Data and Computing Substrate

Monica Lam
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with Dan Boneh, Bernd Girod, Leo Guibas, Jeff Heer, Scott Klemmer, Paul Kim, Ramesh Johari, Nick McKeown, Roy Pea, and many students.

NSF Site Visit, June 2010
POMI Research Agenda

Infrastructure

Applications

Data & Computing Substrate
PrPl, Junction and Concierge

Network Substrate
Software Defined Network & OpenFlow

Radio Technology

Economics

Handheld

UI

Secure mobile browser

Cinder: Energy aware, secure OS

HW Platform
• Problem: Barriers 1 & 2
• Strategy to break the barriers
• 3 new social interaction paradigms – experience
• 3 new social interaction paradigms – infrastructure
• Applications on the 3 infrastructures
• Self assessment
• Future work
Barriers 1 & 2

- Big-brother portals will own our data
- We will be locked into applications

Monopoly in the making: Facebook
- 400 million users
- 50% logged in each day
- 1 million developers
- 550,000 applications
- 250,000 websites

Facebook open graph
- Your Facebook friends on every web page
- Facebook monitors all our web activity
- Android SDK announced last week
Do We Need Alternatives?

- EULA: Facebook reserves the right to change its EULA
- Must I join facebook to interact with the Stanford community?
- Lack of open competition
- What when these companies fail?
To Fight Erosion of Privacy

- Decentralized, distributed architectures
- Original proposal (Classical CS response)
  - Distributed semantic web & access control
  - Have not been adopted after years of research
    - Hard to use, deploy, program
- Today: Server-client architecture instead
  - (SAMD) Single App Multiple Data
“Why didn’t OS researchers come up with the Web?”
Butler Lampson, SOSP Keynote, 1999

• Traditional CS systems goals
  Performance, reliability, security, productivity
• Add adoptability to CS research objectives
  • Not an easy problem: end-to-end.
Adoptability Metric of Success

Ultimately:

- Facebook stats
  - 400 million users
  - 50% logged in each day
  - 1 million developers
  - 550,000 applications
  - 250,000 websites

Facebook open graph
- Your Facebook friends on every web page
- Facebook monitors all our web activity

Initially:

Users: Appreciation of experience (user study)
Developers: Code simplicity (number of lines per application)
Privacy requires collaboration

Privacy is the agenda.
Adoption needs users and developers!

1. **Attract users:**
   Create better social networking experience

2. **Preserve privacy:**
   Create egalitarian/decentralized architectures
   Design an API for inter-operability

3. **Attract developers:** Ease of programming
   Create a software infrastructure

4. **Ensure the system is secure**

5. **Establish open standard APIs**

---

**Education**
- Paul Kim
- Roy Pea

**HCI**
- Scott Klemmer
- Jeff Heer

**Applications**
- Dan Boneh
- Bernd Girod
- Leo Guibas

**Systems**
- Monica Lam

**Security**
- Dan Boneh
- John Mitchell
Common Themes

Take advantage of smart phones

• Get physical!
  • Physical locations, physical objects
• Get real!
  • Real identities, real friends, real data, real social interactions, real time.
• Get out! (Get people out of the loop.)
  • Automatic friends ``management’’
  • Intelligent data search and filter
### New Social Computing Paradigms

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Acquaintances
WeTube
To play a video, first open the YouTube application. Once you've found a video to play, long-press it and select 'share', followed by 'weTube'.

Logout
WeTube
WeTunes

WeTunes - Speaker Mode

- In Da Club
  50 Cent

- Check The Rhime
  A Tribe Called Quest

- Gone
  Ben Folds

- Intervention
  Arcade Fire

- Can I Kick It?
  A Tribe Called Quest
WePoker
# New Social Computing Paradigms

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Community
What’s Here?
Geo-Tagged Data (Input & Output)

The total cost to build and furnish the building is $38M.

It took 16 months and 47 subcontractors to build this.

Named after Bill Gates who donated $6 million for the project.

The first building that Stanford President Hennessey fund raised for.

The exhibits were installed by Computer History Museum.
Or Inventions Around You

The Original Google Storage

In 1998, Larry Page and Sergey Brin, then PhD students at Stanford, were working on the Digital Library Project. They needed a large amount of disk space to test their PageRank™ algorithm on actual world-wide-web data. At that time, 4-gigabyte hard disks were the largest available, so they assembled 10 of these drives into a low-cost cabinet.

In 1999, Google Inc. was operating one of the primary search engines on the web, providing replacement storage capacity to the Digital Library project so that we could move the original storage assembly into our history displays. As of September 2007, Google, now located in Mountain View, operated 5000 PCs for searching and web crawling, using the Linux operating system.
Or Murders

Theodore Streleski
A Stanford mathematician grad student. In 1978 he bludgeoned his adviser, Karel deLeeuw, to death with a ball-peen hammer after being told that, after 19 years of graduate school, he wasn’t going to get his doctorate.

He received a sentence of seven years, diminished capacity. He did not get any help and was freed, but said he didn’t kill.
Or Free Food
Or Social Jogging
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Friends & Family

Email

Facebook

LinkedIn

Your Social Topology
Sharing Photos
Or Status

Your status

Enjoying powder at Heavenly! >:-D

Post

Your status

Working from home, sick 😔

Post

Share With

- Everyone
- Stanford Buddies
- Research Teammates
- SocialFlows
- Andy Fang

Catch Up With

- Stanford Buddies
- Research Teammates
- SocialFlows
- Andy Fang
- Ben Dodson
Or Music Playlists
Or Current GPS Locations
Or Entire GPS Traces
Social Shopping

Your Amazon.com order has shipped (#002-6019248-74)
From: Amazon.com <ship-confirm@amazon.com>  Add to Contacts

- Italia
  - 6/6/87
  - 9.99
  - Make Private

- Abbey Midsider Live
  - 6/6/87
  - 9.99
  - Make Private

- Mujer de Cabaret
  - 6/6/87
  - 9.99
  - Make Private

- The Biography
  - 6/6/87
  - 9.99
  - Make Private

- SuperShopper
  - 6/6/87
  - 9.99
  - Make Private

Friends who have bought this:
1) Ruven Chu
2) Monica Larm
3) Ben Dodsion
• Working prototypes of all the applications above
• Built on top of the same 3 infrastructures!
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Junction: Ad Hoc Multi-Party

weTube

weBluff

weHold'Em

Pocket School

Snap2Pass

Snap2Pay
Junction: No Central Application Server

server-side scripting

Poker Portal

html/css/js

Web Browser

Web Browser

Switch Board

Application-independent service

Activity Script

Activity Director

Activity Director

Activity Director

Cross-Platform Native app

[B. Dodson, C. Nguyen, T-Y. Huang, M. Lam, 2010]
Junction: No Central Application Server

Key concepts
• Easy device-spanning computation
• App-independent rendezvous service

Advantages
• Privacy
• More scalable
• Separation of concern between development & deployment
• More multi-party apps
Common Platform & API

Pocket Social

Pocket Junction
- Invitation
- Code download
- Joining activities

Friends (devices) in proximity
## Junction Applications

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<tr>
<th>Application</th>
<th>Lines of Code</th>
<th>Dev. Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>weMeet</td>
<td>200</td>
<td>1</td>
</tr>
<tr>
<td>weClick</td>
<td>260</td>
<td>1</td>
</tr>
<tr>
<td>weTube</td>
<td>1050</td>
<td>1</td>
</tr>
<tr>
<td>weTunes</td>
<td>940</td>
<td>2</td>
</tr>
<tr>
<td>weBluff</td>
<td>1500</td>
<td>3</td>
</tr>
<tr>
<td>weHold’Em</td>
<td>3200</td>
<td>30</td>
</tr>
<tr>
<td>Snap2Web</td>
<td>720</td>
<td>1</td>
</tr>
<tr>
<td>Snap2Pass</td>
<td>2120</td>
<td>6</td>
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Consumer-Friendly Secure Web Transactions
Consumer-Friendly Challenge Response

- Simple login using cell phone camera
- Challenge in QR code. Phone computes response and sends to site.
- Login with zero clicks

[B. Dodson, D. Sengupta, D. Boneh, M. Lam, 2010]
Easy One-Time Use Credit Card

• Checkout using phone camera

• Challenge and cart details in QR code.

  User confirms on phone and sends signed response to site

• A secure version of verified by Visa

Snap2Pay

camera + network
1. **Commit**
   Each picks a random $r$, declares $g^r \mod p$ where $g, p$ are agreed upon.

2. **Give to owner**
   If not owner, reveal $r$. Owner calculates value of die as $(r_a + r_b + r_c) \mod 6$.

3. **Reveal**
   Owner makes his $r$ public.

4. **Verify**
   A revealed $r$ is only valid if $g^r$ matches $g^r$ from step 1.
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Concierge

Mobile Campus Tour

Free Food

Photo Chat

Inventions

Social Jogging
Community has many reasons to interact
• Web apps are too heavy weight.
• Emails require human attention

Concierge
• Creates a place where all the info can flow through
• Provides a programmable pub-sub engine
• New services that tap into the data stream
• Provide info to any who cares

SDMA (Single Data Multiple Apps)
Get out!
Common Platform & API

Pocket Social

Pocket Concierge
- Submit intents from apps
- Register interests with community
- Receive notifications
- Download apps
## Concierge Applications

<table>
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<tr>
<th>Application</th>
<th># Lines of Code</th>
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<tbody>
<tr>
<td>Photo Chat</td>
<td>20</td>
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<tr>
<td>Social Jogging</td>
<td>11</td>
</tr>
<tr>
<td>Mobile Campus Tour</td>
<td>10</td>
</tr>
<tr>
<td>LiveShout (Free food)</td>
<td>47</td>
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# New Social Computing Paradigms

## Experience vs. Social Application Infrastructures

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PrPl: Private-Public Data Infrastructure
A Safe Haven for Personal Data

Where is our data consumed?

TBs of personal data!

32 GB instantaneously. With you all the time, Even when not connected. Private.

Person-Cloud Butler

Pocket Butler
Two Key Ideas

• Friends Topology
• Distributed search of friends’ Personal Cloud Butlers
Most social software is arguably autistic...

Are you my friend? YES or NO.

Friend recommendation: your ex.

How might social services generate and utilize more nuanced models of communities and relations?

Applications to online sharing, access control, privacy management, and recommenders.
Real-world social groups are:
• Overlapping
• Nested
• Highly Contextual
New Algorithm for Social Topologies

Analyze co-occurrence in communication.

1. Identify and infer repeated recipient groups
2. Prune groups according to a sharing error
3. Infer macro-structure via group unions
4. Organize results into a hierarchy

Developed and evaluated on e-mail archives, but generally applicable to social co-occurrence.

User study found SocialFlows **significantly faster and more useful** than the Gmail contact management UI. In addition, 6 out of 19 users found the Gmail intolerable and **quit the task!**
Social Multi-Database

Pocket Social

Pocket Butler

Personal-Cloud Butler

Data Manager
Semantic Index
Access Control
OpenID Manager

Data Steward API

home server
facebook
imap

SocialLite Database Query Language

Friends’ Butlers
SocialLite:
Location-agnostic query language based on Datalog

FoaF(p) :- Friend(p)
FoaF(p) :- FoaF(x), Friend [x] (p)
FoaF-CurrLoc (p,l) :- FoaF(p), CurrLoc [p] (l)
## PrPrI Applications

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<tr>
<th>Application</th>
<th># Queries</th>
<th># Lines of Code</th>
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<tbody>
<tr>
<td>Unified address book</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Aggregated friends’ feed</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Collaborative photo browser</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Chat / messager</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Common interests discovery</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Social charts</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Collaborative slide show</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>List of friends</td>
<td>2</td>
<td>9</td>
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<tr>
<td>Photos</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Locations</td>
<td>1</td>
<td>3</td>
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<td>Social Shopping</td>
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**Junction**
- Easy device-spanning computation
- App-independent rendezvous service

**Concierge**
- SDMA (Single Data Multiple Apps)
- App engine for data filtering/processing

**PrPl (Private-Public)**
- SFMA (Single Friends-list Multiple Apps)
- Distributed search of safe havens
Towards Mobile Augmented Reality

[John Hong, Qualcomm]
Linking Real Objects and Online Social Worlds

Mobile Campus Tour

Mobile Augmented Reality

Monroe Decimal Calculator, 1930

Social Shopping

Social Music Snap2Play

TV2GO: Video Recognition at a Glance

Product Search

Monroe Calculating Machine Company, in New Jersey. The Monroe Company is now located in Lebanon, PA and still sells calculators, although from 1953 to the early 1960’s it also made a series of small computers: MonRobots (I to XI), as part of Lion Industries. This 10-key calculator provided accurate manual computation. Its operator was called a computor. Each complete forward turn of the large crank on the right will add the value set into the 8 x 10 keys into the bottom register of the carriage. The main register on the carriage shows the result. The smaller register above it counts the turns. Subtraction is achieved by turning the crank in reverse. To multiply by more than one digit the Repeat button is pressed and the crank turned as often as needed for the low-order digit. Then the carriage is moved to the right with the handle in front, so the next digit of the factor can be cranked in. The crank on the carriage is for re-setting result and counter registers. Division is performed by subtracting the divisor left to right.
Baldwin patented a pinwheel device that enabled carries in a compact device. In 1900 he invented a method that allowed digits to be entered by a single stroke. In 1912 Baldwin joined Randolph Monroe and founded the Monroe Calculating Machine Company, in New Jersey. The Monroe Company is now located in Lebanon, PA and still sells calculators, although from 1953 to the early 1960's it also made a series of small computers: MonRobots (I to XI), as part of Lion Industries. This 10-key calculator provided accurate manual computation. Its operator was called a computor. Each complete forward turn of the large crank on the right will add the value set into the 8 x 10 keys into the bottom register of the carriage. The main register on the carriage shows the result. The smaller register above it counts the turns. Subtraction is achieved by turning the crank in reverse. To multiply by more than one digit the Repeat button is pressed and the crank turned as often as needed for the low-order digit. Then the carriage is moved to the right with the handle in front, so the next digit of the factor can be cranked in. The crank on the carriage is for reserving result and counter registers. Division is performed by subtracting the divisor left to right.
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Linking Real Objects and Online Social Worlds

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Personal Cloud Butler
Monroe Decimal Calculator, 1930

Baldwin patented a pinwheel device that enabled carries in a compact device. In 1900 he invented a method that allowed digits to be entered by a single stroke. In 1912 Baldwin joined Randolph Monroe and founded the Monroe Calculating Machine Company, in New Jersey. The Monroe Company is now located in Leominster, PA and still sells calculators, although from 1953 to the early 1960's it also made a series of small computers: MonRobots (I to XI), as part of Lion Industries. This 10-key calculator provided accurate manual computation. Its operator was called a computor. Each complete forward turn of the large crank on the right will add the value set into the 8 x 10 keys into the bottom register of the carriage. The main register on the carriage shows the result. The smaller register above it counts the turns. Subtraction is achieved by turning the crank in reverse. To multiply by more than one digit the Repeat button is pressed and the crank turned as often as needed for the low-order digit. Then the carriage is moved to the right with the handle in front, so the next digit of the factor can be cranked in. The crank on the carriage is for resetting result and counter registers. Division is performed by subtracting the divisor left to right.
Mobile Visual Search

Comparison
Feature Extraction on the Phone

- Camera
- Feature Extraction
- Coding
- Client

Features → Wireless Network → Information

Server
VocTree Image Matching
## New Social Computing Paradigms

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<th>Experience</th>
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<td><strong>Junction</strong></td>
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<td>Ad hoc</td>
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<td>Personality with you</td>
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<td><strong>Community</strong></td>
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<td>Real-time, p2p</td>
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<td>Info targeting/filtering</td>
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<td><strong>Friends and Family</strong></td>
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<td>Share personal data</td>
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<td>With access control</td>
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Self Assessment

Identified an important problem early!

Facebook's Mark Zuckerberg says privacy is no longer a 'social norm'

Offer no alternative to the public yet!
Current Status

- Users: Novel user experiences appear to be attractive
- Developers: Applications are easy to write
  - Prototypes of applications and infrastructures
- Junction: preliminary version available
- Papers submitted to major conferences;
  Preliminary papers & demos to appear in workshops
- Companies expressed interest in our research
Future: Large Experiments

Junction
- Snap2Pass/Snap2Pay: early discussions with Verisign

Concierge
- Student orientation, September 2010
- Stanford’s Be Well initiative
- P2P taxi: Carpool initiative

PrPl
- Social topology
  - Longitudinal deployment with Mozilla Thunderbird
  - Facebook application on friends’ photo tags
- PrPl light – supports real-time sharing with email accounts
Ultimate Goal: Open Standard API

1. Continue to make software available.
2. Get more experience.
3. Create an Open MobiSocial consortium.