**From Social Trust Assisted Reciprocity (STAR) to Utility-Optimal Mobile Crowdsensing**

Xiaowen Gong\(^1\), Xu Chen\(^1\), Junshan Zhang\(^1\), H. Vincent Poor\(^2\)

\(^1\)School of Electrical, Computer, and Energy Engineering, Arizona State University, Tempe, AZ
\(^2\)Department of Electrical Engineering, Princeton University, Princeton, NJ

**Motivation & Challenge**

Effective *incentive design* is essential for realizing mobile crowdsensing, since sensing tasks incur overhead (e.g., resource consumption, privacy loss). Most existing work use a (virtual) currency to stimulate users to participate in crowdsensing, which typically incurs a high implementation overhead.

Social relationships increasingly influence people’s behaviors due to the explosive growth of online social networks. We exploit *Social Trust Assisted Reciprocity (STAR)*, a synergistic marriage of social trust and reciprocity.

**STAR: Social Trust Assisted Reciprocity based Incentive Mechanism**

**System model**

- Users’ sensing requests are modeled by a request graph; the flow on a request edge represents the amount of sensing service provided by a user to another
- Social trust structure among users is modeled by a social graph; the flow on a social edge represents the amount of social credit transferred from a user to another, and is constrained by the social credit limit

A social trust assisted reciprocity cycle is a directed cycle in the social-request graph. The aggregate flow of balanced flows along STAR cycles should satisfy the capacity constraints:

\[
-S_{ij} \leq f_{ij}^S \leq S_{ij}, \quad f_{ij}^S = -f_{ji}^S, \quad \forall e_{ij} \in E^S
\]

\[0 \leq f_{ij}^R \leq R_{ij}, \quad \forall e_{ij} \in E^R.
\]

**Conditions for satisfying all sensing requests**

Define users’ request surplus/deficiency and the aggregate surplus/deficiency. Based on this we construct an extended social graph.

\[
P_i = \sum_{j: e_{ij} \in E^R} R_{ji} - \sum_{j: e_{ij} \in E^S} R_{ij} + P_i = \sum_{i: P_i > 0} P_i - \sum_{i: P_i < 0} P_i
\]

**Theorem:** All sensing requests can be satisfied under STAR if and only if \( P \) is equal to the maximum flow value from \( s \) to \( d \) in the extended social graph.

**Utility maximization for sensing service**

The maximum utility of sensing service provided under STAR is equal to the maximum utility of a circulation flow in the social-request graph:

\[
\text{maximize } \sum_{i,j: e_{ij} \in E^R} U_{ij} f_{ij}^R
\]

subject to constraints (1), (2), (3).

**Algorithm 1:** Find the optimal flow for problem (4) in social-request graph \( G \)

input : Social-request graph \( G \)

output: The optimal flow for problem \( (4) \)

1. Initialize an empty flow \( f \) in \( G \);
2. while There exists a cycle of positive weight in the residual graph \( G_f \) of flow \( f \) do
3. Find a cycle \( c \) of positive weight in \( G_f \);
4. Compute the residual capacity \( r_c \) of cycle \( c \);
5. Augment flow \( f \) with a balanced flow of value \( r_c \) along cycle \( c \);
6. end
7. return Flow \( f \);