

# Distributed Constraint Reasoning

## Multiagent Systems

November 19, 2019

### 1 Meeting Scheduling

John needs to meet during the week with both, Alice and Bob. Their availability is as follows: 1) Alice can meet John on Monday and Thursday; 2) Bob can meet John on Tuesday and Thursday; and, 3) John can meet any of them on Monday, Tuesday and Thursday. Due to time constraints, John can meet them only during the same day.

- i) Formalize the problem as a Distributed Constraint Satisfaction Problem (DCSP).
- ii) Use the Asynchronous Backtracking (ABT) algorithm to find a solution to the problem.

### 2 Production Line

- i) Five independent companies (Company A, Company B, Company C, Company D and Logistic company L) need to schedule their production so that the following objectives are met:
  - Company A produces product A. The production of A takes 4 days.
  - Company B produces product B. The production of B takes 8 days.
  - Company C produces product C. The production of C takes 3 days.
  - Company D produces product D. The production of D takes 2 days. Before the production of D can start, the production of all products A, B and C must have been completed. Moreover, due to the nature of products A, B and C, the production of D must be completed before 5 days pass after the completion of any (all) of the products A, B or C.
  - Product D must be completed by January 29 (i.e. the last day the production of D can still be ongoing is January 29).
  - After the product D is ready, Logistic company L is supposed to carry it.
  - There is a need for supervision while producing products A and B, hence production times of A and B cannot overlap.
  - Once the production starts, it cannot be interrupted (i.e. preemption is not allowed).

*Example:* If the production of B starts on January 4, the production of B occupies whole 8 days from January 4 to January 11. The production of product D can then start no earlier than on January 12.

Formalize the above described scheduling problem as a distributed constraint satisfaction problem (DCSP). Use formal language to describe sets  $X, D, C, A$  and do not forget to explicitly mention what variables are controlled by individual agents. Discretize the time per days. Assume that all events happen in January. Please provide brief description of the meaning of your variables and constraints.

- ii) Draw a constraint graph for the problem described above. Indicate by arrows the direction in which Ok? messages used in the ABT algorithm are being sent given the following priorities of the agents:

- a) Company A - the highest priority
  - b) Company B
  - c) Company C
  - d) Company D
  - e) Logistic company L - the lowest priority
- iii) Simulate the ABT algorithm from the perspective of Company D. First, show how to initialize all the necessary data structures of Company D, and write what messages are sent by Company D during the initialization period. Then, process the following messages received by Company D in the given order (process one message at a time). Be specific, and justify each of your steps: describe how do the data structures of Company D get modified and why. Write the content of messages being sent and mention the agent to which each message is sent to. Consider the priorities used in task (ii).
- a) Ok? ("production of B starts on January 19")
  - b) Ok? ("production of A starts on January 27")
- Important:** Simulate the algorithm **only** from the perspective of Company D (i.e., do not show how other agents are initialized and do not discuss how they react on messages sent to them). When selecting a new assignment for a variable, select the lowest value possible.
- iv) What happens in the basic ABT algorithm when the solution has been found and how do we call such a situation in multiagent systems?
- v) Find a solution of the problem or discuss why there is none.