Using Object Orientated (OO) and Artificial Intelligence (AI) technologies to solve complex forestry logistics issues

Liro Conference
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Summary

"Anyone can cut a log, but only a few are making money out of it" - a truism which is particularly relevant to-day. In New Zealand we have the additional costs of managing and developing forests, with smaller markets and wider product ranges. These create more complex planning problems than elsewhere.

New technologies enable the wood products industry, specifically logistics in forestry, to maximise profitability and improve strategic agility in responding to change.

We need to think and act smarter in managing and maximising the complexity in our forestry logistics and apply appropriate solutions in this field. The two issues to bring focus to this session are :

- How important is it?
- What are the benefits?

Firstly, a definition of Logistics

Logistics encompasses everything involved in getting the right product to the right place at the right time and the right price -

- at maximum profitability and
- with greatest efficiency

The case for 'profit' optimisation

Planning processes in manufacturing tend to be top-down :

1. Strategic and Tactical Planning

Strategic and Tactical Planning seeks to find the most profitable way forward using simulation or linear programming (LP) optimisation techniques.

Simulation allows you to examine very complex situations on a step-by-step basis. By comparing one step with the next, you can figure out how to move to better situations.

LP (or LP-type) optimisation examines every possible combination of costs and/or selling prices presented to it, and re-iterates and re-iterates until an 'optimal' solution is found; either least cost or most profitable.

In logistics, LP simultaneously considers all costs, constraints, business objectives, and other variables across logistics (supply and revenue) structures, processes, and activities to identify all feasible options to determine the most profitable resource flow.

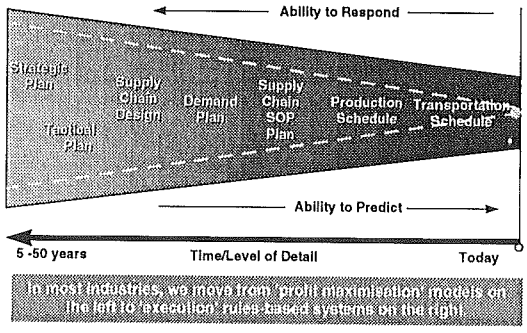
2. Sales and Operational Planning (SOP)

Following the Tactical guidelines of where to produce which products, SOP produces the Master Production Schedule (MPS). Forecasts, current and planned orders drive the MPS process, which requires complete visibility across the supply chain as to what is Available-to-Promise (ATP) and what are the capacity constraints.

3. Execution

The detailed synchronisation of production and logistics schedules 'executes" the SOP using rules-based heuristic algorithms.

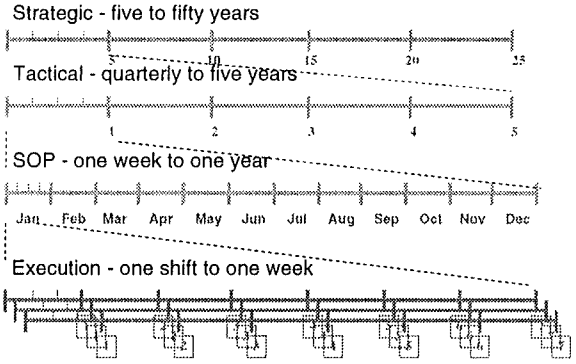
Integrated Planning Heirarchy moves from cost to execution focus



Profit optimisation in forestry

However, there is a strong case for a continued focus on profit optimisation at all planning levels in forestry.

Planning Horizons in Forestry



Empirical evidence appears to indicate that LP-type optimisation has achieved :

Strategic level	2 - 6%
Tactical level	3 -10%
Operational level	2 - 4%
Execution level	1 - 3% of sales

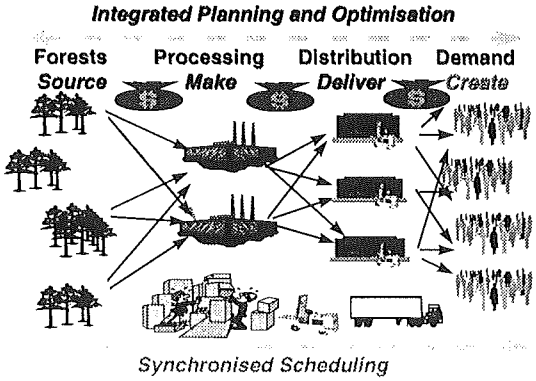
turnover being added to the bottom-line.

This is due to the complexity of the issues and the variability of raw materials, WIP and product outputs.

What is the complexity?

Questions such as *"Which trees or stands do we fell?, which 'cut patterns' do we use at which mill or process line?, what market shall we go for?"*, in order to maximise profitability for the next week or over the next 30 years is as complex a problem as you would face in any industry to-day.

The Forestry Supply Chain



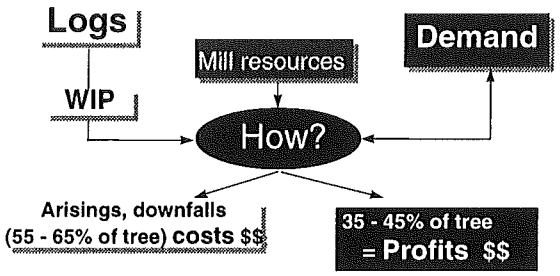
Synchronised Scheduling

In fact, the forestry industry was one of the first users of linear programming (LP) techniques over 30 years ago in addressing this problem.

To-day optical scanners compute the best cuts or best utilisation of incoming logs using LP. But this may not necessarily be the most profitable cut in terms of market demand.

The Mill Planning dilemma :

How to meet demand in the most profitable way



Getting an extra 3 - 4% out of a tree is an attractive possibility!

Demand-driven LP models achieve most profitable situations across the entire supply chain at the higher levels of planning, strategic and tactical. At these levels, the higher level costs and product characteristics (grade, condition only) keep the time to solve to acceptable limits.

But at the SOP and the Execution levels where detailed activity costs, product SKU's (size and length) are essential ingredients, solve time is of the essence. Generic LP engines, examining every possible option) are just not able to solve within acceptable time limits.

Not only are you increasing the complexity (number of variables and number of constraints) as you drill down, but you also introduce "rules-based' heuristics to deal with the more detailed and operational aspects of your business.

For example, as you step costs or test for price / volume breaks, an LP can only solve for a linear data, i.e. one set of costs or prices at a time. Having solved for one set of data, it would store and compare these against the best results for the next set of cost or price / volume ranges, and so on, until it has solved for every business step or rule you introduce.

Stepping down from a Tactical model (say, 3 hours to solve) to the SOP level, a 30 hour solve time is not acceptable. Especially if you want to run a couple of 'what if's" options

or scenarios. Certainly a 150 hr 'Execution' solve time needed every day is out of the question.

Improving solve time performance

Obviously, CPU clock speed is critical but even future 600Mhz speeds are not going to be adequate. A 20% increase in speed may produce a 20% (not more) whereas we are looking for 10x - 100x faster solving times.

Creating boundaries or barriers around your 'solve area' within the solve engine has produced as much as a 50% reduction in solve time, but this is still not adequate.

Using hardware and software parallel solving capabilities is one possibility, but package solution vendors would need to re-write their software, which prepares both the LP instructions and the data, for the parallel LP engine to solve. And again, this would only be useful or applicable where parallel solving is a requirement within the problem definition.

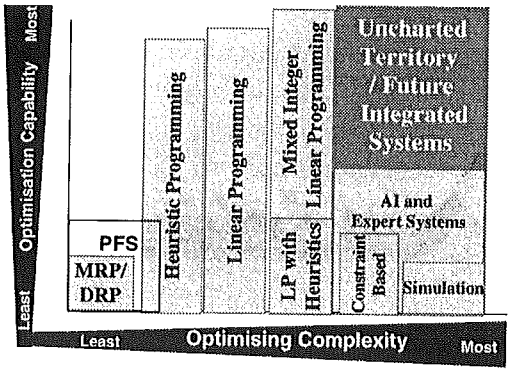
Mixed integer linear programming (MILP) enables one to 'write' the business rules or heuristics into the solving engine. This produces dramatic improvements in performance (claims of 10 x - 100x have been made). But these are highly customised to a particular set of circumstances and business rules, and would take time and expense to develop, even if you had the right resources. This has, however, been done successfully by some chemical and wood products companies.

AI and Expert systems

These enable you to combine your operational and business knowledge and experience with 'profit maximisation' (LP-type) models. They also provide a 'learning' mechanism to assimilate this knowledge and experience into rules-based or heuristic models.

Both heuristics and simulation techniques are used to manage the constraints and reduce the feasible solve area to one which an LP or MILP can solve within acceptable time limits.

Solver Technology Positioning



(Note that, as a matter of interest, Constraint Based or TOC-type models are similar to pure simulation in that their inherent design characteristic allows for only 'one pass' solving.)

Proven solutions

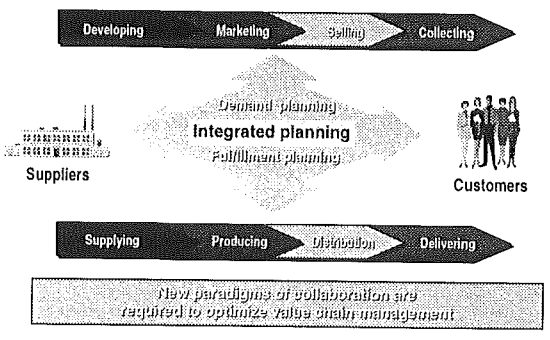
Within the wood products industry, there are possibly more than the three successful AI, expert systems or constraint managed optimisation that I have come across. But it is clear that such approaches seem to be the only ones that provide the performance, flexibility and integration required at the SOP and Execution levels of planning.

The Case for OO technologies in streamlining forestry logistics.

Value-added Logistics Management

This is an approach whereby cost and benefit options in the logistics process are aligned with or related *to the other strategic planning units as a means of improving stakeholder value. Integrating both the revenue chain and the supply chains enables us to assess the impact of changes of any one element or to suggest optimal scenarios.

Integrated value chain management enables breakthrough competitive advantage



Logistics Agility

This is the ability to respond to and seize emerging opportunities in a competitive environment of continuous, unanticipated change. Tools that enable you to do this and to assess the impacts on your business, give you increased agility.

You need to re-configure, or re-model (benefits of OO) your business process and capabilities, both internally and externally, rapidly and accurately.

Strategic Agility

The annual compound growth rate in the market value of companies who adopt strategic agility doubles that of companies who are effectively cost cutters. *"... The compound annual growth rate in the market value of the companies that achieved higher-than-average profit growth but lower revenue growth than their industry's average - the cost cutters, in other words - was 11.6% from 1989 to 1992. By contrast, the companies that achieved their higher-than-average revenue growth saw their market value jump at an annual rate double that - 23.5%. As usual, the market looks forward with wise eyes."* Fortune Magazine March 7, 1994.

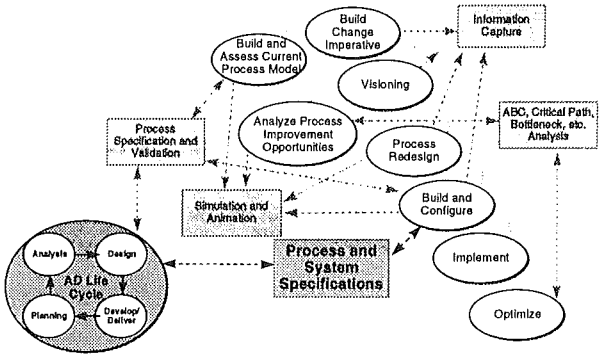
Value Added Logistics Costing.

An activity based costing methodology is critical to the process of measuring costs and benefits in both the supply and revenue chains. This provides the benchmark for assessing improvement strategies and the absolute foundation for effective optimisation for solving the most profitable options.

Generally OO enables us to :

- model business processes
- measure the processes, cost them,
- collect information,
- understand relationships and impacts,
- run simulations in seeking better ways or solutions in business processes,
- build enterprise systems and
- maximise profitability through an optimiser, quicker, more effectively than any other tool.

Process modeling tools have come a long way and are now designed to assist in each phase of a large BPR engagement



Compared to other techniques, OO enables :

1. Faster Development

- Model the process with the user,
- Rapid prototyping replaces conventional development
- Building software out of standard objects
- Re-using existing models of processes

2. Higher quality

- Programs assembled out of existing, proven components

3. Easier maintenance

- Higher quality leads to less maintenance
- Superior modularisation of OO reduces interactions between software components
- Easier to verify program functionality
- Impacts or effects of changes more localised

4. Reduced Cost

- Programming - assemble new programs out of existing components
- Design - rapid prototyping with user
- Administration - user involvement.
- Buying components is cheaper than making them

5. Increase scaleability

- Large systems are easier to build and test highly modular OO subsystems
- Easy to add new object types from existing proven components

6. Better Information Structures

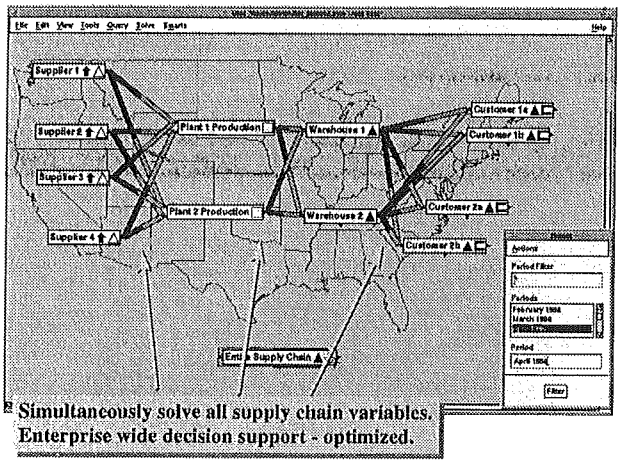
- OO can more effectively represent more complex information scenarios
- OO reflects the way people and organisations naturally think and organise
- OO enables a transition from information systems to knowledge systems

7. Increased Adaptability and Flexibility

- OO inherent adaptability is crucial in an ever changing world
- OO enables changes without re-building systems

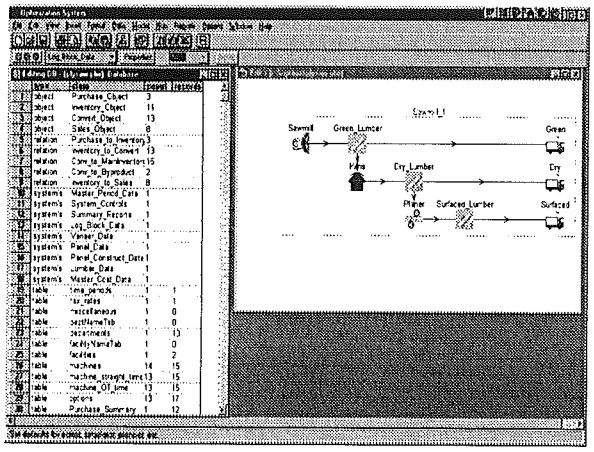
Examples of OO in :

a) Supply Chain Optimisation

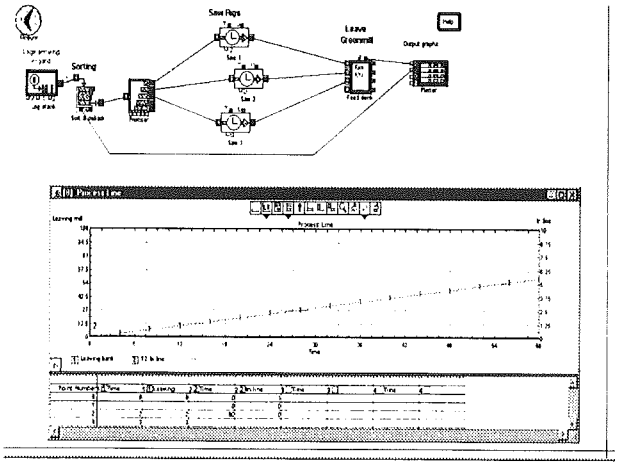


Simultaneously solve all supply chain variables.
Enterprise wide decision support - optimized.

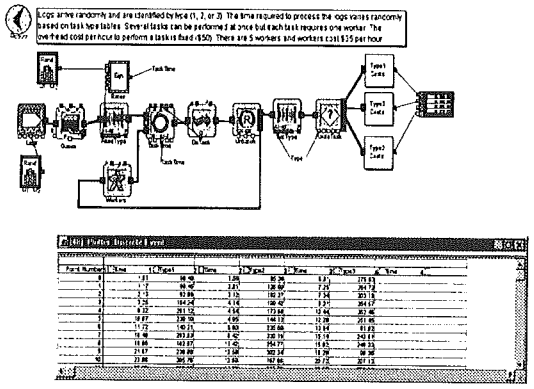
b) Mill Allocations (where to cut and how best to meet current demand). This tool uses OO to compile your own 'knowledge-base' of your specific operations, using AI with 'constraint orientated reasoning' logic in selecting the right mathematical models (simulations, heuristic algorithms, LP (or MILP) or combinations thereof).



c) Process modeling (simulation of which logs to send to which saw to get best throughput).

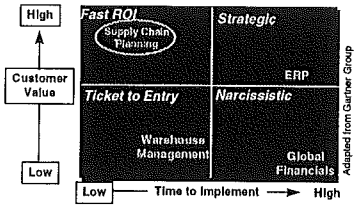


d) Activity Based Costing



Conclusions

Supply-chain initiatives can produce high value in short time horizons



A future vision and prioritized implementation strategy can be designed to be self-funded

Our experience is that Tactical opportunities offer the highest, quickest and easiest results since we are not dealing with the 'nth degree of detail and of data accuracy.

Using the latest technologies in optimisation and OO tools, Tactical models can be designed and implemented in 3 months, with results maturing within 6 months.

Using a bureaux service, like CTJ Technologies, to provide the right tools, skills and experience on an 'assignment' basis reduces both cost and risk significantly in obtaining the benefits of optimisation and OO tools. This provides opportunities to both large or small companies to become competitive in world markets.

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