

# The New Casper: Query Processing for Location Services without Compromising Privacy



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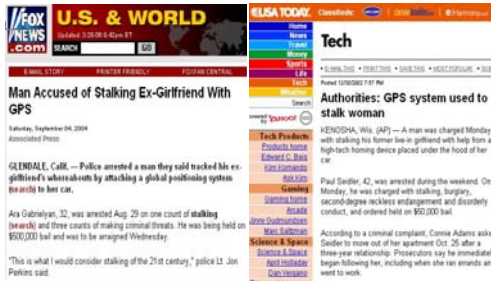
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## Major Privacy Threats in Location-based Services



"New technologies can pinpoint your location at any time and place. They promise safety and convenience but threaten privacy and security"  
Cover story, IEEE Spectrum, July 2003



With all its privacy threats, why do users still use location-detection devices?

Wide spread of location-based services

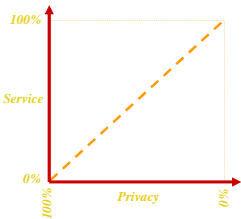
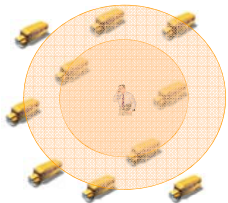


- Location-based store finders
- Location-based traffic reports
- Location-based advertisements

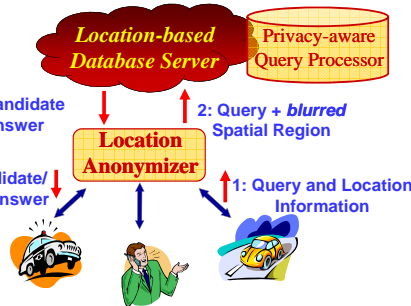


## Service-Privacy Trade-off

Example: Where is my nearest bus?



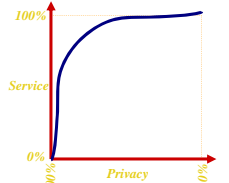
## The Casper Architecture



## User Privacy Profile

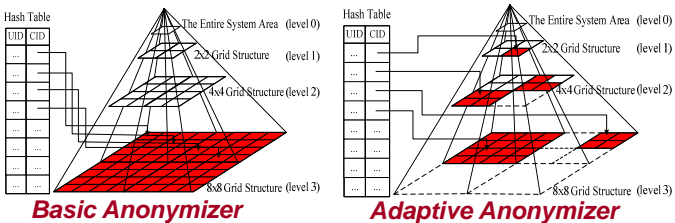
- Each user has a *privacy-profile* that includes:
  - $K$ : A user wants to be  $k$ -anonymous
  - $A_{min}$ : The minimum required area of the blurred area
  - Multiple instances of the above parameters to indicate different privacy profiles at different times

Time	$k$	$A_{min}$
8:00 AM -	1	—
5:00 PM -	100	1 mile
10:00 PM -	1000	5 miles



## The Location Anonymizer

- The entire system area is divided into grids.
- The Location Anonymizer incrementally keeps track of the *number of users* residing in each grid.
- Traverse the pyramid structure from the bottom level to the top level, until a cell satisfying the user privacy profile is found.



## The Privacy-aware Query Processor

### Data Types

- Public data:** Gas stations, restaurants, police cars
- Private data:** Personal data records

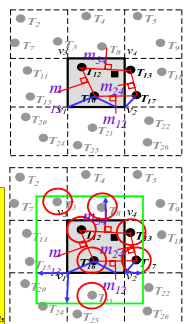
### Query Types

- Private queries over Public data:** What is my nearest gas station
- Public queries over Private data:** How many cars in the downtown area
- Private queries over Private data:** Where is my nearest friend

- Step 1:** Locate four filters (the NN target object for each vertex)
- Step 2:** Find the middle points (the furthest point on the edge to the two filters)
- Step 3:** Extend the query range
- Step 4:** Return candidate answers

**Theorem 1:** Given a cloaked area  $A$  for a user  $u$  located anywhere within  $A$ , Casper returns a candidate list that includes the exact answer.

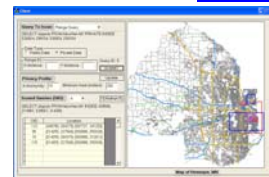
**Theorem 2:** Given a cloaked area  $A$  for a user  $u$  and a set of filter target object  $t_1$  to  $t_4$ , Casper issues the **minimum possible range query** to get the candidate list.



## Privacy-aware Location-based Database

### Location Anonymizer

### Mobile Users



Private Range Query



Private Nearest Neighbor Query