**Performance tests and analysis**

In order to optimize this project, the first step is profiling to discover if it is efficient or quick. Timing by hand is the method that was chosen to reduce impact on overall code performance. Through adding some timing calls, the results showed that the updating part cost the most CPU time. It was exactly what we expected. For improving the performance, the logic of the calculation the new number of animals was optimized. In this project, the water part does not need to be calculated in iterations, which increases the time-consuming of the whole code. Therefore, the project only calculates the non-water part through updating. The experiment was conducted in different size of landscapes, which indicated the larger size caused more CPU time.

For compiler part, JVM of IBM can conduct mathematical computation in a quite fast level of speed. Also, JVM of BEA handles a large number of threads and network sockets in best performance. However, JVM of Sun usually handles whole business logic in best performance, and it has been used for out project due to that reason. Although Java does not have such many flags to improve compiling performance compared with C language, VM supports HotSpot compilation, which introduces the cache mechanism to store binary codes temporarily generated by Java codes with high frequency of being executed. The garbage collection is embedded by virtual machine automatically, and that kind of mechanism can collect memory that was not used by object and clear the fragments of memory.

From the results, some conclusions can be obtained.

Firstly, if the initial numbers of hares and pumas obey the natural laws, the trend of changing in pumas is always following the trend of changing in hares.

Figure 1. The average population per square of pumas (0 to 5) and hares (0 to 5) in different times of output in 2000 x 2000 grid squares

It is in line with the ecological laws of nature. In a certain extent, an increase in the number of prey will cause an increase in the number of predators, but both growth and reduce of the number is not on the same period of time. The time of maximum number of prey is not same with the maximum number of predator. The reason is that the time of maximum number for predators is the greatest inhibition to prey.

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Figure 2. The average population per square of pumas (0 to 20) and hares (0 to 5) in different times of output in 2000 x 2000 grid squares

Figure 3. The average population per square of pumas (0 to 5) and hares (0 to 20) in different times of output in 2000 x 2000 grid square

Secondly, when the number of pumas and hares start with different level from the natural theory, for example, the density of pumas takes random values from 0 to 20 and hares from 0 to 5(Figure 2), and the reverse situation(Figure 3). From the results of the experiment, we can find that the initial setting of percentage or the gap of predators and preys will not influence the global trend of the change of pumas and hares, which means on the overall perspective, the number of pumas are always changed by the number of hares. However, from Figure 2 and Figure 3, there are also some differences from Figure 1. For the circumstance of more pumas, the number of preys will drop dramatically due to the reason of pumas’, and meanwhile pumas will also decrease in this period of time, while in the latter case, the large number of preys will lead to the increase of the number of predators.

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Figure 4. The average population per square of pumas (0) and hares (0 to 5) in different times of output in 2000 x 2000 grid squares

Figure 5. The average population per square of pumas (0 to 5) and hares (0) in different times of output in 2000 x 2000 grid square

Thirdly, when setting the densities of pumas and hares to 0 respectively, the number of prey grows exponentially in the absence of the presence of predator (Figure 4) while the number of predator decrease exponentially in the absence of prey (Figure 5).

Fourthly, the “gif” file was created from many .ppm files in output to show the results clearly. It indicates that no matter how uneven the initial densities of pumas and hares are, they will shortly distribute evenly. And the densities or the numbers will rise and drop circularly.

Finally, the situation that non-water grid squares is discontinues was considered, but it caused the non-real birth and death.