Coordinated Decision Making in Telecommunications Supply Chains

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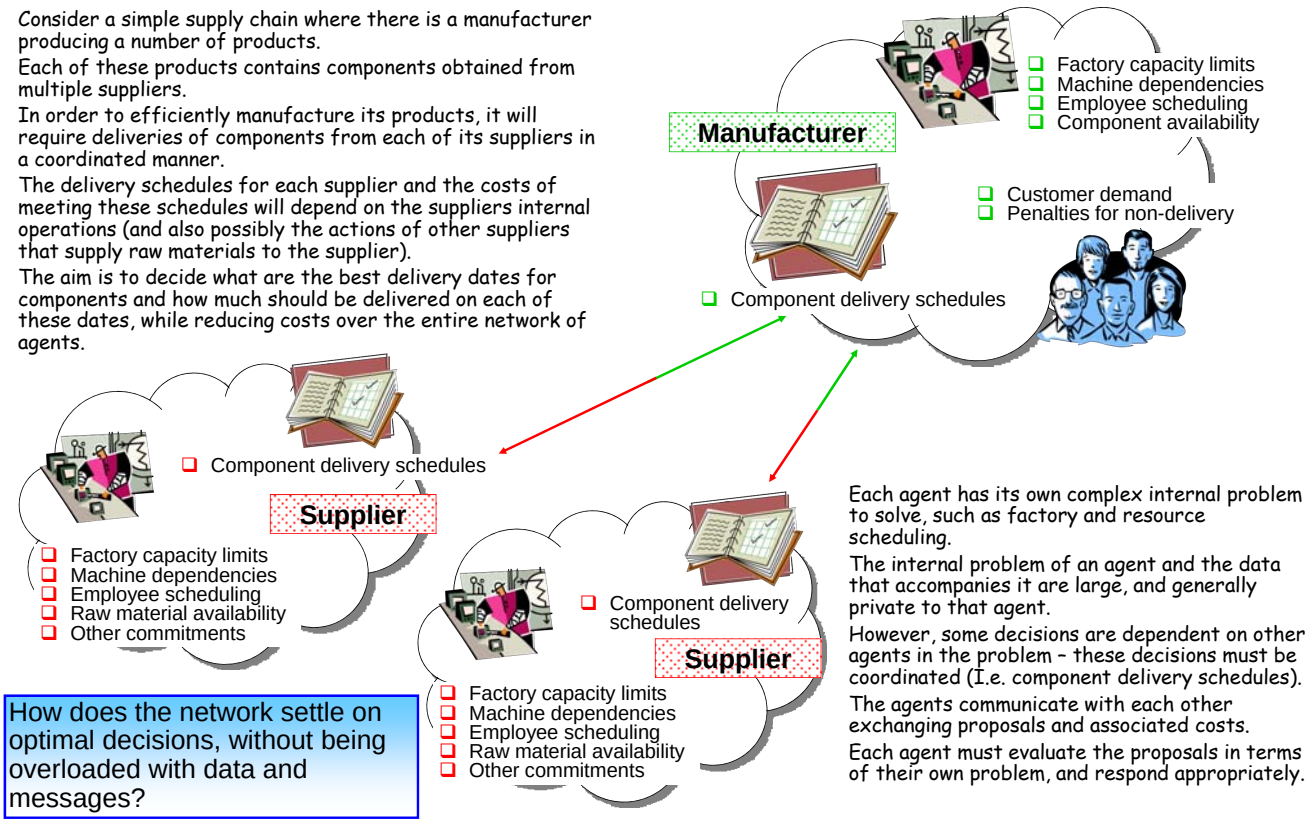
Telecommunications supply chains involve the supply, assembly and delivery of expensive components and systems across global markets. Improving total value requires effective management of this process, involving financially autonomous and geographically distributed business units and companies. We are developing methods for streamlining this coordination, allowing more efficient decision making.

Consider a simple supply chain where there is a manufacturer producing a number of products.
Each of these products contains components obtained from multiple suppliers.
In order to efficiently manufacture its products, it will require deliveries of components from each of its suppliers in a coordinated manner.
The delivery schedules for each supplier and the costs of meeting these schedules will depend on the suppliers internal operations (and also possibly the actions of other suppliers that supply raw materials to the supplier).
The aim is to decide what are the best delivery dates for components and how much should be delivered on each of these dates, while reducing costs over the entire network of agents.

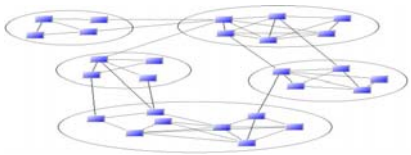


How does the network settle on optimal decisions, without being overloaded with data and messages?

Each agent has its own complex internal problem to solve, such as factory and resource scheduling.
The internal problem of an agent and the data that accompanies it are large, and generally private to that agent.
However, some decisions are dependent on other agents in the problem – these decisions must be coordinated (I.e. component delivery schedules).
The agents communicate with each other exchanging proposals and associated costs.
Each agent must evaluate the proposals in terms of their own problem, and respond appropriately.

Distributed Constraint Optimisation

- A Distributed Constraint Optimisation Problem consists of a set of *agents*, where each agent has a set of *variables*.
- Each variable has a corresponding *domain* of *values*.
- There exists a set of *constraints*, where each constraint acts on a subset of the variables. Each constraint is a *cost function*, specifying a cost for each combination of values assigned to the variables in its scope.
- The problem also has an *objective function*, which is a function over the constraints (e.g. summation).
- A solution to a DCOP is an assignment to each variable a value from its domain. An optimal solution is one which minimises the objective function.
- The solution process is restricted. Each agent is responsible for the assignment of its own variables – agents must communicate to solve the problem.



Our Research

- Existing DCOP algorithms assume very simple local problems for each agent, and so require more complex problems to be transformed before solving.
- We have developed techniques for analysing the structure of complex local problems and have developed a new "compilation" technique based on this analysis.
- This new compilation technique gains orders-of-magnitude speed-up over existing methods.
- We have also developed a new inline search technique based on this analysis, and it is even faster than our compilation method.
- We have developed an initial benchmark problem for coordination of decisions across the telecommunications supply-chain, with Ben Lowe and Mustafa Dogru of Bell Labs Ireland
- The research has been published at the European AI conference (ECAI'06) and at an international workshop at the multi-agent conference (AAMAS'06).

Related Publications

[1] David A. Burke and Kenneth N. Brown: *"Efficiently Handling Complex Local Problems in Distributed Constraint Optimisation"*, In proceedings of ECAI'06, the 17th European Conference on Artificial Intelligence, Riva del Garda, Italy, August 2006, pp701--702.

[2] David A. Burke and Kenneth N. Brown: *"A Comparison of Approaches to Handling Complex Local Problems in DCOP"*, In proceedings of DCSP, the Distributed Constraint Satisfaction workshop, Riva del Garda, Italy, August 2006, pp27--33.

[3] David A. Burke and Kenneth N. Brown: *"Applying Interchangeability to Complex Local Problems in Distributed Constraint Reasoning"*, In proceedings of DCR'06, the 7th International Workshop on Distributed Constraint Reasoning, Hakodate, Japan, May 2006, pp132--146.

[4] David A. Burke, Kenneth N. Brown: *"Interleaved Search in DCOP for Complex Agents"*. In proceedings of Doctoral Program, Principles and Practice of Constraint Programming (CP), Nantes, France, September 2006.

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