The Building Blocks of the City: Points, Lines and Polygons

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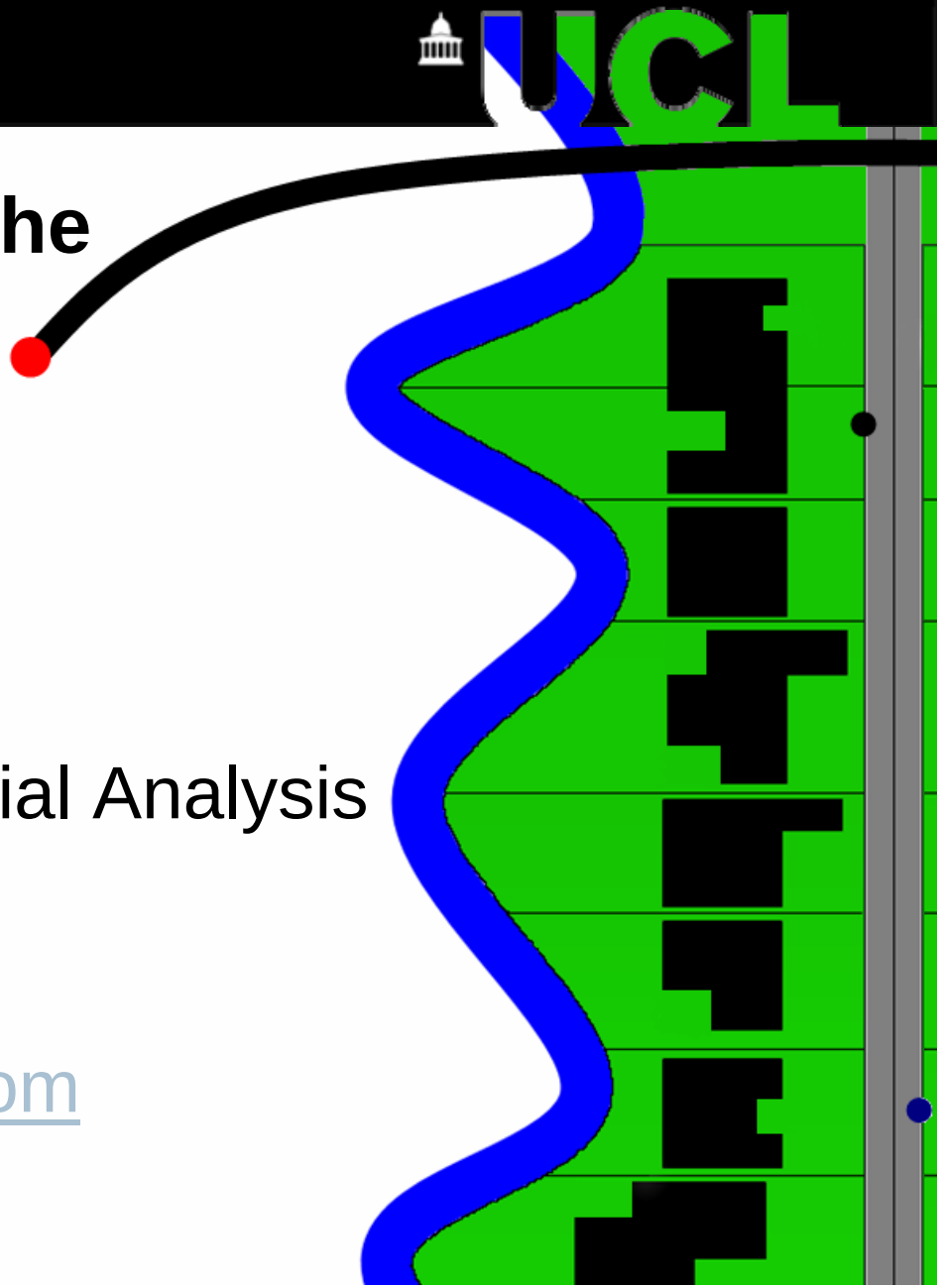
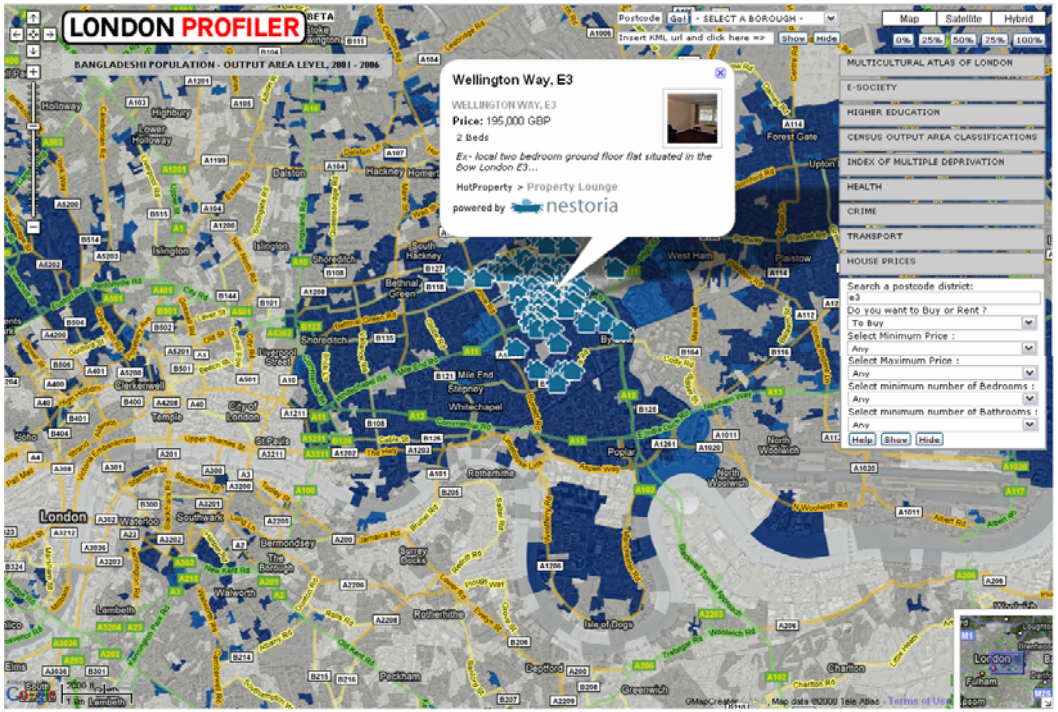


Why use ABM for Residential Location & Housing?

- Urban systems composed of many individuals:
  - Interacting with each other & their environment.
- Each person faces the fundamental question of where to locate.
- Location is a trade-off between many factors.
  - E.g. dwelling type, social class, neighbourhood, income, ethnicity, gender, age etc…
- Leads to urban structure developing (e.g. spatial clustering).



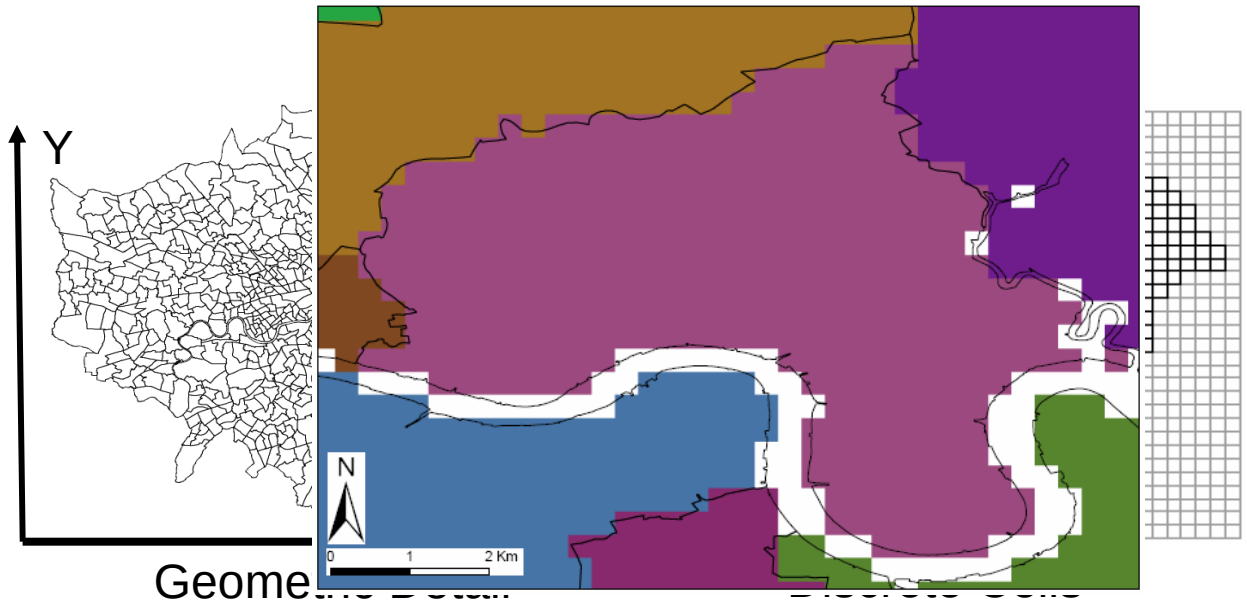
- Residential location and other studies of urban phenomena are active ABM research topics (see Batty, 2005a; Benison & Torrens, 2004; Portugali, 2000).

The Context

- The world is inherently spatial : objects have a location and events are embedded in time (Wegener, 2000).
- Growing interest in GIS and ABM integration (e.g. Gimblett, 2002; Benenson and Torrens, 2004; Parker 2005).
  - Allows agent-based modellers to have agents related to actual geographic locations (Batty, 2005a).
  - For GIS users, it provides the ability to model the emergence of phenomena through the individual interaction of features in a GIS over space and time (Najlis and North, 2004).

The Problem

- Many ABM applications represent space as a series of discrete cells.
- These applications capture geographic detail but miss geometric detail (Batty, 2005b).
  - Explore geographically explicit agent-based models which consider geometric detail directly in the simulation process.



UCL

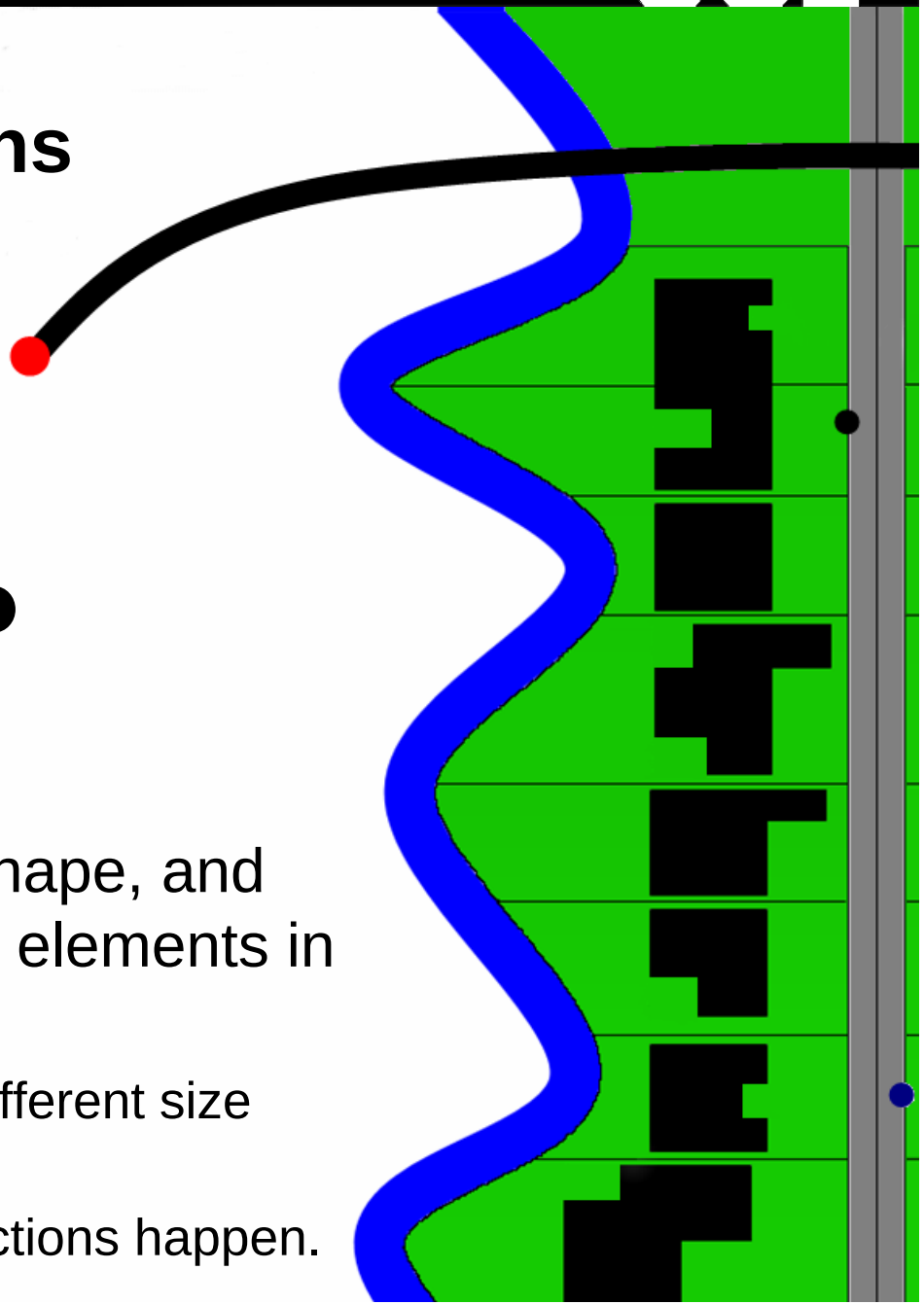
Points, Lines & Polygons

Point

(X=1, Y=1)

Line

Polygon

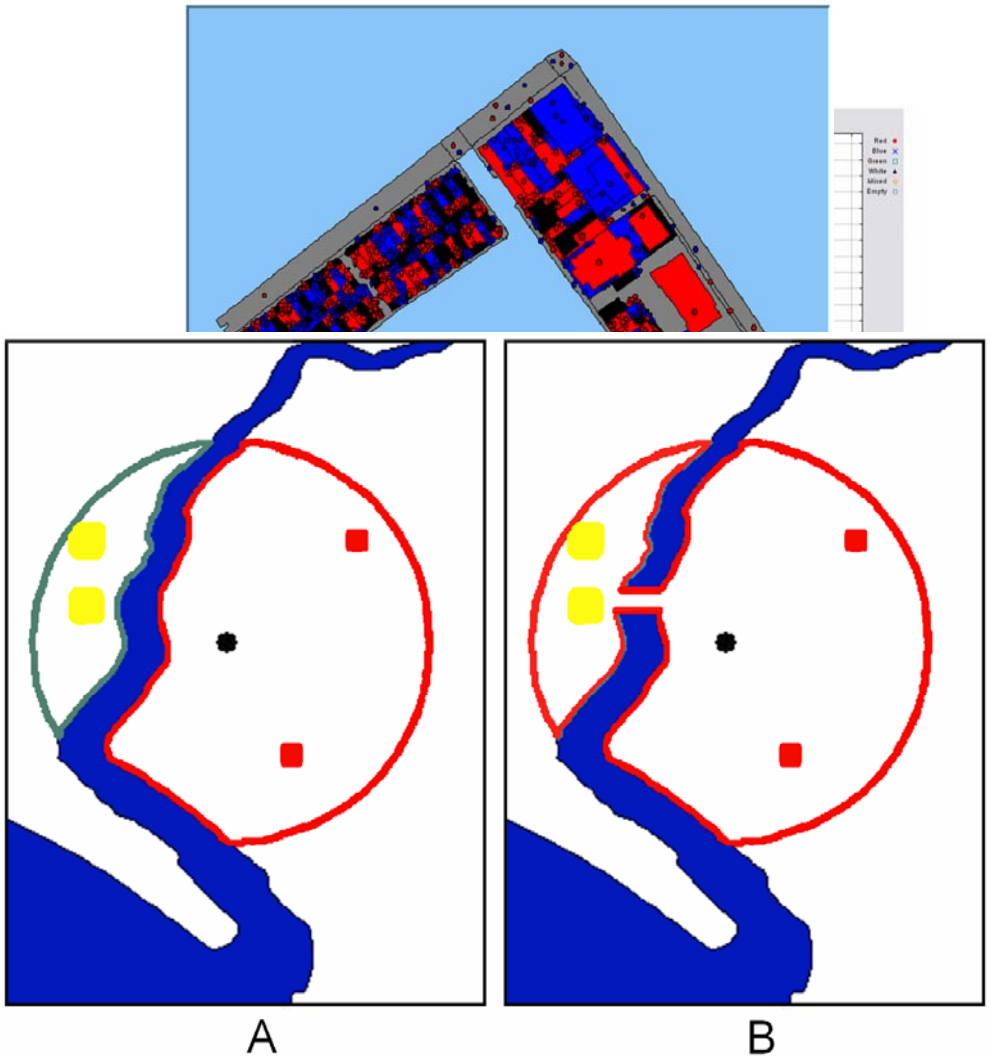


- Geometry: provides the size, shape, and relative position in space for all elements in the city.
  - Allows for the representation of different size objects.
  - Acts as a container to which all actions happen.

The Approach

Created a Basic Model:

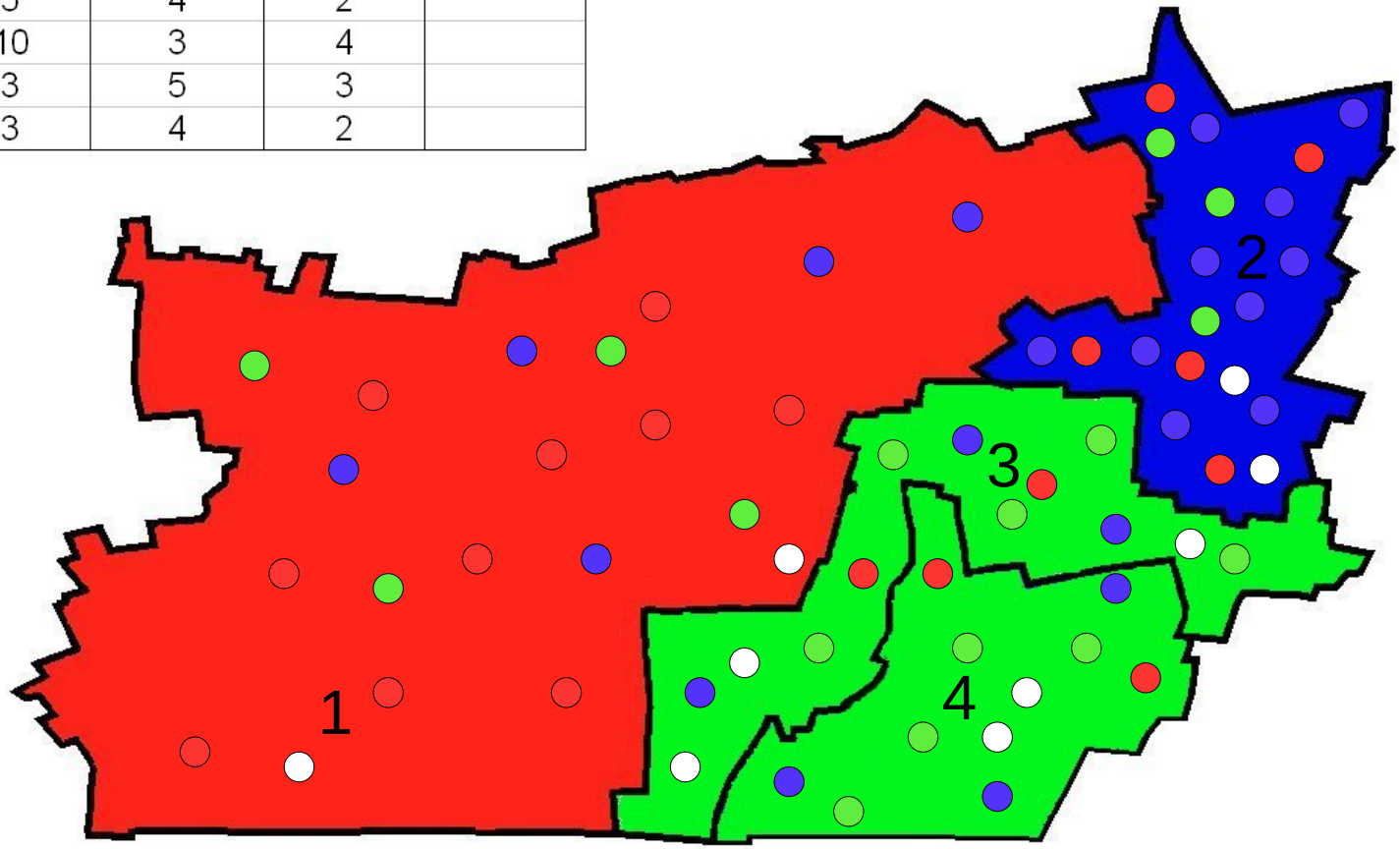
- Utilizing and extending RepastJ.
- Easily extended.
- Represents the world as a series of points, lines and polygons:
  - At different geographical scales & shapes.
- Direct consideration of geographical features:
  - Utilising GIS methods.
- User Interaction, parameter setting and Data capture.
- Use data held within fields of data files to create agents.



Representing Different Geographical Features
For example, Rivers in neighbourhood calculations
A. Individual Buildings
B. Entire Metropolitan Areas

Reading in the Data & Building the Model

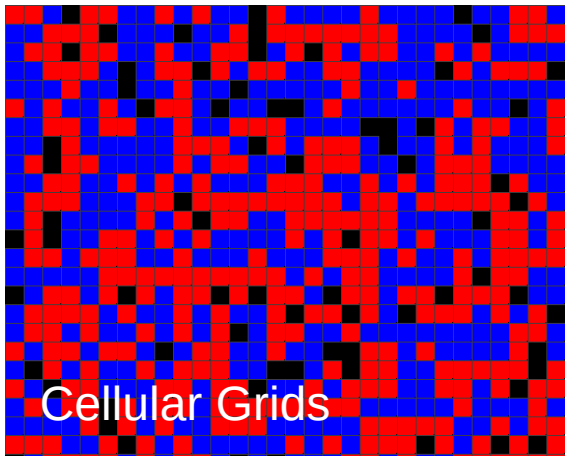
Ward	No. Red	No. Blue	No. Green	No. White	Other info
1	10	5	4	2	
2	5	10	3	4	
3	2	3	5	3	
4	2	3	4	2	

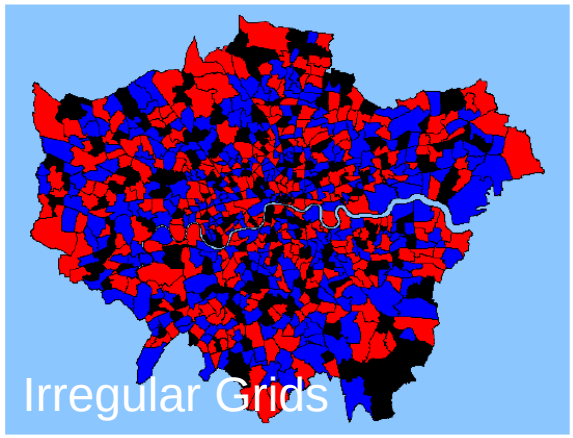


Actions of individual agents will create changes in their physical environment.

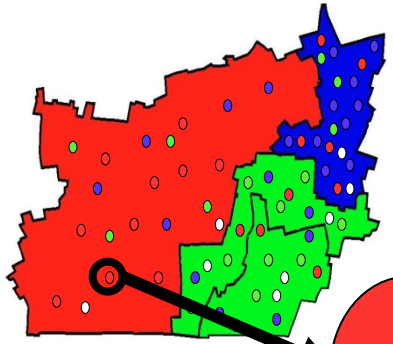
Application: Residential Segregation Model

- Many different types of segregation.
- Seen within many cities.
- Model based on Schelling's (1971) "Dynamic Models of Segregation."
  - Good example of emergent phenomena.
  - However there are criticisms of it e.g. neighbourhood tolerances (see Fossett, 2006).
- Previous versions focus on cellular or irregular grids.
- Allows for testing of the basic model – multiple agents in 1 area.

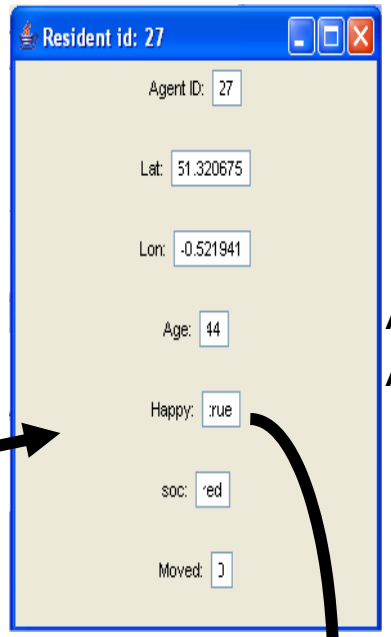




Segregation Model Structure



Urban Environment



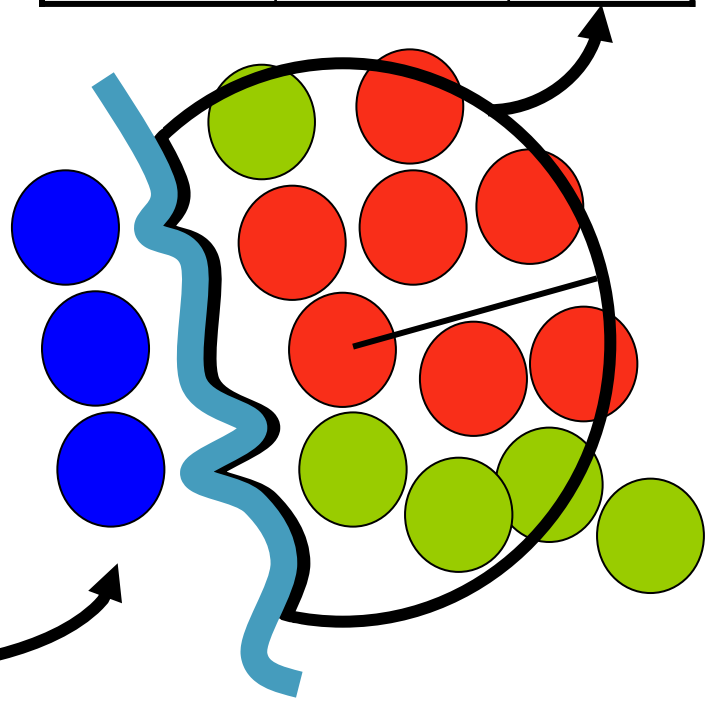
Agents Attributes

Red Agent Preferences	
Red with Red	>= 50% Red
Red with Blue	< 30%
Red with Green	< 50%
Red with White	< 10%

Example of Agent Preferences

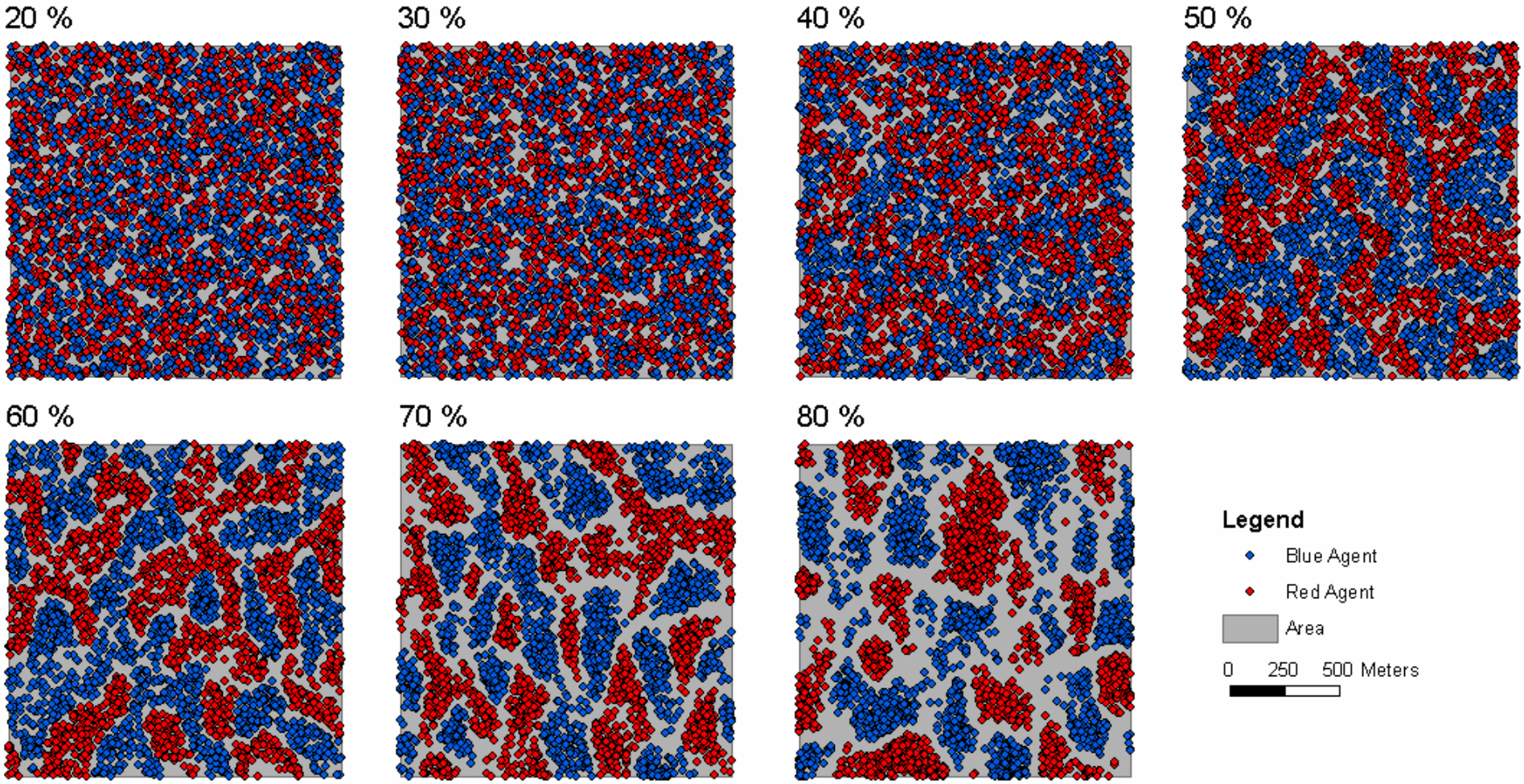
Results from Neighbourhood Calculation

Neighbours	No. of Agents	Percentage
Red Agents	6	60%
Blue Agents	0	0%
Green Agents	4	40%
White Agents	0	0%



Calculating Neighbourhoods

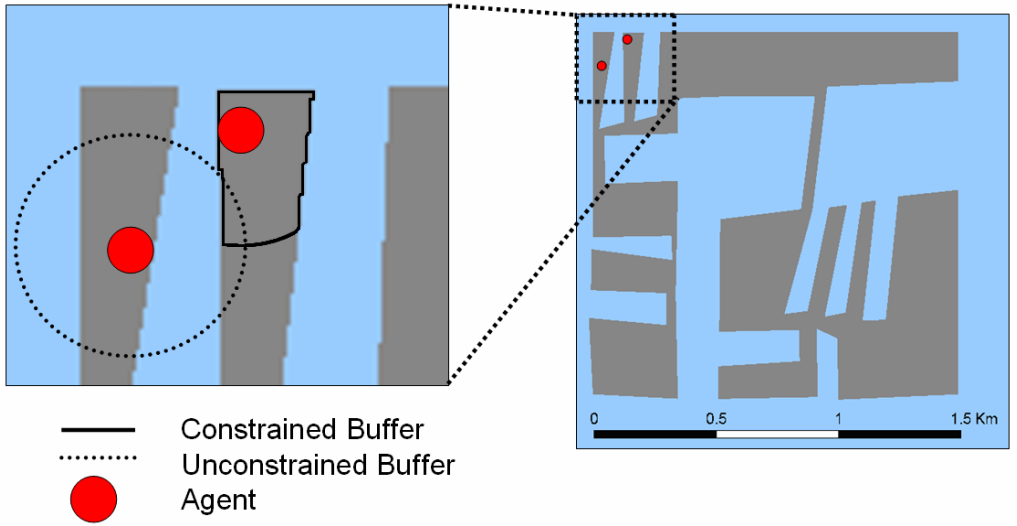
The Role of Preferences



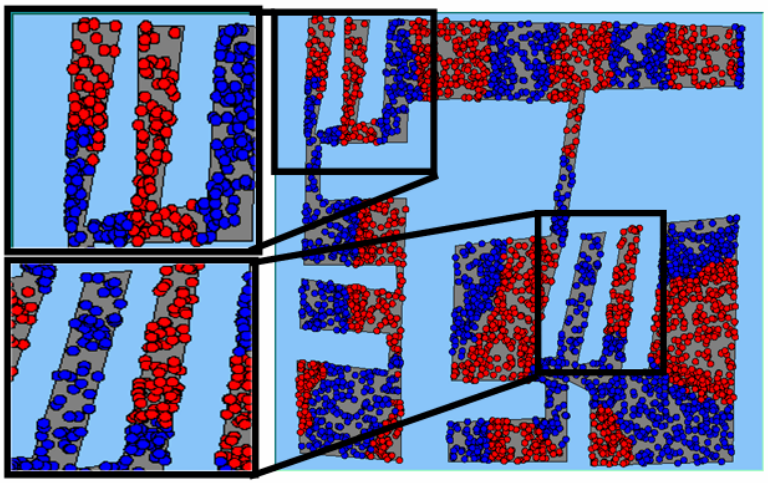
Agents satisfied if a certain % of their Neighbourhood >=%

The Impact of Geographical Features

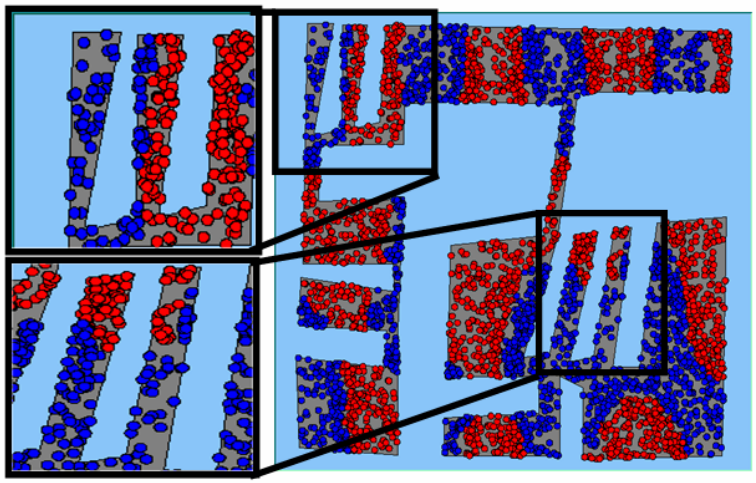
- Physical features can act as boundaries between areas (Talen 2003).
- Compare constrained & unconstrained buffers.
- Patterns of Segregation are different.



Constrained Buffer



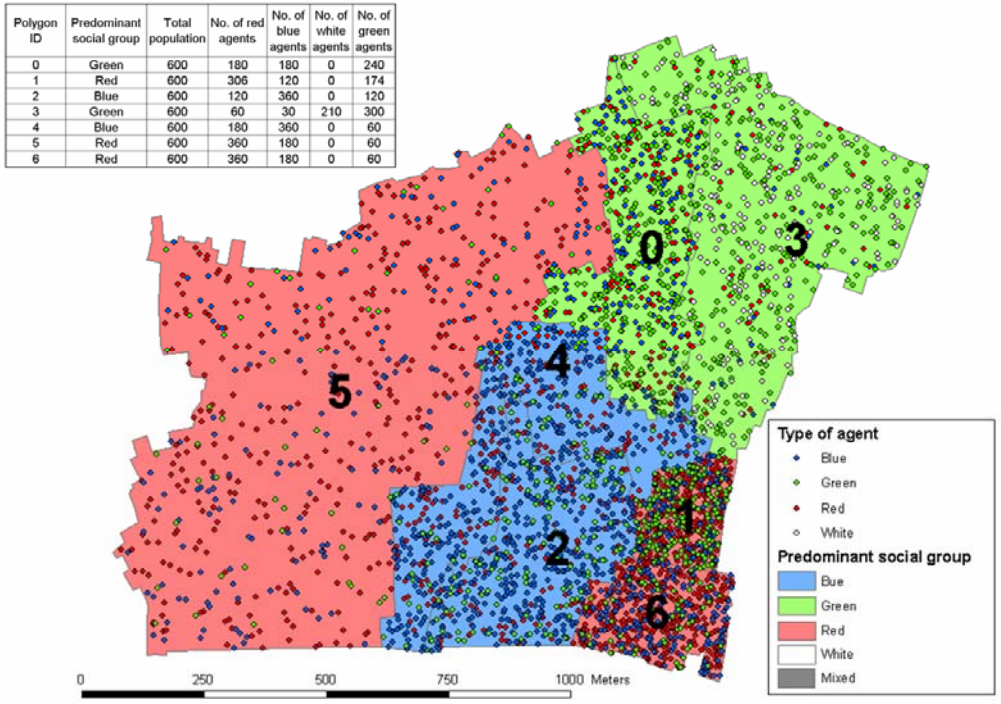
Unconstrained Buffer



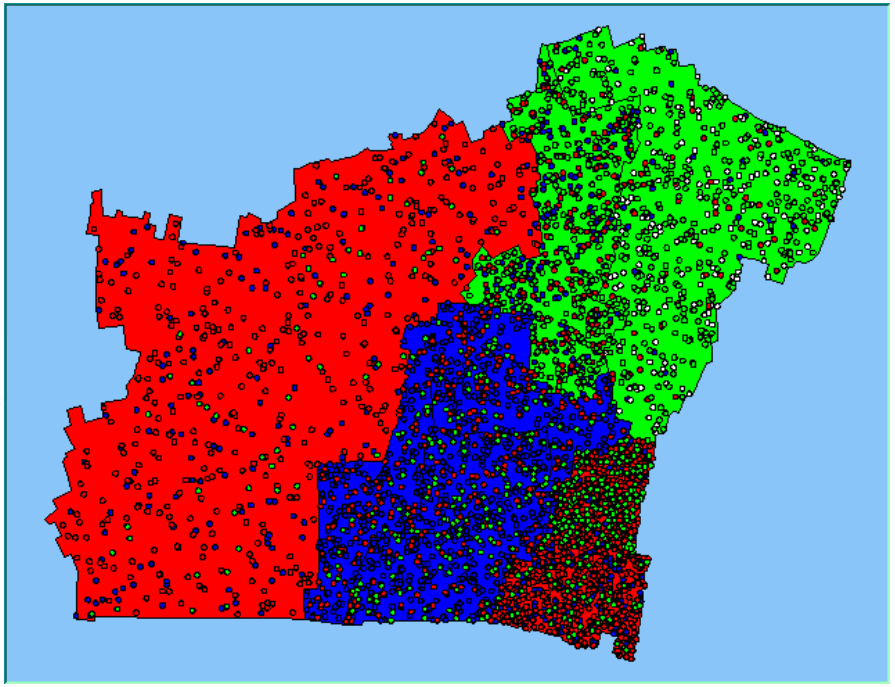
5% of the Population are White at the Start

Initial Conditions

Polygon ID	Predominant 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

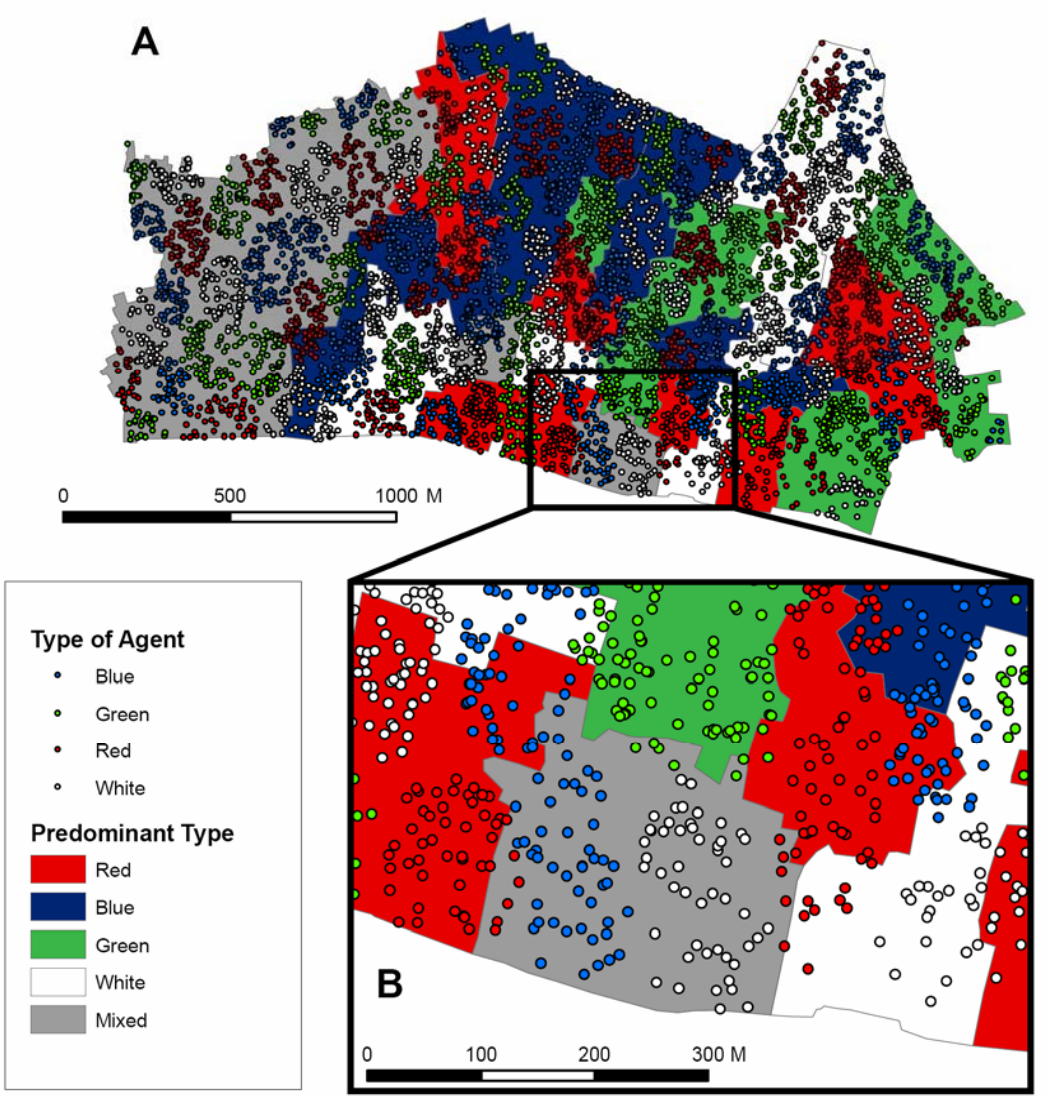


Simulation Run



- The 5% of White agents are concentrated in area 3.
- As agents are added, whites concentrate in one area and slowly spread out – forcing other types to move.

Application: Residential Segregation Model



Segregation within areas and across boundaries. A: the entire area, B: a zoomed in section of A.

- By looking only at the aggregate information we loose what is happening at the boundaries.

Current Work: taking the models further

Current work: linking people to places, grounding previous models with data.

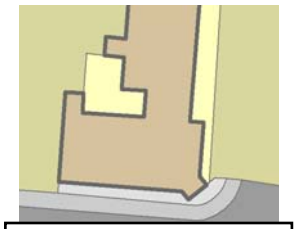
- Can a geographically explicit agent-based model be developed to explore residential dynamics such as residential location & housing, at the fine scale?
- Thus improve our understanding of residential location?

But before we do this, we need data:

- Lack of property data.
  - No national cadastre on housing attributes (such as size, type and age). Restricts application of GIS in planning.
- New datasets are becoming available.
  - Could combining recent datasets, such as OS address data and Land Registry transaction data etc., begin to fill this data gap?

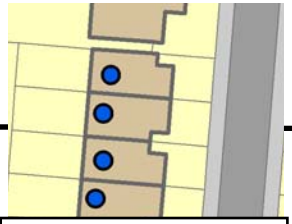
Current Work

Geometry



OS MM Building Footprints

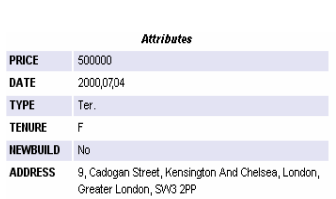
LIDAR Building Heights



OS MasterMap Address Data

Fine Scale Socio-Economic Data

Cities Revealed Land Use, Building Age & Type



Land Registry House Price Transaction Data

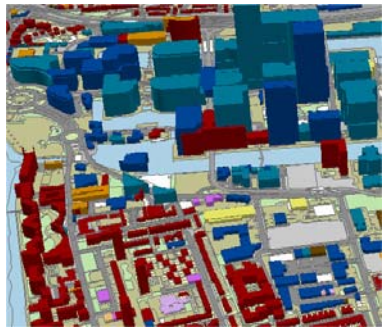
VOA Business Rates (floor space)

Transport Network

Housing & Built Environment Database

Zonal Geographies

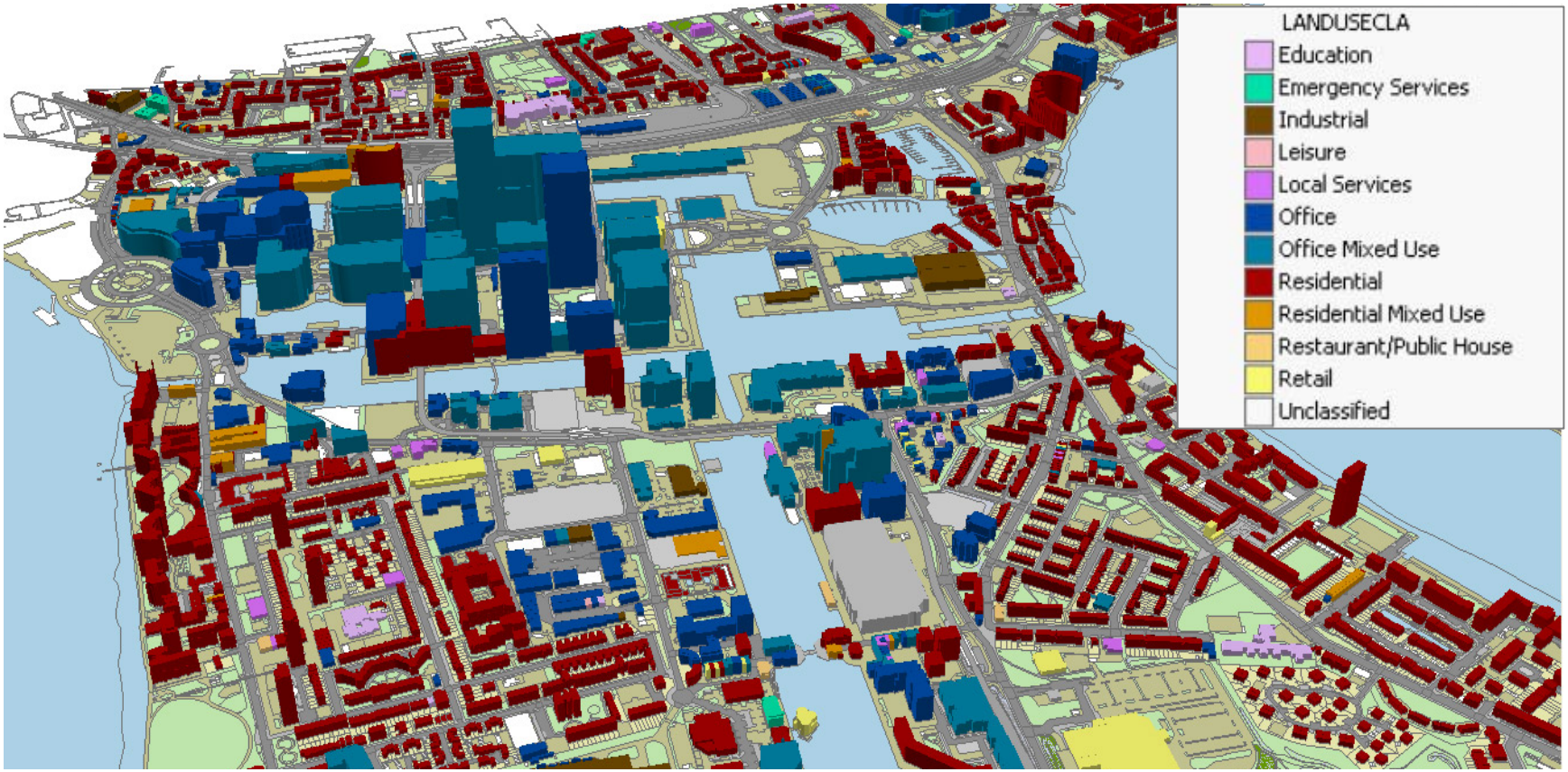
Geodemographic Data, Census Data, Employment Data



Core and Potential Applications

- Land use
- Urban Modelling
- Housing
- Energy Usage
- Density (e.g. density of dwellings)
- Access to local services & green spaces
- Explore uplift rates (e.g. new builds)& hedonic modelling
- Accessibility Measures

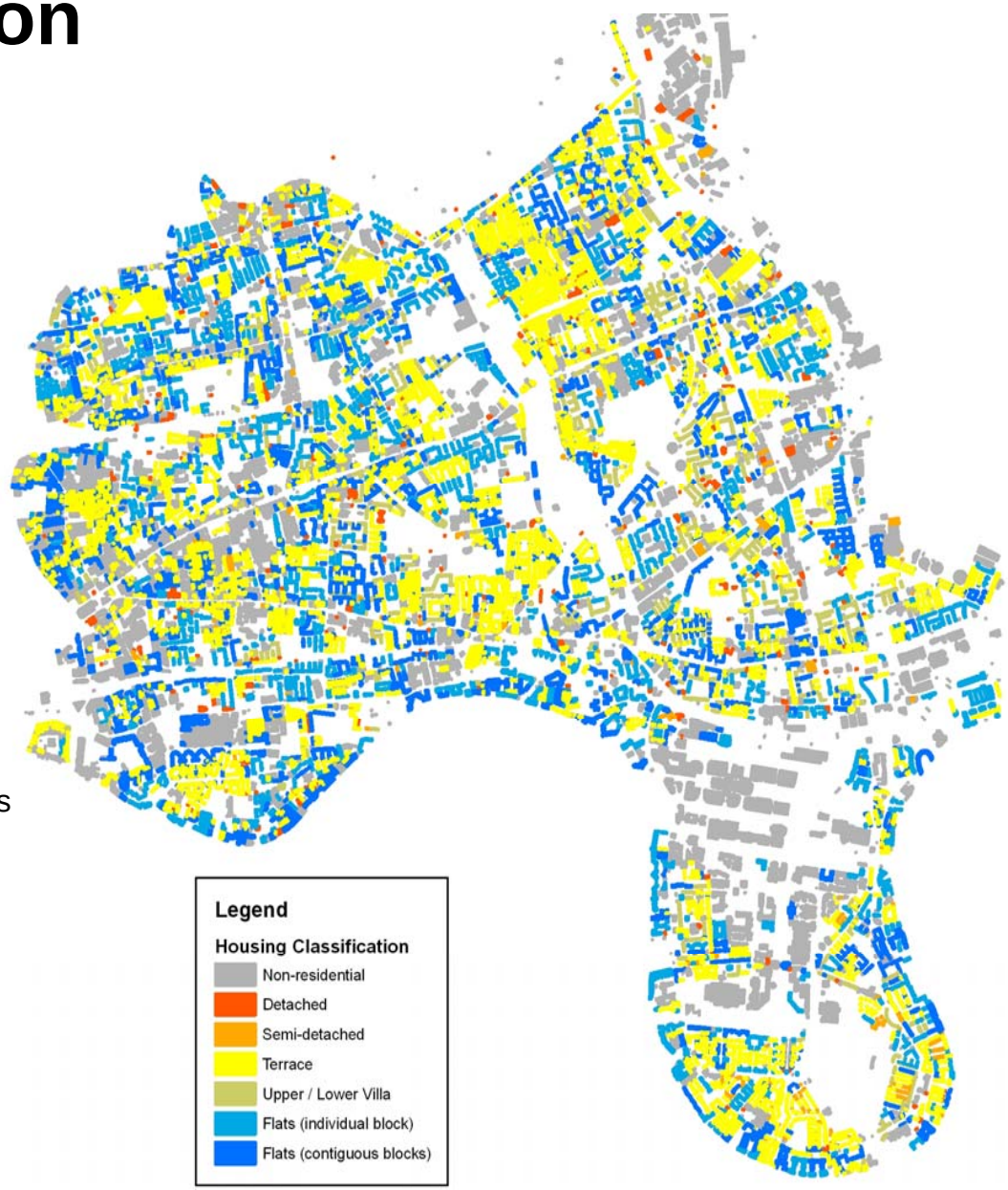
Building Function and Land Use Data



- Simplified to basic classes in this example (e.g. *Office Mixed Use* – offices with retail).
- Useful in planning to see patterns of land use and urban texture.

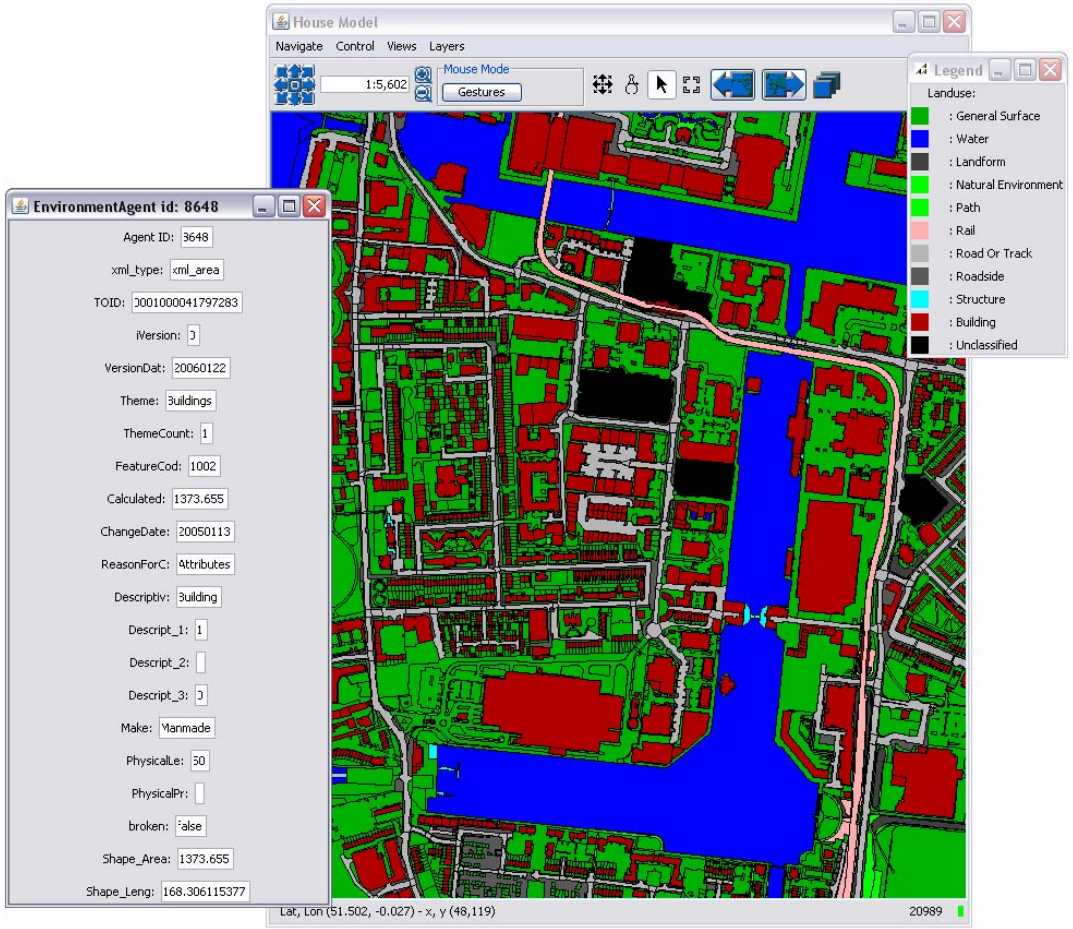
Housing Classification

- **Straightforward classification of housing types-**
- **Detached housing-** 1 Building with 1 Dwelling per block.
- **Semi-detached housing-** 2 Buildings each with 1 Dwelling per block.
- **Terraced housing-** more than 1 Building each with 1 Dwelling per block.
- **Flats-** 1 or more Buildings per block with more than 2 Dwellings.
- **Housing Classification Patterns**
  - Identify fine scale variation in the housing market.
  - Can be matched to transaction data at address level and other land use information.
  - Shows complex overlapping submarkets, due to mixed housing stock, pace of development & path dependence.
- **The data can be used to ground the Agent-based model.**



Prototype Residential Housing Model

- Using a similar approach to building the basic agent-based models, the Housing & Built Environment Database allows:
  - MM TOIDS to represent the built environment.
  - MM Address Layer for no. of Units tagged to buildings.
  - Attach Agents to such Units.
  - Land Registry data for prices.
- Agents behaviours & preferences for locations can be based on both the built environment & socio-economic characteristics:
  - Agents choice of location can be trade off between price, type of residence, its location both in terms of neighbourhood & place of work, etc (Alonso, 1964)…
  - All vary depending on age, sex, marital status & income.



Conclusion

- Shown how geographical explicit agent-based models can be built from points, lines & polygons.
  - Models incorporate geometrical relationships directly into the simulation process.
- The application explores general questions of residential location and spatial interaction:
  - Agents locate and interact with their surrounding environment.
  - Competition for land results in distinct spatial patterns emerging (Crooks, 2008).
- Demonstrates the importance of space in the simulation process.

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Potential Problems

- Numerous issues/challenges with this approach and ABM generally:
  - Purpose of the model, Theory and Model, Replication and Experiment, Verification, Calibration/Validation, Agent Representation and Dynamics, Sharing/Communication (see Crooks et al 2007) etc.
- Too much data?
- MAUP & Ecological Fallacy with zonal geographies.
  - Boundaries are drawn quite randomly
- Is Vector better than Raster?
  - Depends on Purpose (see Landis, 2001; Benenson *et al.,* 2005).