Hierarchical QoS Provisioning and Scheduling for Wireless Networks

Dragos Niculescu

dnicules@cs.rutgers.edu

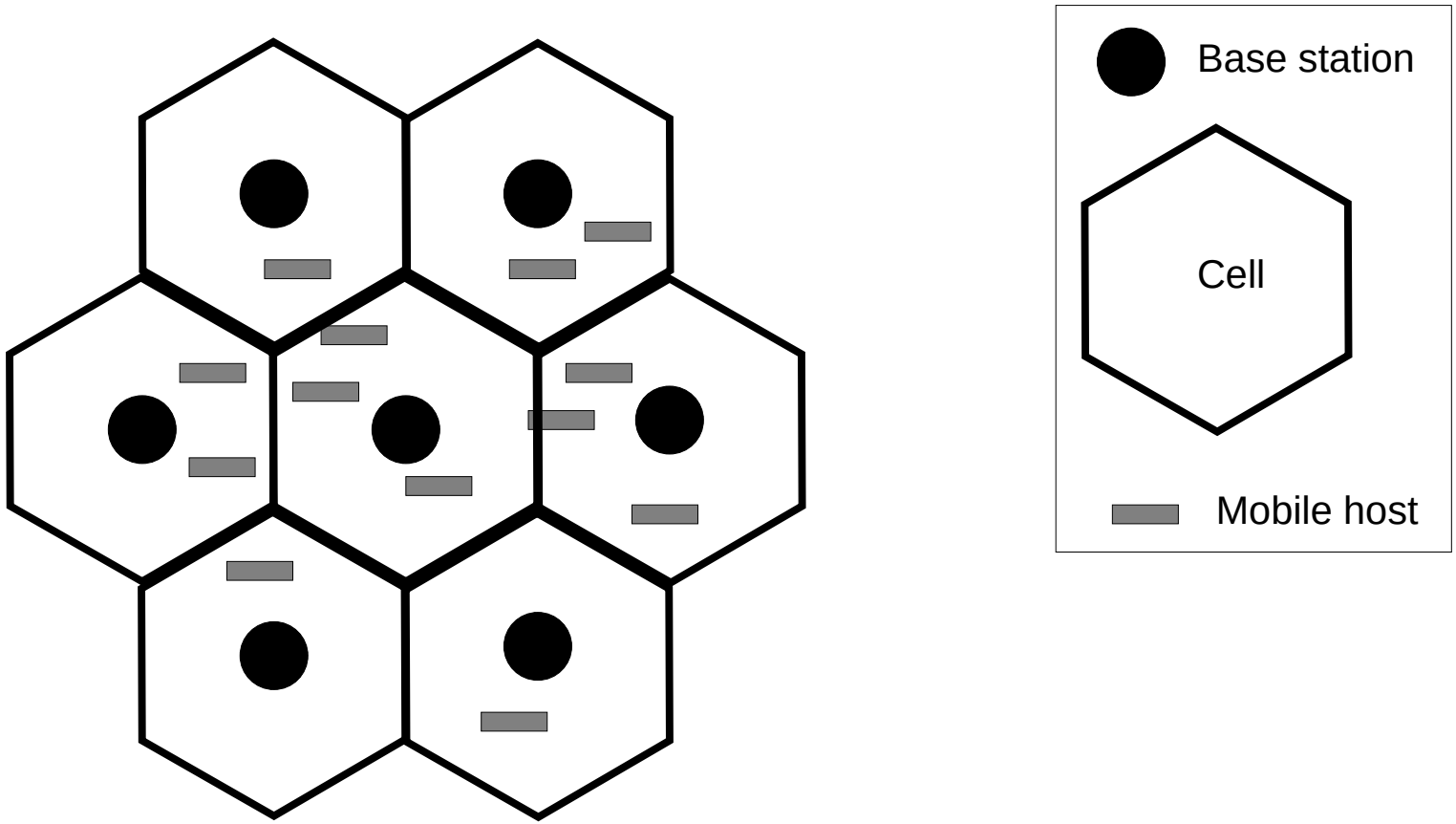
Outline

- network models
  - cell occupancy
  - spatial mobility
- call admission
- hierarchical call admission
- preliminary results
- future work

Goals

- investigate resource provisioning schemes for QoS in a mobile environment
- investigate hierarchical call admission decisions
- integrate the scheduling scheme with the call admission process

Network Infrastructure



Network Model - Cell Occupancy

- mobiles have no identity
- state of the network is described by the number of mobiles in each cell
- cell occupancy parameters - uniform case:
  - λ - new call rate
  - μ - mean call holding time
  - h - handoff rate
  - B - number of channels available in each cell
  - α - fraction of channels reserved for handoff
- in the non-uniform case these parameters may vary across the map

Network Model - Spatial Mobility

- mobiles have velocity (direction and speed)
- mobiles have more consistent patterns of movement
- state of the network is given by
  - position (cell)
  - velocity of each mobile
- allows for more fine-grained representation of resources

Scheduling - LBMA

- mobiles have lottery tickets of various colors (service classes)
- slots are allocated to each color based on priority
- among holders of the same color, LBMA achieves fair sharing
- advantages:
  - low bookkeeping footprint
  - better integration with call admission
    - pricing based schemes
  - easy creation of new services

Call Admission

- acceptable operating region: service meets QoS parameters
- the operating region is defined by a collection of parameters:
  - probability of overload
  - average bandwidth received
- a new call is admitted if
  - the new state is also inside the acceptable region
  - estimations of the future states are also in the acceptable region

Call Admission - comparison with voice networks

- voice networks
  - a single class of calls
  - new calls may be blocked
  - handoff calls may be dropped
  - "guard channel" type policies are proven optimal

- data networks
  - calls are never dropped
  - connections share bandwidth
  - in the worst case, there may be high overload
  - there are multiple classes of traffic

Previous Work

- guard channels:
  - a fraction of cell's bandwidth is reserved for handoff calls
  - works good for one class of service
- region based:
  - neighboring cells are involved in the call admission decision
- mobility specs (Badri)
- mobility prediction may provide hints to
  - resource reservation
  - a more informed call admission decision

Hierarchical Call Admission

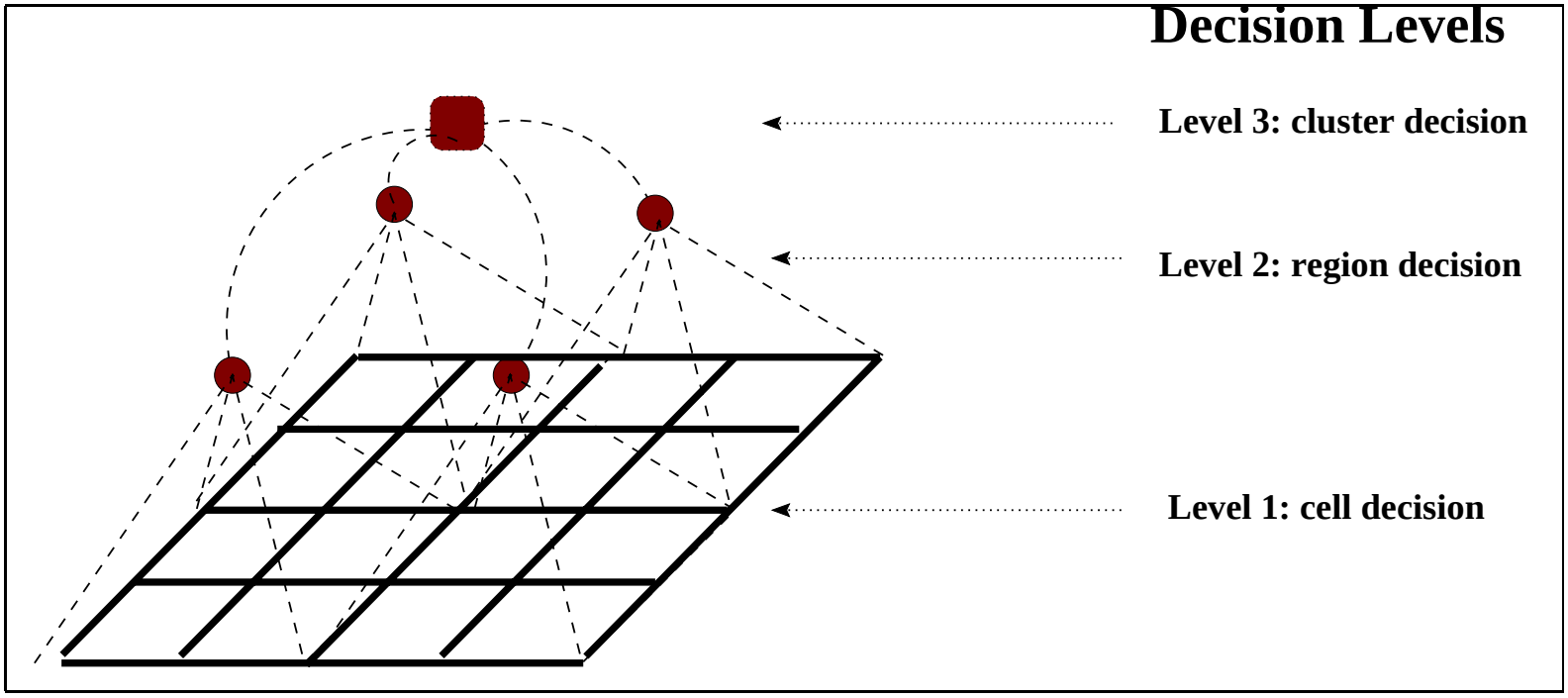
- at each level the entire map is partitioned into disjoint, exhaustive regions

- admission for a new call in cell C
  - is evaluated at each layer by the region containing C
  - is a function of the decisions from all the levels

- decision within a single region may be based on
  - region occupancy
  - mobility patterns inside the region
  - distribution of calls across classes
  - predictions of future region state

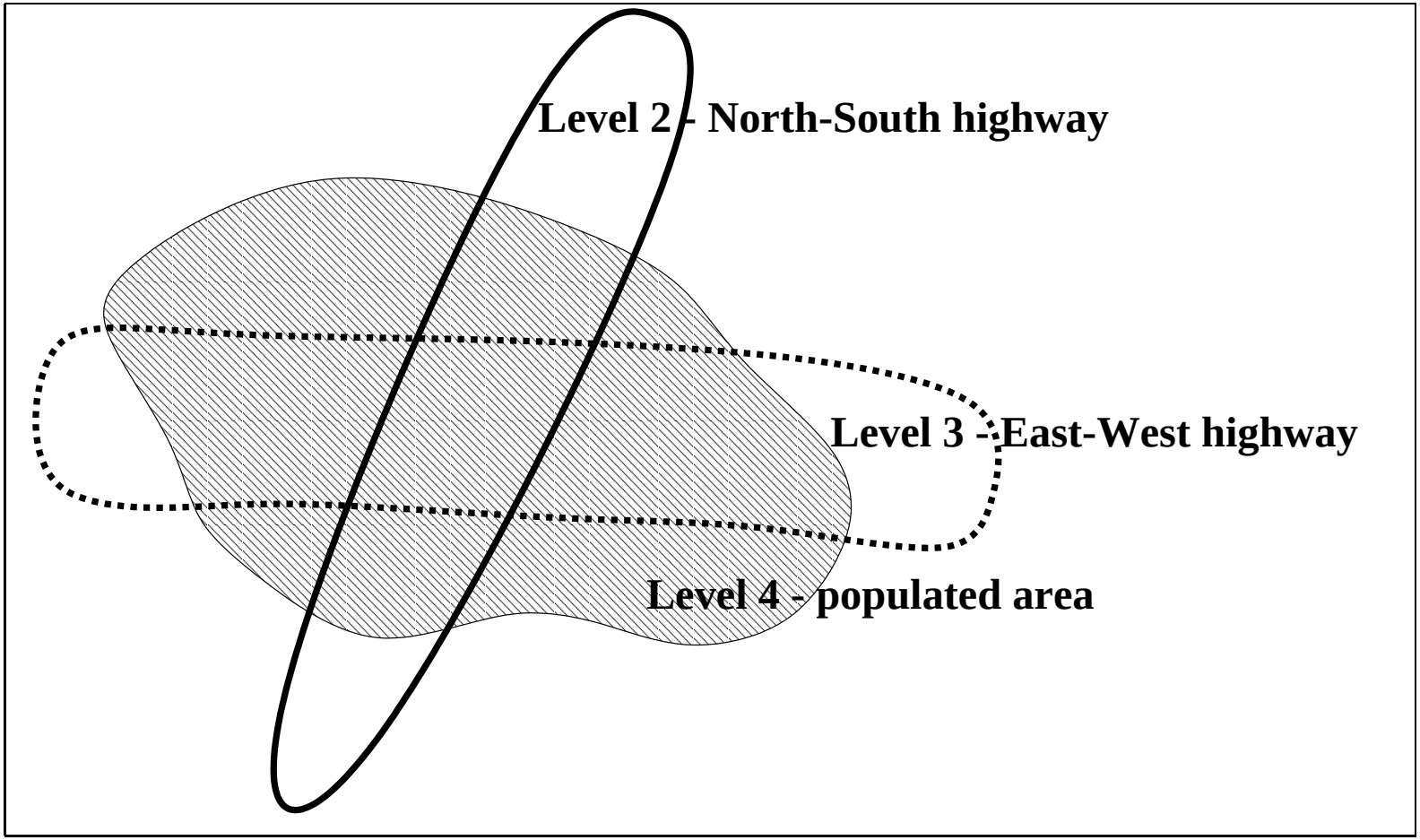
Hierarchical Call Admission

Oblivious partitioning



Hierarchical Call Admission

Map specific partitioning



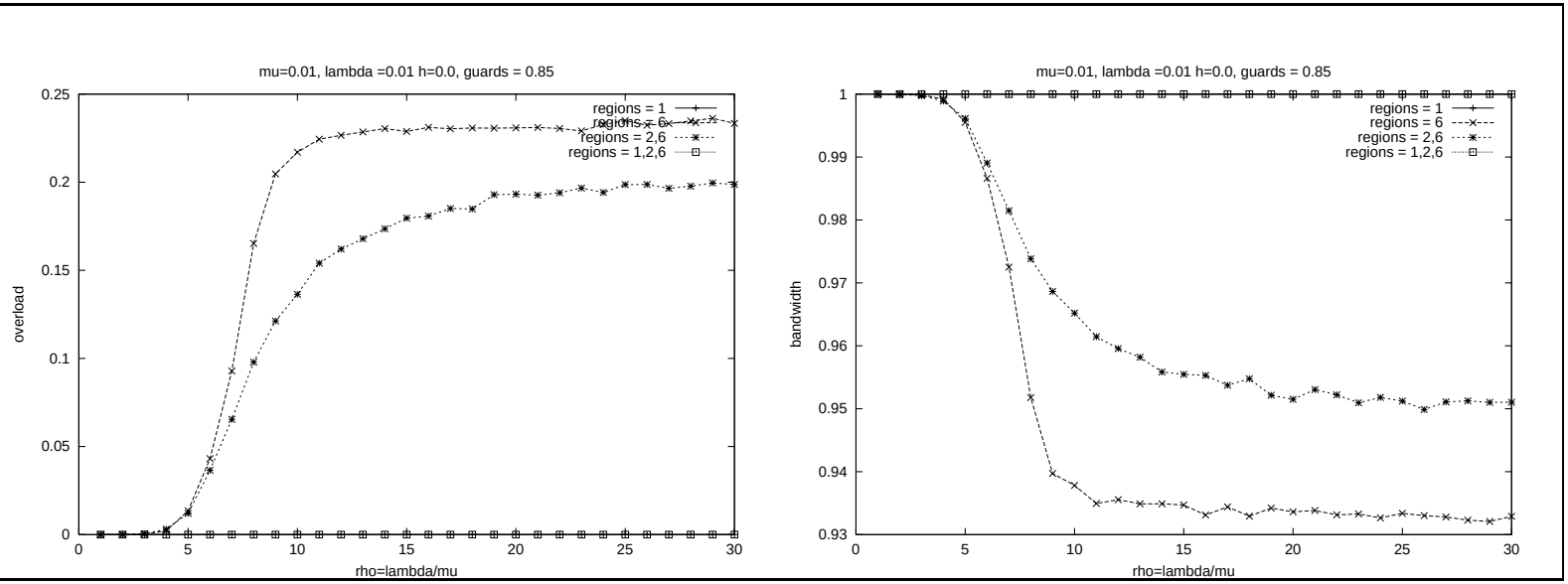
Hierarchical Call Admission

- advantages:
  - extends the decision base for admitting a call
  - allows for potentially overlapping regions
  - enforces more uniformity in the non-uniform models
  - cell-based and region-based call admission are a particular cases of the hierarchical call admission

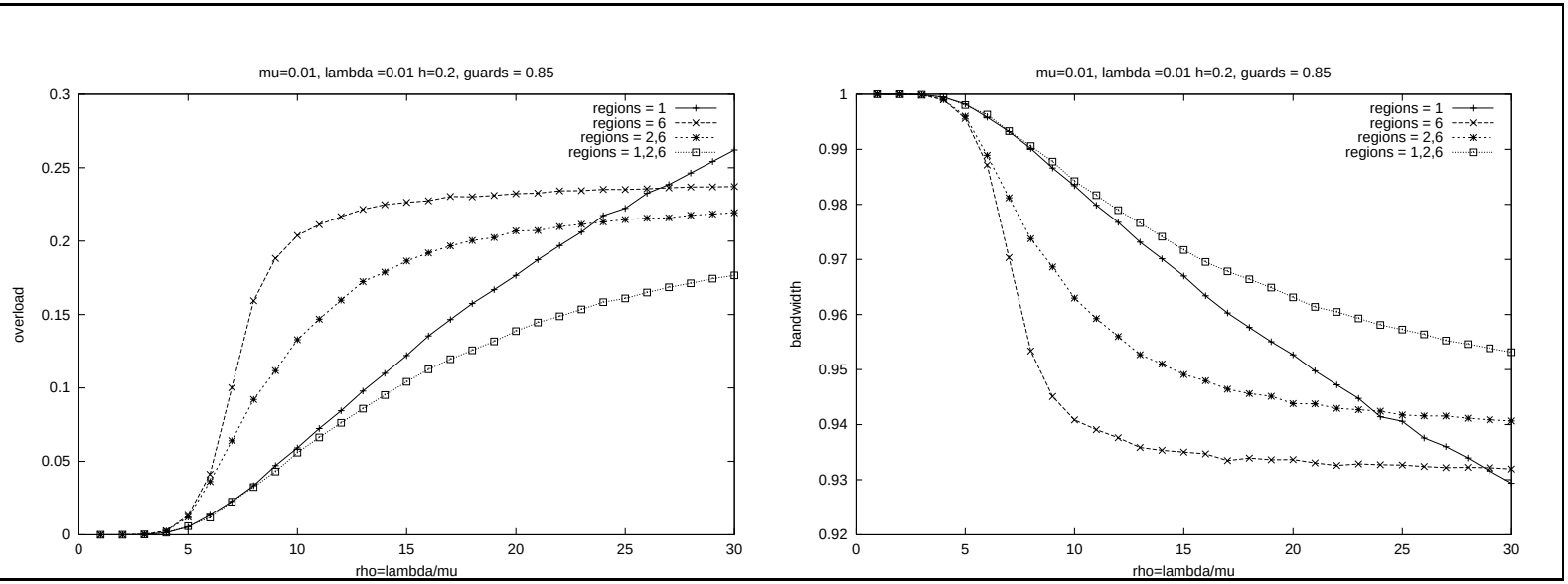
Simulation models

- event driven simulator
- rectangular, wrapped around map
- allows for regions of arbitrary shape
- uniform and non-uniform cell occupancy models
- “guard channel” type admission

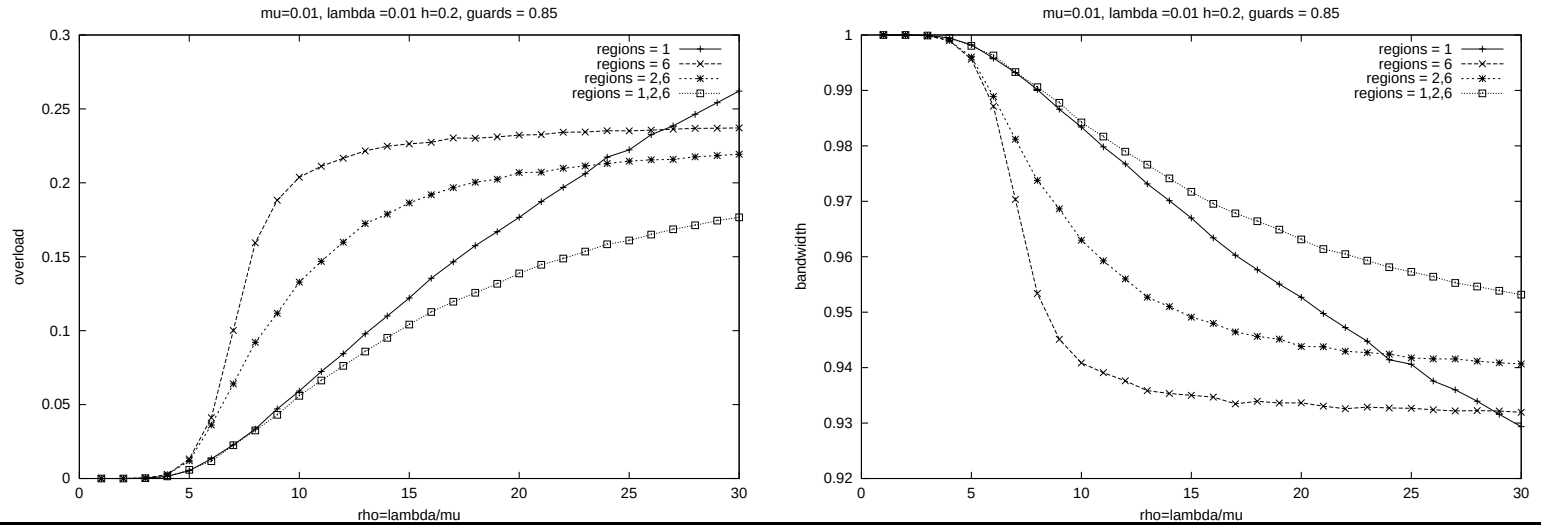
Simulation Results -effect of mobility



$\lambda = .01 - .5, \mu = .01, h = .2, B = 10, \alpha = .9$



Simulation Results - effect of hierarchy

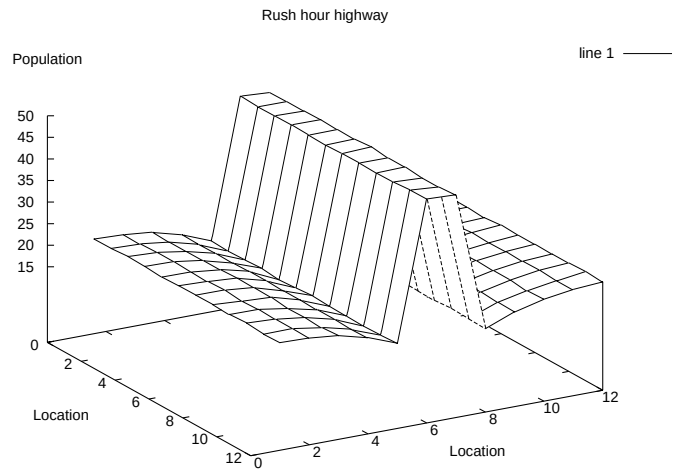


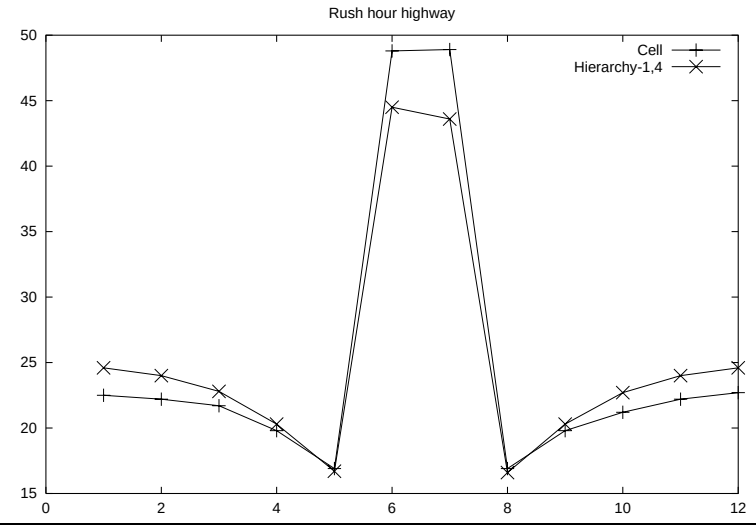
$\lambda = .01 - .5, \mu = .01, h = .2, B = 10, \alpha = .9$

- hierarchical decision may:
  - provide more consistent behavior at different loads (graceful degradation)
  - be more effective for transient states

Simulation Results - nonuniform models

- under the same load, hierarchy shows 10% improvement in overload probability over the cell based decision





$\lambda = .2, \mu = .005, h = .2, B = 25$

Future Work

- apply hierarchical decision to spatial mobility models
- how does it work with multiple classes, on top of LBMA?
- apply cost based schemes to scheduling
- non-uniform regions:
  - overlapping regions
  - dynamic, adaptive regions
- policies to dynamically set thresholds with traffic conditions
- mobility-prediction enhancements