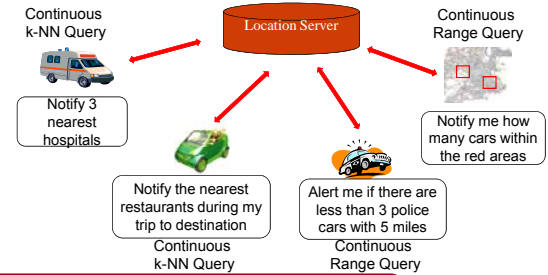
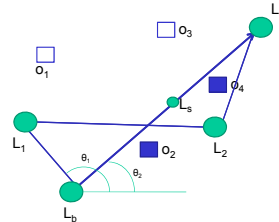


Goal: Develop metrics and techniques in order to enhance location privacy while satisfying the quality of service (QoS) requirement in continuous LBS environments

Continuous Location Based Services (LBS)

- Given a future trajectory movement, the query answer can be pre-computed in advance
- LBS now need the future trajectory movement from the users
 - Query direction, current location, and query duration are required



Issues of Naïve Anonymization: anonymization of trajectory results in considerable location expansion for cloaked region, thus resulting considerable loss of accuracy

Approach and Impact

New Approach

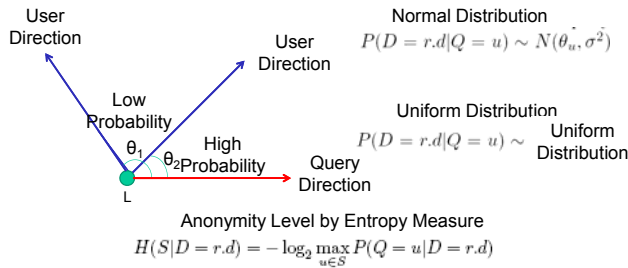
- Address privacy and QoS issues of continuous LBS environment through proposing anonymity models and trajectory partitioning methods
- Use non-linear programming methods to find optimal partitioning.

Research Impact

- Develop formal suite of anonymization models for continuous LBS
- Develop novel privacy and QoS enhancing methods for trajectory anonymization

Risk Scenarios and Anonymization Models

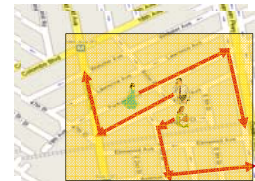
1. Location and Direction are Revealed



Increase the anonymity set until user-specified level of anonymity is satisfied

2. Future Trajectories are Revealed

- Increase the GR so that at least k number of users' trajectories are fully enclosed
- It is important to find a group of candidates so that the GR is not enlarged more than the threshold level
- This model is general enough to encapsulate previously proposed trajectory anonymization models.
- However, this results in considerable loss of accuracy

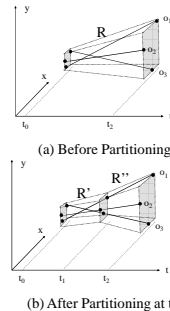


Find a group of users' trajectories and anonymize the request by increasing regions

Optimal Trajectory Partitioning for Better Privacy and QoS

- Given # of partitions and trajectories, find smallest summation of partitioned volume
- Benefits
 - Improved Privacy
 - Improved QoS
- Problem formulation using nonlinear programming

$$\text{Minimize } t_b \leq t_1 \leq \dots \leq t_n \leq t_e \quad F(t_1, \dots, t_n) = \sum V(\text{TMBT}(t_j, t_{j+1}))$$
 and $t_0 = t_b$ and $t_{n+1} = t_e$ subject to $C_j = t_j - t_{j-1} - m \geq 0$ for $j = 1, \dots, n+1$

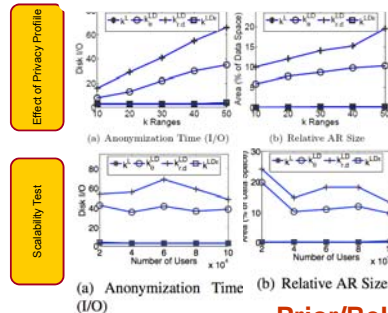


Future Work

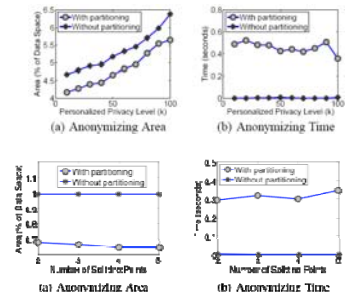
- Efficient query processing techniques are required to support our models
- Remove the reliance to the trusted third party (anonymizer)

Experimental Results

1. Location and Direction Anonymization



2. Trajectory Anonymization



Prior/Related Work

- Location Privacy based on location k-Anonymity
 - Mobility or trajectory information is ignored
- Trajectory Anonymization for offline analysis