移動体通信のシミュレーション技術

Mineo Takai, Ph.D. (mineo@ieee.org)
UCLA Computer Science Department

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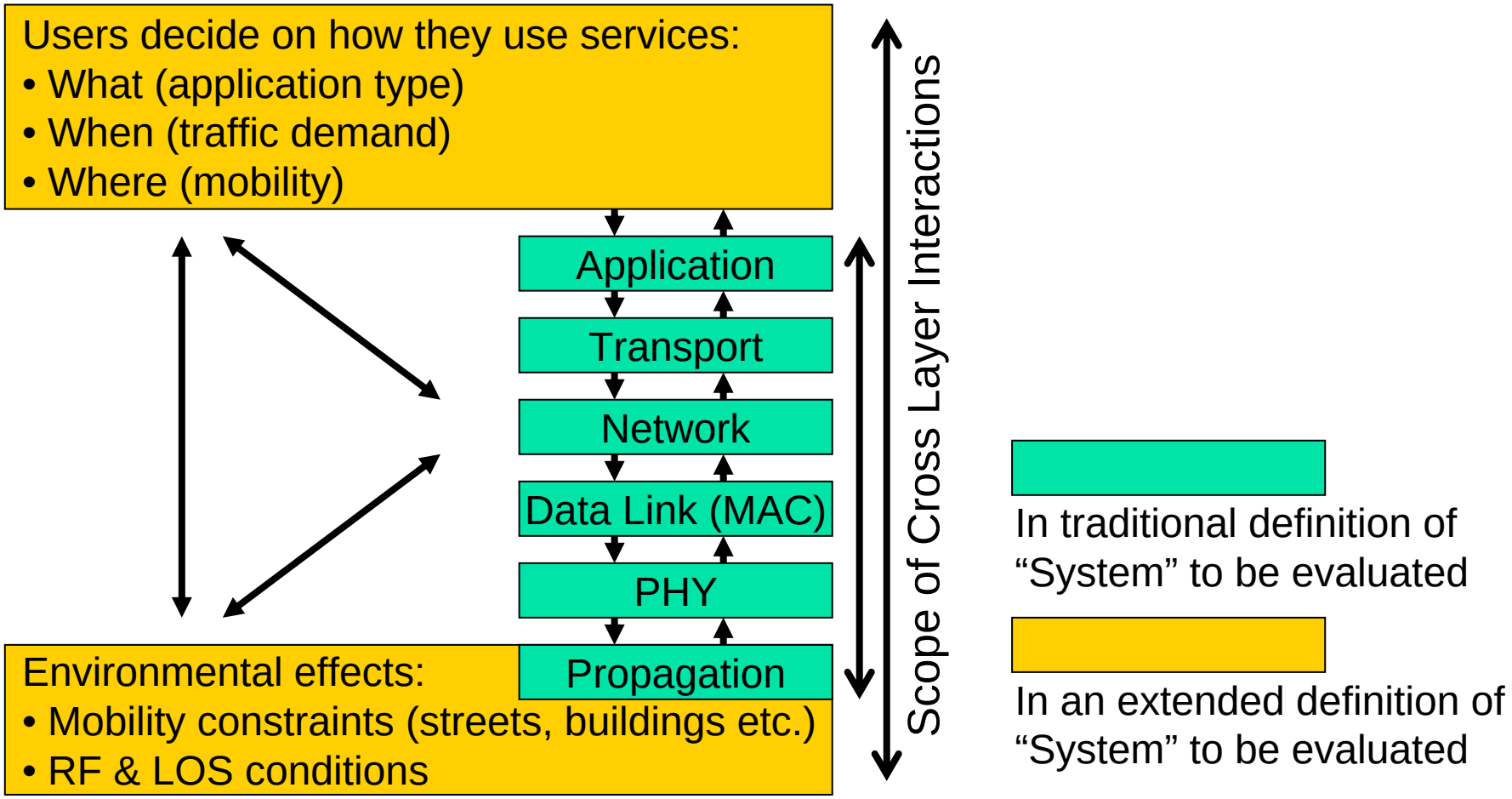
Talk Outline

- Evaluation of network systems via simulation
- ITS simulation requirements: Propagation
- Propagation models for ITS
- ITS simulation requirements: Mobility
- ITS simulation requirements: Integration
- Development of simulation framework for ITS
- Roles of ITS simulation

Evaluation of Network Systems via Simulation: Wider Scope of Cross-Layer Interactions

- Broadening the scope of “System” to be evaluated
  - Network to “Network + Users + Environment”



ITS Simulation Requirements: Propagation

- Low Antenna Heights (1): Empirical models do not apply
  - COST-231 Hata: 30~200m (BS) 1~10m (MS)
  - COST-231 Walfisch-Ikegami: 4~ 50m (BS) 1~ 3m (MS)
  - Vehicle-to-Vehicle (V2V): 1.5~2.0m at both ends
- Low Antenna Heights (2): Vehicles themselves as obstacles
  - NLOS created by vehicles in between
- Mobile at both ends: Path loss precomputation unrealistic
  - N_{BS} x N_{MS} to N_{MS} x N_{MS}
    N_{MS}: Number of positions where MSs can possibly move
  - Accounting for moving obstacles complicates precomputation

Fast site-specific propagation model essential for ITS simulation

Propagation Models for ITS

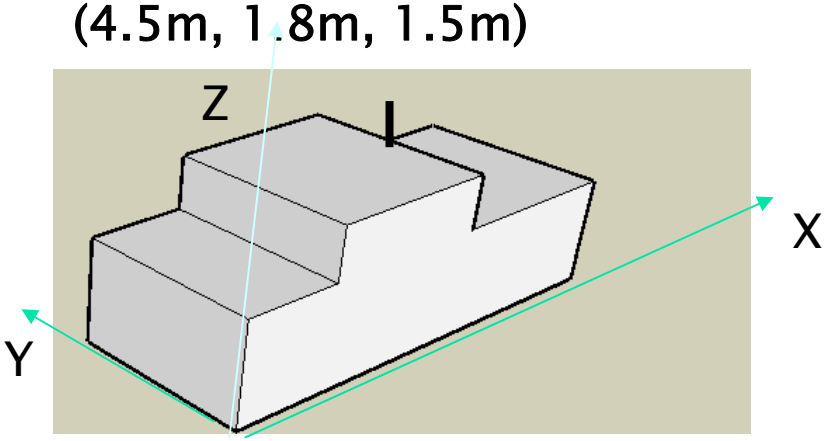
- Common site-specific propagation model: ray-tracing
- Two ray-tracing methods depending on ways to search paths
  - Imaging method for point-to-point
  - Shooting & bouncing ray method for coverage
- Significant computational resources required for the path search
  - Numbers of reflections and diffractions limited:
    Typically 10 and 2 respectively
- Another site-specific propagation model: wall counting
  - Direct path analysis only
  - Used mostly for indoor, some studies for outdoor
- Urban Propagation Prediction System (UPPS) proposed by Remcom, Inc. (Pennsylvania, USA)
  - Known for XFDTD

Demo: Path loss with Moving Objects (1)

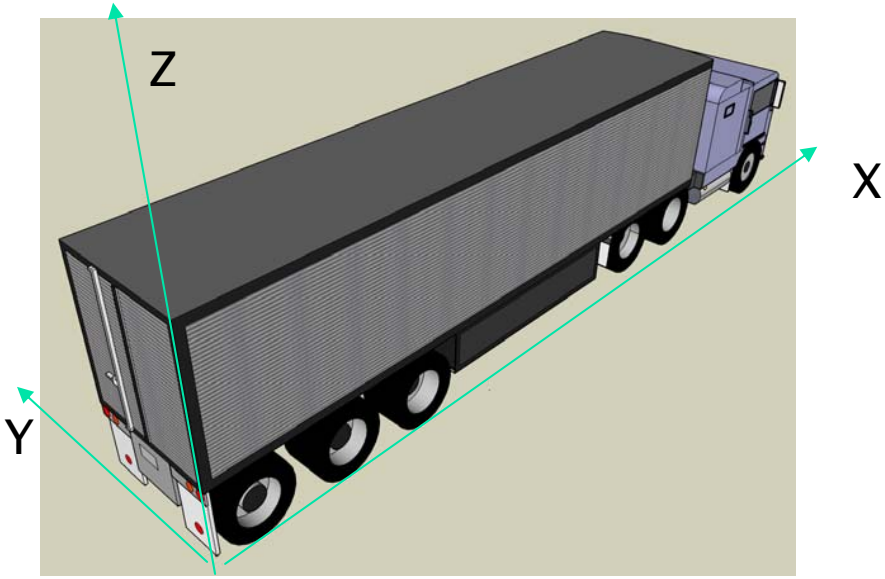
- UPPS Demos
  - Vertical plane graphics generation
  - Effects of moving objects in the scene
    - When obstacles move
    - When Tx and Rx both move

Antenna:
(2.7m, 0.9m, 1.51m)

(4.5m, 1.8m, 1.5m)

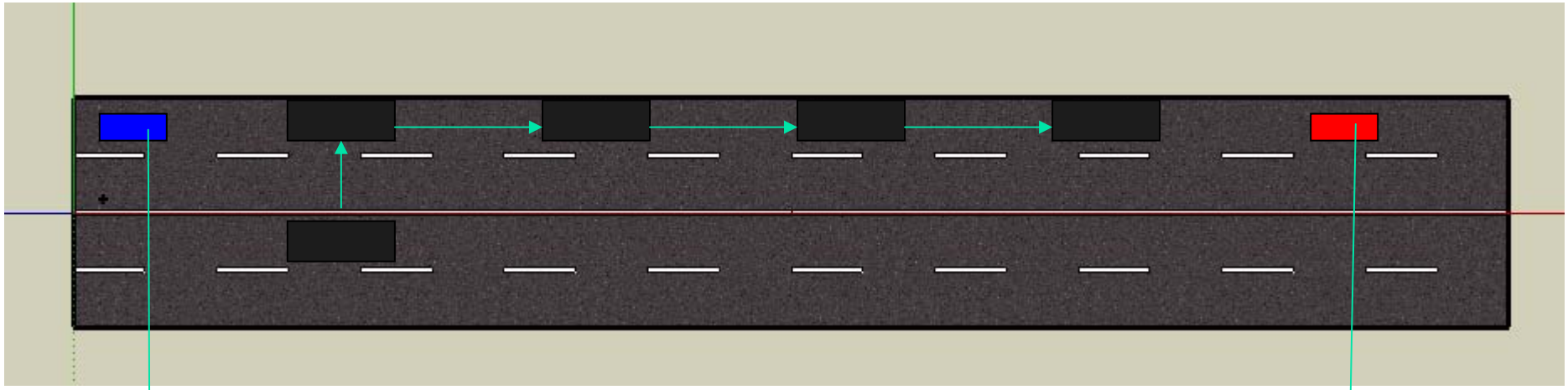


(16.0m, 2.6m, 4.0m)



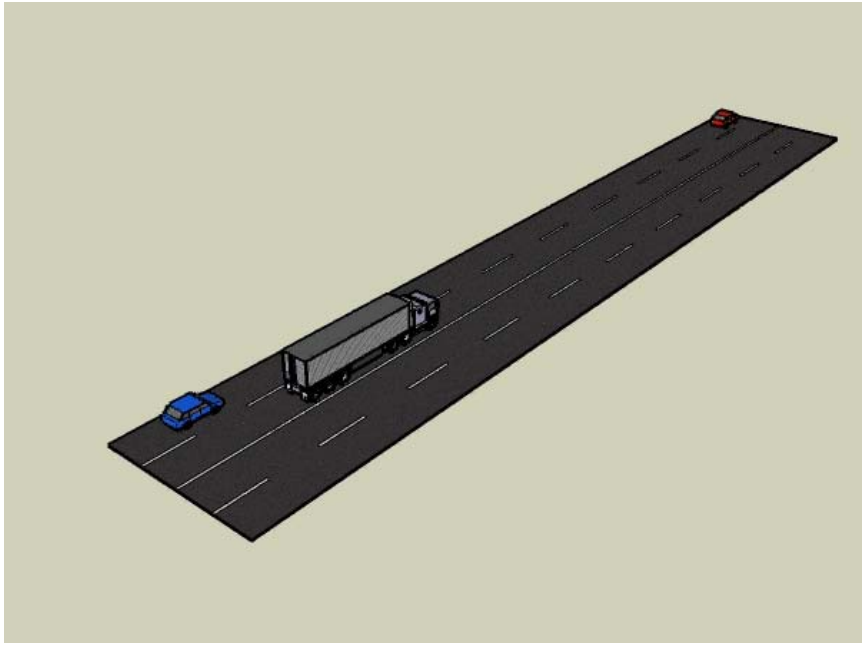
Demo: Path loss with Moving Objects (2)

Tx: Blue
Rx: Red

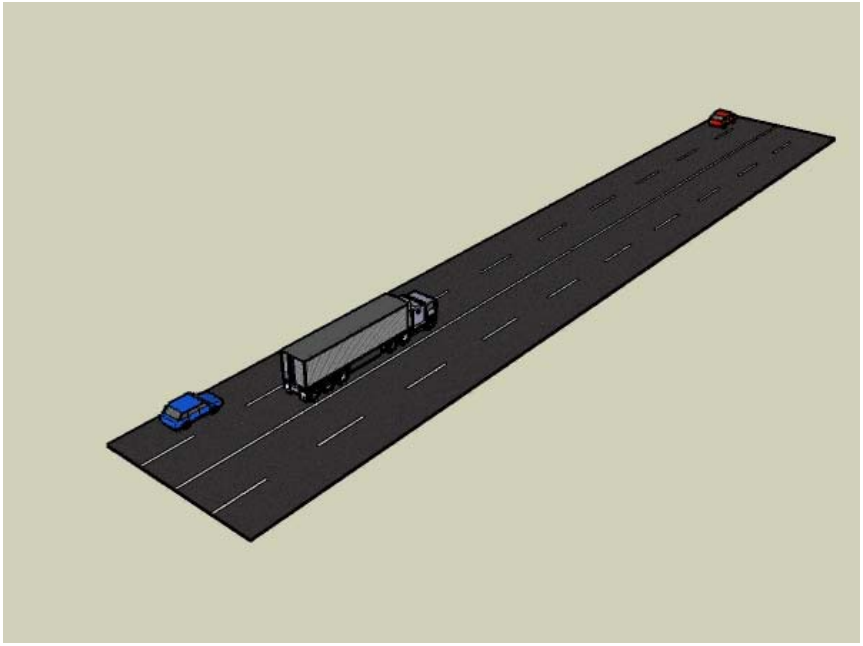


Demo: Path loss with Moving Objects (3)

One trailer cutting in

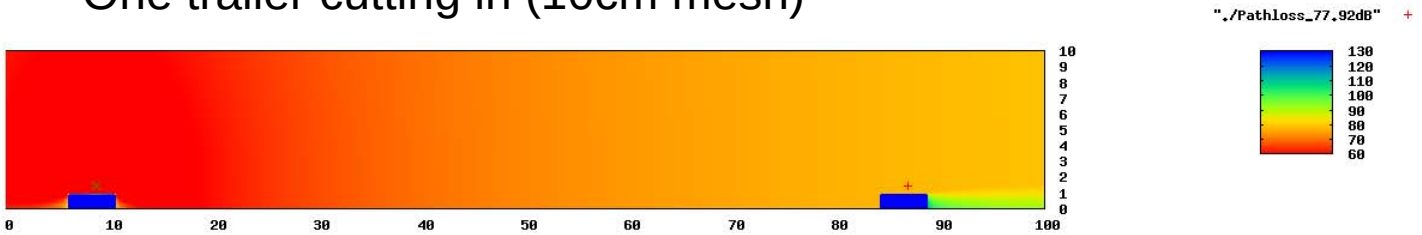


Two trailers cutting in

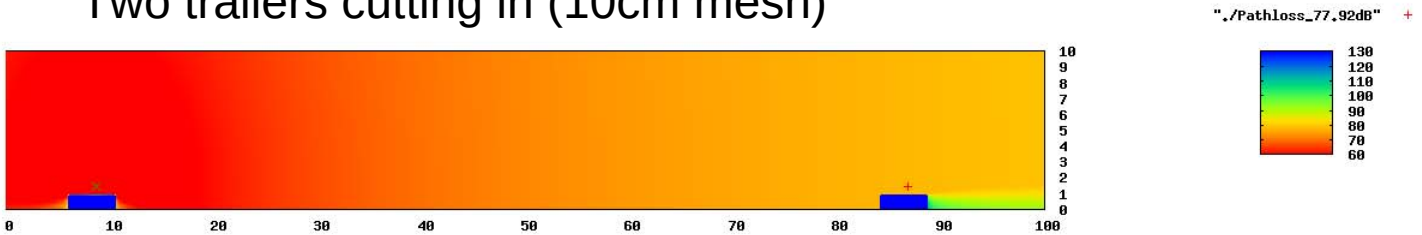


Demo: Path loss with Moving Objects (4)

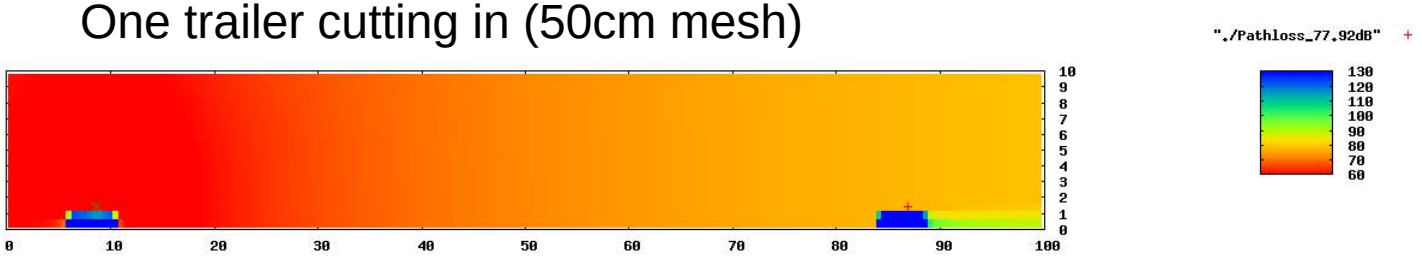
One trailer cutting in (10cm mesh)



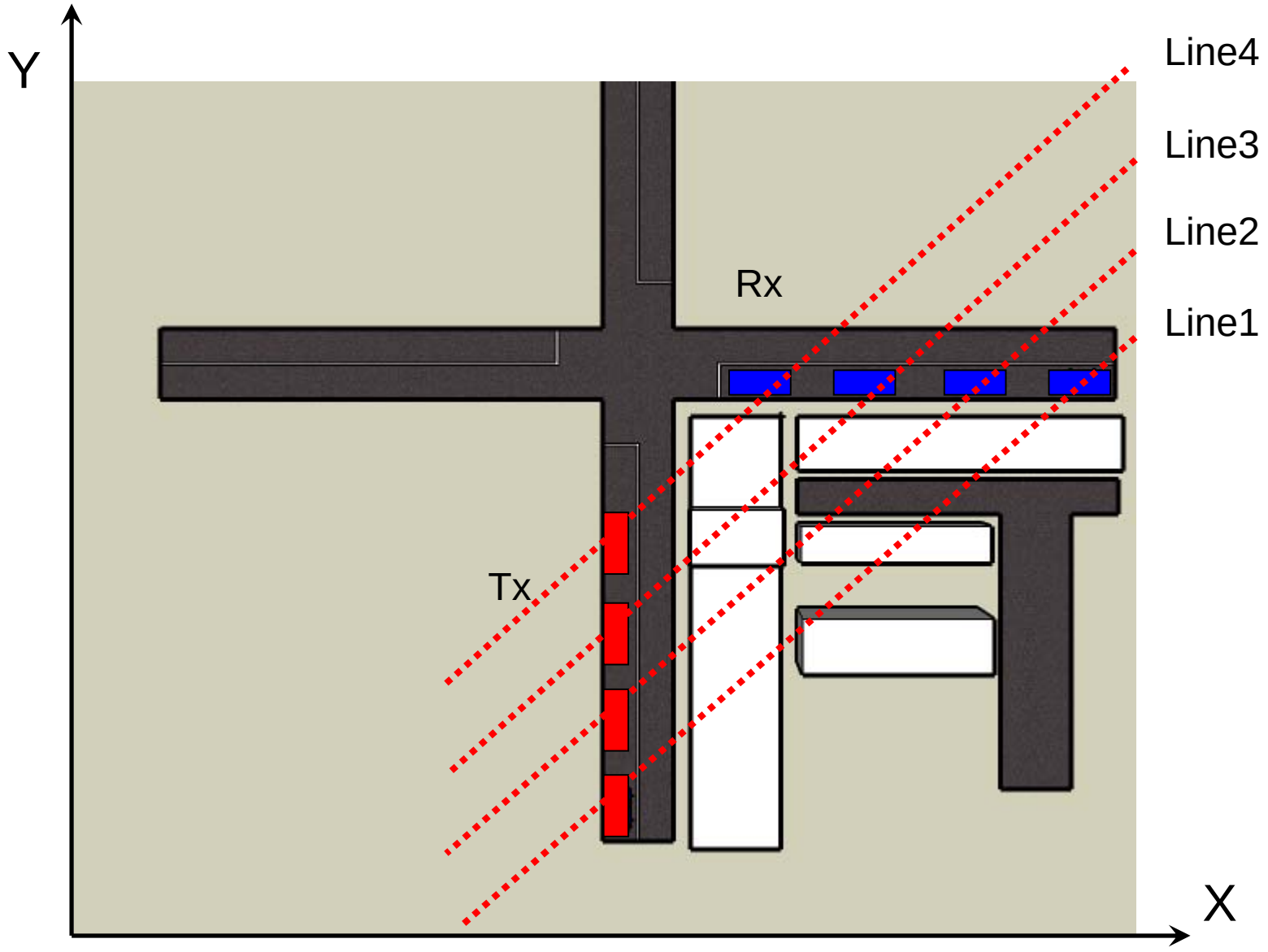
Two trailers cutting in (10cm mesh)



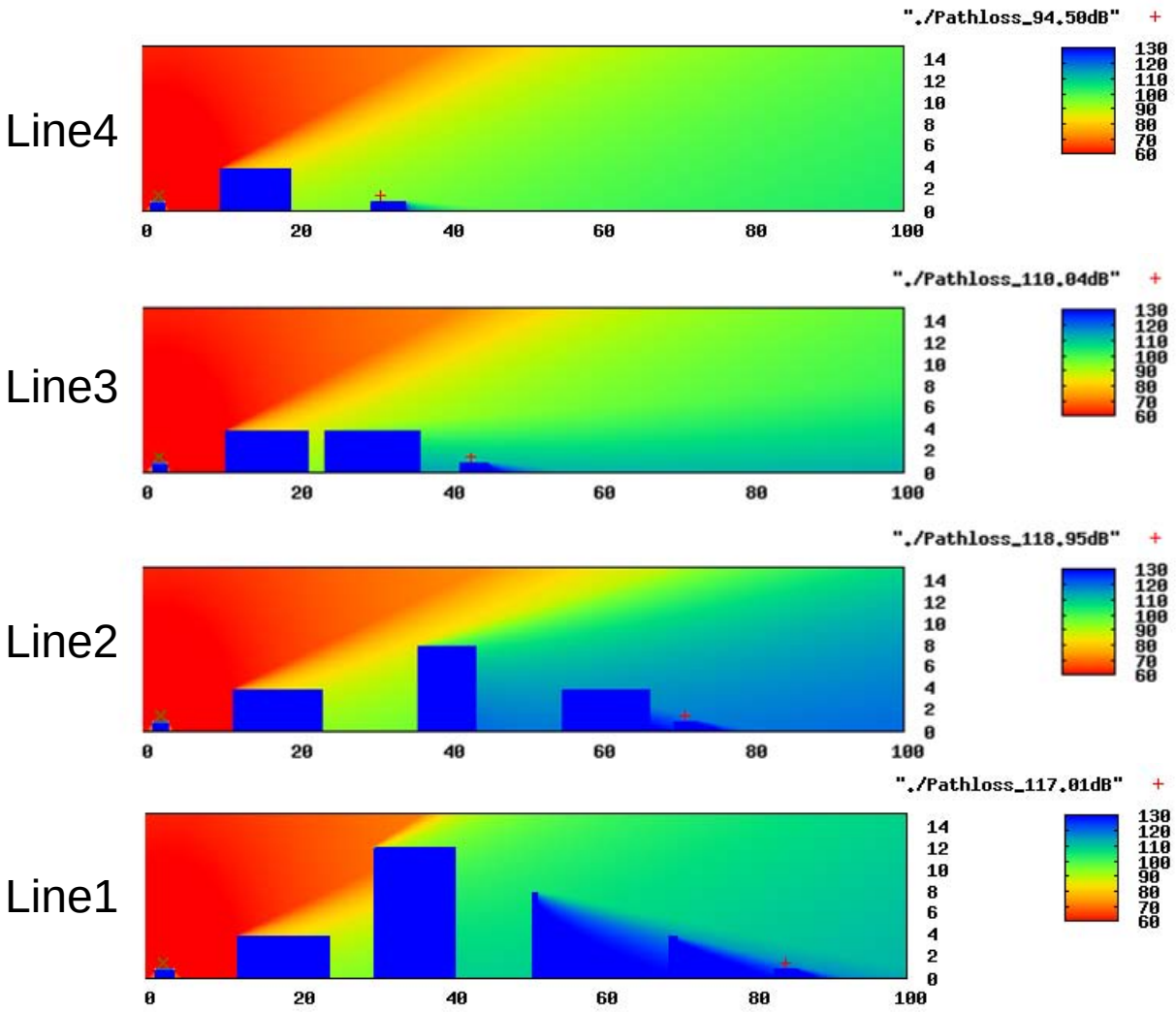
One trailer cutting in (50cm mesh)

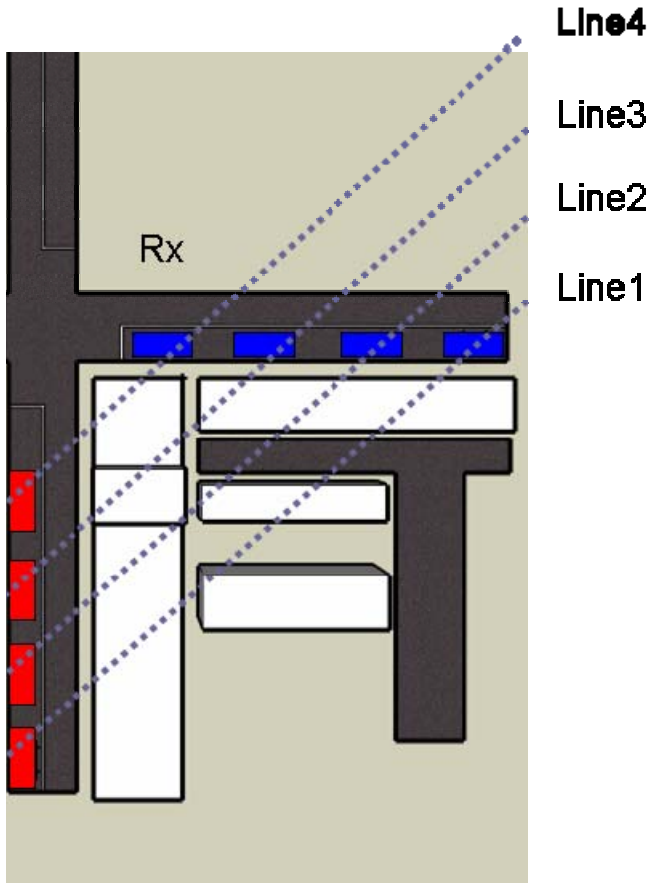


Demo: Path loss around Intersection (1)

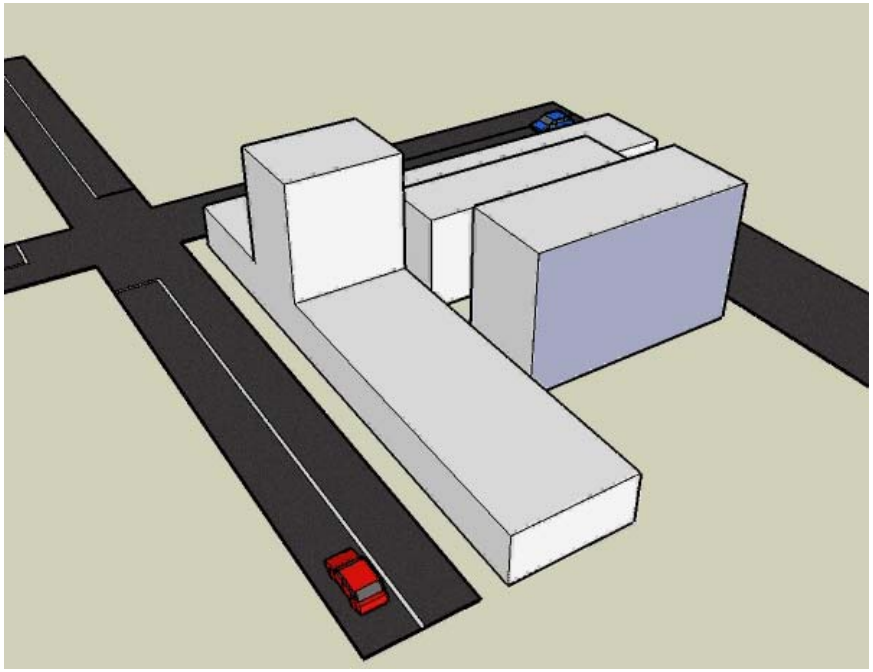


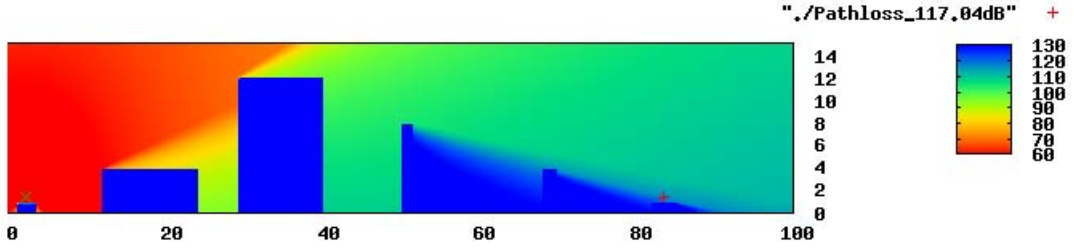
Demo: Path loss around Intersection (2)





Demo: Path loss around Intersection (3)





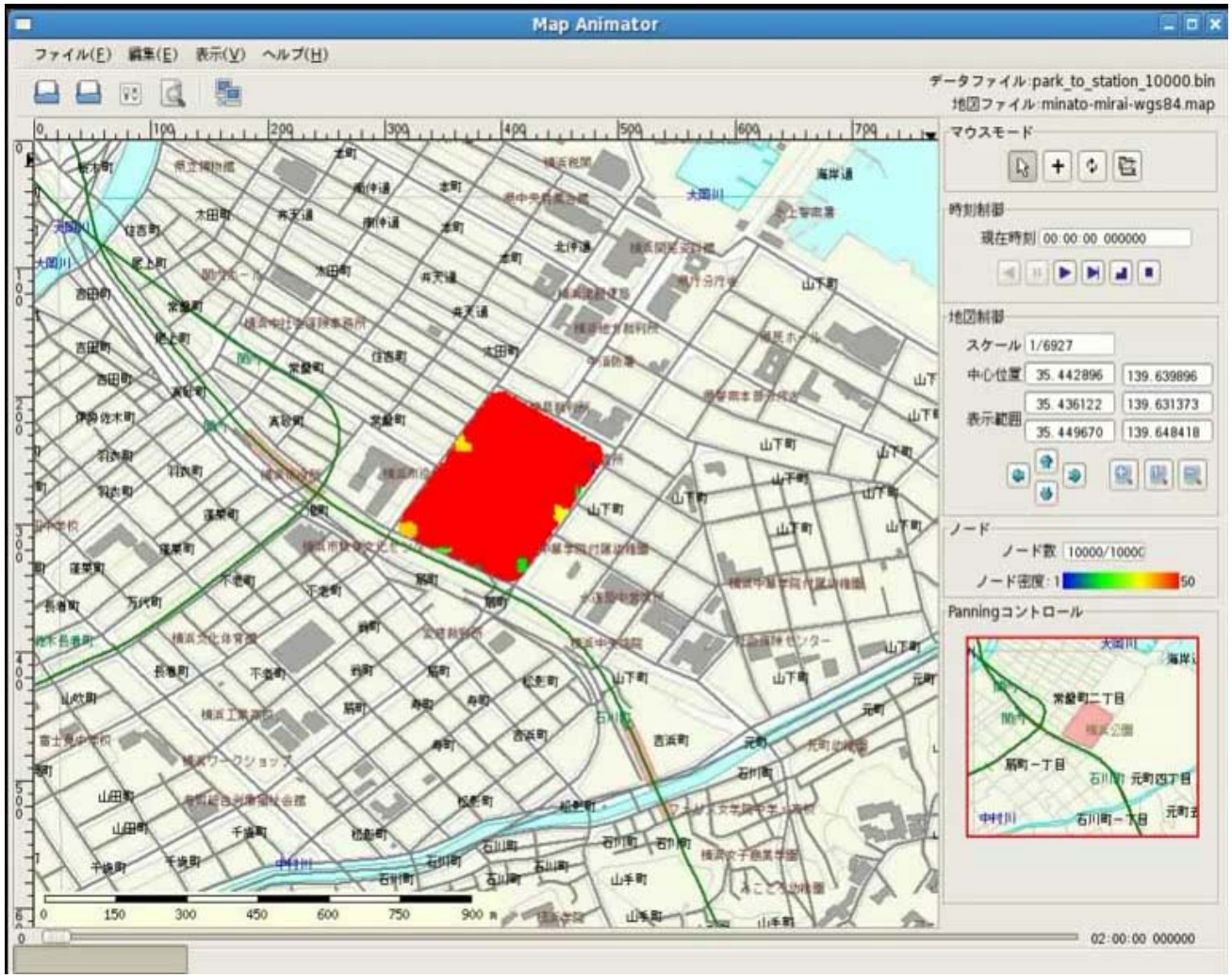
ITS Simulation Requirements: Mobility & Traffic

- Driver behaviors reactive to info. carried via comm. system:
  Use of COTS vehicle traffic and/or driving simulators difficult
  - Vehicle traffic (congestion) information dissemination
  - Collision avoidance and other driving safety information

- Site data required not only for RF propagation:
  Strong correlations between
  - Streets, buildings and other GIS data
  - Mobility and distribution of comm. devices
  - Application traffic demands

Both GIS data and user behaviors essential for ITS simulation

Demo: User Behaviors on a Map (10,000 Users)



ITS Simulation Requirements: Integration of Multiple Technologies

- Integration of multiple technologies into one system simulation highly challenging
  - Unavailability of COTS model sources
  - Different time granularities required for different models (1 : 10,000 : 500,000)
    - Wireless communications: 1us
    - Vehicle mobility: 10ms (180km/h = 0.5m/10ms)
    - Pedestrian mobility: 500ms (3.6km/h = 0.5m/500ms)

Efficient simulation engine with flexible APIs anticipated

Scenargie System Simulation Framework

- A new system simulation framework to meet all ITS simulation requirements by Space-Time Engineering, LLC
- Scenario Generation and Management Framework for In-Depth System Analysis and Evaluation
- Synergy with various technologies
  - Geographical Information System (GIS)
  - Network simulators and models (QualNet, ns-2/3 etc.)
  - RF propagation models (Wireless InSite, UPPS etc.)
  - Multi-agent simulation (Vehicle traffic, driving, pedestrian etc.)
  - Measurement traces (GPS logs, RF measurements etc.)
  - Parallel & distributed computing
- First release scheduled in April 2008
- Beta version demonstration

Roles of ITS Simulation

- Crucial to share a common set of models & scenarios for:
  - System verification and validation
  - Simulation validation against physical system measurements
  - Fair comparison of various ITS proposals
  - Identifying system requirements
- Common simulation components:
  - RF propagation model
  - Vehicle mobility model
  - Pedestrian & (motor) cycle mobility models
  - (Baseline) communication system model
  - (Typical) service & application models
  - Test & evaluation scenarios