Battle of sexes

1 Structure

The project consists of 5 classes:

1. Population class: has defined attributes that characterize population such that population number that tracks number of all instantiated humans, state of population that keeps ratios of each type of individuals w.r.t population number in percentages and type count attributes that counts total number of representatives of each type. Constructor of population class sets population number to zero, sets all portions as well as number of individuals of each type to zero. Generate method generates 50 objects of class Men or Women depending on a gender argument provided. Function randomly decides of which type from the defined array of types newly created object will be. Update hp method updates hp of pair of humans passed to method as argument and invokes check hp method that interrupts a thread if its hp is smaller than 1

    1.1. Human class (inner class of Population) that extends Thread class has following attributes: name of individual, health points that is sort of level of happiness, and type that can one of the following values: F stands for faithful, P stands for philanderer, C stands for coy and S stands for fast. Constructor of class Human first calls super constructor of Thread class and assigns the object to static ThreadGroup variable that is initialized in Main class. Then constructor sets hp to zero, increases population number by 1 and updates state of population as well as type count attribute

2. Men class is a child class of Human that has counter attribute that increases whenever new object of class Men is instantiated and a static list of all Men objects. Men's class constructor first calls its parent's constructor, increases the

counter and adds object to the men's list. Then it has run method that is the core functionality of program that will be described later.

3. Women class is also a child class of Human with counter, list of all Women objects and a queue where women are waiting for their couple. Constructor of Women class is pretty the same as constructor of Men class. Then it has date, birth and run methods that will be described later

4. SynQueue class is a class where a synchronized queue is defined together with basic operations that can be performed with the queue such as insert, extract

   4.1. Elem class is nothing more than an inner class of SynQueue where a structure of the queue element is defined

5. Main class contains driver code

6. The last class is Utility class that was made to store some utility functions to make code more compact and readable. It has following functions implemented: cos_sim that measures similarity of two sequences of numbers and copy that copies values from hash map to list

2 Model

In run method of Women class, woman object gets into a loop where she enqueues herself using synchronized insert method, so insertion is completed sequentialy and waits for a man to "go on a date" with, when men "appoaches" the queue and "invites her on a date" i.e., extracts her from a queue that is also synchronized action, men thread invokes date method that do 2 things: calls

birth method and notifies a womam thread. Birth method creates new Woman or Man object using already described constructors based on a random choice. When gender is chosen, type is assigned based on a gender, if it's a boy then he is of father's type, if it's a girl then she is of mother's type. Then a "born" thread is started and update hp method is called, where hp of parents are updated accordingly to Dawkins' payoffs matrix and parameter values . After that update check hp method is invoked that checks hp of parents, if hp of one of the parents is below 1 then it "dies" i.e.,thread is interrupted. In case when Men approaches the queue and there is no woman, he has to wait until a woman gets in a queue. 1 iteration can be interpreted as 1 year. At the end of each iteration hp of a Human is checked, if it is below 0 then thread is interrupted, in other words it "dies"

3 Simulation

Simulation is driven by Main class. Initially 50 men and 50 women are created, as it has been previously mentioned type of each individual from initial population is chosen randomly using Random class. Then all the threads are started and run methods are invoked. To keep track of previous state of each iteration, a variable prev state is initialized that initially is the same as current state. After that we are entering the loop where condition regarding similarity of current state and previous state is put, since in the first iteration current state and previous state are identical, there is additional condition that is in disjunct from the previous one that checks if it is the first iteration. In other words, if similarity is greater than and it's not a first iteration than simulation terminates, otherwise it goes on. Inside the loop the main thread sleeps 2 seconds to let simulation evolve. One iteration in main has nothing to do with

the Men and Women run method iteration. Here program just takes snapshots of simulation at a different point in time and checks for a convergence. When simulations is terminated all threads are interrupted and final state is returned

4 State similarity function

In order to measure similarity between current state of simulation and its previous state I used so called cosine similarity that takes two vectors of numbers and returns number in range [0;1] where 0 means that vectors are orthogonal and 1 that they are colinear. I chose to set threshold to 0.9999, that is 1 degree angle between vectors, above which simulation will be terminated. Mathematical formula for cosine similarity is following:

$$\text{similarity} = \cos(\theta) = \frac{\mathbf{A} \cdot \mathbf{B}}{\|\mathbf{A}\|\|\mathbf{B}\|} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}},$$

Where A and B are n-dimensional vectors, in my case they are 4-dimensional, since there are 4 types of humans.

5 Observations

Test number	Parameters	Initial population	Final state (P,C,S,F)	Iterations until convergence
1	A=15, B=20, C=3	100	(26,24,26,24)	7
2	A=15, B=20, C=3	100	(22,21,29,28)	4
3	A=15, B=20, C=3	100	(19,27,24,30)	7
4	A=15, B=20, C=3	100	(22,21,28,29)	6
5	A=15, B=20, C=3	100	(20,27,23,30)	7

With Dawkins' suggested parameters values and initial population equal to 100, model converged in average in 6 iterations with average final state (22,24,26,28). Let's halve the initial population and see how this nuber changes

Test number	Parameters	Initial population	Final state (P,C,S,F)	Iterations until convergence
1	A=15, B=20, C=3	50	(22,32,18,28)	4
2	A=15, B=20, C=3	50	(24,23,27,26)	4
3	A=15, B=20, C=3	50	(26,23,28,23)	4
4	A=15, B=20, C=3	50	(30,29,21,20)	3
5	A=15, B=20, C=3	50	(27,30,20,23)	8

With Dawkins' suggested parameters values and initial population equal to 50, model converged in average in 4 iterations with average final state (26,27,23,25). Let's change the parameters values. No essential changes are observed

Test number	Parameters	Initial population	Final state (P,C,S,F)	Iterations until convergence
1	A=5, B=20, C=3	100	(22,33,16,29)	6
2	A=5, B=20, C=3	100	(25,35,15,25)	13
3	A=5, B=20, C=3	100	(33,43,6,18)	9
4	A=5, B=20, C=3	100	(27,40,10,23)	13
5	A=5, B=20, C=3	100	(36,43,6,15)	9

After decreasing A value to 5 we can see significant decrease in proportion of 'Fast' women in a final state of simulation with average 11% and hence significant increase in proportion of 'Coy' women with average 39%.Average number of iterations is 10. Let's increase A value back to 15 and increase C value to 20

Test number	Parameters	Initial population	Final state (P,C,S,F)	Iterations until convergence
1	A=15, B=20, C=20	100	(24,13,37,26)	7
2	A=15, B=20, C=20	100	(32,14,36,18)	5
3	A=15, B=20, C=20	100	(33,18,33,16)	6
4	A=15, B=20, C=20	100	(36,23,27,14)	10
5	A=15, B=20, C=20	100	(31,13,37,19)	8

After increasing C value to 20 we can see decrease in average share of 'Coy' women in a final state to 18% and consequent increase in ''Fast' women share to 34%, also for the first time we can see considerable difference in share of 'Faithful' and 'Philanderer' men with 19% and 29% shares respectively

6 Screenshots of differents runs