UrbanSim: Integrated Land Use, Transportation, and Environmental Modelling

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Other CSE People Currently working on the Project

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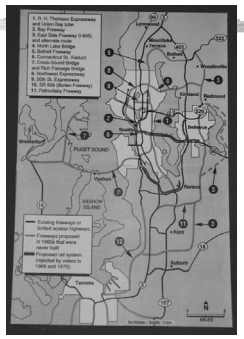
Land Use/Transportation Interactions

- Patterns of land use and transportation are critical in determining economic vitality, livability, and sustainability of urban areas
- Land use and transportation interact with each other and with the environment.
- Example: Suppose you were a Puget Sound resident in the early 1960s. Three alternative transportation plans are proposed.
  - a freeway-oriented system
  - a rail-oriented system
  - do nothing

Puget Sound Freeway Plans from early 60s



Forward Thrust Light Rail System

Forward Thrust Light Rail System -- voted down in 1968 and 1970. Map shows completed system as planned for 1985.

Puget Sound Example continued

We might want to ask questions such as:

- What will the region look like in the year 2000 under these different scenarios?
- How will people and goods move around?
- What will be the density and character of development?
- How much open space will there be?
- What will be the environmental impacts on air and water quality?

Applications to Date

- Eugene/Springfield, Oregon (including historical validation — started with 1980 data and predicted state in 1995)
- Salt Lake City
- Honolulu
- now working on Puget Sound (substantially larger area than the others)

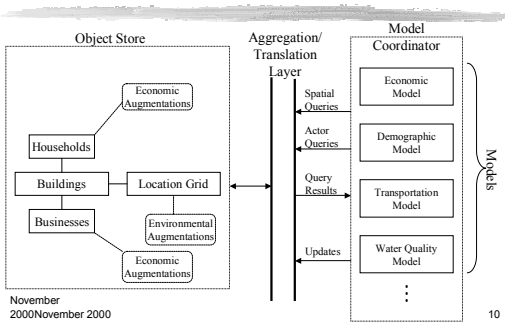
Software Status

- Written in the Java programming language (about 200,000 lines, plus 100,000 more lines of Java that is automatically generated)
- Software is under the GNU Public License (so it's free, and freely redistributable)
- We have made an initial release of the system, with several hundred downloads

Software Architecture – Overview

- UrbanSim is composed of interacting models that simulate particular aspects of the urban environment
  - Demographics (people moving in and out of the area, births and deaths)
  - Residential location choice
  - Business location choice
  - Transportation
  - …

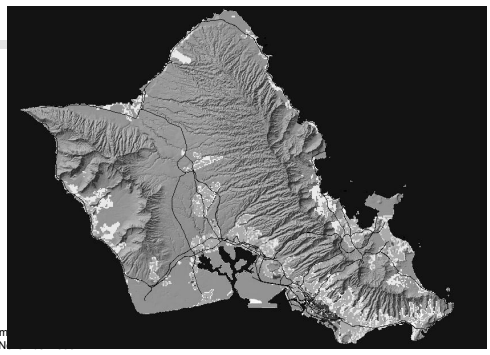
System Architecture Diagram



Spatial Representation

- Geographic information is of the essence!
- UrbanSim currently represents a region using a 2-dimensional grid.
  - Analogy: Game of Life grid
- Each grid cell is 150 meters square
- Grid cell attributes include:
  - Building type, square feet
  - Number of residents
  - Number of employees (for businesses)
  - etc

Hawaii -- Housing Density

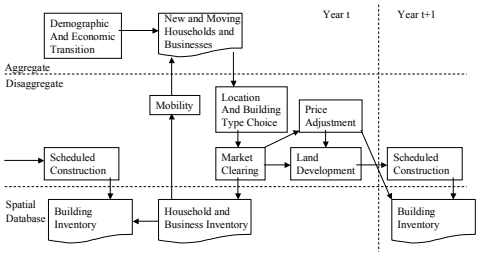


Hawaii -- Grid Cells

Time

- As with most simulations, UrbanSim keeps track of simulated time
- There is a global variable currentYear
  - Analogy: "stepCount" in Game of Life
- Typical simulation is run for 20 years
- Most models run once each simulated year

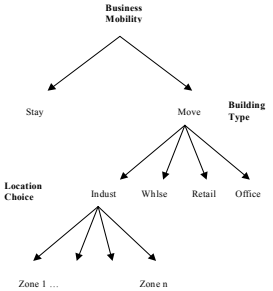
Temporal Representation



The Model Coordinator

- Handles initialization of models
- Coordinates execution of all models
- Notifies models of updates
  - For example, the Land Developer model might build some new houses.
  - The Model Coordinator notifies the Residential Location Choice model that new housing is available.

Business Location Model



Nested Logit Structure

$$P(h) = \frac{e^{V_h + \mu V'_h}}{\sum_{h'} e^{V_{h'} + \mu V'_{h'}}}$$ Marginal Choice of Building Type

$$V'_h = \ln \sum_l e^{V_l}$$ Logsum

$$P(l|b) = \frac{e^{V_l}}{\sum_{l'} e^{V_{l'}}}$$ Conditional Choice of Location

Latent Demand

$$D_{lbt} = \sum_i P(lb)_{it} M_{it} R_{lb} + \sum_i T_{ilbt} - (AV_{lbt} + TV_{lbt})$$

$P(lb)_{it}$ is the prob. that a mover of type i will choose bldg type b in loc. l in year t
M_{it} is the total number of movers of type i in year t
R_{lb} is the utilization rate for bldg type b (for res=1, for nonres=sqft/emp for b)
T_{ilbt} is the total quantity of occupied space in building type b, location l in year t
AV_{lbt} is the total actual vacancy (from prev year) in bldg type b, loc l, and year t
TV_{lbt} is the tentative vacancy (movers subtracted) in bldg type b, loc l, and year t

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Market Price Adjustment

$$P_{lbt} = P_{lbt-1}\left[\frac{D_{lbt}}{(1-\alpha)S_{lbt}}\right]^{\beta}$$

P_{lbt} is the land price of building type b in location l in year t
P_{lbt-1} is the previous year closing land price for the same building and location
D_{lbt} is the total demand in the current year for space in the bldg type and location
S_{lbt} is the current year total supply of space of building type b in location l
α is the normal vacancy rate
$\beta$is a scaling parameter for the price adjustment, initially set to 1

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