Outline

- Agent based models
- Case study – disease in a primary school
- Applications to public-health and pollution

Social systems

- Are complex dynamical systems with multiple feedbacks
- Depend upon the beliefs, behaviour and decisions of individuals
- Are affected by culture, politics, structural inequalities and environmental effects

Agent-based models

- Explicitly represent individuals
- Allow us to simulate human actions and effects of human behaviour
- Can be used even without explicit equations for the dynamics of the system
- Build the large scale system "from the bottom up"
-

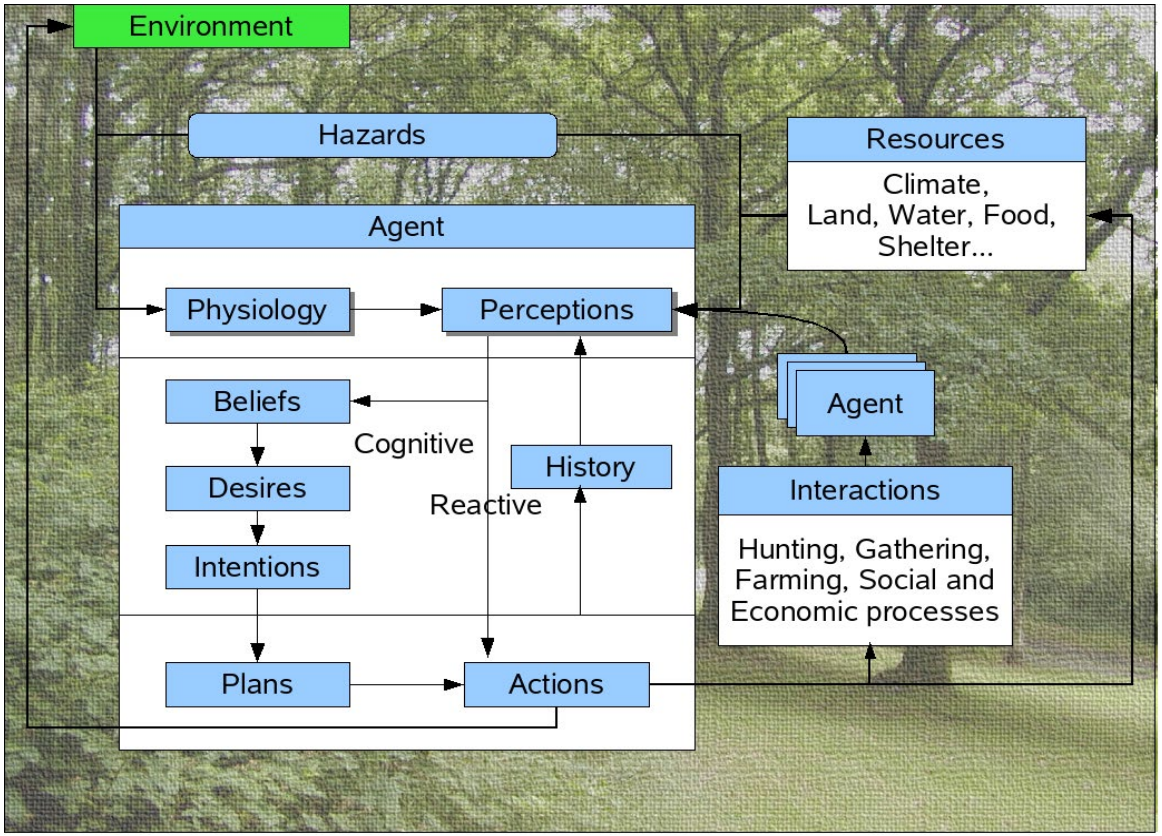
Large scale physical or economic simulations may seem remote, and may be hard to translate into a form that relates to everyday experience.

Agents might be

or governments,cities, countries…

- Generally any individual objects for which we can define some kinds of behaviour
- Many different agent types might be present in a single model
- Interactions between agents and/or their environment drive change over time
  - Individual actions may lead to large-scale “emergent properties” at societal level
  - Feedback between society/environment and agents may lead to behavioural change

Internally, agents may be very simple,
or have complex learning and reasoning algorithms



We might use Agent-based models when

- Need to avoid assuming individual experience is like the average
- Individual behaviours are important (and may affect outcomes)
- Feedbacks between behaviour and environment are significant
- Need to disentangle effects of movement and other parameters
- Changes are made that move a system outside past historic configurations
- There are complex interacting heterogeneous types of individuals or stakeholders
- Need to make models that can be visualised with familiar everyday content

More generally we can try to

To test possible outcomes of decisions and look for unintended consequences, where actual experiments mike be unachievable or unethical.

Small Scale Modelling of **Infectious** Disease Transmission

A study in a small primary school

- The Place (s)
  - A small primary school – about 100 children
  - Small – few agents – easier to observe
  - Closed system – little in-out activity during the day
  - Limited number of locations for activity
- Events
  - Controlled – limited range of activities
  - Largely driven by teachers
  - Relatively fixed schedule of activities

Outline

- Infectious Diseases and data
- Places and Events
- Model Construction
- A movie!
- Missing things

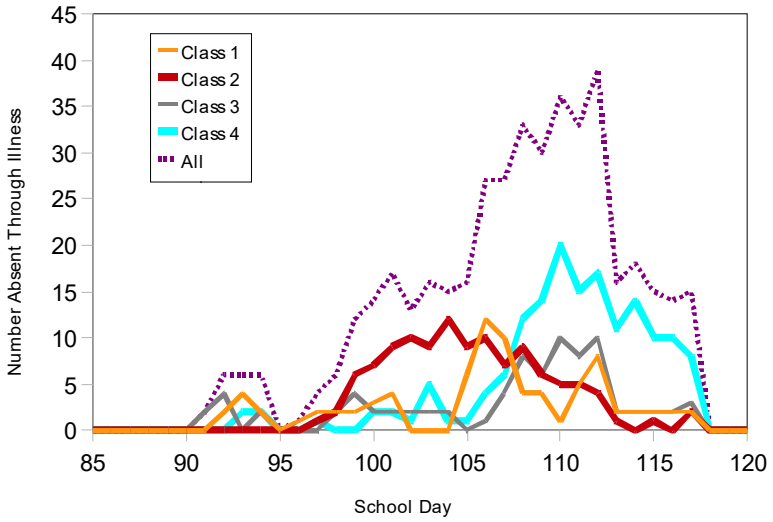
Outline

- Infectious Diseases and data

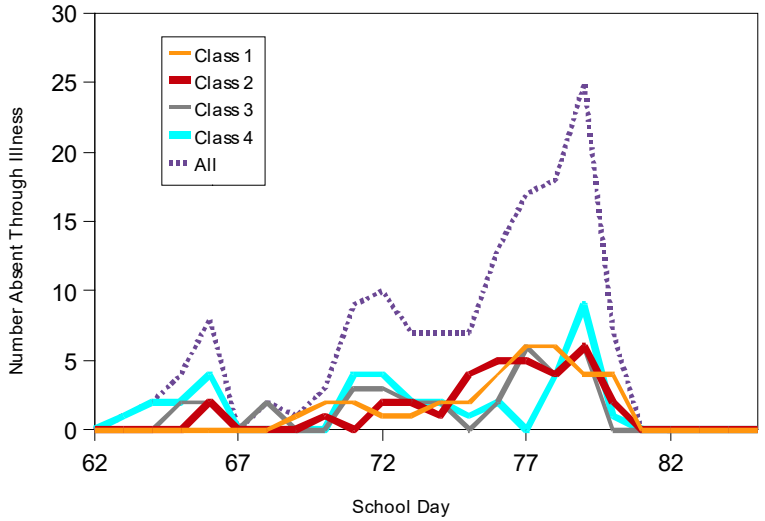
- **Infectious disease transmission**
  - Driven by mixing of infected and uninfected agents
    - Transmission can be by
      - Surface or other contamination
      - Direct contact
  - For direct contact infected agents need to be
    - Close enough - **proximity**
    - For long enough – **contact time**
  - **Proximity and contact time are functions of**
    - ***Places***
    - ***Events***

    which jointly structure the activities of agents and so determine which agents are in contact and for how long.

Five years of recorded absences (for medical reasons)



Sometimes there seems to be class-to-class propagation



Sometimes not

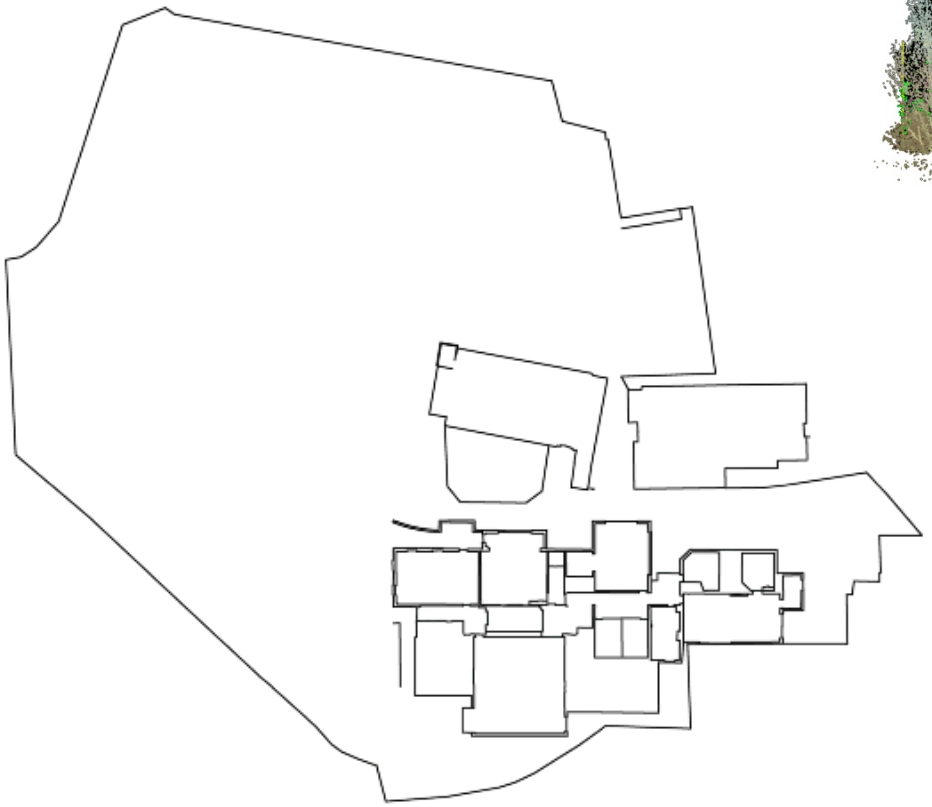
Outline

- Infectious Diseases
- **Places and Events**

Complete laser survey of school interior and exterior at 5cm resolution

Includes all desks, chairs, whiteboards, computers, clocks, pens, pencils...

Thin section allows 2D plan to be extracted



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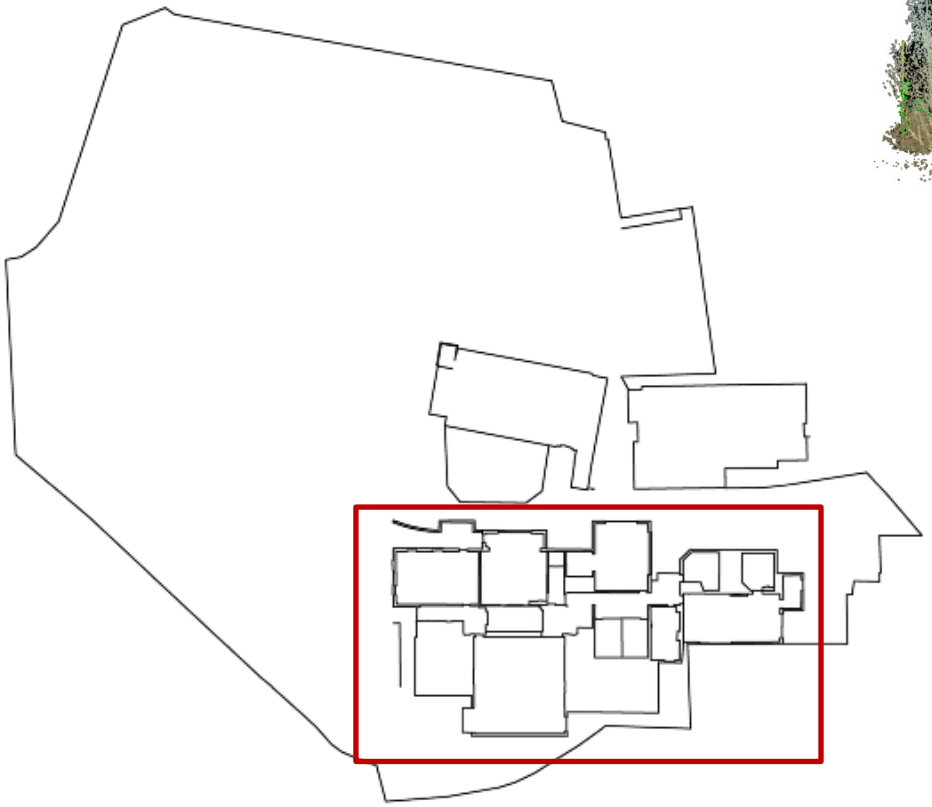
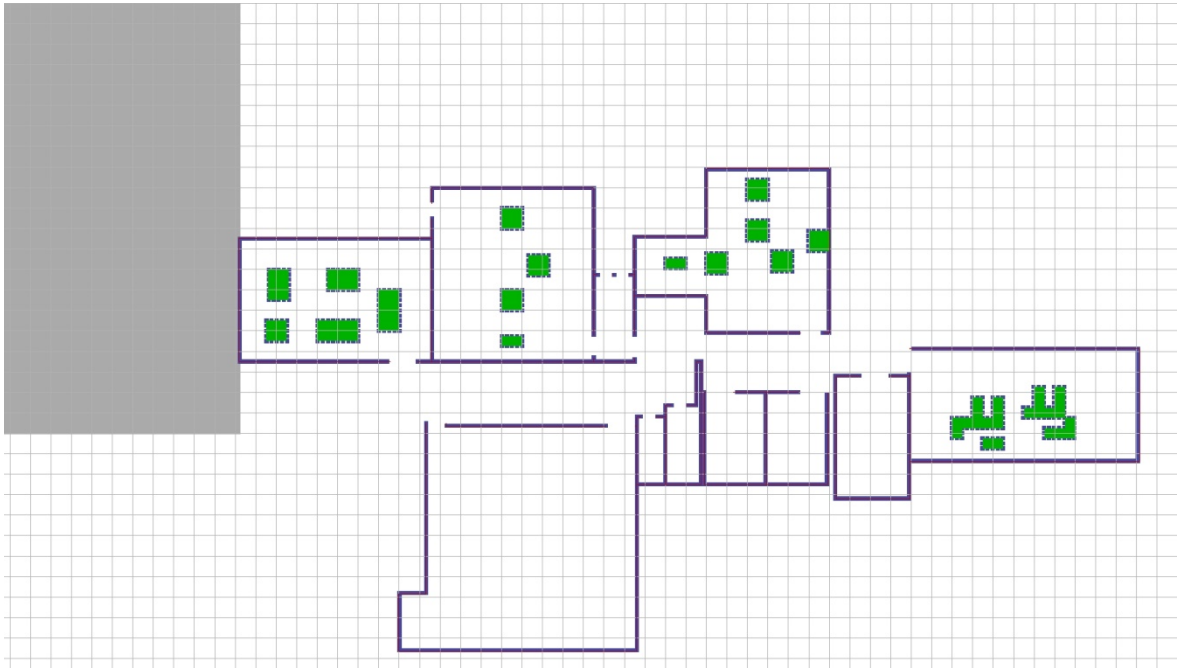


Plan further simplified for model construction



Plan further simplified for model construction

• Events

- Event changes are communicated to teachers (school bell)
- Teachers can vary the timing of events (asynchronous updates)
  - Events are then communicated to children
- Teachers can add complete extra schedules into a lesson
- Children can add specific events (e.g. go to toilet)
- Children have free schedule variation in the playground

- 08:58 End of time in playground
- 09:00 Go into school
- 09:10 End of registration - go to assembly
- 09:30 End of assembly - go to first lesson
- 10:45 End of first lesson - breaktime
- 10:58 End of break
- 11:00 Go back into school - second lesson
- 12:00 End of lesson - lunchtime
- 12:20 End of lunch - breaktime
- 12:58 End break
- 13:00 Final lesson
- 15:25 Leave final lesson
- 15:30 End of school

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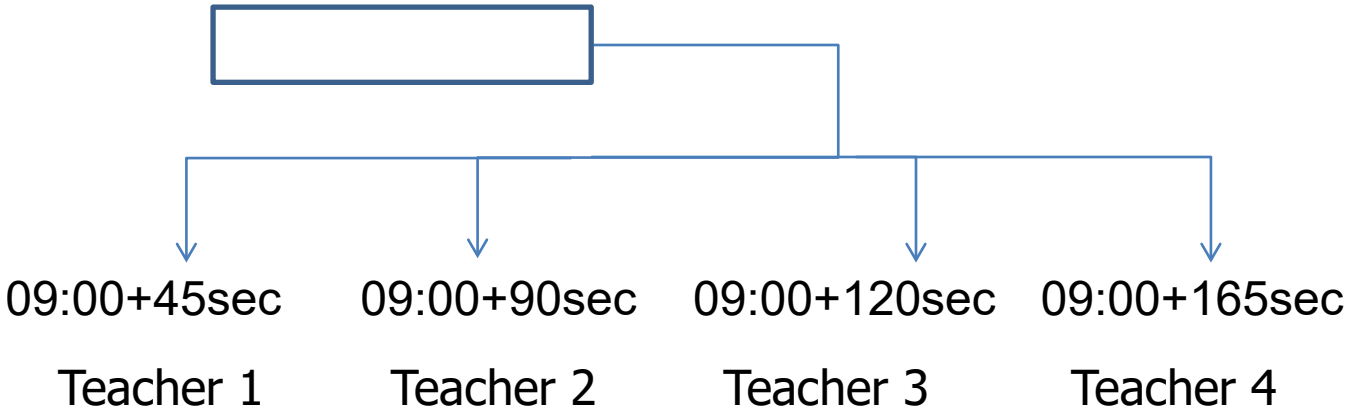

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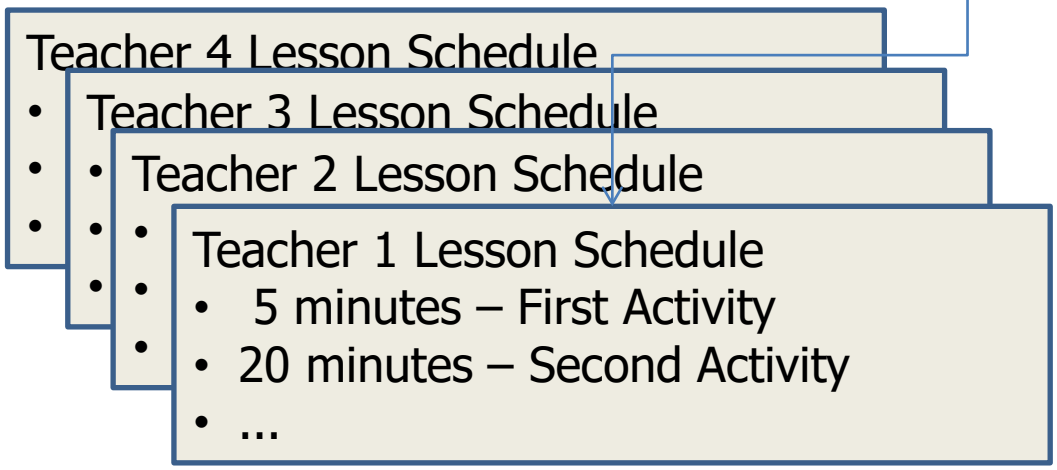
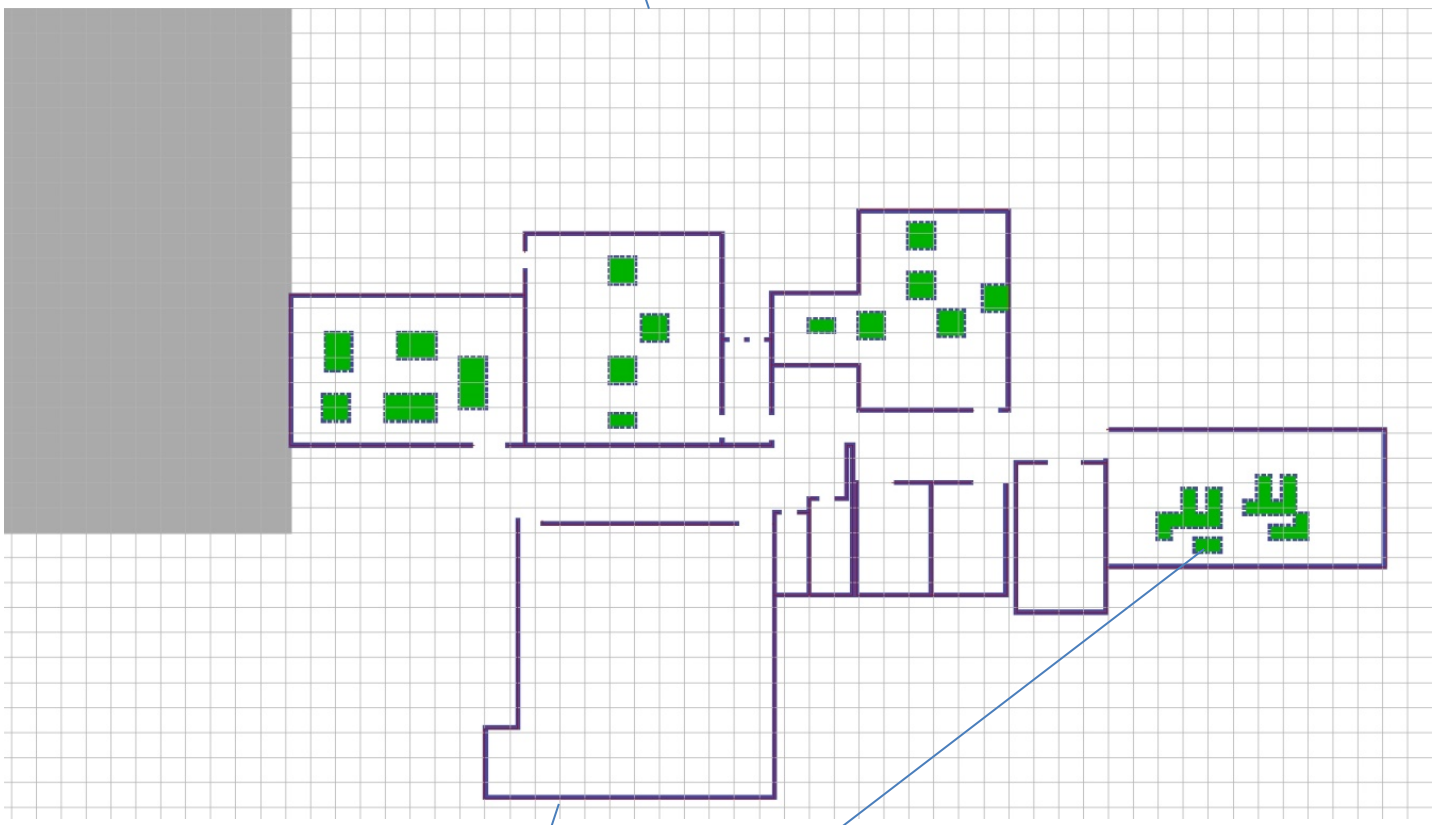


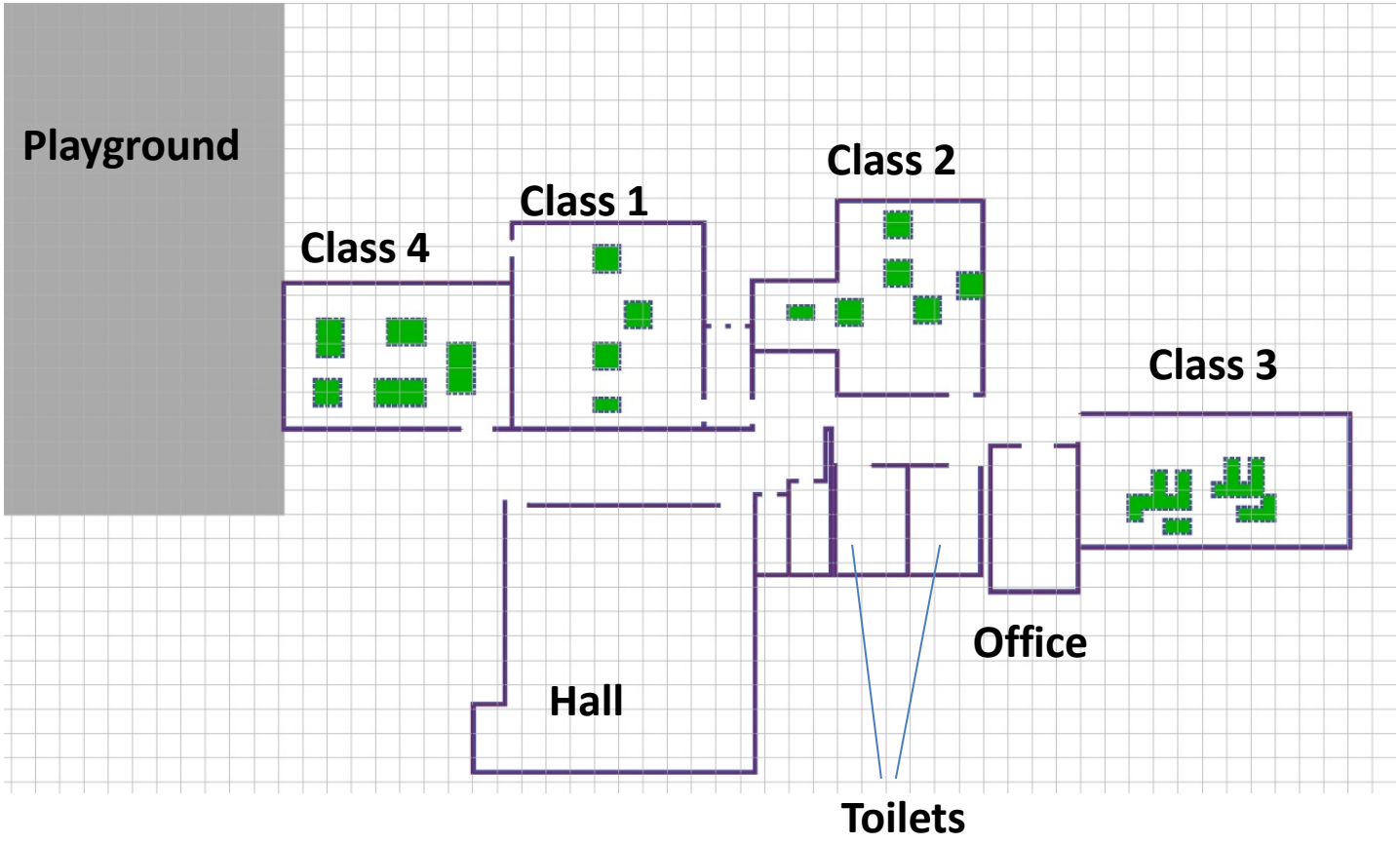
Outline

- Infectious Diseases
- Places and Events
- **Model Construction**

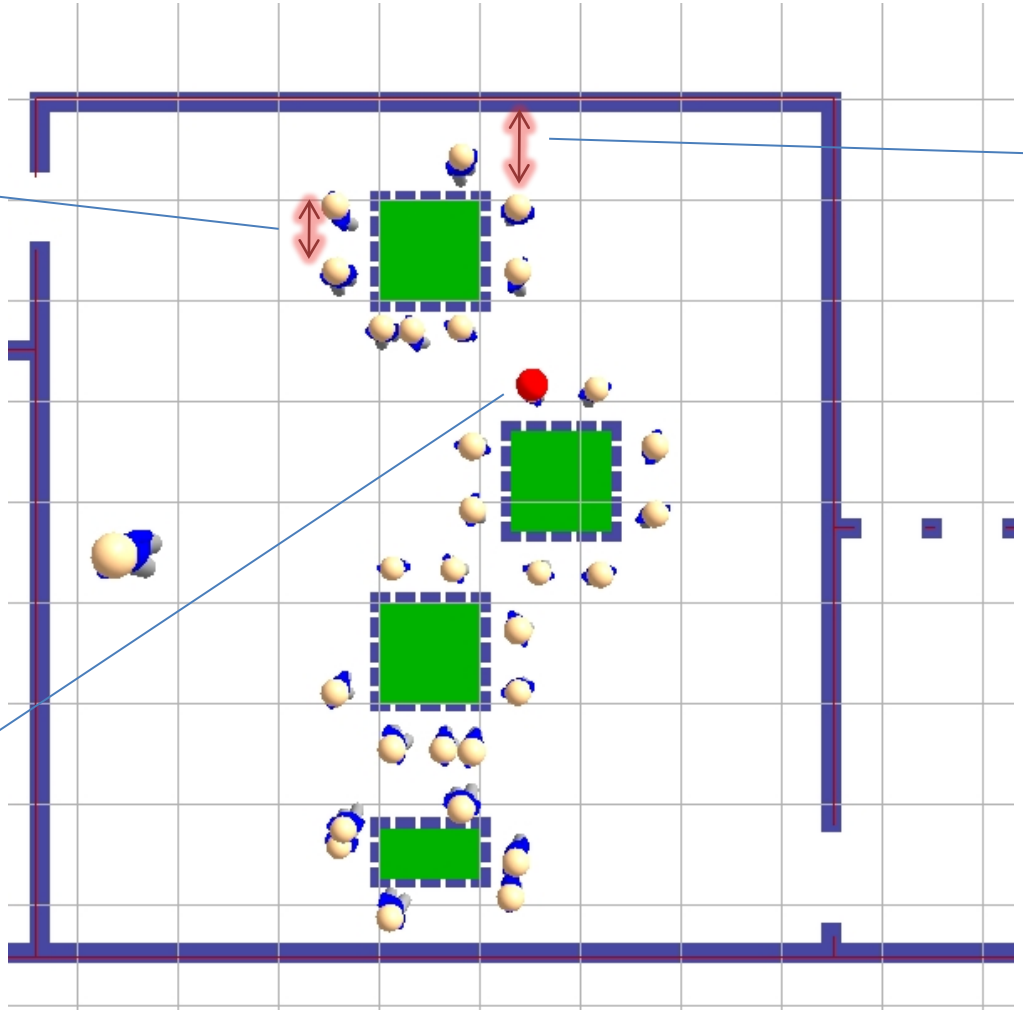
1m grid to show scale



walls and desks are obstacles to agent movement


Playground
Class 4
Class 1
Class 2
Class 3
Hall
Office
Toilets

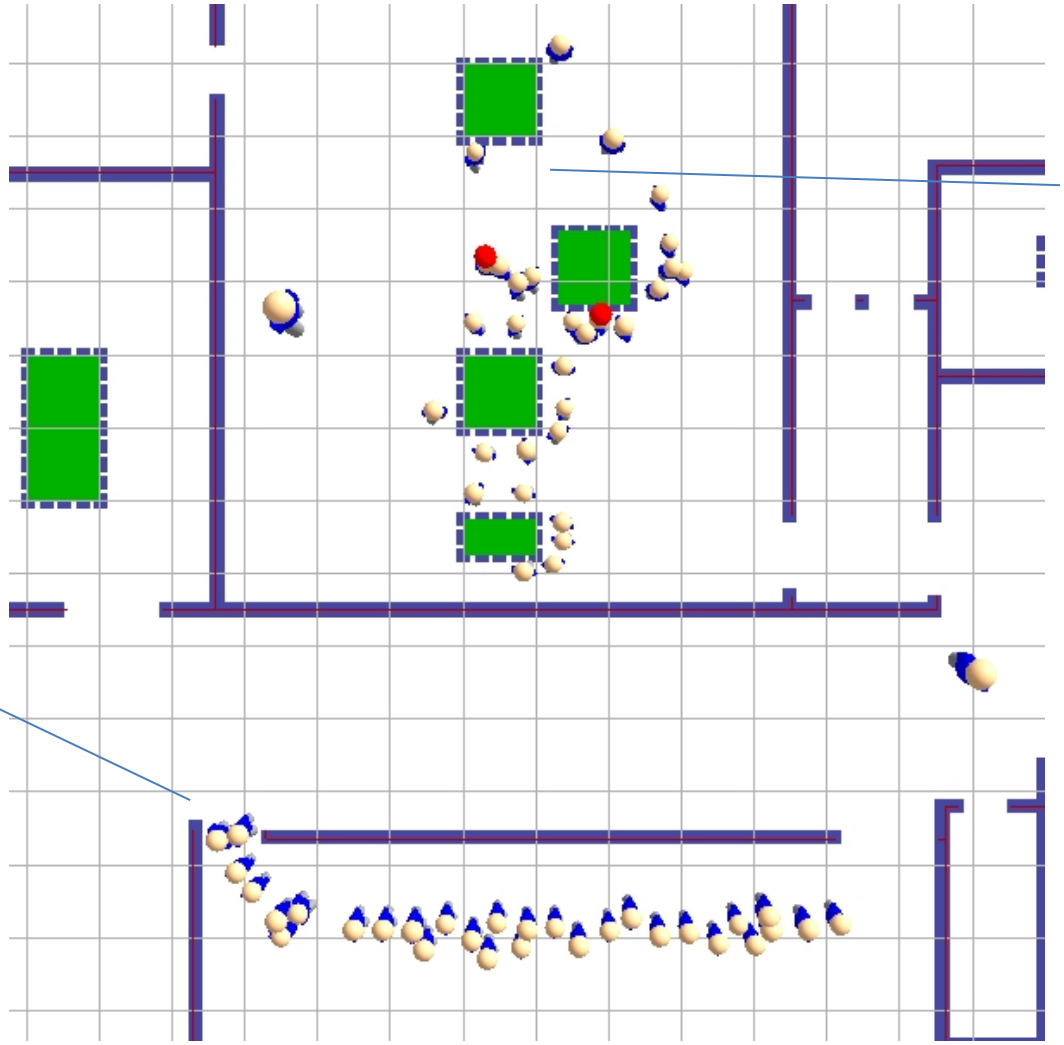
"Social force" acts between agents



And between agents and obstacles

Infected agent

Agents in transit attempt to follow known paths



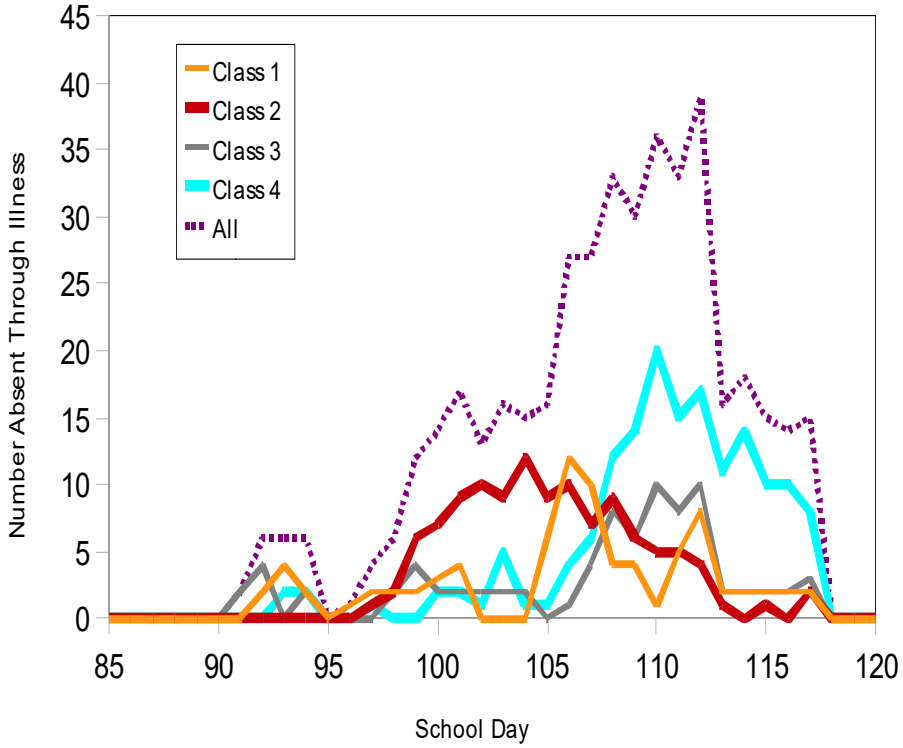
But have free movement in classrooms and playground

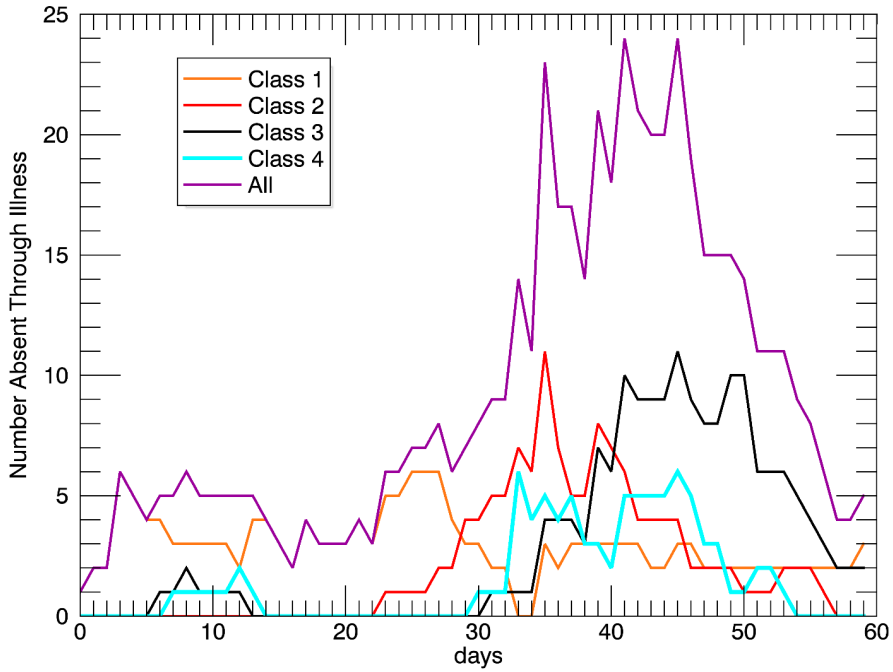
Outline

- Infectious Diseases
- Places and Events
- Primary School Data
- Model Construction
- **A movie!**

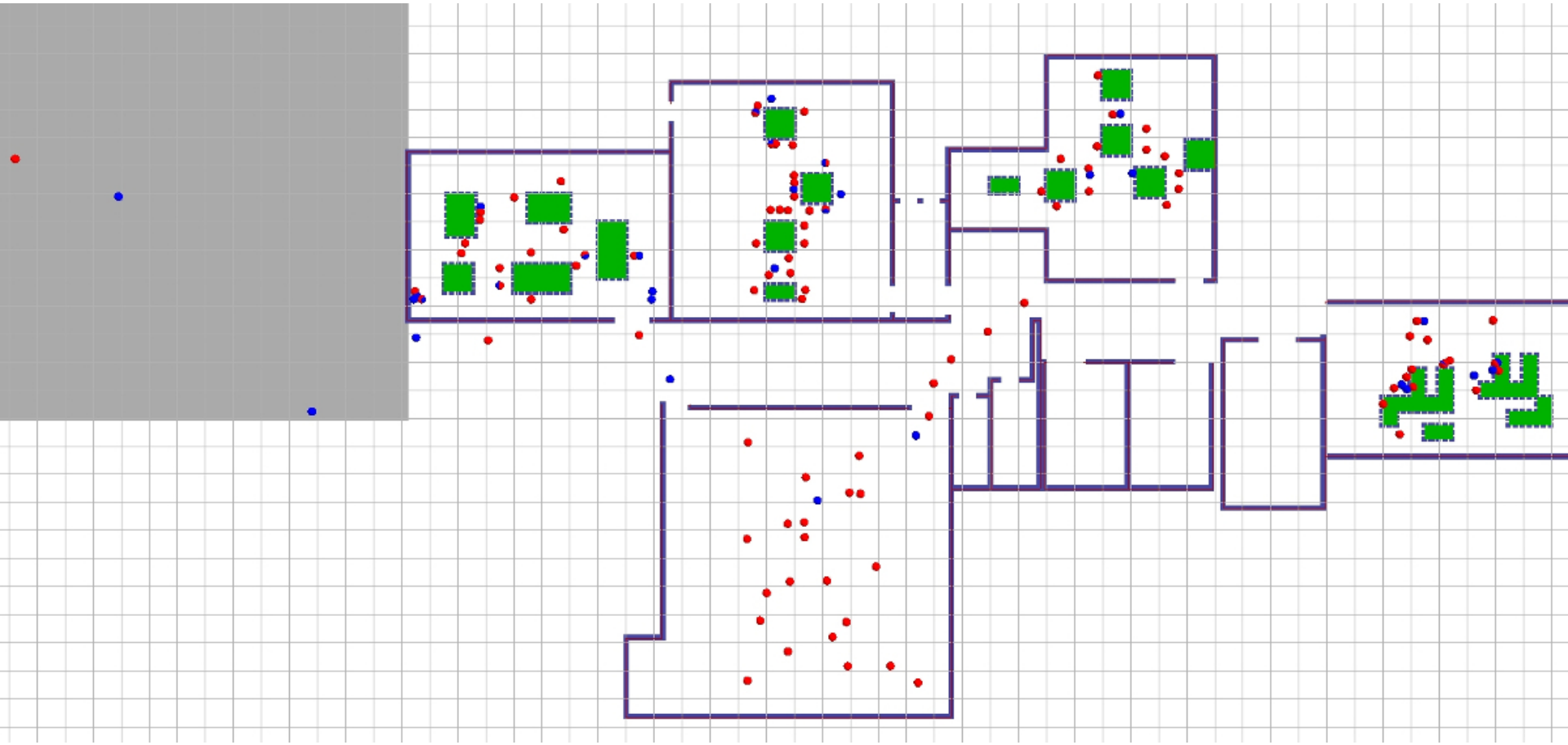
Outputs- different infection histories

- We can get class to class propagation
- Timescale and magnitude allow inferral of possible intrinsic disease infection and recovery rates



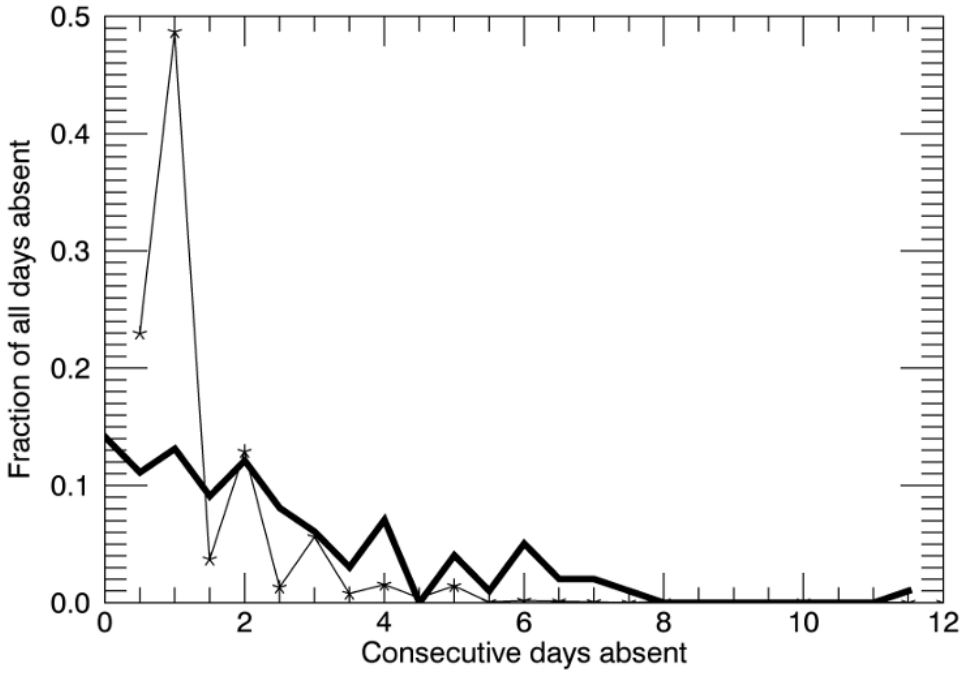


Outputs-infection and recovery locations



- Places where infection occurs can be simulated

Outputs-days absent

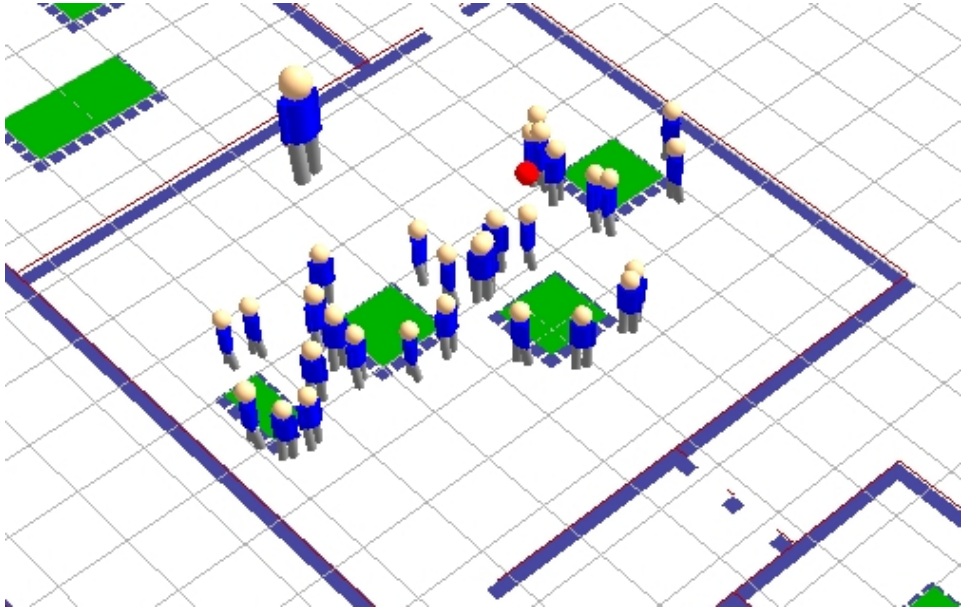


- Number of days absent is not captured (heavy line is model)

Missing things

- Social Networks – e.g. friends
- Parents and support staff
- Precautionary Absences
- Social Distancing
- Adaptation
- Seasonality
- Air flow…

School's out for ~~summer~~ pandemic?



- We are grateful to the head teacher,school governors and staff who gave permission for and facilitated the data collection exercise. We would also like to thank E.G. Bithell for assistance during 2006/7 and subsequent discussions.

Agent Based models and Public Health

- Most models to date have focussed on infectious disease
  - A few have tackled other subjects such as food/exercise
- Traffic models are reasonably well developed
  - Function at large (up to city) scale
  - to an extent simulate pollution generation
- A few examples incorporating traffic and pollution
  - Status is largely proof-of-concept
  - Dependent on parameterisation of
    - behaviour
    - health effects (physiology)
    - pollution generation
    - air flow...weather...