Privacy in Online Social Networks - Part I

Outline

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- Trust models based on subjective logic
- Trust Network Analysis

Part II

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- Combining Trust and Reputation
- Trust Derivation Based on Trust Comparisons
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Online Social Networks

Definition of online social networks

- Professor J. A. Barnes has introduced the term “Social Network” in 1967 - to describe the **associations of people drawn together by family, work, hobby etc. for emotional, instrumental, appraisal and information support.**
- The **first online social networks** were called **UseNet Newsgroups** designed and built by Duke University graduate students Tom Truscott and Jim Ellis in 1979.
- A January 2009 compete.com study ranked **Facebook** as the **most used social network** by worldwide monthly active users (MAU).

Rank	Site	Monthly visit
1	facebook.com	1,191,373,339
2	myspace.com	810,153,536
3	twitter.com	54,218,731
4	flixster.com	53,389,974
5	linkedin.com	42,744,438

Table 22.2 Top ten mostly visited social networks in Jan’09– based on MAU

Growth rate of Monthly Active Users of Facebook – Feb 2010

Table 22.3 Country wise monthly growth of Facebook users- as on Feb 2010

Country	1/1/2010	1/2/2010	Change	Change (%)
U.S.	102,681,240	108,062,900	5,381,660	5
Indonesia	15,301,280	17,301,760	2,000,480	13
Turkey	16,961,140	18,556,840	1,595,700	9
U.K.	23,076,700	24,342,820	1,266,120	5
France	14,301,020	15,498,220	1,197,200	8
Mexico	6,671,560	7,624,120	952,560	14
Germany	5,796,940	6,674,740	877,800	15
India	5,658,080	6,342,800	684,720	12

Trust in Online Environment

Trust in Online Environment – Problem with defining trust

- **Trust** has become **important topic of research** in many fields including sociology, psychology, philosophy, economics, business, law and IT.
- Trust is a **complex word** with **multiple dimensions**.
- Though dozens of proposed definitions are available in the literature, a **complete formal unambiguous definition** of trust is **rare**.
- In many occasions, **trust is used as a word or concept** with **no real definition**.

Trust in Online Environment – Two types of trust

- **Hussain and Chang** present an **overview of the definitions** of the terms of **trust and reputation** from the existing literature.
- They have shown that none of these definitions is fully capable to satisfy all of the
  - context dependence
  - time dependence
  - dynamic nature of trust
- Two generalized definitions of trust was defined by **Jøsang et al.**
  - Reliability trust aka "evaluation trust"
  - Decision trust

Trust in Online Environment – Evaluation trust and decision trust

Evaluation trust

- **Evaluation trust** can be interpreted as the **reliability of something or somebody**.
- It can be defined as the subjective probability by which an individual, A, expects that another individual, B, performs a given action on which its welfare depends.

Decision trust

- Decision trust captures broader concept of trust.
- It can be defined as the extent to which one party is willing to depend on something or somebody in a given situation with a feeling of relative security, even though negative consequences are possible.

Trust in online environment

- Trust is a social phenomenon - the model of trust for the artificial world like Internet should be based on how trust works between people in society.
- Mui et al. proposed a computational model based on sociological and biological understanding.
  - The model can be used to calculate agent's trust and reputation scores.
  - They also identified some weaknesses of the trust and reputation study which is the lack of differentiation of trust and reputation and the mechanism for inference between them is not explicit.
- Pujol et al. proposed a method for calculating the reputation of a given member in a society or in a social network by making use of PageRank algorithm.

Trust Models Based on Subjective Logic

Trust Models Based on Subjective Logic

- **Subjective logic** is a type of **probabilistic logic** that explicitly takes **uncertainty and belief ownership** into account.
- **Arguments** in subjective logic are **subjective opinions about states in a state space.**
- A **binomial opinion** applies to a **single proposition**, and can be represented as a **Beta distribution.**
- A **multinomial opinion** applies to a **collection of propositions**, and can be represented as a **Dirichlet distribution.**

Trust Models Based on Subjective Logic

- Subjective logic defines a trust metric called *opinion* denoted by

$$\omega_X^A = (\vec{b}, u, \vec{a})$$

- expresses the relying party A's belief over a state space X.
- Here b (vector) refers belief masses over the states of X
- *u* represent uncertainty mass .
- Such that b (vector) € [0, 1] and $\sum \vec{b} + u = 1$
- The vector $\vec{a} \in [0, 1]$ represents the base rates over X
- It is used for computing the probability expectation value of a state x as
- E(x) = $\vec{b}(x) + \vec{a}(x)u,$
- a (vector) determines how uncertainty contributes to E(x).

Trust Models Based on Subjective Logic

- Binomial opinions are expressed as $\omega_x^A = (b, d, u, a)$ where d denotes disbelief in x.
- When the statement x for example says ***"David is honest and reliable"***, then the opinion can be interpreted as **reliability trust** in David.
- As an example, let us assume that Alice needs to get her car serviced, and that she asks Bob to recommend a good car mechanic.
- **When Bob recommends David, Alice would like to get a second opinion, so she asks Claire for her opinion about David.**

Trust Models Based on Subjective Logic - Operators

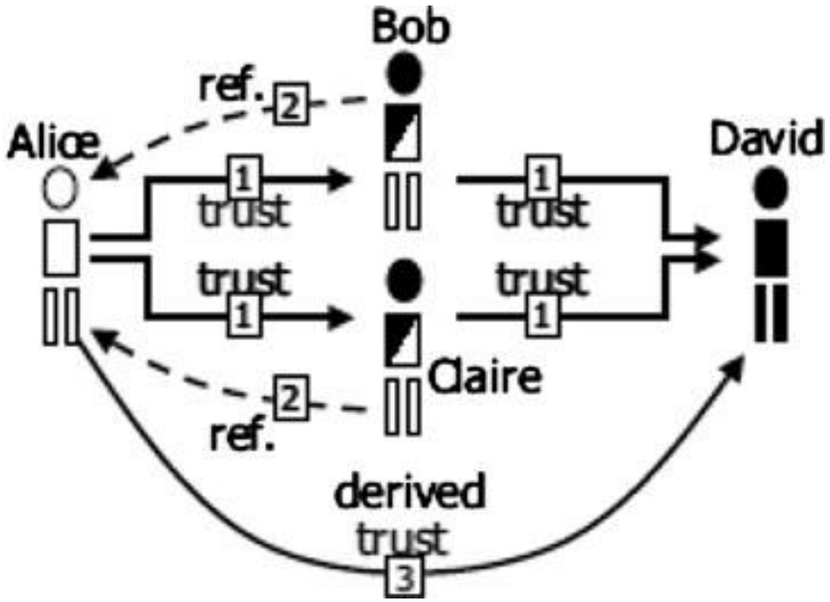
- When trust and referrals are expressed as subjective opinions, each transitive trust path **Alice → Bob → David**, and **Alice → Claire → David** can be computed with the transitivity operator.
- The referrals from Bob and Claire are discounted as a function Alice's trust in Bob and Claire respectively.
- 

Fig. 22.1 Deriving trust from parallel transitive chains

Trust Models Based on Subjective Logic – Operators for Relationships

- Finally the **two paths** can be **combined** using the **cumulative or averaging fusion operator**.
- These operators form part of ***Subjective Logic***.
- Semantic constraints must be satisfied in order for the transitive trust derivation to be meaningful .
- A **trust relationship** between A and B is denoted as **[A:B]**.
- The **transitivity** of two arcs is denoted as "**:**"
- The **fusion** of **two parallel paths** is denoted as "**◇**".

$$[A, D] = ([A, B] : [B, D]) \diamond ([A, C] : [C, D])$$

Trust Models Based on Subjective Logic – Operators for Opinions

- The corresponding transitivity operator for opinions denoted as $\otimes$
- The corresponding fusion operator as $\oplus$.
- The mathematical expression for combining the opinions about the trust relationships of the Alice scenario is:

$$\omega_D^A = \left(\omega_B^A \otimes \omega_D^B\right) \oplus \left(\omega_C^A \otimes \omega_D^C\right)$$

Trust Network Analysis

Trust Network Analysis

- **Trust networks** consist of **transitive trust relationships** between people, organizations and software agents **connected** through **a medium for communication and interaction**.
- By formalizing trust relationships, trust between parties within a domain can be derived by analyzing the trust paths linking the parties together.
- A method for **trust network analysis** using **subjective logic** (TNA-SL) has been described by **Jøsang et al**.
- TNA-SL takes **directed trust edges** between pairs as **input**, and can be used to **derive a level of trust between arbitrary parties** that are interconnected through the network.
- Even **if there are no explicit trust paths** between two parties , subjective logic allows a level of trust to be derived through the **default vacuous opinions**.
- TNA-SL therefore has a general applicability and is suitable for many types of trust networks.

Trust Network Analysis - Limitation

- A potential limitation with the TNA-SL is that **complex trust network must be simplified to *series-parallel* networks** in order for TNA-SL to produce consistent results.
- **The simplification consisted of gradually removing the least certain trust paths until the whole network can be represented in a series-parallel form.**
- As this process removes information it is intuitively **sub-optimal**.

Trust Network Analysis - *Operators for Deriving Trust*

- **Subjective logic** is a **belief calculus** specifically developed for modeling trust relationships.
- In subjective logic, **beliefs** are represented on **binary state spaces**, where each of the two possible states can consist of sub-states.
- **Belief functions on binary state spaces are called subjective opinions and are formally expressed in the form of an ordered tuple**

$$\omega_x^A = (b,\ d,\ u,\ a)$$

- where b, d, and *u* represent belief, disbelief and uncertainty respectively.

$$b,\ d,\ u \in [0,1] \text{ and } b + d + u = 1.$$

Trust Network Analysis - *Operators for Deriving Trust*

- The base rate parameter a € [0, 1] represents the base rate probability in the absence of evidence
- It is used for computing an opinion's probability expectation value.

$$\mathrm{E}\left(\omega_x^A\right) = b + au.$$

- **a** determines how uncertainty shall contribute to $E\left(\omega_x^A\right)$
- A subjective opinion is interpreted as an agent A's belief in the truth of statement x.
- Ownership of an opinion is represented as a superscript so that for example A's opinion about x is denoted as ω_x^A

Method 1 : Compute Trust using Transitivity

- *Transitivity* is used to compute trust along a chain of trust edges.
- Assume two agents A and B where A has referral trust in B, denoted by ω_B^A

for the purpose of judging the functional or referral trustworthiness of C.

- In addition B has functional or referral trust in C, denoted by ω_C^B
- Agent A can then derive her trust in C by discounting B's trust in C with A's trust in B, denoted by $\omega_C^{A:B}$

$$\omega_C^{A:B} = \omega_B^A \otimes \omega_C^B \begin{cases} b_C^{A:B} = b_B^A b_C^B \\ d_C^{A:B} = b_B^A d_C^B \\ u_C^{A:B} = d_B^A + u_B^A + b_B^A u_C^B \\ a_C^{A:B} = a_C^B . \end{cases}$$

- **Problem :** uncertainty increases, not disbelief

Method 2 : Compute Trust using Fusion

- Cumulative *Fusion* is equivalent to Bayesian updating in statistics.
- The cumulative fusion of two possibly conflicting opinions is an opinion that reflects both opinions in a fair and equal way.
- Let ω_C^A and ω_C^B be A's and B's trust in C respectively.

The opinion $\omega_C^{A\diamond B}$ is then called the fused trust between ω_C^A and ω_C^B,

$$\omega_C^{A\diamond B} = \omega_B^A \oplus \omega_C^B \begin{cases} b_C^{A\diamond B} = (b_C^A u_C^B + b_C^B u_C^A)/\left(u_C^A + u_C^B - u_C^A u_C^B\right) \\ d_C^{A\diamond B} = (d_C^A u_C^B + d_C^B u_C^A)/\left(u_C^A + u_C^B - u_C^A u_C^B\right) \\ u_C^{A\diamond B} = (u_C^A u_C^B)/\left(u_C^A + u_C^B - u_C^A u_C^B\right) \\ a_C^{A\diamond B} = a_C^A. \end{cases} \tag{22.4}$$

Method 2 : Compute Trust using Fusion

where it is assumed that $a_C^A = a_C^B$. Limits can be computed [40] for $u_C^A = u_C^B = 0$. The effect of the cumulative fusion operator is to amplify belief and disbelief and reduce uncertainty.

Trust Path Dependency and Network Simplification

- We will use basic constructs of directed graphs to represent transitive trust networks, and add some notation elements which allow us to express trust networks in a structured way.
- A **single trust relationship** can be expressed as a **directed edge between two nodes** that represent the **trust source** and the **trust target of that edge**.
- For example the **edge [A, B] means that A trusts B**.
- The symbol **":"** is used to denote the transitive connection of two consecutive trust edges to form a transitive trust path.

$$([A, D]) = ([A, B] : [B, C] : [C, D])$$

$$([A, D]) = (([A, B] : [B, D]) \diamond ([A, C] : [C, D]))$$

$$([A, D]) = (([A, B] : [B, D]) \diamond ([A, C] : [C, D]) \diamond ([A, B] : [B, C] : [C, D]))$$

Fig. 22.2 Network simplification by removing weakest path

Thank You