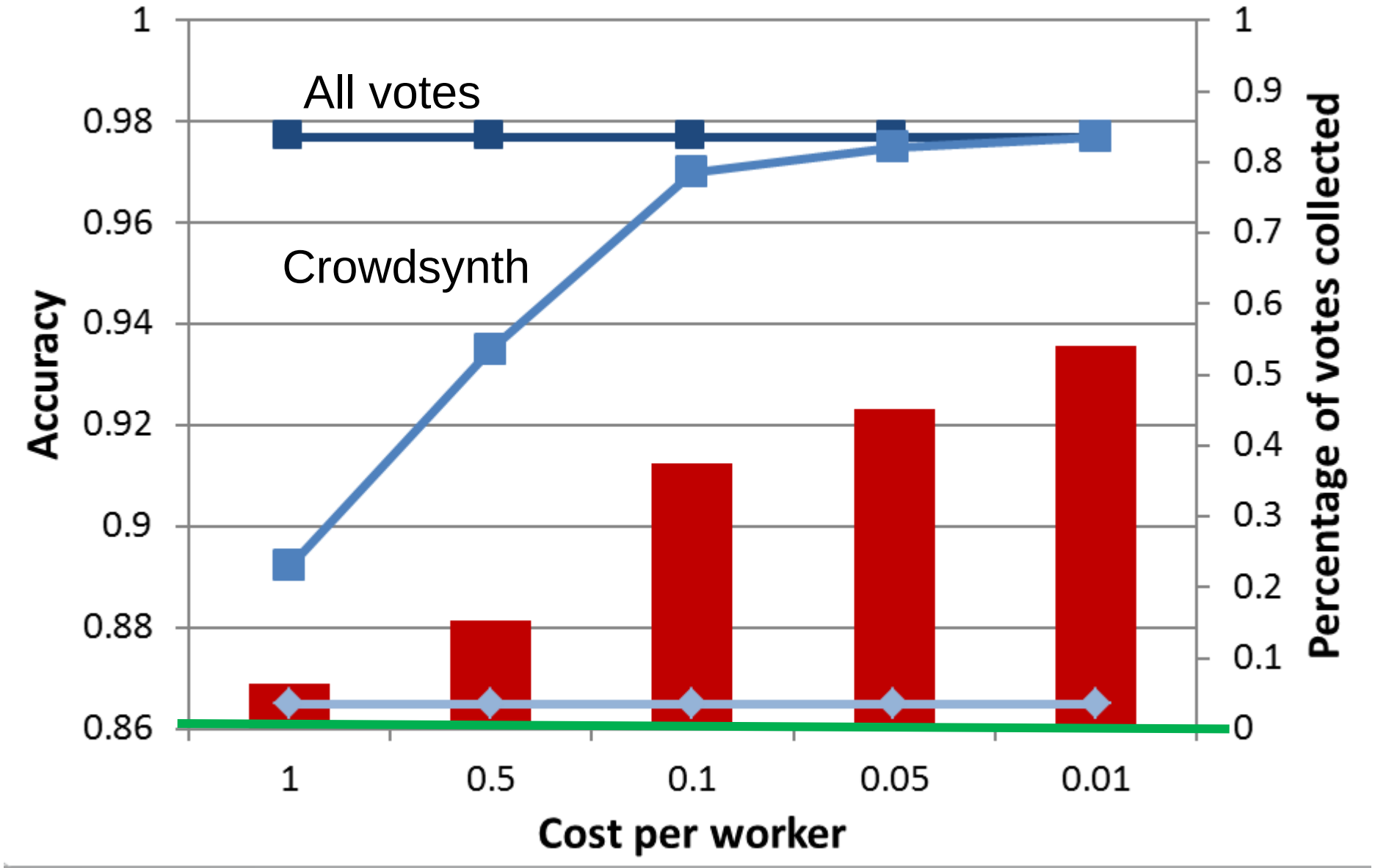
Machine learning, prediction, action

E. Kamar, S. Hacker, P. Koch, A. Smith, C. Lintott, H.

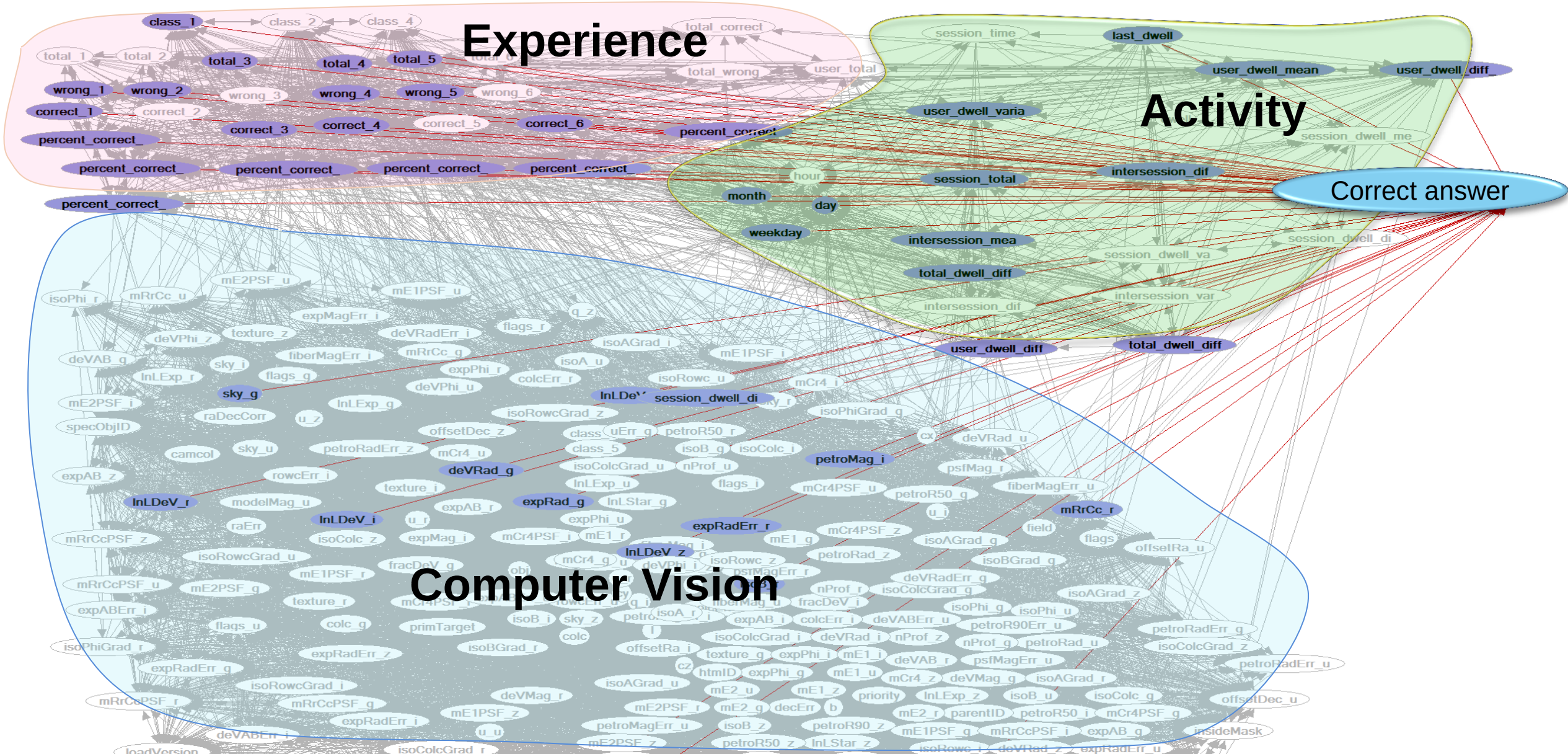
Predict Next Votes & Ground Truth



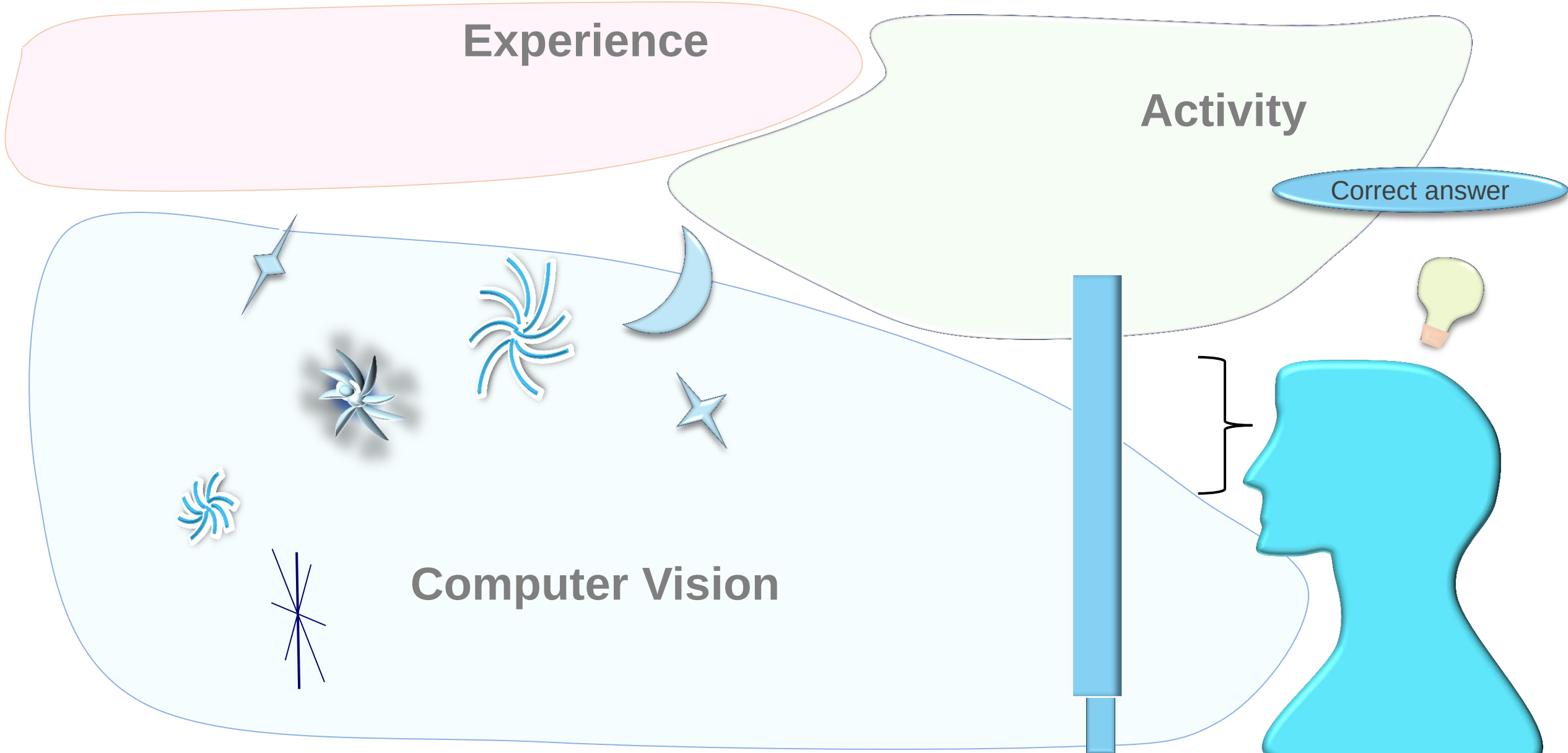
Predict Next Contributions & Ground Truth



Learn about Abilities & Engagement



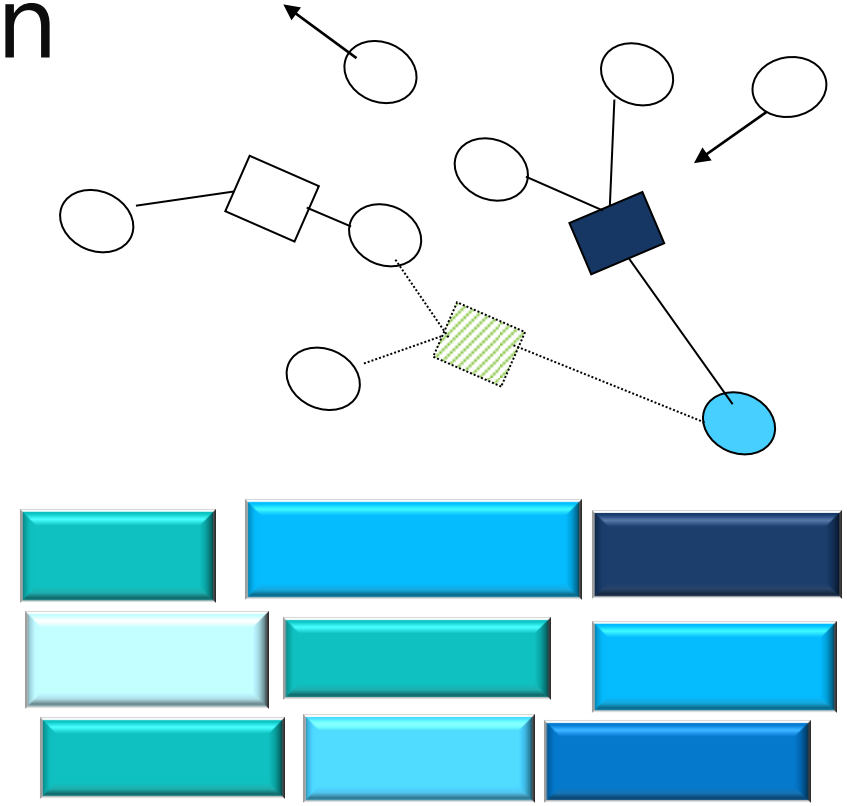
Learn about Abilities & Engagement



Dreams of Richer Machine Intelligence

Intelligence via composition

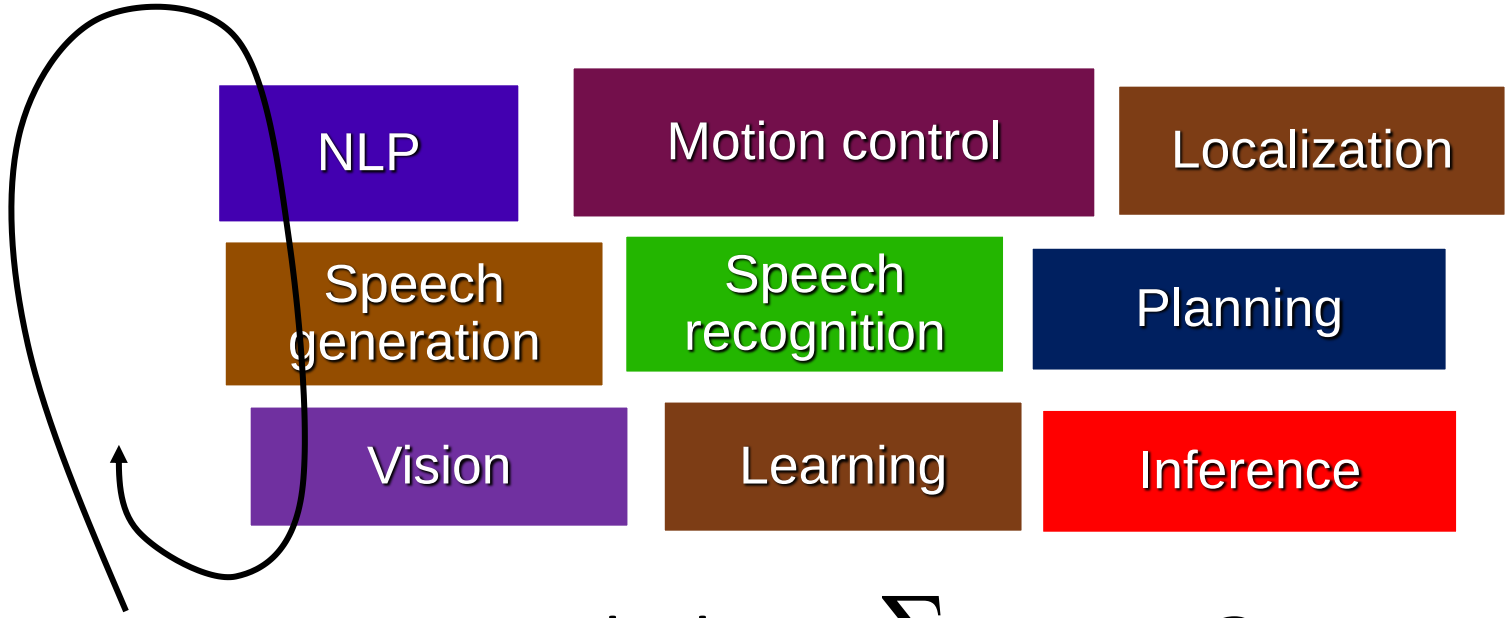
Principles of situated sensing & action



with D. Bohus, P. Choudhury, R. Hughes, E. Kamar, P. Koch, S. Rosenthal, N. Saw, A. Thompson, W. Wang

Integrative AI: Intelligence via Composition

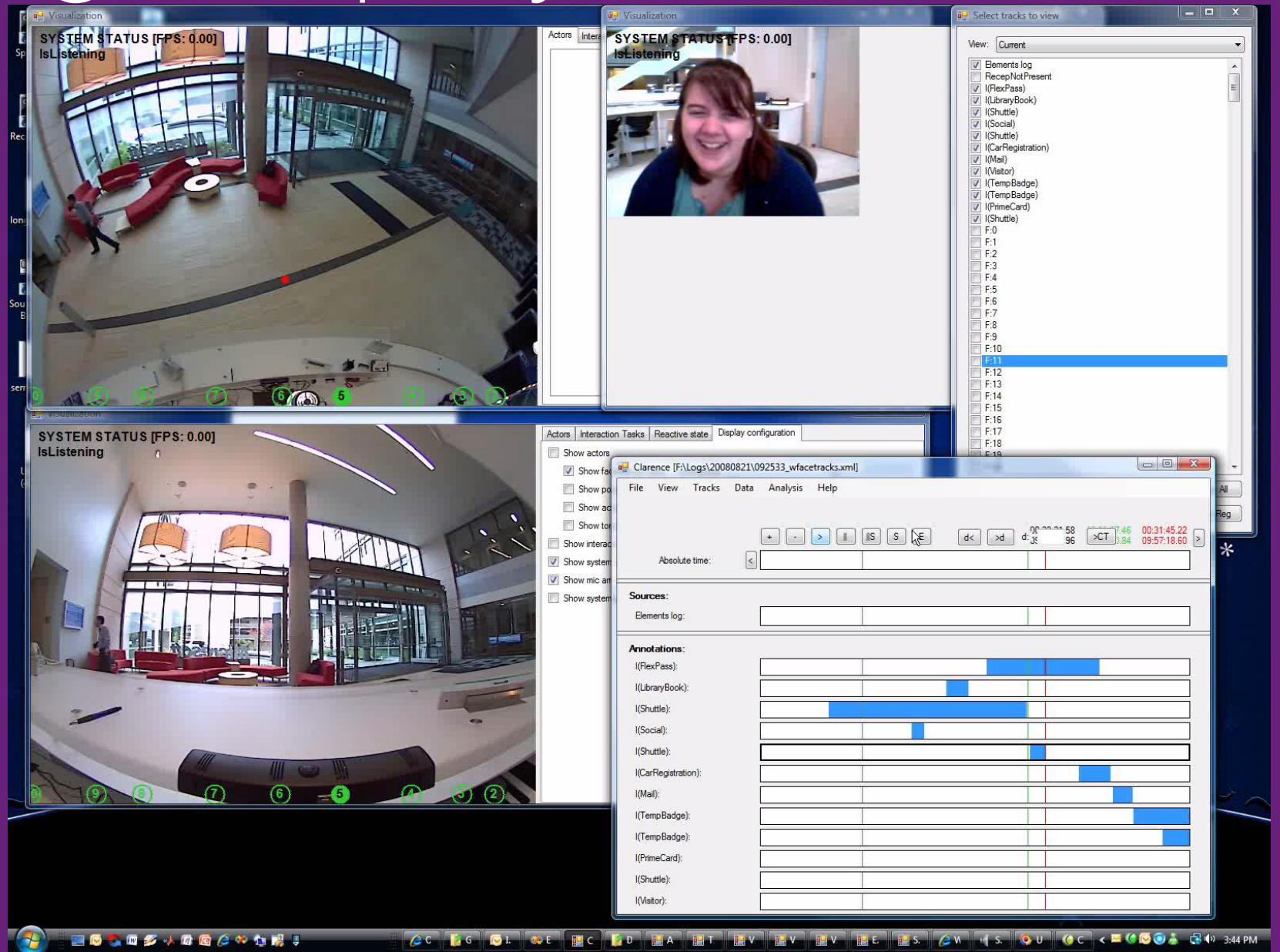
- Leveraging tapestry of components
- Understanding synergies & dependencies
- Whole more than sum?



Whole >> Σ_i part $_i$?

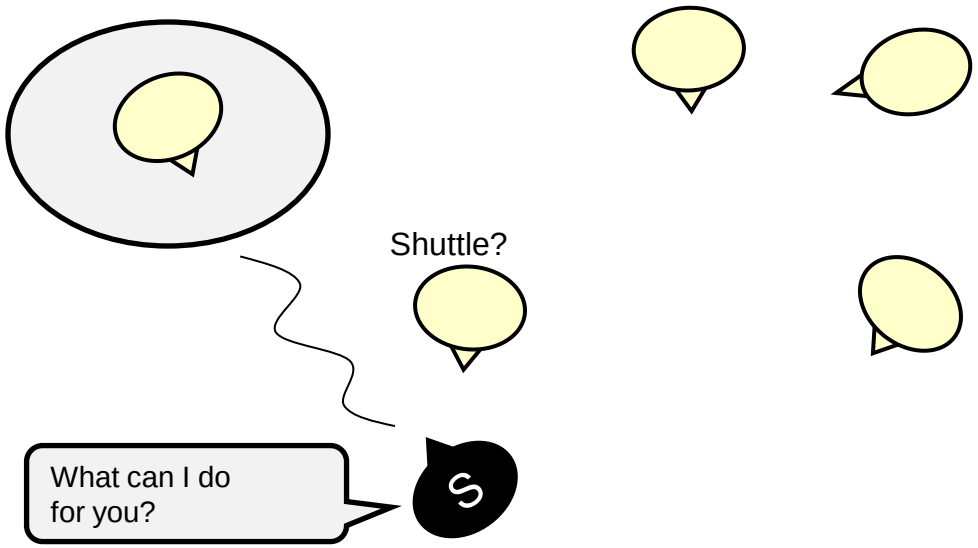
Situated Interaction Project

Studying Multiparty Situated Interaction

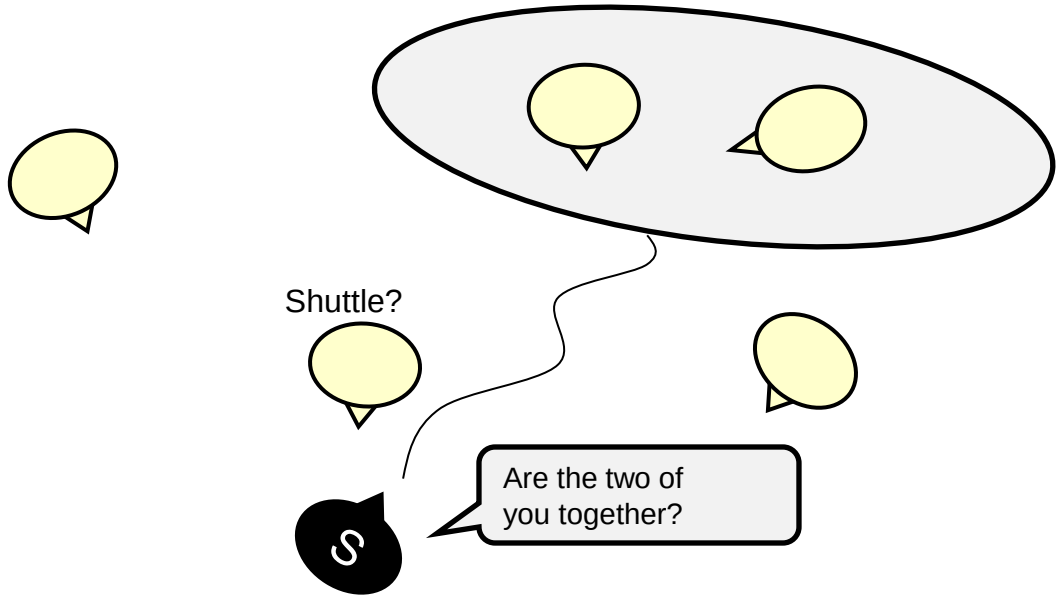


Models of Multiparty Collaboration

Models of Multiparty Collaboration



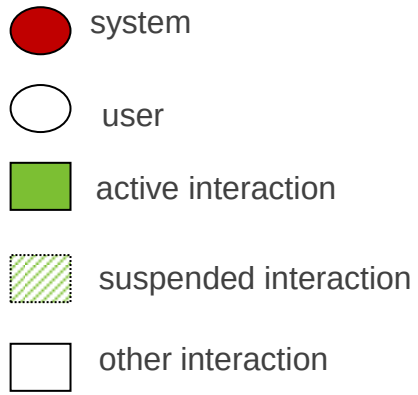
Models of Multiparty Collaboration

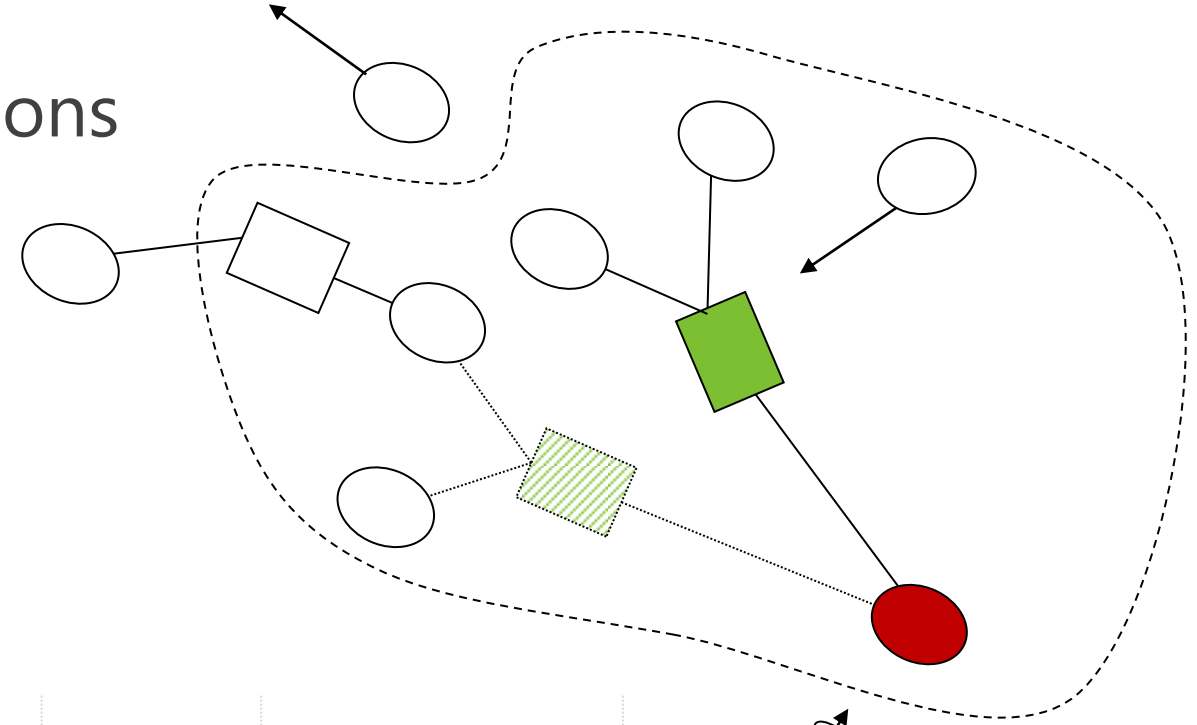


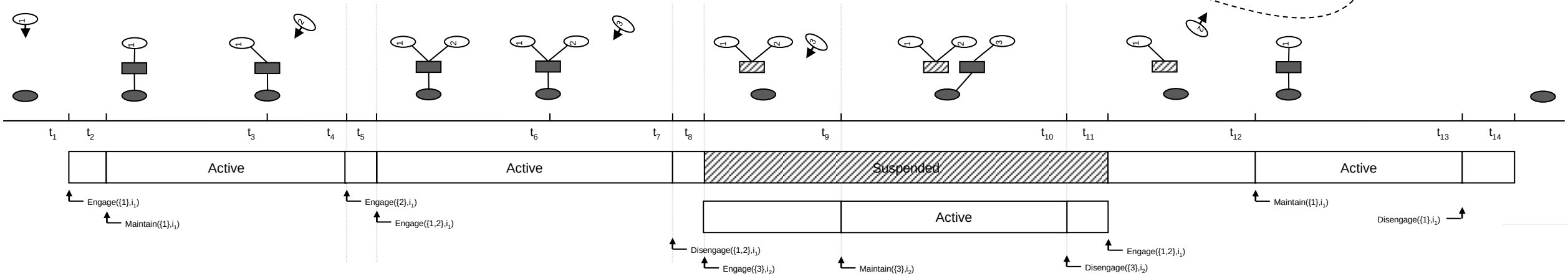
Contributions and Turns in the Open World

Track conversational dynamics

Time-critical turn-taking decisions







Composing and Exercising a Platform

wide-angle camera

4-element microphone array

touch screen

card reader

speakers

Speech Synthesis

Avatar Synthesis

Speech Recognition

Tracker

Output Management

Conversational Scene Analysis

Behavioral control

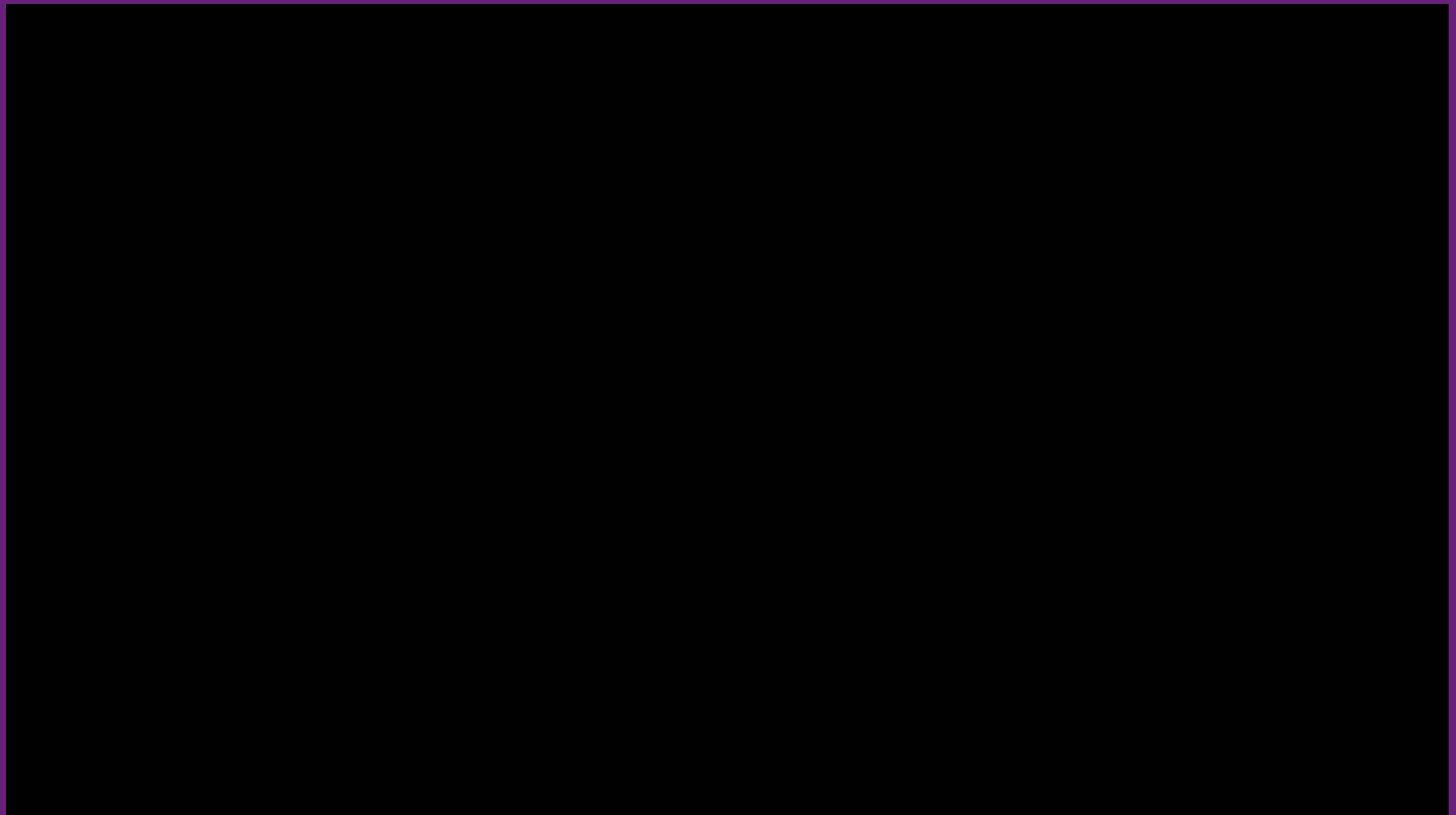
Dialog and interaction planning

Models of user frustration, task time

Machine learning about interaction

Composing and Exercising a Platform

Composing and Exercising a Platform



Multiple Experiments & Refinements

Multiple Experiments & Refinements

P: arrow indicates direction of attention

P: P has floor

P: P is the target of the floor release

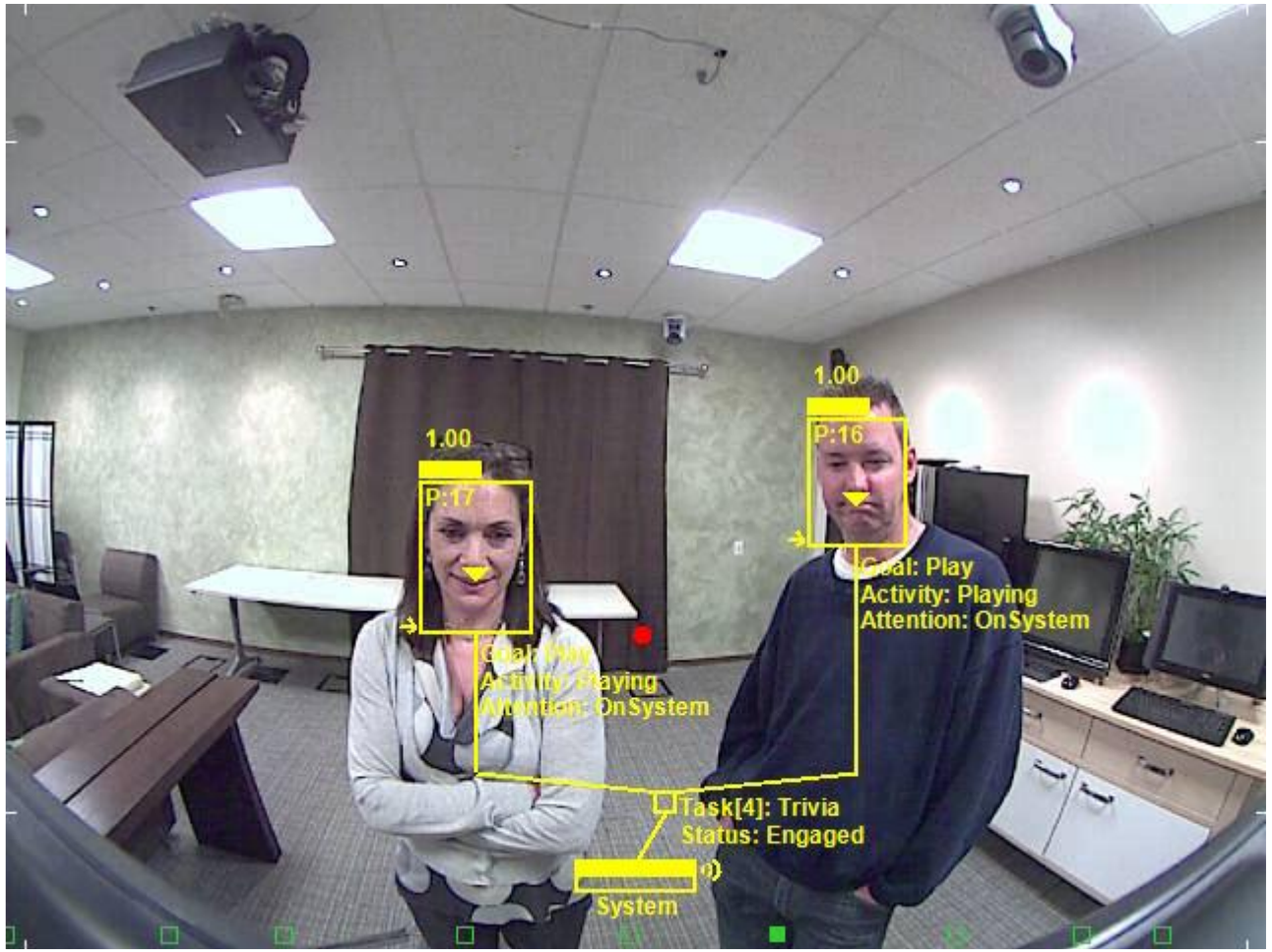
P: P is releasing the floor

P: P is trying to take the floor (performs TAKE action)

P: P is speaking

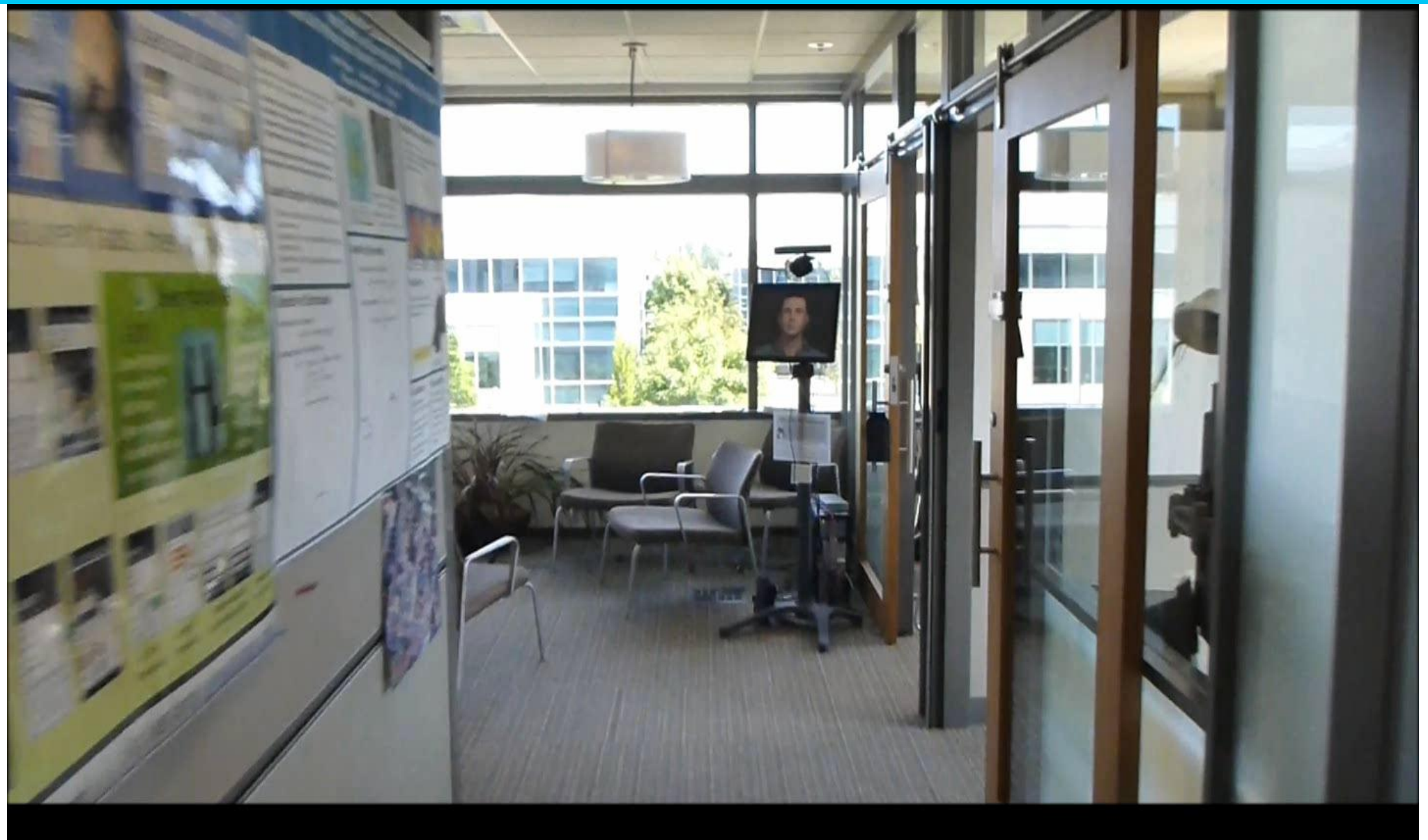
P: P is an addressee

● indicates system's gaze direction



Studies in the Wild

Current Focus: *The Assistant*



The Assistant

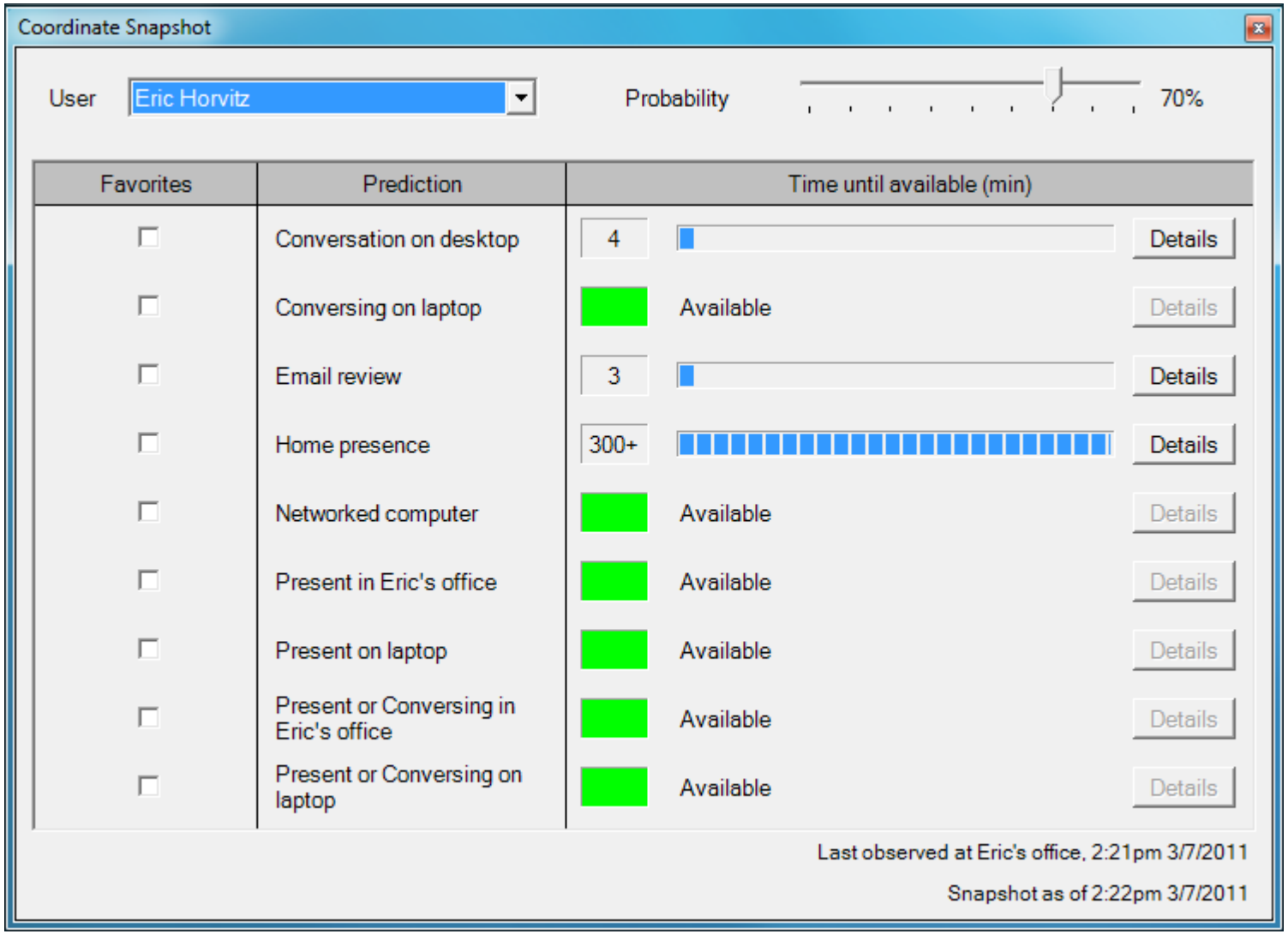
- Multiple components
  Perception, learning, reasoning

Multiparty Engagement & Dialog

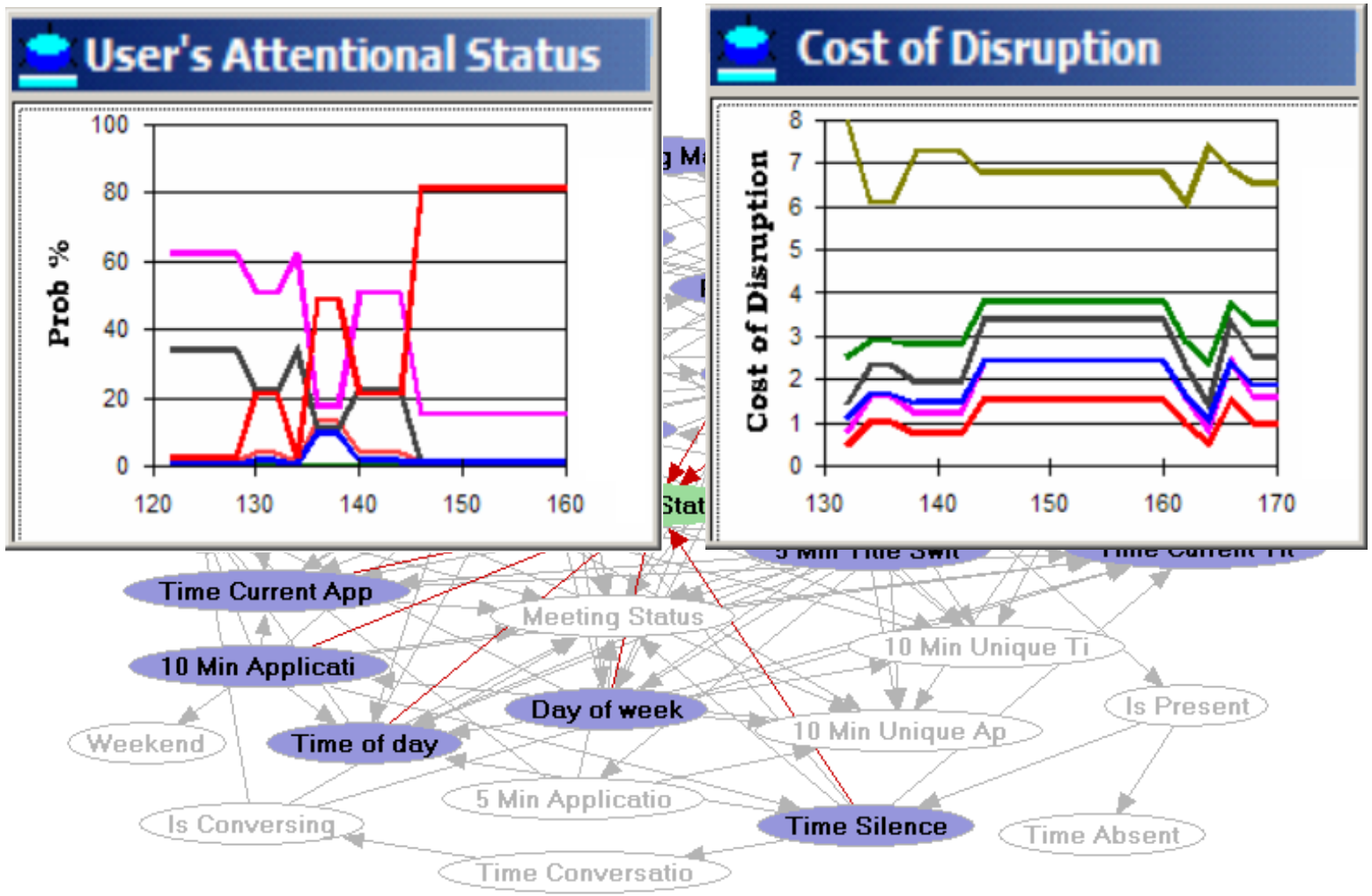
Presence & Availability Predictor

Awareness & Coordination

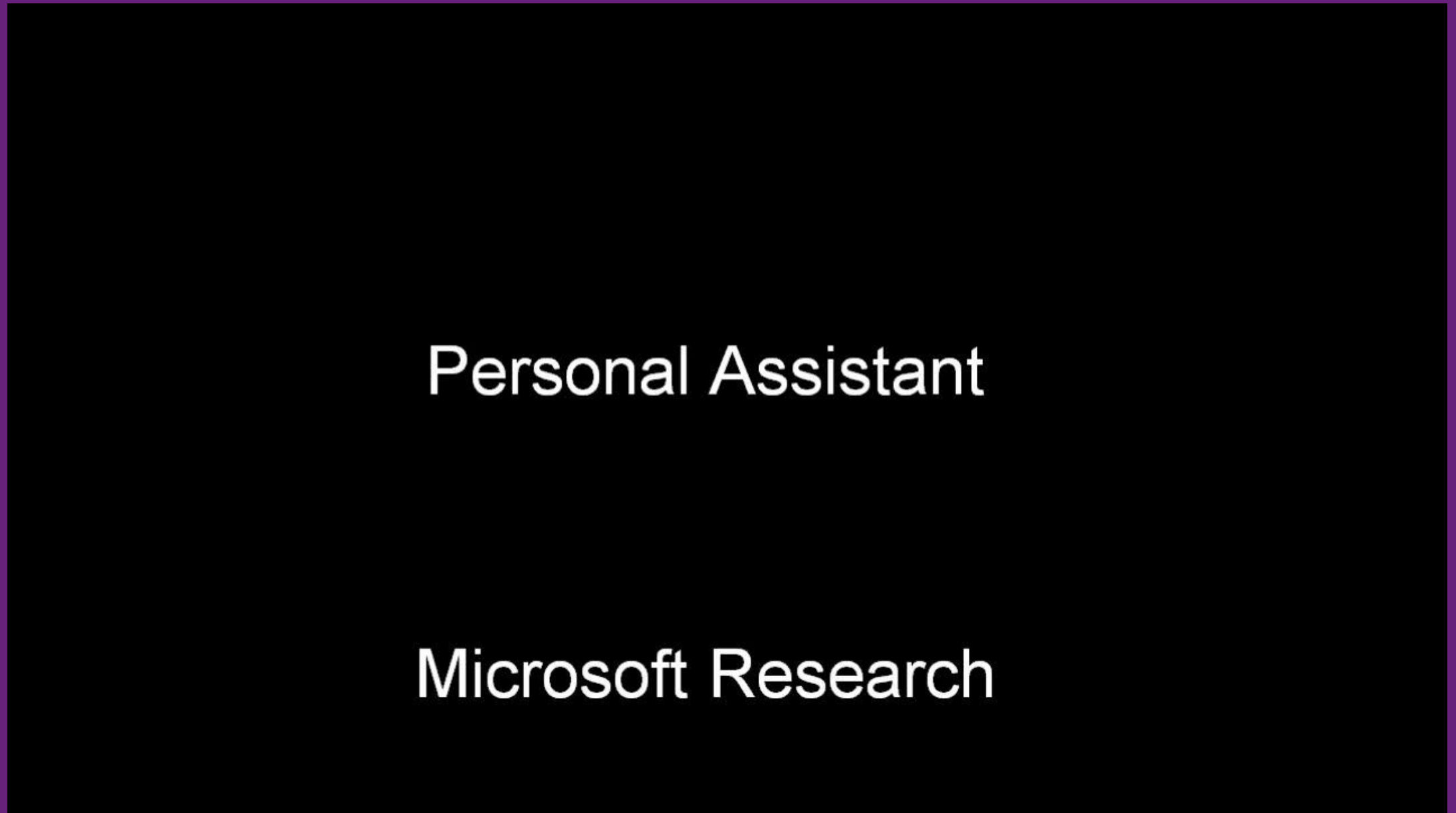
Coordinate: Presence & Availability Forecasting



BusyBody: Attention & Interruption



The Assistant

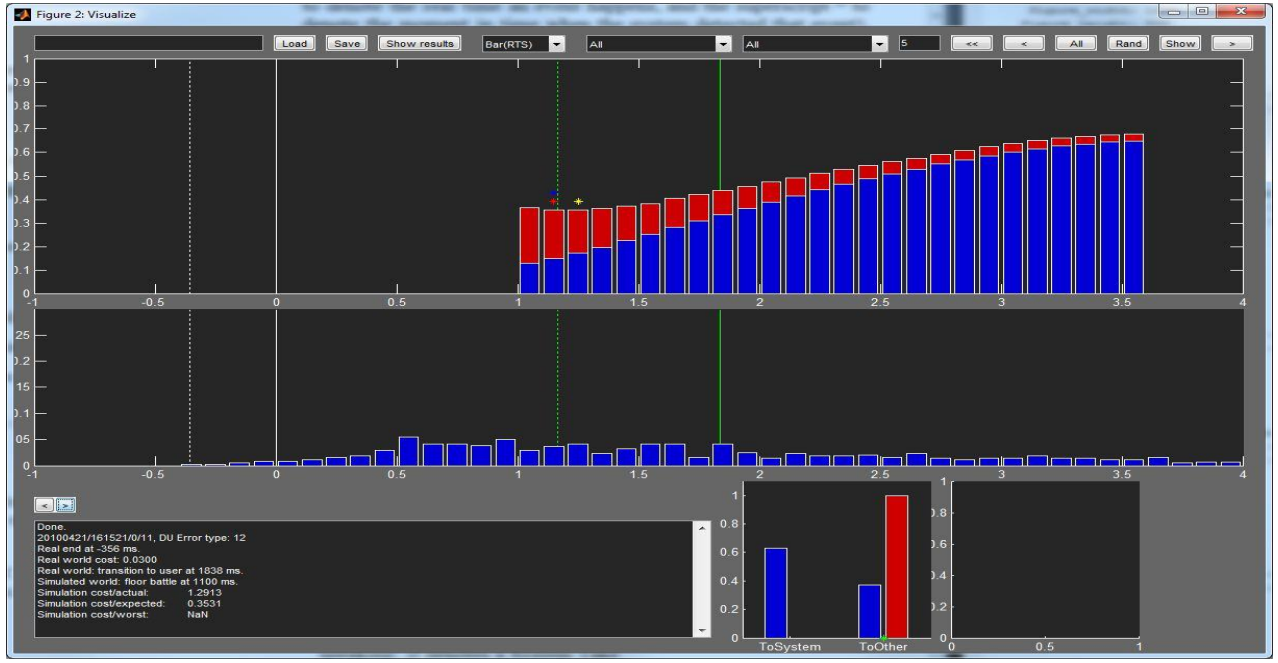


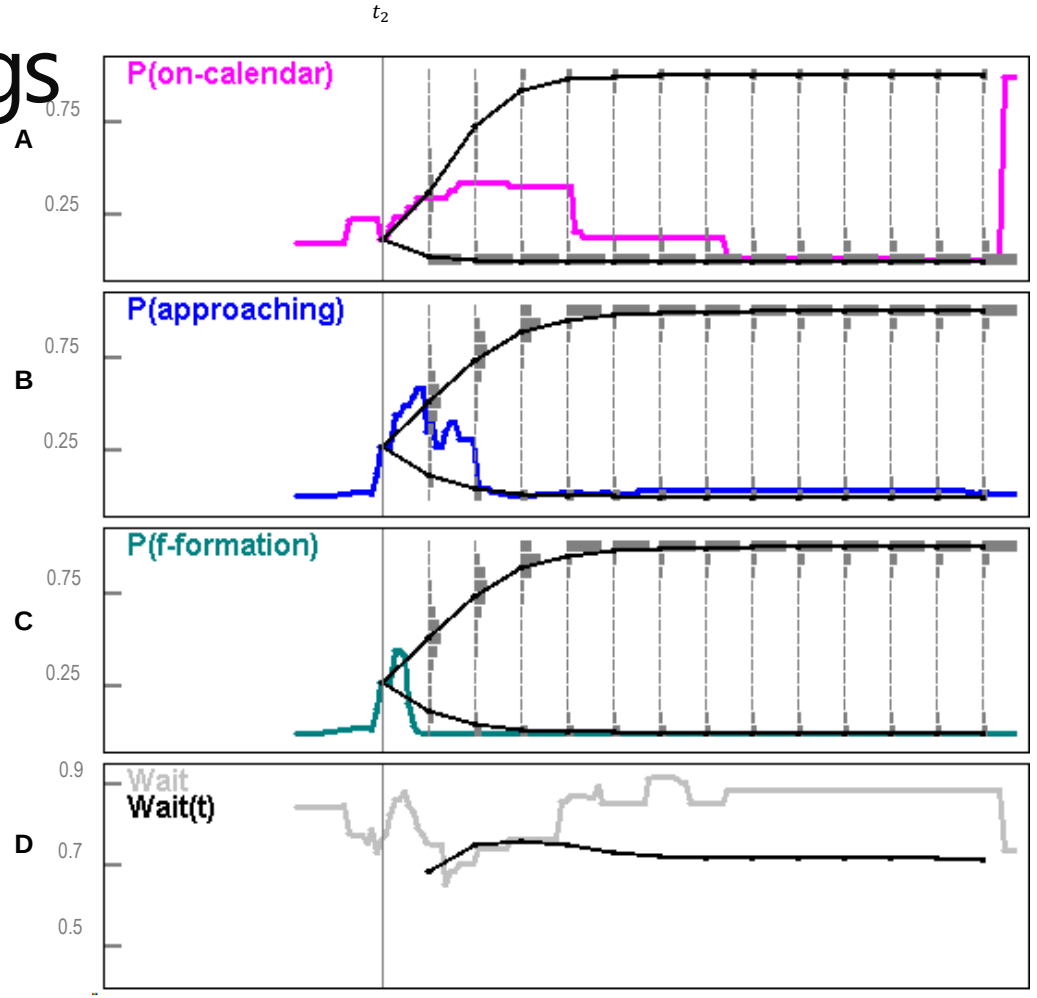
New Methods and Principles

Learning & inference from real-time streams

Information value in streaming settings

Time-critical tradeoffs





Multiple Applications of the Platform…

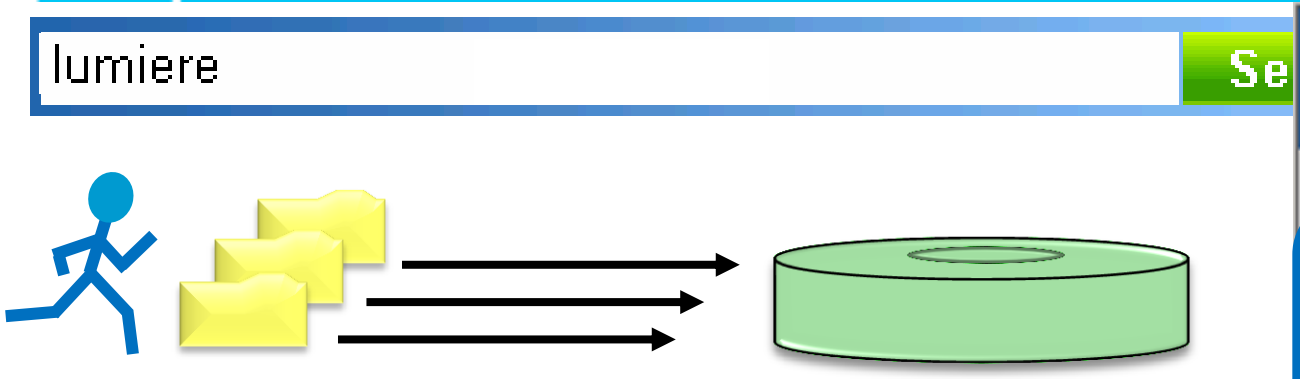
Project 3E

Privacy, Data, and Machine Learning

Urgency …and optimism

- Clarity, preferences, and handles
- Decision-theoretic mediation
- Differential privacy
- Protected sensing & personalization

Example: PSearch



With J. Teevan and S. Dumais

Example: Lifebrowser

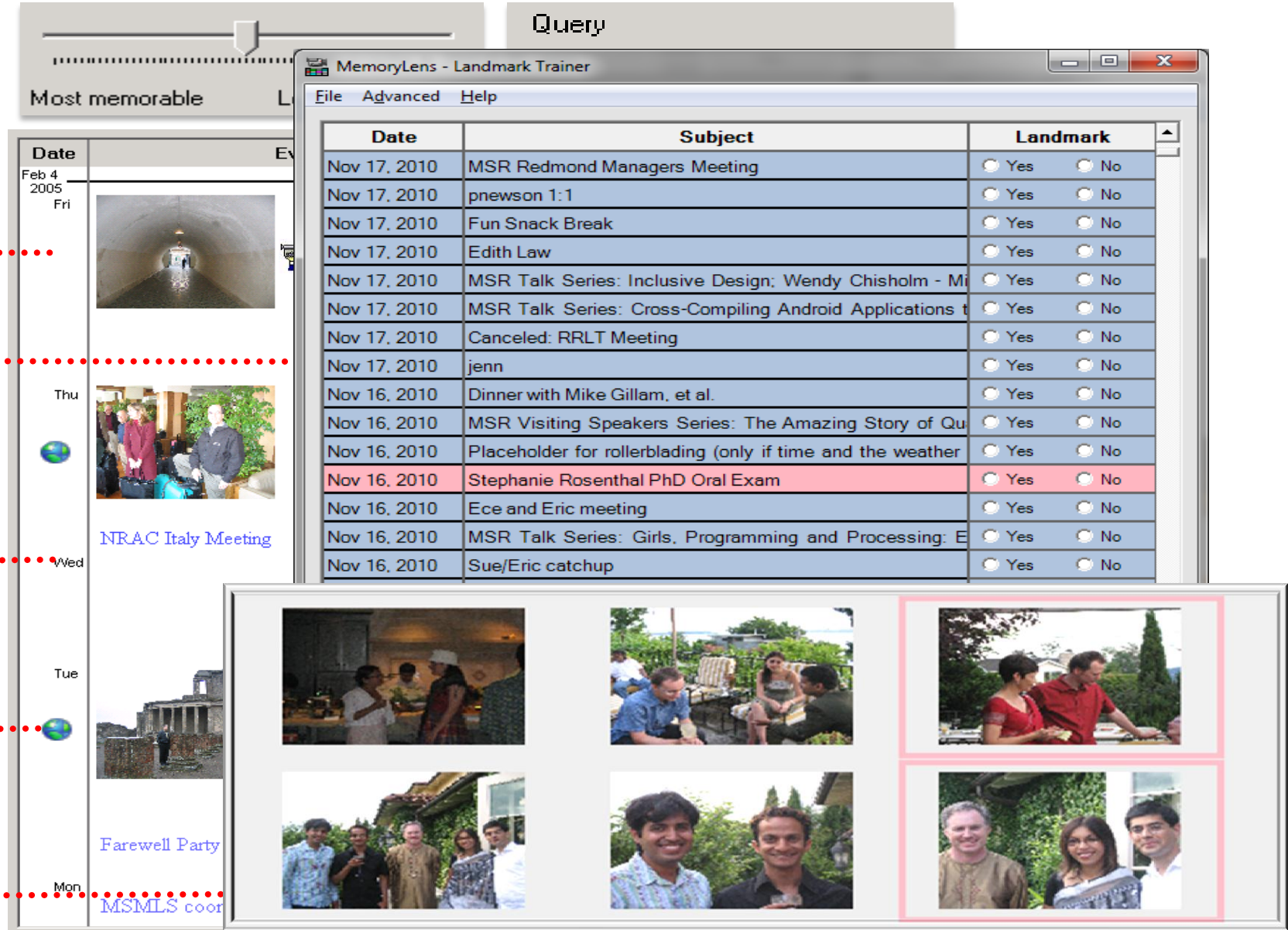
Images & videos

Desktop & search activity

Appts & events

Locations

Whiteboard capture



Summary

- Applications of sensing, learning, and reasoning still in infancy
- Studies and themes
- Unprecedented value to people and society
- Principles → Applications → Principles …

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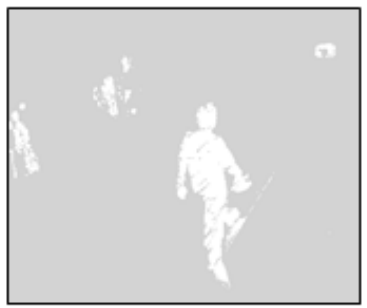
3rd Generation Elevator

Captain Kirk never had to push a button to order an elevator on Star Trek—nor did he have to wave his arm or leg to keep the turbolifter door open if Spock was racing to get on. Elevators that require people to push a button to summon them, or to jam their hands and legs into closing doors to say, "Don't close them just yet!" are remnants of the 20th Century. We're testing out Project 3E (*3rd Generation Elevator*) in the lobby of Building 99. 3E is a cross-group effort at Microsoft Research, exploring the use of machine learning and perception to make automated doors more intelligent and elegant via intention recognition.

Video is recorded for research purposes by two cameras near the elevators, but stored images are modified so that people are not recognizable – see image to the right. No audio is recorded.



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