

The Repast Simulation/Modelling System for Geospatial Simulation

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<http://www.casa.ucl.ac.uk>
<http://www.gisagents.blogspot.com>

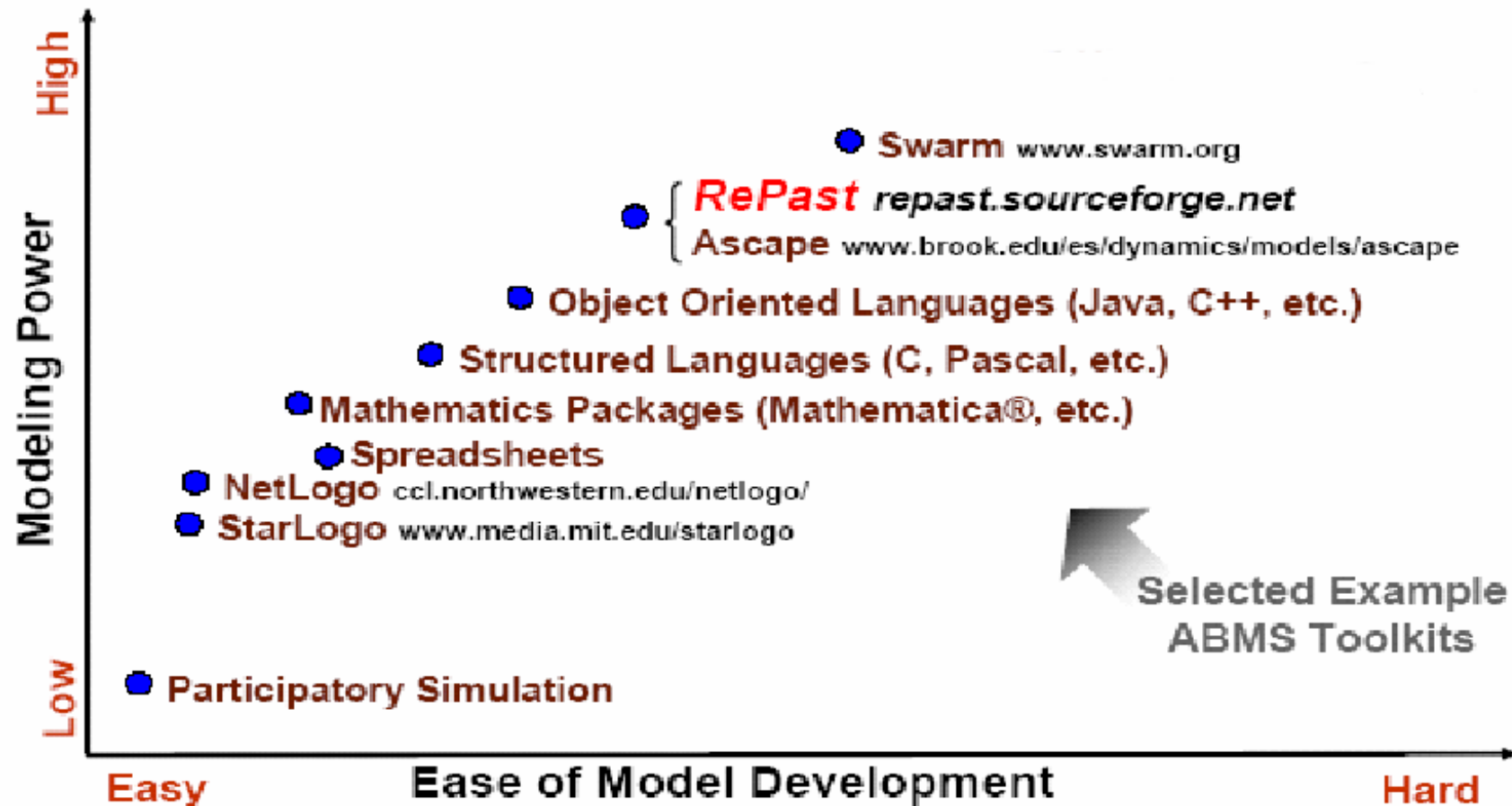
Introduction

- Introduce Repast
- Install Java, Repast etc.
- Import some sample models
- Describe core Repast components
- Run some models
- Examples/discussion of Raster and Vector Integration
- Summary

What is Repast?

- **Recursive Porous Agent Simulation Toolkit.**
- Open Source.
- Provides functionality to create, run, display, and collect data from agent-based models.
 - More time can be spent developing models.
- One of the few generic toolkits which support both raster and vector integration.
- But this comes at a price: need to have basic programming skills.

Selected ABM tools

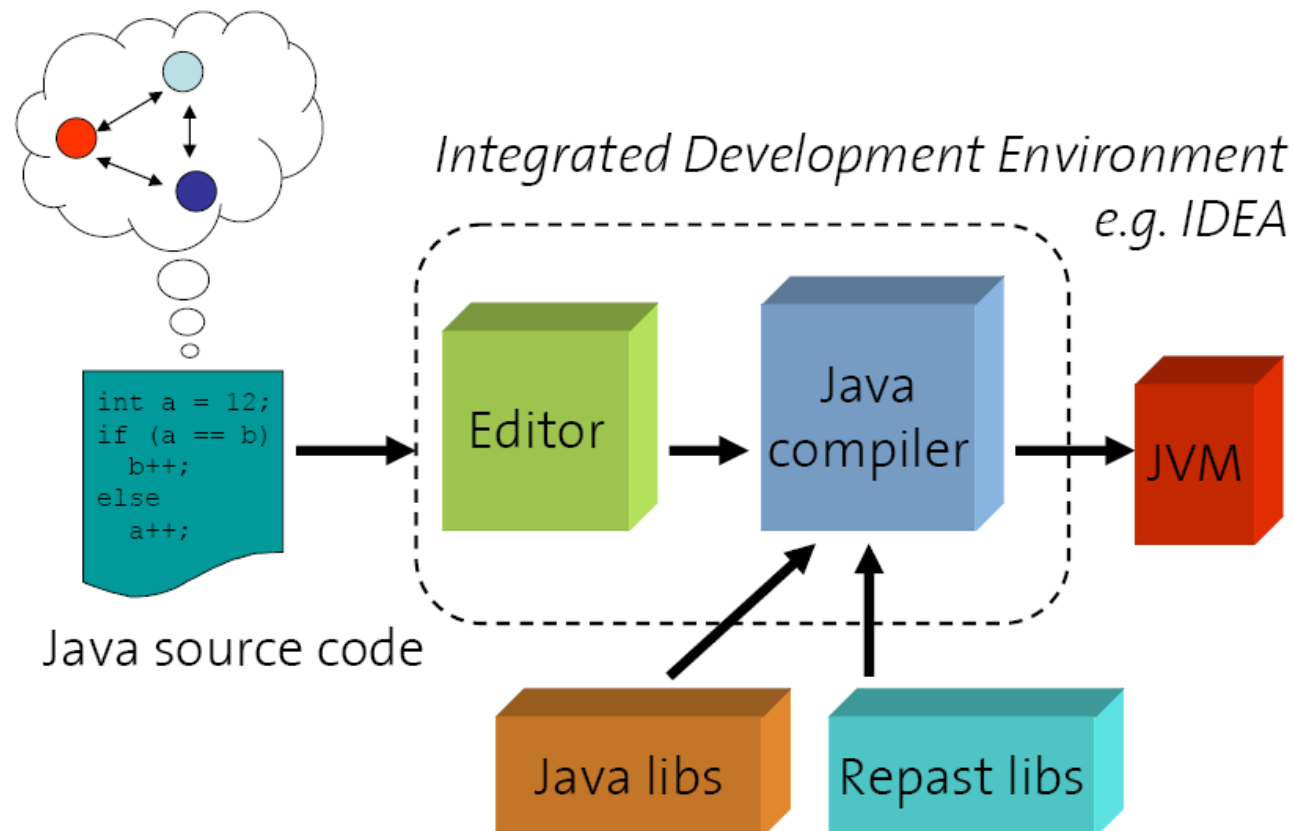


Source: North et al (2005) Agent-Based Modeling with Agent Analyst

Getting Started

- First we install all the necessary components to create and run a Repast model
 - Java
 - Eclipse
 - Repast (note the extra packages in the lib folder)

Development Environment



Where the models come from:

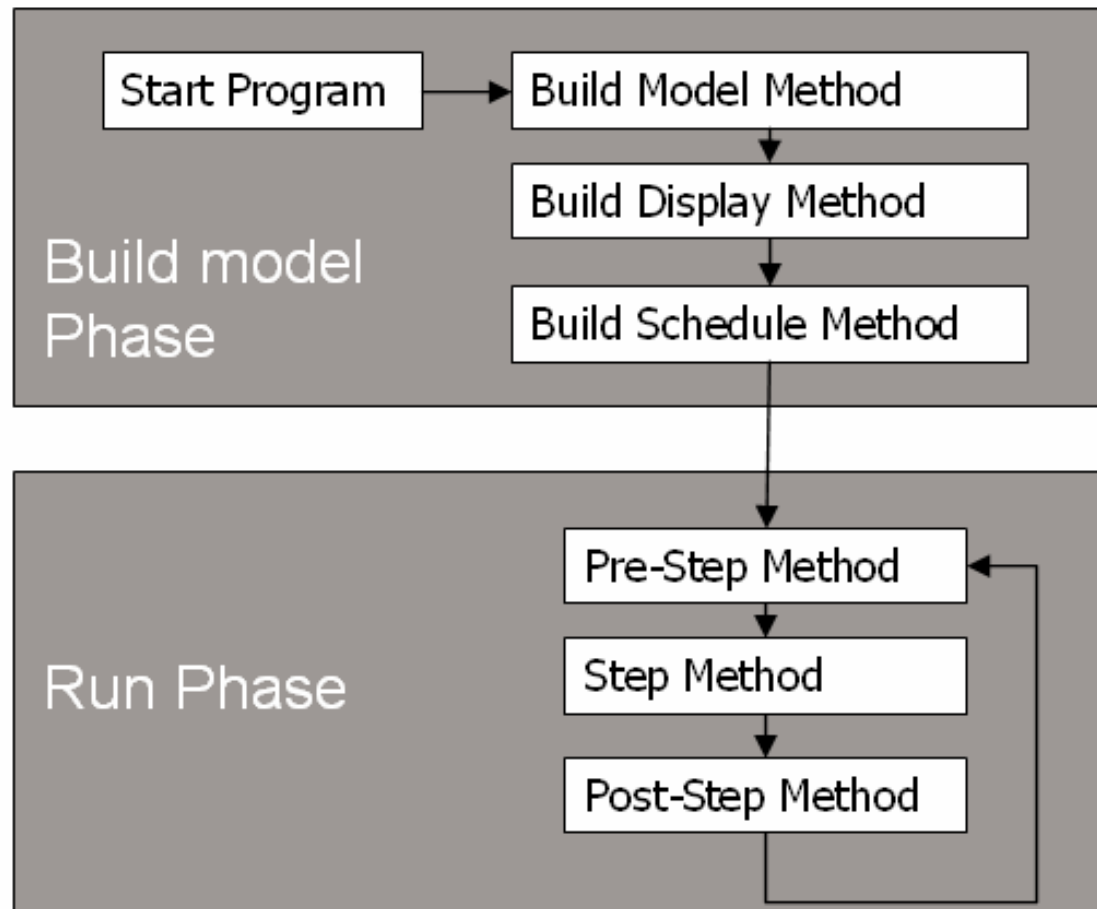
- International Conflict Research Group at ETH Switzerland:
<https://www.icr.ethz.ch/teaching/archive/compmodels/>
- Repast Source folder
- Various other places from the internet

Note later how there are many different ways to create and utilize the Repast toolkit.

Recap

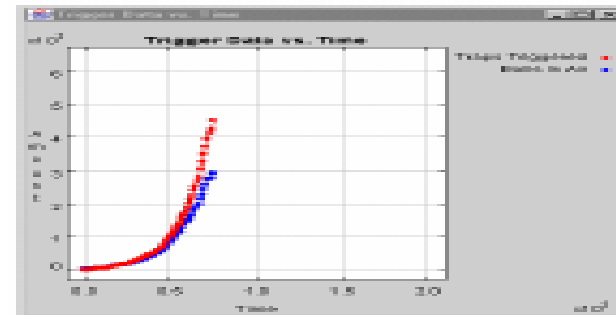
- Introduced Repast
 - Installed Repast, Java and Eclipse
 - Imported some models
- Today:
 - Run through some of Repasts core functionality
 - Discussion and examples of Geospatial agent-based models
- Note that much of this can be supported by the articles on the CD.

Basic Structure of most Repast Models



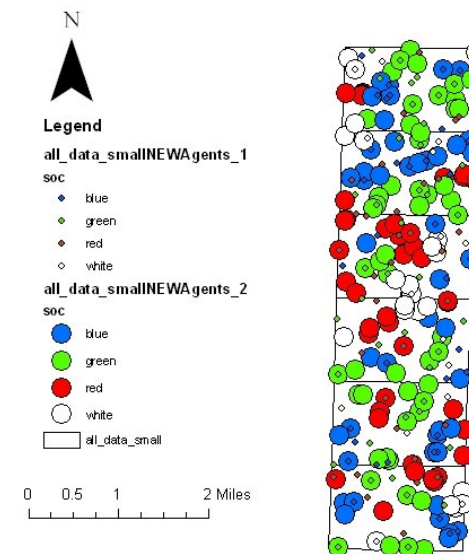
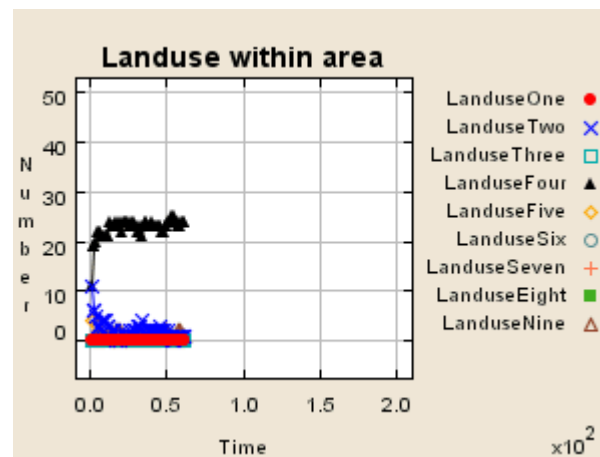
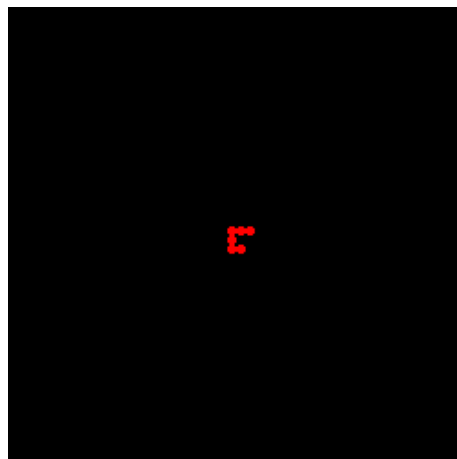
Inbuilt Charting options

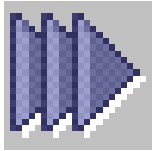
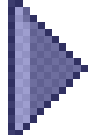


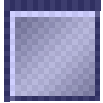


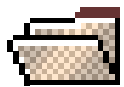


- **Time series:** used defined variable (s) over time.
- **Histograms:** bar chart showing a variable distribution.
- **Scatter plot:** snapshot of two variables
- Can be extended e.g. s



Inbuilt Data Collection

- Inbuilt data recording facilities (Data Recorder) to .txt files (as comma, space or tab delimited).
- Movies and snapshots.



									
Start Multi-Run	Start	Step	Initialize	Stop	Pause	Setup	Load	View settings	Exit

Start Multi-Run: starts a batch run of a simulation.

Start: starts the simulation when it is paused or has not yet been started, iterating through the scheduled behaviour.

Step: starts the simulation when it is paused or has not yet been started, iterating through a single iteration the scheduled behaviour.

Initialize: starts the simulation but pauses before iterating any scheduled behaviour.

Pause: pauses the simulation.

Setup: "sets up" the simulation by executing the user defined setup code.

Load Model: pops up a dialog allowing the user to specify a model to load.

View Settings: will display the various model settings panel if it is hidden or destroyed.

Exit: will shutdown the simulation and exit.

Example application

- Run through the segregation polygon model highlighting the basic functionality.
 - Debug mode
 - Vector models don't use Repasts displays but can use the same charting options
- See how source code can be attached.

Exploration of the Models

- The models provided allows one to explore the various models:
 - Note:
 - How schedules are set,
 - Which spaces are used,
 - Displays are built
 - What is being recorded.
 - There may be some errors due to files being in the wrong place
- Many different ways to create models
- Only use Repast functionality as needed.

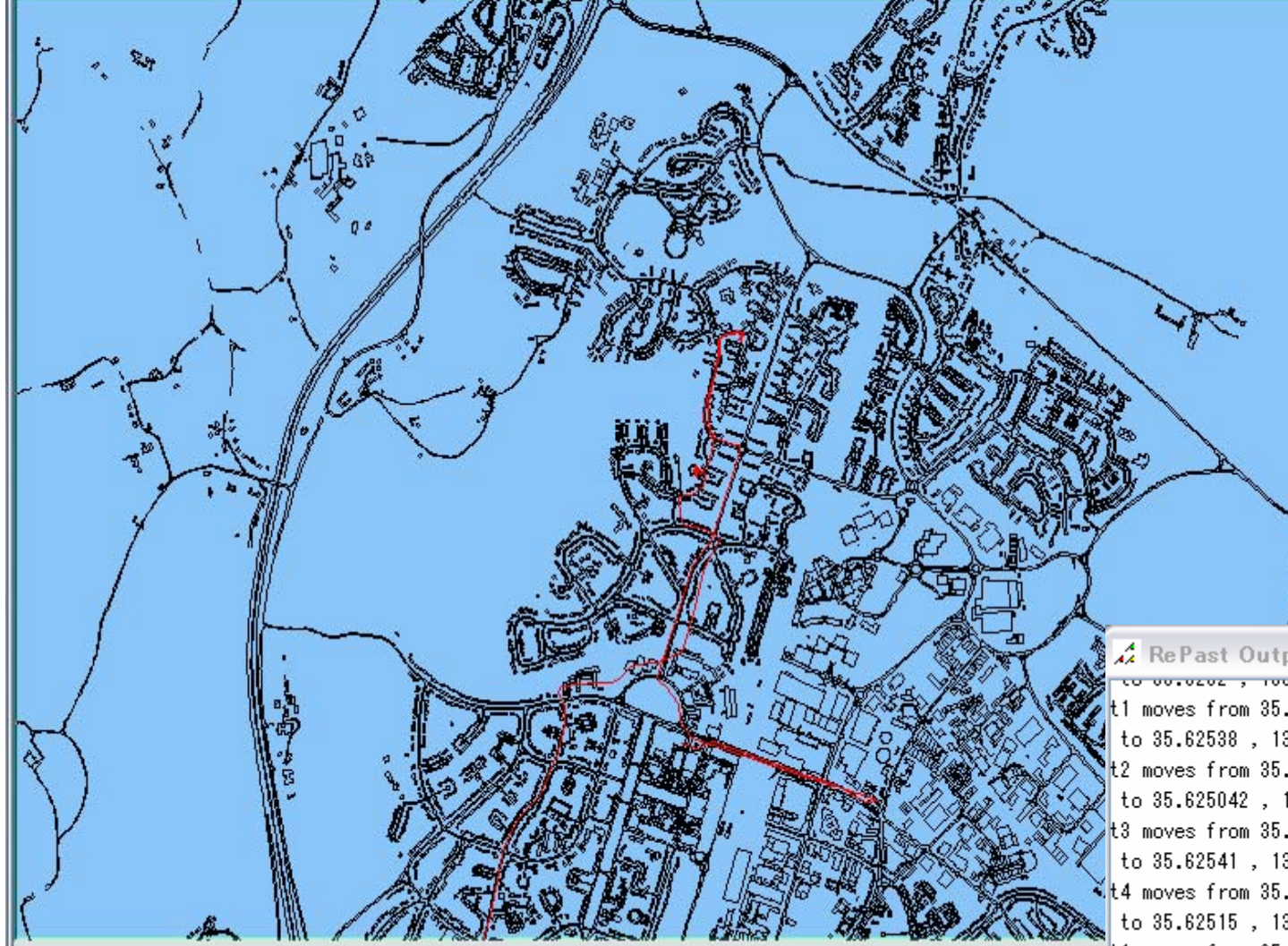
Repast [min] [max] [close]

[stop] [play] [refresh] [lightbulb] [X] Tick Count: 11.0 Run: 1

CAPABLE GPS Survey [min] [max] [close]

Control Navigate Views Layers

Mouse Mode: Navigation 1:31,744 [compass] [pin] [arrow] [pan] [home] [back] [forward] [refresh]



Lat, Lon (51.814, -0.241) - x, y (1,209)

GPS TestApp Setti... [min] [max] [close]

Parameters

Custom Actions Repast Actions

Make Movie

Take Snapshot

Create / Edit Charts

In Alpha Order

Stdout to Console

Stderr to Console

Rng Seed in Defaults

Update Probes

Show Custom Charts

Set As Default

Write Parameters

About

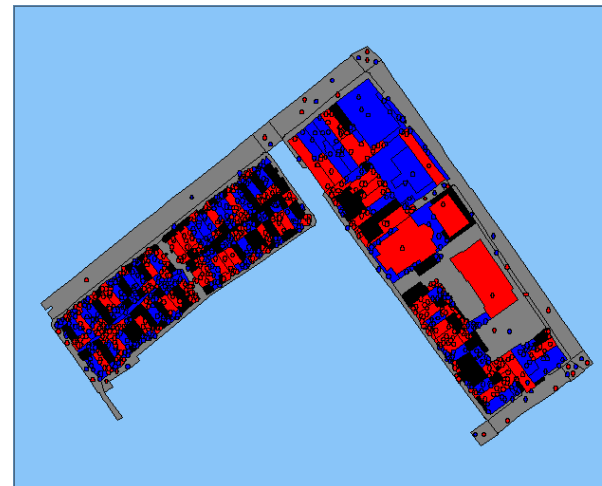
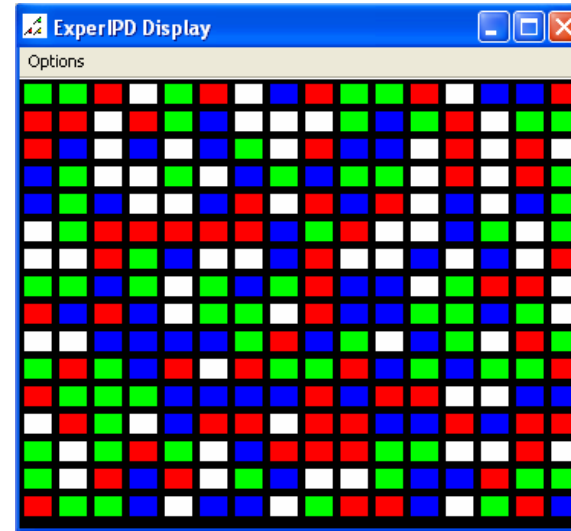
RePast Output [min] [max] [close]

```
to 35.62502 , 139.78000
t1 moves from 35.625427 , 139.78043
to 35.62538 , 139.78041
t2 moves from 35.625046 , 139.78087
to 35.625042 , 139.78078
t3 moves from 35.62538 , 139.78067
to 35.62541 , 139.78064
t4 moves from 35.6252 , 139.78055
to 35.62515 , 139.78049
```

Space in Repast

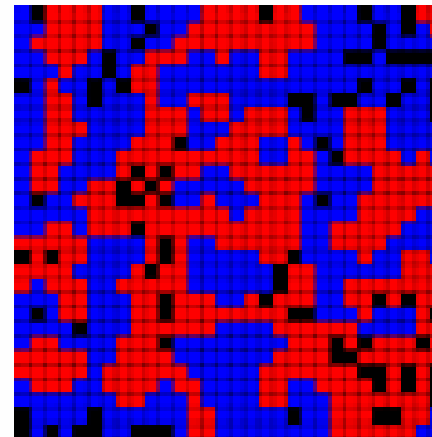
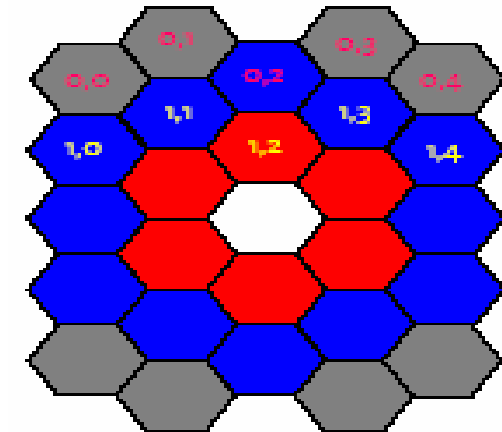
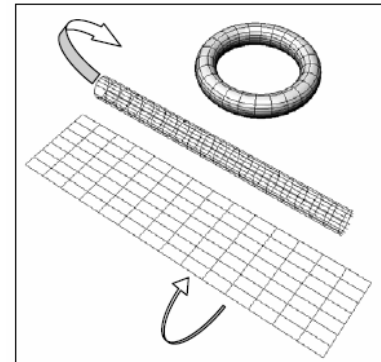
- 2 main types:
 - Cellular
 - GIS vector
- Layers can be combined
- Space has Two purposes:
 - Contain a collection of agents (e.g. the world).
 - Define Spatial relationship of agents relative to each other.
- Another type of space is Network space.
- See Repasts “Overview of Spaces”

<http://repast.sourceforge.net/how-to/spaces.html>

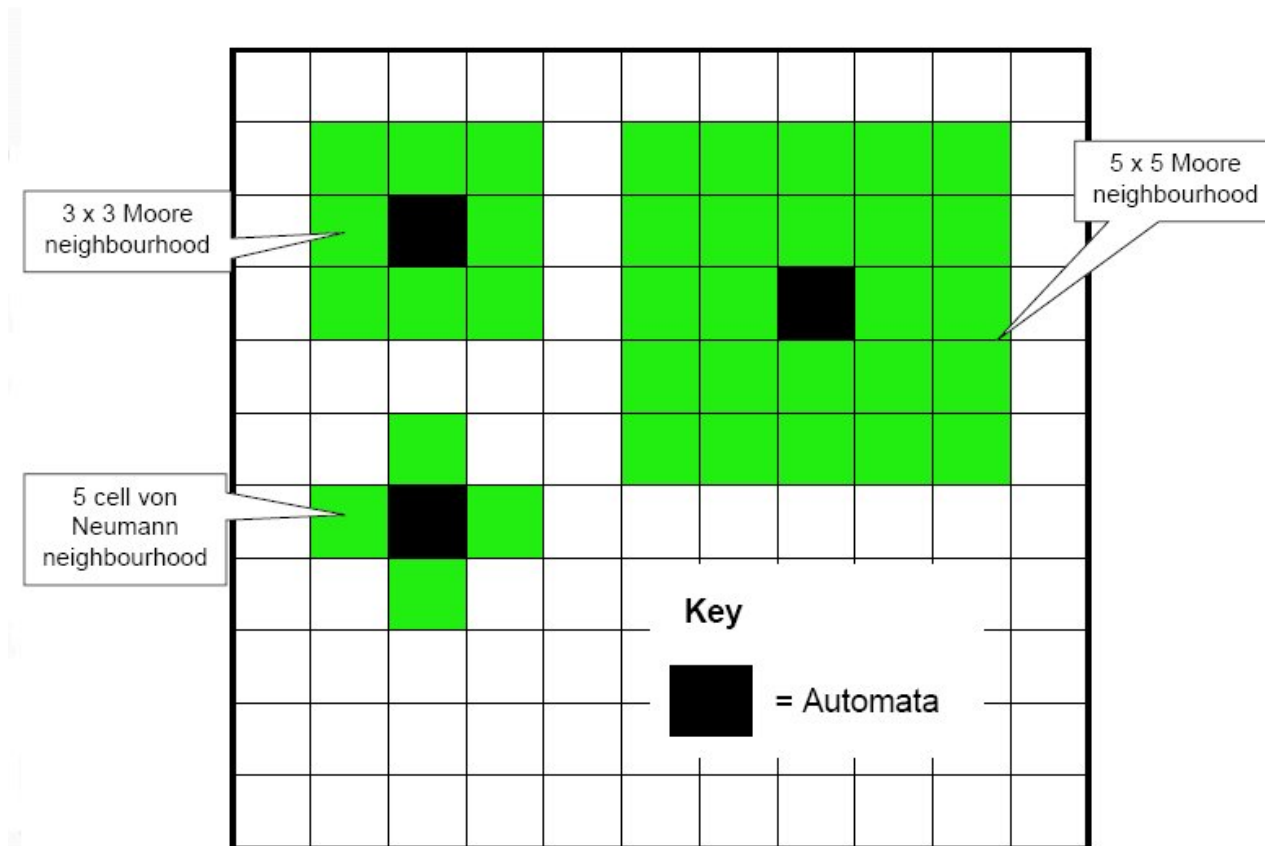


Cellular Space

- **Boundaries**
 - Grid or Torus
- **Cell's shape**
 - Regular or hexagonal
- **Cell's content**
 - One object or a collection of agents
- Also includes Raster-Space (inbuilt functions for reading ASCII & .pgm files)



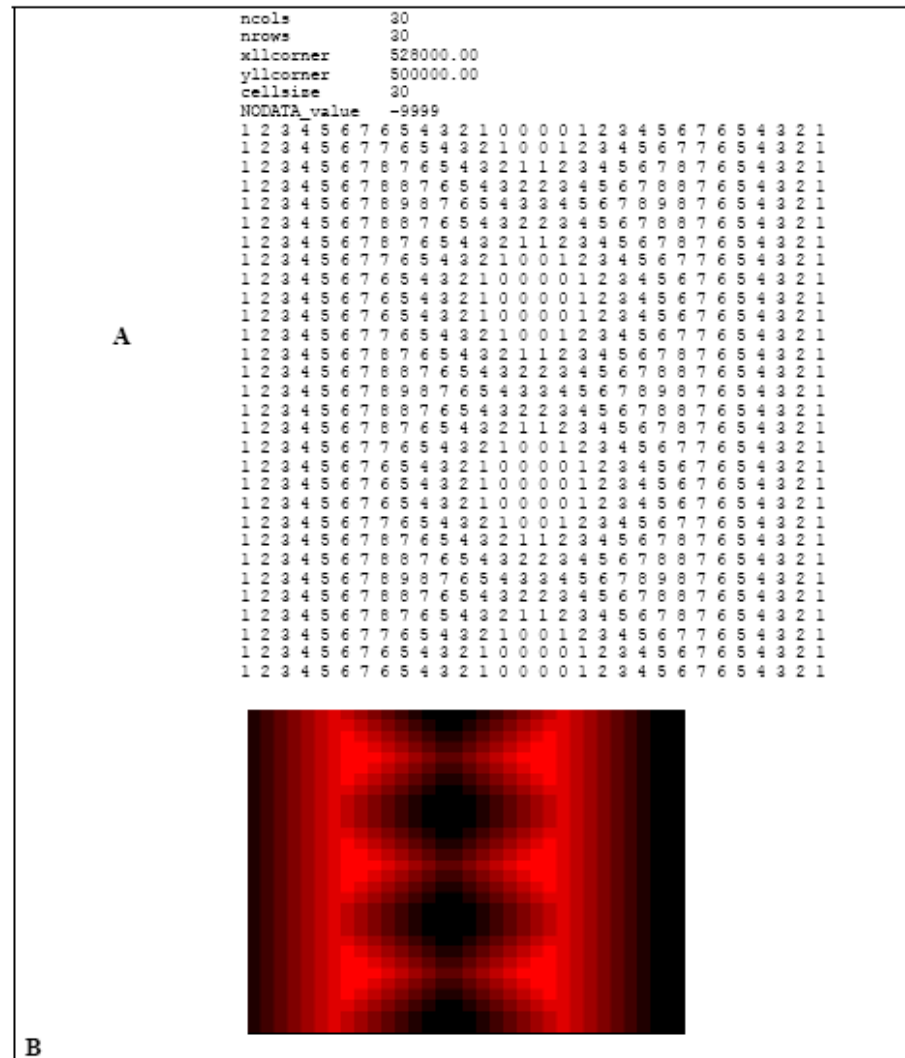
Common Neighbourhoods in Cellular Space



- The models include here use a variety of neighbourhoods

Raster Integration

- Agents can either be the cells imported into the model or sit on top of the cells and interact with the surface generated using raster data.
- See `gisModel` in `RepastModels`

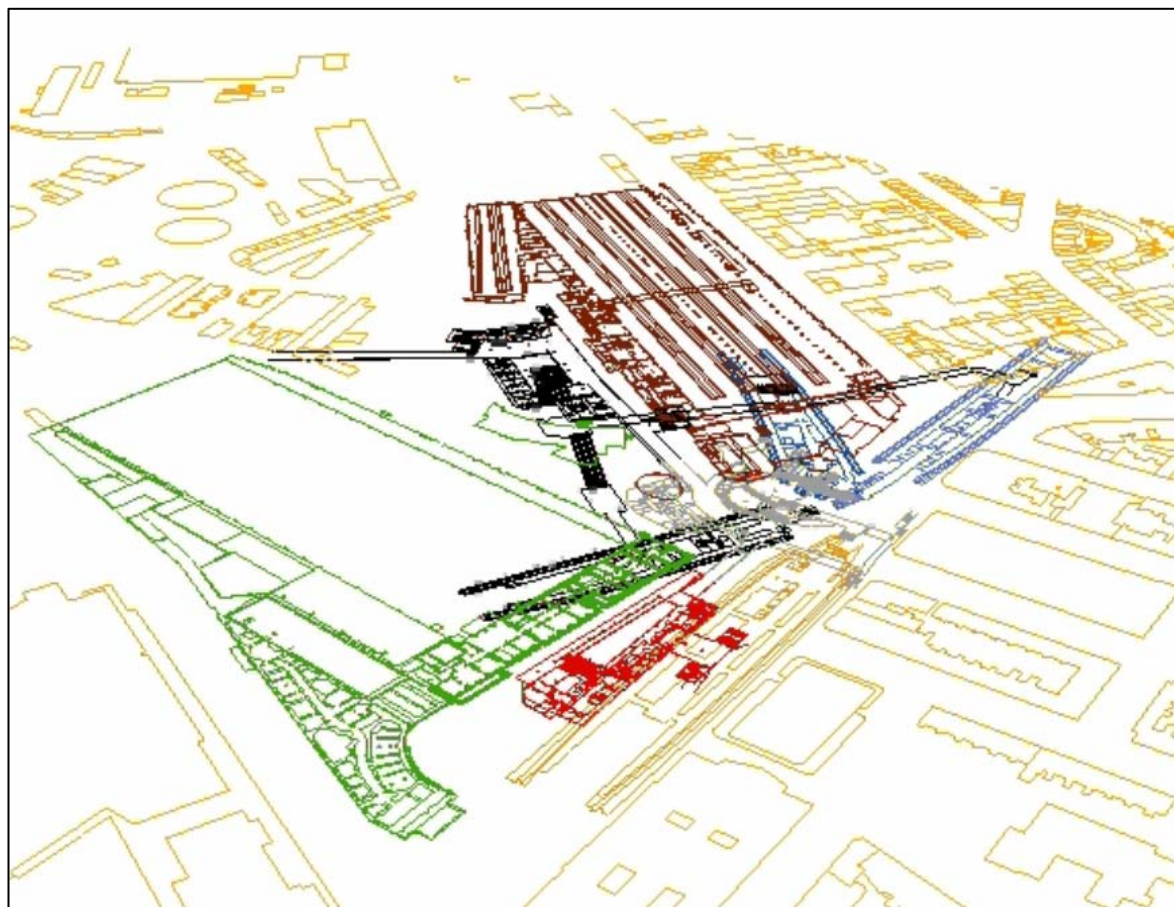


Reading in a raster data and creating a landscape (ESRI ASCII file) A: the original file from a GIS. B: the resulting space created in Repast.

Raster Integration (cont)

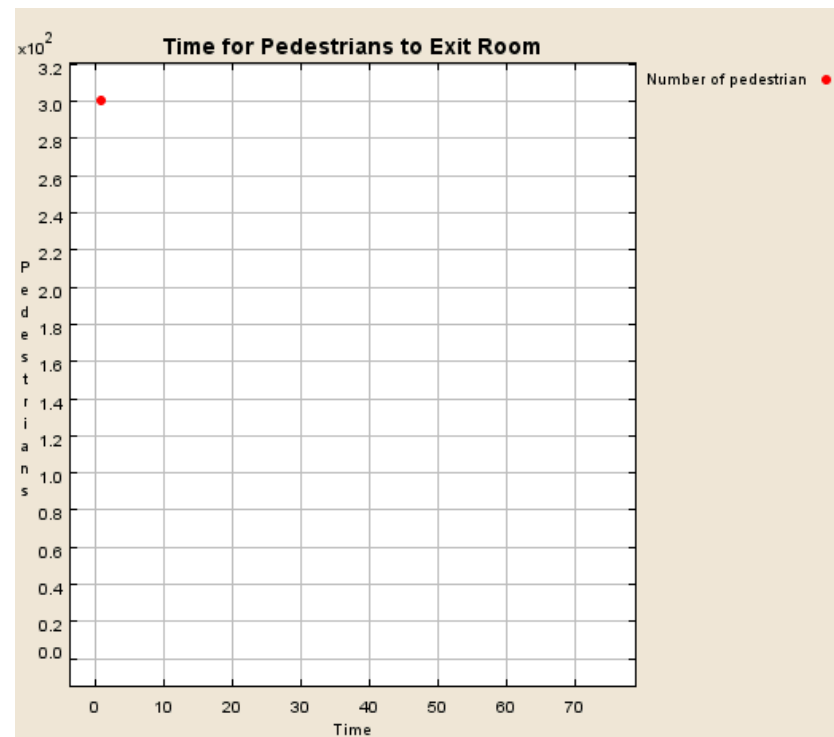
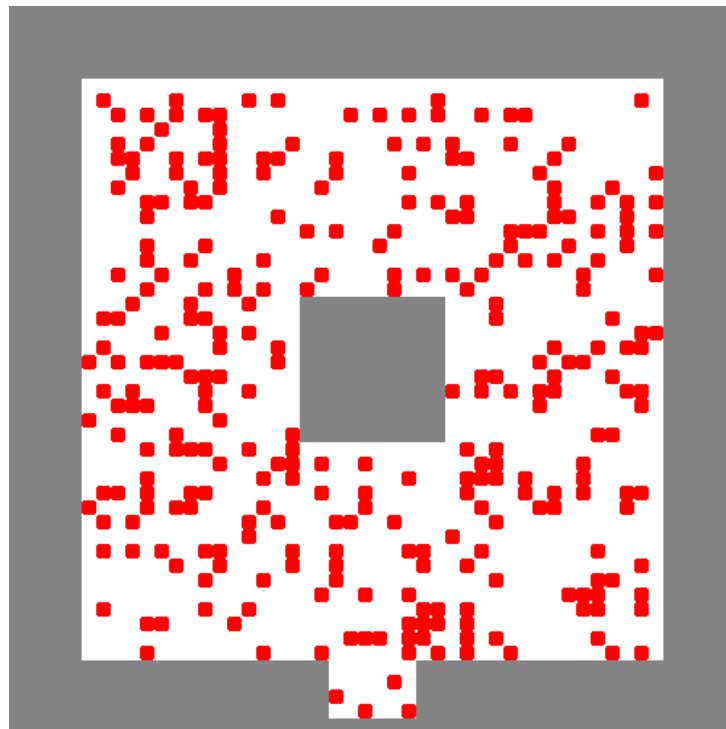
- Agents can either be the cells imported into the model or sit on top of the cells and interact with the surface generated using raster data.
- Agent movement is a matter of changing the agent's internal x and y coordinates, removing it from its previously occupied cell and adding it to the new one.
 - See `moveAgent ()` in `sugarScape` model
- Example models:
 - `gisModel` (just colours in the landscape based on cell value)
 - `sugarScape` for `.pgm` integration (probing also searches for a best spot (`moveToBestSpot()`))
 - `Fire` for `.txt` file (see how information spreads and agents die and move)

A Model for Emergency Evacuation - KXPPEM

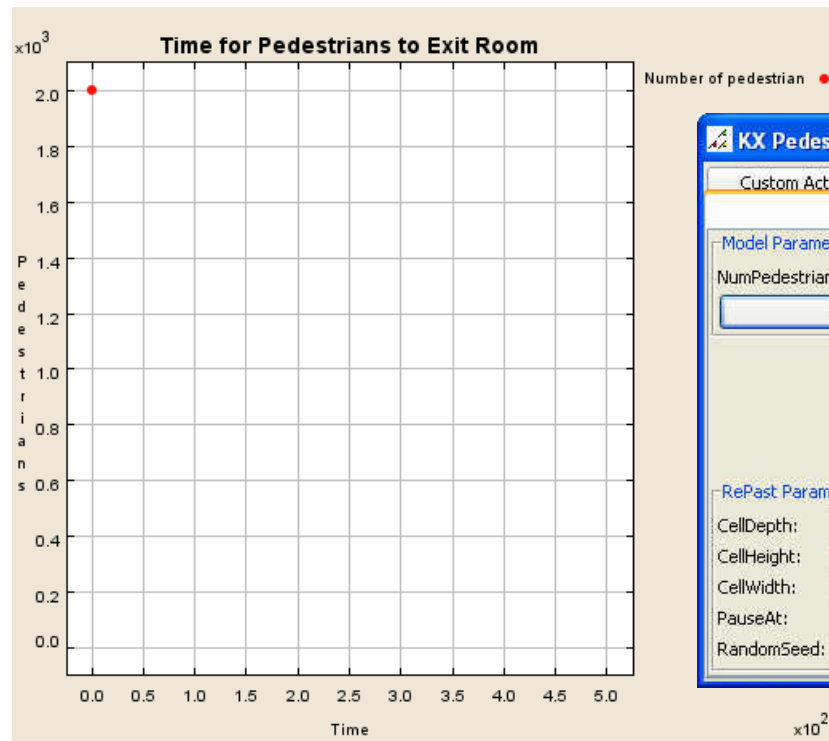
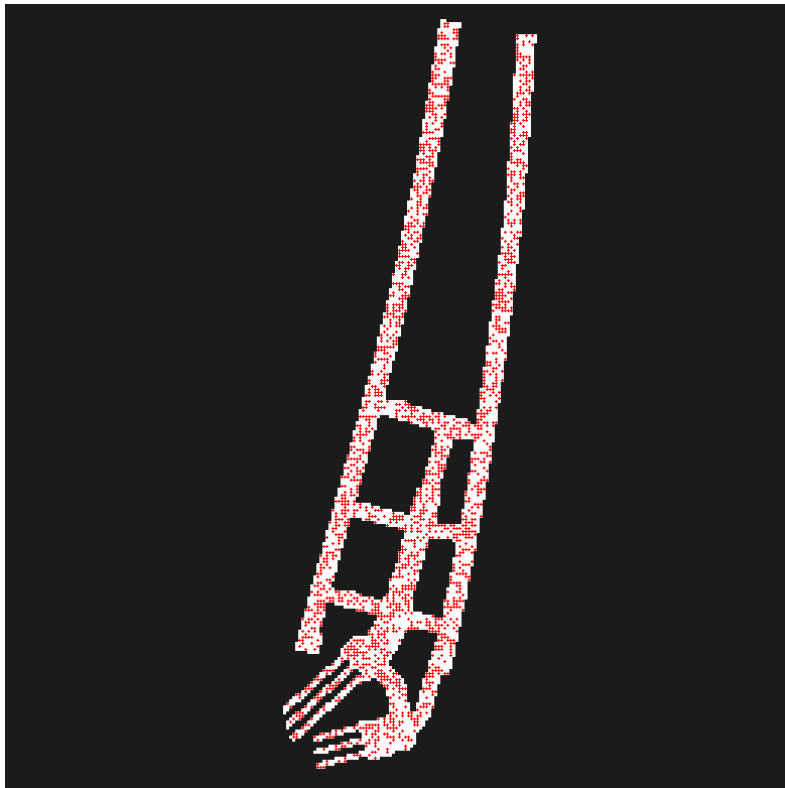


Developed by Christian Castle

Basic Pedestrian Model



One Level



KX Pedestrian Evac...

Custom Actions Repast Actions

Parameters:

Model Parameters

NumPedestrians: 2000

Inspect Model

RePast Parameters:

CellDepth: 5

CellHeight: 5

CellWidth: 5

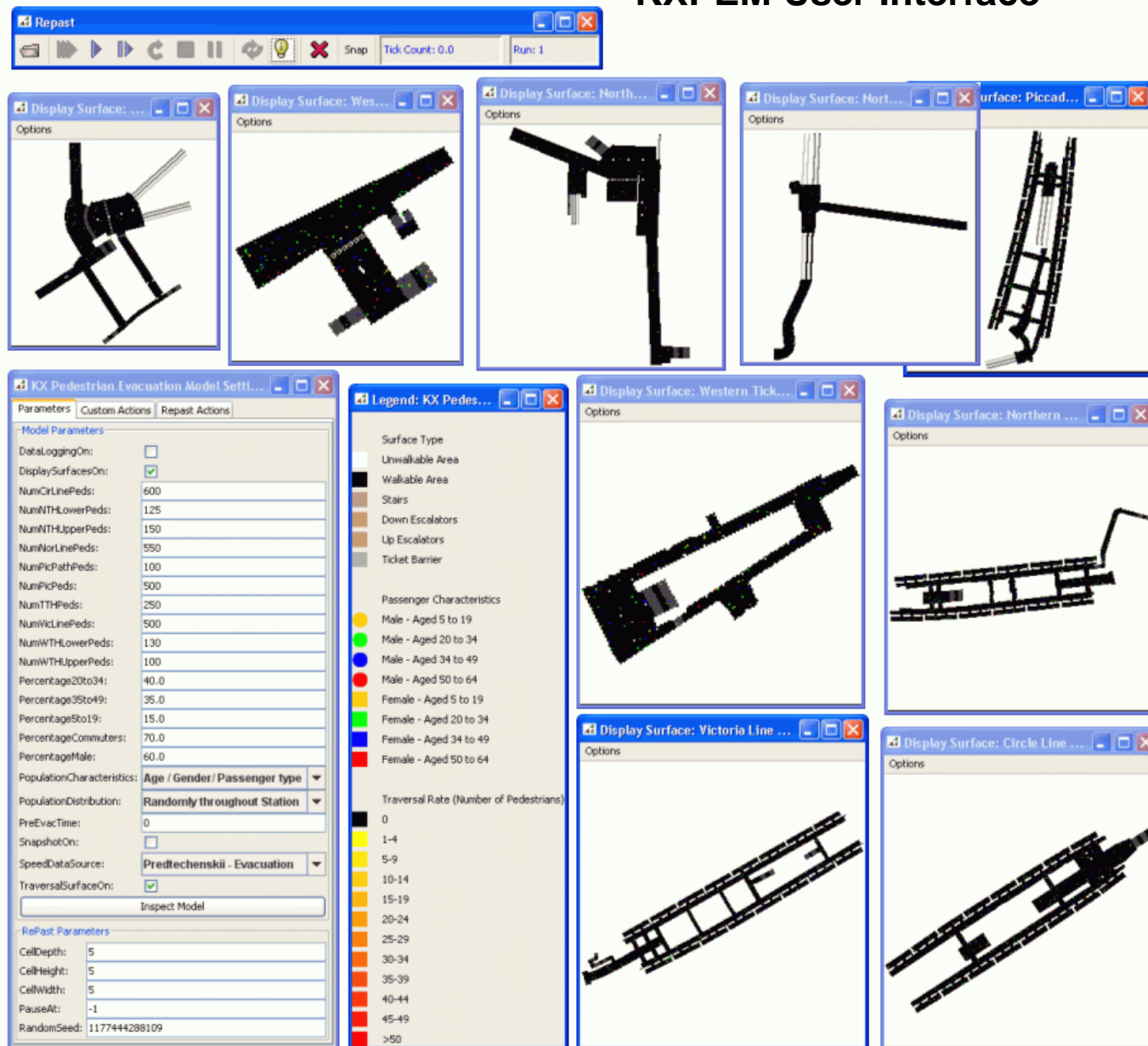
PauseAt: -1

RandomSeed: 1157981973250

Legend...

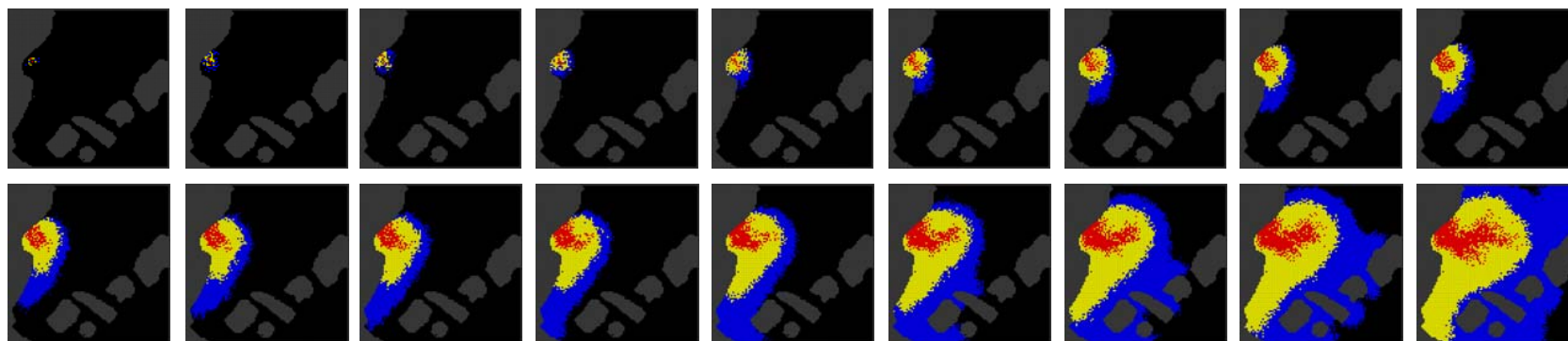
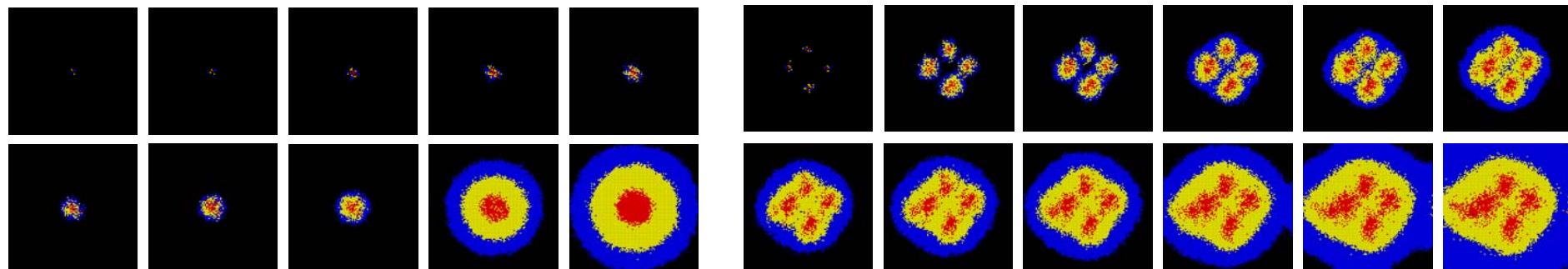
- Unwalkable Area
- Walkable Area
- Cost Surface
- Pedestrian

KXPEM User Interface



Movie

Urban Growth in Latin American Cities

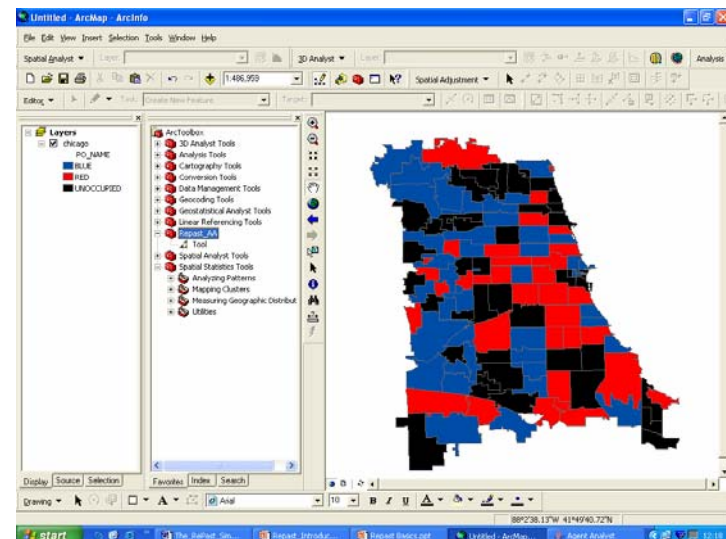
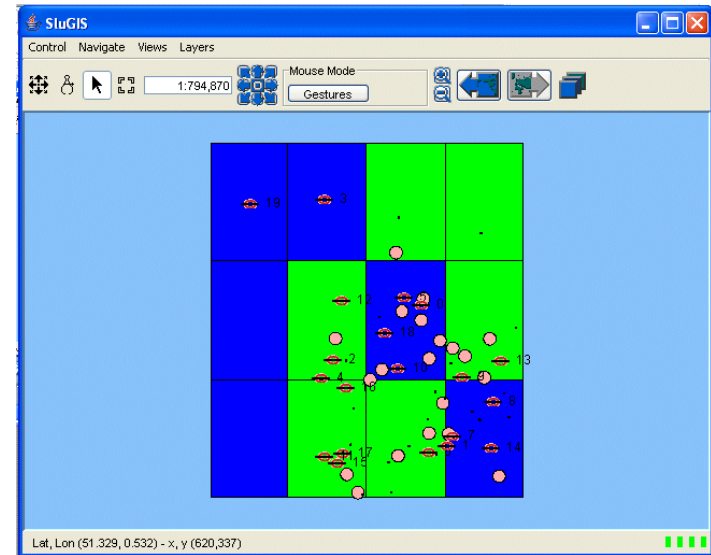


- Barros, J. (2004), *Urban Growth in Latin American Cities: Exploring Urban Dynamics through Agent-Based Simulation*, Ph.D. Thesis, University College London, London, UK.

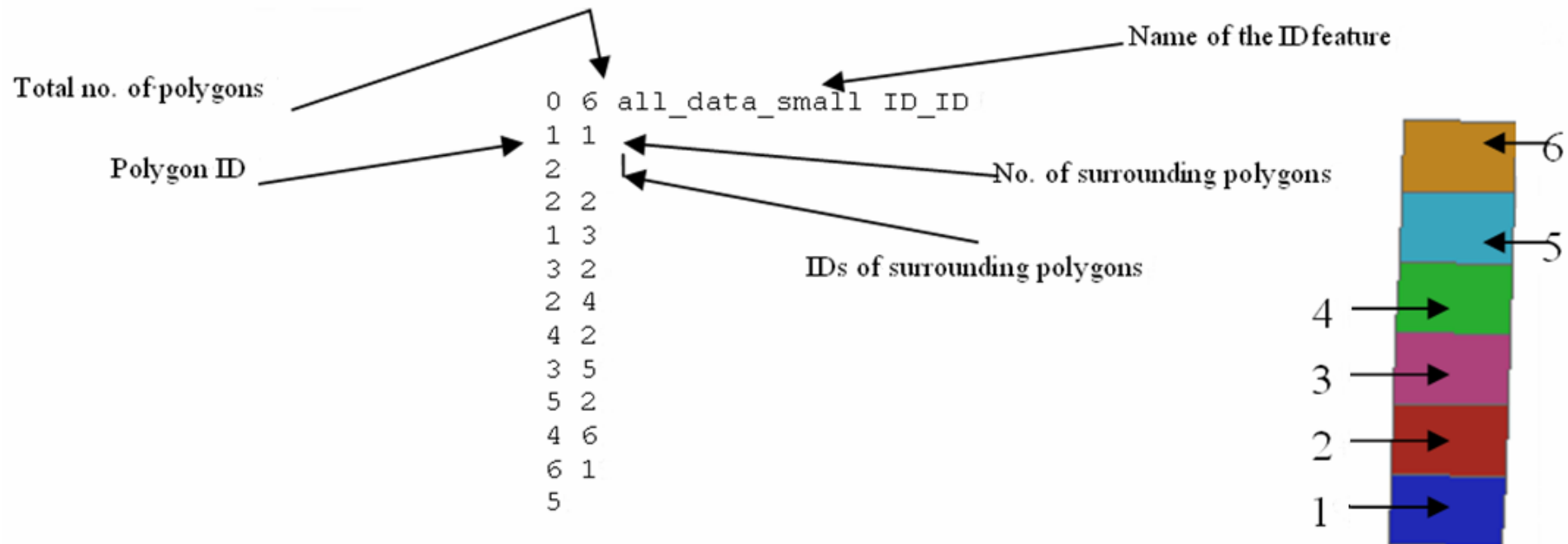
Vector GIS

- More complicated (own packages) but highly adaptable.
- Agents either
 - Points (Generic agent).
 - Polygons (Vector agent) (static) => detailed boundaries.
- Needs its own displays: ESRI's ArcGIS or OpenMap.
- See: http://repast.sourceforge.net/how-to/Gis_How_To.html

anl.repast.gis anl.repast.gis.display
anl.repast.gis.data anl.repast.gis.data.dbf

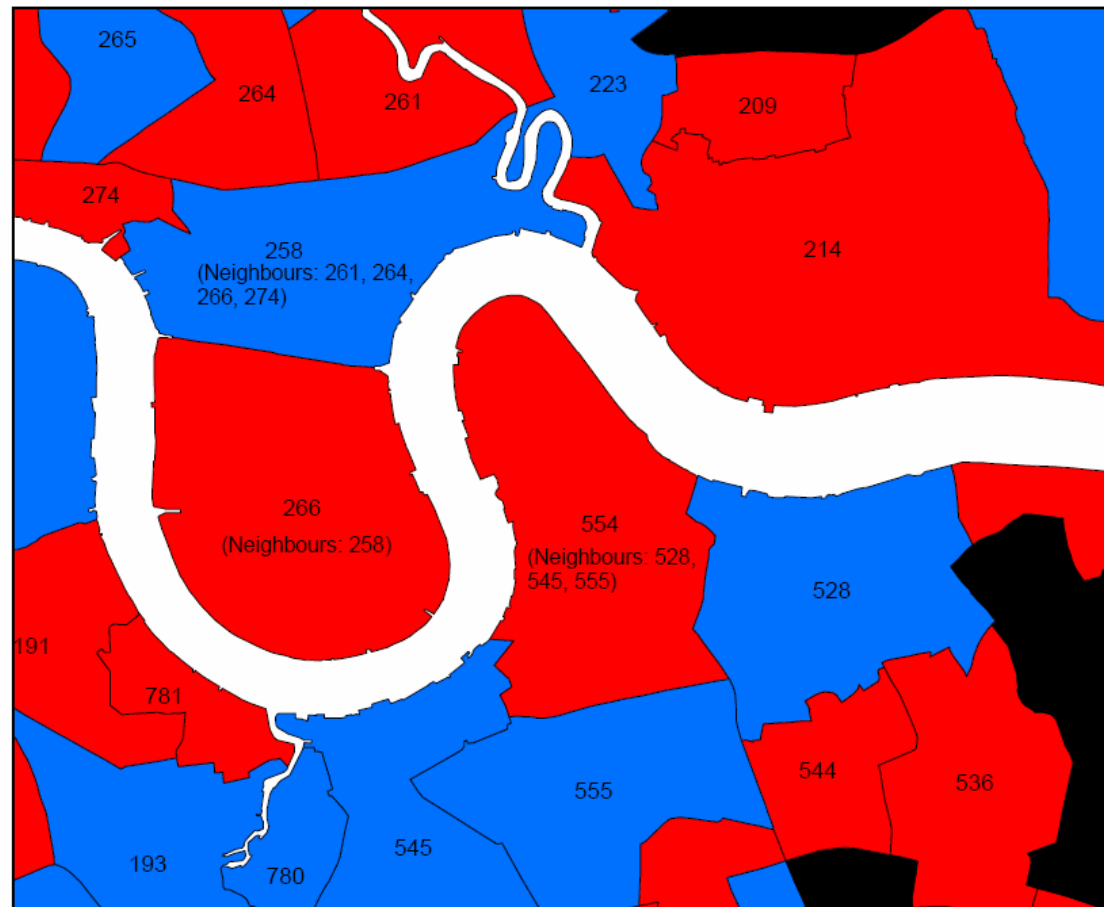


Storing Neighbourhood Information



- Stored in a .GAL File
- Can be created using GeoDa: <https://www.geoda.uiuc.edu/>

Combining the GAL file and the Segregation Model

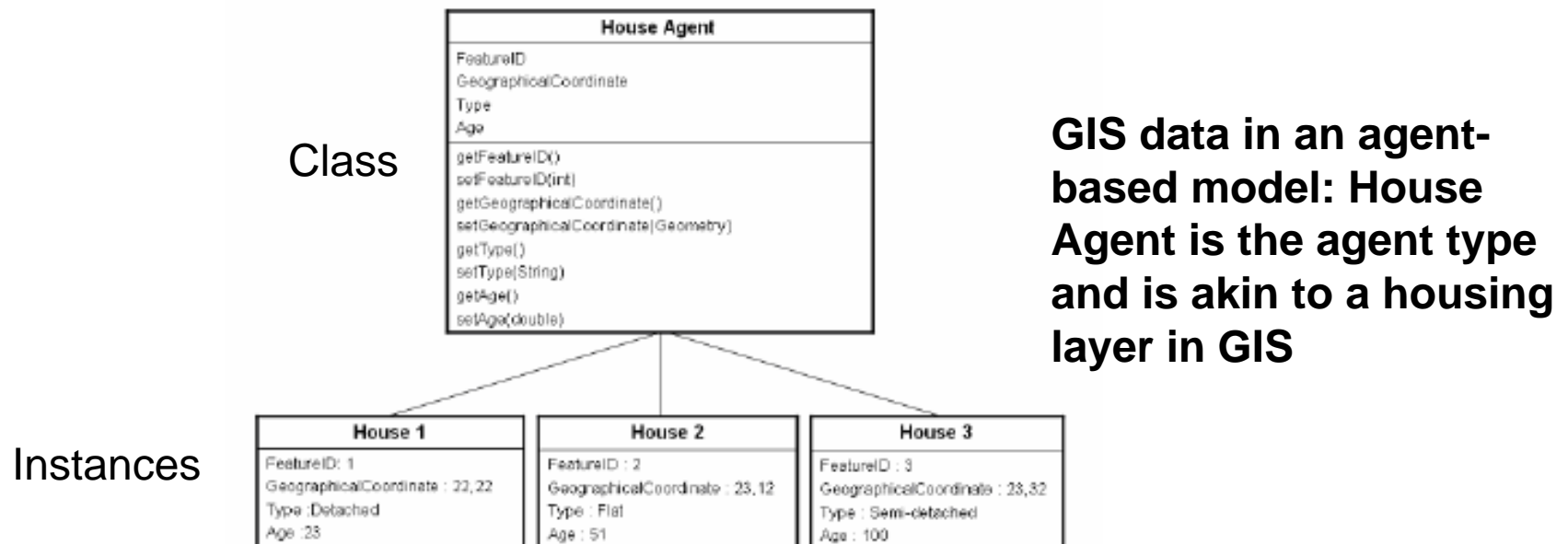


0 1 2 3 4 5 Km

Converting a GIS Layer into a Series of Agents

House Layer			
Feature ID	Geographical Coordinate	Type	Age
1	22,22	Detached	23
2	23,12	Flat	51
3	23,32	Semi-detached	100

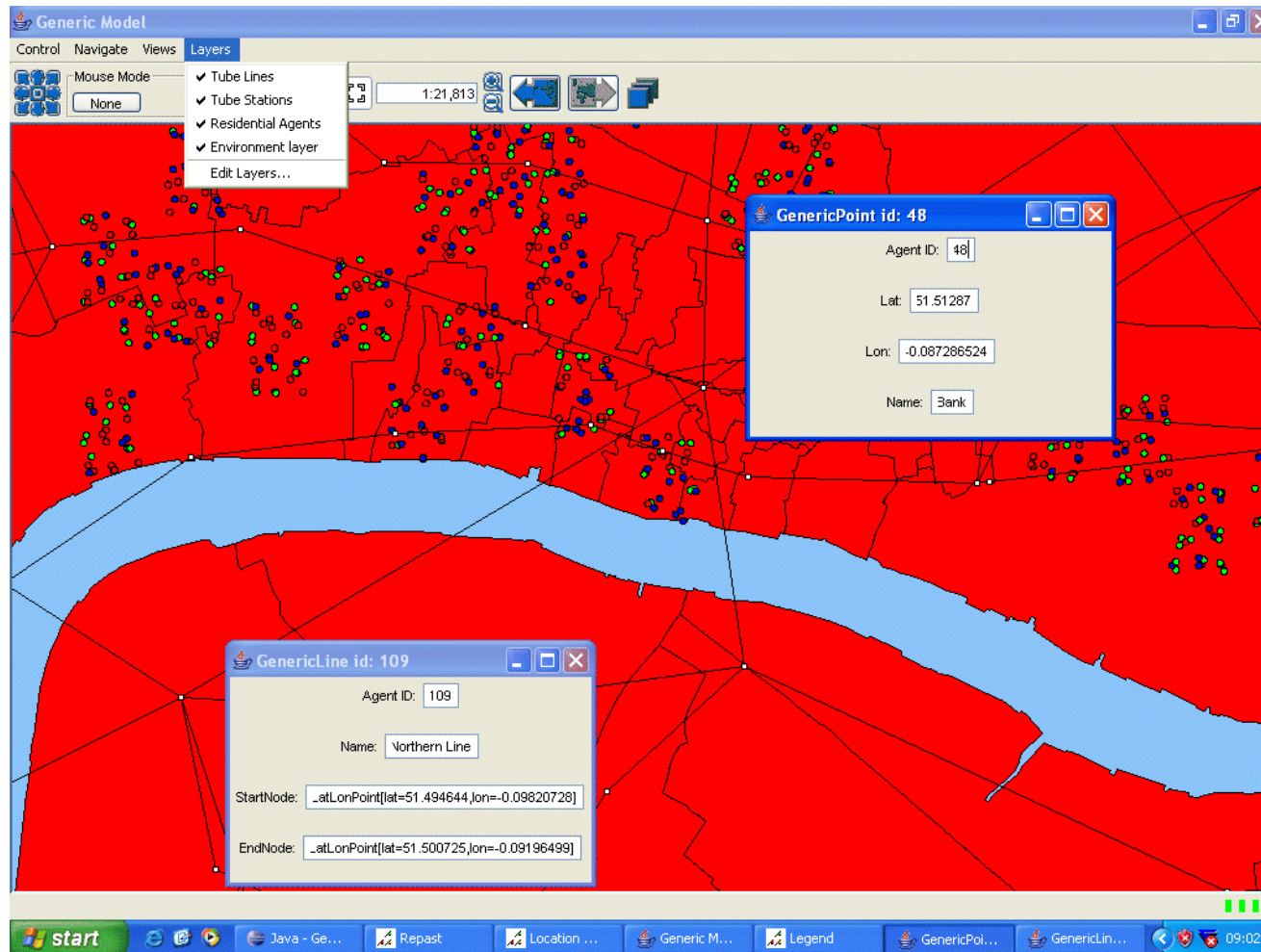
Sample of GIS type data, representing a layer of data in a GIS.



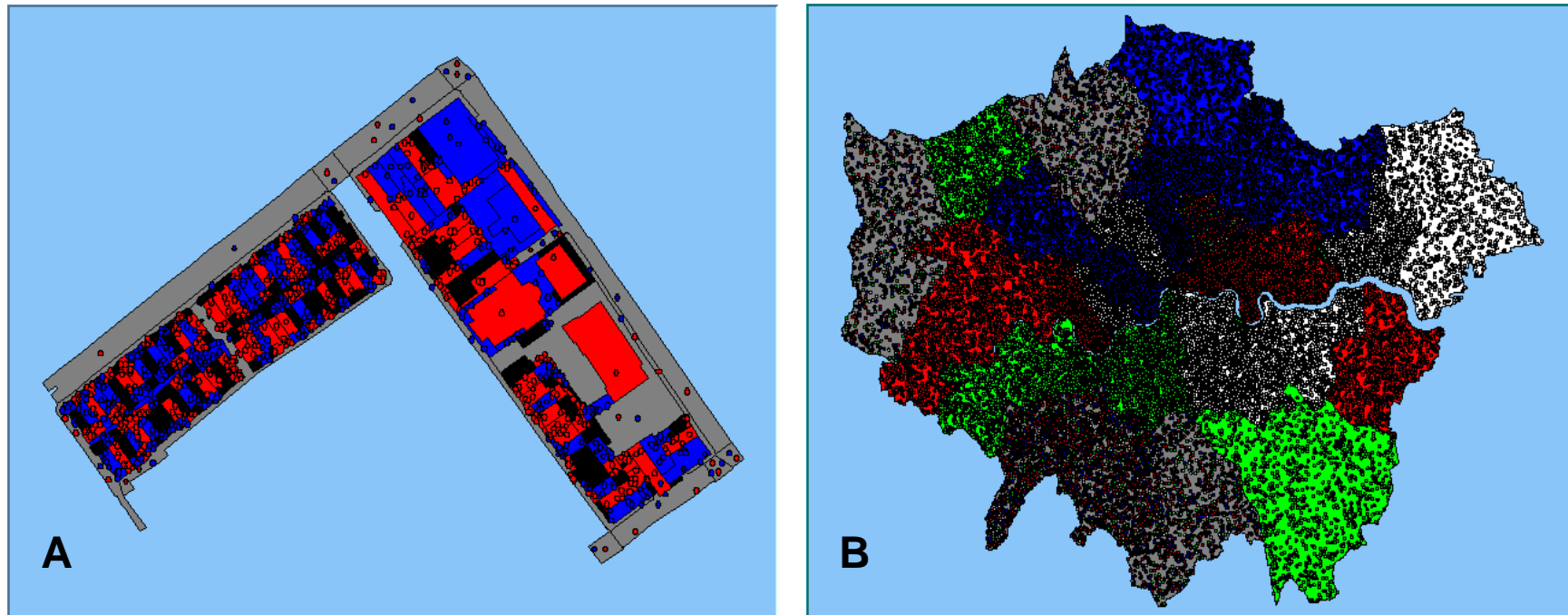
Models that use Vector Space:

- Example models
 - sluGISopenmap
 - OpenmapDemo
 - segModelPolygon
- These models can be combined and easily extended.

Adding Extra Layers

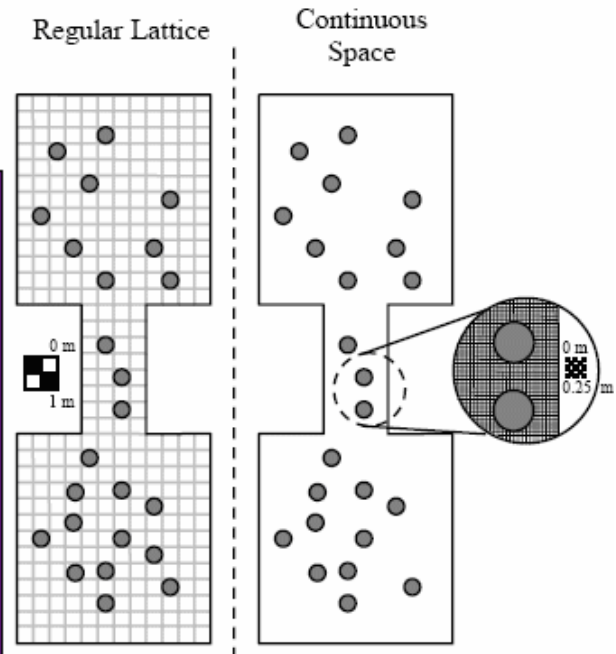
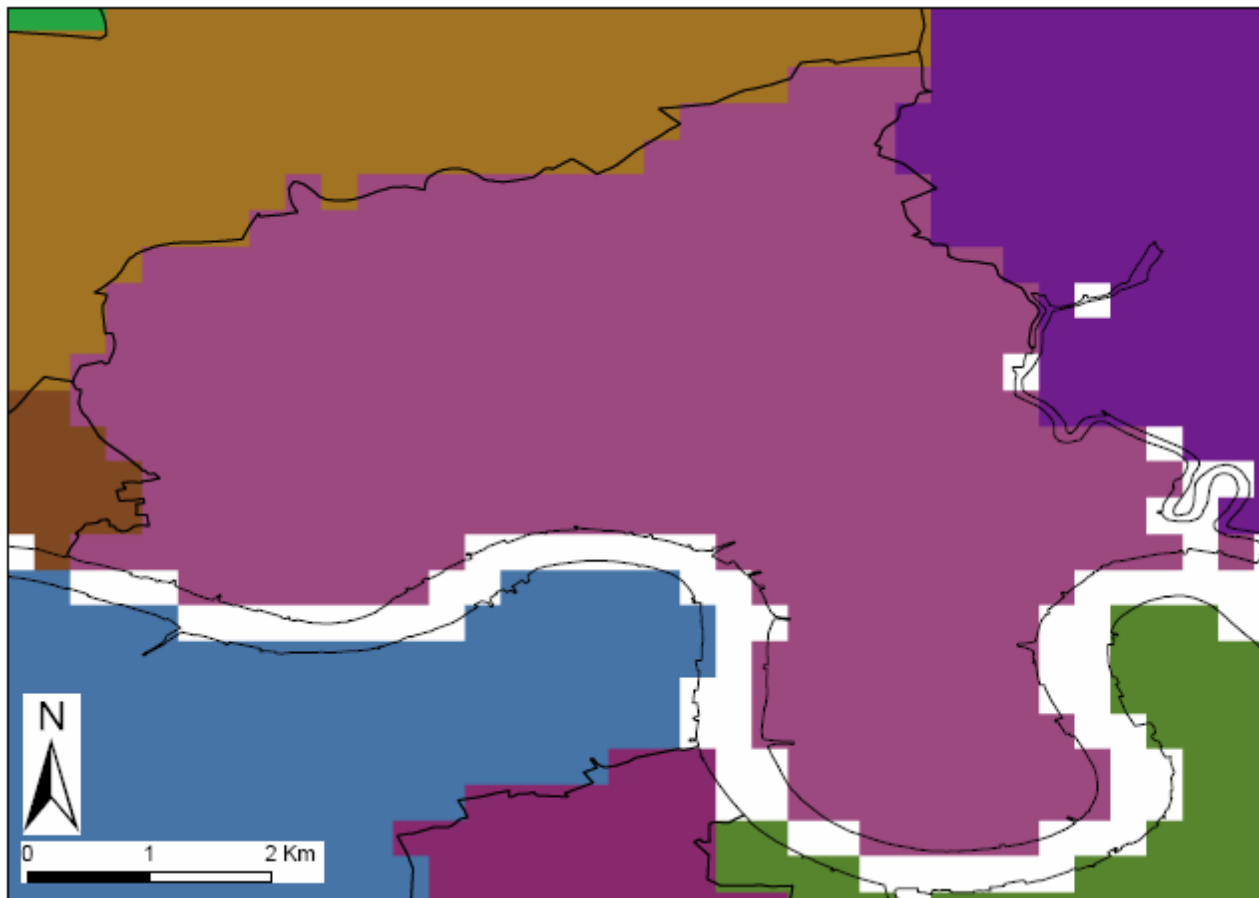


Vector Representation



Spatial representation within a model. A: street section composed of Individual buildings. B: London composed of boroughs. Agents are shown as dots.

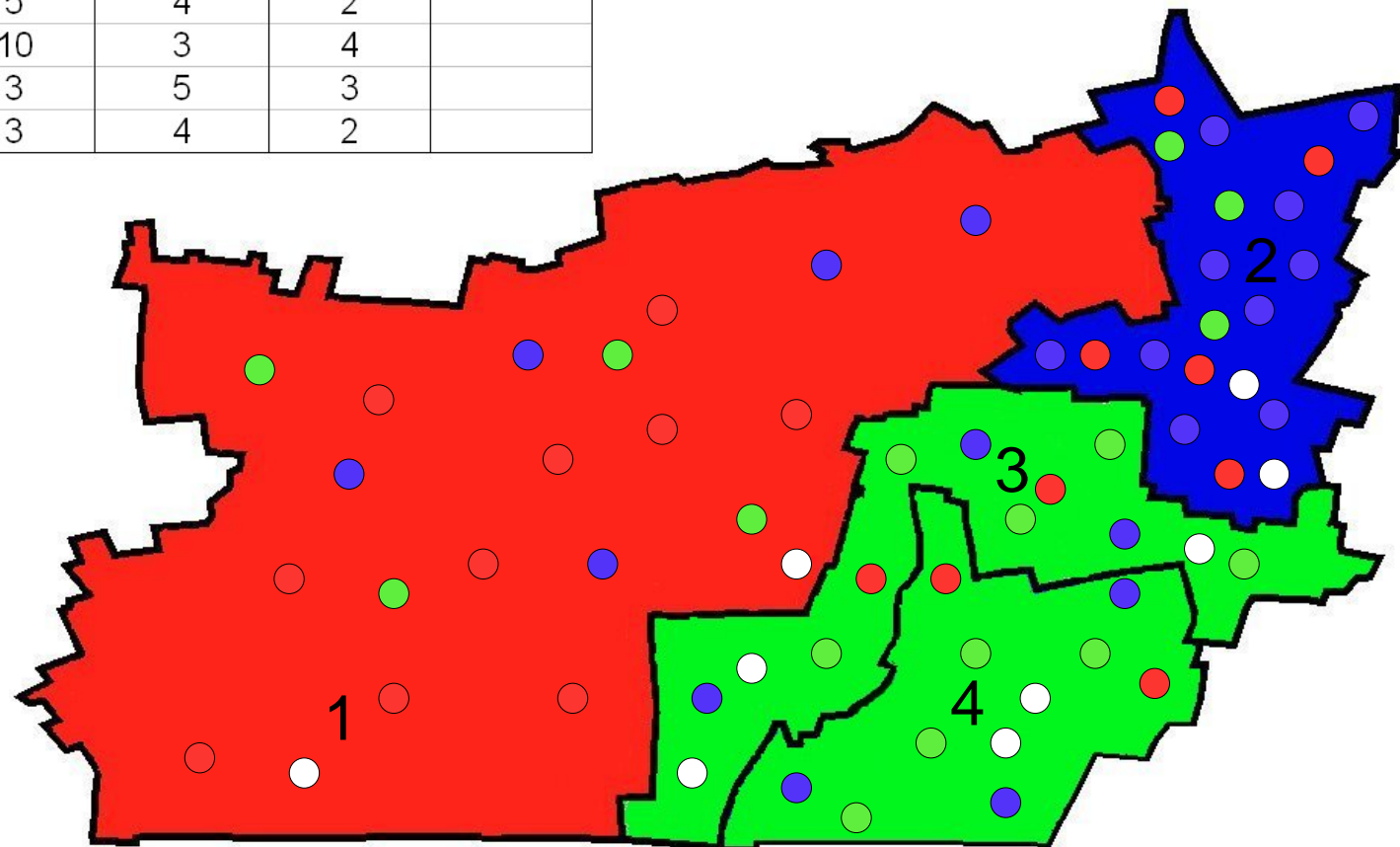
Comparison of Raster and Vector



Need to consider what type of space is needed

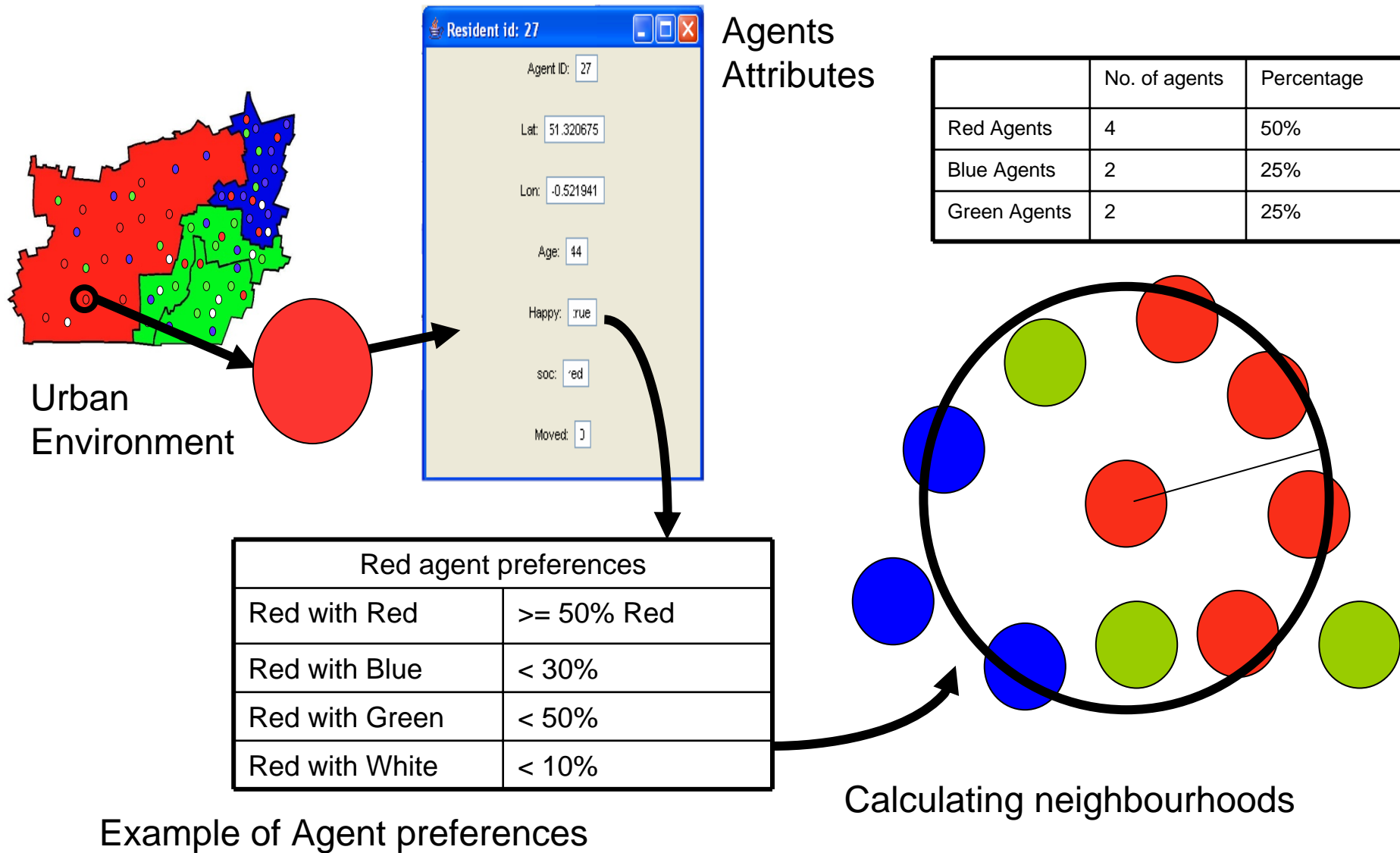
Reading in the data & building the model

Ward	No. Red	No. Blue	No. Green	No. White	Other info
1	10	5	4	2	
2	5	10	3	4	
3	2	3	5	3	
4	2	3	4	2	



Actions of individual agents will create changes in their physical environment.

Segregation Model Structure



Agents Attributes

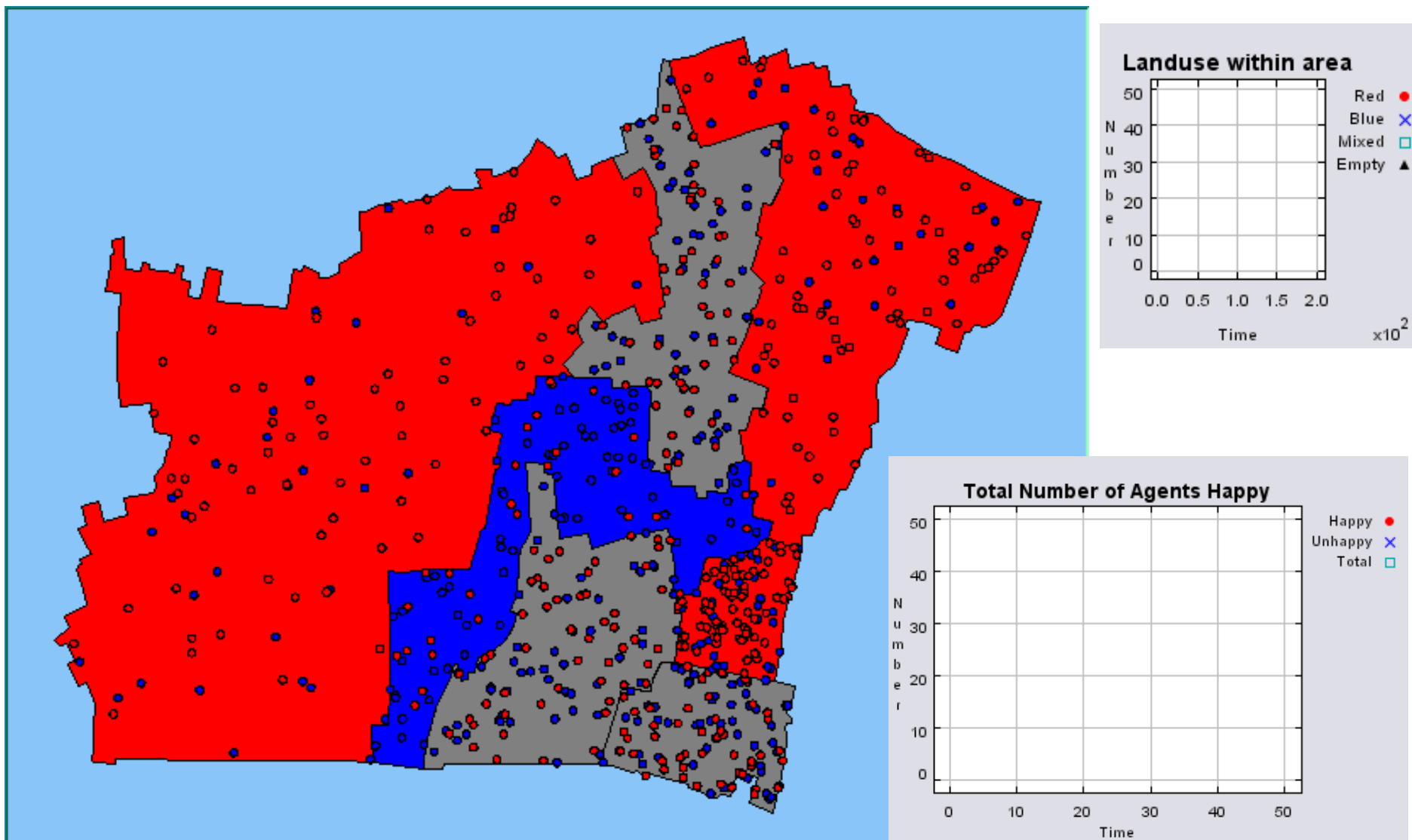
	No. of agents	Percentage
Red Agents	4	50%
Blue Agents	2	25%
Green Agents	2	25%

Red agent preferences	
Red with Red	>= 50% Red
Red with Blue	< 30%
Red with Green	< 50%
Red with White	< 10%

Example of Agent preferences

Calculating neighbourhoods

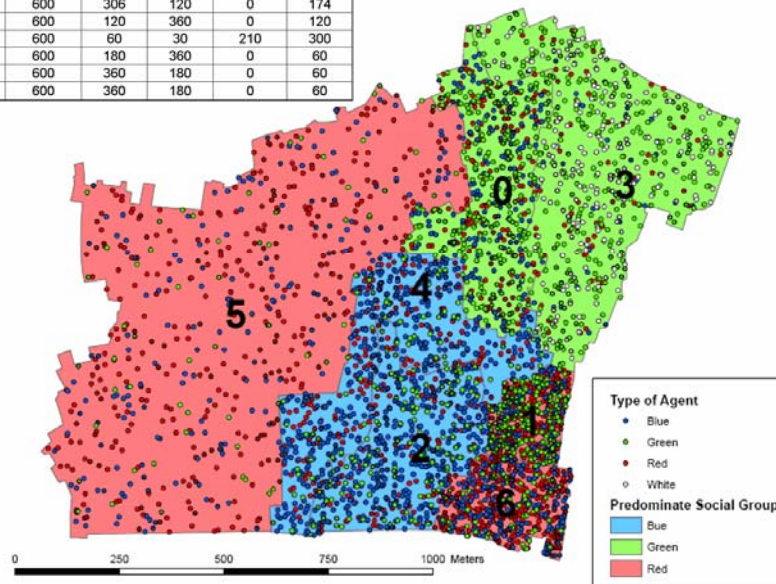
The addition and removal of agents



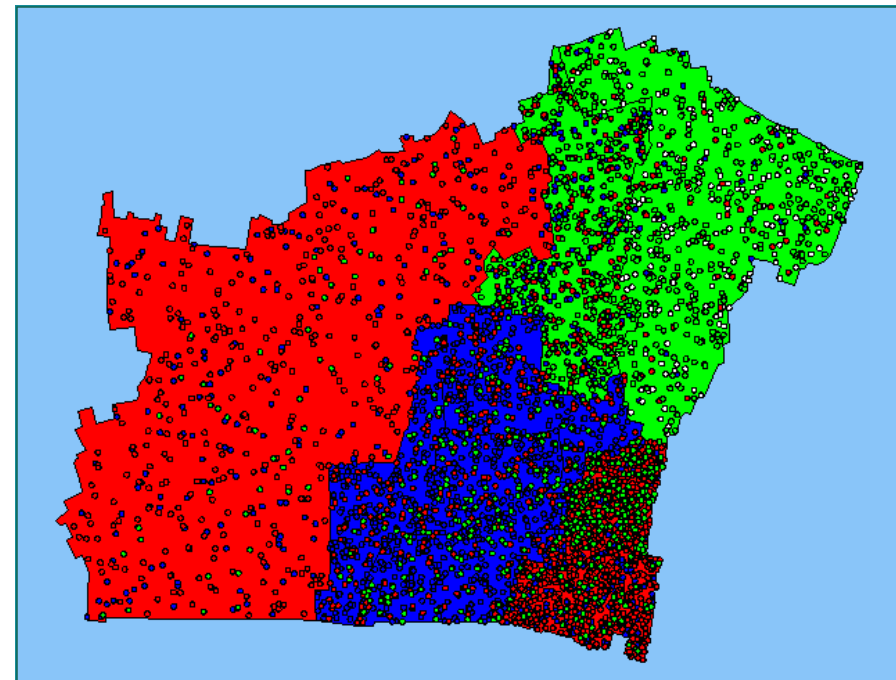
5% of the population are White at the start

Initial Conditions

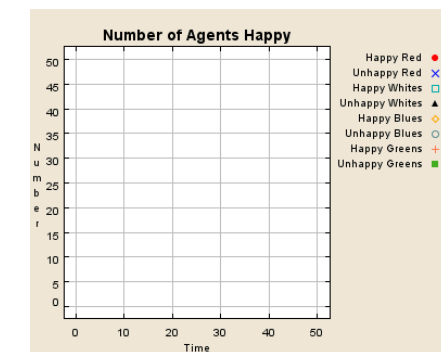
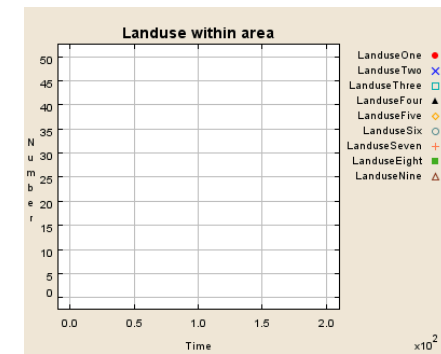
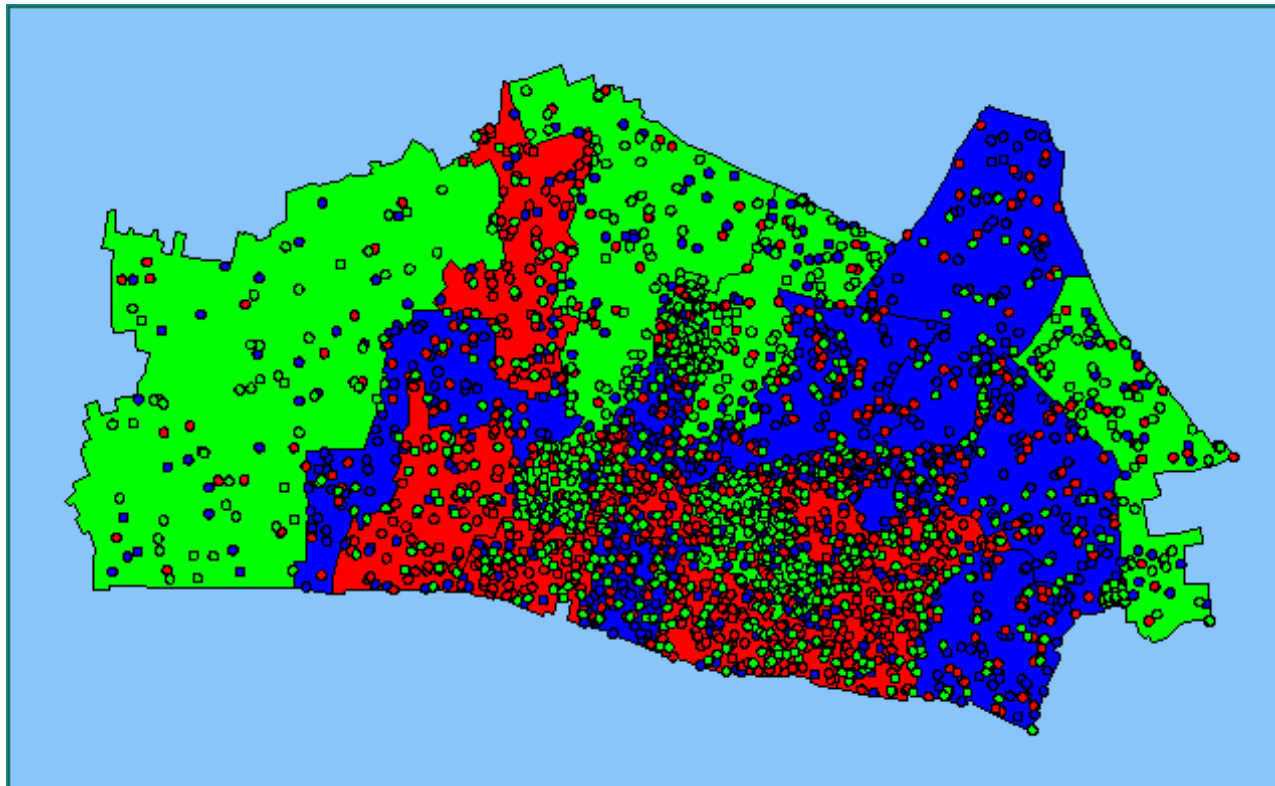
ID	Predominate Social Group	Total Population	No of Red Agents	No. of Blue Agents	No of White Agents	No. of Green Agents
0	Green	600	180	180	0	240
1	Red	600	306	120	0	174
2	Blue	600	120	360	0	120
3	Green	600	60	30	210	300
4	Blue	600	180	360	0	60
5	Red	600	360	180	0	60
6	Red	600	360	180	0	60



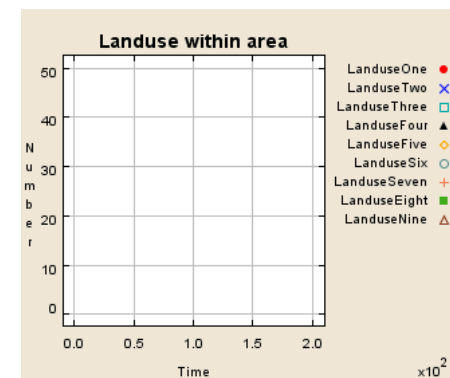
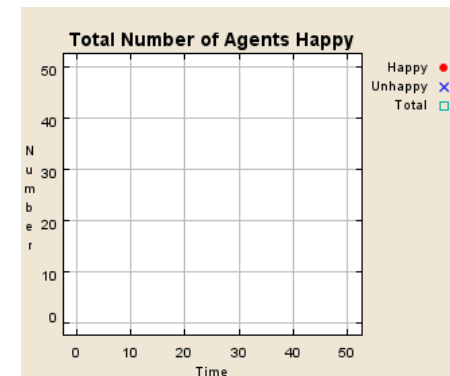
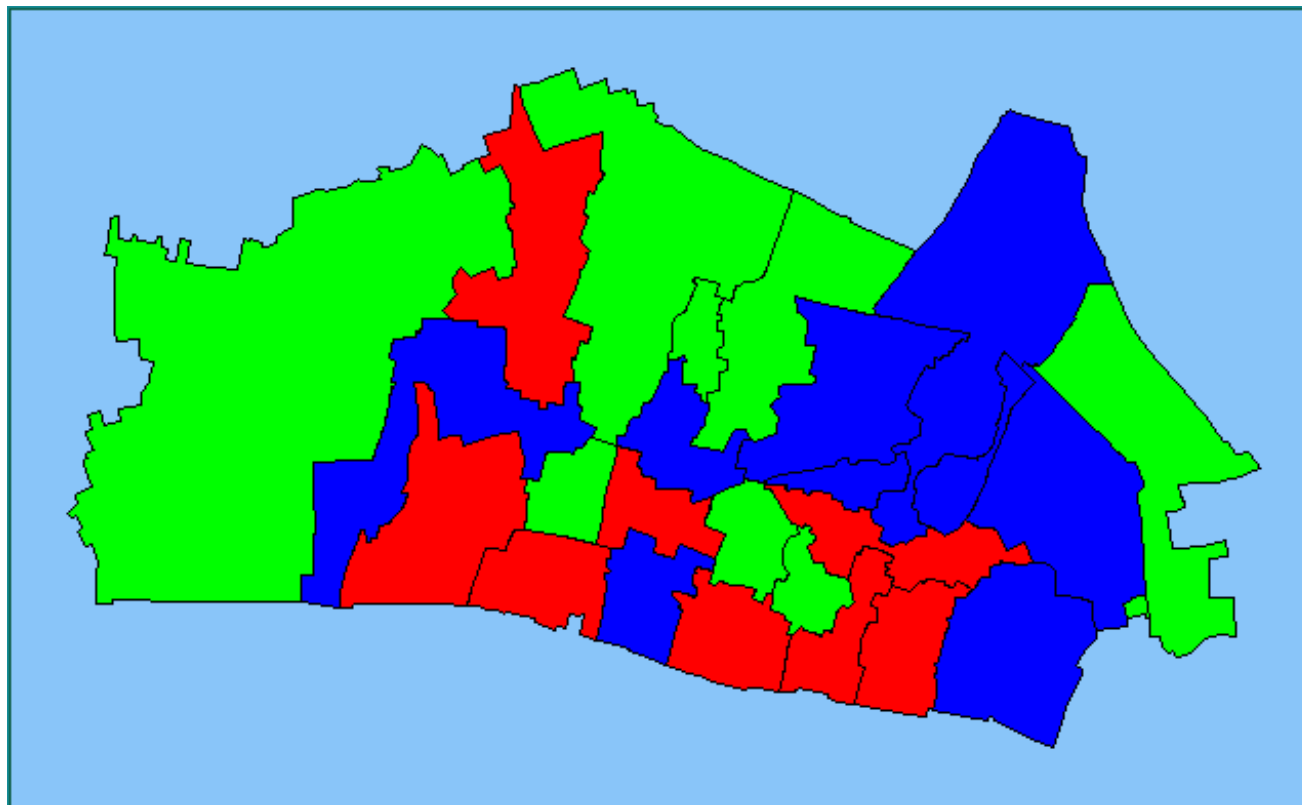
Simulation Run



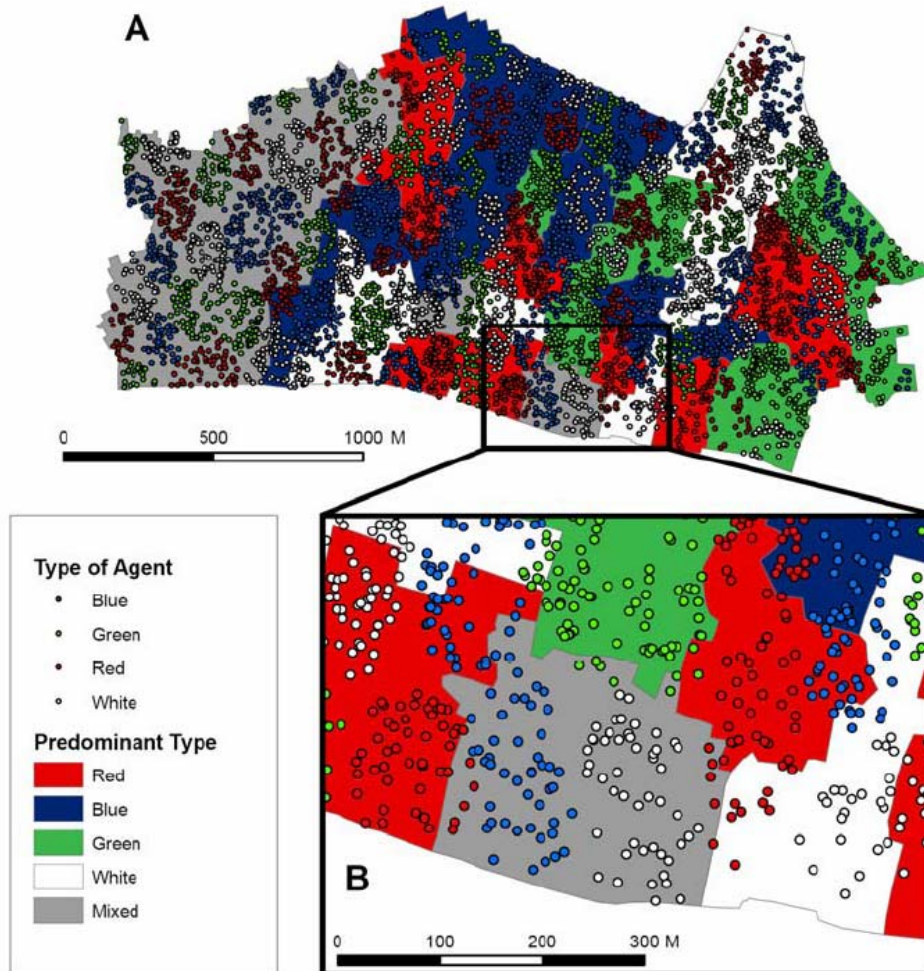
Segregation Simulation: 4 types of agents



Segregation Simulation: 4 types of agents



At one level everything is changing, at another level very little is changing



By looking only at the aggregate information we lose what is happening at the boundaries

Figure 5: Segregation within Areas and across Boundaries

A: The Entire Area, B: A Zoomed in Section of A

Who is using Repast?

- Designed for social scientists but not confined to it
- Examples include:
 - **Politics:** the rise and fall territories.
 - **Economics:** Banking strategies. Revenue management, evolution of firms, dynamics between firms, electricity markets
 - Segregation, Pedestrian modelling, disease transmission,
 - **Physical environment:** water shed modelling
 - **Landuse models:** SLUCE (change at urban rural fringe), LUCITA (Amazon farming), urbanisation.
 - **CASA**
 - Extensions also:
 - GeoGraph (3D extensions), AgentCell (biochemical reactions 3D) and parallel processing.

Useful Resources

- The Repast website <http://repast.sourceforge.net/>
- Murphy's 'How to Create a Repast Model' tutorial <http://www.u.arizona.edu/~jtmurphy/H2R/HowTo01.htm>
- Tesfatsion's 'Self-Study Guide for RepastJ' <http://www.econ.iastate.edu/tesfatsi/repastsg.htm>
- GIS and Agent-Based Modelling: <http://gisagents.blogspot.com/>
- [Professor Cederman](#) from the International Conflict Research Group at ETH Switzerland:
 - For Repast models: <https://www.icr.ethz.ch/teaching/archive/compmodels/ws2004/models>
 - For slides and more details on Repast <https://www.icr.ethz.ch/teaching/archive/compmodels/ws2004/slides>

Summary

- Shown the basic Repast structure and how to set up Repast.
- Import models –helps with the understanding of Repast and its limitations
- Examples of Raster and Vector Integration

Further Information and Examples

<http://www.casa.ucl/repast/>

<http://www.gisagens.blogspot.com>

<http://www.casa.ucl.ac.uk/andrew/phd/>

