An Object-oriented DEV Approach to ARGESIM Benchmark C16 ‘Restaurant Business Dynamics’ using Enterprise Dynamics

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Simulator: Enterprise Dynamcis (ED) is a discrete-event simulation tool for modelling, simulating, visualizing, and monitoring dynamic-flow process activities and systems. It is based on an object-oriented concept represented by so called atoms. Atoms are objects with four dimensions (x, y, z, and time) that can be dragged and dropped from a library into the modelling window e.g. source, sink, queue, server. It is also possible to create new atoms by using Taylor ED’s Atom Editor. Defining the dependencies between atoms is done by connecting atoms through channels. Each atom may have multiple input and output channels. For a certain behaviour und functionality of an atom its parameters have to be set accordingly.

Model: An event driven approach was used and the following atoms were defined:

- `InitializeRestaurantBusinessDynamics`
- `Town`
- `tableRestaurant`
- `tablePeople`
- `Restaurant`
- `People`

The atom `InitializeRestaurantBusinessDynamics` places all the cities (atom `town`) and restaurants in the model window and randomly calculates the places where the people will be positioned. The probability of each position will depend on the catchment area of the cities.

The simulation is initialized by loading all atoms into the library of Taylor ED, dragging the initialization-atom into the model window and resetting the simulation using the *Reset* button. An example screenshot of the situation directly after the initialisation is shown in Figure 1. During initialization two tables (atoms) `tableRestaurant` and `tablePeople` are created to simplify the calculations. The first table provides a list of active restaurants with some actual values like profit and tax. The second table contains the number of people living in each 20x20 cell.

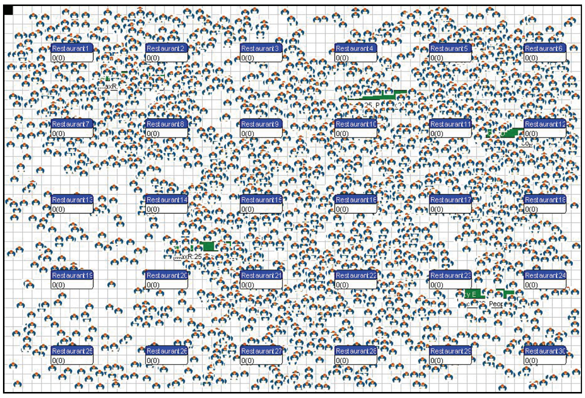

Figure 1. Screenshot of an initial state

The people atom is placed 3000 times into the 600x400 area; it triggers an event for visiting a certain restaurant nearby. After visiting a restaurant the next dining event is randomly set within an interval of 8 days. The visited restaurant is also selected randomly from those which are in proximity (distance < 100) of the person. For faster simulation runs only people having at least one restaurant nearby are taken into account during the calculations.

The atom `restaurant` calculates its revenue every week. The revenue is incremented by one each time a restaurant gets a visit event from a people atom. After each week a fixed amount of running costs (= 150) is subtracted and if still positive the tax of the remaining revenue is paid to the government. If the remaining profit is higher than the profit margin (=350) then with a certain opening probability a new restaurant-atom is created. For calculating the new position with the best ratio of People Density / Restaurant Density ratio (see Task c) the `tablePeople` atom is needed. If the profit is below the threshold the active restaurant-atom is destroyed with some closing probability.

A-Task: Several simulation runs were executed with times of 1, 5, and 10 years. The results are shown in Table 1.

The number of restaurants levels off at 4.6 after a short period of time. Therefore there is no advantage in simulating over a greater period of time. Interest-

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period	mean	minimum	all
1 year	4.61	2	45
5 years	4.61	2	111
10 years	4.6	2	195

Table 1. Results of Task a

ingly to see is that only about 3.3 of the 4.6 restaurants exist over a longer period of time and make appreciable profit while the others only exist for a shortl time. The minimum number of existing restaurants was 2. The column 'all' shows the number of all restaurants having existed up to now (even if they existed only for a short period of time). So every year about 15 new restaurants are opened.

B-Task: Table 2 and Figure 2 show the results of task b. During several simulation runs the tax income for the government and the profit of the restaurants was recorded while varying the tax rate from 15% to 45%. As expected the higher the tax rate the less restaurants survived during the first year. Taking 45% as tax rate only 0.6 restaurants survived, while using 40% increased the number of active restaurants after one year to 1.8. As seen in Figure 2 there are some local maxima but the optimum tax rate for the government is 40%.

	10%	15%	20%	25%
Tax income	12831	19085	21784	21146
Profit	112198	105320	84337	61299

	30%	35%	40%	45%
Tax income	33366	29776	34394	21705
Profit	76032	53794	49795	25254

Table 2. Results of Task b

C-Task: Again several simulation runs were executed over the time period of one year. This time we were varying the weight coefficient k from 0 to 6 to get the highest profit for new restaurants. We

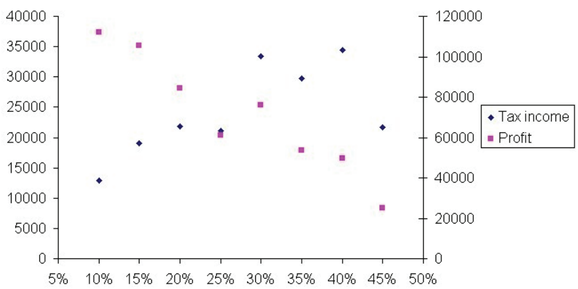

Figure 2. Results of Task b – Tax Income and Profit in Dependency on Tax Rate

K	0	0.5	1	2	3	4	5	6
Profit	20	45	37	25	18	17	8	3

Table 3. Profit of new Restaurants in Thousands

expected that a k of zero will not lead to a maximum since the calculation of the new location of a restaurant only depends on the people density within a certain cell ignoring the number of restaurants nearby completely. On the other hand the higher k is set the worse it is for cells with a restaurant in close proximity, but a high people density, to open a new restaurant.

Our simulation results have shown that 0.5 is the optimum k for the maximum profits of new restaurants (see Table 3 and Figure 3 for details).

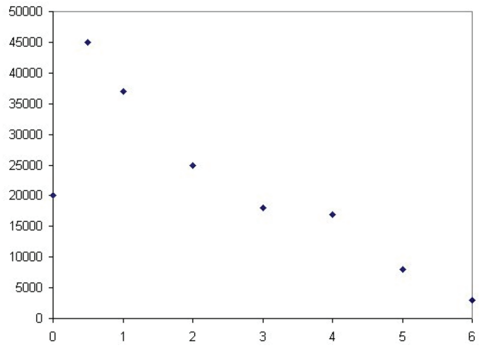

Figure 3. Results of Task c – Profit of new Restaurants Depending on the Weight Coefficient k

Resumé: Enterprise Dynamics is able to handle the high amounts of events created by the restaurants as well as the people. For executing the Tasks the Experiment Atom could be used, that allows to execute several simulation runs quick and efficiently.

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