# Analyzing spatially constrained Power of two choice based policies in a two-dimensional distributed service network

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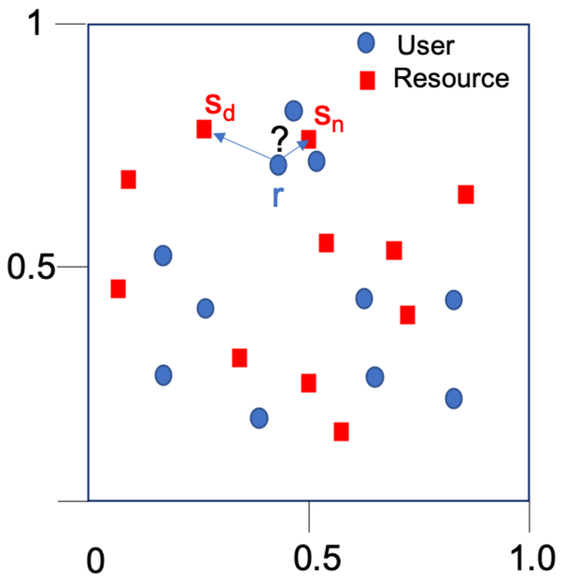
## Overview




- Distributed analytics network
  - R: Set of users requesting services
  - S: Set of resources
- Problem:
  - how should users request resources so as to maximize performance?
  - minimize server loads? Ex: if resource $s_n$ is heavily loaded, user r should select less loaded resource $s_d$
- Power of two choices (*POT*)
  - Simple, yet powerful policy for distributed load balancing
  - Maximum Load: $O(\log \log n)$ with $|R| = |S| = n$
- Goal
  - Maximum load for POT under spatial constraints?
  - Can we obtain *POT benefits*?

## Technical Challenges

- Specific consideration of Geometric Structures
  - Voronoi Diagram and Delaunay Graph of resources
  - Higher order Voronoi Diagram
- POT on non-uniform Delaunay Graphs

## Military & Coalition Relevance

- Distributed analytics at tactical edge
- User requests execution of analytic service
- Resources: Agile code + Data

## Approaches

| Policy | Description |
|---|---|
| Power of One (POO) | Select one of the $n$ resources uniformly at random. |
| Power of Two (POT) | Select the least loaded resource among two of the n resources chosen uniformly at random. |
| Spatial POO (sPOO) | Select nearest resource. |
| Spatial POT (sPOT) | Select least loaded resource among two nearest resources. |
| Candidate Set Based sPOT (k-sPOT) | Select least loaded resource among two resources chosen randomly from $k$ nearest. |

## Results

- sPOT with grid based resource placement

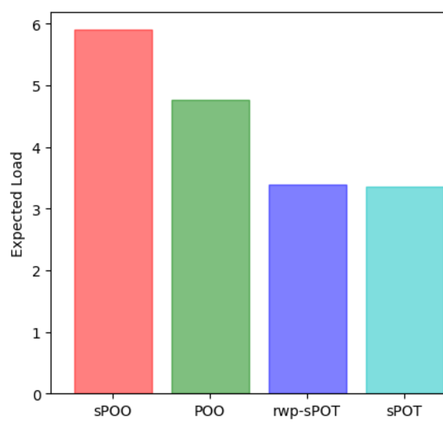
*Theorem: Suppose resources are placed on a two dimensional grid with wrap-around. Let users be placed independently and uniformly at random on the grid. Under sPOT, maximum load over all resources is* $\Omega(\frac{\log n}{\log \log n})$ *with probability of* $1-1/n^{\Omega(1)}$

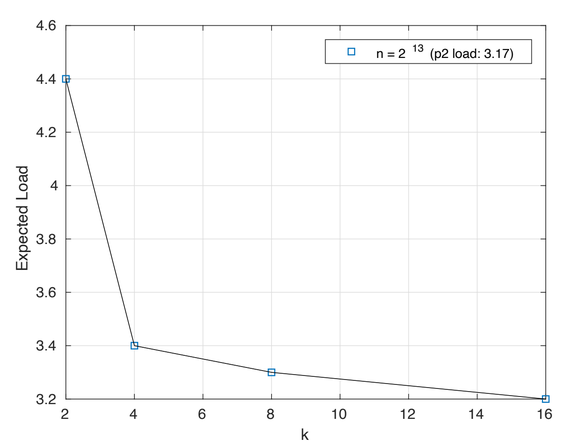
- sPOT with uniform based resource placement

*Conjecture: Suppose both users and resources are placed independently and uniformly at random on 2-D plane. Under sPOT, the maximum load over all resources is at least* $\Omega(\frac{\log n}{\log \log n})$ *with probability of* $1-1/n^{\Omega(1)}$*, i.e., we do not get POT benefits.*

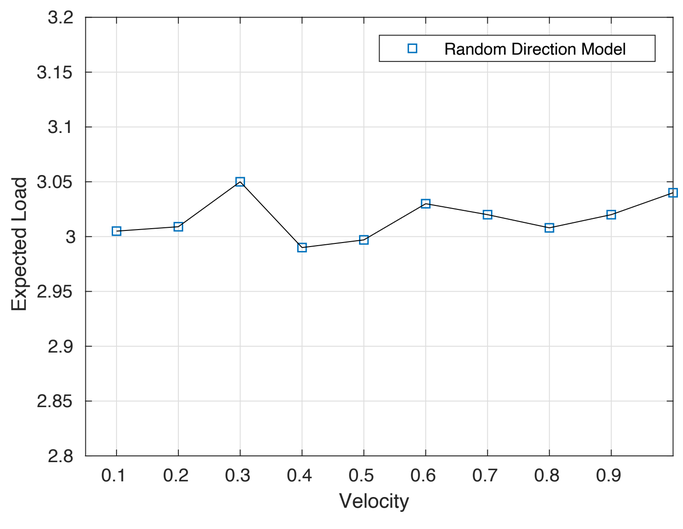
## Simulation Results

- Comparison of allocation policies and POT benefits




- Does mobility improve expected load?




## Summary & Future Work

- Summary
  - No POT benefits for sPOT
  - POT benefits for k-sPOT for $k = O(\log n)$
  - Mobility does not improve load behavior
- Future Work
  - Analyze heuristics based allocation policies
  - Communication vs Load tradeoff
  - Jointly optimizing of matching, routing and scheduling of resources