Visualising Urban Models

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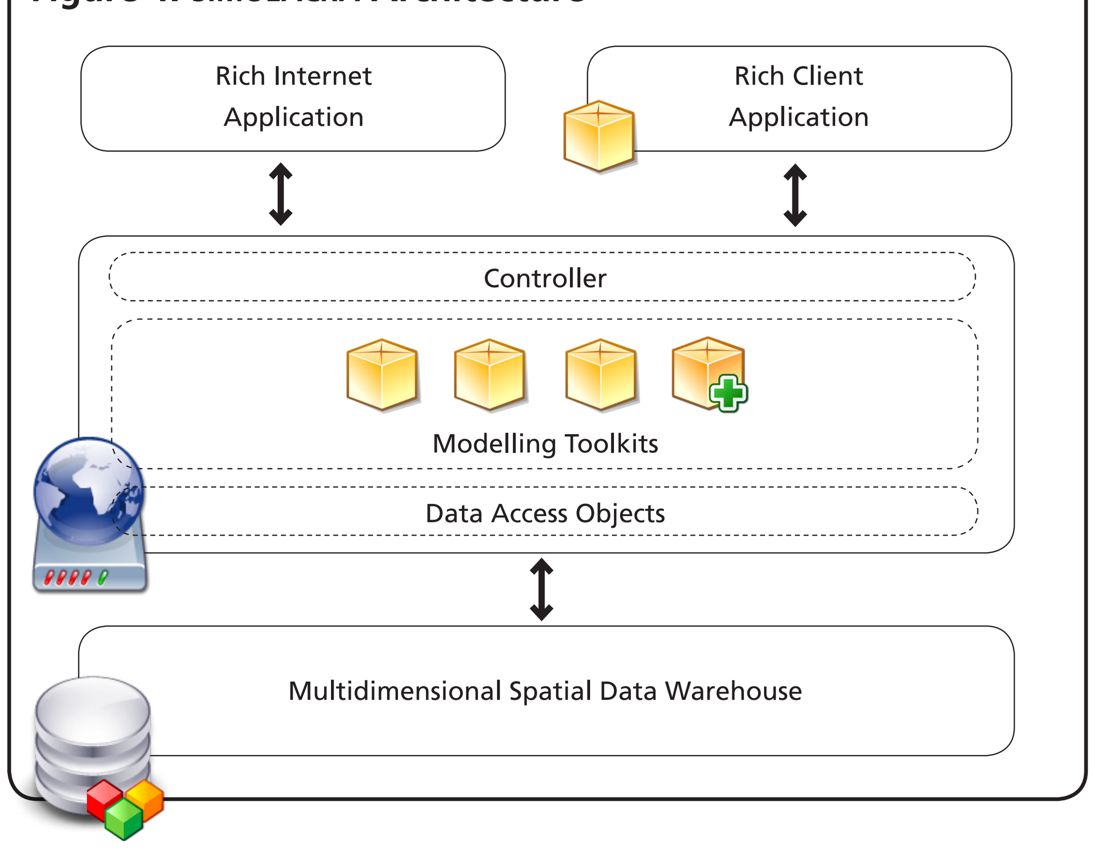
Overview

We are developing an extensible framework for the modelling of large metropolitan areas that will enable us to rapidly test many different scenarios pertaining to both short and long term urban futures. This fast, visually accessible, and cross-sectional framework – which we call SIMULACRA – is designed to serve as a platform for quickly developing and testing many different models across a wide range of scenarios. The models are multi-sectoral – dealing with residential, retail/service and employment location – and disaggregated, while remaining subject to constraints on land, income, and house prices. Ultimately, we intend to implement an aggregate representation of multi-modal transport networks that will enable us to produce more meaningful results for large cities, such as London, where this type of travel is quite common.

Background

Since the earliest days of the 1950s CATS study and SYMAP graphics, our understanding of the role of models in the planning and design of city systems has radically changed. Fifty years ago, many model-builders and stakeholders expected models to establish the impact of their plans on cities and regions with a high degree of certainty. This confidence is now widely regarded as having been misplaced, and even though there are persistent pleas for practical guidance from policy-makers the role of most models is now seen to be informing, steering and focusing dialogue (Epstein, 2008). In short, interaction between model-builders and stakeholders has become 'the name of the game' and this is the context in which the SIMULACRA platform is being developed.

Figure 1. SIMULACRA Architecture



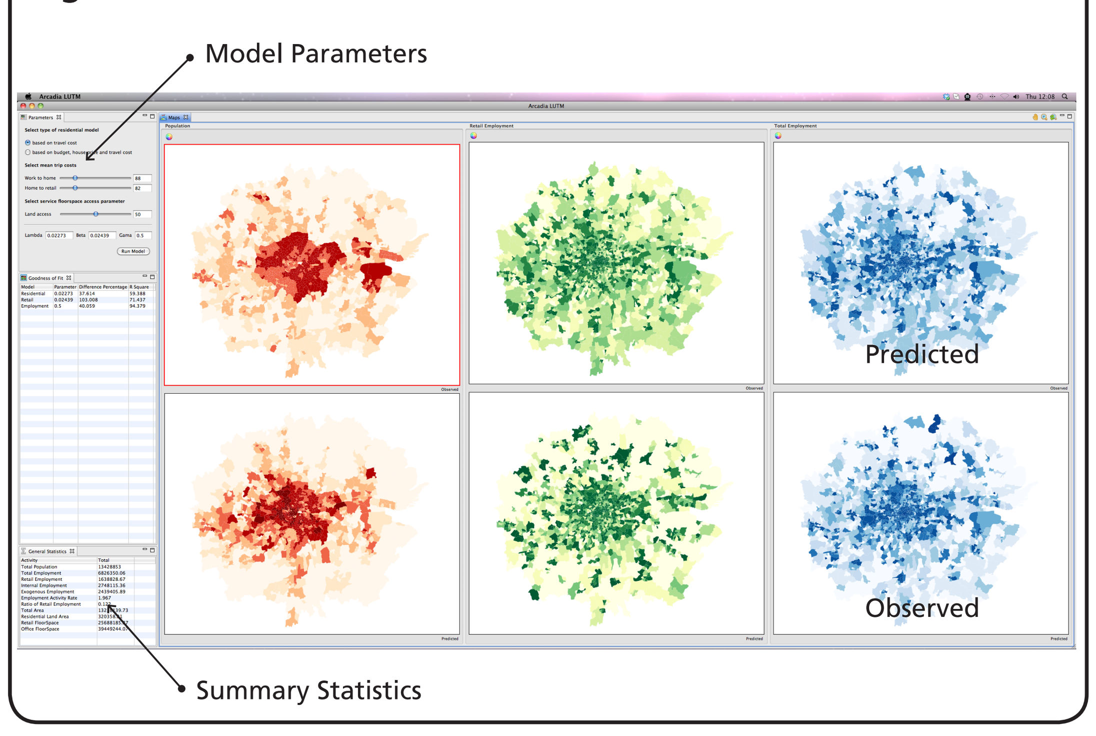
Another factor in our approach to the new platform is the increasing power of computer systems. Many researchers have made use of this added processing capacity to make their narrowly-focussed models more complex and more extensive, but we wanted to develop a framework within which several simple models for very different domains could interact with one another in near real-time. The combinatorial possibilities embedded in this coupling have not been explored in models of this kind, largely because the necessary computer resources were not available when these models were first devised and because the subsequent history of ever more disaggregation has meant that the aggregate equivalents have not actually been substantively explored.

Modelling Approach & Implementation

SIMULACRA links four activity types – workplace employment, residential population, retail consumption, and 'local industry', which we define as endogenously generated (or internal) employment – through three sets of spatial interactions. In line with the many models originating from Lowry's (1964) work, the causal chain in our first iteration of the platform runs from total employment to population, from population to retail and, finally, to internal employment. But there are actually many ways in which the four sub-models can be knit together and balanced through iteration: the equations for each activity type could be solved in any order, and if constraints are invoked then these can be resolved either through an inner iteration or as part of the outer activities balancing loop.

The current implementation is, in part, derived from earlier work with a more restricted land use transport interaction (LUTI) model built to examine the impact of climate change on Greater London. The earlier system – output from which is shown in Figure 4 (right) – piloted the kind of rich visual interface and close tie-in between model outputs and consumer-oriented mapping tools that we wanted to refine in a more powerful and extensible design. Consequently, the principal focus of our current efforts is a Java-based application that will enable both rich client (i.e. pseudo-desktop) and thin-client (web-based) interactions with a backing data store and modelling toolkits (see Figure 1). Java was chosen for its cross-platform compatibility and modularity: the specification allows third-parties to implement their own sub-models and have them interact with the four existing ones. The use of Java also enables us to draw on a great deal of effort in other domains, including the incorporation of NASA's 3D 'World Wind' tool and commonly-used GIS functionality via uDig. Particular importance was attached to the user interface, enabling less technical users to easy manipulate model parameters and view the results in an intuitive fashion (see Figure 2).

Figure 2. SIMULACRA Interface



Initial Results

Although the platform can work with nearly any zonal system and set of spatial attributes, we chose to implement a first version using data for a city with which we were intimately familiar. The model encompasses all 1,767 wards of London's Outer Metropolitan Region which is, roughly, defined as the area within which at least 10% of residents commute into Central London for work. This region extends from Reading in the West to Southend in the East, and from Luton in the North to Gatwick-Crawley in the South, and it is knit together by a wide variety of public and private transportation options: car, bus, train, underground, and even ferry along the Thames River!

The variety of transport options is one of the key aspects of life in a 'world city' that we wish to capture in our model: many commuters use two or more methods of transport regularly in a single day: bus to Tube, rail to shared bicycle, and so on. The ability to switch modes in response to long-term congestion and short-term disruption is clearly crucial to developing realistic urban models, and it is particularly important when trying to model growth: what is, for instance, the most likely impact of CrossRail on the bike share programme?

However, multi-modal transport models that incorporate capacity constraints (i.e. forcing users off of congested modes on to slower, but less congested ones) have proved conceptually and computationally challenging. The explosion in possible routes means that it can take hours to calculate the shortest path between any two points in the network, and this is clearly an issue that we will need to overcome. Consequently, we are in the process of testing a small-scale multi-modal network for the city of Milton Keynes; this will allow us to experiment with different abstraction and aggregation schemes that will preserve they key features of the network while radically reducing its complexity.

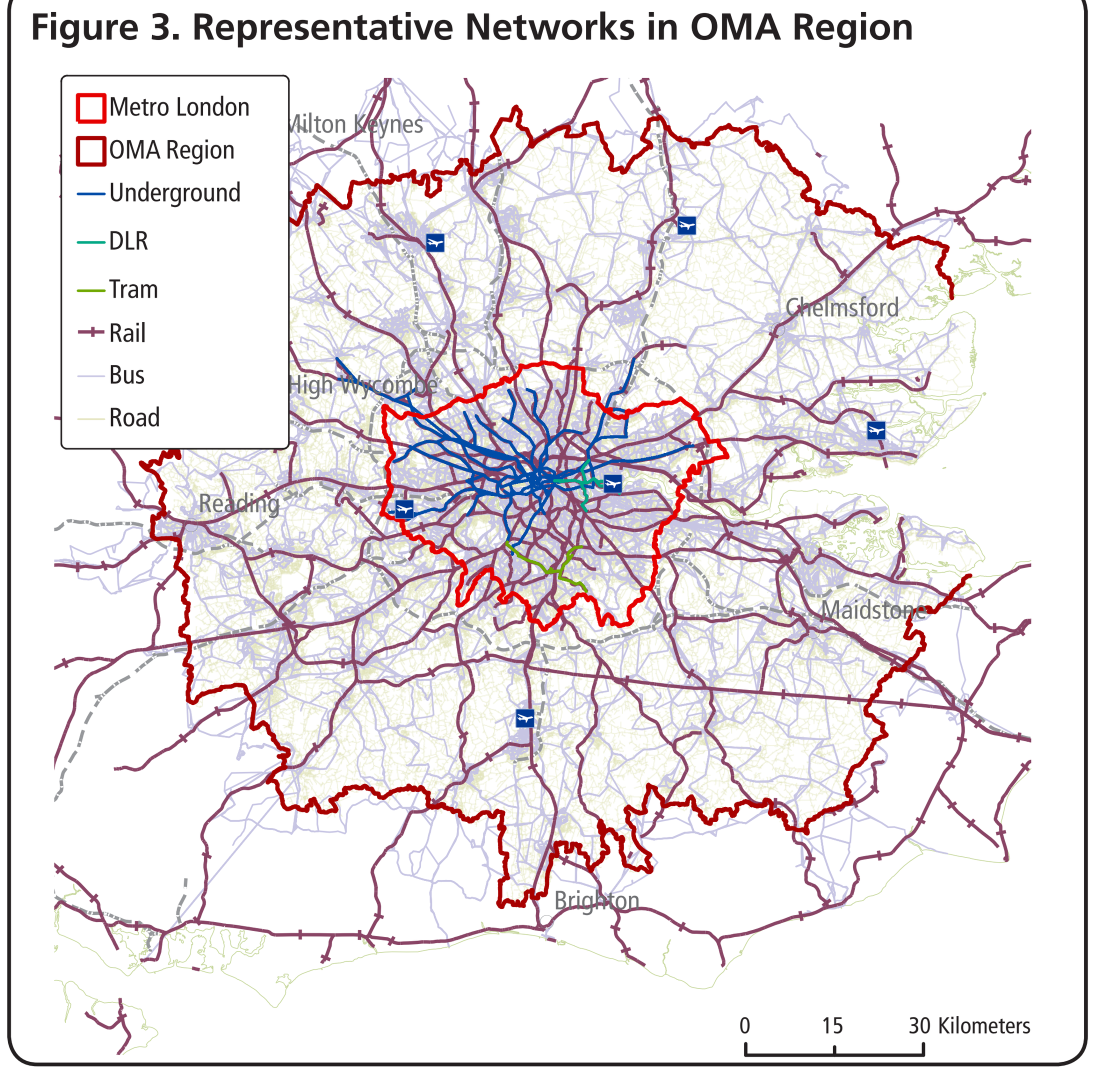
Figure 4. 3D View of Employment Density & Flows

This 3D projection shows the predicted flows of workers from the Heathrow Airport area at the Western edge of Greater London Authority to other parts of metropolitan core. Users are able to view and interact (e.g. fly through) with the data dynamically thanks to NASA's World Wind and Google Earth.

Next Steps

Clearly, the current implementation of the model is highly aggregated, and the outputs could be substantively improved by allowing for greater levels of disaggregation in each of the main categories; but most especially in employment and income since these are known to have an enormous impact on commuting distances. We should note, however, that the results will be strongly influenced by the interactions between groups across the different domains and so the distribution for each requires careful thought. As with multi-model transport networks, the nature and degree of disaggregation will have an important impact on model run-times and the issue calls for careful study.

Figure 3. Representative Networks in OMA Region



One of our key concerns is to build an economic model of money flows in parallel to this model of physical flows. We have data on income received at place of residence, and wages earned at workplaces, together with travel costs from the transport network, and average house price data. We can use these inputs to compute the flow of wages from workplaces to residences, using travel and housing costs to constrain household budgets. However, we do not yet have flows of money within the retail sector, and this is a crucial next step since it will allow us to work with disaggregated household budgets in order to identify the impact of anticipated increases in energy costs over the coming years.v

Ultimately, we also envision extending the platform to deal with increments of time that are encapsulated within the assumed overall equilibrium. But we also anticipate extending the platform 'laterally' to offer the flexibility of running on a wider variety of hardware – the ability to interact with urban models on, for instance, an iPad, would make the outputs of interactive, user-guided simulations useable in contexts where such tools have never before been available.

Working Papers & Related Resources

Two CASA Working Papers on the SIMULACRA platform are available for download from our web site:

- Paper #164 'Visually-Driven Urban Simulation: Exploring Fast and Slow Change in Residential Location' by Michael Batty can be obtained from: `http://www.casa.ucl.ac.uk/working _ papers/paper164.pdf`
- Paper #163 'Visually-Intelligible Land Use Transportation Models for the Rapid Assessment of Urban Futures' by Michael Batty, Camilo Vargas-Ruiz, Duncan Smith, Joan Serras, Jon Reades and Anders Johansson is available from: `http://www.casa.ucl.ac.uk/working _ papers/paper163.pdf`

The SIMULACRA blog contains recent news of work on this and other projects (`http://simulacra.info/`), while the Complex City web site (`http://www.complexcity.info/`) contains considerable background material on the history of these kinds of models.

For more information about this research please contact Michael Batty: m.batty@ucl.ac.uk

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