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My Agents can't decide...could Bayesian Belief Networks be the solution?

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Presentation contents

- Background on DSE
 - *The ‘journey’...*
- The not-so-good bits (about ABM)
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 - Aerospace case study
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 - How agents make decisions?
 - Incorporating Bayesian statistics & ABM
- Opportunities to find out more

The 'journey'..

- Logistics Analyst / General Manager: 1998 – 2003
 - Mainly DE
 - Sometimes Arena
 - Often VBA
- UNOTT: 2003 – 2007
 - System Dynamics becomes Agent-Based modelling
- DSE: 2007 to date
 - Simulation becomes a decision making tool
 - ABMS



About dse

- Specialists in providing decision support solution based on Agent-Based modelling & Simulation consultancy



- AnyLogic and Simul8 partner



- *additional specialist skills in...*

- *Business Modelling & Optimisation using Enterprise Optimiser*
- *Operations Strategy & Management*



The not-so-good bits (about ABM)

- lack of "paper theory"
 - an applied discipline but it doesn't have a significant body of insight
- Has the ability to handle more real-world complexity but does this over-complicate the decision support process
 - Similar to some of the drawbacks of SD
- The modelling framework is easier than the simulation application
 - Partially affected by available tools (or lack of)

The good-bits

- Intuitively correct
 - Significantly better engagement from (less involved) stakeholders
 - Board level modelling workshops
 - The first time we've ever “Understood the **problem** from a **shared view-point**”
- Great for visualising the interactions and root cause of decisions
 - And thereby the *unintended consequence*
 - Organisation are merely a representation of the view of a mass of people working to their own objectives
- Can be applied more broadly than traditional approaches and opens up the *market* for OR
 - Great opportunities for working with Marketing and Strategy

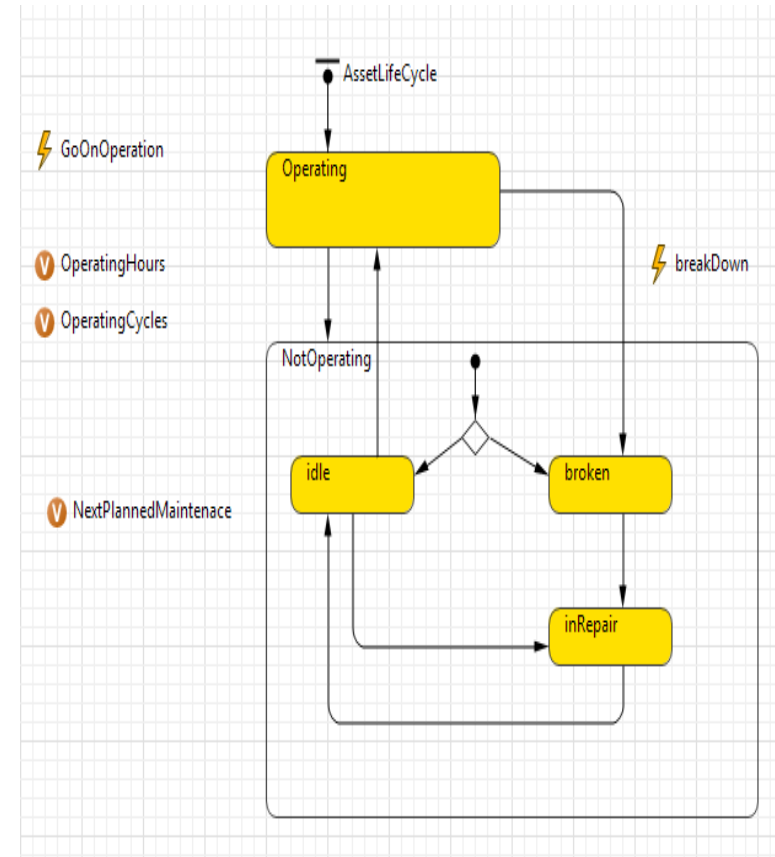
Some examples...

1. General Agent-Asset Model

- **BUSINESS STRATEGY:**
 - “If I have \$20 million to spend, should I invest in the cSeries or wait for Airbus / Boeing to make their decisions
 - If I launch now, how will the market respond?”
- **SERVICE DESIGN:**
 - “If I fly my fleet of helicopters twice as often, can my MRO operations support this?
 - And do I have enough new aircraft in the pipeline?”
- **FORECASTING:**
 - “Spares arising, and in which *locations*”
- **What’s the common theme?**
 - A range of strategic & tactical questions, but the answer always lies in the detail

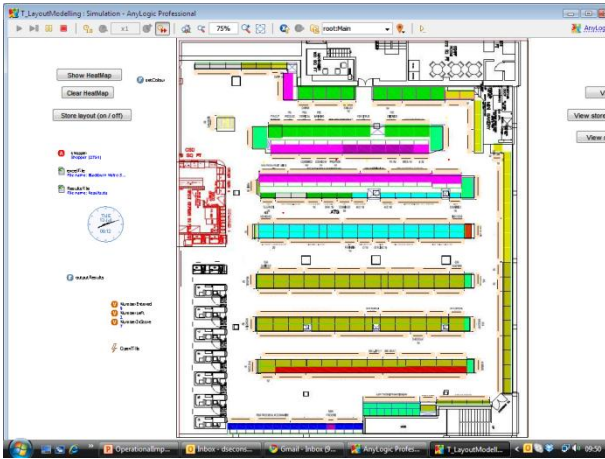
What does my General Asset look like? And why is it useful?

- **Agents** or more specifically **Populations of Agents** drives systems, i.e.
 - Logistics networks, MRO (and spare parts supply), Manufacturing, Labour supply (including Education / training)
- And can be influenced by strategic and tactical decisions taken by other **agents**
 - either to individuals or to the population as a whole
 - How they are used – frequency & intensity
 - When to replace – Cost / Benefit
 - How to sell - price setting, discounting, etc

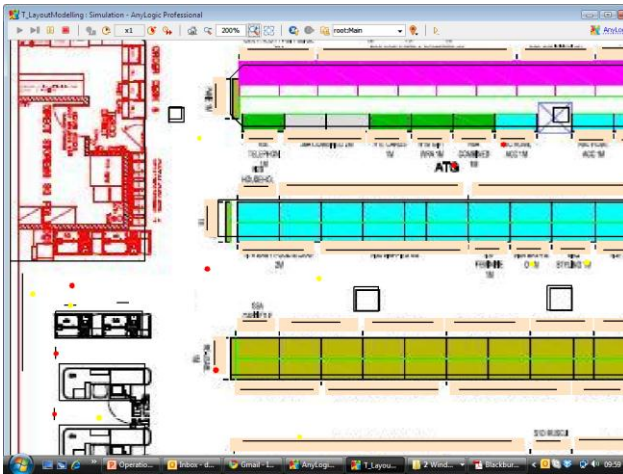


2. Doing more with pedestrians

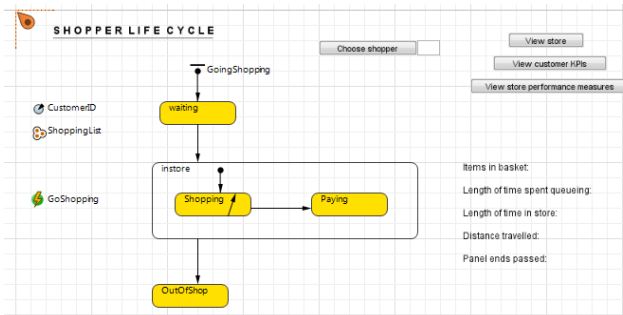
- **Retail Space Strategy**
 - *“If I move my bread department to the back, and reduce the ambient department size, then what will be the affect on the flow of the shopper?”*
- Current models tend to be macroscopic focussing on people moving as continuous flows
- Therefore, limited opportunities to understand how flow can be affected by person-to-person and person-to-environment interactions
- If we include Agents, we get opportunities to
 - Understand tactical decisions:
 - Understand the effects of the environment: ***How do people interact with panel end displays?***
 - Understand the effect of strategic decisions: ***What happens is we move bread?***



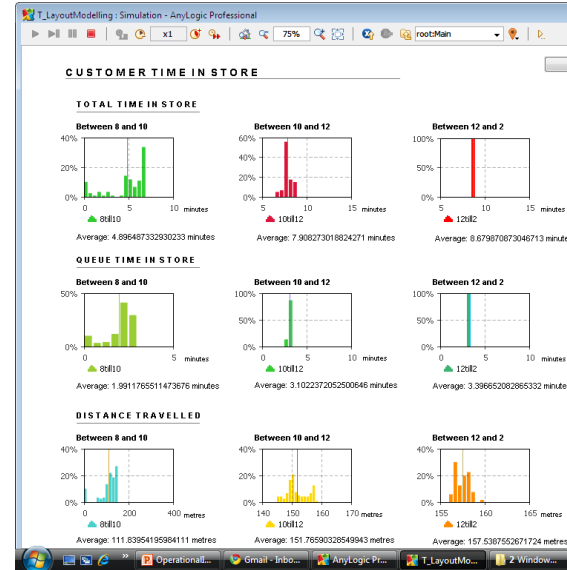
The store plan is constructed in the simulation software



Close up shot of shoppers in the store. Shoppers are represented by red and yellow dots showing customer segment



View of an 'shopping lifecycle' for an individual shopper



Customer KPI view

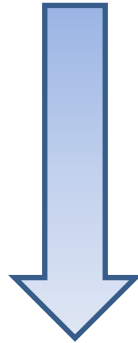


Operations KPI view

3. Nudge modelling

- When agents are non-deterministic, they make decisions?

Pure facts



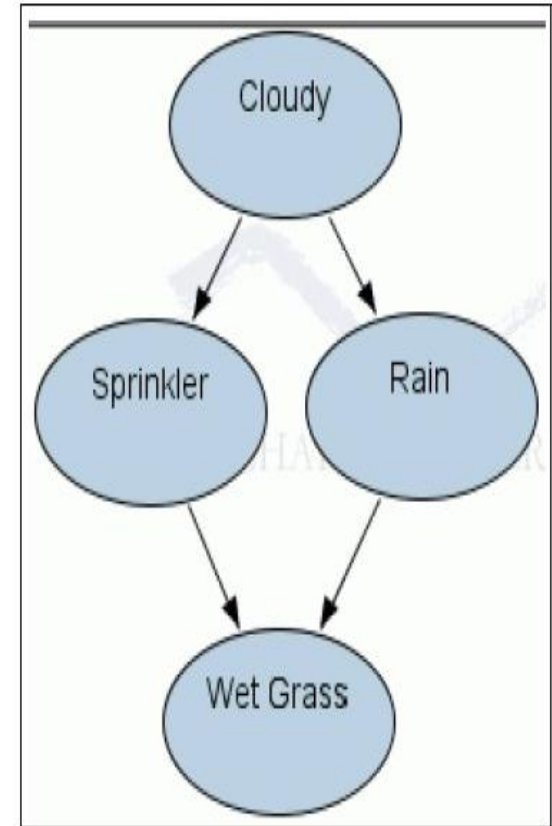
Pure psychology

- Multi-criteria decision making (simple decision rules)
- Learning and altering simple decisions
- Belief Desire Intention (BDI) modelling
- Neural networks
- Genetic algorithms
- Artificial intelligence

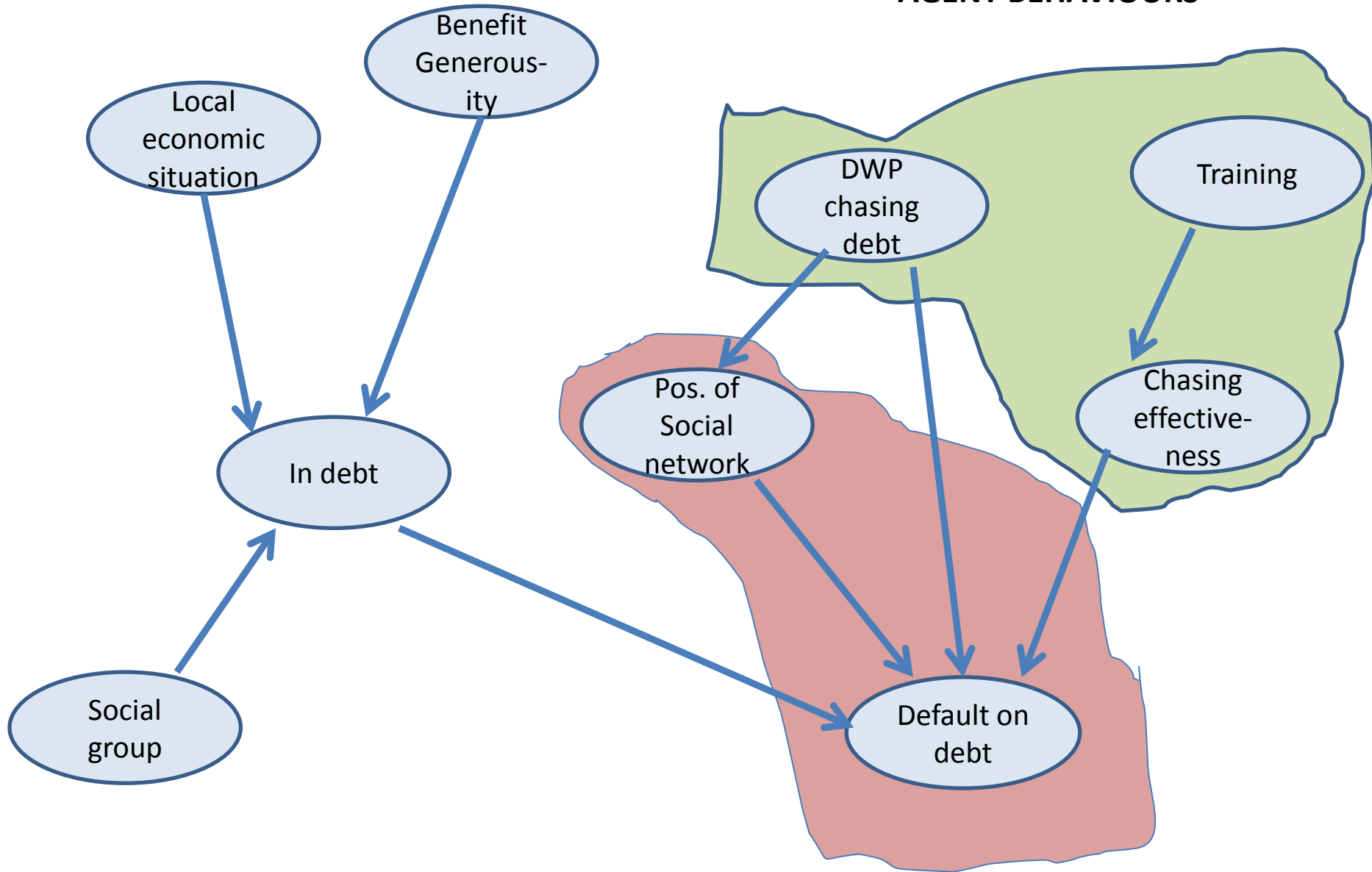
- But what if we don't know how?
 - *Bayesian Belief Networks...*
- *Debt Management Policy for the UK Public sector*
 - “How can we get more money back [with less resources]”

What are Bayesian Belief Networks?

- BBNs are a visual representation (*a graph*) of *things* (nodes) that we may be interested in, and how these things are connected (arcs)
- Each node has a set of probabilities describing the likelihood that your *thing* will be in that *state*
- Functions are description how connected things alter likelihoods
- Used for calculating the *likely* root *cause* when a thing is found in a certain state
- How could they be used in ABMs?
 - Calculate a starting probability
 - then continually update this probability based on incoming information about the current situation



AGENT BEHAVIOURS



AGENT BEHAVIOURS

Doesn't this undermine the main principle of Simulation???

- **We are** showing effects of combined and repeated actions on a population
- And we can look at the **cumulative effects** of agent to agent interactions
- The primary objective of many models is to improve the modellers understanding of the system under study
 - And using Bayesian Statistics, we just still don't necessarily understand why...

Questions & opportunities to find out more...?

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- Training / Conference options
 1. 3 days *official software* training in AnyLogic (30th March to 1st April, London)
 2. Young OR conference 5th – 7th March, UNOTT
 3. OR Society training: 2 day course covering ABMS in collaboration with UNOTT (December 2011, Birmingham)