Dynamic Data Driven Crowd Sensing Task Assignment

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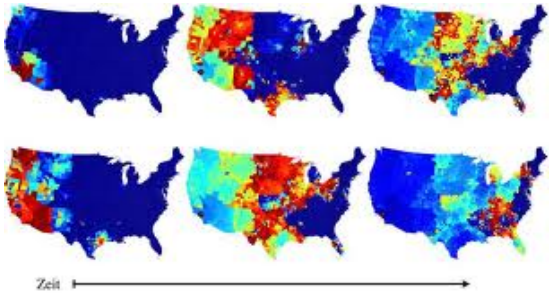
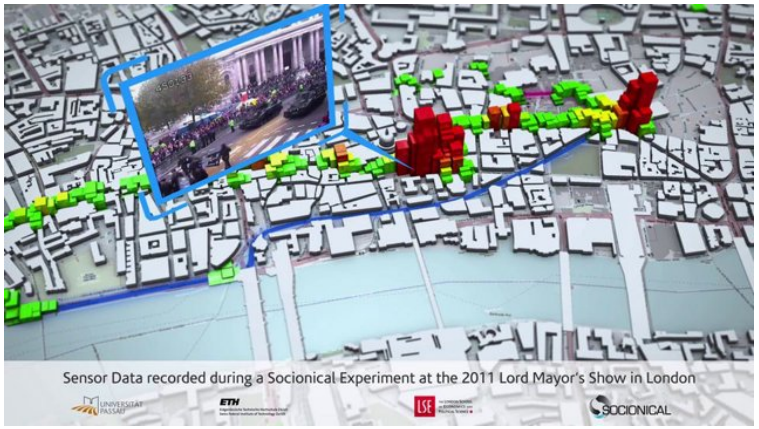
Crowd Sensing

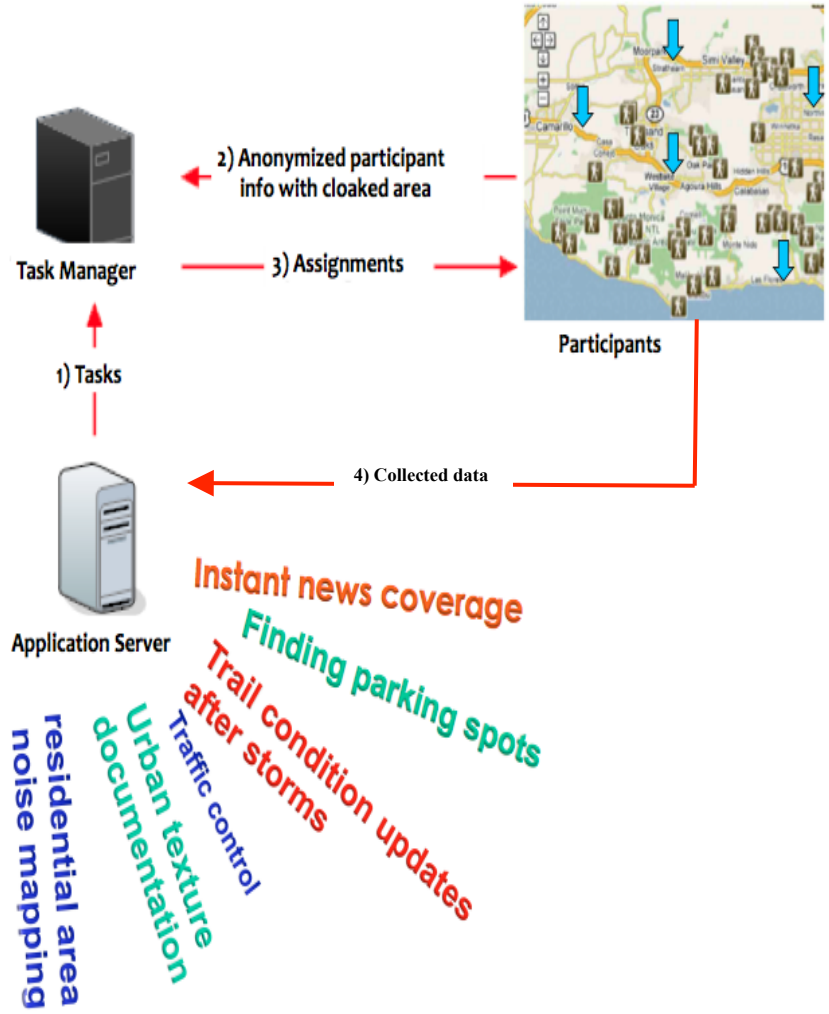
- Sensing paradigm using mobile devices
- Syndromic surveillance, traffic monitoring, news coverage, intelligence data collection, crowd/congestion monitoring





Spatial Crowd Sensing Task Assignment

- Sensing tasks: collect data about specific targets at particular locations.
- Task assignment
- Maximize sensing coverage
- Minimize sensing cost



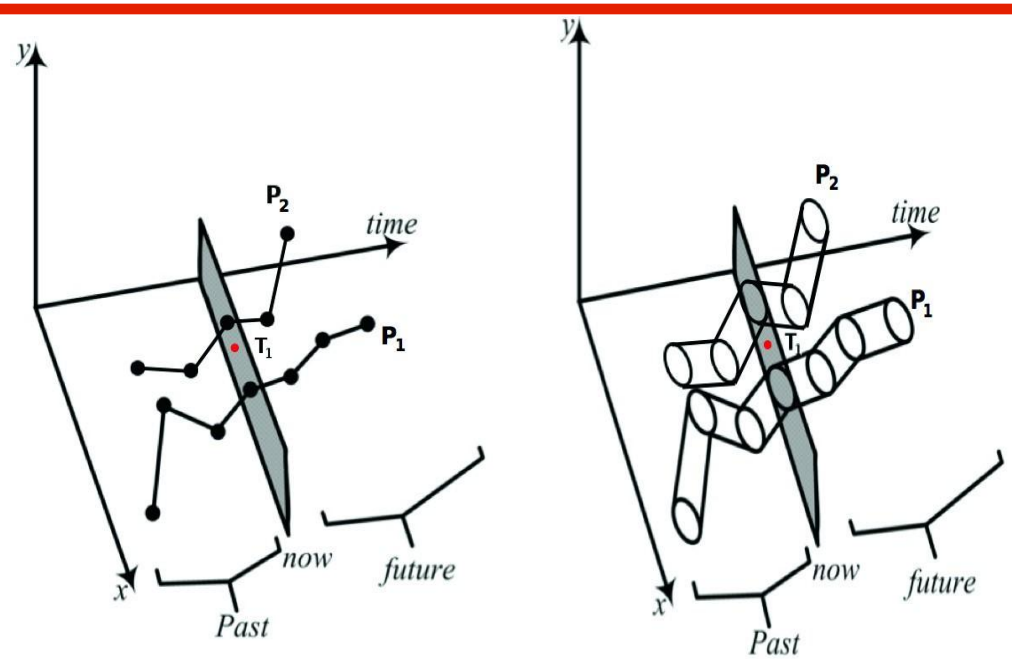
Challenges

- **Uncertain and dynamic trajectories of participants:**

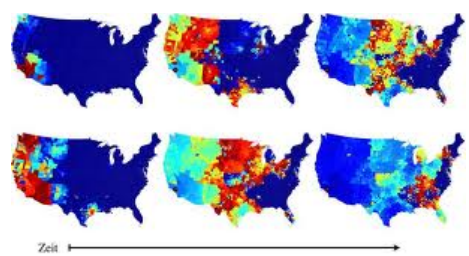
  1) Error in location-detection devices, noisy transmissions, or explicit location perturbation due to privacy concerns

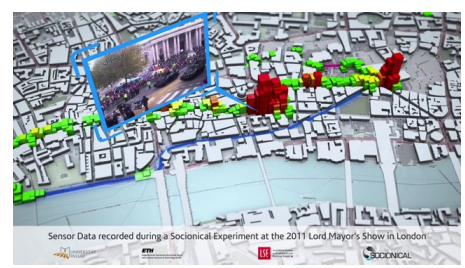
  2) Participants may be constantly moving (e.g. commuters) and

- **Dynamic tasks:** Sensing tasks may be updated (e.g. spread of disesase outbreak, moving crowd in an event)



a) Exact Trajectories b) Uncertain Trajectories





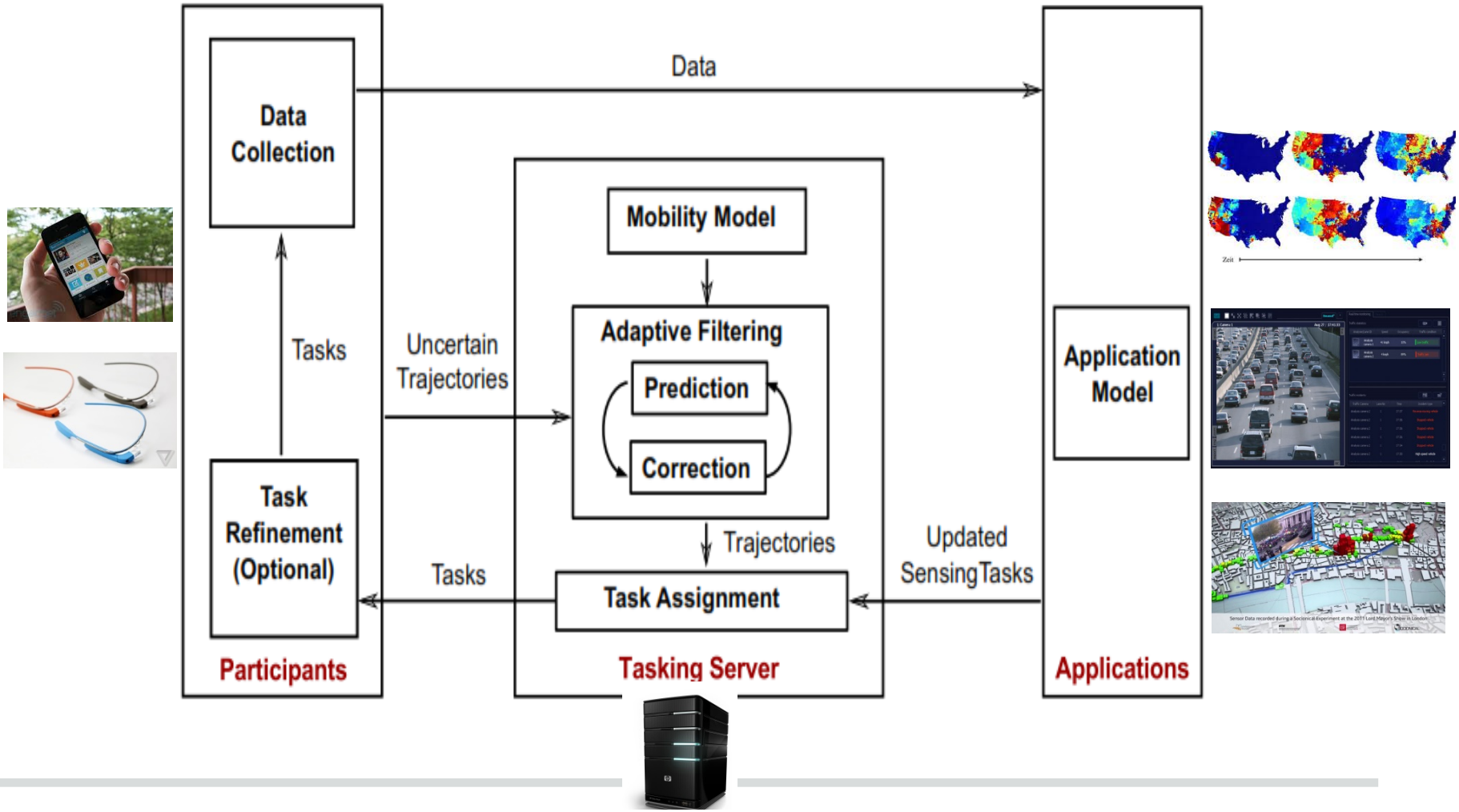
Contributions

- A dynamic data driven framework for spatial task assignment in mobile crowd sensing with dynamic and uncertain participant locations

- Utilize DDDAS to steer and assign the sensing tasks in targeted ways, adapting dynamically to

  1) sensing/application needs
  2) uncertain and moving locations of participants

Adaptive dynamic data driven framework



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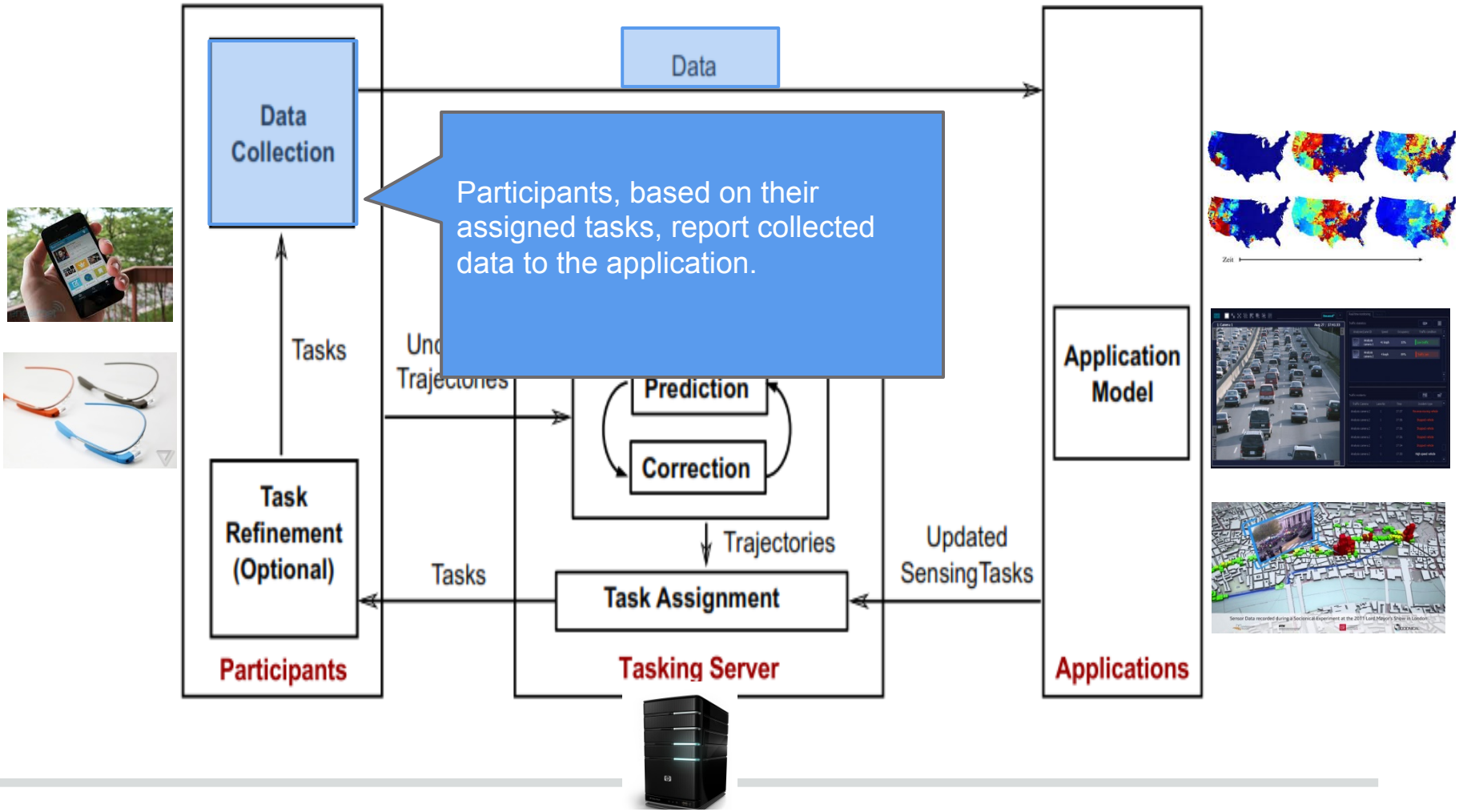

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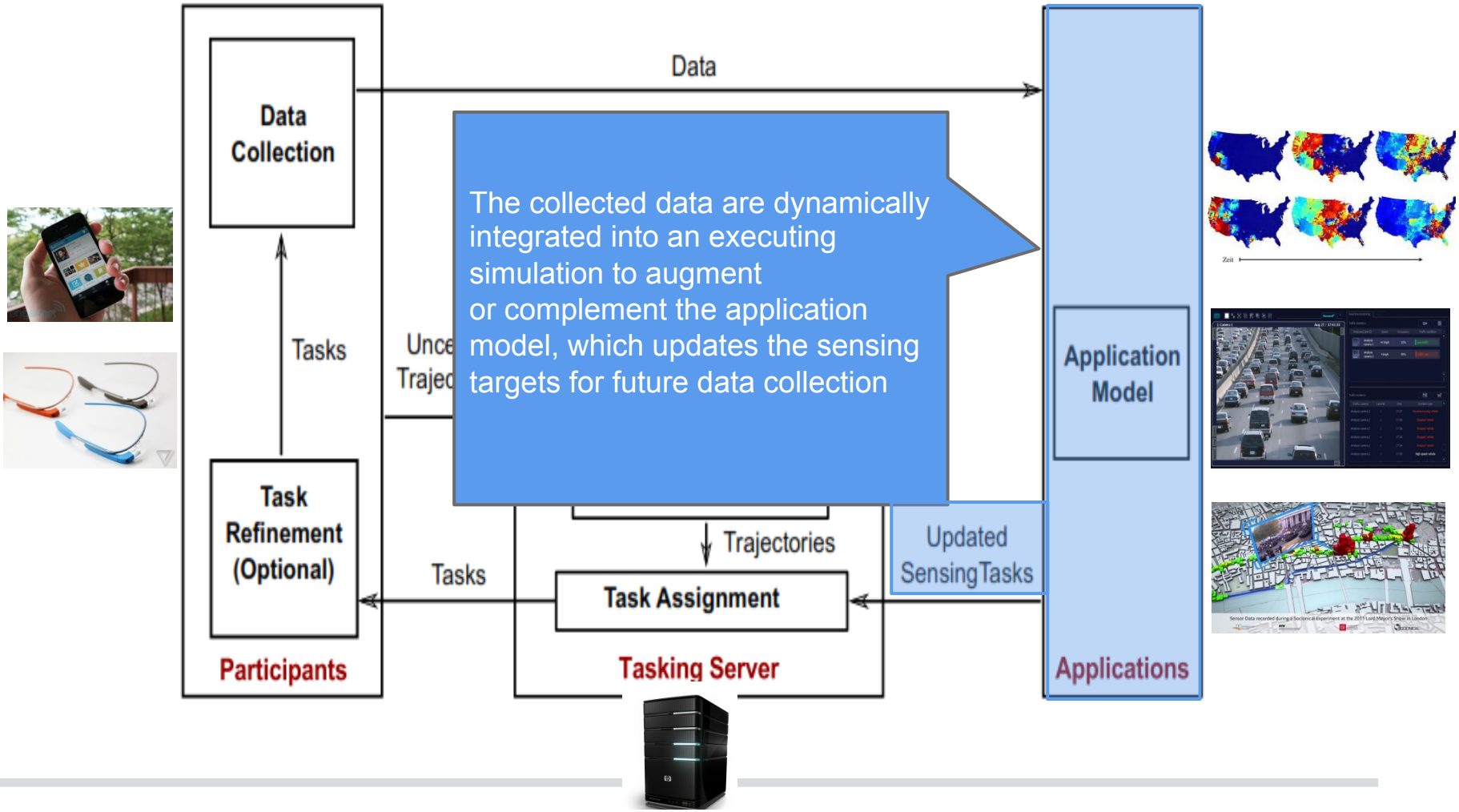

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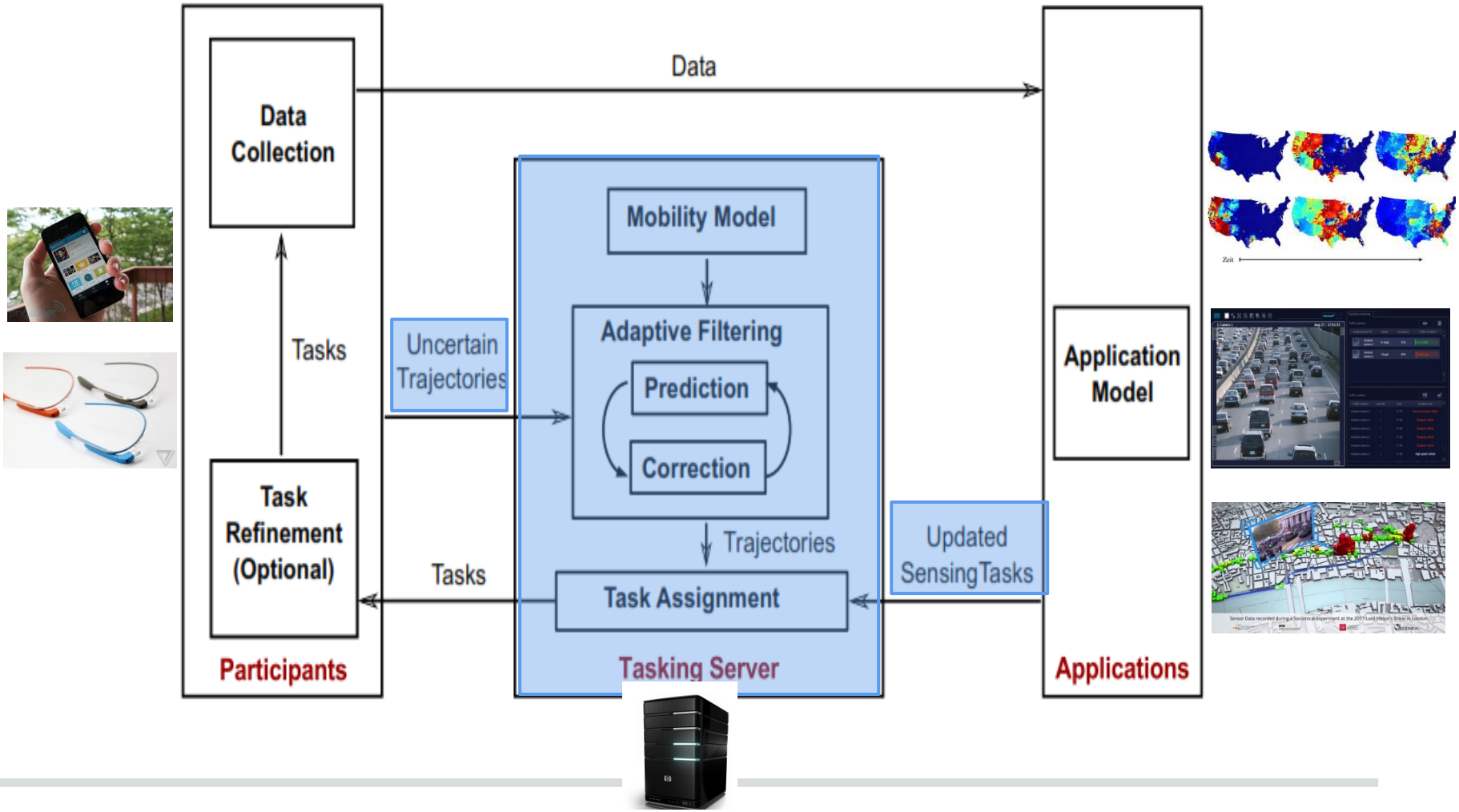

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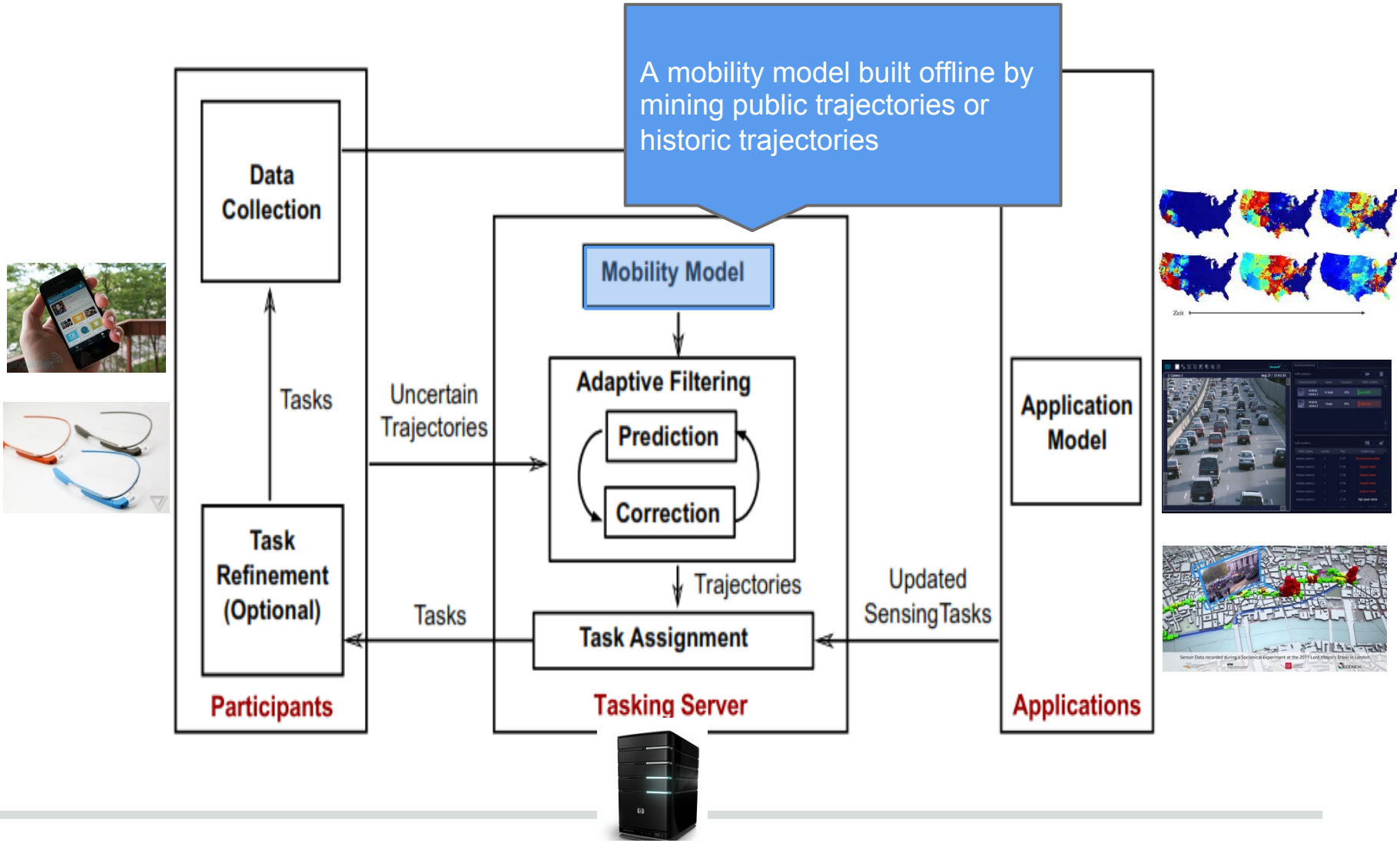

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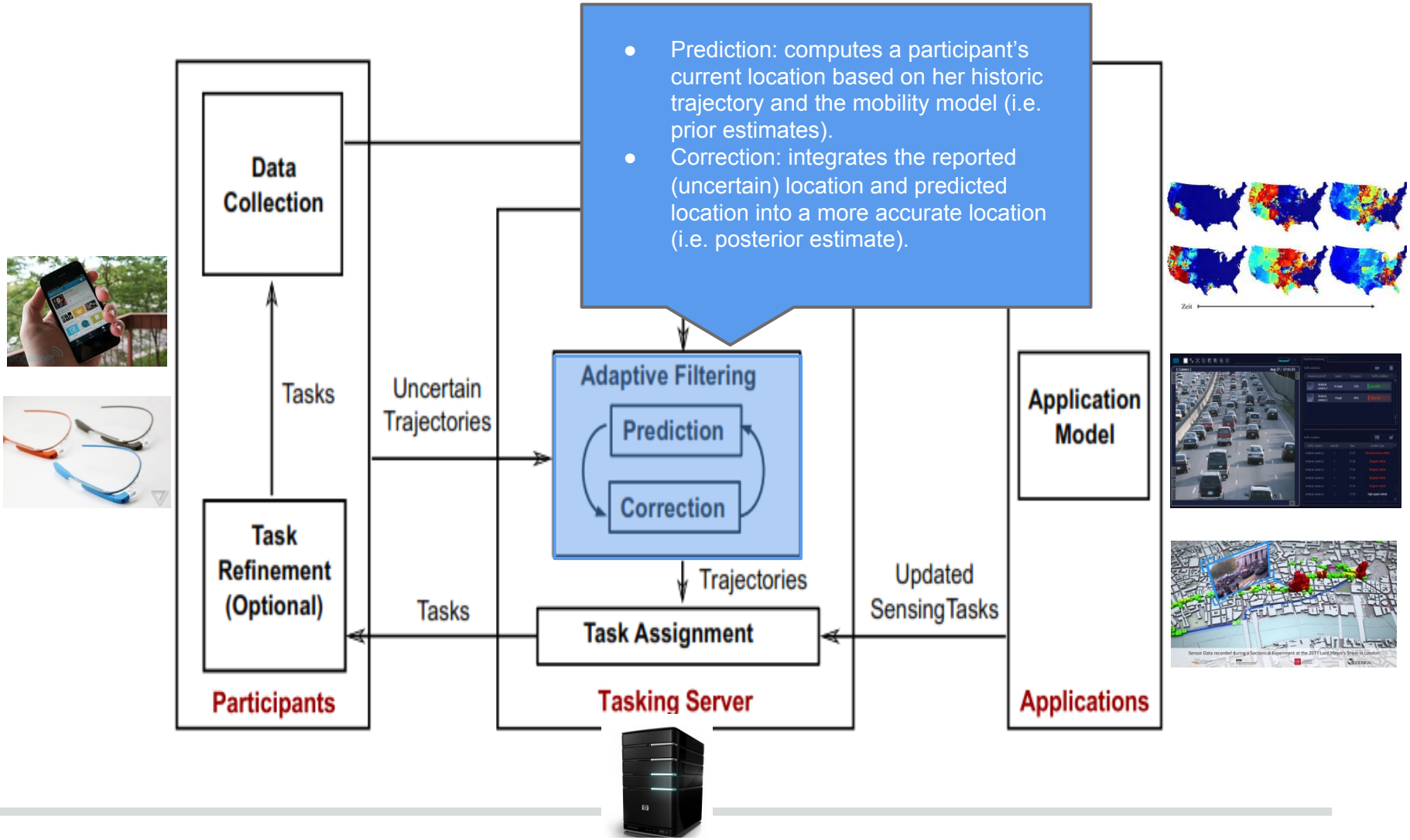


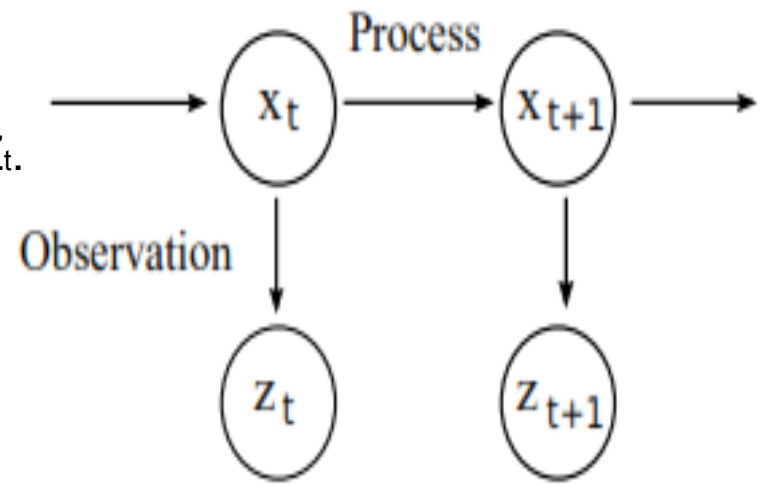
Bayesian Filtering

- **State space model:**

  $X_t \sim p(X_t \mid X_{t-1})$

  $Z_t \sim p(Z_t \mid X_t)$

- **Measurement sequence** $Z_{1:t} = Z_1, \ldots, Z_t$.



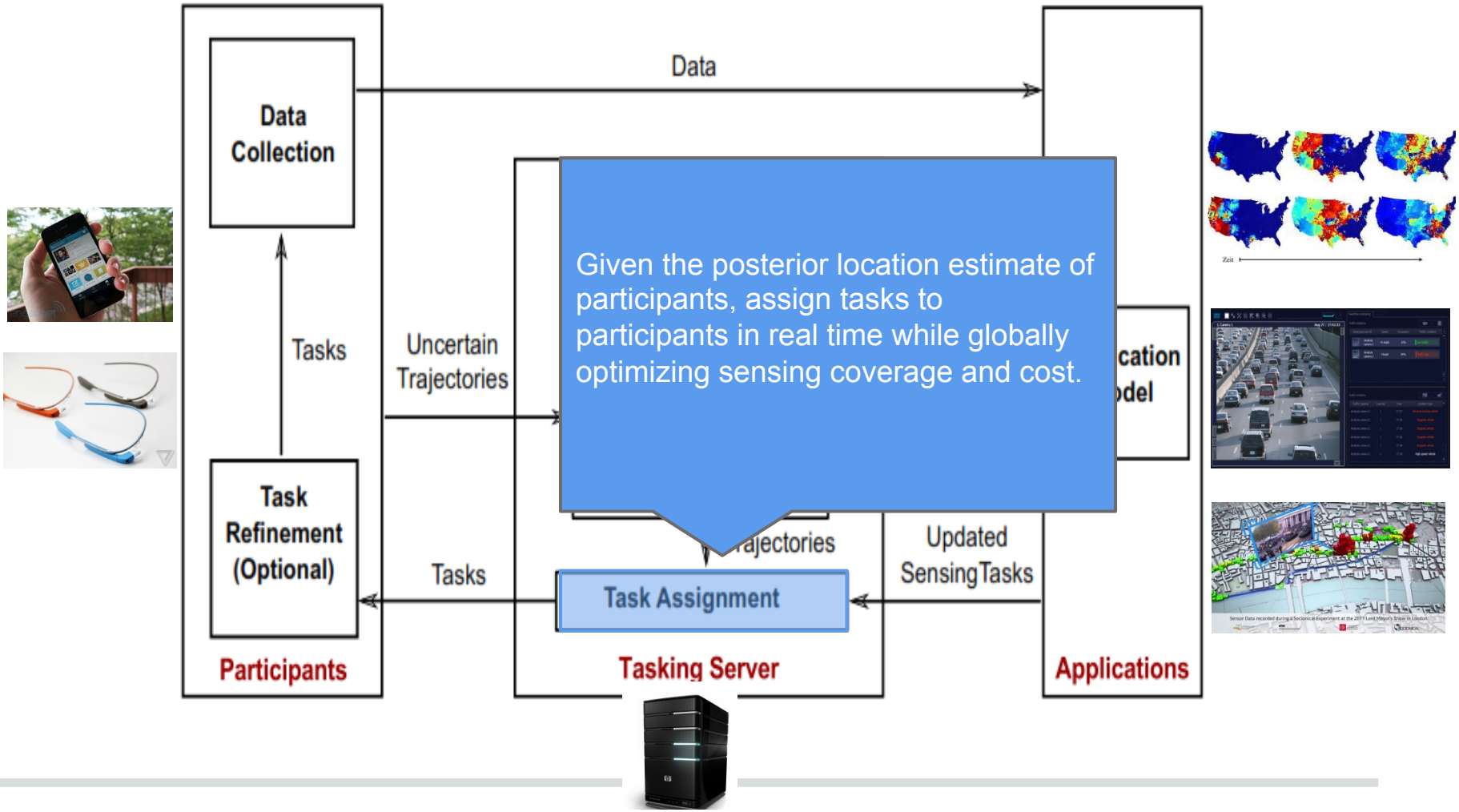
Prediction:

$$p(X_t \mid Z_{1:t-1}) = \Sigma\, p(X_t \mid X_{t-1})\, p(X_{t-1} \mid Z_{1:t-1})$$

Update:

$$p(X_t \mid Z_{1:t}) = \frac{p(Y_t \mid X_t)\, p(X_t \mid Z_{1:t-1})}{\Sigma\, p(Y_t \mid X_t)\, p(X_t \mid Z_{1:t-1})}$$

Adaptive dynamic data driven framework



Global Task Assignment

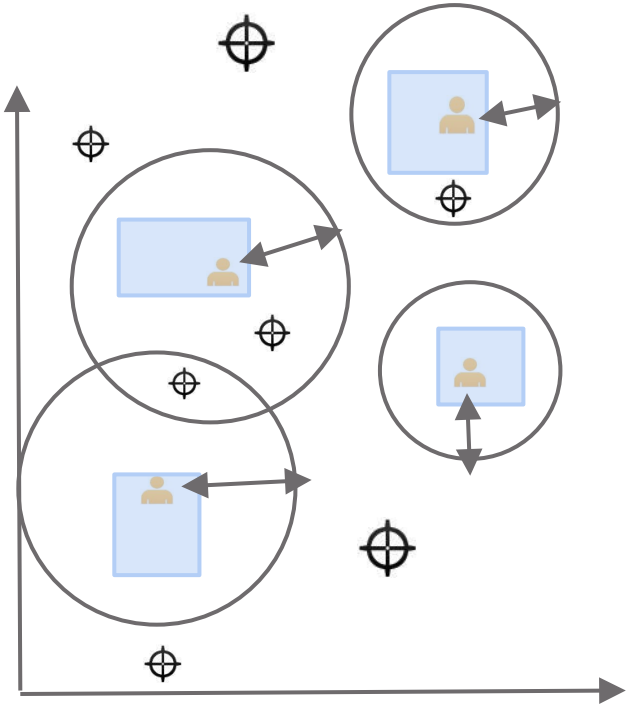
- Given a set of N participants with **uncertain locations** and **sensing range**, a set of M sensing targets, a desired task coverage goal, assign targets to qualified participants with minimum cost

- Task Cost :

$$TC = \sum_{j \in M} \sum_{i \in N} x_{i,j} d_{i,j}$$

- Task Coverage:

$$TU = \sum_{j \in M} \frac{\sum_{i \in N} x_{i,j}}{k_j}$$



Global Task Assignment

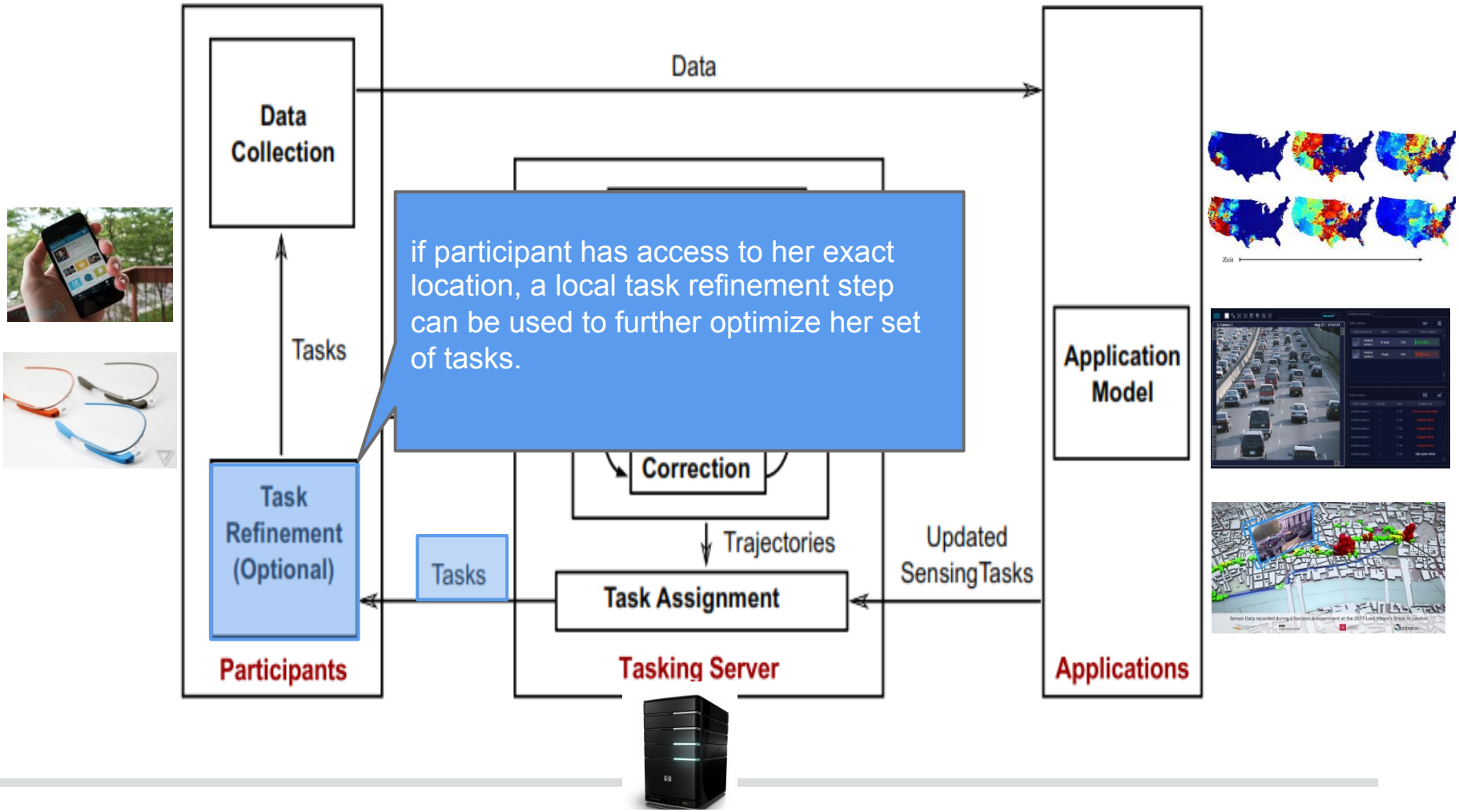
$$\min_{x} \sum_{i \in N} \sum_{j \in M} d_{i,j} x_{i,j}$$

$$\text{s.t.} \quad \sum_{j \in M} \frac{\sum_{i \in N} x_{i,j}}{k_j} \geq gm$$

$$\sum_{j \in M} x_{i,j} d_{i,j} \leq b_i$$

- Matrix d is uncertain, hence distances should be estimated.
- NP-Hard Problem (Minimum Set Cover Problem reduction)
- Probabilistic greedy algorithms

Adaptive dynamic data driven framework

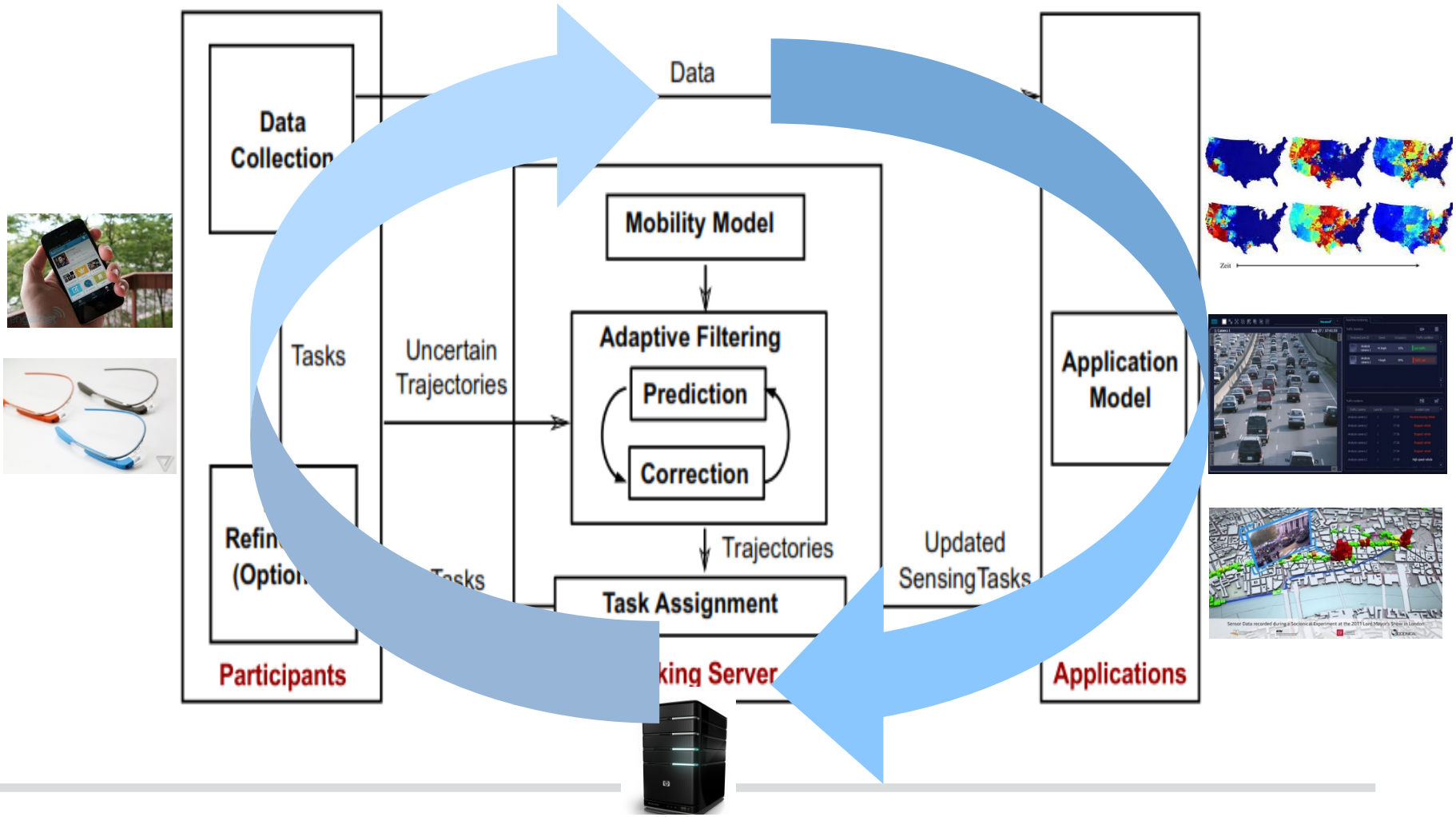


Local Task Refinement

$$
\begin{aligned}
& \min_{y} \sum_{j \in M} d_{i,j} y_{i,j} \\
\text{s.t.} \quad & |\mathbf{y}_i - \mathbf{x}_i| < \epsilon \\
& \sum_{j \in M} \frac{y_{i,j}}{k_j} \geq \sum_{j \in M} \frac{x_{i,j}}{k_j} \\
& \sum_{j \in M} y_{i,j} d_{i,j} \leq b_i
\end{aligned}
$$

- Minimize distance to travel
- To avoid over/under coverage, the difference between refined assignments (y) and global assignments (x) should be small
- NP-Hard Problem (Minimum Set Cover Problem reduction)
- Probabilistic greedy algorithms

Adaptive dynamic data driven framework

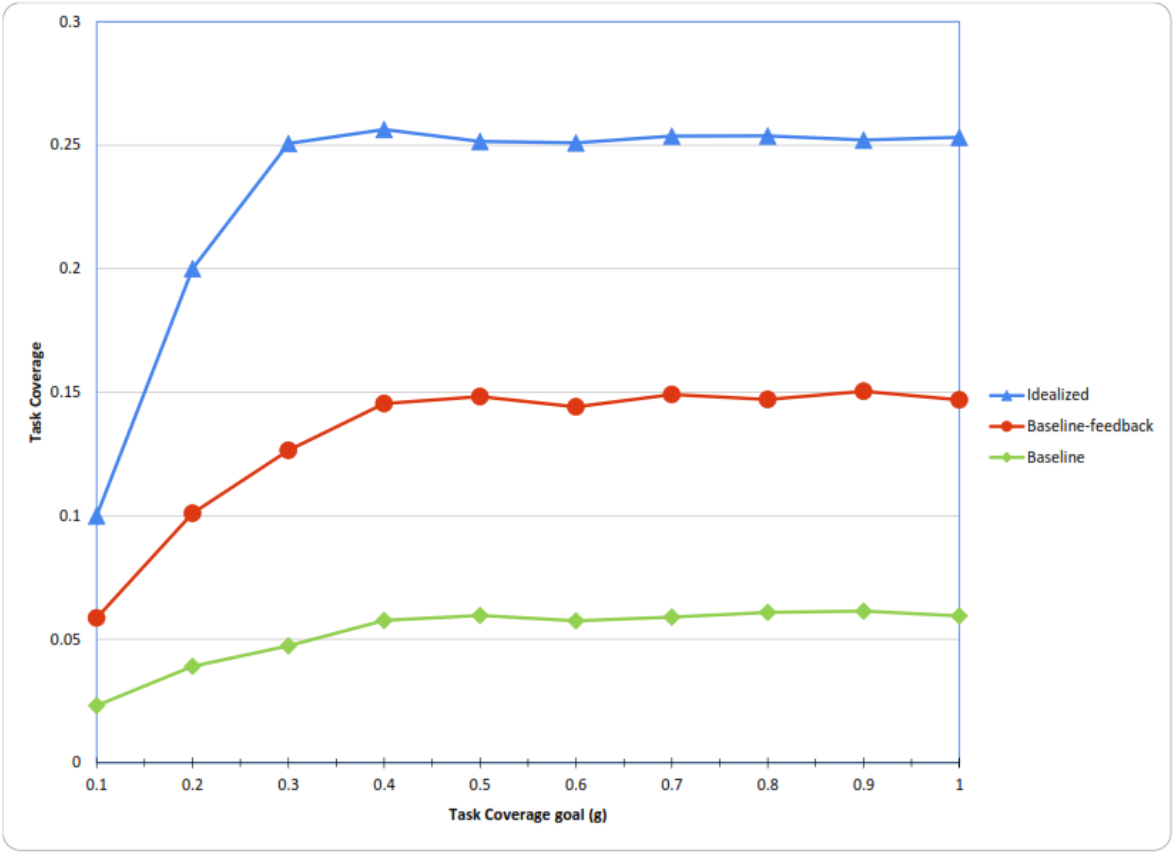


Experiments : Data Sets

- **Gowalla**: A real−world data set which contains check-−in information of users in a location--based social network

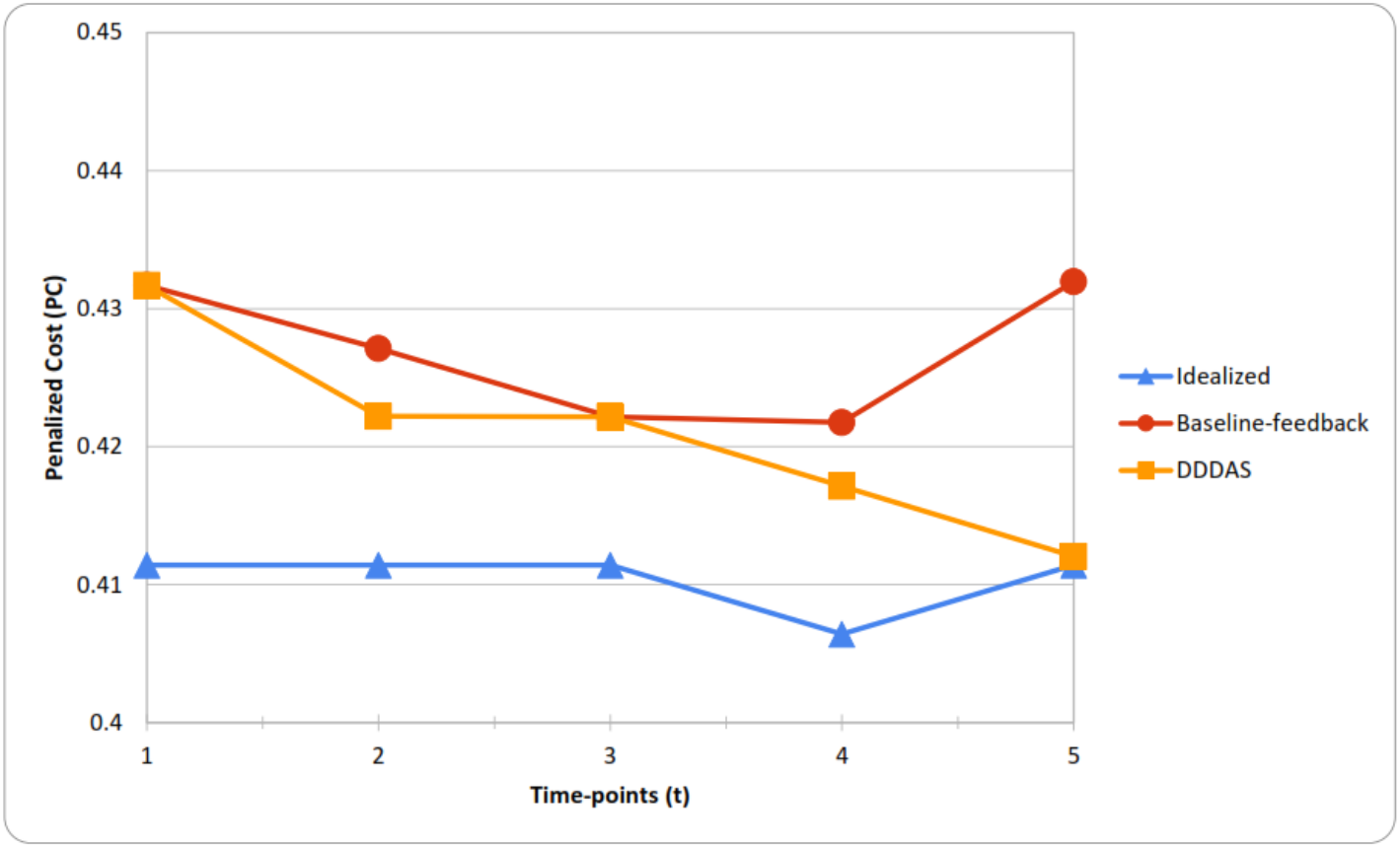
- **Geolife GPS Trajectories**: Collected in (Microsoft Research Asia) Geolife project by 182 users in a period of over three years (from April 2007 to August 2012).

Results



Relative task coverage for different coverage goal, n = 200, and m = 200, using datasets Gowalla

Results



Penalized cost for different timepoints, n = 100, and m = 100, using dataset Geolife

Ongoing and Future Work

- Enhanced mobility modeling and trajectory prediction algorithms for more accurate participant tracking
- Implementing mobile app and server software for crowd sensing with dynamic task assignment
- Formal location perturbation mechanisms
- Trustworthiness of participants in terms of the quality of the data contributed by them