SOCIAL ON THE ROAD: ENABLING SECURE AND EFFICIENT SOCIAL NETWORKING ON HIGHWAYS

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ABSTRACT

This article presents SOR, a vehicular social network to enable social communications and interactions among users on the road during their highway travels. Motivated by the limited connection to Internet contents and services, the essential goal of SOR is to encourage distributed users on the road to spontaneously contribute as the information producer, assembler, and distributer in order to provide timely and localized infotainments to each other through low-cost inter-vehicle communications. To be specific, SOR enables individual users to maintain a personal blog, similar to one on Facebook and Twitter, over which users can create and share personal content information to the public such as travel blogs with pictures and videos. By accessing each other's SOR blogs and commenting on interesting topics, passengers can exchange messages and initiate social interactions. In the specific highway environment, SOR addresses two challenges in the context of vehicular social communications. First, vehicular social communications tend to be frequently interrupted by diverse vehicle mobility and intermittent intervehicle connections, which is annoying to users. To address this issue, SOR adopts a proactive mechanism by estimating the connection time between peer vehicles, and recommending vehicles with relatively long-lasting and stable intervehicle connections for social communications. Second, as users on the road are typically strangers to each other, they are reluctant to disclose personal information to others. This makes it challenging to identify users of shared interests and accordingly restricts the scale of users' social interactions. To remedy that, SOR provides a secured solution to protect sensitive user information during social communications. Lastly, we use simulations to verify the performance of SOR.

INTRODUCTION

People have strong social instincts and are closely connected with each other in a variety of ways. By exploiting different aspects of these social features, social networking and applications have recently achieved immense success and popularity.

As to vehicle travelers on the road, communicating with each other over social networks can be an even more attractive and effective venue for infotainments (e.g., trip planning/guidance, information sharing, and mutual support on the road). To be concrete, direct inquiry of others with similar experience in proximity over social networks [1] tends to be the most convenient and efficient approach to acquire up-to-date, specialized, and domain-specific content and information for travelers. Meanwhile, it has been shown that travelers have strong willingness to share their experiences and joy in traveling through social networks. Such a phenomenon can readily be demonstrated by a recent survey of TripAdvisor,[1] in which 76 percent of 1700 respondents are reported to share travel experiences via social networks, and 91 percent among them post photos of their vacations. Furthermore, 42 percent of respondents use social media for travel planning, and 37 percent think social networks have made their travel planning easier. Note that on road trips, travelers in proximity tend to have shared interests on the local information, inquire about related contents, and encounter similar issues. Therefore, to provide efficient social communications among them and connect people as a community on the road is an efficient means of information sharing and mutual support.

While social networking has already proliferated in the Internet user community, social communications and low-cost infotainment services on highways are still not available or very limited to vehicle passengers. This is mainly attributed to the limitation of high-rate Internet connections on the road. Using traditional cellular networks, not only is the aggregate bandwidth per user very limited due to the need to serve a large population of users simultaneously, but also the bandwidth cost is high, which is prohibitive to bandwidth consuming social applications (e.g., travel experience sharing with rich images and video clips). Moreover, as highways often pass through sparsely populated rural areas, cellular base stations tend to be sparsely deployed due to cost concerns, resulting in limited network coverage and frequent connection interruptions. For similar reasons, high-rate and ubiquitous connections to other infrastructure networks on highways (e.g., WiFi hotspots and

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[1] See "TripAdvisor Survey Reveals Three Quarters of U.S. Travelers Sharing Trip Experiences on Social Networks."

roadside units in vehicular networks) tend to be a distant objective to reach. Without high-rate and ubiquitous connections to the Internet, or equivalently Internet-based social and infotainment services, a localized social network, which explores low-cost infrastructureless intervehicular communications and relies on distributed vehicles in proximity for information production, assembling, and disseminating, is thus desirable.

Toward this goal, we present SOR, a distributed social network to facilitate social communications among fast-motion vehicular users[2] on highways. SOR enables social messaging and information exchange among vehicles through distributed intervehicle communications (IVC). Using SOR, each vehicular user maintains a personal blog, like those on Facebook and Twitter, to post user-generated information to the public. Over wireless IVC links, users in different vehicles are then able to access each other's blogs and explore desired contents. By commenting on the posts of others and leaving messages, users can exchange information and initiate social interactions among each other. Consider a motivating example where Bob and David are both heading to Toronto for an international film festival, but reside in different vehicles and are unknown to each other. By accessing each other's blogs in SOR, they may become familiar, and share their information and experience on the road. With the same purpose of traveling, they may also become friends and attend the event together. In this process, SOR is self-organized in a fully distributed manner without the assistance of any infrastructure.

In the remainder of the article, we describe the detailed design of SOR. We first review the recent literature on enabling mobile and vehicular social communications, and then discuss the features and challenges of social communications in the vehicular environment. After that, we describe the building blocks of SOR to achieve the design goals of efficient and secure vehicular social communications. We then verify SOR using simulations, and lastly close the article with conclusions and discussions on future work.

Related Work on Mobile and Vehicular Social Networks

Mobile Social Networks

Mobile devices of ubiquitous connections to cellular networks have made people indulge in social communications anywhere on the go. Thanks to the rich and powerful sensing and processing capabilities of mobile devices, various mobile social networks and services, as categorized below, have emerged that significantly extend the known types of social services and applications in our lives.

***Explore Location Information with Location-Based Services* —** Based on geometric location of mobile users, location-based mobile social applications provide timely, relevant, and engaging social contents and information based on the specific location of users, such as social friends nearby (e.g., MobiLuck [2]), desired social sites and events (e.g., Micro-Blog [3]), and potential social friends and shared interests (e.g., E-SmallTalker [4]).

***Explore Mobility Information for Content Relay and Dissemination* —** The distinct social ties and interactions of mobile users lead to heterogenous mobility patterns. Exploiting the diversity of user mobility and social features for content relay is a promising and efficient scheme in wireless networks when the end-to-end path between the content sender and receiver is not available, and the data relay is necessary. For example, [5] exploits the mobility of super users in the social network to optimize content delivery among social communities via a traveling salesman model. Reference [6] develops a privacy preserving content relay scheme that protects sensitive location and mobility information of social users while not degrading delivery performance.

***Explore Crowd Sensing and Processing Capabilities for Crowd Sensing, Sourcing, and Searching Applications* —** The ubiquitous adoption of mobile devices worldwide and their close connections to human lives make the mobile user crowd a valuable source for data sensing, searching, and processing. Crowdsensing relies on ubiquitous mobile devices to collect data on the go and extract information at central servers to measure social phenomena and interests. For example, [7] collects the communication records of mobile phones to estimate the presence of visitors in a city, and help urban studies and tourism planning. Crowdsourcing is a means of problem solving by outsourcing tasks to a large group of people, and crowdsearching exploits the experience and knowledge of distributed mobile users for content searching. For example, [8] employs crowdsourcing to capture users' expectations on sensitive information exposed to mobile apps and enable privacy preservation. PeopleNet [1] is a crowdsearching application that relies distributed mobile users to relay search queries among each other in a peer-to-peer manner until finding the matching result.

Vehicular Social Networks

While many emerging mobile social networks as aforementioned can readily be used to serve vehicle users as well, in the specific context of the vehicular environment, the vehicular social network, which is dedicated to drivers and back seat passengers, can provide more specialized services for road traveling related to road traffic monitoring, travel plans, and intelligent transportation.

Drive and share (DaS) [9] is a vehicular social application installed on the mobile phones of users aboard vehicles. Using ubiquitous connections to cellular networks, DaS assists drivers and passengers in exchanging location-based information on the road, such as road traffic and social infotainment information.

RoadSpeak [10] connects distributed vehicular users through Internet infrastructure to form voice chat groups based on their locations and interests. Users of the same voice chat group are able to communicate on the road through voice chat messages.

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[2] We use vehicular users and travelers interchangeably in the article to refer to the passengers on board vehicles. SOR targets to serve passengers, rather than drivers.

Unlike online social networks, for example, Facebook, where the connected users are typically already known to each other in the real-world or closely associated with certain social tie, the users on the highways are anonymous and unknown to each other before the contacts.

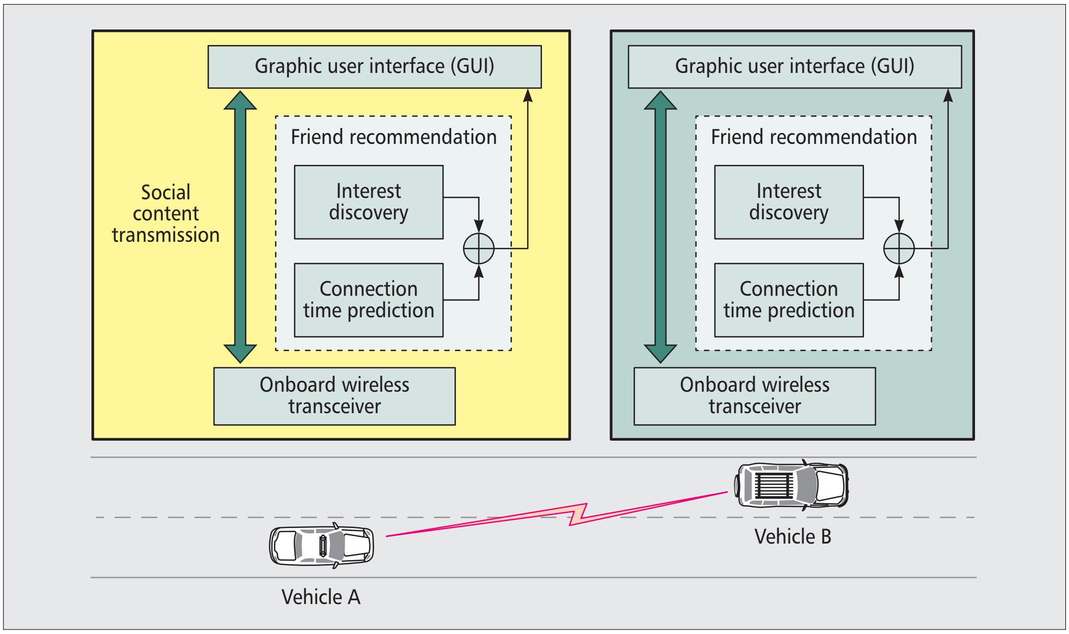

Figure 1. Building blocks of SOR.

IC NoW [11] provides a generic framework to support futuristic information-rich vehicular network applications, including social communications, safety applications, location-based services, city-wide alerts, and interactive services. The applications are delivered based on the spatial, temporal, and interest scope of vehicular users, which define the area, time, and targeted vehicles of data spreading, respectively. IC NoW is an integrated system built on the IP protocol stack with the support of cellular network infrastructure.

Toyota lunched Toyota Friend [12], an in-car private social network for Toyota owners in Toyota's electric vehicles in 2012. It allows drivers to interact with their cars in ways similar to Twitter and Facebook through PCs, tablets, and smartphones. Via Toyota Friends, drivers can connect to their dealers to get maintenance tips and service information, and set up appointments for inspections. They are also connected to their cars and receive alerts on their smartphones, similar to Tweets, when a car's battery needs recharging.

Features and Design Challenges of SOR

Most existing proposals as described above require users to have ubiquitous Internet connections. This, however, is not practical or is very expensive for highway travelers. To address this issue, SOR is an infrastructureless system relying on fully distributed IVC only. Constrained by the limited coverage of IVC, SOR is a proximity-based social network where the connected users must be in physical proximity. The location proximity and highway application scenarios have accordingly rendered the following unique features and engineering challenges to distributed vehicular social networking in general and SOR in specific:

***Users Have Shared Interests Due to Location Proximity* —** Due to location proximity, vehicular users tend to be interested in similar regional information, such as road traffic information, weather conditions, and regional news. In addition to that, as users on the highway may commute between the same cities, they may travel with similar goals, shared experiences and interests of trips, and similar social, education, racial and religious backgrounds, potentially associated with related communities. These features enable them to have common interests and drive them to connect.

***Users Are Unknown and Anonymous to Each Other* —** Unlike online social networks such as Facebook, where connected users typically already know each other in the real-world or are closely associated through certain social ties, users on highways are anonymous and unknown to each other before contact. They are driven to connect due to the constrained wireless connectivity and potential common interests. In this case, the key issue is how to efficiently explore shared interests among users and identify the appropriate social friends for users in proximity. Moreover, as interests and friend discovery may expose users' personal information to the unknown public to some extent, it is of paramount importance to protect the sensitive privacy information of individuals while not hindering the search for social friends and interesting topics during social communications.

***Communications Are Hampered by Short-Lived Connectivity* —** Stable communication connections are prerequisite to meaningful social communications. However, this is hard to achieve in highway vehicular environments; with users staying in fast-moving vehicles, the connectivity among them is susceptible to frequent interruptions due to heterogenous velocities and driving habits. Therefore, to enable effective social communications among vehicles requires long-lasting connections for social contracts to be established.

To address the aforementioned challenges and features, SOR targets the achievement of the following two design goals from the aspects of efficiency and security of social communications. First, to address the anonymity and dynamic features of vehicular social communications, SOR aims to connect users in proximity with both reliable V2V connections and shared interests as social friends. Second, as users are concerned about disclosing personal and privacy information to the public, SOR is motivated to protect the sensitive information and privacy of users without interrupting their opportunities to exploit interesting social contents and interactions.

Building Blocks of SOR

SOR is essentially a software program installed on vehicles to enable distributed social communications among vehicle passengers during their highway travels. Figure 1 exhibits the structure of SOR in individual vehicles, which is composed of three blocks.

Graphic User Interface (GUI) — This block provides the interfaces for the vehicular user to:
- Publish content information to public and meanwhile download and browse the content files and information posted by social friends
- Configure the policies for friend selection and manage the personal information exposed to the public

Interest Matching — This block explores potential social friends by comparing the social interests of vehicular users in proximity.

Connection Time Predication — Based on the velocities of vehicles, this block estimates the connection time of V2V connections between users in proximity. By doing so, vehicles with long connection times will be highlighted through the GUI and recommended for social interactions.

As shown in Fig. 1, the interest matching block works with the connection time prediction blocks to elect the qualified neighboring vehicular users and recommend them to SOR owners for connections through the GUI. The social communications and message exchanges are conducted through the onboard wireless transceivers among vehicles. In what follows, we elaborate on the detailed design of each block.

Graphic User Interface

Figure 2 illustrates an example of a GUI in SOR, which can be divided into four panes.

Pane 1: This part lists the toolbar of SOR, allowing users to configure the software, including the personal information exposed to public (e.g., nickname, gender, etc.) and criteria for friend explorations.

Pane 2: This part exhibits the blog information posted by the user and connected social friends selected by the users in pane 4. By clicking on the specific items, the user can retrieve the corresponding contents from its publisher for browsing and making comments.

Pane 3: This part lists the content files, such as MP3 songs and video clips, and so on, shared by the selected social friend in pane 4. By clicking specific files, the user can download the files to their local buffer for playback.

Pane 4: This part lists the nearby vehicular users in proximity. They are ranked and highlighted in different colors based on the attractiveness of the content information posted, and the reliability of their connection to the user. The two metrics are evaluated by the interest matching and connection time prediction blocks, respectively.

Interest Matching

To facilitate the social communication, SOR requires each user to indicate his/her interests represented by a social interest profile I. Each element of I is a binary variable indicating one specific item of social interest of the user. For example, assuming that the social interest profile of a user is $I = \{1, 0, 1, 0\}$, with the four elements in sequence corresponding to {*Hockey*, *Soccer*, *Political News*, *World News*}. This implies that the user is interested in playing hockey and reading world news, but dislikes soccer games and political news. The social interest profile of each user can be either input manually by the user or acquired from the online social networks where the user has provided similar information. It can also be additively built based on the blog information posted or accessed by the user. For example, a user who frequently reads, shares, and comments on sport contents will be automatically denoted as interested in sports in I by SOR.

Based on the social interest profile I posted by each user, the interest matching block compares the similarity of social interests among users and then makes recommendations accordingly on social contacts based on this result. Evaluating the similarity of social interests has been studied extensively in the context of online social networks. In SOR, we implement the vector space model (VSM) as described in [13]. Specifically, let $I_X = \{I_{X,i}\}_{1\times n}$ denote the social interest profile of vehicle X, where the dimension of social interest profile, n, is the same to all vehicles, and $I_{X,i} \in \{0,1\}$ with $1 \le i \le n$. The interest similarity between vehicles A and B is evaluated as

$$sim(A,B) = \frac{\sum_{k=1}^{n} I_{A,k} I_{B,k}}{\sqrt{\sum_{i=1}^{n} I_{A,i}^2}\sqrt{\sum_{j=1}^{n} I_{B,j}^2}}. \quad (1)$$

In Eq. 1, $sim(A, B)$ is 1 if the corresponding elements of I_A and I_B match exactly, indicating the strong similarity and high potential of common interests between A and B; $sim(A, B)$ is 0 if none of the interest attributes between A and B match.

Connection Time Prediction

At a given time t_0, let T denote the connection time between two vehicles (e.g., A and B), which starts at t_0 until the distance between A and B exceeds the communication coverage R. Apparently, T is a random variable that is dependent on the initial distance, denoted by r, between vehicles A and B at initial time t_0, and the velocities of the

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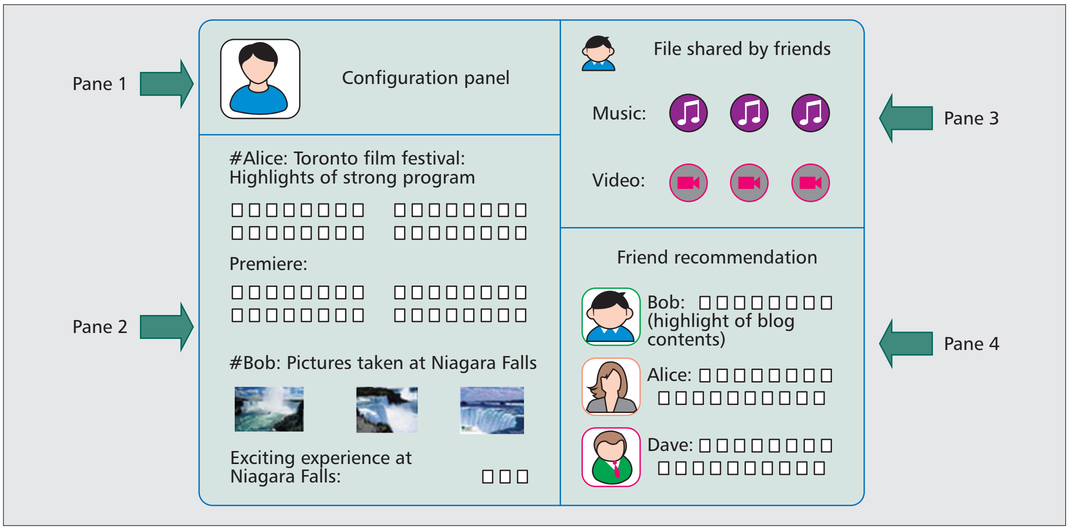

Figure 2. Example of SOR GUI.

two vehicles. Let υ_A, α_A (resp. υ_B, α_B) denote the mean and variance of vehicle A's (resp. B's) velocity. By modeling the distance between vehicles A and B as a Wiener process [14], the probability that the connection is still available after a given period P can be calculated as

$$P(\phi) = \Pr\{T \geq \phi\} = \int_{-R}^{R} p(x \mid d_0, \phi)\, dx, \quad (2)$$

where $p(x|r, t)$ is the probability density function of the distance between A and B, mathematically [14, p. 222]

$$p(x \mid r, t) = \frac{1}{\sigma\sqrt{2\pi t}} \sum_{n=-\infty}^{\infty} \left[\exp\left\{ \frac{\mu x'_n}{\sigma^2} - \frac{[(x-r) - x'_n - \mu t]^2}{2\sigma^2 t} \right\} - \exp\left\{ \frac{\mu x''_n}{\sigma^2} - \frac{[(x-r) - x''_n - \mu t]^2}{2\sigma^2 t} \right\} \right], \quad (3)$$

with $x'_n = 4nR$ and $x''_n = 2R - x'_n$. $\sigma^2 = \alpha_A + \alpha_B$ and $\mu = \upsilon_A - \upsilon_B$.

Friend Recommendation

Based on the results of interest similarity and connection time, the SOR software periodically evaluates a social contact score at intervals of δ for each vehicle in the radio coverage of the host user.

Let $S_{A,B}$ denote the social contact score of vehicle B investigated from vehicle A. In essence, the social contact score $S_{A,B}$ evaluates the probability that within the interval of δ the host, vehicle A, can establish a reliable social connection for information retrieval from vehicle B. It has an expression as $S_{A,B} = sim(A, B) \times P(\delta)$ where $sim(A, B)$ is the interest similarity in Eq. 1, representing the likelihood that vehicle B has interesting contents for vehicle A. $P(\delta)$ is evaluated by Eq. 2, representing the probability that within an interval δ vehicles A and B are in mutual radio coverage.

Based on the social score values, the SOR software agent ranks nearby vehicles in descending order of the social contact score, and updates the rank periodically. The rank is shown to users through the GUI in pane 4, as shown in Fig. 2.

Privacy Preservation in Social Communications

In the process of interest matching, SOR requires users to compare the social interest profiles through Eq. 1 in order to measure the similarity of interests and explore potential social friends accordingly. This, however, may disclose sensitive information of individuals to the public (e.g., birthday, hobbies, professions, associations) and consequently violate the user's privacy. To tackle this issue, SOR is embedded with a privacy preserving interest matching scheme as proposed in [15], which evaluates the similarity of users' interests according to Eq. 1 without disclosing users' information to others. This proceeds with the following operations.

Consider the example shown in Fig. 1, where vehicle A intends to evaluate its similarity of interests between vehicle B according to Eq. 1. To this end, rather than sending its social interest profile I_A directly to vehicle B, A first executes the operations in step 1 of Algorithm 1 (Fig. 3) to convert I_A to a vector (α, β, c_i, c'_i), and then transmits the vector to vehicle B. As such, I_A is kept secret from vehicle B. Based on the vector (α, β, c_i, c'_i) received, vehicle B converts its social interest profile I_B to D and D', as in step 2 of Algorithm 1, and sends (D, D') to vehicle A. By doing so, I_B is unknown to vehicle A. With the operations in steps 1 and 2 of Algorithm 1, the scalar product $\Sigma_{k=1}^{n} I_{A,k} I_{B,k}$ in the numerator of Eq. 1 equals the coefficient of α^2 in the polynomial D. Vehicle A then evaluates $sim(A, B)$ based on step 3 of Fig. 3. In this process, as neither A nor B discloses its social interest profiles to the other, their privacy can be preserved.

Simulation Verification

This section evaluates the performance of SOR based on a customer simulator coded in C++. As shown in Fig. 1, we simulate a scenario in

Vehicle A | Vehicle B

Social interest profile $I_A = (I_{A,1}, (I_{A,2}, \ldots, I_{A,n}) \in F_2^n$ | Social interest profile $I_B = (I_{B,1}, (I_{B,2}, \ldots, I_{B,n}) \in F_2^n$

Step-1: Vehicle A

Choose three large primes α, β, ρ, where $|\alpha| = 160$, $|\beta| = 336$, $|\rho| = 512$, a large random $s \in Z_p$

For $i = 1, 2, \ldots, n$

choose two random numbers x_i, y_i, such that $x_i + y_i = \beta$

compute $c_i = \alpha \cdot I_{A,i} + x_i$, $c_i' = s \cdot y_i \bmod \rho$

End for

Keep $s^{-1} \bmod \rho$, β, send (α, ρ, $\{c_i, c_i'\}$), for $i = 1, 2, \ldots, n$ to vehicle B

Step-2: Vehicle B (assume not all $I_{B,i} = 1$)

For $i = 1, 2, \ldots, n$

If $I_{B,i} = 1$ then set $D_i = \alpha \cdot c_i$, $D_i' = \alpha \cdot c_i' \bmod \rho$

else if $I_{B,i} = 0$

set $D_i = r_i \cdot c_i$, $D_i' = r_i \cdot c_i' \bmod \rho$ where $r_i < \frac{\alpha}{n+1}$ is a random

end if

End for

Compute $D = \Sigma_{i=1}^n D_i + r \cdot \alpha$, where $r < \frac{\alpha}{n+1}$ is a random, and

$D' = \Sigma_{i=1}^n D_i' \bmod \rho$, send (D, D') back to vehicle A

Step-3: Vehicle A

Compute $E' = s^{-1} D' \bmod \rho = \Sigma_{bi=1} \alpha \cdot y_i + \Sigma_{bi=0} r_i \cdot y_i \bmod \rho$, from the parameter settings,

we know $\Sigma_{bi=1} \alpha \cdot y_i + \Sigma_{bi=0} r_i \cdot y_i < \rho$, thus $E' = \Sigma_{bi=1} \alpha \cdot y_i + \Sigma_{bi=0} r_i \cdot y_i$

Compute $E = (D + E') \bmod \beta$

Return $\frac{E\text{-}E \bmod \alpha^2}{\alpha^2}$ as the scalar product $I_A \cdot I_B = \Sigma_{i=0}^n I_{A,i} \cdot I_{B,i}$

Figure 3. Algorithm 1: Privacy-Preserving Interest Matching.

which two vehicles, A and B, move over a linear highway topology in physical proximity and are connected wirelessly for social communications. Their velocities at each time follow the normal distribution with the fixed mean value and variance. The communication range of vehicular communications is set to be 300 m. Assuming the known social interest profiles of A and B, and the statistics of A and B's velocities (i.e., mean and variance), we conduct two experiments:

- Validate the accuracy of Eq. 3 on estimating the connection time between two vehicles.
- Evaluate the execution time of secured interest matching.

In the first experiment, we set the mean value of B's velocity to be 110 km/h, and the standard deviation of vehicles A and B's velocity to be 33 km/h. We evaluate the connection probability $P(T \geq \phi)$ of vehicles A and B over time ϕ with different values of υ_A and r, respectively, and plot the results in Figs. 4 and 5, respectively. Intuitively, as υ_A is set greater than υ_B in the simulated scenario, by increasing υ_A, the connection time between A and B would reduce due to the enlarged difference of velocities. This is verified by Fig. 4. As we can see, when $\upsilon_A = 120$ km/h, the probability that the connection is still available after $\phi = 50$ s (i.e., $T \geq \phi$ is greater than $\phi = 100$ s) is around 0.72. When $\upsilon_A = 130$ km/h, the probability diminishes to 0.2 due to the enhanced mobility of A. Figure 5 shows the connection probability between A and B over time when $\upsilon_A = 120$ km/h and different values of r are applied. As we can see, when r increases from 0 m to 200 m, indicating the enlarged initial distance between A and B at the time for connection time prediction, the curves shift to the left side, indicating the decrease of probability that the connection is available at a given time.

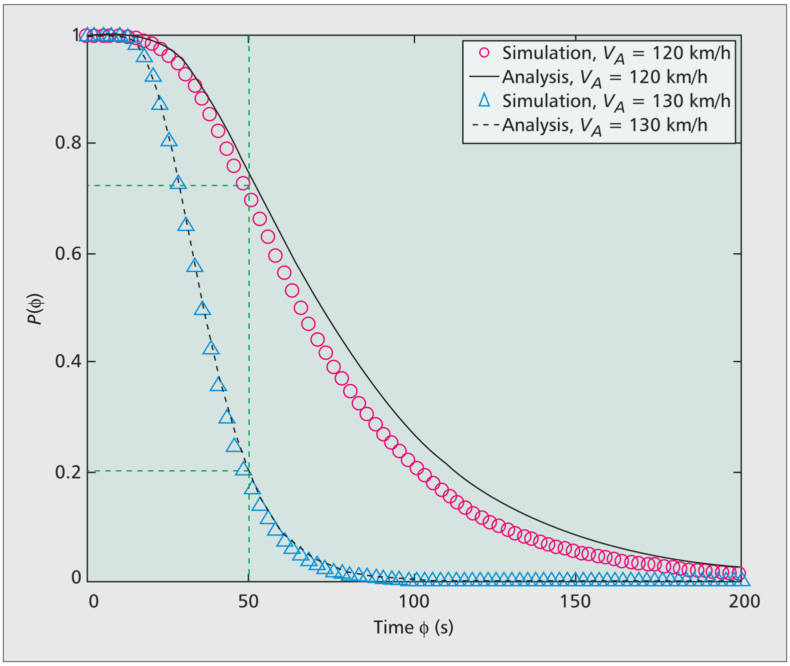

Figure 4. Distribution of distance between A and B with different υ_A.

In the next experiment, we evaluate the execution time of Algorithm 1 in Fig. 3 with different vector sizes of the social interest profile. To this end, we consider that I_A and I_B are known a priori with each element randomly selected from {0, 1}. The vector size n of I_A and I_B are adjusted from 10 to 100. For each particular n, we execute Algorithm 1 for 100 runs on the PC with CPU cycle of 2.5 GHz. Figure 6 shows the mean and standard deviation of the execution time of Algorithm 1, without considering the communication delay between A and B for information exchange. As we can see, with n increasing from $n = 10$ to $n = 100$, the execution time of Algorithm 1 remains almost the same in which the mean execution time is below 120 ms and the standard deviation remains below 60 ms. This indicates the scalability and efficiency of Algorithm 1.

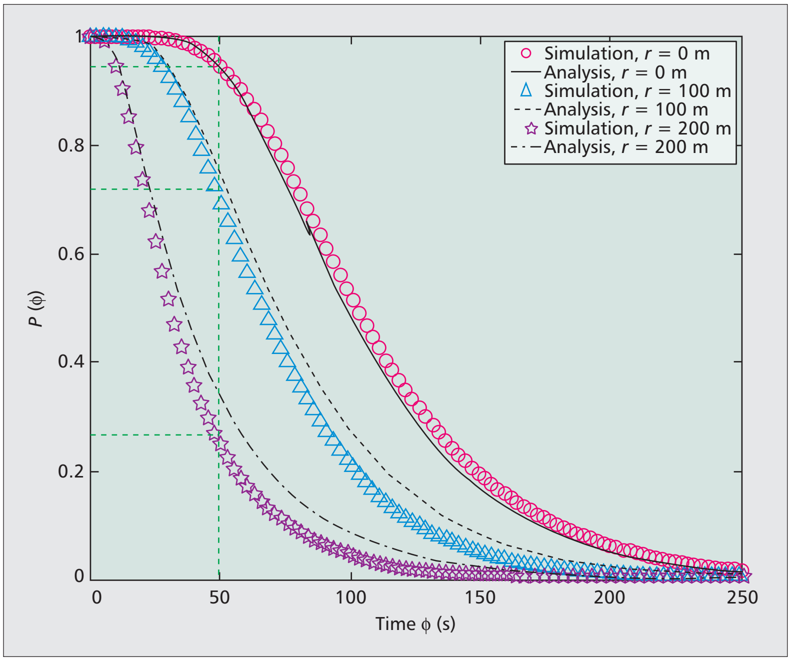

Figure 5. Distribution of distance between A and B with different r.

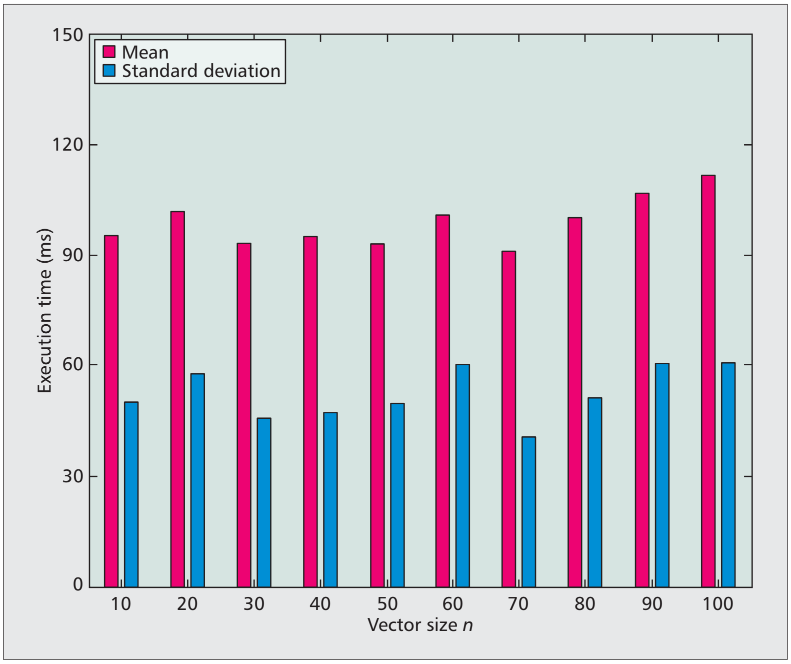

Figure 6. Execution time of Algorithm 1 in Fig. 3 with increasing size of I_A and I_B.

Conclusion and Future Work

We have introduced SOR, a vehicular proximity social network to facilitate social communications among vehicle passengers on highways. SOR addresses two challenges of vehicular social communications:

- Users are unknown to each other.
- The wireless connections among them are highly dynamic and intermittent.

To this end, SOR has been embedded an interest matching block to exploit potential social friends with shared interests, and a connection time prediction block to recommend users with relatively longer connection times for social interactions. Note that the interest matching operation requires users to indicate their social interests to others for evaluating the similarity of interests. This may disclose sensitive personal information if inappropriately managed, thus violating important user privacy. To tackle this issue, SOR has employed a privacy preserving mechanism that avoids the direct transmission of users' social interests to others and therefore ensures user privacy.

This article represents the initial step toward infrastructureless vehicular social communications. There are many open issues that deserve in-depth investigations.

Media-Rich Social Services — The secured interest matching and connection time prediction blocks in SOR provide the basis for distributed vehicular social communications on the highway. Based on the social interests, mobility and bandwidth availability among users, advanced social applications/services can be devised to enable the media-rich social communications among pairs (e.g., online gaming, video streaming, and telephony among social friends) or within a group (e.g., information broadcast to a social group of shared interests). With users belonging to different social groups and subscribing to different social services coexisting in proximity, how to schedule the wireless medium access of vehicles to achieve the best service quality is a challenging issue.

Integration to Infrastructure-Based Social Networks — SOR is an infrastructureless social network that relies on the distributed intervehicle communications. When the infrastructure connections to the Internet are available, SOR can be incorporated with the online social networks and infrastructure-based mobile social networks to facilitate proximity-based social communications with extensive services, such as travel planning, vehicle route optimization, and location attraction exploration. As such, how to integrate the different social network applications is challenging. Moreover, SOR can also be used to offload the traffic load and bandwidth cost of infrastructure-based social networks. In this case, how to economically utilize the infrastructure connection and fully explore the distributed intervehicle connection in SOR to provide users with cost-effective and high-quality services is an open issue.

Security Attacks in Vehicular Social Communication — SOR addresses the fundamental privacy preservation issue to protect the social interest information of users during social communications. However, there are many other potential attacks related to vehicular social communications. For example, a user may over-claim its social interests by making all the elements on his/her social interest profile equal to 1 to lure others for connection. When required to upload contents or social information, a user may transmit fake or harmful contents with a virus. How to identify and prevent the potential attacks in a fully distributed manner deserves further investigation.

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With users belonging to different social groups and subscribing to different social services coexisting in proximity, how to schedule the wireless medium access of vehicles to achieve the best service quality is a challenging issue.