An Agent-based Approach to ARGESIM Comparison C16 'Restaurant Business Dynamics' with AnyLogic

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Simulator: AnyLogic (www.xjtek.com) is a multi-paradigm simulator supporting Agent Based modeling as well as Discrete Event (flowchart-based) and System Dynamics (stock-and-flow) approaches. Due to its very high flexibility AnyLogic is capable of capturing arbitrary complex logic, intelligent behavior, spatial awareness and dynamically changing structures.

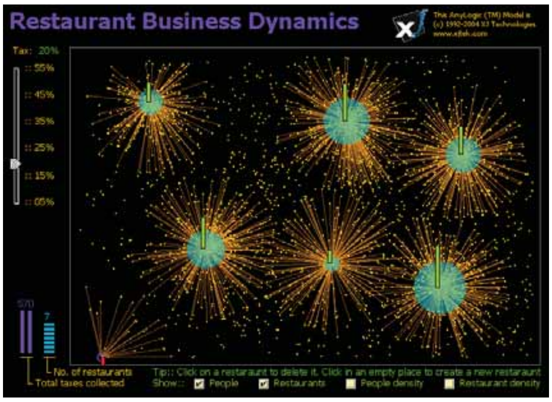
Model: The model was developed in a pure Agent Based "decentralized" style where the modeler defines the behavior of the individual agents (people or restaurants) and observes how the global behavior emerges from their interactions instead of defining a flowchart or other "centralized" view on the system. At top level there is a number of active objects of class Person and a number of objects of class Restaurant.

Space: Both people and restaurants have *(x,y)* coordinates in 2D continuous space, and their initial placement is done at model startup using various probability distributions. The *distance* function is also defined at this level. The people density is calculated once at startup and remembered in the array *pdensity* and the restaurant density *rdensity* is calculated each time a restaurant is opened or closed. *Time:* Restaurants act on weekly "ticks" generated by the *weeklyUpdateTimer* and people have their own events.

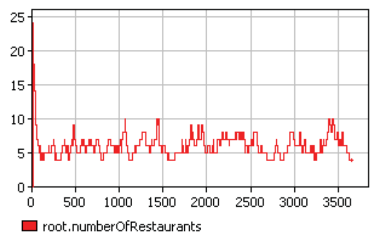
Person: Each person keeps a list of nearest restaurants *nearest* that is updated upon opening or closing down event, and a *diningTimer* that is setup to go off with the uniformly distributed inter-dining interval as required by definition (only when the current *nearest* list is nonempty). The function eat() of a randomly chosen restaurant is called in this case, which adds 1 to its *thisWeekRevenue* variable. *Restaurant:* Each restaurant has variables corresponding to its weekly financial results that are updated synchronously at the end of each week. After that the restaurant applies the strategies defined in Java:

```
//find cell with better people/restaurants ratio
  int k = bestCellForNewRestaurant();
  r.x = 20*(k%(int)(Model.width/20))+uniform(20);
  r.y = 20*(k/(int)(Model.width/20))+uniform(20);
  r.runningCost = runningCost;   r.tax = tax;
  m.setup_restaurants(r,uniform_discr(0,10000) );
```

The AnyLogic animation shows all individual objects in 2D space, their dynamic interactions (restaurant visits), current financial status of the restaurants and all aggregated characteristics such as weekly taxes collected or people and restaurant densities.



Task a – Time Domain Analysis. The model shows highly dynamic behavior with restaurants being started and going out of business quite a lot even with the fixed parameter values, given in the following chart of the number of restaurants (the model time unit is 1 day). It is well seen that the warm-up period for this model is about half year. The table shows the statistics on the number of restaurants at the end of the fifth year over 50 runs.



Mean	6.34
Min	4
Max	10
Variance	1.98
Deviation	1.41
Mean Confidence	0.40

Task b – Tax Income Maximisation. We have used OptQuest™ optimizer (modified genetic algorithms) built into AnyLogic. The objective function is the accumulated tax collected during the time from 180 days (end of warm-up) to two years from all restaurants. Searching in the range [5%,60%], after about 100 iterations, OptQuest has determined the best *Tax Rate* value at **39.85%** with objective function value is 17,727.

Task c – Restaurants' Revenue Analysis. *k=0* means we ignore other restaurants, starting restaurant where people live more densely. High values of *k* mean we open restaurants as far as possible from other restaurants paying less attention to people density. The criteria for choosing the best value for *k* is the accumulated revenue averaged for all restaurants over a period of 5 years. For simplicity, again optimisation was used, OptQuest™ found a value at 0.546 that corresponds to maximal revenue of 7838 – so that **0.5** is the best value for *k*.

C16 Classification: Agent-based Approach
Simulator: AnyLogic 5.0.2, 2004