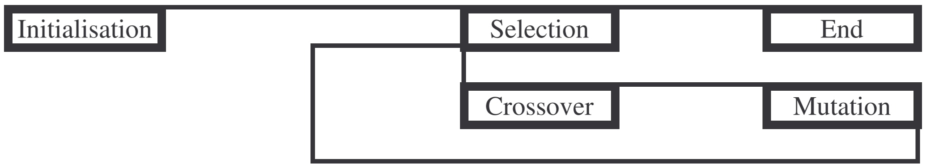
Production Schedule by Means of Genetic Algorithms

There are problems that nature handles easily, although they are irresolvable by man-made algorithms. The problems of this kind are usually encountered in complex and changing environments such as economy. Mathematicians have studied nature and by analogy have developed two methods; Artificial Neural Networks and Genetic Algorithms. The Genetic Algorithms are used when seeking an exact solution through a systematic examination would be almost infinitely long. The Genetic Algorithms offer a very elegant solution to complex decision problems such as production schedule.
The Genetic Algorithms provide a computerised solution and can be applied to problems which can be compared to the evolution of an animal species population. The surviving selected individuals and the descendants of parents of other selected individuals form a new generation of solution while the past generation becomes extinct. This process reoccurs in series of hundreds or thousands.

The repeating reproduction process is called a generation and consists of the three following phases: selection, crossover and mutation.



Reproduction process

Selection: Two chromosomes are selected for the reproduction process according to their strength; stronger chromosomes are more likely to take place in reproduction.
Crossover: During the crossover a chromosome couple is matched with a new chromosome couple. The crossover consists in a mutual exchange of identically long sections of the two bit chains.
Mutation: The chromosome mutation produces a new chromosome while there is little probability of bits changing into their components.

The Genetic Algorithms can be applied to calculate an optimum production process. The following practical example demonstrates the determination of the optimum production schedule.

Production schedule – basic definitions
The models used to determine an optimum chronology of operations sequence (order) can be applied to working a production schedule. Therefore, they are sometimes referred to as **sequencing problems. These problems occur whenever there is a choice of more different sequences of performing individual operations.** In concrete terms, it can be scheduling manufacture through various machines, organising a queue of tasks to be executed by a computer or finding an optimal route for a travelling salesman. **It is crucial to find out which, out of all the possible sequences, is the optimum according to a particular criterion.** For example, **the minimum processing time for the given operation or the minimum penalty for the delayed completion of work.** The optimum solution to these problems can be found by means of various (standard) analytic models.

The advantage of using analytic models for production scheduling **lies in** their **high precision** – if there is an optimum, it will be found. However, there is one **major limitation** of these models regarding their use in practice and that is the number of machines employed in manufacture. The standard models such as Johnson's Algorithm only count with two machines and they strive to find a sequence of processing pairs of jobs through both the machines which would minimise the processing time. Some modifications to these models allow for processing through three machines.

These are the basic principles of production schedule optimisation according to standard Johnson's Algorithm when the following in known:

$A_i = t_{i1}$ - processing time of ith operation on the first machine
$B_i = t_{i2}$ - processing time of ith operation on the second machine
F_i - total processing time of ith operation performed on a product. There are two times (A_i, B_i) indicated for each product. Moreover, it applies that

1) each machine can only process one job at a time
2) each job can only be processed on one machine at a time while time A_i for each i must elapse before time B_i starts.

To sum up, according to **John's Algorithm,** jobs with the minimum processing time of one of its operations are scheduled either as first or last depending on whether the minimum processing time concerns operation A or B. If there are two jobs with the same processing times, it does not matter which will be processed first.

In practice, at first the production schedule is optimised for the two-machine system. The results of these optimisation are used as input values in another model in which the two original machines create one (fictitious) machine of the new model. In this way (in the upward sequence) the optimum solution can be finally reached. There are also modifications to the standard algorithms enabling scheduling production through three machines. **Solving practical situations (problems) is** however **a domain of heuristic and simulation techniques** often using **principles of the network analyses or even the theory of queues.**

Application of Genetic Algorithms to production schedule working

There are 12 products to be manufactured of which 2 products are of A type, 3 products of B type, 2 products of C type, 3 products of D and 2 products of E types. The processing is through 6 different machines. The processing times are different for different products on different machines and they are displayed in the table. There are a total number of 21 machines and their locations are also displayed in the table. If the products were manufactured one by one from number 1 to number 12, the total processing time would be 26 hours and 24 minutes. The total processing time can be minimised by finding the optimum sequence of the products manufacturing. As a result, when scheduling the process in the following sequence: 11, 4, 1, 6, 9, 12, 7, 8, 3, 10, 5, 2, the total processing time will be 22 hours. This reduces the processing time by 6 hours and 24 minutes, shortens idle time and consequently saves production costs.

Before optimal.:

After optimal.:

Product number	Product type
1	A
2	A
3	B
4	C
5	B
6	D
7	E
8	E
9	B
10	D
11	C
12	D

Sequence of products		Sequence of products
1	First	**11**
2	.	**4**
3	.	**1**
4	.	**6**
5	.	**9**
6	.	**12**
7	.	**7**
8	.	**8**
9	.	**3**
10	.	**10**
11	.	**5**
12	Last	**2**
26.40		22.00

Operation number	Number of machines
1	2
2	3
3	4
4	5
5	4
6	3

Operation number	A	B	C	D	E
1	0.2	0.4	3.0	1.4	1.2
2	0.4	0.6	4.0	1.2	0.6
3	0.6	0.8	5.0	1.0	0.8
4	0.8	0.6	4.0	0.8	1.0
5	0.6	0.4	3.0	1.6	8.0
6	0.5	2.0	3.0	0.9	1.6

Table displaying the sequence of products processing before and after optimisation

It is evident that all the input values can be changed (the number of products to be manufactured, number of product types, processing time with regard to a product and workplace as well as the number of machines in the operation). That is how the application of Genetic Algorithms can help to optimise operation, reduce costs and increase the product profit.

Conclusion

Genetic Algorithms can be successfully applied to some traditional areas of the operations research which used to work only with deterministic models. However, the models based on the principles of Genetic Algorithms should not be interpreted as a competitive instrument against the simulation models but as another possible method to simulate complex decision processes, often difficult to express in algorithms. Practical operation management (machine or electronic manufactures) is certainly one of these processes. This paper aspires to show (mainly to the management of these manufactures) how the Genetic Algorithms (or other instruments of artificial intelligence) can be used in the process of production schedule optimisation.