



A Framework for Computing the Privacy Scores of Users in Online Social Networks



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freecreditreport.com

Wait a minute, how come the talk is related
Credit Score?

From humble beginnings in 1956, Fair Isaac Corp.'s credit score has come to loom over consumer finance like no other statistical measure ever has.

So, how about a **Privacy Score** that indicates the privacy risk of online social-networking users?

Do you want to design a privacy score and other advanced privacy and risk management mechanisms so that 50 years (or much less) later, people will appreciate your effort?

Roadmap

- Motivation and Goal
- Privacy Score and Its Applications
- Privacy Score and Facebook/OpenSocial
- Proof of Concept: The Privacy-Aware Market Place
- Conclusions

Motivation

Millions of users share details of their personal lives with vast networks of friends, and often, strangers

Disclosure of personal info expose the users to identity theft, digital stalking, etc.



Courtesy to: <http://www.contrib.andrew.cmu.edu/%7Egct/mygroup.html>



Courtesy to: http://i.ehow.com/images/GlobalPhoto/Articles/4873454/identity-theft-protect-yourself-main_Full.jpg

Motivation (Co

My God! What information I have shared all these years and who can view these information?

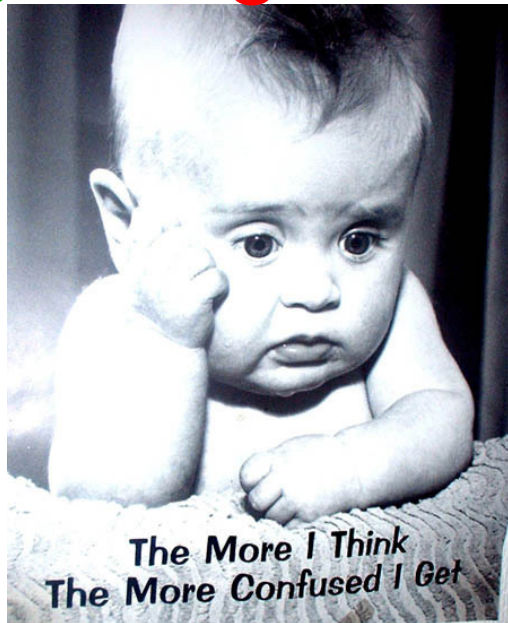
How to prevent my ex from seeing my status updates?

All my friends have shared their hometown and phone number, maybe I should also do this?

How to hide my friend list in the search results?

I enjoyed sharing my daily activities with the World! But any adverse effects?

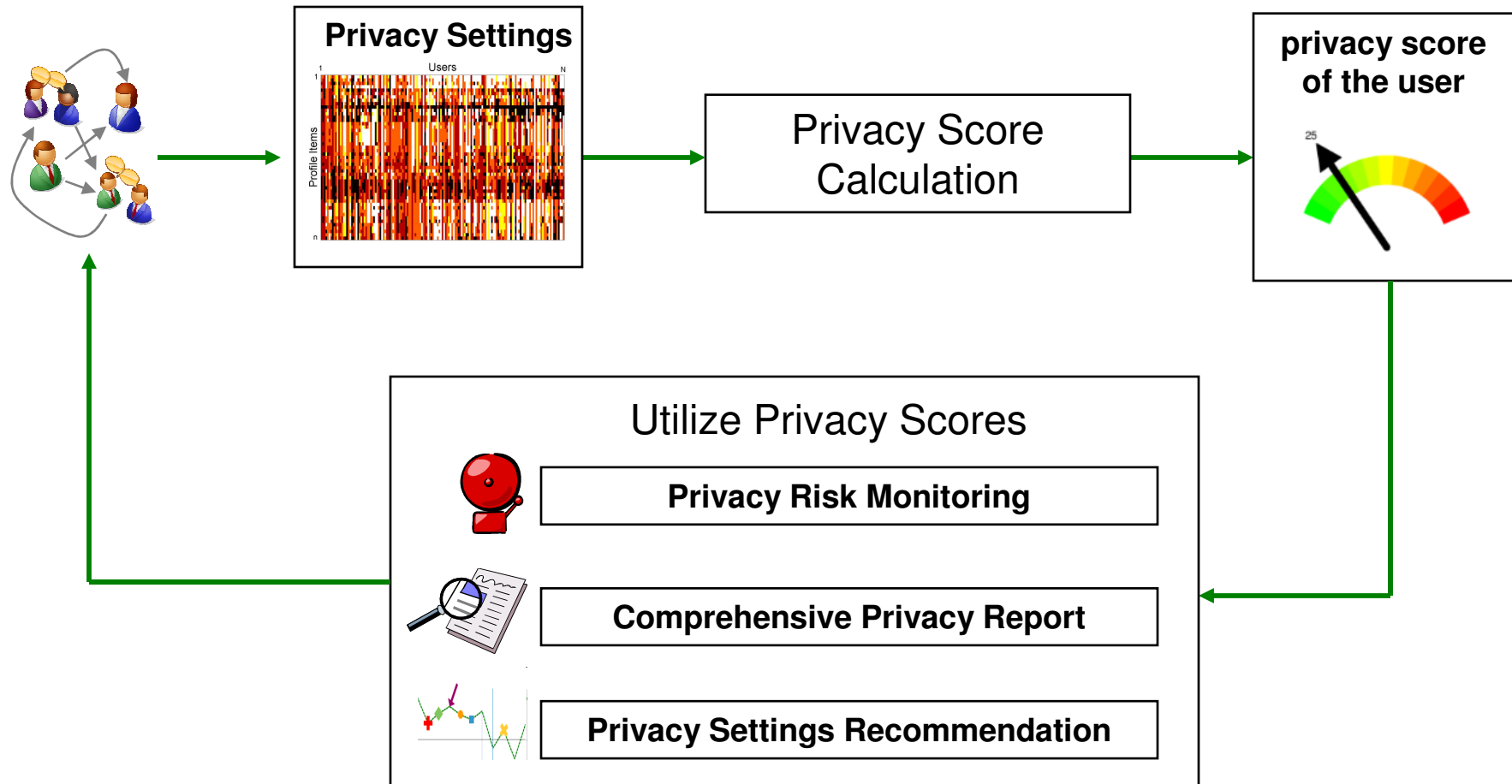
How to prevent the applications my friends installed from accessing my information?



Goal

- Our goal is to develop a mechanism that is able to
 - Measure/monitor the privacy risk of social-networking users
 - Boost public awareness of privacy
 - Help users to easily manage their information sharing
- Our goal is NOT to prevent people from sharing information
- How to achieve this goal?
 - Privacy-score calculation
 - Comprehensive information-sharing report
 - Privacy-settings recommendation
 - and more ...

Life Cycle of Privacy Score



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Basic Premises of Privacy Score

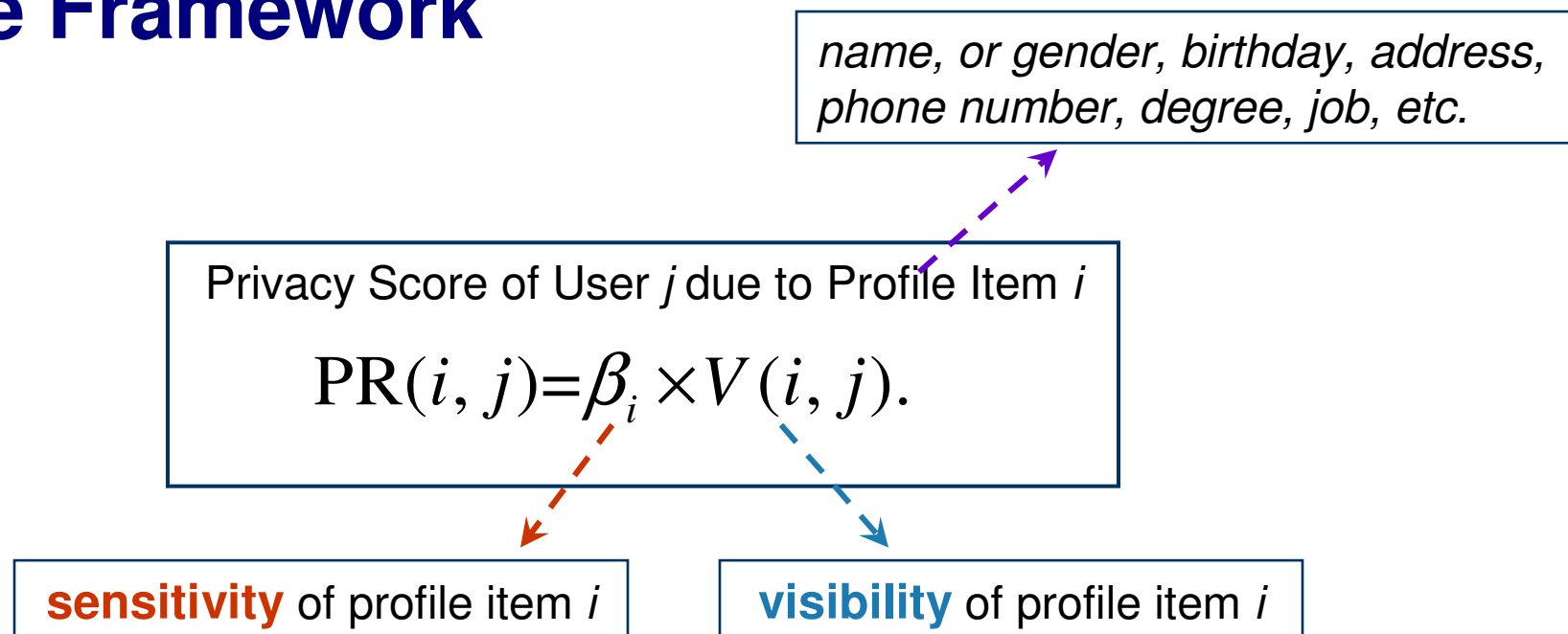
- **Sensitivity**: The more sensitive the information revealed by a user, the higher his privacy risk.

mother's maiden name is more sensitive than *mobile-phone number*

- **Visibility**: The wider the information about a user spreads, the higher his privacy risk.

home address known *by everyone* poses higher risks than *by friends only*

The Framework



The Framework

*name, or gender, birthday, address,
phone number, degree, job, etc.*

Privacy Score of User j due to Profile Item i

$$\text{PR}(i, j) = \beta_i \times V(i, j).$$

sensitivity of profile item i

visibility of profile item i

Overall Privacy Score of User j

$$\text{PR}(j) = \sum_i \text{PR}(i, j) = \sum_i \beta_i \times V(i, j).$$

The Naïve Approach

	User_1				User_j				User_N
Profile Item_1 (birthday)	R(1, 1)	R(1, 2)							R(1, N)
Profile Item_i (cell phone #)					R(i, j)				
Profile Item_n	R(n, 1)								R(n, N)

□ share, $R(i, j) = 1$

■ not share, $R(i, j) = 0$

The Naïve Approach

	User_1	User_j						User_N
Profile Item_1 (birthday)	R(1, 1)	R(1, 2)						R(1, N)
Profile Item_i (cell phone #)					R(i, j)			
Profile Item_n	R(n, 1)							R(n, N)

$$|R_i| = \sum_j R(i, j)$$

□ share, $R(i, j) = 1$

■ not share, $R(i, j) = 0$

Sensitivity: $\beta_i = \frac{N - |R_i|}{N}$

The Naïve Approach

	User_1				User_j				User_N
Profile Item_1 (birthday)	R(1, 1)	R(1, 2)							R(1, N)
Profile Item_i (cell phone #)					R(i, j)				
Profile Item_n	R(n, 1)								R(n, N)

share, $R(i, j) = 1$
 not share, $R(i, j) = 0$

$|R^j| = \sum_i R(i, j)$

$|R_i| = \sum_j R(i, j)$

Sensitivity: $\beta_i = \frac{N - |R_i|}{N}$

Visibility: $V(i, j) = \Pr\{R(i, j) = 1\} \times 1 + \Pr\{R(i, j) = 0\} \times 0$

The Naïve Approach

	User_1				User_j				User_N
Profile Item_1 (birthday)	R(1, 1)	R(1, 2)							R(1, N)
Profile Item_i (cell phone #)					R(i, j)				
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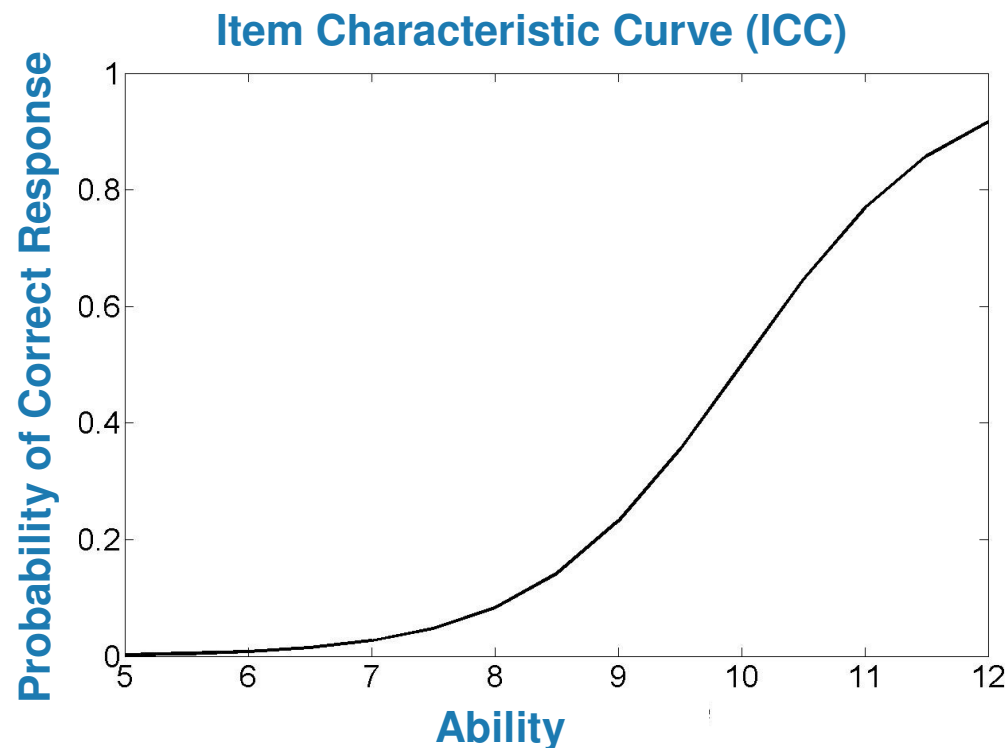
Sensitivity: $\beta_i = \frac{N - |R_i|}{N}$

Visibility: $V(i, j) = \Pr\{R(i, j) = 1\} \times 1 + \Pr\{R(i, j) = 0\} \times 0$

$\Pr\{R(i, j) = 1\} = \frac{|R_i|}{N} \times \frac{|R^j|}{n}$

Item Response Theory (IRT)

- IRT (Lawley, 1943 and Lord, 1952) has its origin in psychometrics.
- It is used to analyze data from questionnaires and tests.
- It is the foundation of Computerized Adaptive Test like GRE, GMAT



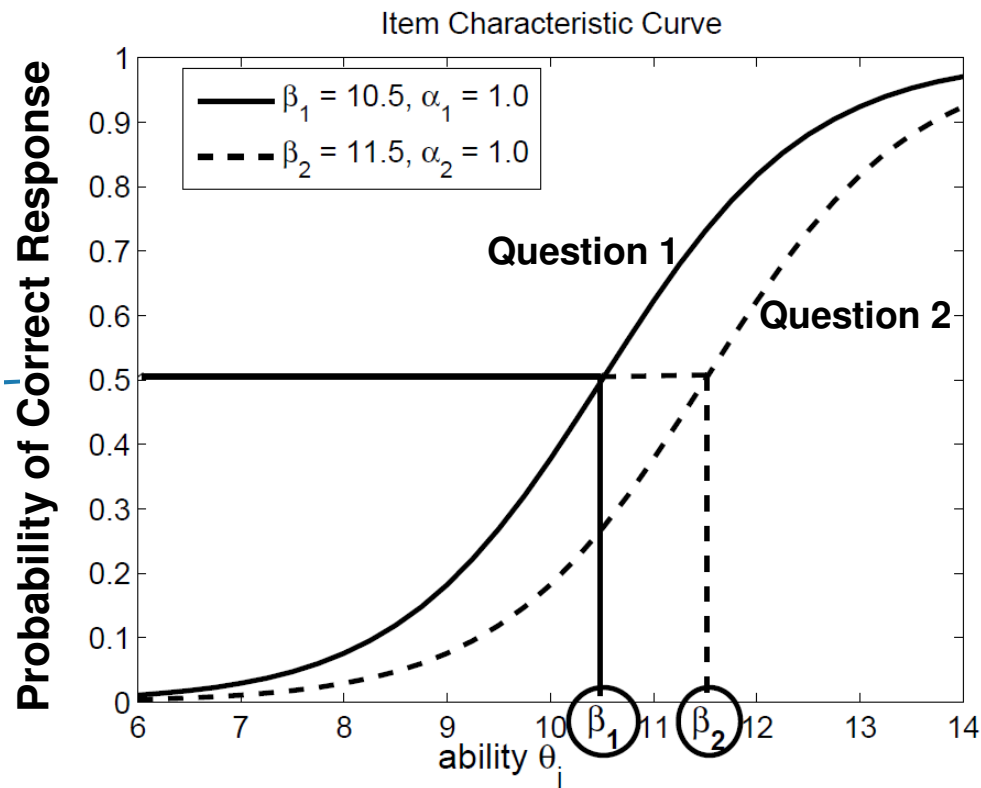
Item Characteristic Curve (ICC)

$$\Pr\{R(i, j) = 1\} = \frac{1}{1 + e^{-\alpha_i(\theta_j - \beta_i)}}$$

Question i 's discrimination

Student j 's ability

Question i 's difficulty



The Item Response Theory (IRT) Approach

	User_1	User_j						User_N
Profile Item_1 (birthday)	R(1, 1)	R(1, 2)						R(1, N)
Profile Item_i (cell phone #)					R(i, j)			
Profile Item_n	R(n, 1)							R(n, N)

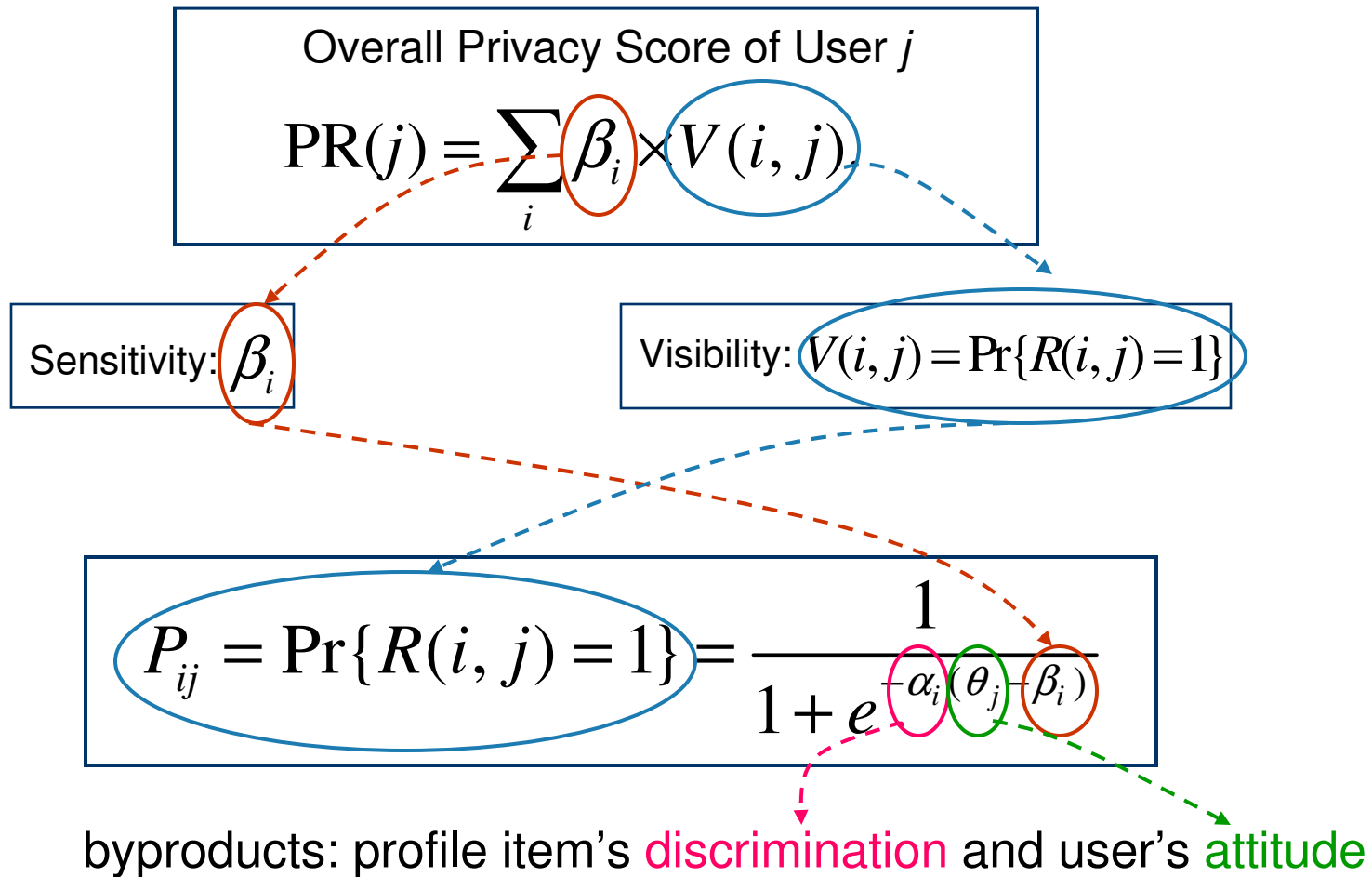
□ share, $R(i, j) = 1$

■ not share, $R(i, j) = 0$

$$P_{ij} = \Pr\{R(i, j) = 1\} = \frac{1}{1 + e^{-\alpha_i(\theta_j - \beta_i)}}$$

Profile item i 's true visibility (points to P_{ij})
Profile item's discrimination (points to α_i)
User's attitude, e.g., conservative or extrovert (points to θ_j)
Profile item's sensitivity (points to β_i)

Calculating Privacy Score using IRT



All parameters can be estimated using
Maximum Likelihood Estimation and Expectation-Maximization.

Advantages of the IRT Model

- The mathematical model fits the observed data well
- The quantities IRT computes (*i.e.*, sensitivity, attitude and visibility) have intuitive interpretations
- Computation is parallelizable using e.g. MapReduce
- Privacy scores calculated within different social networks are comparable

Interesting Results from User Study

Survey

We collected the information-sharing preferences of **153 users** on **49 profile items** such as *name, gender, birthday, political views, address, phone number, degree, job, etc.*

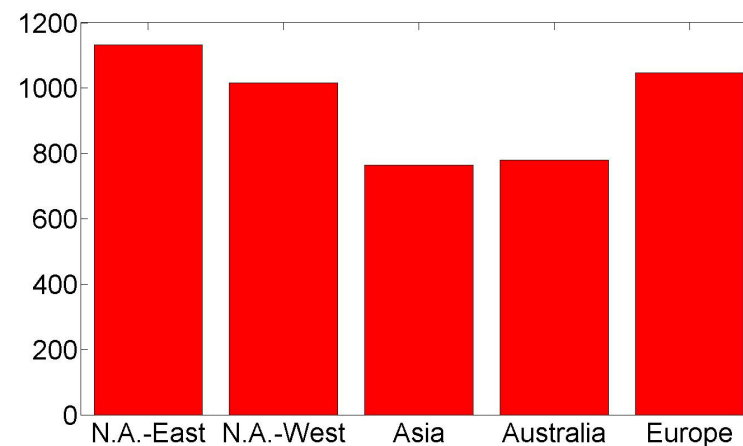
Statistics

- 49 profile items
- 153 users from 18 countries/regions
- 53.3% are male and 46.7% are female
- 75.4% are in the age of 23 to 39
- 91.6% hold a college degree or higher
- 76.0% spend 4+ hours online per day

Sensitivity of The Profile Items Computed by IRT Model




Average Privacy Scores Grouped by Geographical Regions



Utilize Privacy Scores

- Privacy Risk Monitoring
- Privacy (Information Sharing) Report
- Privacy Settings Recommendation

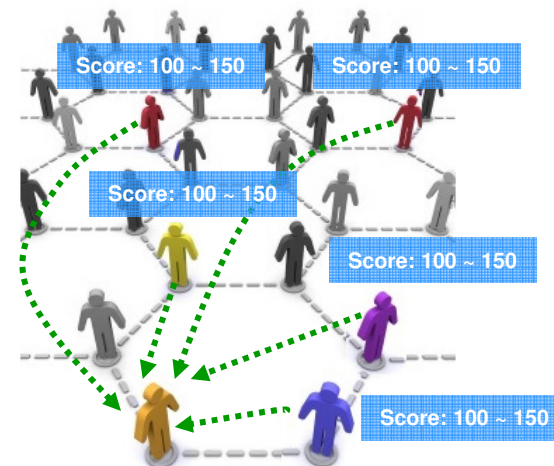


How is your privacy score compared to others?
View a summary of your scores and analyze how your scores compare to others around the world.



Category	Score	Global Avg
Overall Score	100	100
Information Sharing	100	100
Privacy Settings	100	100
Privacy Risk	100	100
Privacy Policy	100	100
Privacy Notice	100	100
Privacy Controls	100	100
Privacy Training	100	100
Privacy Audits	100	100
Privacy Impact Assessments	100	100
Privacy Breach Response	100	100
Privacy Governance	100	100
Privacy Culture	100	100
Privacy Leadership	100	100
Privacy Accountability	100	100
Privacy Transparency	100	100
Privacy Trust	100	100
Privacy Reputation	100	100
Privacy Innovation	100	100
Privacy Resilience	100	100
Privacy Sustainability	100	100
Privacy Ethics	100	100
Privacy Compliance	100	100
Privacy Regulation	100	100
Privacy Standards	100	100
Privacy Best Practices	100	100
Privacy Innovation	100	100
Privacy Resilience	100	100
Privacy Sustainability	100	100
Privacy Ethics	100	100
Privacy Compliance	100	100
Privacy Regulation	100	100
Privacy Standards	100	100
Privacy Best Practices	100	100

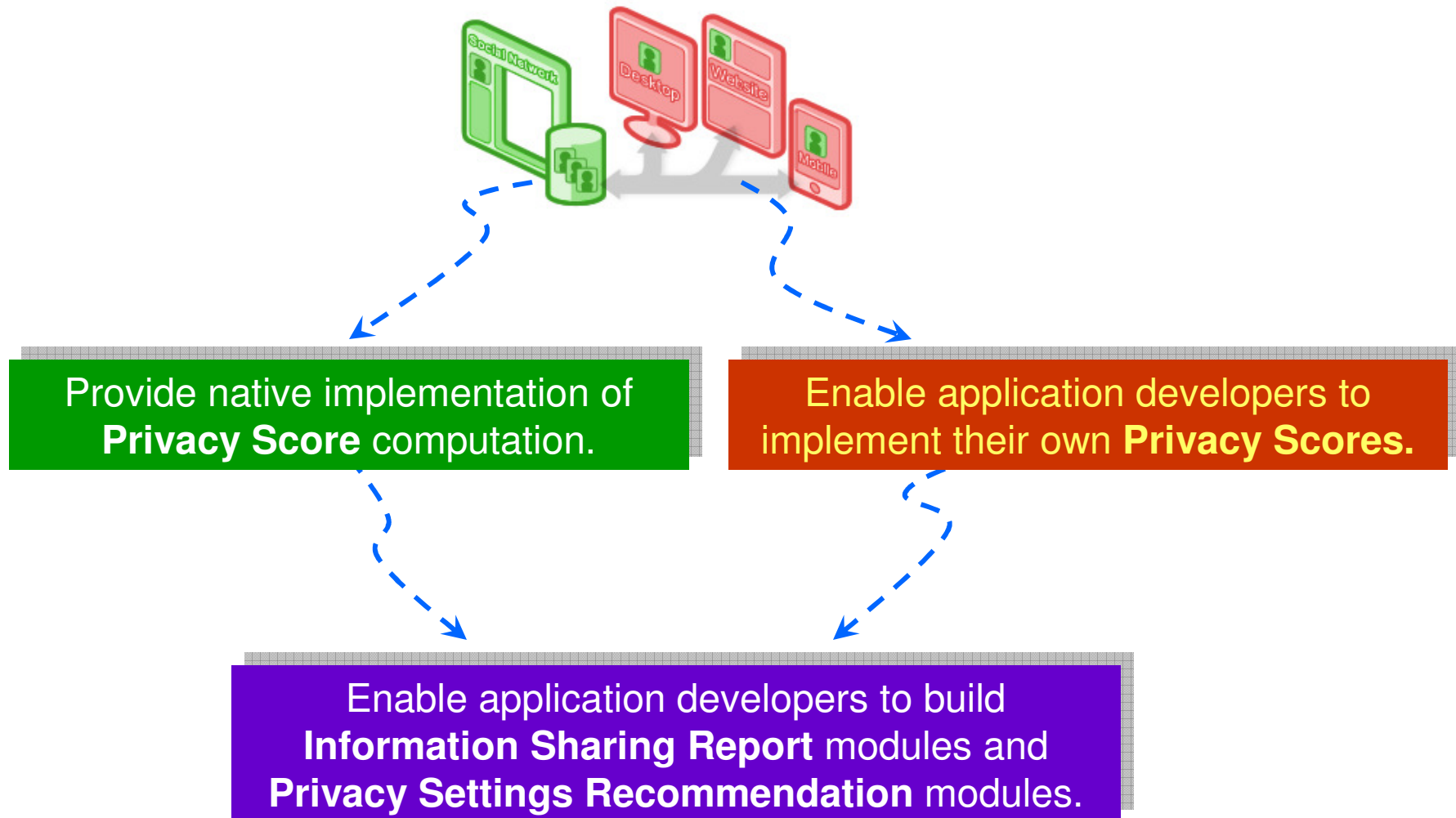
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Privacy Score and Facebook/OpenSocial



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Privacy-aware Marketplace (PaMP)

The screenshot displays the Facebook Privacy Settings page for a user named Kun Liu. The page title is "Privacy-aware Market Place". Under the "Choose Privacy Settings" section, there are two options: "Profile" (User Profile) and "Item" (Items for posting). Below this, the "Privacy Score" section explains that the Recommended Privacy Score is provided. It shows two gauges: "Current" with a score of 26 and "Recommended" with a score of 25. A button labeled "Change to Recommended Privacy" is located below the gauges.

facebook Home Profile Friends Inbox Kun Liu Settings

Invite your friends | My Profile < (please update all fields) > | My Privacy | Contact us | FAQs Help

Privacy-aware Market Place

Home Add a new post My posts Admin About

Choose Privacy Settings

Profile User Profile Item Items for posting

Privacy Score

The Recommended Privacy Score is provided for you. Note that if your current privacy score is lower than your recommended privacy then that implies your current settings are more private.

Current Recommended

26 25

Change to Recommended Privacy

Conclusions

- In this talk, we have discussed
 - the importance of privacy score and privacy management
 - two ways to compute privacy score using privacy settings
- Our goal is to develop a mechanism and a platform that will
 - Measure/monitor the privacy risk of social-networking users
 - Boost public awareness of privacy
 - Help users to easily manage their information sharing
- We believe that
 - simple and effective privacy management makes one feels safe and comfortable about sharing information online, which will eventually facilitate the information sharing and integration.

Thank you and Questions?