MOBILITY MODEL

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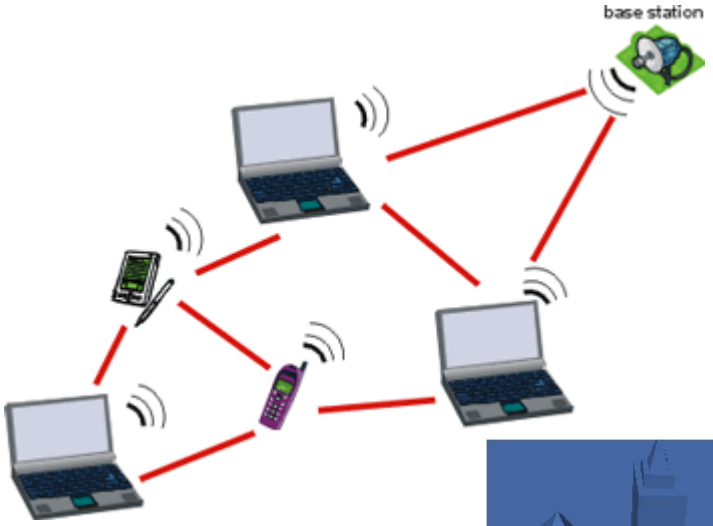
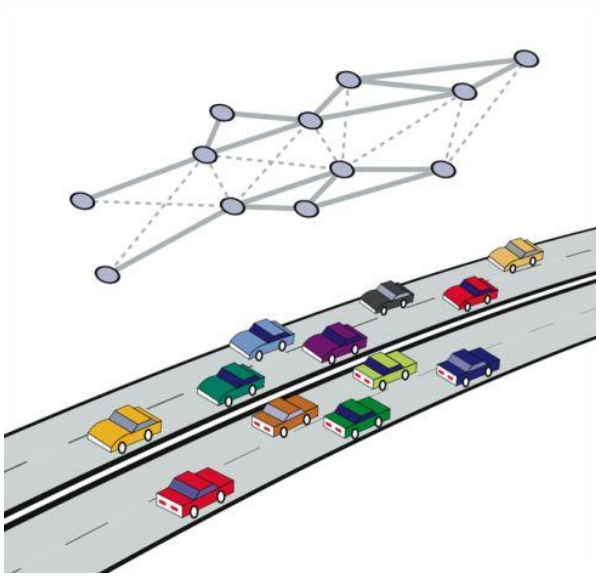
Wireless Mobile Ad hoc Networks (MANETs)

- A Mobile Ad hoc Network (*MANET*) is a collection of mobile devices forming a multi-hop wireless network with minimal (or no) infrastructure
- To evaluate/study adhoc networks mobility and traffic patterns are two significant factors affecting protocol performance.
- Wireless network performance evaluation uses:
  - Mobility Patterns: usually, uniformly and randomly chosen destinations (random waypoint model)
  - Traffic Patterns: usually, uniformly and randomly chosen communicating nodes with long-lived connections
- Impact of mobility on wireless networks and ad hoc routing protocols is significant

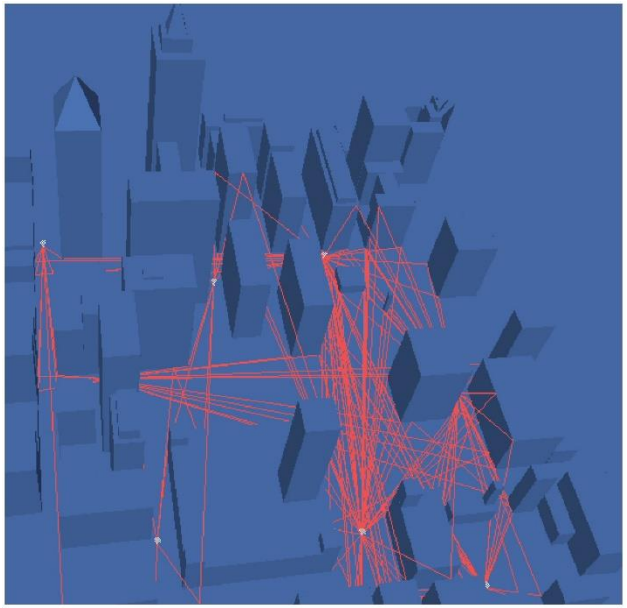
Example Ad hoc Networks



Mobile devices (laptop, PDAs)



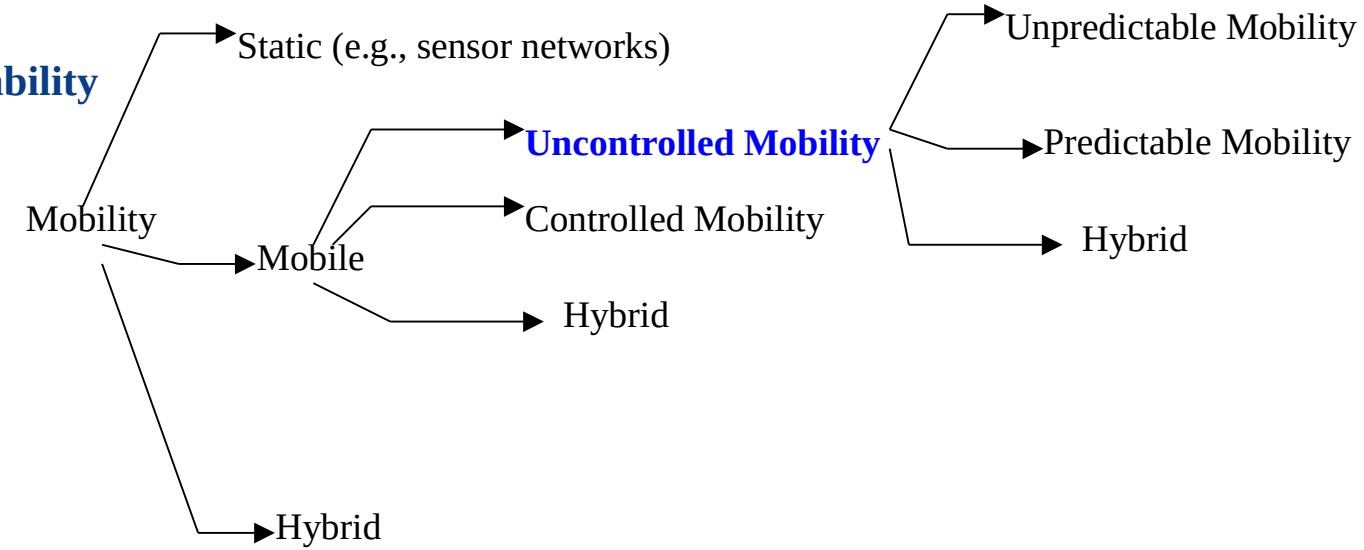
Vehicular Networks on Highways



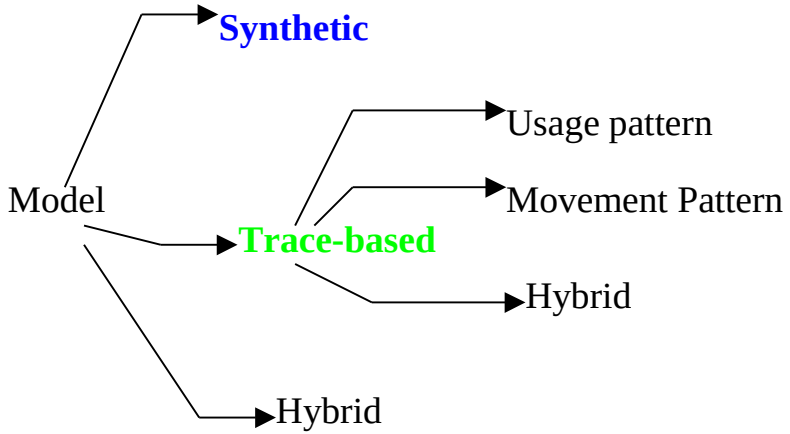
Hybrid urban ad hoc network (vehicular, pedestrian, hot spots,…)

Classification of Mobility and Mobility Models

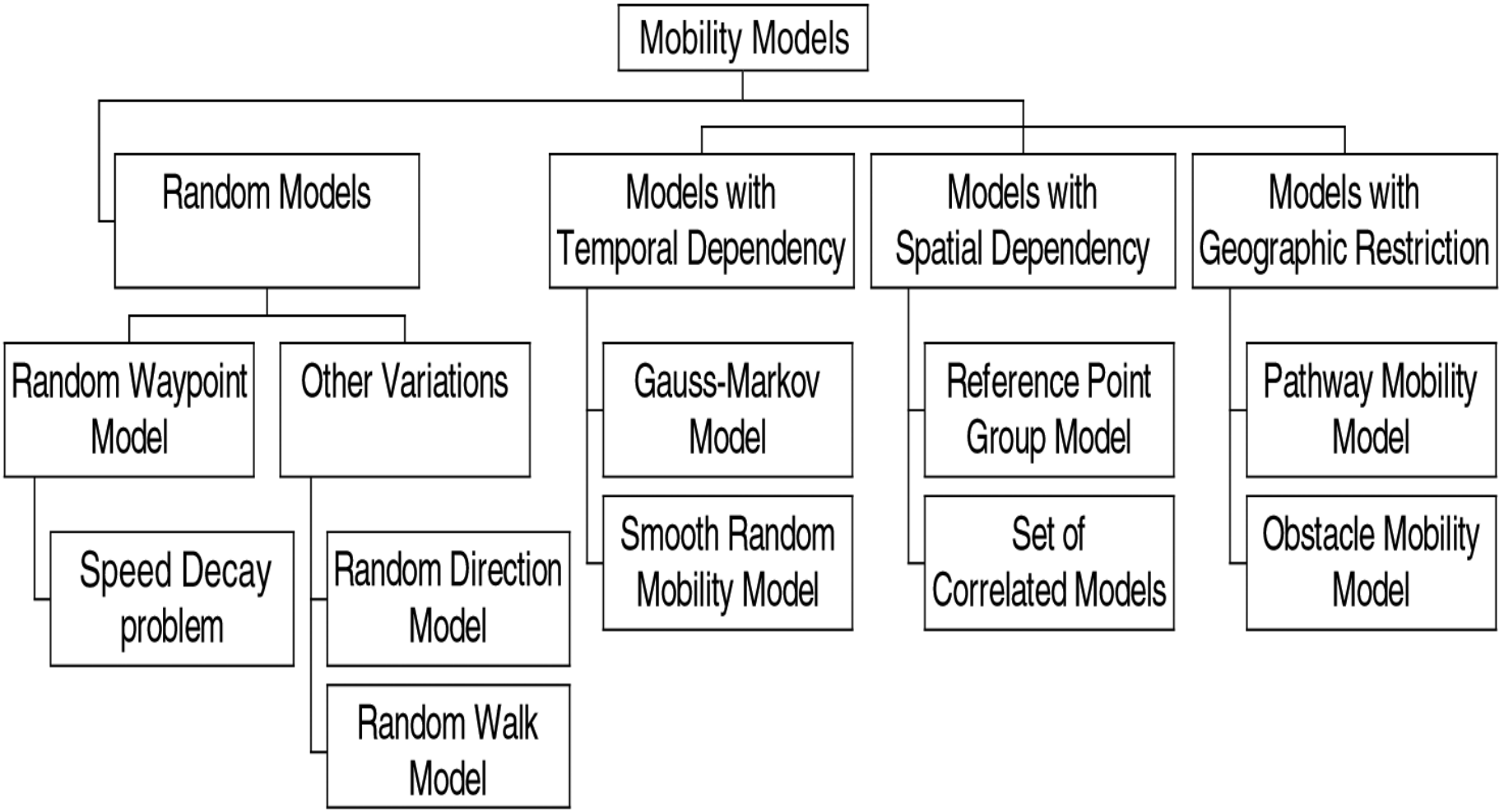
I- Based on Controllability



II- Based on Model Construction



Mobility Dimensions & Classification of Synthetic Uncontrolled Mobility Models



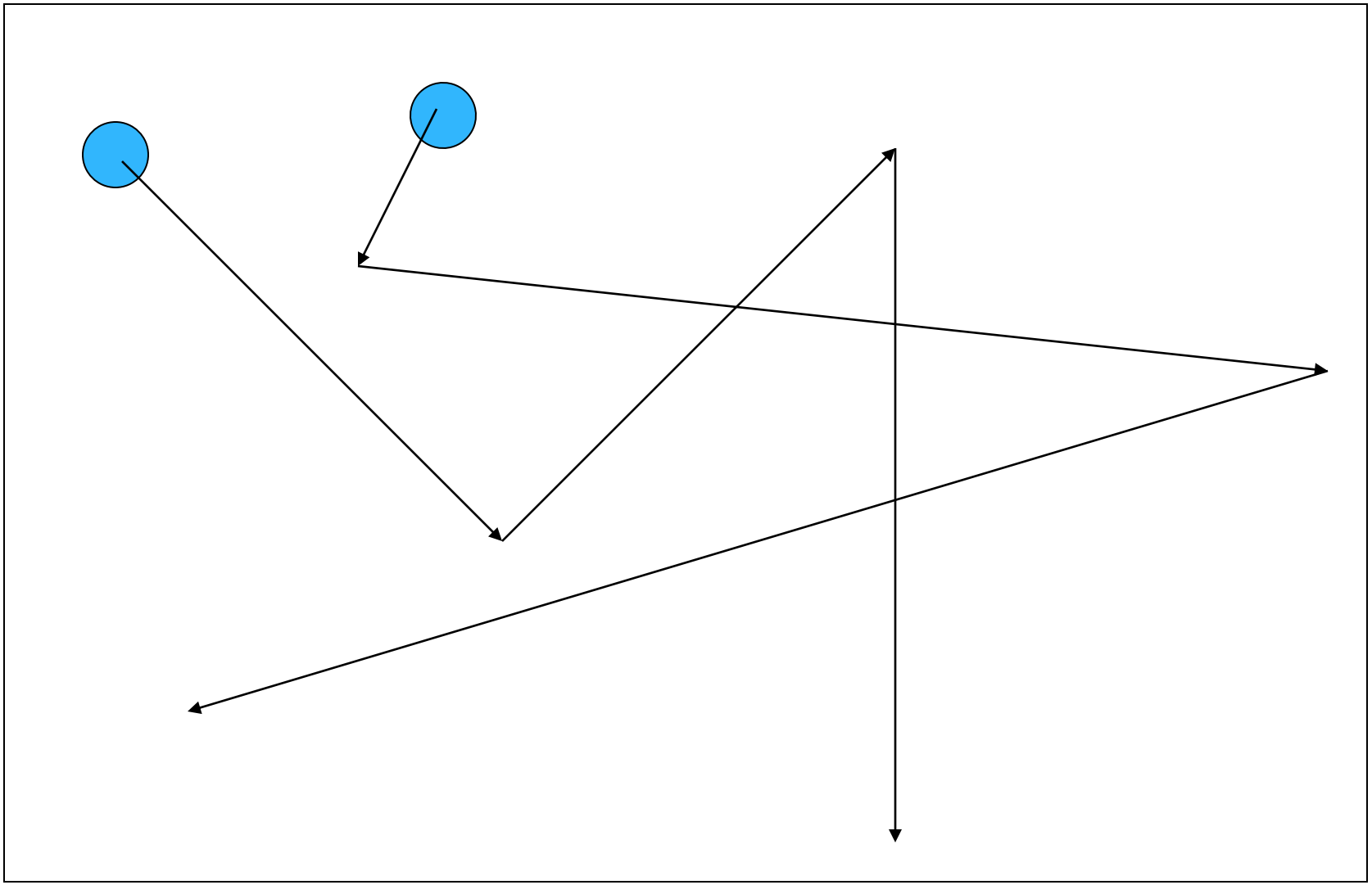
* F. Bai, A. Helmy, "A Survey of Mobility Modeling and Analysis in Wireles Adhoc Networks", Book Chapter in the book "Wireless Ad Hoc and Sensor Networks", Kluwer Academic Publishers, June 2004.

I. Random Waypoint (*RWP*) Model

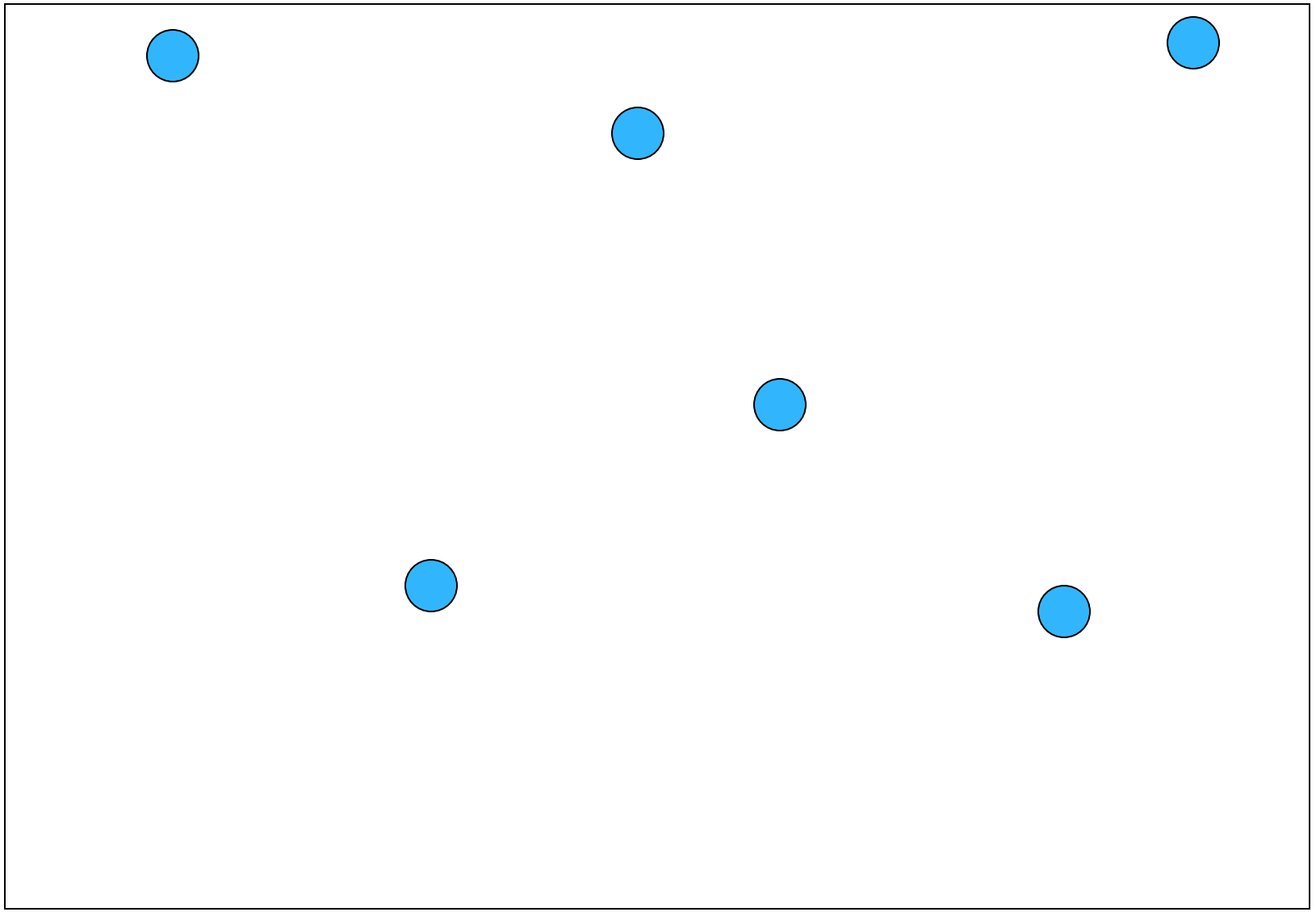
1. A node chooses a random destination anywhere in the network field
2. The node moves towards that destination with a velocity chosen randomly from [0, *Vmax*]
3. After reaching the destination, the node stops for a duration defined by the “pause time” parameter.
4. This procedure is repeated until the simulation ends

- Parameters: Pause time T, max velocity *Vmax*
- Comments:
  - Speed decay problem, non-uniform node distribution
  - Variants: random walk, random direction, smooth random, ...

Random Way Point: Basics



Random Way Point: Example



II. Random (*RWK*) Walk Model

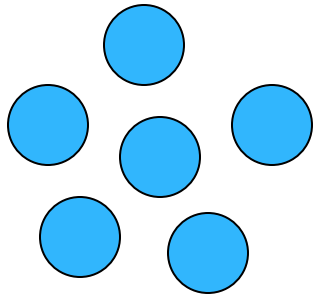
- Similar to RWP but
  - Nodes change their speed/direction every time slot
  - New direction θ is chosen randomly between $(0,2\pi]$
  - New speed chosen from uniform (or Gaussian) distribution
  - When node reaches boundary it bounces back with $(\pi-\theta)$

Random Walk

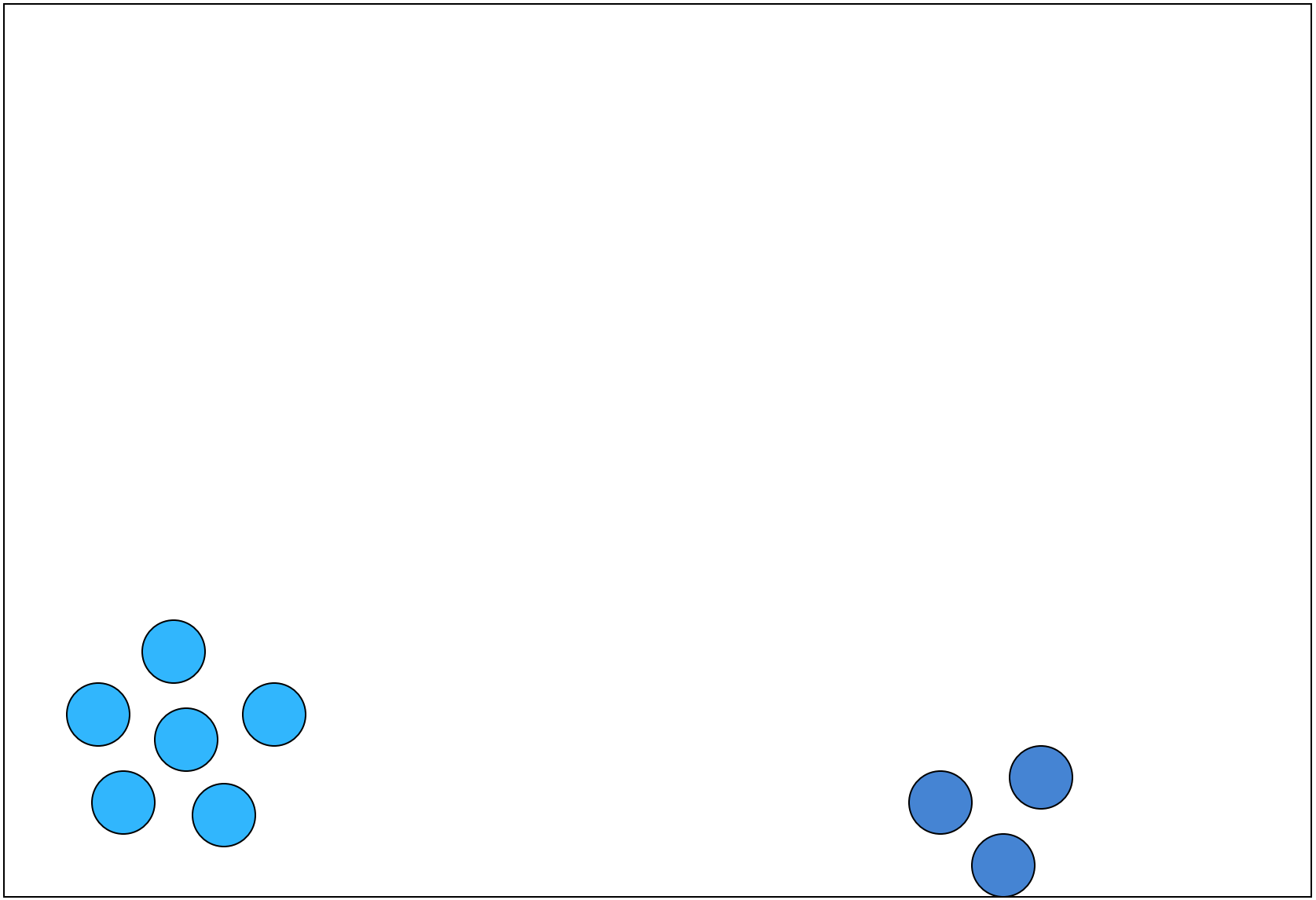
III. Reference Point Group Mobility (*RPGM*)

- Nodes are divided into groups
- Each group has a leader
- The leader's mobility follows random way point
- The members of the group follow the leader's mobility closely, with some deviation
- Examples:
  - Group tours, conferences, museum visits
  - Emergency crews, rescue teams
  - Military divisions/platoons

Group Mobility: Single Group

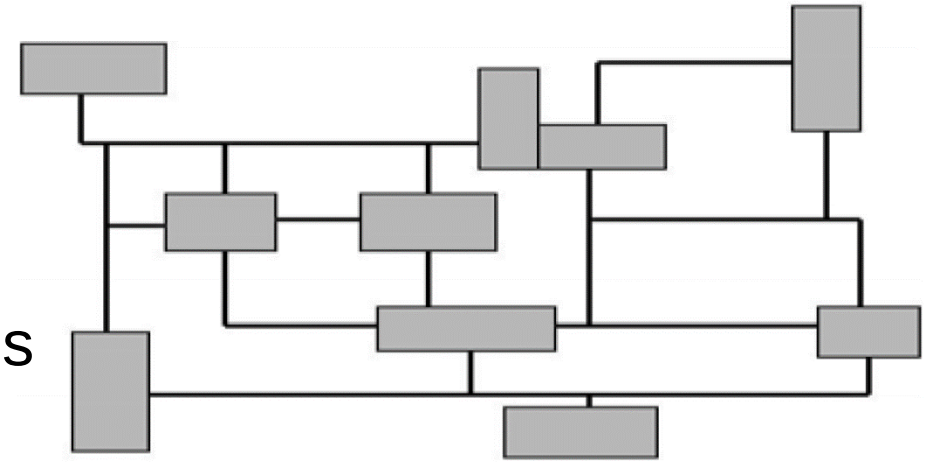


Group Mobility: Multiple Groups



IV. Obstacle/Pathway Model

- Obstacles/bldgs map
- Nodes move on pathways between obstacles
- Nodes may enter/exit buildings

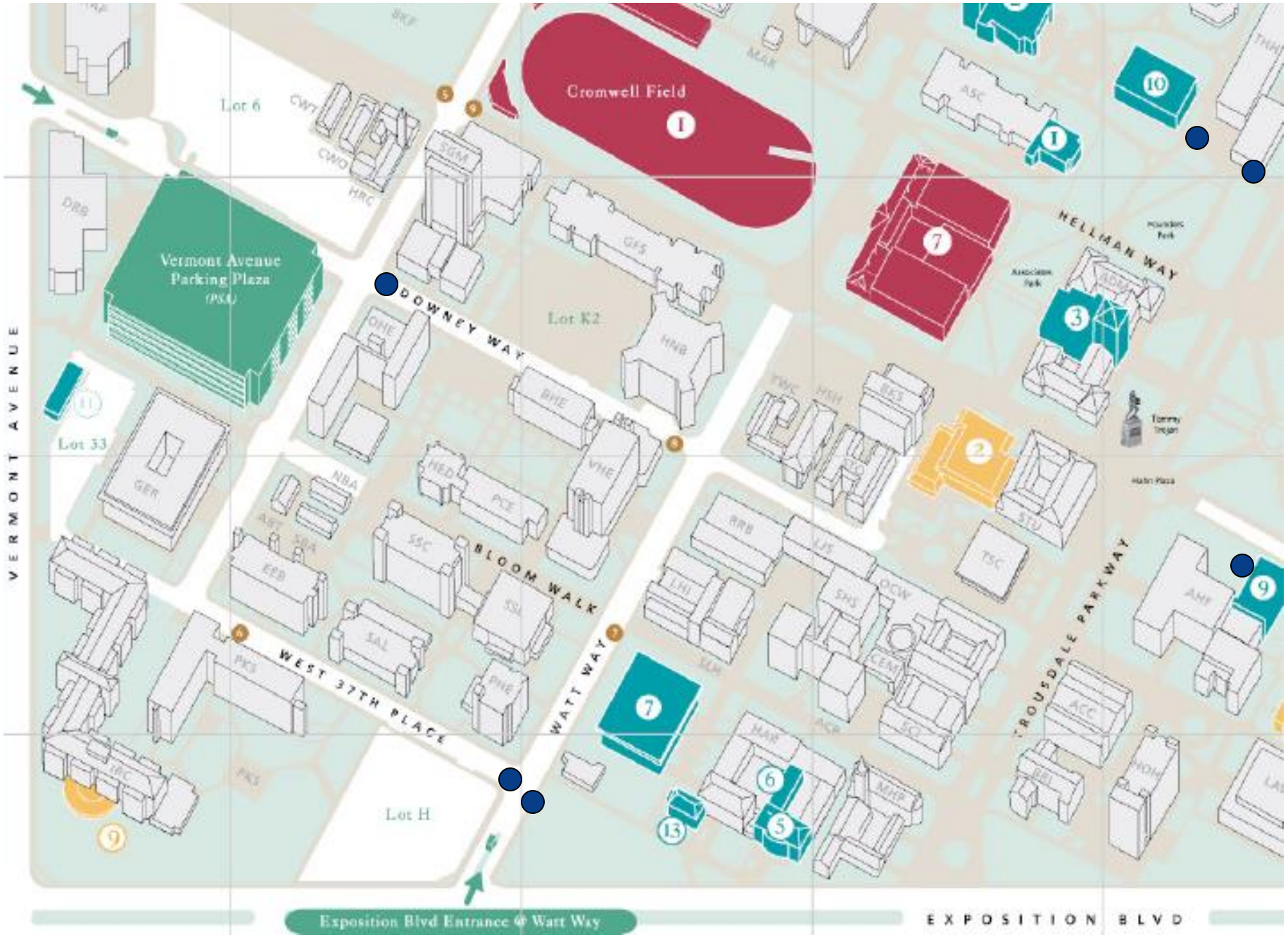


(c) Pathway Graph on a Campus

- Pathways constructed by computing Voronoi graph (i.e., pathways equidistant to nearby buildings)
- Obstacles affect communication
  - Nodes on opposite sides (or in/outside) of a building cannot communicate

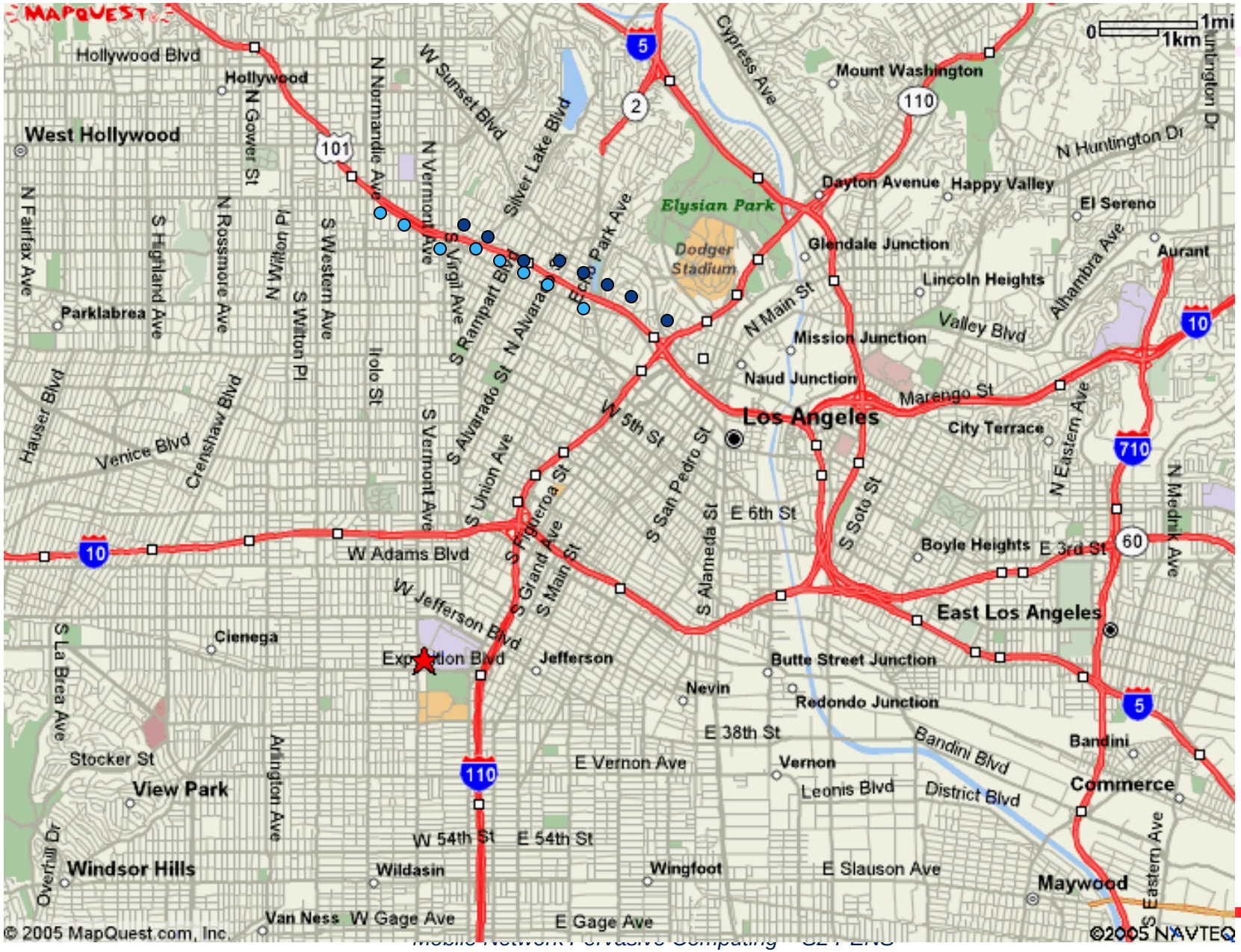
V. Related Real-world Mobility Scenarios

- Pedestrian Mobility
  - University or business campuses
  - Usually mixes group and RWP models, with obstacles and pathways
- Vehicular Mobility
  - Urban streets (Manhattan-like)
  - Freeways
  - Restricted to streets, involves driving rules


Cromwell Field
Lot 6
Lot K2
Lot 33
Lot H
Vermont Avenue Parking Plaza (PSA)
DOWNEY WAY
BLOOM WALK
WEST 37TH PLACE
WATT WAY
HELLMAN WAY
JEFFERSON BLVD
VERMONT AVENUE
EXPOSITION BLVD
Exposition Blvd Entrance @ Watt Way

Urban Street Streets - Manhattan

Freeway Map


MAPQUEST
0 1mi 1km
Hollywood Blvd
Hollywood
West Hollywood
N Gower St
N Normandie Ave
W Sunset Blvd
Silver Lake Blvd
Cypress Ave
Mount Washington
N Huntington Dr
Dayton Avenue
Happy Valley
El Sereno
Elysian Park
Dodger Stadium
Glendale Junction
Aurant
Alhambra Ave
Lincoln Heights
N Fairfax Ave
S Highland Ave
N Rossmore Ave
S Western Ave
S Virgil Ave
S Rampart Blvd
N Alvarado St
E 1st St
E 4th St
N Main St
Valley Blvd
Parklabrea
Mission Junction
Naud Junction
Marengo St
Los Angeles
City Terrace
Hauser Blvd
Venice Blvd
Crenshaw Blvd
Irolo St
S Vermont Ave
S Union Ave
W 5th St
S San Pedro St
S Alameda St
E 6th St
S Soto St
N Eastern Ave
N Mednik Ave
Boyle Heights
E 3rd St
W Adams Blvd
S Figueroa St
S Grand Ave
S Main St
W Jefferson Blvd
East Los Angeles
S La Brea Ave
Cienega
Jefferson
Butte Street Junction
Nevin
Redondo Junction
Stocker St
E 38th St
Bandini Blvd
Bandini
Arlington Ave
View Park
E Vernon Ave
Vernon
Leonis Blvd
District Blvd
Commerce
Overhill Dr
W 54th St
E 54th St
Windsor Hills
Wildasin
Wingfoot
E Slauson Ave
Maywood
Eastern Ave
Van Ness
W Gage Ave
E Gage Ave
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IMPORTANT: A framework to systematically analyze the "***I***mpact of ***M***obility on ***P***erformance ***O***f ***R***ou***T***ing in ***A***d-hoc ***N***e***T***works"

Fan Bai, Narayanan Sadagopan, Ahmed Helmy

{fbai, nsadagop, helmy}@usc.edu

website "http://nile.usc.edu/important"

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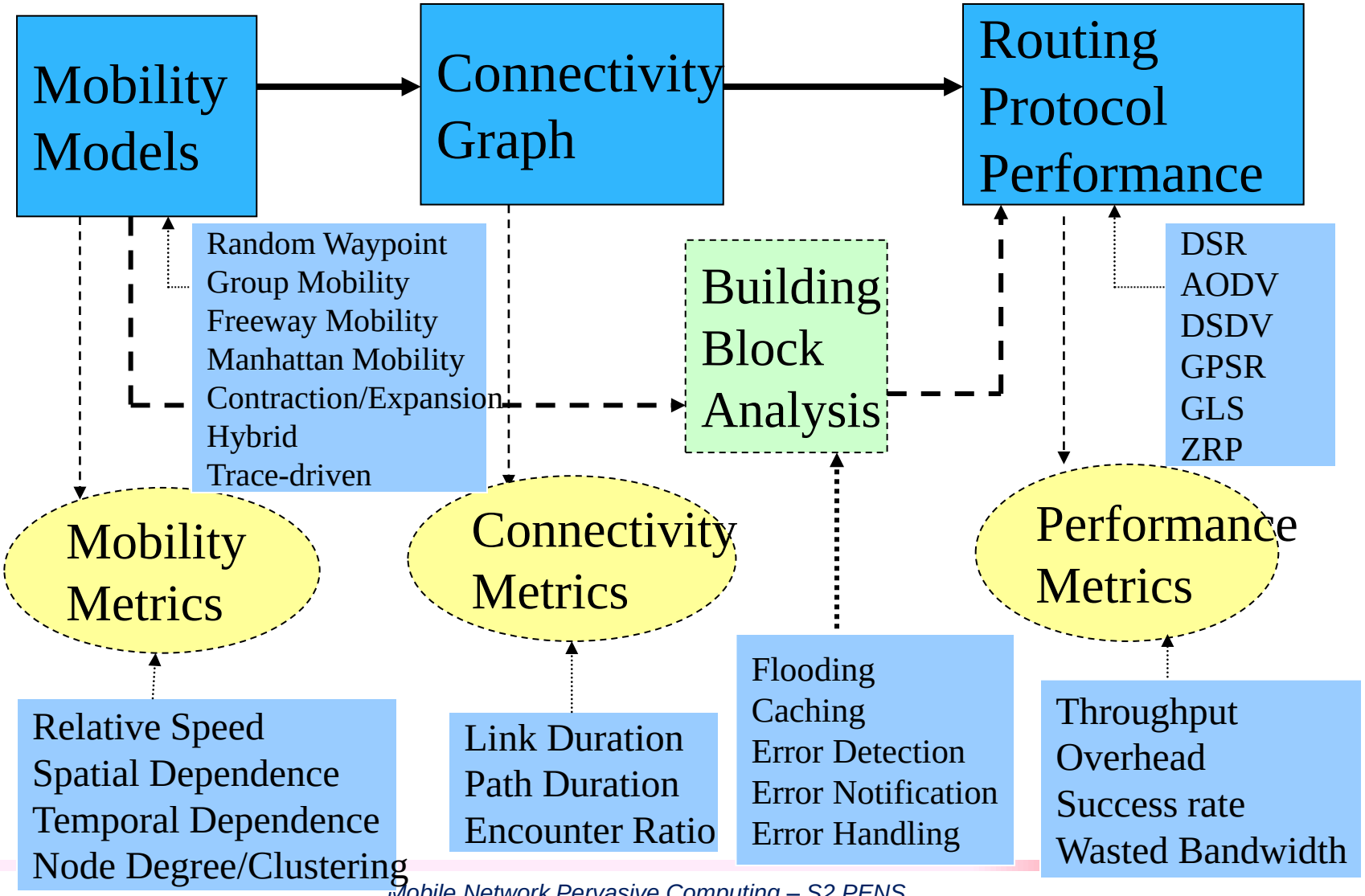
* F. Bai, N. Sadagopan, A. Helmy, "*IMPORTANT*: A framework to systematically analyze the Impact of Mobility on Performance of RouTing protocols for Adhoc NeTworks", *IEEE INFOCOM*, pp. 825-835, April 2003.

* F. Bai, N. Sadagopan, A. Helmy, "The *IMPORTANT* Framework for Analyzing the Impact of Mobility on Performance of Routing for Ad Hoc Networks"*AdHoc Networks Journal - Elsevier Science*, Vol. 1, Issue 4, pp. 383-403, November 2003.

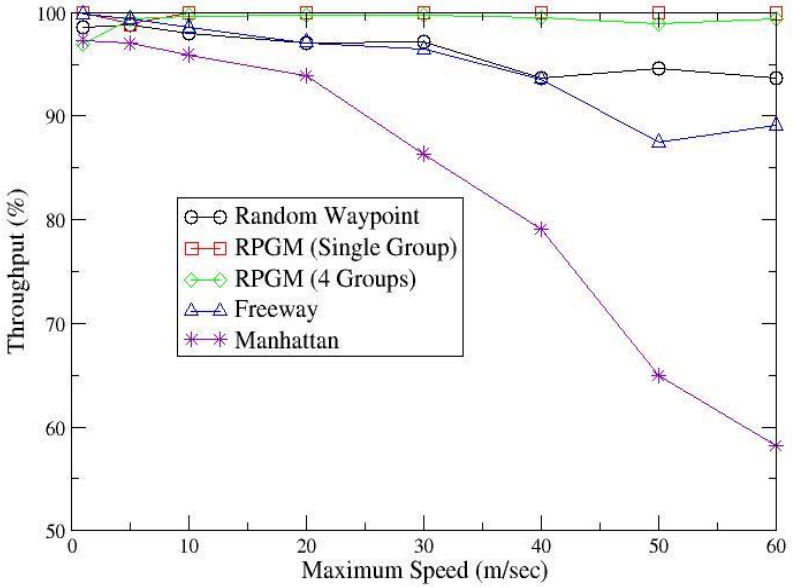
* F. Bai, A. Helmy, "The *IMPORTANT* Framework for Analyzing and Modeling the Impact of Mobility in Wireless Adhoc Networks", Book Chapter in the book "Wireless Ad Hoc and Sensor Networks", Kluwer Academic Publishers, June 2004.

The IMPORTANT Framework Overview

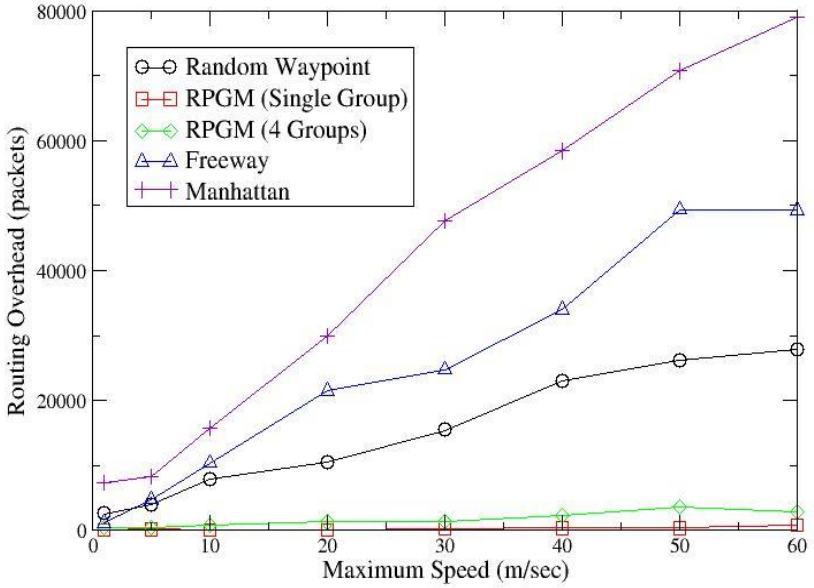


Results and Observations

- Performance of routing protocols may vary drastically across mobility patterns (Example for DSR)



Throughput

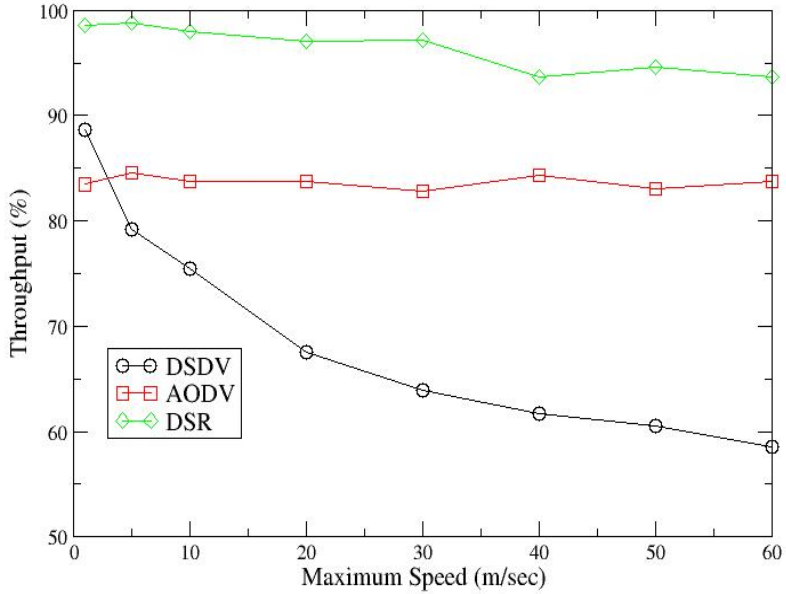


Routing Overhead

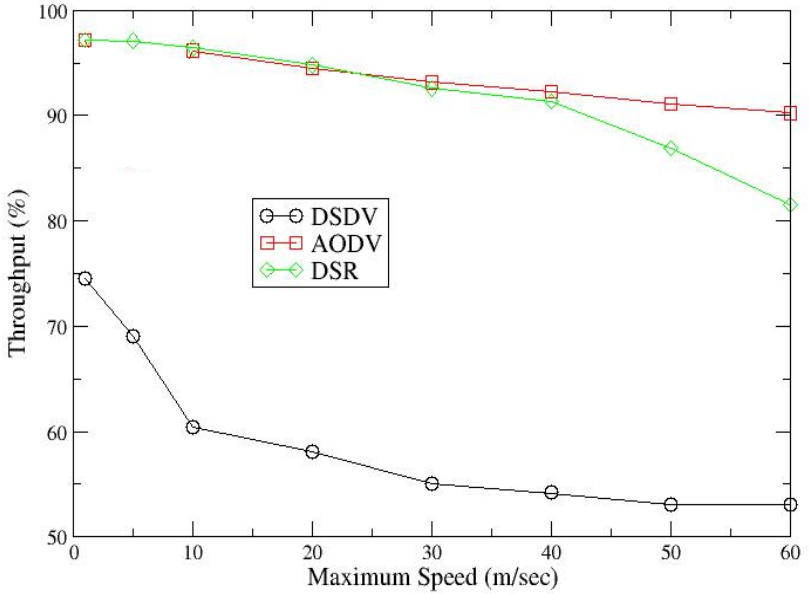
- There is a difference of 40% for throughput and an order of magnitude difference for routing overhead across mobility models!

Which Protocol Has the Highest Throughput ?

- We observe that using different mobility models may alter the ranking of protocols in terms of the throughput!



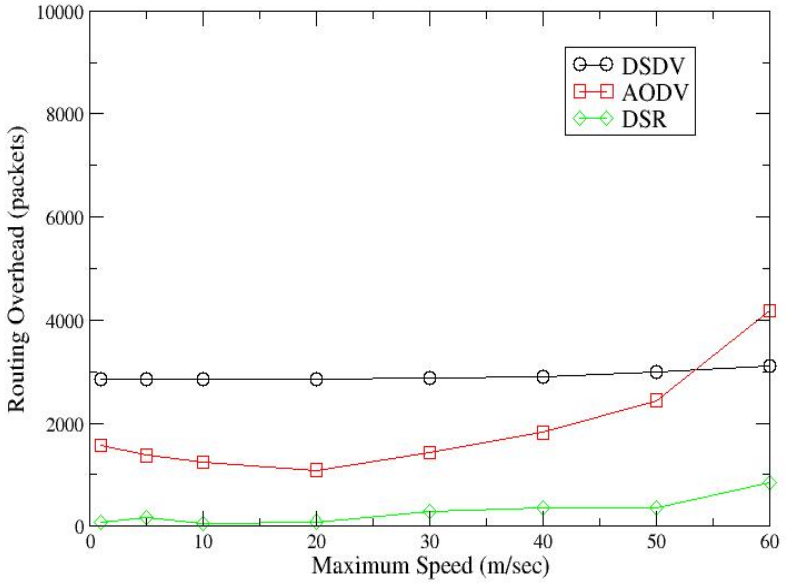
Random Waypoint : DSR



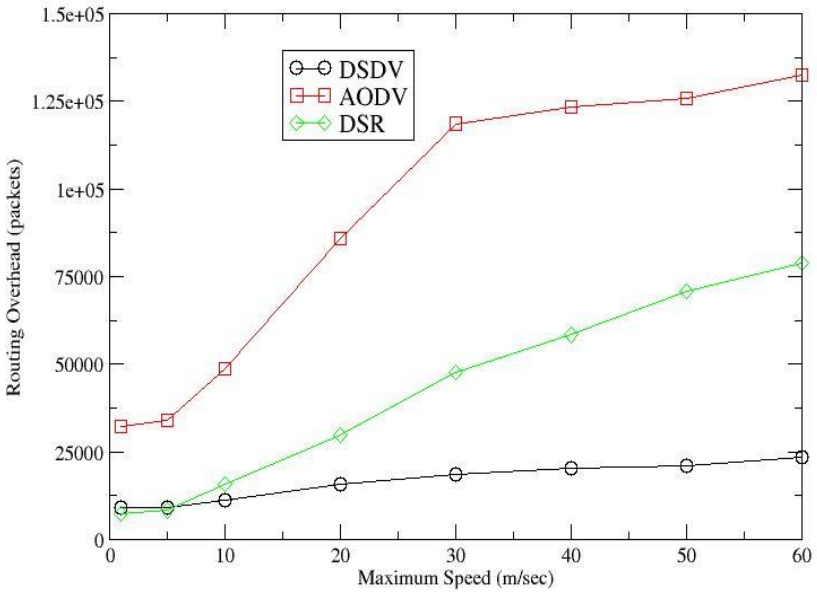
Manhattan : AODV !

Which Protocol Has the Lowest Overhead ?

- We observe that using different mobility models may alter the ranking of protocols in terms of the routing overhead!



RPGM(single group) : DSR



Manhattan : DSDV

- Recall: *Whether* mobility impacts protocol performance?
- Conclusion: Mobility DOES matter, significantly, in evaluation of protocol performance and in comparison of various protocols!

Mobility Model: ns3

- A set of mobility models which are used to track and maintain the current cartesian position and speed of an object.
- Mobility model:
  - ConstantPosition
  - ConstantVelocity
  - ConstantAcceleration
  - GaussMarkov
  - Hierarchical
  - RandomDirection2D
  - RandomWalk2D
  - RandomWaypoint
  - SteadyStateRandomWaypoint
  - Waypoint

Bonnmotion Mobility Model

- BonnMotion is a Java software which creates and analyzes mobility scenarios and is most commonly used as a tool for the investigation of mobile ad hoc network characteristics.
- The scenarios can also be exported for several network simulators, such as ns-2, ns-3, GloMoSim/QualNet, COOJA, MiXiM, and ONE.
- Mobility model:
  - Random waypoint model
  - Manhattan Grid model
  - Gauss-Markov model
  - Reference Group Mobility model (RPGM)
  - Static scenario
  - Disaster Area model
  - Tactical Indoor Mobility model
  - Self-similar Least Action Walk (SLAW)
  - Column Mobility model
  - Nomadic Community Mob. Model
  - Pursue Mobility model
  - Chain model
  - Boundless Simulation Area model
  - Random Direction Model
  - Random Street
  - etc.

References

- Ahmed Helmy, *Tutorial Mobility Modeling for Future Mobile Network Design and Simulation*, Computer and Information Science and Engineering (CISE), College of Engineering, University of Florida
- Ha Yoon Song, Overview of Mobility Models, ICT, TUWien