Agent Based Models for Spatial Systems in Social Sciences & Economic Science with Heterogeneous Interacting Agents

Agelonde, La Londe les Maures (var, France),

Monday, 17th September 2007

Workshop B

How to Build an Agent-Based Model,

in two parts, and both today and tomorrow

Andrew Crooks and Michael Batty
University College London

Agent Based Models for Spatial Systems in Social Sciences & Economic Science with Heterogeneous Interacting Agents

Agelonde, La Londe les Maures (var, France),

Monday, 17th September 2007

Workshop B

(1) Models & Theories: Science, Validation, Verification and Calibration

Michael Batty
University College London

Agent Based Models for Spatial Systems in Social Sciences & Economic Science with Heterogeneous Interacting Agents

Agelonde, La Londe les Maures (var, France),

Monday, 17th September 2007

Workshop B

(2) Software Environments: Repast

Andrew Crooks

University College London

Outline of Lecture

- What are Models? Relationships to Theory
- Definitions of Models
- A Classification: Icons, Analogs, Symbols,
- A Traditional Example: Urban Economics
- Facts: Stylized Facts
- Validation, Verification, Calibration
- Developing Models: The Software Environment
- Generic v Specialist Environments: ABM
- Andrew with then run the tutorial with **Repast**

What are Models? Relationships to Theory

A theory is an *abstraction* of some phenomena, usually '*real*' but sometimes imagined in a form that makes the *simplification* or abstraction clear. A model is a simplification of *reality* which takes the theoretical abstractions and puts it into a form that we can manipulate. Simulation is often used to characterise this process of implementation.

In everything we do, we theorise, and more and more frequently we build models to demonstrate theory.

This is all fairly obvious – but the focus on theory is important because theory can be implicit as well as explicit. In fact in our growing quest describe the world through models, theory is tending to become part and parcel of models.

The main reason for beginning with theory is that the conventional wisdom of science begins with theory and then *tests* theory against observations – data. It is impossible to approach the world without prior theory and without getting involved in where theory comes from, let us assume that whenever we model a phenomena we have in mind theory.

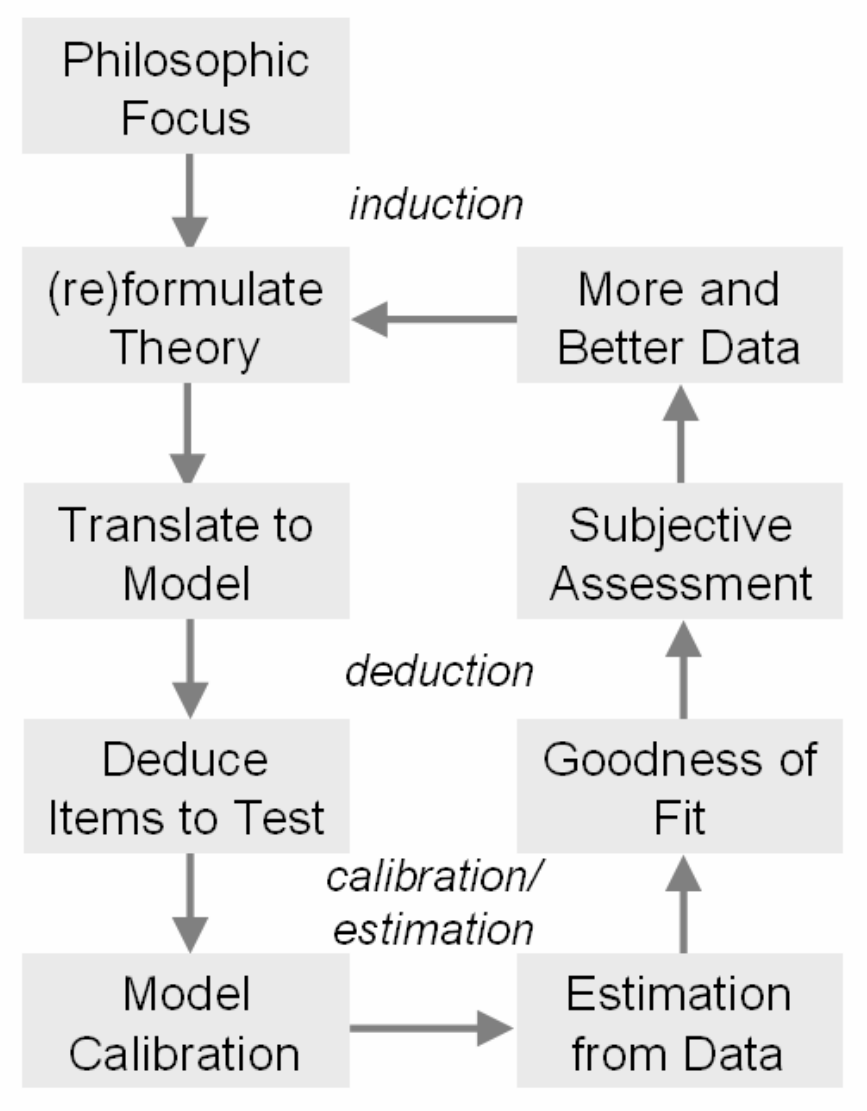
Thus the model- building process is really part and parcel of the scientific process – the scientific method where the current wisdom is that science tests theory by assembling data about reality which is designed to '*falsify*' the theory.

This is scientific method a la Popper and it suggests that data or observations is the ultimate arbiter of what is good theory. The method implies that this process of testing takes place in systems which are controllable in some science, are not volatile, as in experimental lab contexts. In fact as science has progressed, these conditions appear to be increasingly unlikely.

Hence the need for models – for theories in a form other than in the laboratory, where we can perform good testing.

The new form of the laboratory is the computer and instead of experimentation there is simulation. We could and perhaps we should spend time talking about this issue – for by no means all models are simulation models and all science is not based on computers. But increasingly science is intrinsically about computation and this is changing science itself. I also use the term ‘ science’ advisedly, in its most catholic sense ….. another debate perhaps later

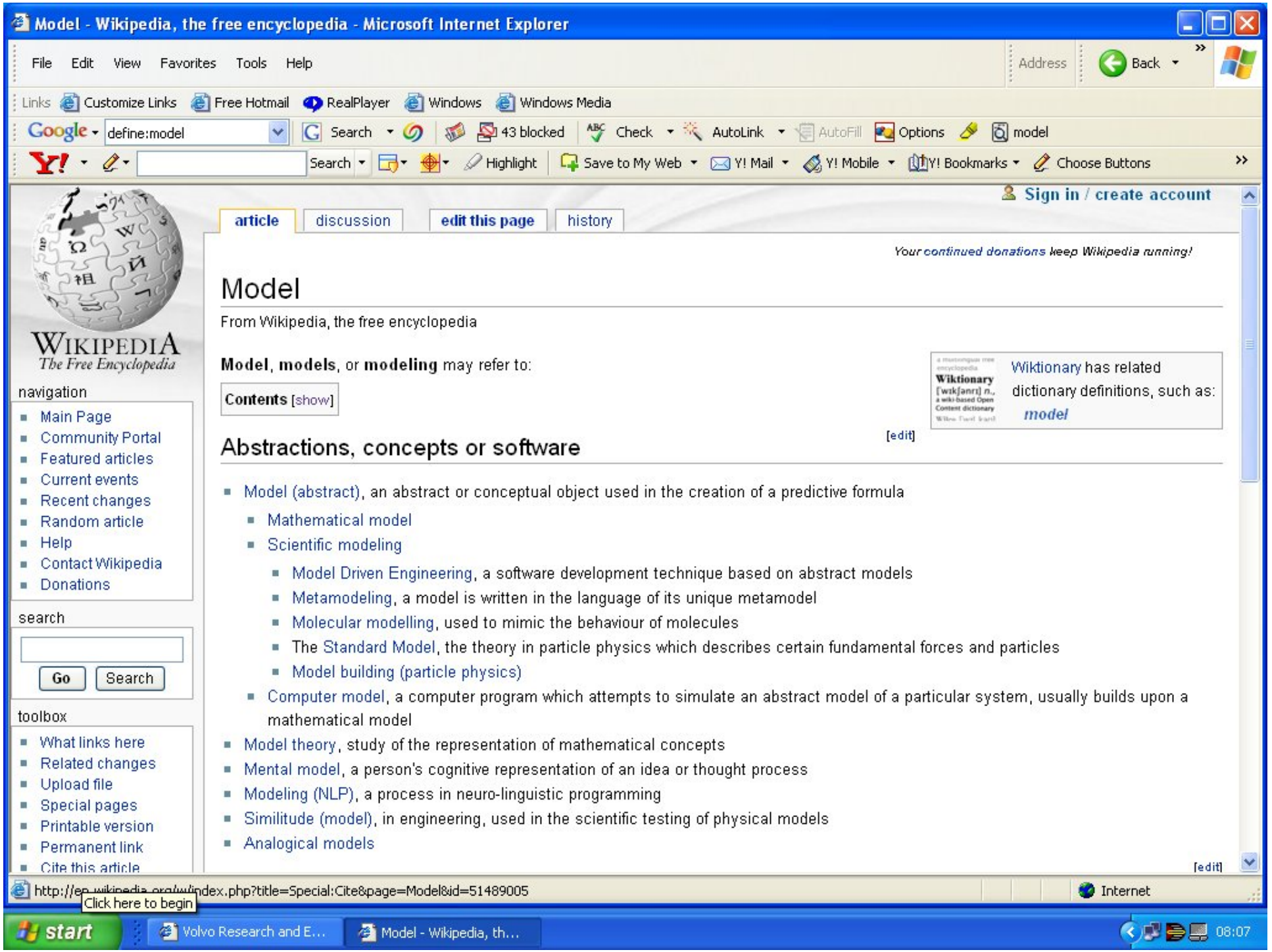
Let me get some more terms out of the way – and to do this here is a simple picture of the scientific method.



Definitions of Models

There are of course many types of models and although you may think that here we are only going to deal with mathematical or symbolic models, nothing could be further from the truth. Lowry's paper that I recommended you read classifies models, and we will draw loosely on his scheme.

There seem to be three or perhaps four different generic ways of abstraction – iconic, analog, symbolic and logic and these categories are not mutually exclusive.


Model - Wikipedia, the free encyclopedia - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address
Back
Links Customize Links Free Hotmail RealPlayer Windows Windows Media
Google define:model Search 43 blocked Check AutoLink AutoFill Options model
Search Highlight Save to My Web Y! Mail Y! Mobile Y! Bookmarks Choose Buttons
Sign in / create account
article discussion edit this page history
Your continued donations keep Wikipedia running!
WIKIPEDIA
The Free Encyclopedia
navigation
Main Page
Community Portal
Featured articles
Current events
Recent changes
Random article
Help
Contact Wikipedia
Donations
search
Go Search
toolbox
What links here
Related changes
Upload file
Special pages
Printable version
Permanent link
Cite this article
Model
From Wikipedia, the free encyclopedia
Model, models, or modeling may refer to:
Contents [show]
Wiktionary has related dictionary definitions, such as: model
[edit]
Abstractions, concepts or software
Model (abstract), an abstract or conceptual object used in the creation of a predictive formula
Mathematical model
Scientific modeling
Model Driven Engineering, a software development technique based on abstract models
Metamodeling, a model is written in the language of its unique metamodel
Molecular modelling, used to mimic the behaviour of molecules
The Standard Model, the theory in particle physics which describes certain fundamental forces and particles
Model building (particle physics)
Computer model, a computer program which attempts to simulate an abstract model of a particular system, usually builds upon a mathematical model
Model theory, study of the representation of mathematical concepts
Mental model, a person's cognitive representation of an idea or thought process
Modeling (NLP), a process in neuro-linguistic programming
Similitude (model), in engineering, used in the scientific testing of physical models
Analogical models
[edit]
http://en.wikipedia.org/w/index.php?title=Special:Cite&page=Model&id=51489005
Click here to begin
Internet
start
Volvo Research and E...
Model - Wikipedia, th...
08:07

A Classification: Icons, Analogs, Symbols

Iconic models are representations that visually convey what the real things looks like – maps are the classic example – these are largely representations – they may have some symbology but they are scaled down versions of the real thing.

Symbolic models represents system in terms of the way they functions, often through time and over space – these models are invariably mathematical.

Analog models are a half way house between iconic and symbolic. The key issue is that they take a representational and/or functional form of one system and apply it to another.

For example analogies between physical and human systems – the flow of blood in analogy to theories of hydrodynamics developed for models of the atmosphere, traffic flow as an analog of an electrical network, and so on.

Logical models are symbolic in a sense but are based on causal connections composed of rules. We can mix, of course, any of these four types.

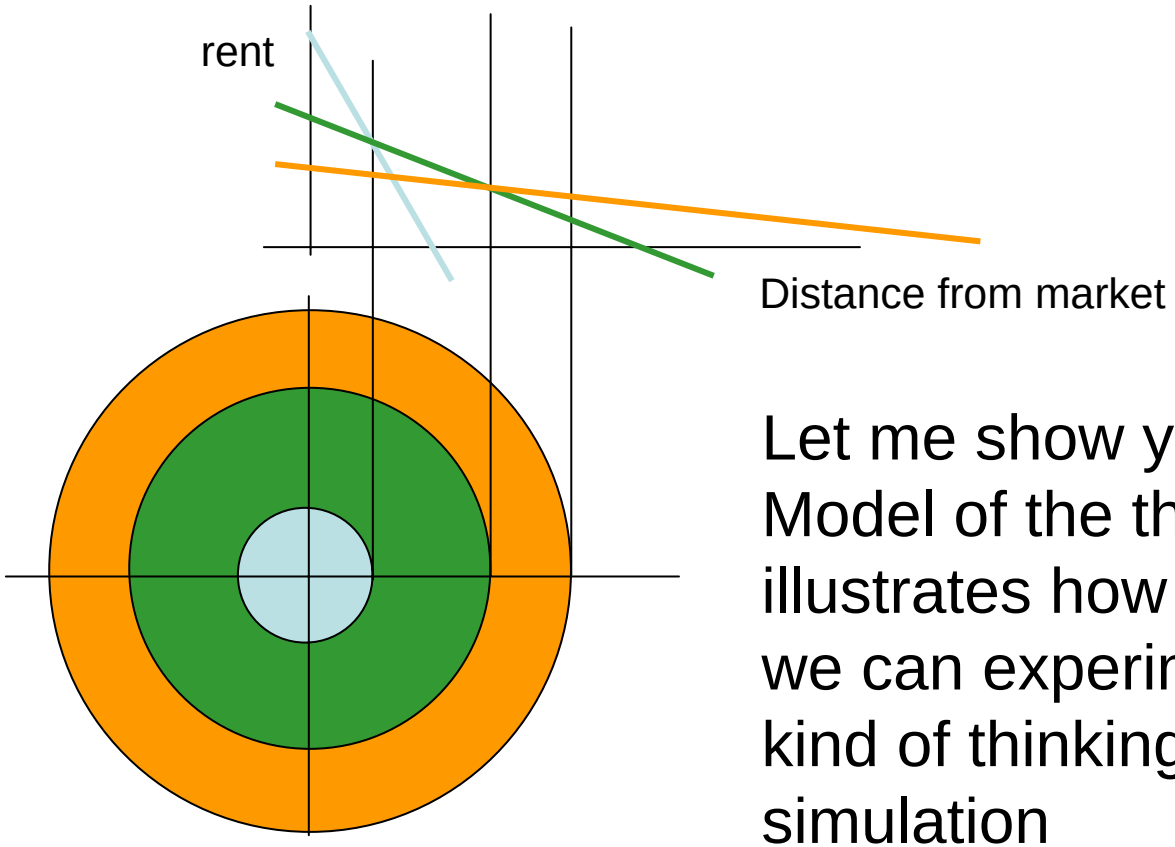
The reason why the term model has become so significant is that computers are increasingly being used as the ‘container’ or ‘media’ for many models as our world becomes digital.

Computers mean that iconic, analog, symbolic and logical models merge into one another, so for example we can have iconic models but built of mathematical structures as in GIS

And computer models are being generalised to all sorts of other things that we never used to call models – to plans, to processes of participation and so on. Even to models of computers …….

A Traditional Example: Urban Economics

The theory is based on relating land rent – bid rent curves to the space required: demand and supply



Let me show you a simple Model of the theory that illustrates how
we can experiment with this kind of thinking using simulation

Let us launch the software & run the model

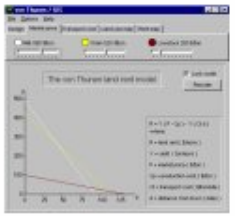
CASA

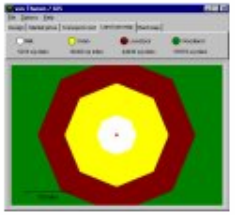
Research

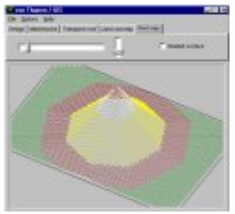
Urban Economic Sketch Planning Using Complexity Theory

THE VON THUNEN MODEL - An Example of the Kind of Software that we intend to develop with the ESRC CASE Award

To illustrate what we have in mind for the proposed CASA award, Phil Steadman's sketch planning model based on the Von Thunen Model can be run from this web site. In essence what this software does is present the user with a blank homogeneous landscape on which there is a central market planted. The user can then use the ***drawing tools*** in the ***Design*** mode to add more towns, transport routes, rail routes, and non-productive land which act as constraints on the distribution of land uses. If there are no constraints then the model generates a symmetical land use pattern around the central town. The land use pattern depends on how the transport and market price lines - bid rent curves in the jargon - interact with each other. Essentially the von Thunen model assumes that land use is determined by the market price less the transport cost and from the interaction of these bid rent curves, a land use will dominate at any point a given distance from the town (or from competing towns). You can also display alter the shape of the bid rent and cost curve using sliders. You can then display the land use map and look at the map as a 3-D surface of rents. You can manipulate this surface using sliders as well in oblique projection. The various picture to the right of this screen show you the sequence of steps from a single town - the red dot in the middle of the top screen, then just the market rent cost curves, then the land use map which results, and then the surface unshaded as contours and then the shaded surface.You can also import map pictures of real places and run the von Thunen model with towns and roads etc. planted on such backcloths. You can access the drop down menus to do this and you can also change the weights that way and incorporate a fizzy distance calculations.







Have a go by clicking on this button here to access the software

Click Here

Thunen.exe

here is an example of what you get if you put some roads into the town
and take out some unproductive land from the landscape

http://www.casa.ucl.ac.uk/vonthunen/

Facts: Stylized Facts

Generally observations of the system being modelled or simulated are assembled and the model's predictions are compared against 'facts'

- Facts are publicly agreed sets of observations over which there is 'no' disagreement
- Facts can range in quality from well defined observations to highly speculative pieces of data.
- Factoids and stylized facts are two types of observation that are sometimes used in testing a model's predictive abilities

Factoids

A piece of unverified or inaccurate information that is presented in the press as factual, often as part of a publicity effort, and that is then accepted as true because of frequent repetition.

- Combining the word "fact" and the ending "-oid" to mean "like a fact".
- Factoid has since developed a second meaning, that of a brief, somewhat interesting fact, that might better have been called a ‘factette’.
- A 'factlet' is a fact that is tiny and trivial, and also correct.

Stylized Fact

In social sciences, especially economics, a stylized fact is a simplified presentation of an empirical finding. While results in statistics can only be shown to be highly probable, in a stylized fact, they are presented as true.

A stylized fact is often a broad generalisation, which although essentially true may have inaccuracies in the detail.

Highly applicable to the assumptions of agent-based models which may not be verifiable but plausible

Validation, Verification, Calibration

Verification

To check, confirm or prove the truth of something.
To establish, prove, substantiate, attest, corroborate, support, confirm.

Validation

To meet some criterion/criteria associated with the model and or the data/observations.

In general, validation is the process of checking if something satisfies a certain criterion. Examples would be: checking if a statement is true, if an appliance works as intended, if a computer system is secure, or if computer data is compliant with an open standard. This should not be confused with verification.

There are four types of validity commonly examined in social research.

1. Conclusion validity asks is there a relationship between the program and the observed outcome? Or, in our example, is there a connection between the attendance policy and the increased participation we saw?
2. Internal Validity asks if there is a relationship between the program and the outcome we saw, is it a causal relationship? For example, did the attendance policy cause class participation to increase?
3. Construct validity is the hardest to understand in my opinion. It asks if there is there a relationship between how I operationalized my concepts in this study to the actual causal relationship I'm trying to study/? Or in our example, did our treatment (attendance policy) reflect the construct of attendance, and did our measured outcome - increased class participation - reflect the construct of participation? Overall, we are trying to generalize our conceptualized treatment and outcomes to broader constructs of the same concepts.
4. External validity refers to our ability to generalize the results of our study to other settings. In our example, could we generalize our results to other classrooms?

Goodness of Fit

A well defined measure of how the model's predictions match the known observations of facts, typically some measure of difference between predictions and observations. Predictions are any outcome of the model, past, present or future

Calibration and Estimation

Calibration is the generic process of validation and verification. Estimation is the process or method of generating a precise estimate of some parameter characterising the model.

Other Issues – consistency and reliability/
Reliability is the consistency of your measurement,
Robustness- similar performance under extreme conditions

I don’t think there is a coherent discussion of all these issues *per se* as they are pieced together from multiple sources.

Sensitivity Testing
Process Modelling
Parsimony v richness
Scale, aggregation …. Space and time

Developing Models: The Software Environment

Just as I said theory was becoming part of models, then models appear to be becoming part of software –

In the old days – theory, build models in basic software, then calibrate and validate

Increasingly now- define model generically and formulate it within a software packages or tool kit which is a framework that might be generic, like Repast

Generic v Specialist Environments: ABM

I refer you to the paper in the pack that Andrew is about to hand out by Railsback

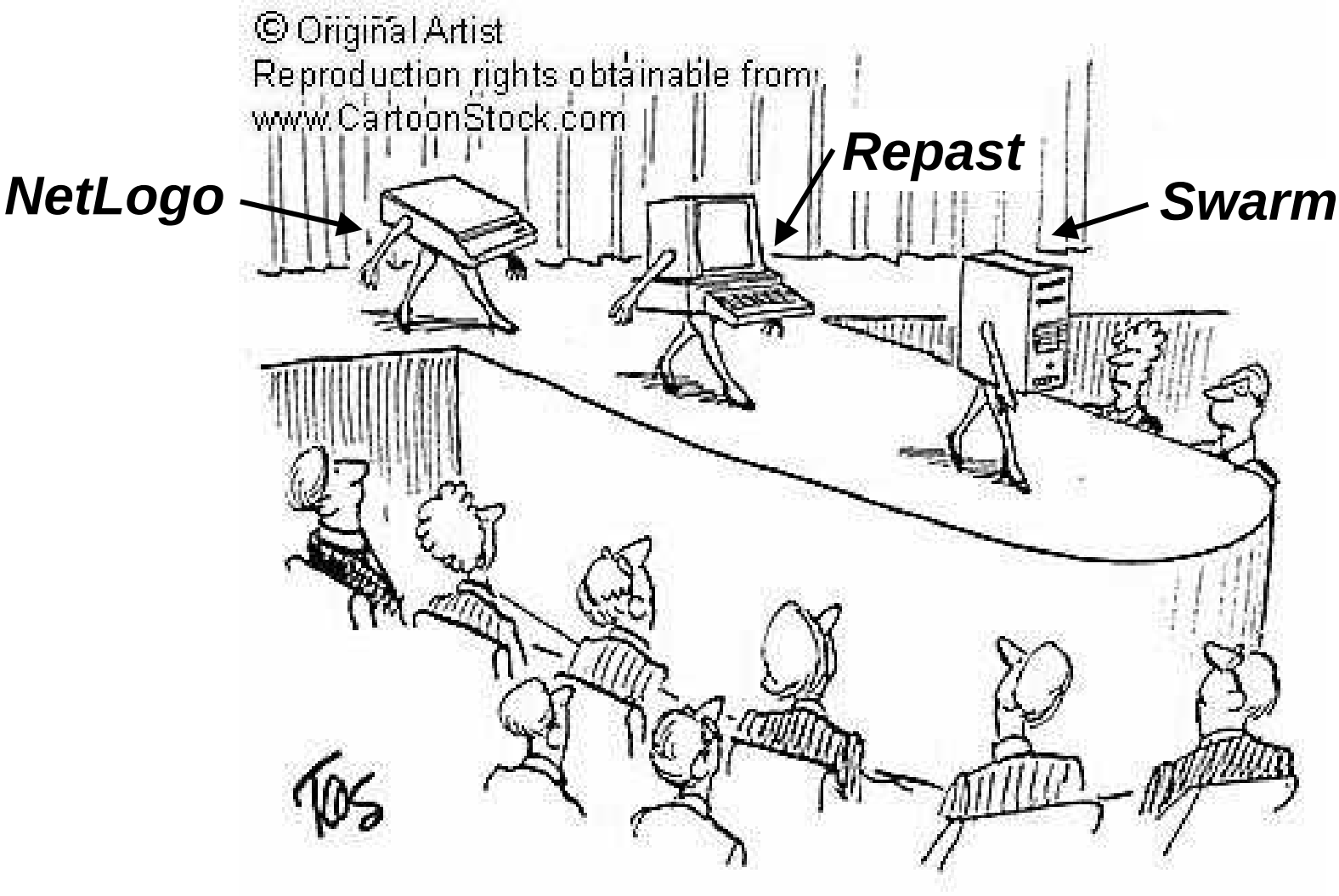
SIMULATION
http://sim.sagepub.com

Agent-based Simulation Platforms: Review and Development Recommendations
Steven F. Railsback, Steven L. Lytinen and Stephen K. Jackson
SIMULATION 2006; 82; 609
DOI: 10.1177/0037549706073695

The online version of this article can be found at:
http://sim.sagepub.com/cgi/content/abstract/82/9/609

There is now consensus about what these are called – frameworks, software environments, toolkits, generic software, packages and so on

To end, If Alan Kirman can show cartoons so can I.



‘Computer Software’ on the catwalk

Agent Based Models for Spatial Systems in Social Sciences & Economic Science with Heterogeneous Interacting Agents

Agelonde, La Londe les Maures (var, France),

Monday, 17th September 2007: **Workshop B**

(2) Building Agent-Based Models Using Repast

Andrew Crooks
University College London