Future directions for modelling fungi: the CoSMoS approach

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The CoSMoS project

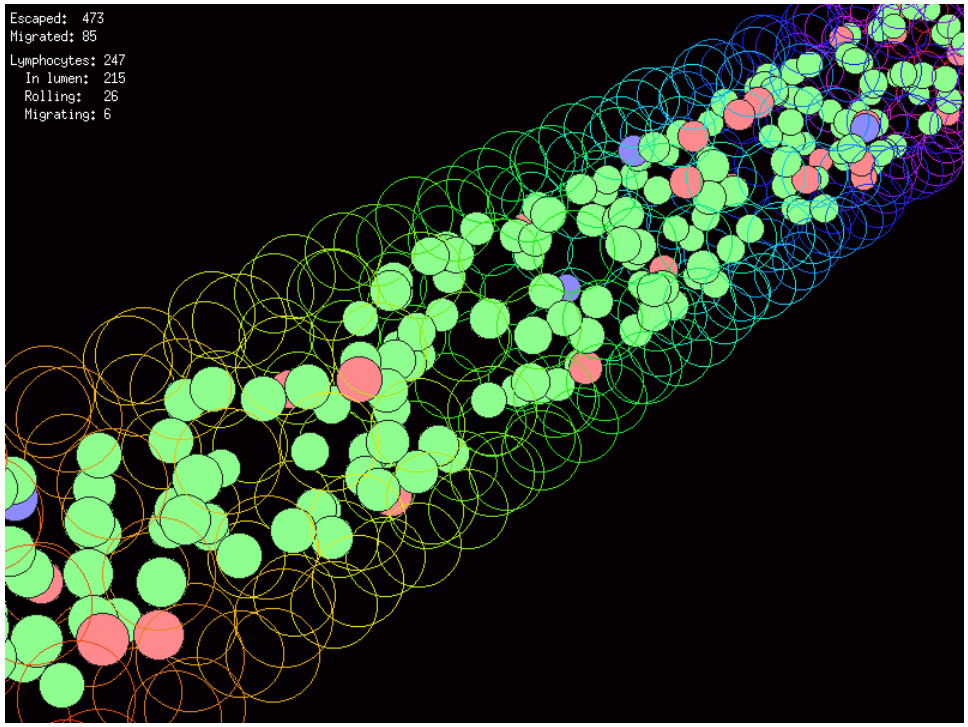
- Developing generic, dependable techniques for **co**mplex **s**ystems **mo**delling and **s**imulation across all fields of scientific experimentation
- £1.5m EPSRC project, Oct 2007 – Mar 2012
- RA working on modelling; RA on simulation
- 5+ RSs working on case studies
- Several institutions: York, Kent, Abertay, UWE

CoSMoS principles

- Simulation is a **scientific instrument**
  - Don’t just build your simulation ad-hoc!
  - Must understand limitations/assumptions
- An **engineering** approach to complex systems: identify and develop existing best practices
  - Design patterns
  - Agile software engineering practices
  - Structured argumentation
- Drawn from real-world **case studies**
  - Working alongside domain experts

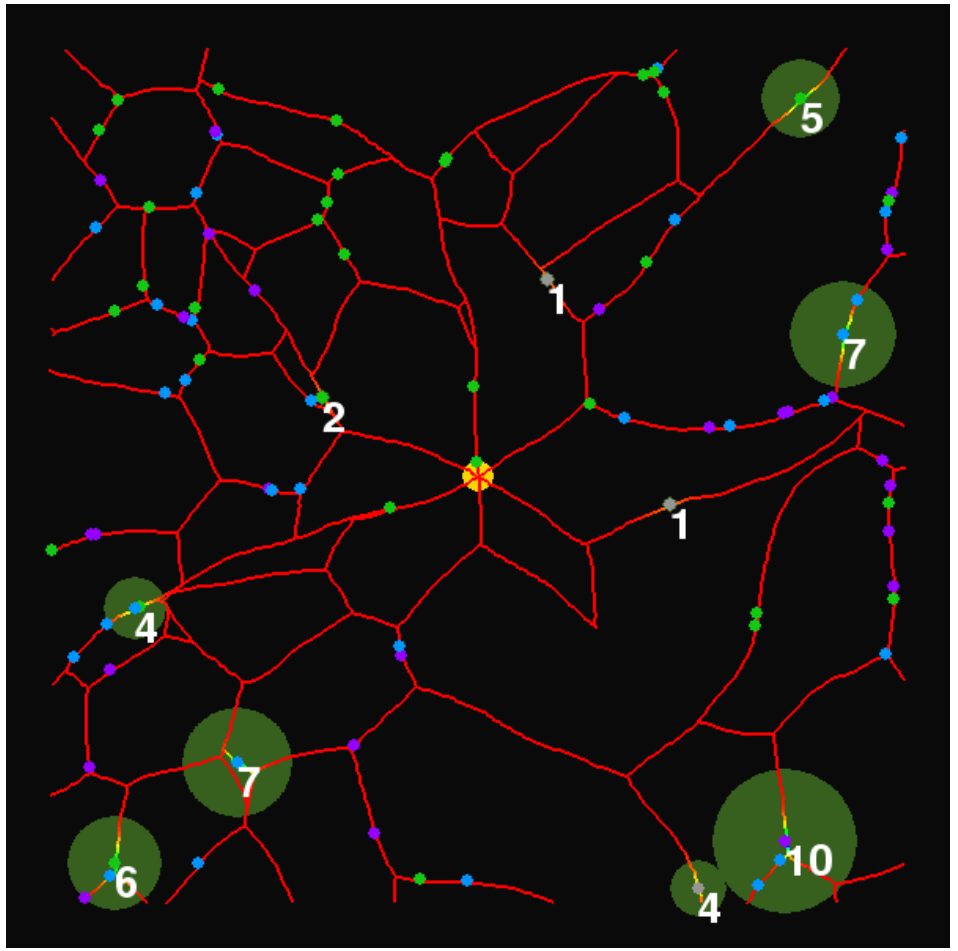
Case study: lymphocyte rolling

- Lymphocytes move from bloodstream into lymph node
- York immunologists wanted to experiment in-silico with HEV size's effect on migration rate
- Based on distributed space model from earlier CoSMoS work



Case study: granuloma formation

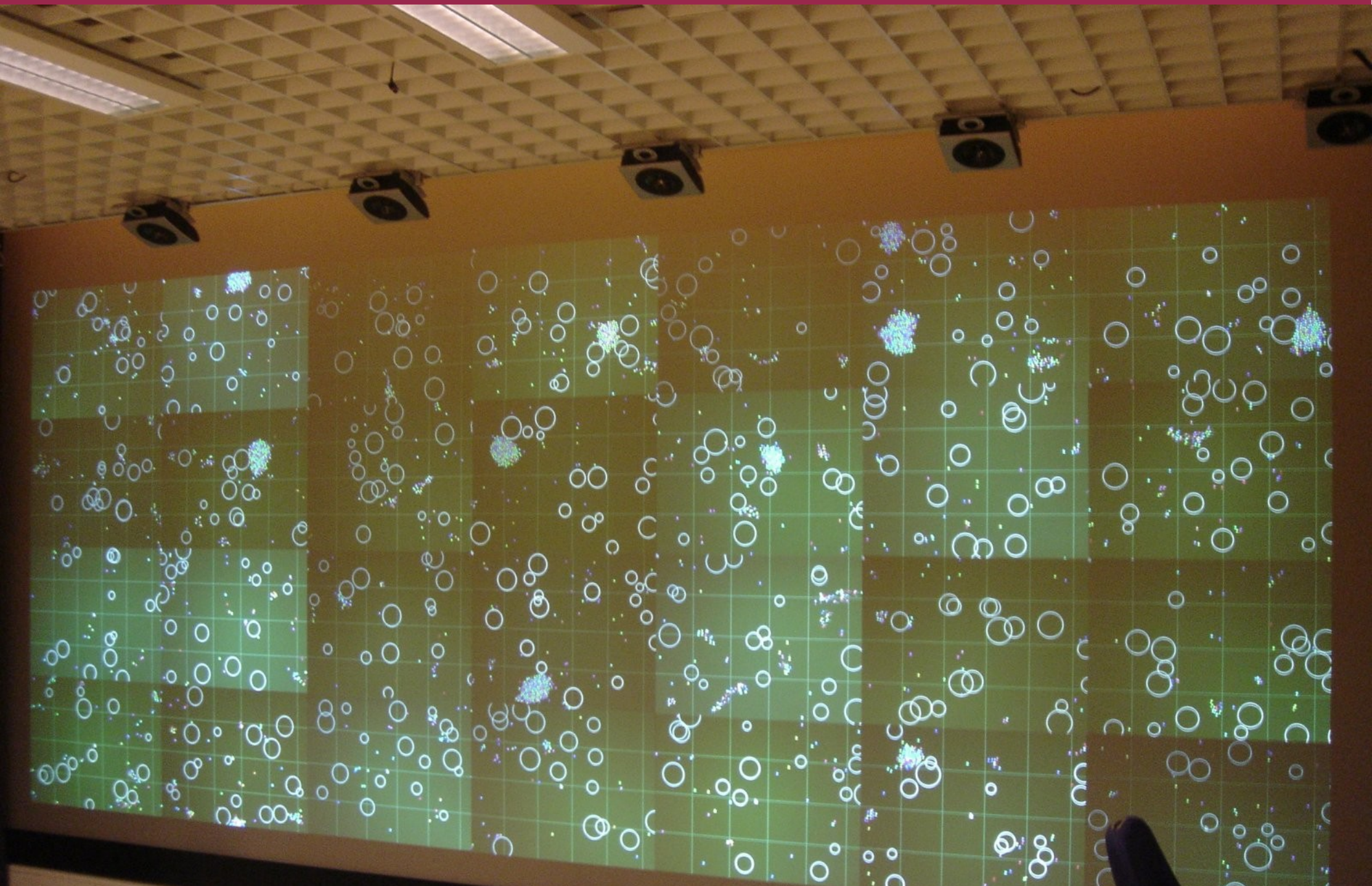
- Granulomas form to contain infected cells in the liver
- What effect does the network structure have?
- Multiple ideas of space: physical, graph-based
- Tools for data analysis



The challenge of scalability

- Small simulations are easy to build...
  - … but we want to operate at **realistic** scales, simulating millions of agents
- We need to use modern parallel hardware: **multicore** CPUs and **clusters** of machines
  - … but how do you build parallel simulations?
  - Take advantage of natural concurrency!
- CoSMoS design patterns show how to use **concurrent programming** techniques to build reliable, massively-scalable simulations

Case study: birds on the wall

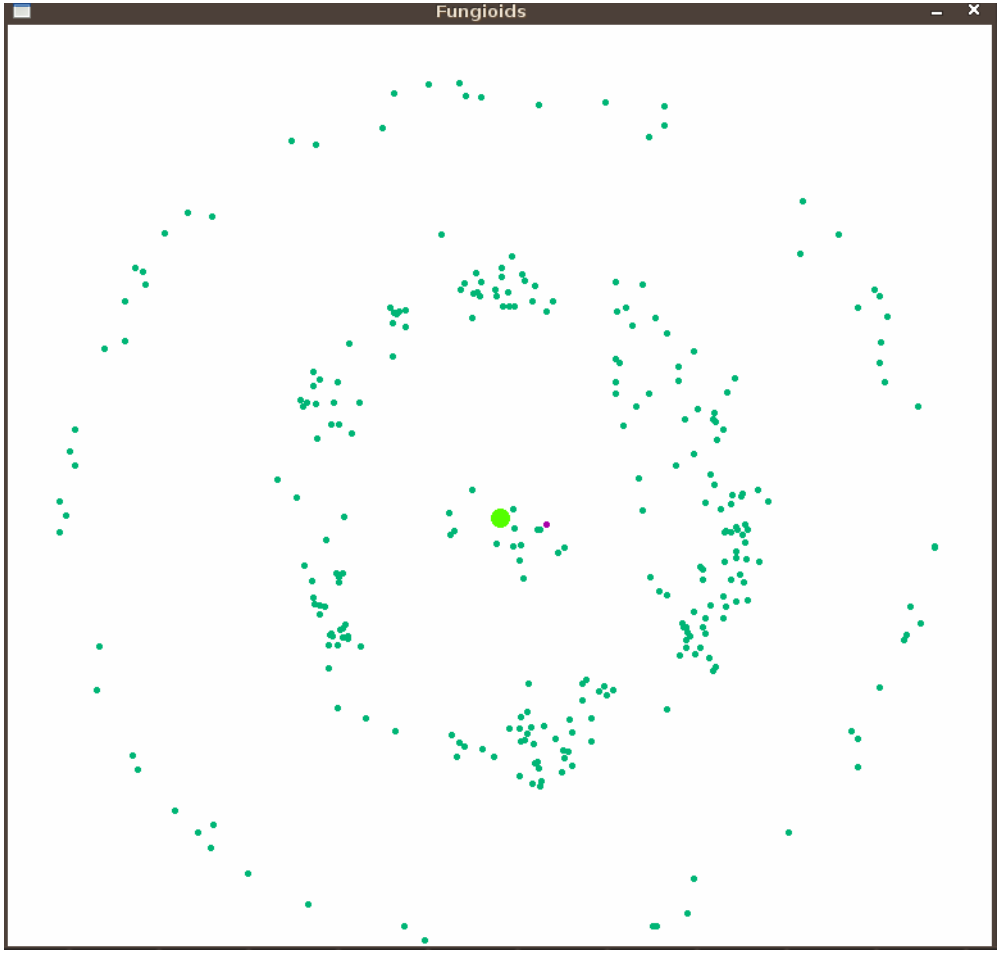


Case study: fungal growth

- Student project at York: Matthew Harbage reimplemented Ruth Falconer's existing model of fungal growth using CoSMoS techniques
  - Original model used PDEs to describe behaviour of units of biomass
  - Converted into behaviours in agent-based model
- Reused CoSMoS continuous space model
  - Added facilities for simulating resources in the environment efficiently as agents

Case study: fungal growth

- Reproduced the behaviour of the existing simulation
- But this is **scalable**: we can make it arbitrarily large, run it on a cluster of machines, etc.
- Simulation techniques have fed into later CoSMoS work



Where next?

- CoSMoS still has a year and a bit to run, and we're putting together follow-up projects now...
- Multiscale and multilevel models
  - e.g. fungus growing in soil – with the soil modelled in detail at a lower level, as appropriate
- Higher-level tools for building simulations
  - Make it easier to use our design patterns
- Better tools for analysing and visualising results
  - Make in-silico experimentation more accessible

Any questions?

More information on CoSMoS:
http://www.cosmos-research.org/

See the simulations in action:
http://www.youtube.com/user/atscosmos