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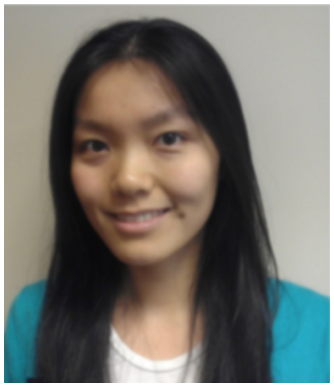
# Real-Time Task Assignment in Hyperlocal Spatial Crowdsourcing under Budget Constraints

*Presented by* **Mohammad Asghari**


**Hien To**



**Dr. Liyue Fan**

**Luan Tran**

**Prof. Cyrus Shahabi**

USC Viterbi
School of Engineering
*Integrated Media Systems Center*

# Weather Crowdsourcing

- ✓Precipitation estimation technologies fail to provide real-time, fine-grained data
- ✓ Smartphones are awesom!!
- ✓Weather crowdsourcing becomes popular

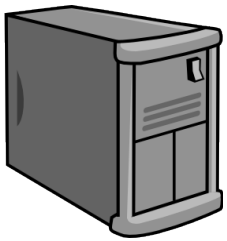

*Crowdsourcing is regarded as "the future of weather forecasting"*

Dorminey, 2014
http://www.forbes.com/sites/brucedorminey/2014/02/26/crowdsourcing-as-the-future-of-weather-forecasting/

# Problem Setup

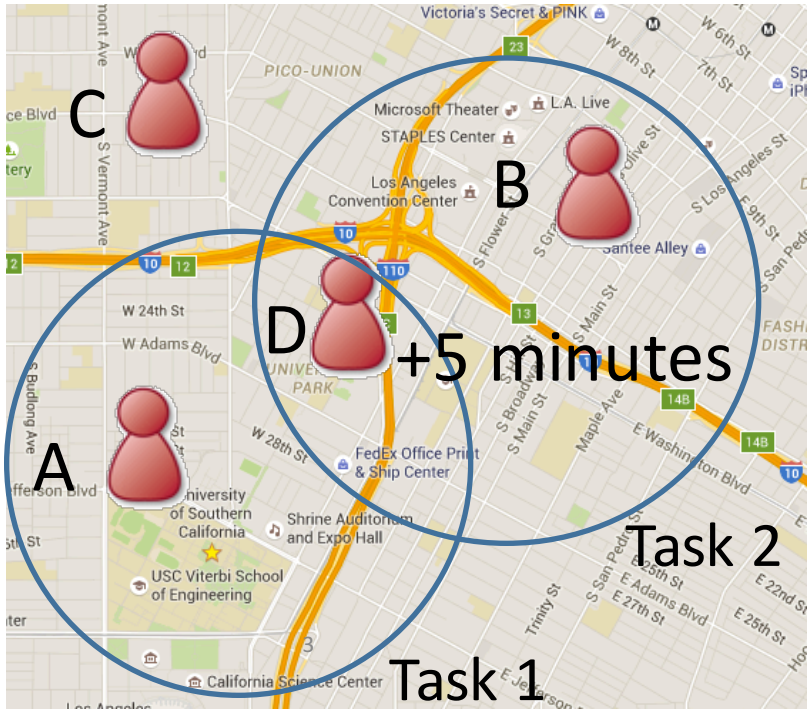
Requesters submit a set of tasks to the Server

Tasks with spatiotemporal continuity in measurement, e.g., rainfall, temperature

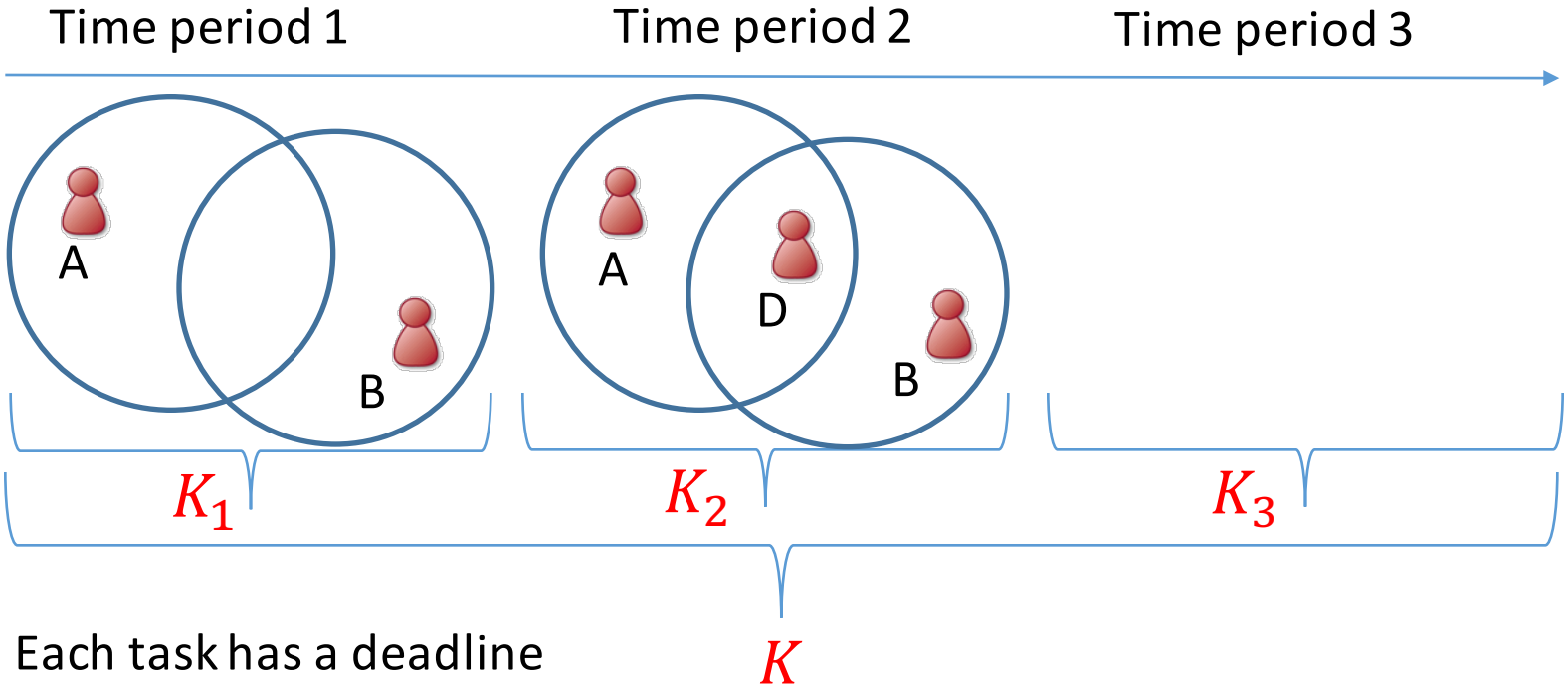


Server

A worker can respond to a task if he is within the task region



# Problem Space




Each task has a deadline

given a total budget $K$ for all time periods

given a particular budget $K_i$ *per* time period

server does not know the future

server knows everything

| | **Dynamic-budget** | **Fixed-budget** |
|---|---|---|
| **Online** | Online d*MTC* | Online f*MTC* |
| **Offline** | Offline d*MTC* | Offline f*MTC* |

# Offline *MTC* Variants

Given $Q$ time period $s_i \in \{s_1, .., S_Q\}$,

**Dynamic-budget maximum task coverage** (d*MTC*) is to select a set of workers $L_i$ at every $s_i$ s.t. #covered tasks is maximized and $\sum_{i=1}^{Q} |L_i| \leq K$

**Fixed-budget MTC** (*fMTC*) is similar to d*MTC,* except the budget is given for each time period $|L_i| \leq K_i$

d*MTC* is more challenging than fMTC

d*MTC* is NP-hard by reduction from maximum coverage problem (MCP) [Feige, JACM 1998]

f*MTC* is NP-hard by reduction from maximum coverage with group budgets constraints problem [Chekuri et. al. APPROX 2014]

# Online d*MTC* – Which worker to select?

Difficult to achieve global optimal solution

Optimizes locally at every time period

f*MTC* for one time period is NP-hard by reduction from MCP

Greedy algorithm (*Basic*) to MCP chooses the worker that covers the largest number of uncovered elements [Feige JACM'98]

*Basic* does not consider spatiotemporal information of each task

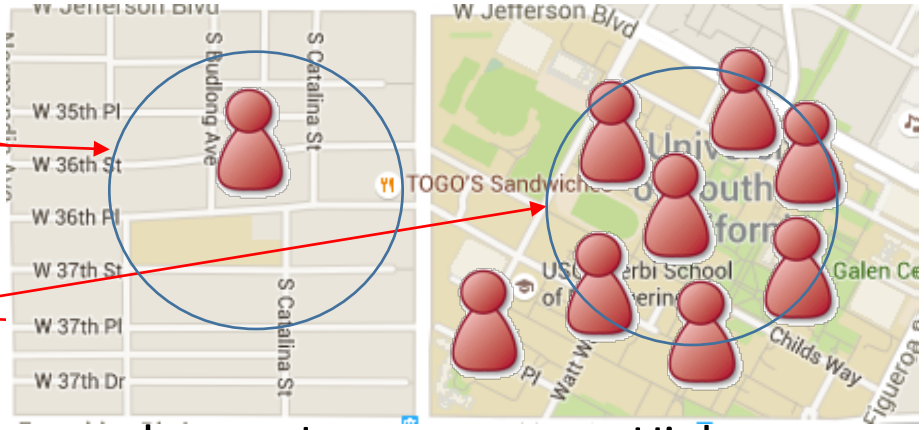
- *Temporal* heuristic: expiring tasks have higher priority
- *Spatial* heuristic: tasks in worker-sparse area have higher priority

Expired in 5 time periods

Task in worker-sparse region

Task in worker-dense region

Expired in 1 time period




Low entropy

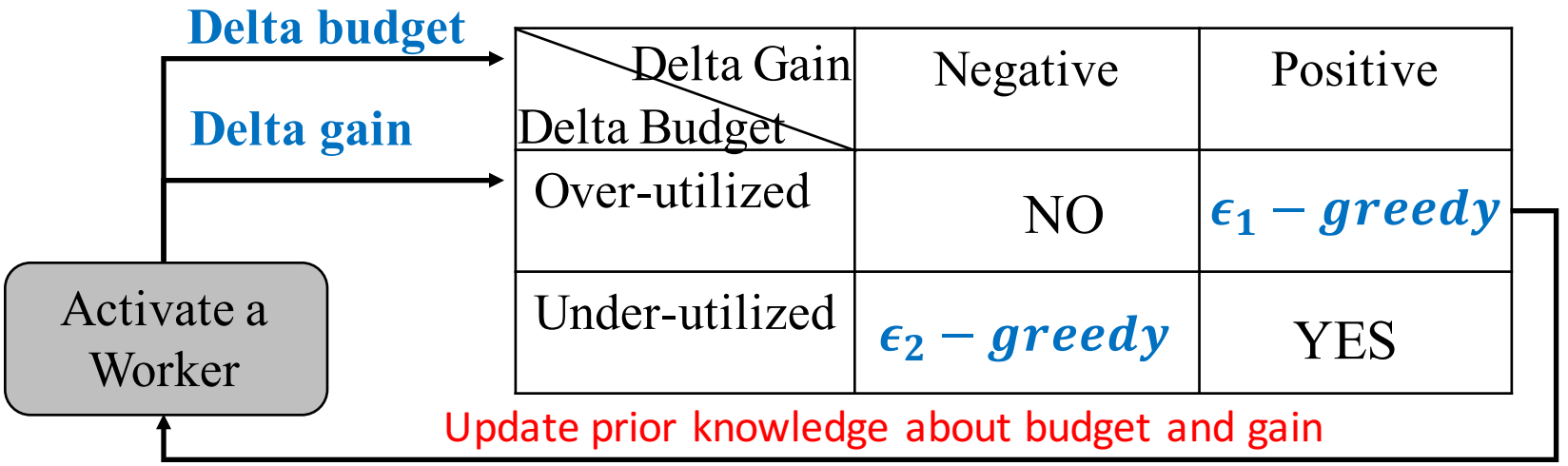
High entropy

# Online d*MTC* – How many to select?

Allocate overall budget *K* over *Q* time periods

*Equal:* strategy equally divides *K* to *Q* time periods *K/Q*

*Adapt:* decision of how many workers to activate depends on 1) budget utilization 2) distribution of workers and tasks




Balance with explore (YES) and exploit (NO) tradeoff

Use contextual $\epsilon - greedy$ algorithm [Li et. al. WWW 2010]

# Experimental Setup

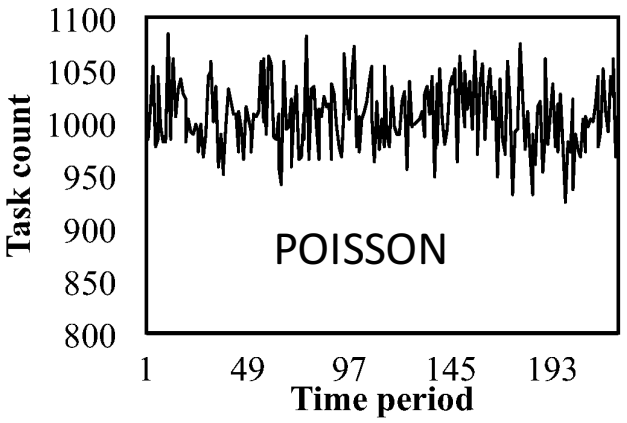
## Real-world datasets

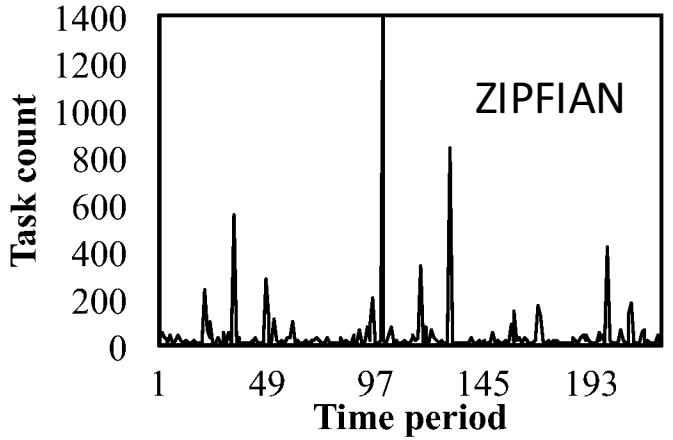
| Name | #Tasks (Check-ins) | #Workers (Users) | Unit time period | #periods |
|---|---|---|---|---|
| **Gowalla** | 151,075 | 6,160 | 1 day | 224 |
| **Foursquare** | 89,968 | 45,138 | 1 hour | 384 |

Time period Q = 28. Task duration = 5 time periods. Task radius = 5 km

## Synthetic datasets

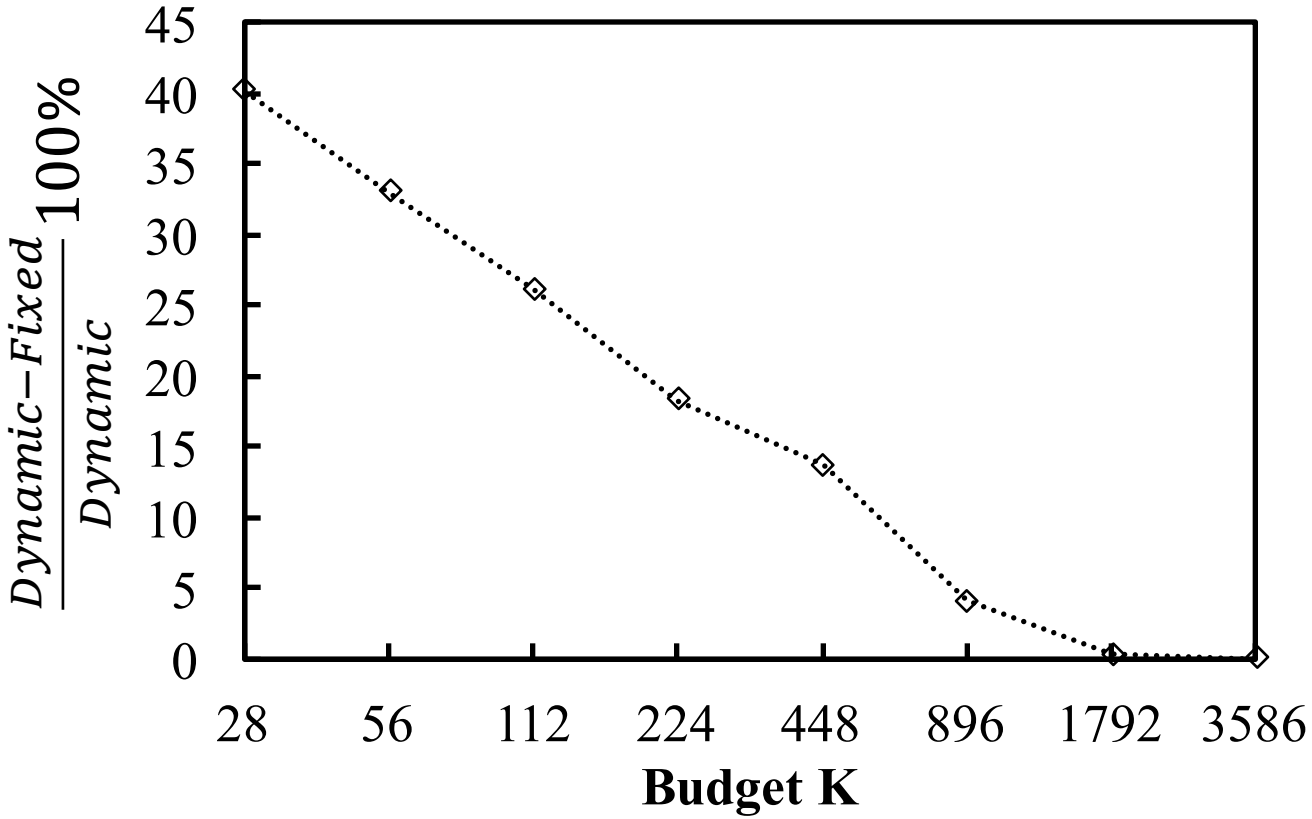
- Synthetically arrival rates of workers and tasks, e.g., GO-ZIPFIAN



# Offline Solutions

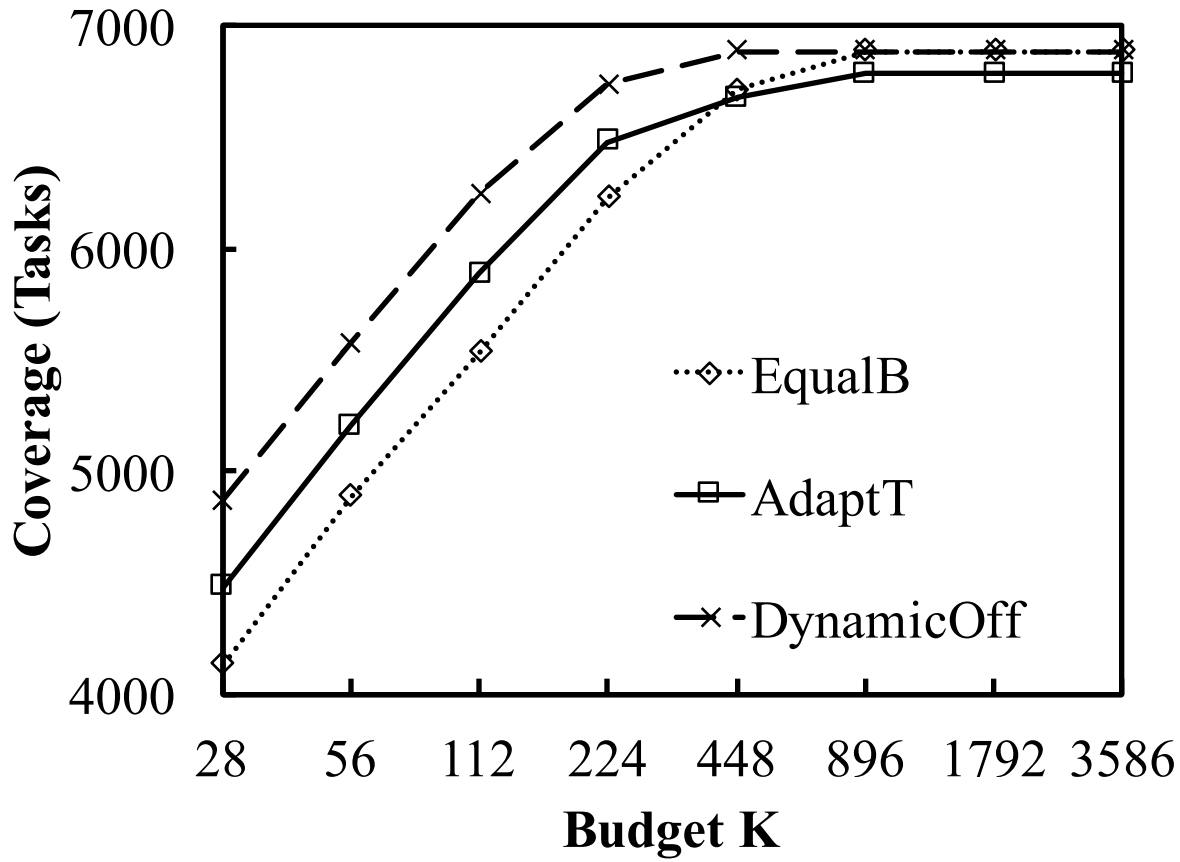
## Varying budget *K* (Go-ZIPFIAN)




- ✓ Dynamic budget allocation is more effective
- ✓ The higher the budget, the smaller the improvement

# Dynamic-Budget Online

Varying radius *r* (Go-POISSON)




✓ *AdaptT (Adapt + Temporal)* comes closer to offline solution

# Conclusion

- ✓ Proposed a framework to maximize task coverage under budget constraints
- ✓ Developed three online heuristics, *Basic, Temporal* and *Spatial* for f*MTC*
- ✓ Developed online budget allocation to dynamically allocate total budget to time periods for d*MTC*
- ✓ Empirical results confirm that online solutions increase task coverage by 40% over basic approach

Q/A

***Hien To***

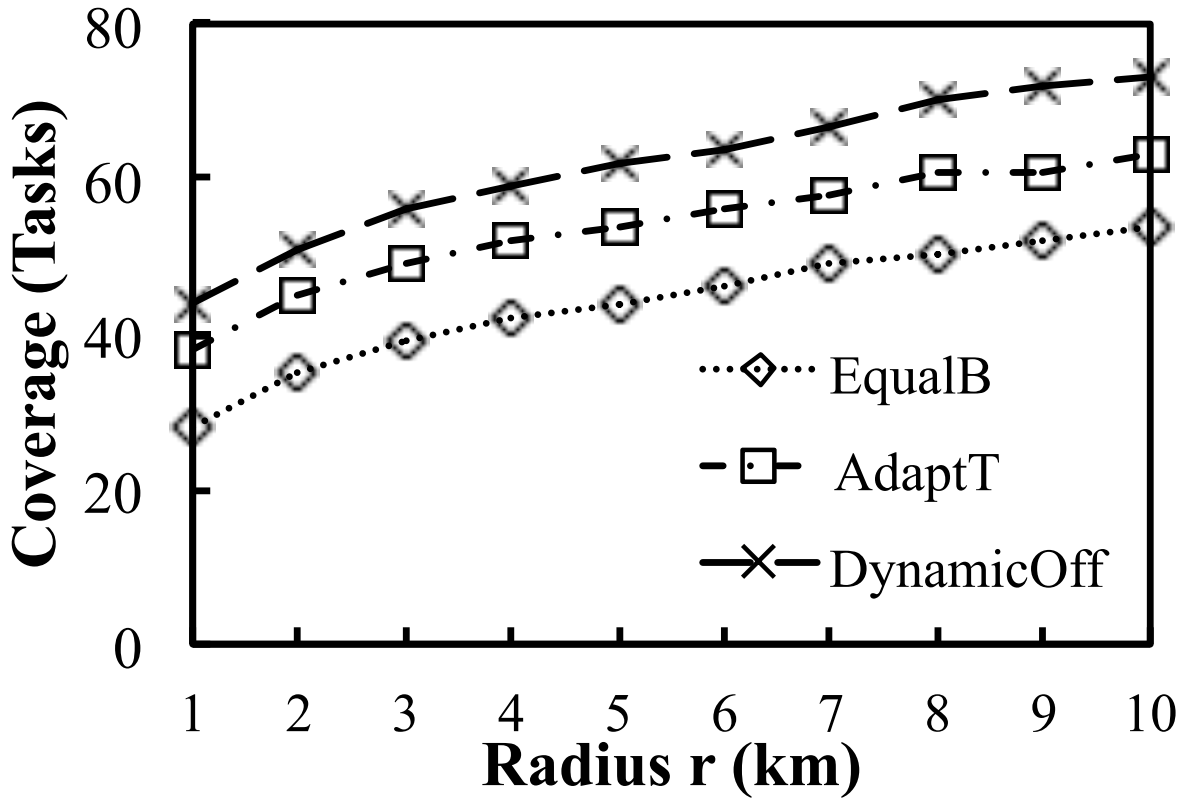
Email: hto@usc.edu

***Liyue Fan***

Email: liyuefan@usc.edu

# Dynamic-Budget Online

Varying radius *r* (Go-POISSON)




✓ *AdaptT (Adapt + Temporal)* obtains up to 40% improvements (at *r*=1)