Shaping the New Human-Technology Frontier
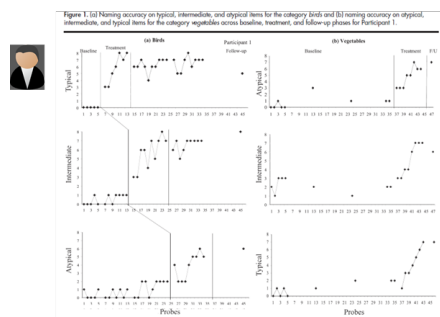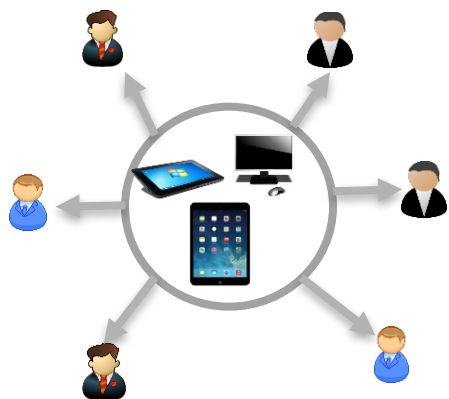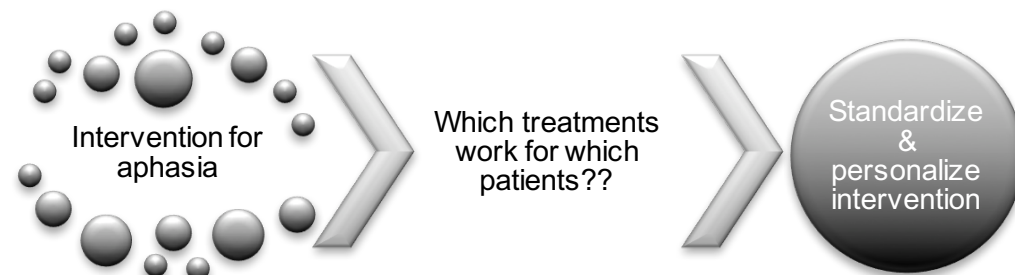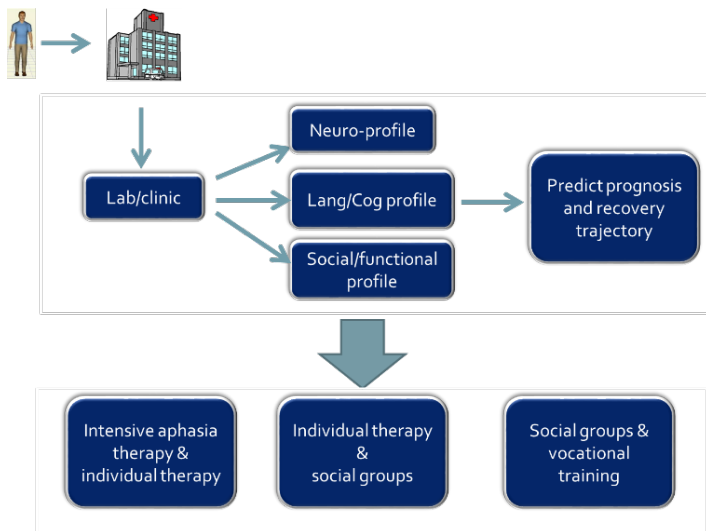
November 15, 2016

Boston University Office of the Vice President and Associate Provost for Research

Swathi Kiran

Professor
Speech, Language & Hearing Sciences
SAR

BOSTON UNIVERSITY

Neuro-profile

Lab/clinic

Lang/Cog profile

Social/functional profile

Predict prognosis and recovery trajectory

Intensive aphasia therapy & individual therapy

Individual therapy & social groups

Social groups & vocational training

Intervention for aphasia

Which treatments work for which patients??

Standardize & personalize intervention

Population analysis

Figure 1. (a) Naming accuracy on typical, intermediate, and atypical items for the category birds and (b) naming accuracy on atypical, intermediate, and typical items for the category vegetables across baseline, treatment, and follow-up phase for Participant 1.

Individual patient analysis

Small cohort analysis

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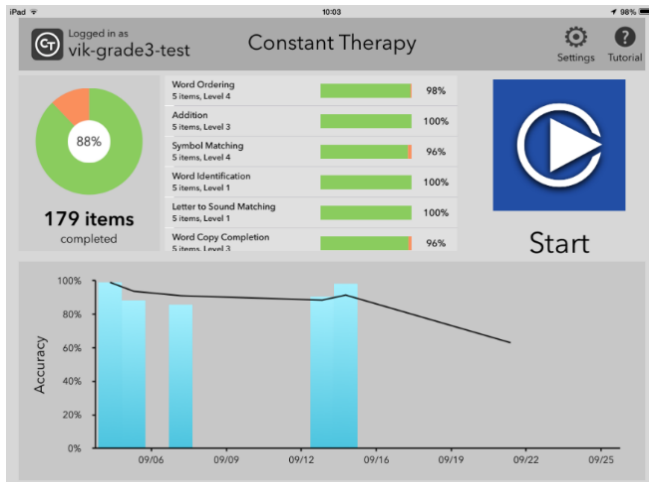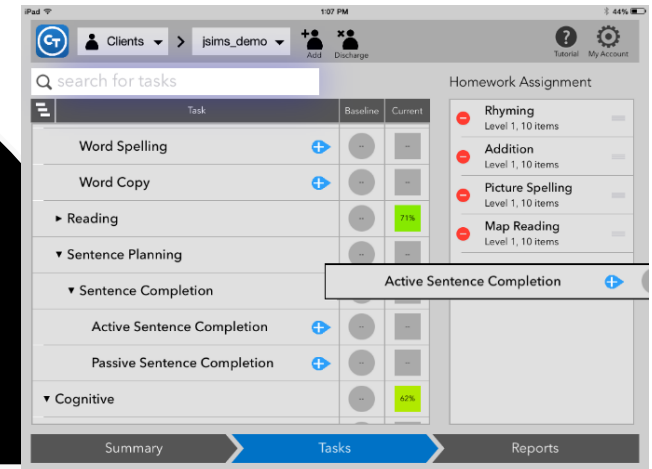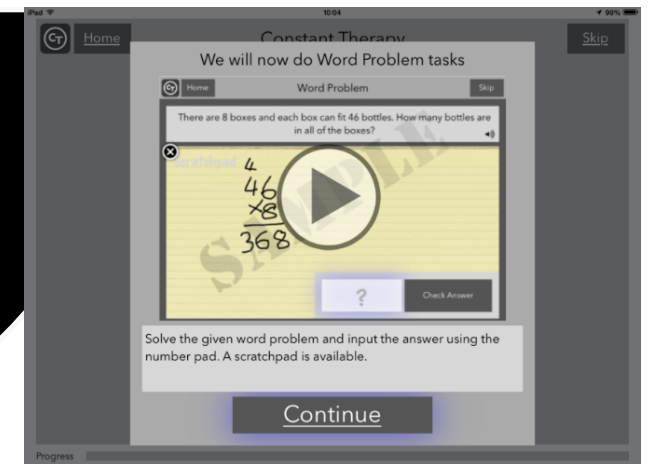
Clinician signs up for constant therapy and enrolls patients
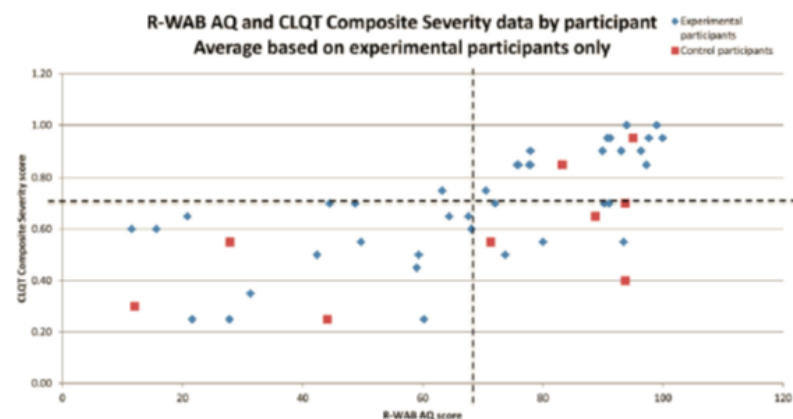
Patients are assigned specific therapy tasks

Clinician Analyzes Data on usage and performance

Patient completes CT program

- 51 patients with stroke or TBI
- 42 experimental patients and 9 control patients
- Both groups matched for WAB AQ, CLQT composite severity and age
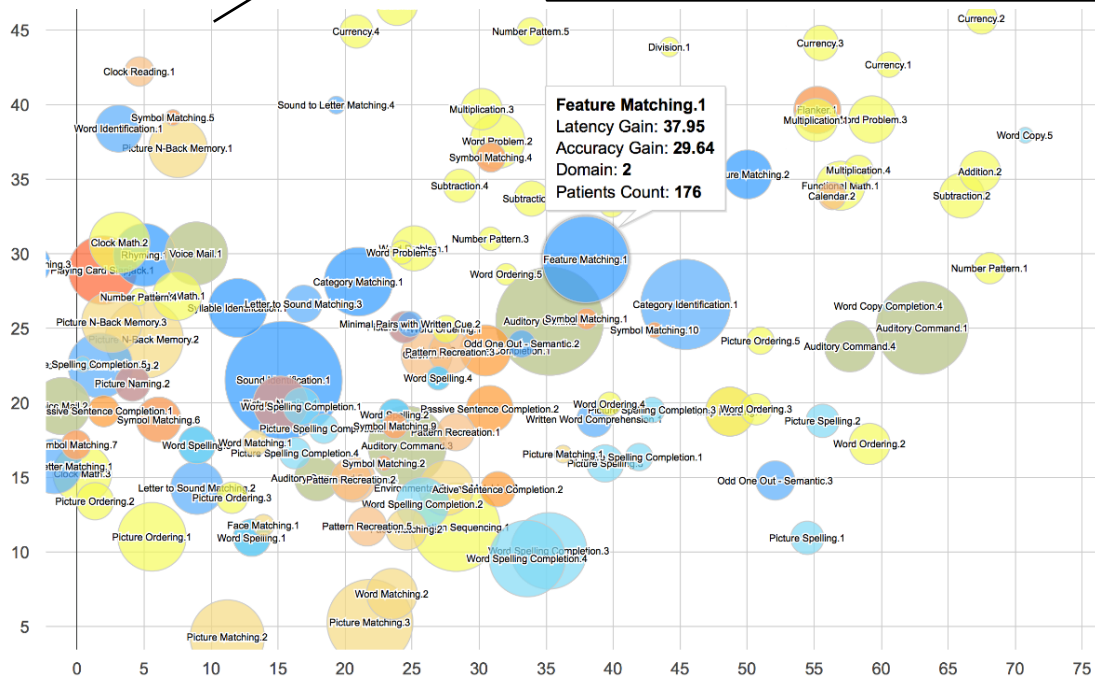- Both groups practiced Constant Therapy on their iPads.

FIGURE 2 | Scatter plot of low vs. high deficits in R-WAB AQ (x-axis) and CLQT Composite Severity (y-axis) by patient. The dotted lines denote the average R-WAB AQ and average CLQT Composite Severity score for experimental participants to provide more information for Table 3B.
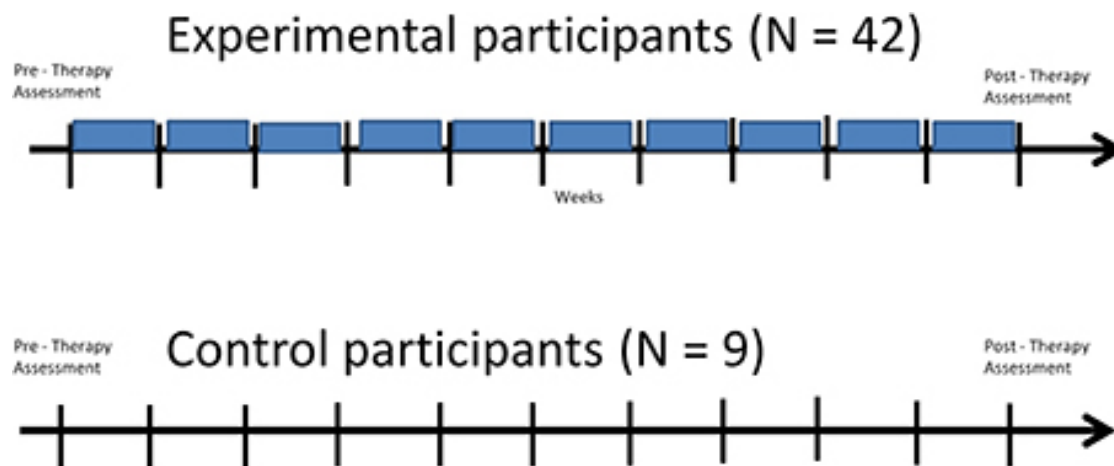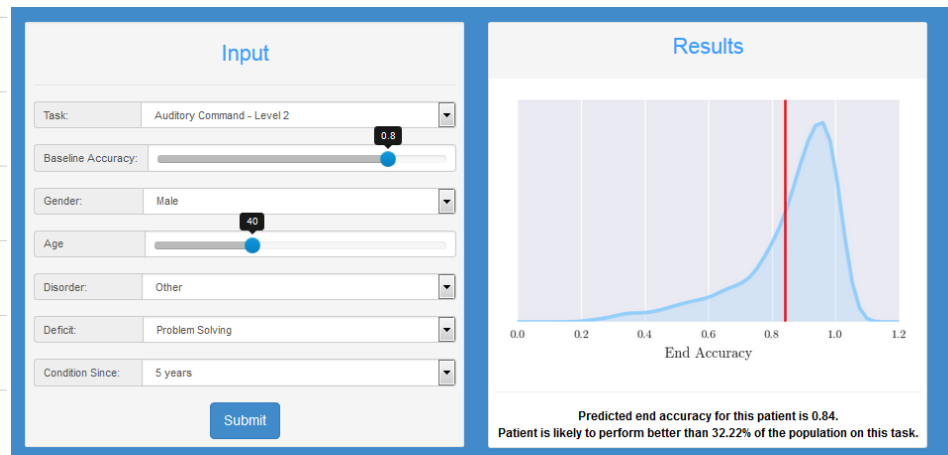
1. Therapy can be standardized and individualized. This approach shows both less severe and more severe patients improve

2. For each patient, starting severity across language and cognitive domains provides a useful indicator to examine outcomes
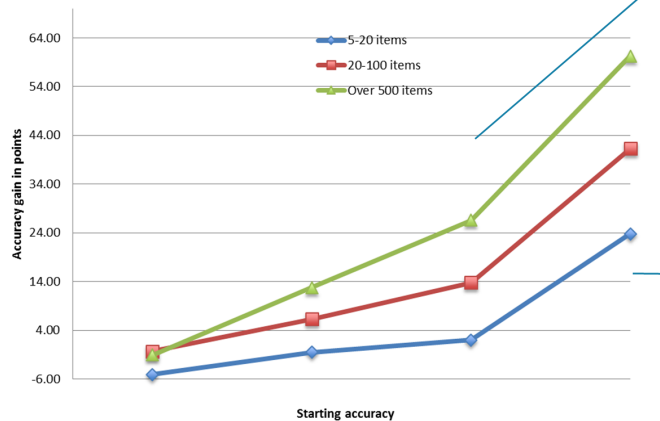
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Example: Gains for Stroke Patients with Moderate Impairments

Predict treatment outcomes

Feature Matching.1
Latency Gain: 37.95
Accuracy Gain: 29.64
Domain: 2
Patients Count: 176

Input

Task:	Auditory Command - Level 2
Baseline Accuracy:	0.8
Gender:	Male
Age:	40
Disorder:	Other
Deficit:	Problem Solving
Condition Since:	5 years

Submit

Results

End Accuracy

Predicted end accuracy for this patient is 0.84.
Patient is likely to perform better than 32.22% of the population on this task.

Input

Task:	Auditory Command - Level 2
Baseline Accuracy:	0.2
Gender:	Male
Age:	40
Disorder:	Other
Deficit:	Problem Solving
Condition Since:	5 years

Submit

Results

End Accuracy

Predicted end accuracy for this patient is 0.49.
Patient is likely to perform better than 4.01% of the population on this task.

Average Gains in Accuracy

- 5-20 items
- 20-100 items
- Over 500 items
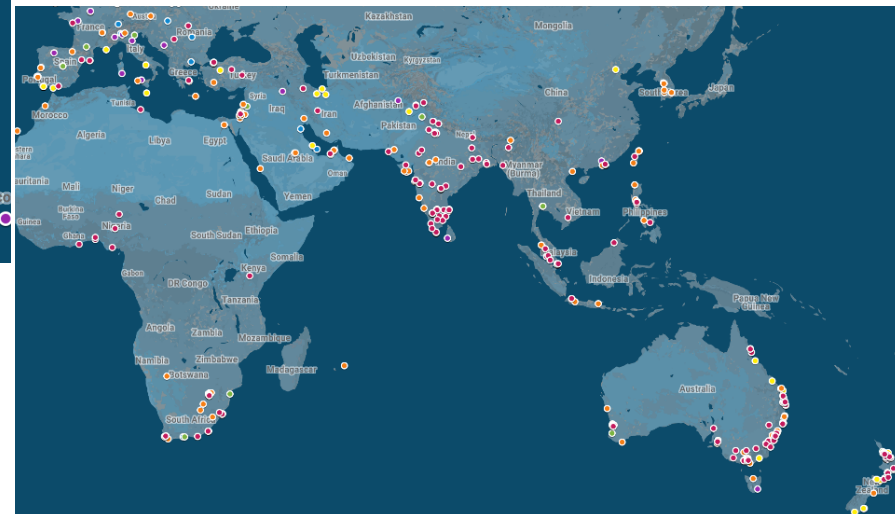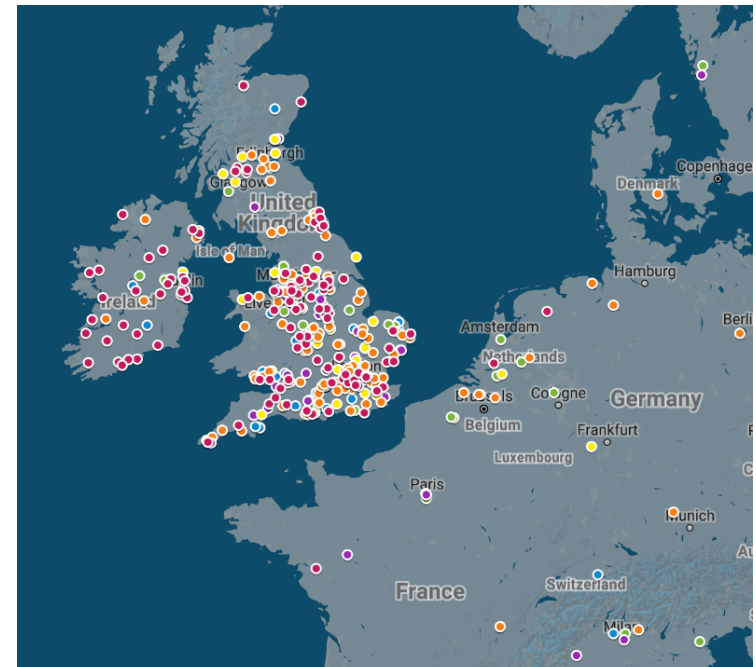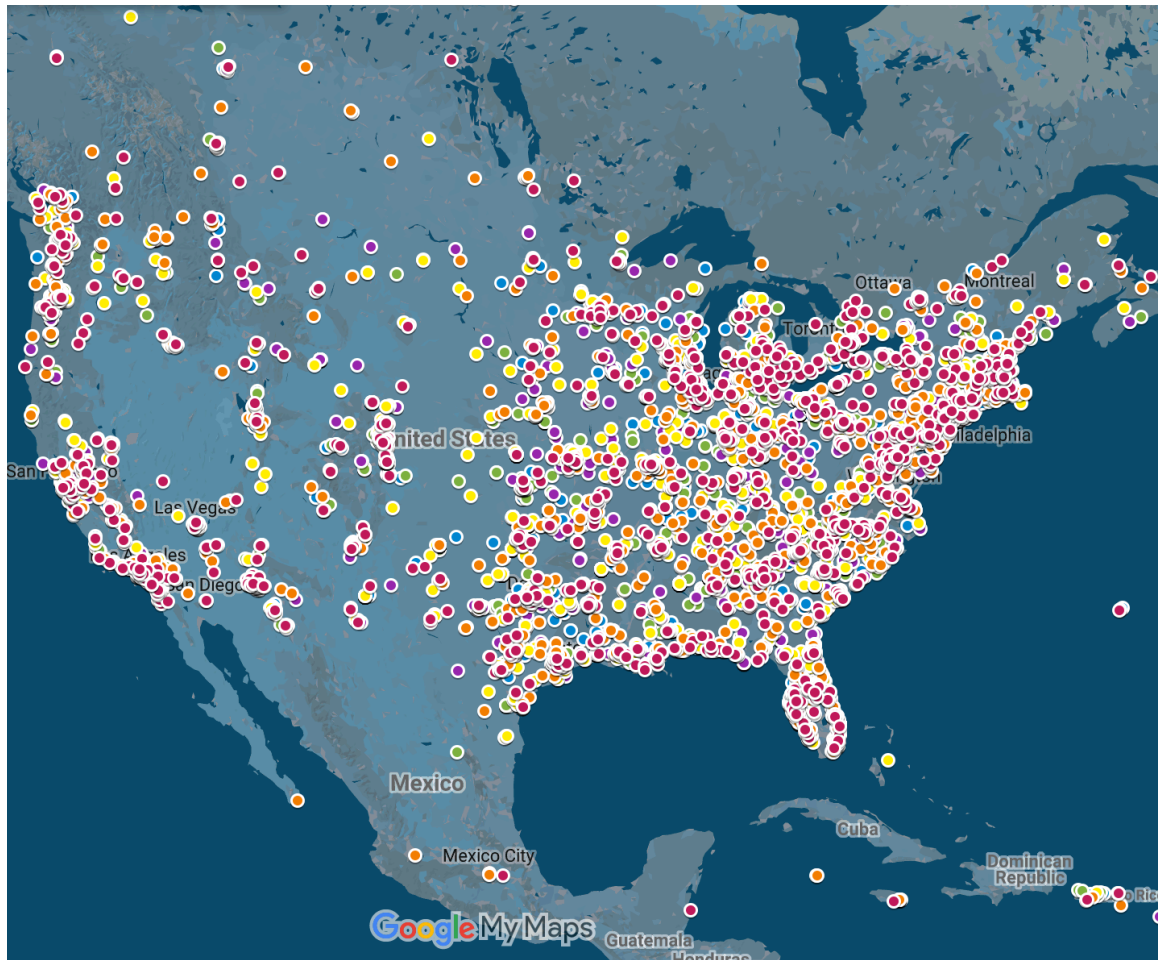
Accuracy gain in points

Starting accuracy

With more practice, greater than 500 items, improvements are between 30-50 points for more severe patients

With less practice, less than 20 items, improvements are between 10-30 points for more severe patients, less for less severe patients

Where it is being used today-

# Dynamic Adjustment of Physical Exercises Based on Performance Using the Proficio Robotic Arm

Margrit Betke

Professor
Computer Science
CAS

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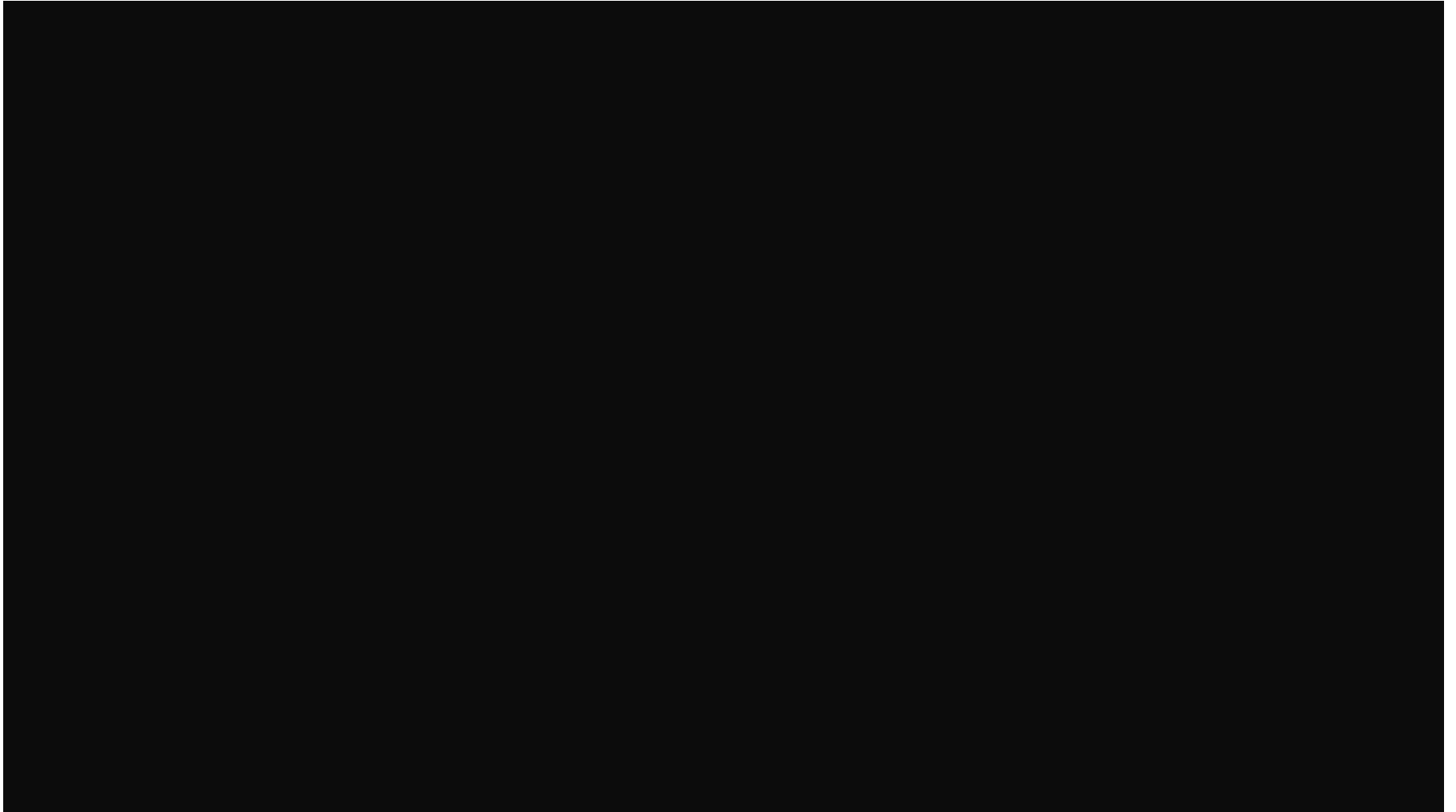
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Proficio Robotic Arm

- Quantitatively measuring the performance of the user
- Recommending adjustments to the difficulty level of exercise based on the results of performance measurements
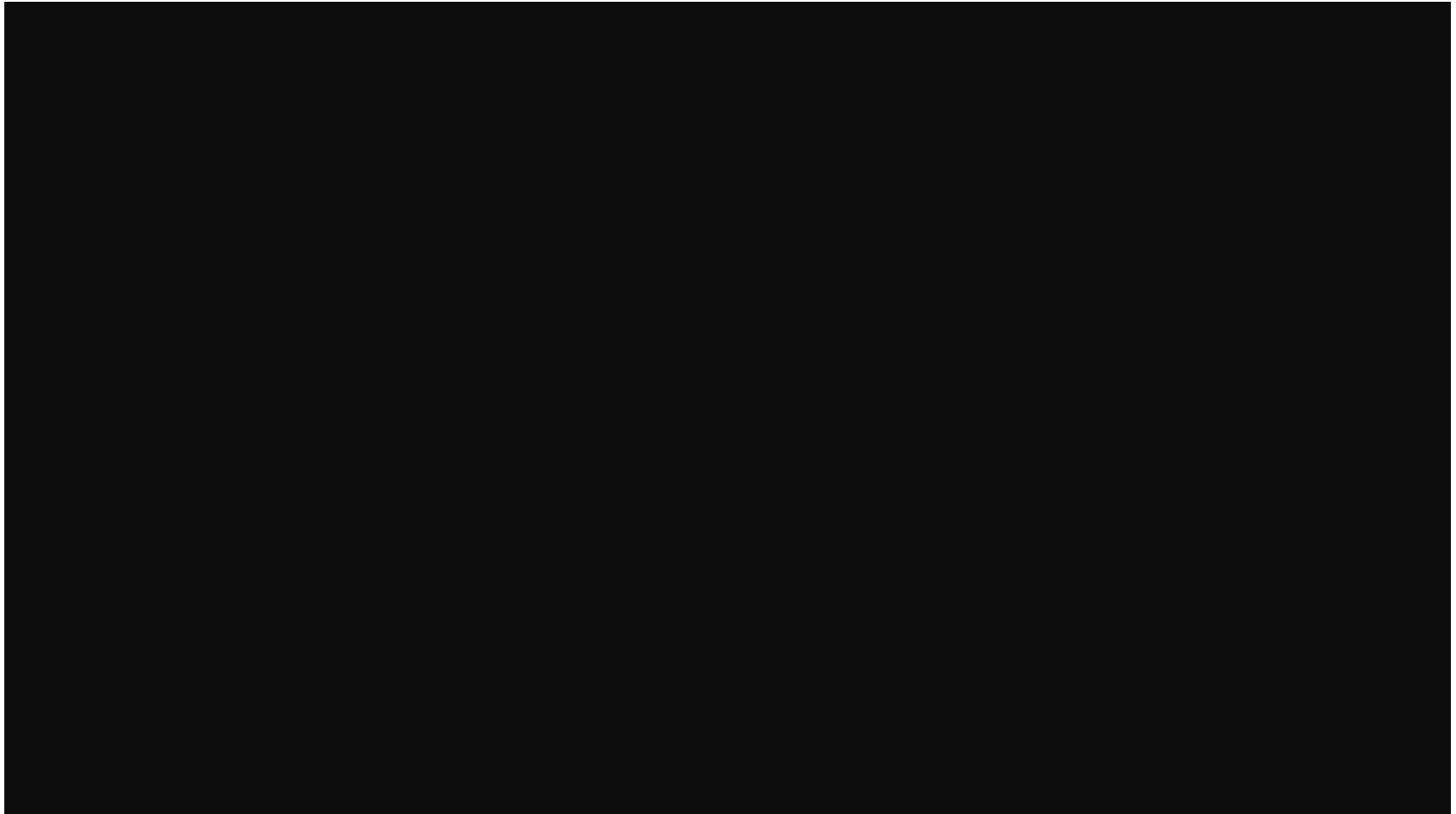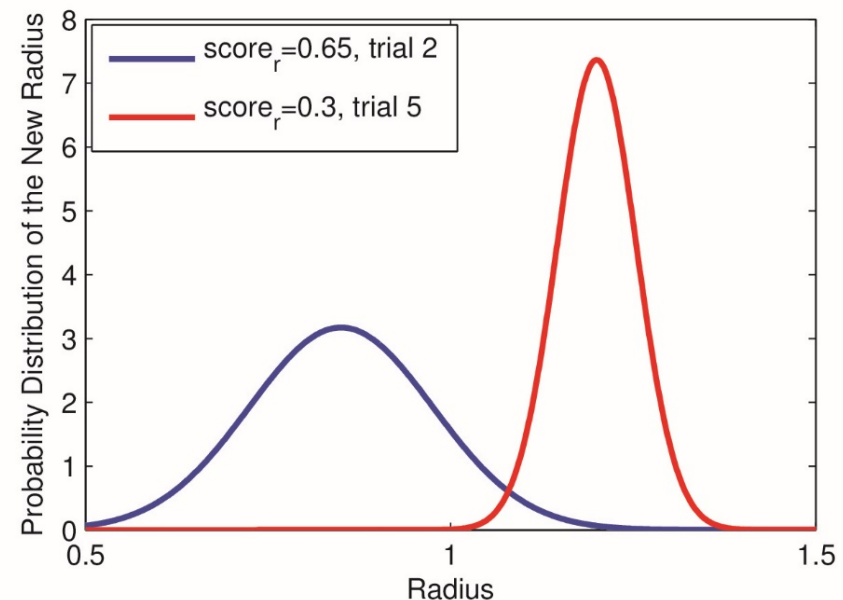
Performance Measurements:
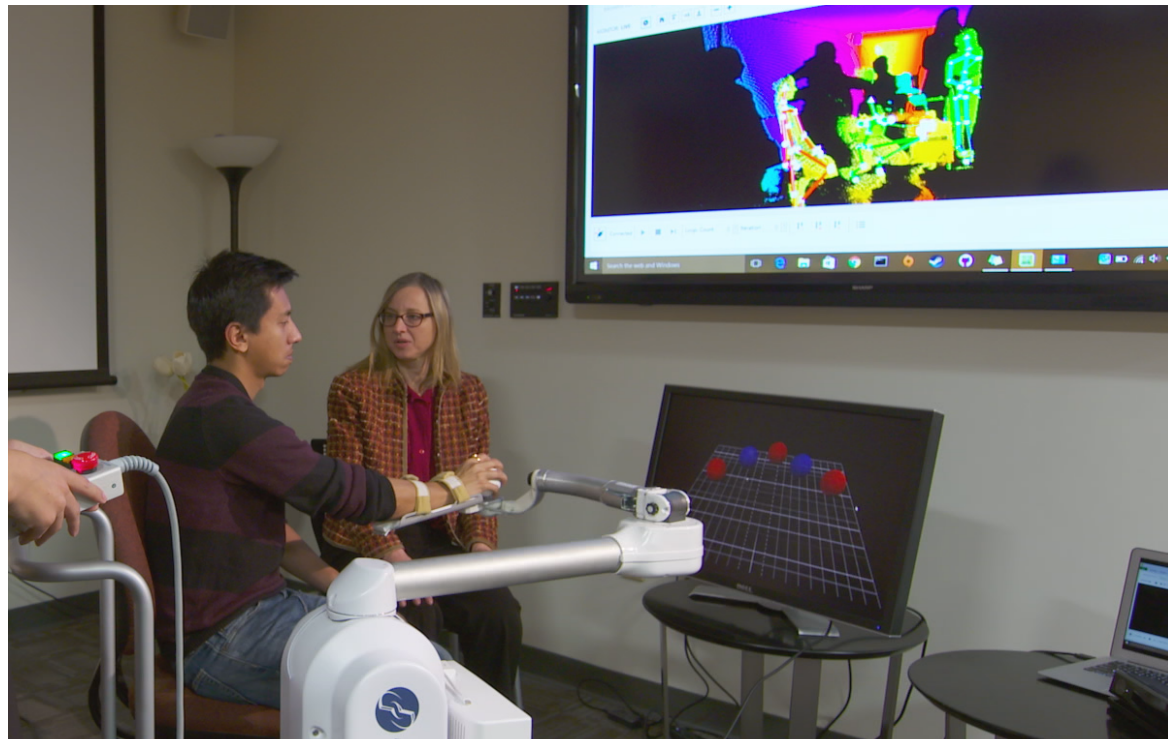
- Dynamic Time Warping
- Smoothness
- Speed

Fitness Function

- ➢ Normal Distribution ⟹ Stochastic Component
- ➢ Biased by performance scores
- ➢ Variance ⟹ Number of trials

The Proficio Versus The Kinect: Measuring Hand Position During Exercise Monitoring

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Ed Damiano

Professor
Biomedical Engineering
ENG

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the iLet™

A fully integrated, fully automated, bionic pancreas for diabetes management.

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the iLet™

A fully integrated, fully automated, bionic pancreas for diabetes management.

Boston University Office of the Vice President and Associate Provost for Research

the iLet™

A fully integrated, fully automated, bionic pancreas for diabetes management.

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Is i2b2 for you?
Monitoring and Evaluation of Urban Health Outcomes using Open-Source Population Health Software

Christopher W. Shanahan, MD, MPH

Assistant Professor, Medicine
Key Personel, BU-CTSI Clinical Research Informatics
Faculty Lead, Research Networking Group
Boston University School of Medicine/Boston Medical Center
chshanaha@bu.edu

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The "EcoSystem"

- BMC is the largest safety net provider in New England
- Nearly all CHCs are FQHCs
- EHR-based care
  - BMC since 1999
  - CHCs since 2003

Massachusetts Health Disparities Repository (MHDR)

Clinical Data

Data:
- Demographic
- Insurances
- Services
- Medications
- Problems
- Labs
- Clinical Observations

Sites:
- Boston Medical Center
- Dorchester House MSC
- Codman Square HC
- Healthcare for the Homeless
- Greater Roslindale MDC
- Whittier Street HC
- Mattapan CHC
- South End CHC
- South Boston CHC
- Uphams Corner CHC

Staging Area

Functions:
- MPI linkage
- Data cleaning
- Standardization
(LOINC, CPT, RxNorm, ICD9, SNOMED CT)

i2b2

Database
- People (1.4+ mil)
- Facts (1+ billion)
- Concepts

Tools
- Query Cell
- HOME Cell

BMC-i2b2
- BMC only
- Web accessible
- Aggregate data
- No additional IRB

MHDR
- BMC + CHCs
- RDP access (with SAS, STATA)
- HOME Cell and data extracts
- IRB approval required
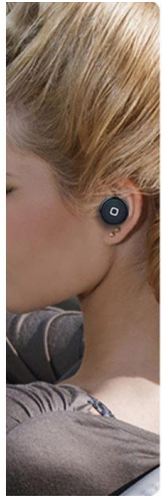
Catchment Area for the MHDR, 2005-2011

	87 to 599
	609 to 1,340
	1,350 to 2,236
	2,253 to 3,225
	3,226 to 6,466

Note: This map shows the number of people, by census tract of residence (2008-2011), who had at least one visit to an MHDR clinical center from 2005-11. Census tracts with fewer than 20 patients are not included.
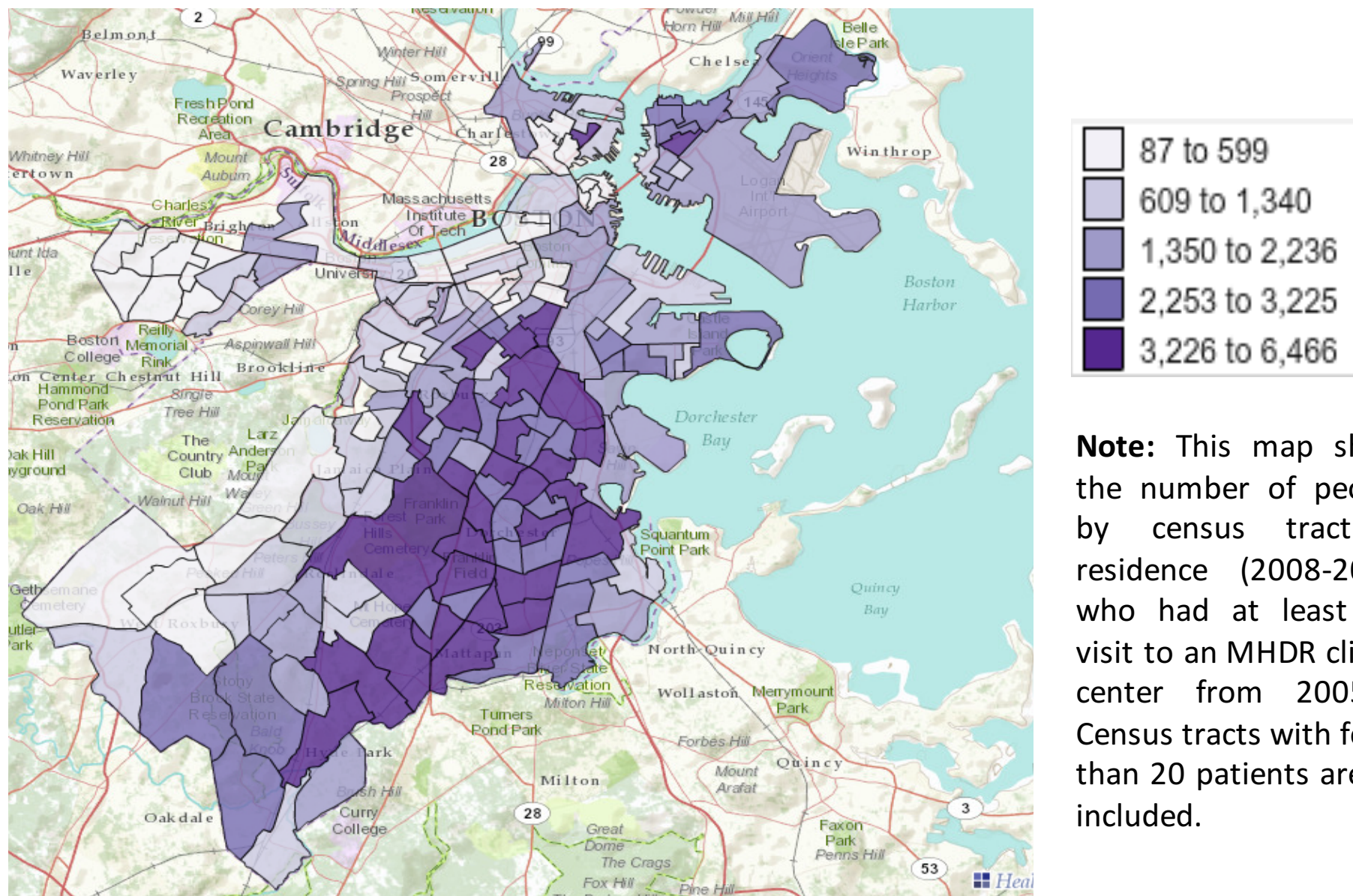
Additional projects/activities

- BMC Cancer Registry Integration
- BP Normalization and Care
- VVV in BP, lipid, and Hgb1C
- Sickle Cell QI (children and adults)
- Sickle Cell BH
- Community-based smoking cessation
- Pneumonia rates in PCV vax era
- HPV vaccination
- Algorithms for Personalized Decision Making

- ePROS: psychotropic medication use in kids
- ePROS: on-off-label safety
- PCORI-CDRN (SCILHS)
- Tele-REDCAP
- Insurance switching
- Vital Village: geographic health effects

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Hearing Technologies of the Future

Barbara Shinn-Cunningham

Professor
Biomedical Engineering
ENG

Boston University Office of the Vice President and Associate Provost for Research

Personal auditory displays
and personal sensors
are ubiquitous and widely accepted

SPINE Framework

INTERNET Cloud Computing

Coordinator Device (e.g. Smart-Phone)

Heart Rate and ECG

Blood Pressure, EMG, GSR, PPG, SpO2

Motion (Accelerometer, Gyroscope)

Pressure, FSR
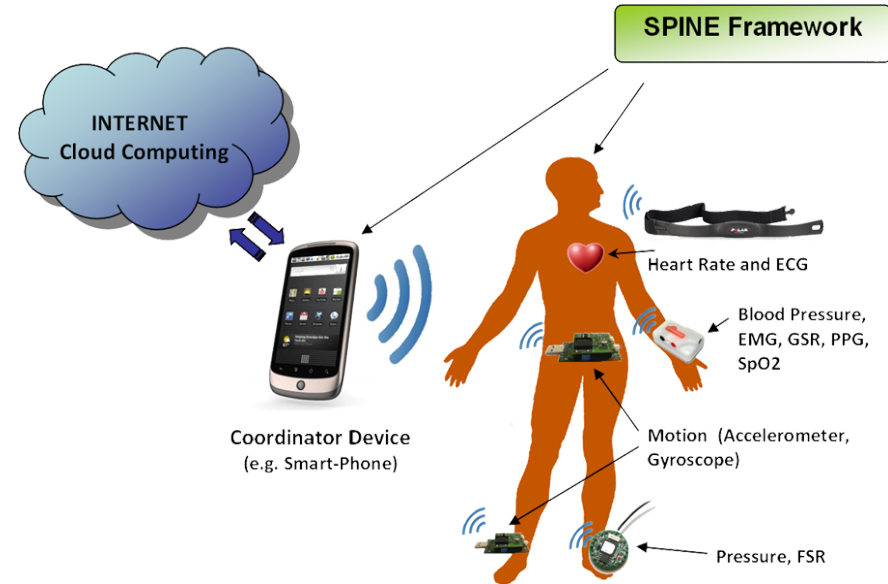
Predicting what you want to hear– and therefore *controlling what you hear*

Next-gen hearing aids will capitalize on these advances

DNN for Speech
10k hours of voice data
10b training samples
Months on a GPU cluster

Voice, Text

Image

User

A

LEFT

40 uV   1 sec

C

5 mm

B

RIGHT

EYES OPEN   EYES CLOSED
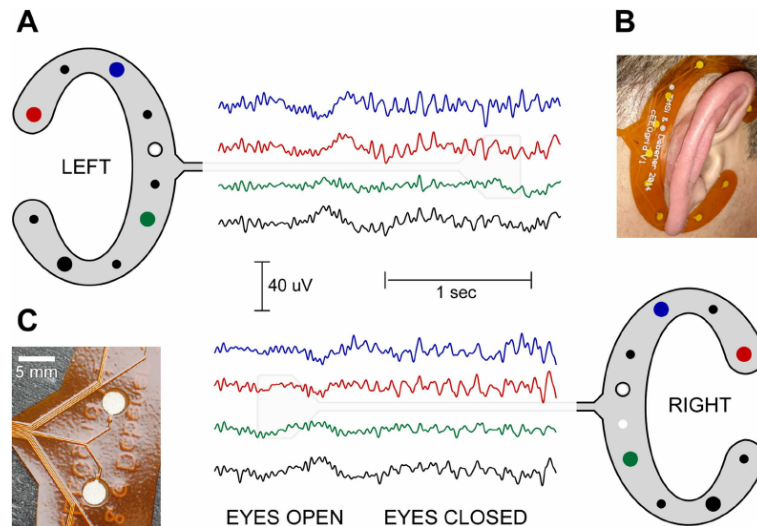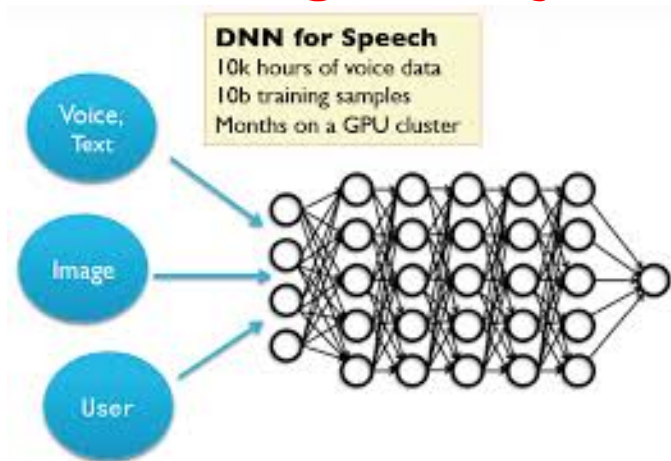
Why Encryption Matters

(or: How to Become a Man In the Middle)

Sharon Goldberg

Associate Professor
Computer Science, CAS
Rafik B. Hariri Institute for Computing and
Computational Science & Engineering

encrypted web traffic

What happens when we visit a website?

google.com

Send traffic to 202.179.177.21

IP address 202.179.177.21

DNS server

What's the IP address for google.com?

202.179.177.21
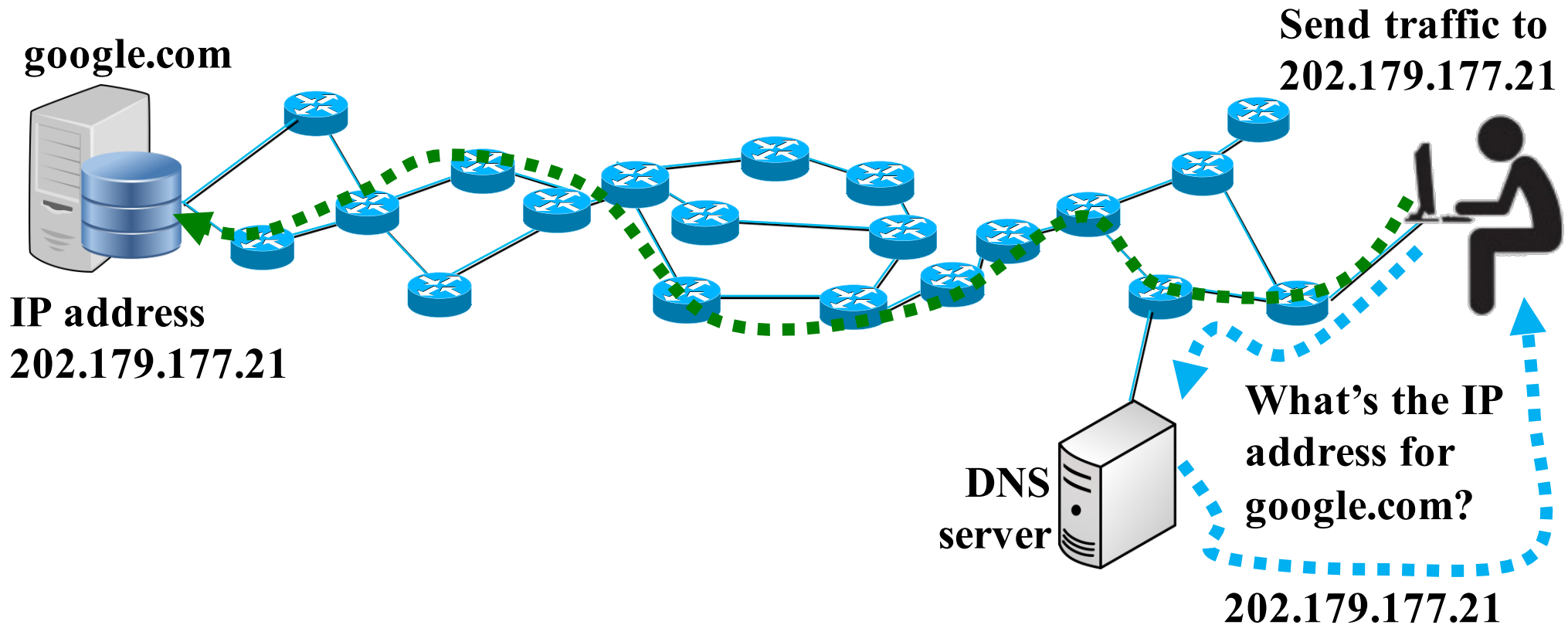
DNS is the Domain Name System
How is it used?
1. Use DNS to learn the destination IP
2. Send traffic to the destination IP

Subverting DNS to become a man-in-the-middle

google.com

DNS attacker

Send traffic to 6.6.6.6

IP address 202.179.177.21

Man in the Middle! 6.6.6.6

DNS server

6.6.6.6

What's the IP address for google.com?

Ok, google.com has IP 6.6.6.6
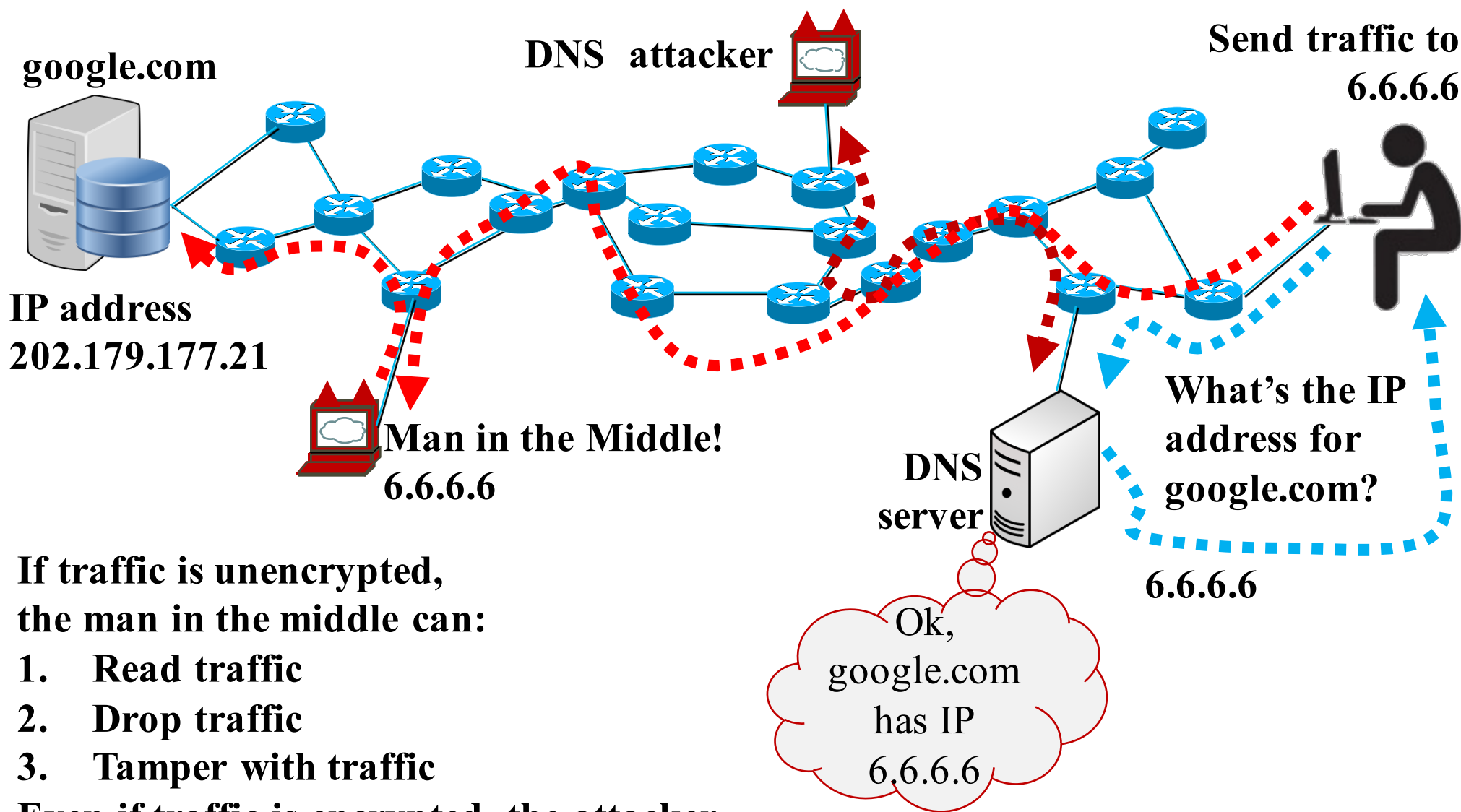
If traffic is unencrypted, the man in the middle can:

1. **Read traffic**
2. **Drop traffic**
3. **Tamper with traffic**

Even if traffic is encrypted, the attacker can still read its "metadata"

Summary + what we do in my lab
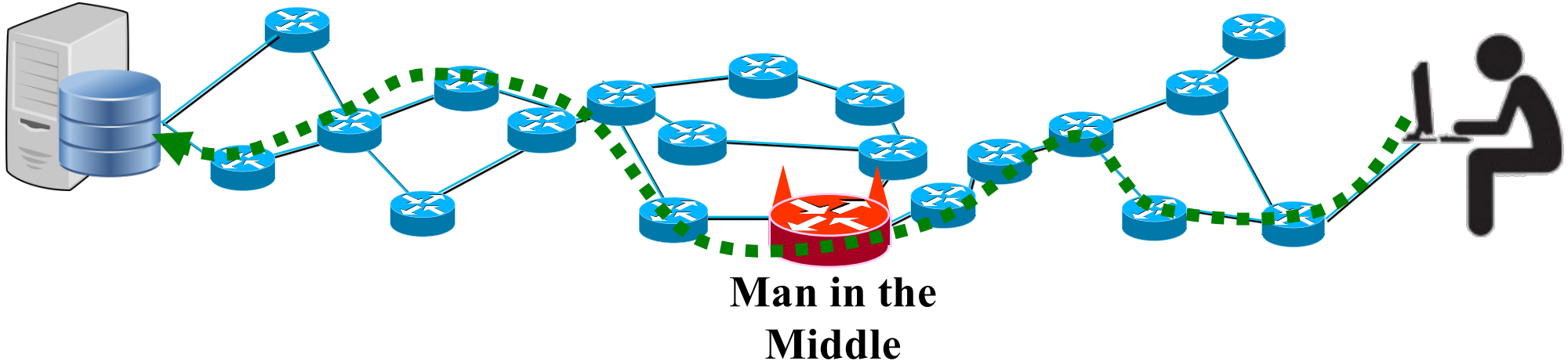
Man in the Middle

1. **Internet protocols can be subverted**
   - **Attackers can become a man-in-the-middle**
2. **Encryption protects thwarts many attacks by a man-in-the-middle**

What we do in my lab
- **Study ways traffic is routed in the Internet**
- **… and how an attacker can reroute to become a man-in-the-middle**
- **… and how network protocols can be designed to prevent this**
- **We use cryptography, simulations, measurement experiments**
- **Work with standards bodies to get our solutions onto the Internet**

DNS attacks in the wild

Category	IPv4 Hosts
DNS servers	13,766,099
Responsive DNS servers	8,868,639
Any invalid MX responses	234,756
Class of invalid behavior:	
Identical response regardless of request	131,898
Returns loopback address	16,015
Returns private network address	7,680
Flipped bits in response	56,317
Falsified DNS record	178,439

Table 14: **Invalid or Falsified MX Records** — We scanned the IPv4 address space for DNS servers that provided incorrect entries for the MX servers for five popular mail providers.

Zakir Durumeric. David Adrian, Ariana Mirian, James Kasten, Elie Bursztein, Nicolas Lidzborski, Kurt Thomas, Vijay Eranti, Michael Bailey, J. Alex Halderman. Neither Snow Nor Rain Nor MITM . . . An Empirical Analysis of Email Delivery Security. SIGCOMM Internet Measurement Conference (IMC), 2015.

Cybersecurity & How it Affects All of Us

Manuel Egele

Assistant Professor
Electrical & Computer Engineering
ENG

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The Internet of Things (IoT) is everywhere and insecure

Sept. 21st, 500,000 hacked IoT devices flood Twitter, Spotify, AirBnB, & more

Billions of mobile devices, millions of apps … trouble awaits
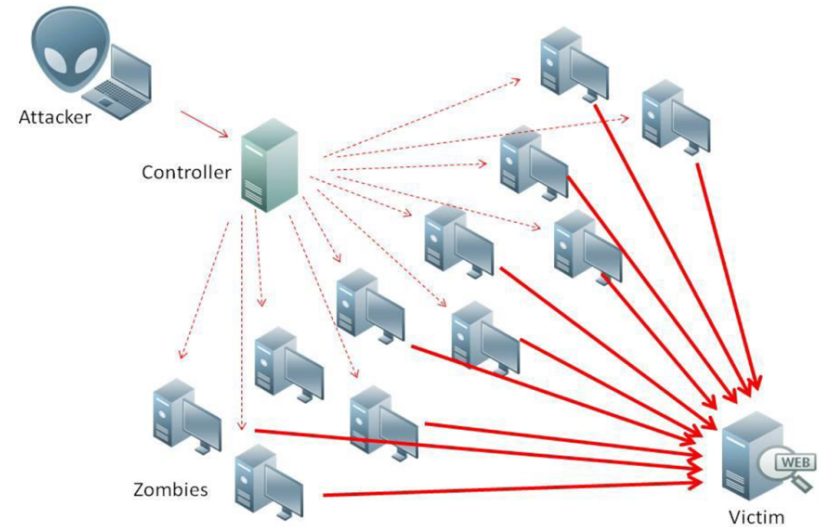
Hackers have sophisticated business models too!

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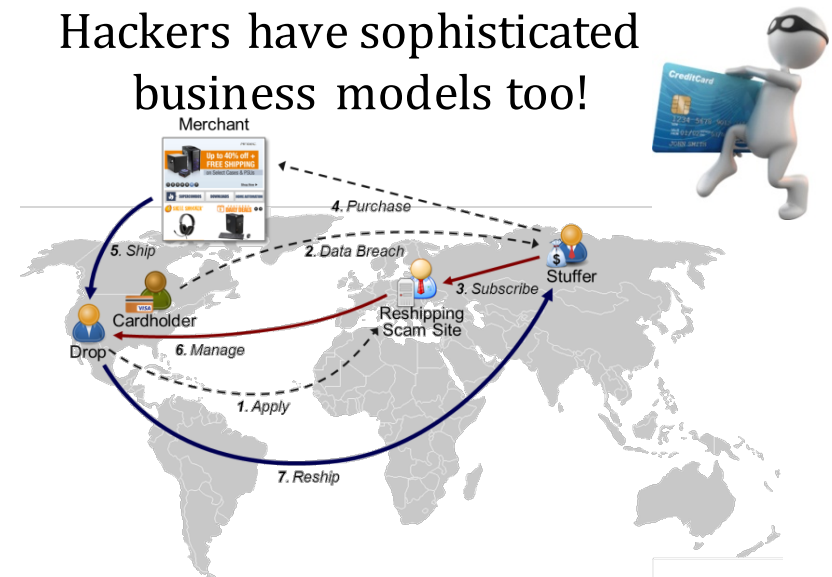
How Things Spread in Online Social Networks

Dylan Walker

Assistant Professor
Information Systems
Questrom School of Business

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poison ivy berries

Clustering in Networks
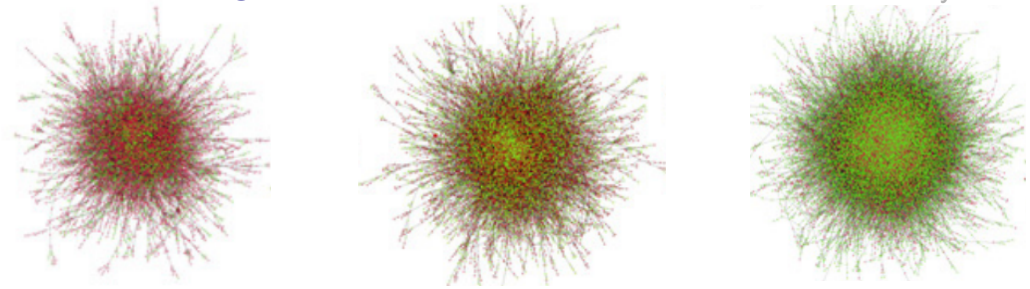
- ➤ product adoption
- ➤ happiness
- ➤ loneliness
- ➤ obesity

But, there are many alternative explanations:

➲ **Homophily** – Birds of a feather flock together

➲ **Confounding** – Friends exposed to same stimuli

➲ **Dynamic Processes** – Price Reductions
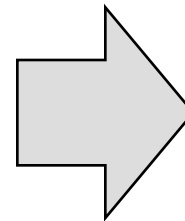
CORRELATION ≠ CAUSATION

Do we care about the difference between clustering and contagion?

(Hint: yes)

How can we determine which is happening?

Randomized Controlled Trials (RCTs)

From traditional RCTs...
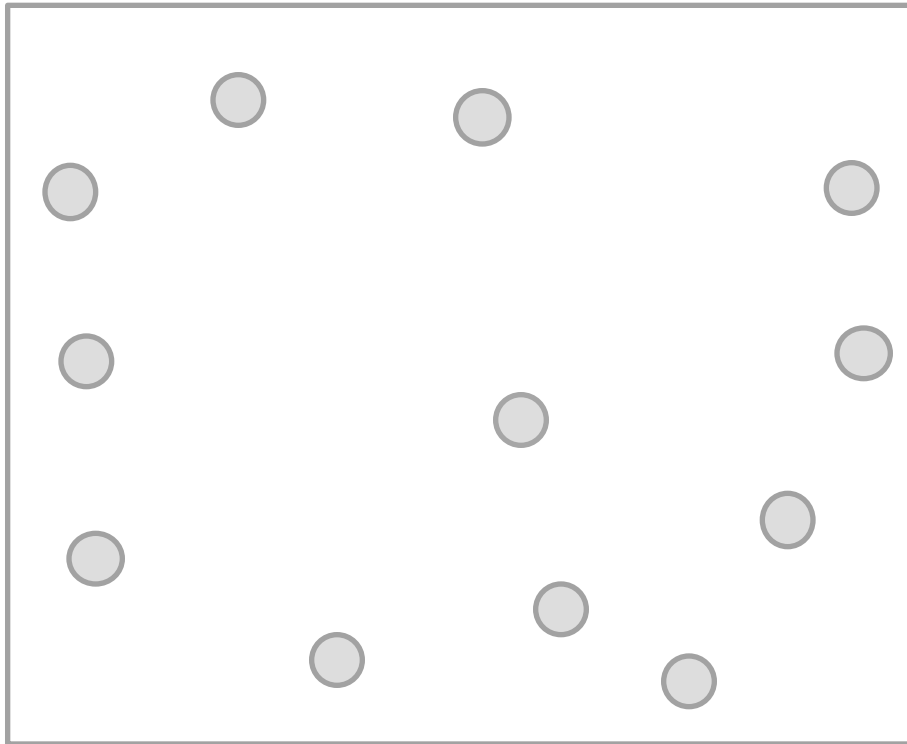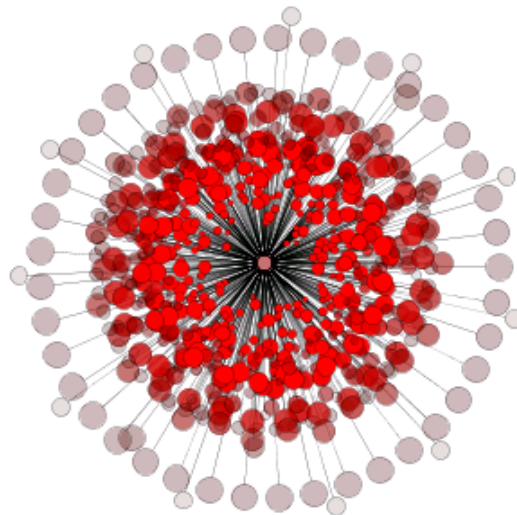
… to networked RCTs

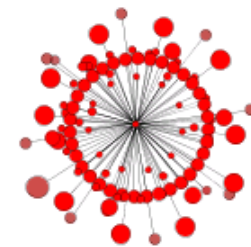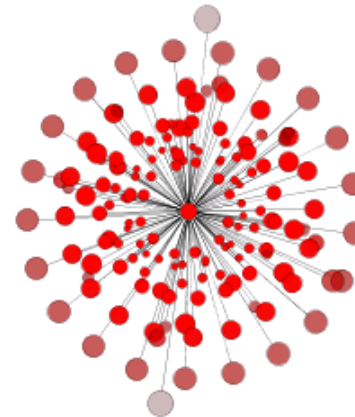Treatment ( )   Control ( )
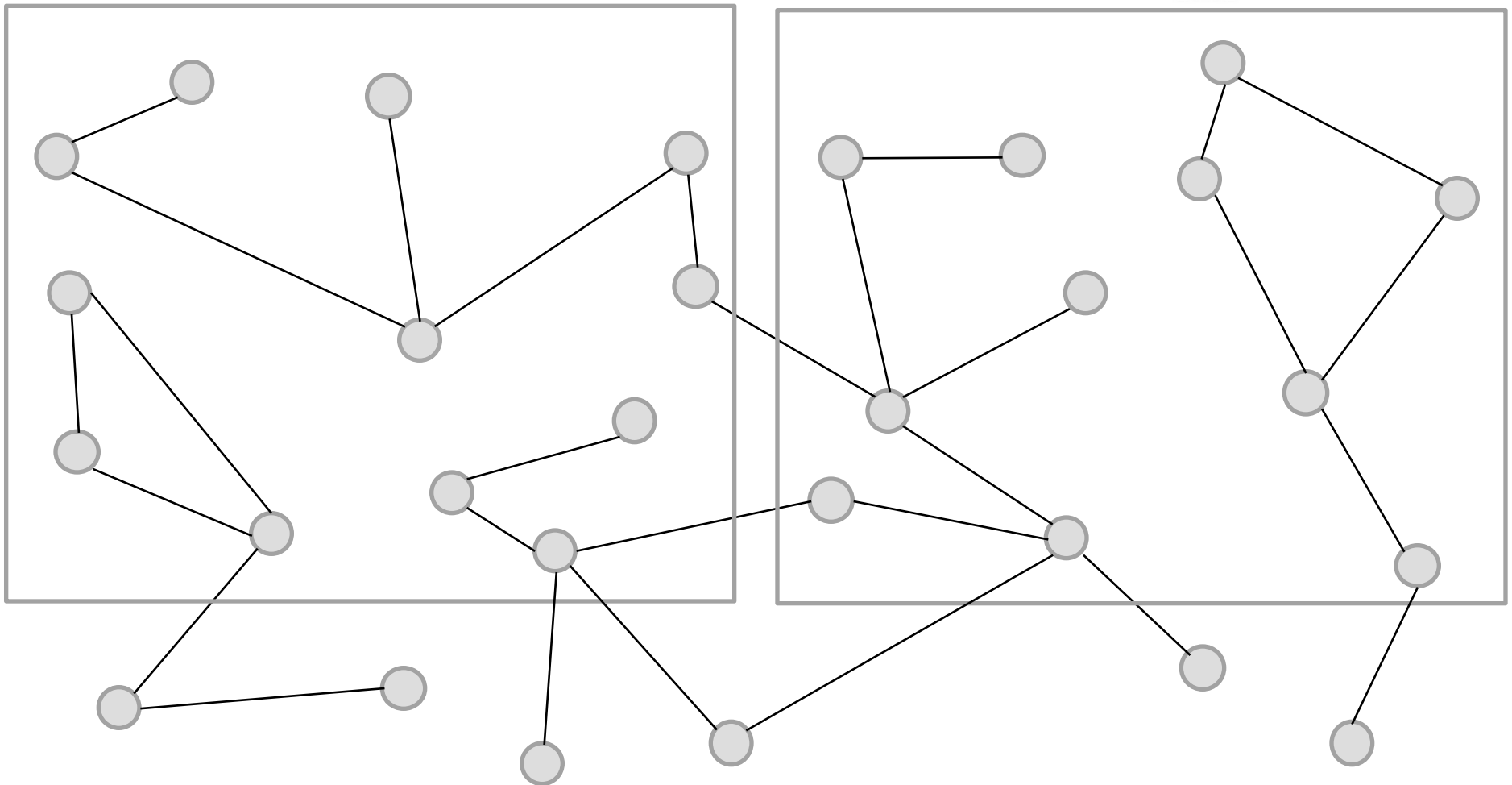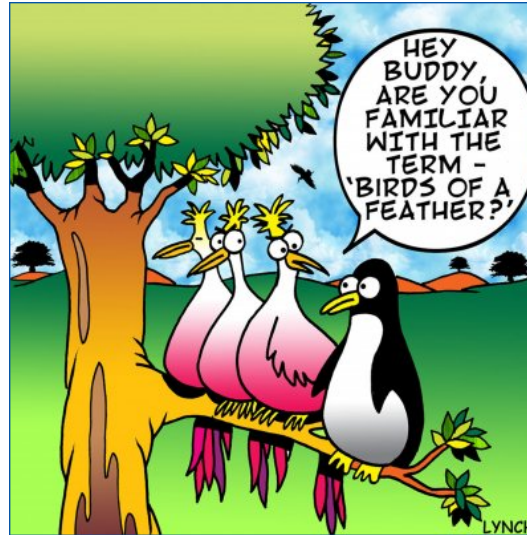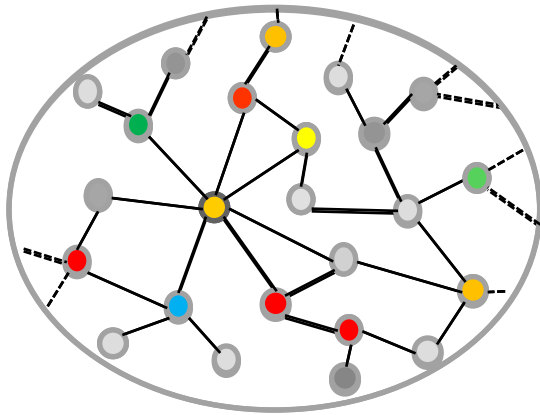
The **influentials** hypothesis

Individuality affects the social influence we exert on our peers and their response.
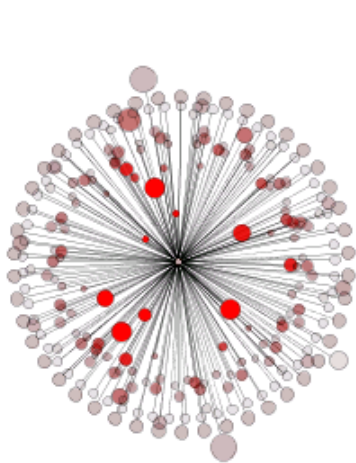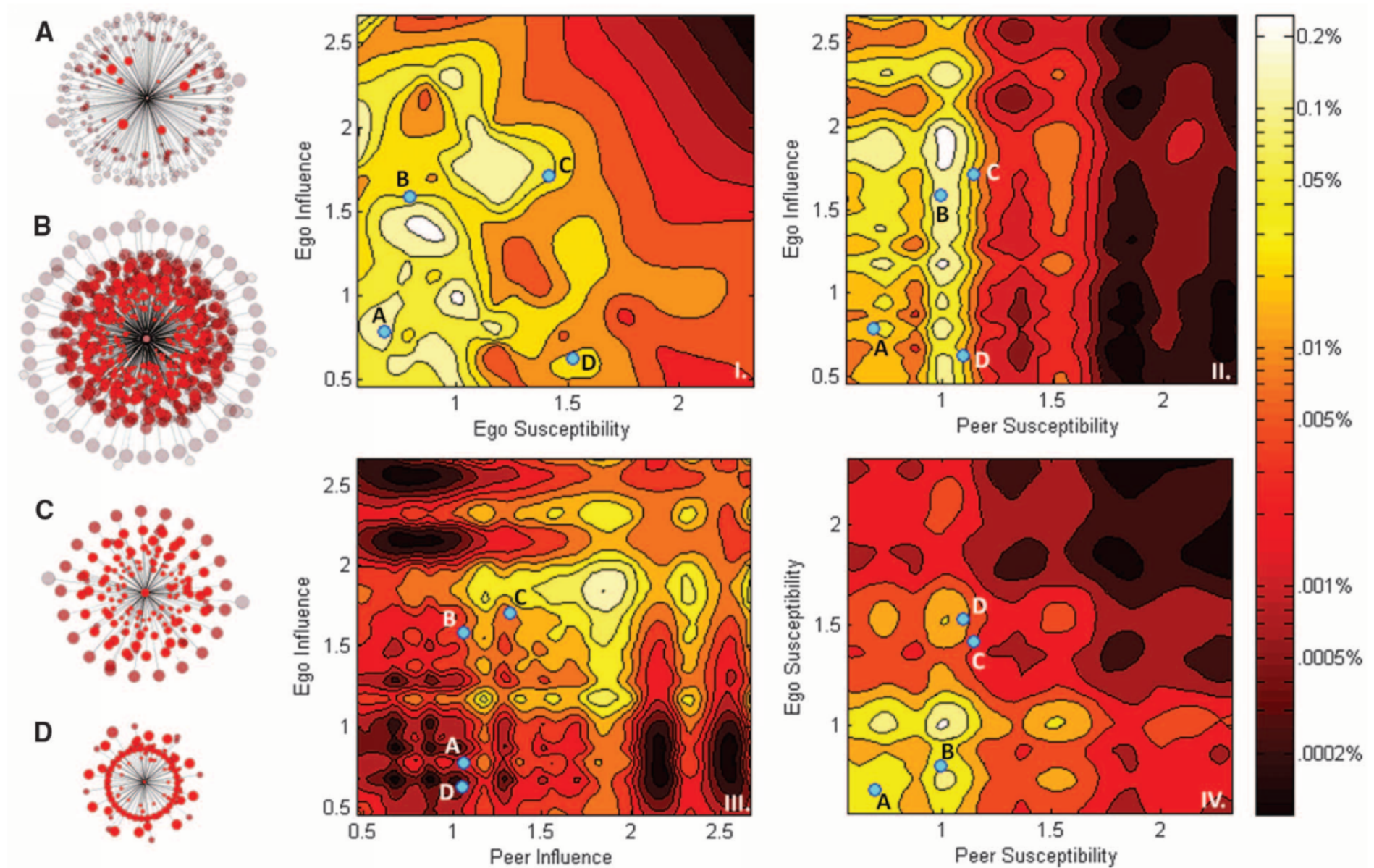

Node size – Influence

Node color – Susceptibility to influence

(Aral and Walker, *Science,* 2012)

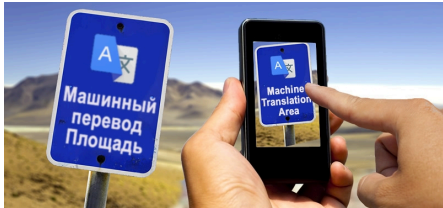# Agh, too many dimensions! What is happening?!?

Brian Kulis

Peter J. Levine Career Development Assistant Professor

Electrical & Computer Engineering, ENG
Computer Science, CAS
Division of Systems Engineering

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Supervised Learning

Unsupervised Learning

Machine Translation

Clustering

Speech Recognition

Outlier Detection

Object Detection

Trend Detection
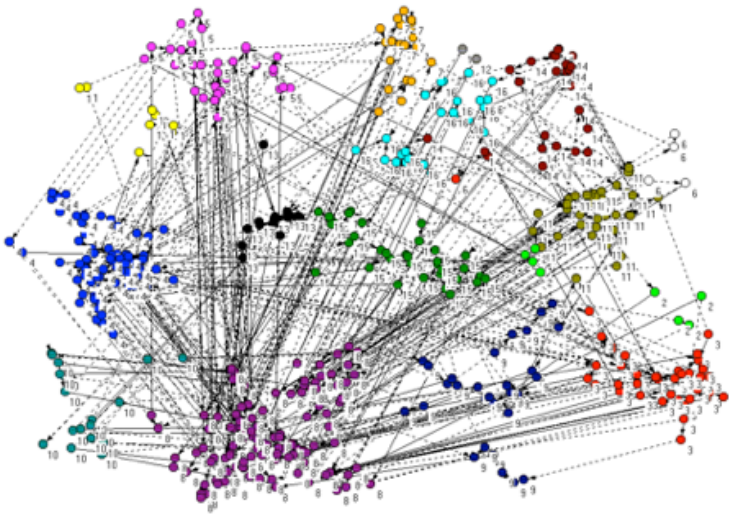

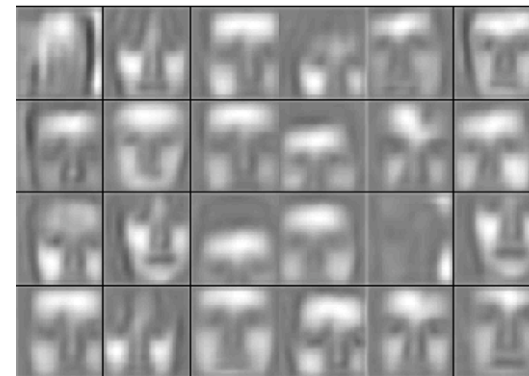**Boston University** Office of the Vice President and Associate Provost for Research
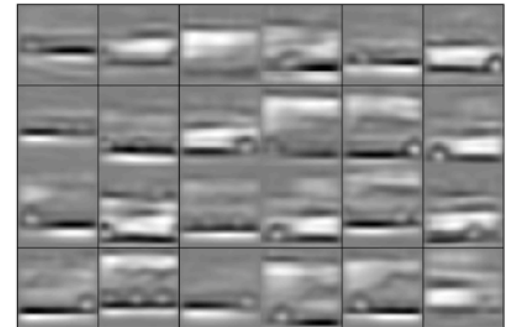
Rich and Scalable Unsupervised Learning

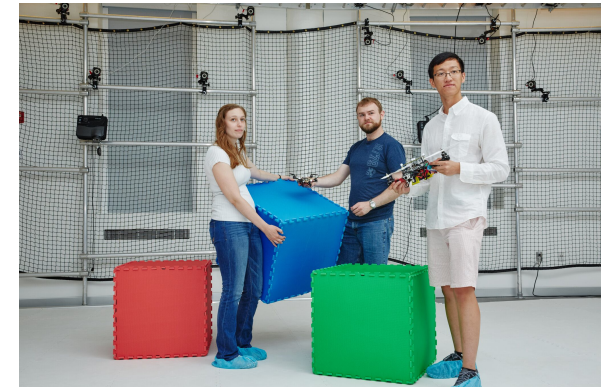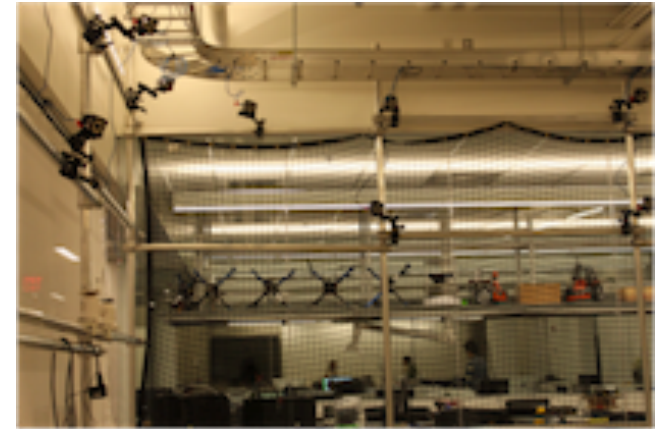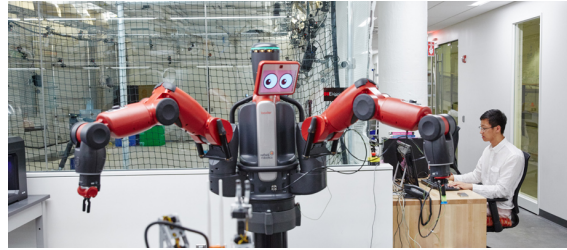Tracking Evolving Communities
Over Time

Understanding the Visual World

Calin Belta

Professor and Tegan Family Distinguished Faculty Fellow
Director of the BU Robotics Lab
Mechanical Engineering
ENG

Boston University Office of the Vice President and Associate Provost for Research
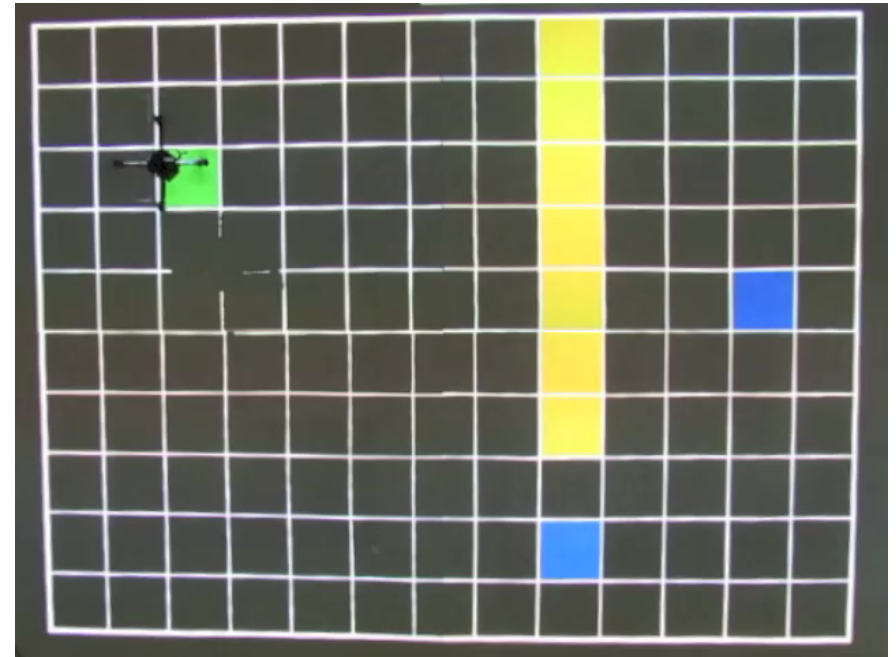
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- self-contained research facility located in the EPIC in the BU CRC
- experimental arena equipped with motion capture system, cameras, projectors
- several wheeled, air, and humanoid robots of various sizes and capabilities.
- dedicated workshop and conference room
- can accommodate about 35 students and postdocs.

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- Control theory
- Formal methods
- Robotics

"Keep taking photos and upload current photo before taking another photo. Unsafe regions should always be avoided. If fires are detected, then they should be extinguished. If survivors are detected, then they should be provided medical assistance. If both fires and survivors are detected locally, priority should be given to the survivors."
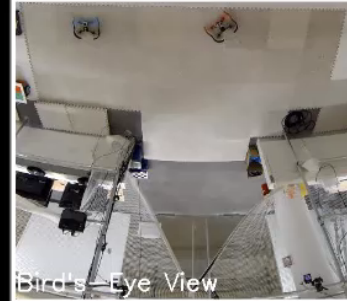

Loop 1
(playback speed x1)

"Service site **A** for **2** time units within **[0, 30]** and site **C** for **3** time units within **[0, 19]**. In addition, within **[0, 56]**, site **B** needs to be serviced for **2** time units followed by either **A** or **C** for **2** time units within **[0, 10]**. Observe charging and battery life constraints. Minimize travelled distance"

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- Control theory
- Formal methods
- Robotics

Building a mosaic map
with two quadrotors

Spec: "Always avoid obstacles and visit regions of interest in specified order and always enforce bridge directionality and uncertainty < 0.9 m^2 at all times and uncertainty < 0.6 m^2 if traveling on bridges"

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