(TASK # 01) CASE STUDY ONE

Case Title: Disaster Response Planning Using Agent-Based Simulation

Overview:

Battelle is the world's largest, non-profit, independent R&D organization, and is a worldwide leader in the development, commercialization, and transfer of technology. They manage or co-manage laboratories for the U.S. Department of Energy, the U.S. Department of Homeland Security, and an international nuclear laboratory in the United Kingdom.

Problem:

In an effort to find practical operational solutions for a fast and effective response to an unexpected crisis or natural disaster, Battelle needed to test the effectiveness of a 48 hour shelter-in-place order for an Improvised Nuclear Device scenario (IND). The intended goal was to reduce radiation dosages received during an uncoordinated mass evacuation, by comparing immediate evacuation and shelter-in-place order.

Modeling a disaster, whether natural or man-made, represents many unique challenges. There are distinctive environments and physical consequences, and numerous scenario possibilities and threat vectors. In addition, disaster response strategies are rarely implemented as planned, and there are unknown human reactions.

Solution:

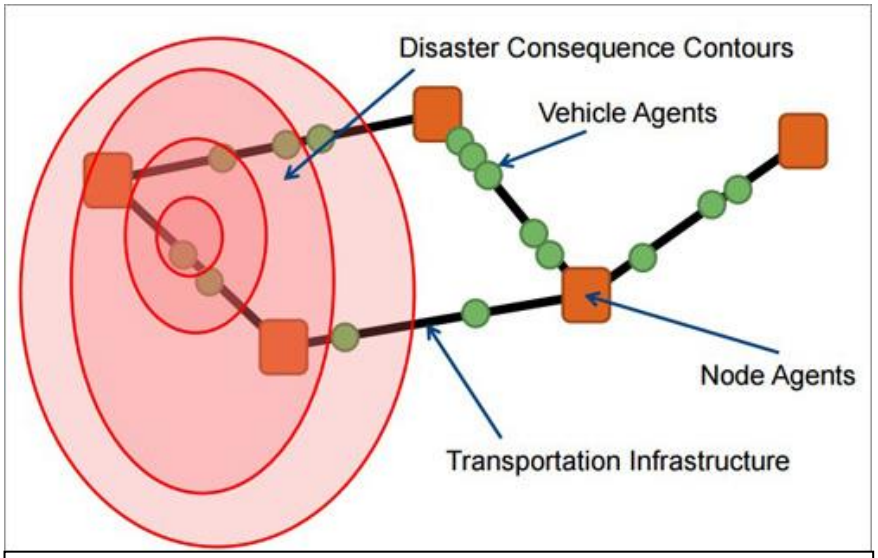
Simulation was chosen for the disaster response planning because it had the capability to evaluate the space of potential scenarios. Deterministic models had limitations incorporating factors, like fundamentally unpredictable human responses and the need to compare alternatives versus looking for exact answers.

AnyLogic software was a natural choice for Battelle, as the software was already being utilized in a broad range of projects within the organization, including:

- Healthcare – Provider Resource Management, Clinical Workflow Modeling, Infection Control
- Economic Development and Industry Cluster Forecasting
- Vehicle Fleet Logistics and Maintenance
- National Security and Disaster Response

In addition, AnyLogic's agent-based capabilities allowed Battelle to capture the most important dynamics of a disaster event. Emergence, or emergent behavior, is a key principal in modeling human behavior. Also, a model can sometimes exhibit unexpected outcomes. Both of these issues can only be captured using agent-based modeling.

The comprehensive model framework included an environment of road networks, vehicles, drivers, and disaster events. The road network was built with road layouts from GIS databases, local highway agency data (speed limits, lane capacity), and agents as node points for greater control. Changes to the network, such as the flooding of roads or destruction of bridges, were incorporated into dynamic events as the disaster unfolded.



Disaster Response Planning Simulation Model Framework

The physical limitations of vehicles were governed by parameter data provided by the US Census, Bureau of Transportation. Data from past disaster response studies was used to represent driver agent behaviors, taking into account the changes in irrational drivers in normal circumstances versus during a mass evacuation. The model also incorporated dynamic route finding (several interlinked agent state sets that were dynamically tracked and updated). In addition, all behavior states were linked to physical vehicle movement parameters to initiate vehicle stoppages as drivers became incapacitated.

Agent behavior variables from initial values were calibrated, and evacuation data was used from past disasters to set accuracy targets, since calibration and validation were critical steps in proving the validity of the simulation model. If no historical data was available, Battelle used data from other major transportation events, sensitivity analysis based on other disaster events, and survey data.

Dynamic contours were used to track regions of disaster consequences, often derived from other simulation models, to compartmentalize processing requirements. Contours updated in real time based on predicted weather patterns, land cover, etc., and multiple interlinked contour sets could be adapted to represent almost any disaster scenario (for example, flooding levels, fire spread, damage path, contamination/fallout spread). In the IND scenario, two main contour sets were used; blast radius levels (fireball and overpressure force contours) and fallout distribution (radiation levels in air and deposition on ground from various radioactive particle types).

Results:

The disaster response planning simulation model built using AnyLogic software compared immediate evacuation versus shelter-in-place order and showed that shelter-in-place order significantly reduced radiation dosage received, as well as cases of severe radiation poisoning for large INDs.

The model also produced downstream outputs to test different disaster response strategies and find the best response strategy among several likely options. Battelle was able to incorporate emergency responder agents, multiple intervention scenarios, and interchangeable model components (different locations for same disaster scenario, or different scenario for same location), to achieve the goal of finding practical operational solutions for fast and effective responses to various unexpected crises or natural disasters.

Read a case study and then discuss the following questions:

- What was the goal of the study?
  The intended goal was to reduce radiation dosages received during an uncoordinated mass evacuation, by comparing immediate evacuation and shelter-in-place order.

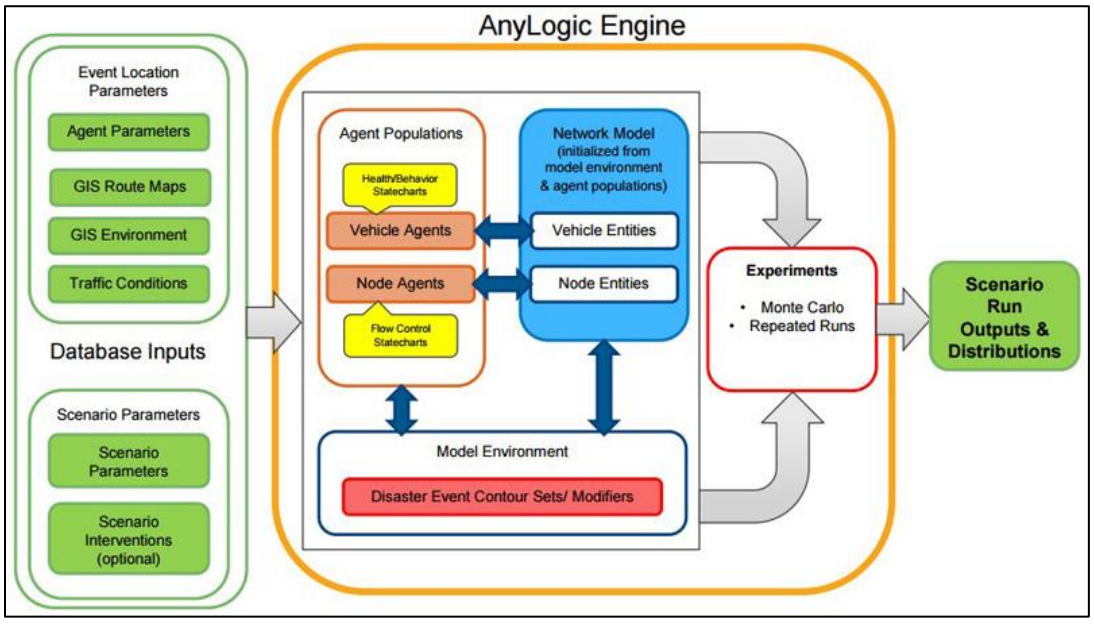
- Why was simulation used?
  Simulation was chosen for the disaster response planning because it had the capability to evaluate the space of potential scenarios. Deterministic models had limitations incorporating factors, like fundamentally unpredictable human responses and the need to compare alternatives versus looking for exact answers.

- What were the challenges?
  AnyLogic's agent-based capabilities allowed Battelle to capture the most important dynamics of a disaster event. Emergence, or emergent behavior, is a key principal in modeling human behavior. Also, a model can sometimes exhibit unexpected outcomes. Both of these issues can only be captured using agent-based modeling.

- What benefits were obtained?
  The disaster response planning simulation model built using AnyLogic software compared immediate evacuation versus shelter-in-place order and showed that shelter-in-place order significantly reduced radiation dosage received, as well as cases of severe radiation poisoning for large INDs.

  The model also produced downstream outputs to test different disaster response strategies and find the best response strategy among several likely options, to achieve the goal of finding practical operational solutions for fast and effective responses to various unexpected crises or natural disasters.

- Model your case study simulation taxonomy.



(TASK # 01) CASE STUDY TWO

Case Title: Population Simulation Modeling Using Real-World Data to Battle Food Insecurity

Problem:

Food security is a complex sustainable development issue, linked to health through malnutrition, but also to sustainable economic development, environment, and trade. Issues such as whether household's population get enough food, how it is distributed within the household and whether that food fulfils the nutrition needs of all members of the household is an ongoing problem in developing countries. An International Civil Agency employed a Major Consulting Firm to analyze food insecurity in developing countries and cultivate a system that enables an economy to prepare for and halt possible food insecurity.

Solution:

The consultancy chose AnyLogic to explore the impacts of food insecurity in developing countries by building a population simulation that leverages Household Economy Analysis (HEA) and places it into a System Dynamics and Agent-Based modelling framework. The population simulation model allowed the Consulting Firm to explore how different mitigation strategies could be employed to reduce or eliminate the human impact of a situation that might otherwise lead to widespread food insecurity.

Household Economy Analysis divides the area under consideration into Livelihood Zones (LZs). A LZ is defined as an area within which, people of the same socioeconomic status make their livings in about the same way (e.g. small land hold farming, or nomadic herding, etc.). The population is then divided into socioeconomic levels, called Wealth Bands (WBs) (e.g. very poor, poor, middle, and better off). By using historical data about the existing population, as well as field work conducted by a partner firm, the consultants were able to build out a System Dynamics population simulation model showing how cash and food flowed into and out of a typical household in each WB.

These typical households were then replicated in the population simulation model as agents, keeping the relative proportion of people in each Wealth Band consistent with real-world data. The agents made decisions annually about crop production (if their LZ and WB contained crop cultivation). Additionally, each agent had an individualized level of risk tolerance and engaged (or didn't) in pre-defined coping behaviors according to the severity of any perceived upcoming food shortage in the context of that risk tolerance.

Outcome:

In conclusion, the consultancy obtained a simulation model of a heterogeneous population that reacts to potential upcoming food insecurity in ways that are more realistic at the population level. In addition, the International Civil Agency gained the ability to deliver food and cash assistance to each wealth band, according to their own schedule.
The research allowed for the exploration of a variety of aid distribution methodologies which ultimately is utilized by the Agency to battle food insecurity.

Read a case study and then discuss the following questions:

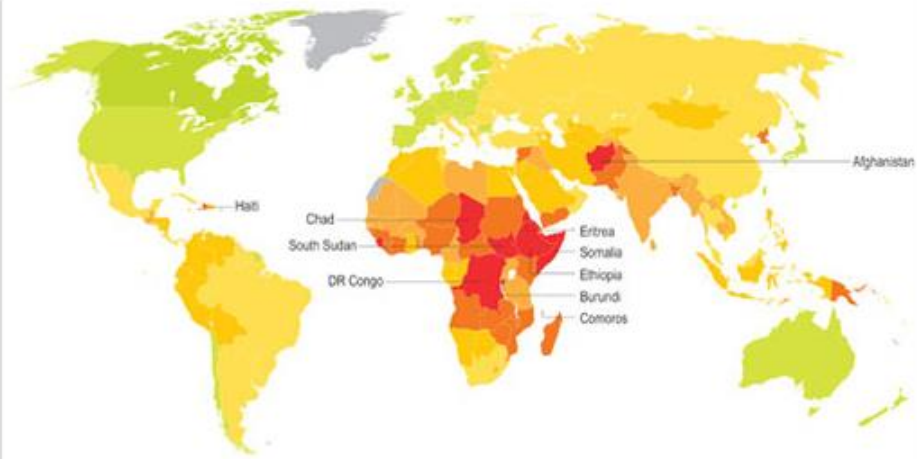
- What was the goal of the study?
  The intended goal was to reduce food insecurity. An International Civil Agency employed a Major Consulting Firm to analyze food insecurity in developing countries and cultivate a system that enables an economy to prepare for and halt possible food insecurity.

- Why was simulation used?
  By using historical data about the existing population, as well as field work conducted by a partner firm, the consultants were able to build out a System Dynamics population simulation model showing how cash and food flowed into and out of a typical household in each WB.

- What were the challenges?
  Issues such as whether household's population get enough food, how it is distributed within the household and whether that food fulfils the nutrition needs of all members of the household is an ongoing problem in developing countries. The consultancy chose AnyLogic to explore the impacts of food insecurity in developing countries by building a population simulation that leverages Household Economy Analysis (HEA) and places it into a System Dynamics and Agent-Based modelling framework.

- What benefits were obtained?
  The consultancy obtained a simulation model of a heterogeneous population that reacts to potential upcoming food insecurity in ways that are more realistic at the population level. In addition, the International Civil Agency gained the ability to deliver food and cash assistance to each wealth band, according to their own schedule.

- Model your case study simulation taxonomy.



Legend	
Extreme risk	
High risk	
Medium risk	
Low risk	
No Data	

Rank	Country	Rating
1	Somalia	Extreme
2	DR Congo	Extreme
3	Haiti	Extreme
4	Burundi	Extreme
5	Chad	Extreme

Rank	Country	Rating
6	Ethiopia	Extreme
7	Eritrea	Extreme
8	Afghanistan	Extreme
9	South Sudan	Extreme
10	Comoros	Extreme

(TASK # 02) CASE STUDY ONE

Case Title: Airport – Simulation Model

https://cloud.anylogic.com/model/7be27b45-0a74-47f9-a78b-9bce22a6faa8?mode=SETTINGS

1. What is the method used?

Discrete Event

2. What are the inputs and outputs?

INPUTS:

- Check in
- Passport control
- Gate control

OUTPUTS:

- Passengers arrive
- Pass security controls
- Customs control

3. What happens if you change parameters?

If we change the parameters there is a clash between registration time and personnel utilization, as they both dependent on each other.

4. What are the elements of variability, interconnectedness, and complexity?

VARIABILITY:

- Flight departure
- Passengers arrive

INTERCONNECTEDNESS:

- Registration time
- Personnel utilization

COMPLEXITY:

- Pass security controls
- Customs control

(TASK # 02) CASE STUDY TWO

Case Title: Call Center – Simulation Model

https://cloud.anylogic.com/model/baa21002-634d-417b-bf3b-81f95fa7f36d?mode=SETTINGS

1. What is the method used?

Discrete Event

2. What are the inputs and outputs?

INPUTS:

- Arrival rate
- Service time distributions

OUTPUTS:

- Queue lengths
- Service levels

3. What happens if you change parameters?

All parameters can be changed on-the-fly, including the routing options.

4. What are the elements of variability, interconnectedness, and complexity?

VARIABILITY:

- Customer service representatives
- Customer's perspective

INTERCONNECTEDNESS:

If no operator is available to answer the call, the call is placed in the queue. If the queue is full, the center attempts to route the call to another center. If there is another center that is able to take the call and there is a link to that center available, the call is transferred. Otherwise the call is discarded (balked).

COMPLEXITY:

- Increasing complexity in call traffic, coupled with the almost ubiquitous use of Skill-Based Routing
- Rapid change in operations due to increased merger and acquisition activity, business volatility, outsourcing options, and multiple customer channels (inbound phone, outbound phone, email, web & chat) to support.