VGO Oil & Gas LLC

How Evolutionary Computation Projects Can Change Large Organizations

“Artificial Intelligence” works for complex operations

How Evolutionary Computation Projects Can Change Large Organizations

- **Evolutionary Computation** is a subfield of artificial intelligence (more particularly computational intelligence) that involves combinatorial optimization problems.
- Evolutionary computation uses iterative progresses, such as growth or development in a population. This population is then selected in a guided random search using parallel processing to achieve the desired end.
- Such processes are often inspired by biological mechanisms of evolution.

From Wikipedia

VGO Oil & Gas LLC

Introduction to Evolutionary Computing

- Evolutionary Computing (**EC**) is the collective name for a range of problem-solving techniques based on principles of biological evolution, such as natural selection and genetic inheritance.

- These techniques are being increasingly widely applied to a variety of problems, ranging from practical applications in industry and commerce to leading-edge scientific research.

A.E.Eiben & J.E.Smith

Outline

- Potential work process and organizational changes
- Case history I: Agricultural company
- Case history II: Air Liquide
- Case history III: Occidental Petroleum
- Conclusions

Potential work process changes

- EC projects can change work processes
  - by doing what people do, and better
  - by integrating functions and/or data
  - by making processes go faster
  - by capturing expertise for future reference
- We make sure in your planning phases that everyone understands what the work process changes will be

VGO Oil & Gas LLC

Potential incentive changes

- When optimization is global rather than local, some people's incentives may be impacted
  - Global allocation may reduce local resources
  - Global allocation may impact key local metrics
- We recommend you understand this impact on everyone's incentives, and modify the incentive structure if required

VGO Oil & Gas LLC

Potential staffing changes

- In general, companies don't fire experts after optimization—their expertise is useful and often can't be put into databases or programs
- Experts may change their activities significantly, however
  - They usually don't like doing what the computer program will do for them
  - We try to make their expertise valuable in the new system

VGO Oil & Gas LLC

Potential budgeting requirements

- EC systems may change the budgets required
- Make sure that changes in the budget caused by an EC system are understood in advance
- Make sure that the financial impacts of the system are quantified after installation and revisions

VGO Oil & Gas LLC

Case history I: Agriculture company

- The system was created to optimize sugar cane planting schedules
- It was resisted each step of the way by the majority of farm managers
  - Their bonuses were linked to their fields' productivity
  - The system would allocate resources globally
  - They did not believe that a computer could schedule better than they could
  - The culture included a proprietary view of the operations of each farm

VGO Oil & Gas LLC

Resistance

- The president of the company required that the farm managers pass their planting data to the research department so the system could be run
  - They did not do so for two years
- The Board of Directors required that the farm managers cooperate with the project
  - They did not do so

Resistance (cont.)

- A large consulting company was hired at great cost to analyze the agricultural company's operations
  - Their first recommendation was that the system be implemented and used
  - Still resistance continued
- Ultimately, after a three-year delay, more than half the farm managers were fired and the system was used
- Its projected increases (4%) were realized

VGO Oil & Gas LLC

A Critical Result

- Production had increased as a result of the system's operation
- The president asked the vice president to determine how much production would be lost if the 10% worst-producing fields were sold
- The answer: Production would increase!
  - Because of a bad constraint on fallowing each seven years

VGO Oil & Gas LLC

Evolution of the system

- The president asked whether it would be useful to put on a second shift at the mill, given the increased production
  - Efficiency of the second shift was reduced
  - Answer: no significant changes in profits
- The president asked whether it would be useful to take in cane from farmer cooperatives
  - Answer: yes, under certain conditions and at certain times

Evolution of the system, cont.

- A simple planting scheduler became the economic oracle for the company
  - It could re-optimize to determine the best reaction to large changes in the supply chain
  - It could integrate economic and other considerations to produce the best schedule under different conditions
  - It had proved itself in multiple ways in the past
  - The farm managers now used its heuristics rather than their own when scheduling

VGO Oil & Gas LLC

Summary of impacts on the company

- Top-level management could plan without depending on the instinctive reactions of the farm managers, which were not always objective
- Increased production—very significant
- Dramatic turnover in staff
- Significant power struggles were resolved
- Change in the power structure of the company
- More effort could have been spent in the beginning to diffuse resistance

Case history II: Air Liquide NA

- Air Liquide does $3B per year in North America, producing and selling industrial gases
- Primarily oxygen and hydrogen
- It has pioneered several applications using complexity science/evolutionary computation techniques
- These systems use Ant Colony optimizers, genetic algorithms, tailored heuristics, human expert heuristics, and mixed integer programming

VGO Oil & Gas LLC

About Air Liquide NA

- Air Liquide delivers products in two ways: gaseous form through twin pipelines, and in liquid form by truck
- 40 producing plants, 8000 client sites
- Solution includes a genetic algorithm for plant production and an ant colony optimizer for planning truck routes

VGO Oil & Gas LLC

How the system changed the way people worked

- The experts in the Operation Control Center reviewed the system's schedules for several months before the system could be approved for use
- They discovered many constraints and model features they hadn't thought to tell us
- They gave us multiple new heuristics that they had developed and that were included in the system

VGO Oil & Gas LLC

Two-way flow of heuristics

- Sometimes the experts reviewed solutions they would never have employed, and discovered that those solutions were viable
- They would then think of new heuristics that could generate those solutions ("consider larger bulk shipments to isolated plants!")

VGO Oil & Gas LLC

Metaphor Changes

- The experts changed some of the metaphors they used to generate schedules and attack new problems
- They had always begun with a “all plants off” state when building a new solution
- They liked the way the system’s seeding algorithm started from an “all plants on” state and sometimes used that

What-if support

- Significant changes to the production and distribution networks could now be assessed through simulation rather than instinct
  - Change truck fleet size?
  - Change empty truck policy?
  - Use client tanks as capacitors?
  - Change red line levels?

Summary of impacts on Air Liquide

- Significant reduction in costs, increases in profits
- Increased visibility of 21st-century approaches in the company
- Increased performance levels for humans in the Operations Control Center
- Ability to optimize globally rather than locally
- Creation of a new, complicated initiative to integrate production and distribution functions
- Requirement to change incentive criteria

VGO Oil & Gas LLC

Case History III: Occidental Petroleum

- Using probabilistic simulation to plan well workover schedules and equipment requirements resulted in many changes to the field organization
  - Flow of information was restructured
  - Approval for ordering equipment that might not be used was required
  - New metaphors used by field personnel
  - New description of the workover process was created and is becoming a company-wide standard

VGO Oil & Gas LLC

Occidental Petroleum

- Occidental is making the transition from deterministic, 20th-century planning to stochastic, 21st-century planning
- The transition has gone very well
- No one in the field would have predicted this when the ideas were first presented
- A tremendous amount of project management expertise was required in order to accomplish this transformation

VGO Oil & Gas LLC

Transforming Effects: Conclusions

- Increased profit, decreased costs, and higher levels of service are wonderful changes in themselves
- Work processes modified to be more effective are good results of EC projects
- Greater use of experts' knowledge and less drudgery on their part are good results
- Changing the metaphors can be a critical outcome of an EC project

VGO Oil & Gas LLC

Transforming Effects (cont.)

- It's good when experts create new heuristics based on observation of system results
- Changing from deterministic to non-deterministic thinking can be a critical outcome
- Use of the system to advise on strategic decisions is a good outcome
- A successful system encourages the company to think about other potential problems and solutions

VGO Oil & Gas LLC