Distributed Constraint Reasoning

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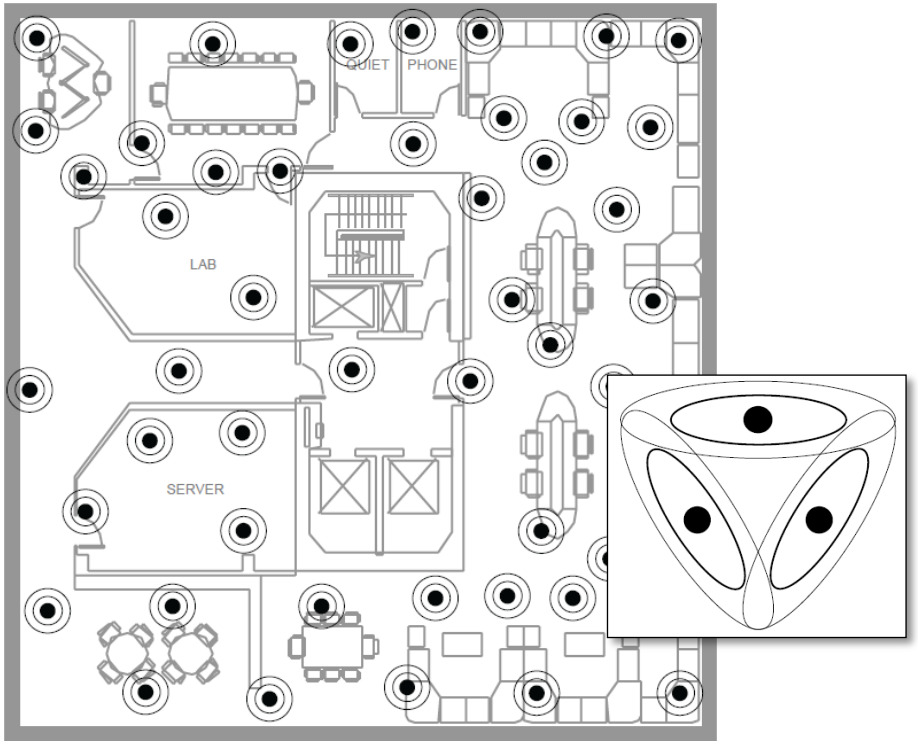
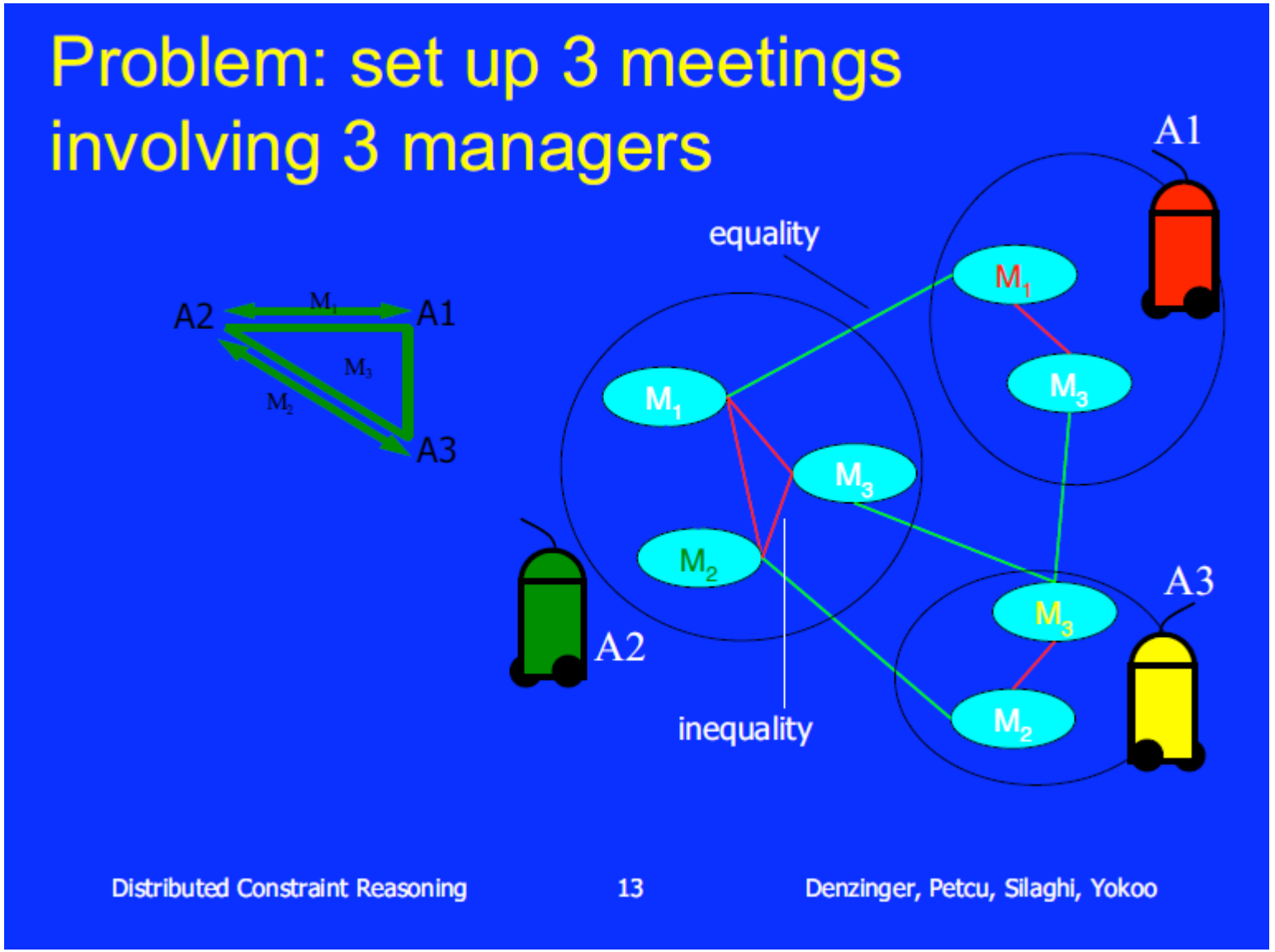
(based on slides by Jose M. Vidal)

Channel Allocation in Sensor Networks



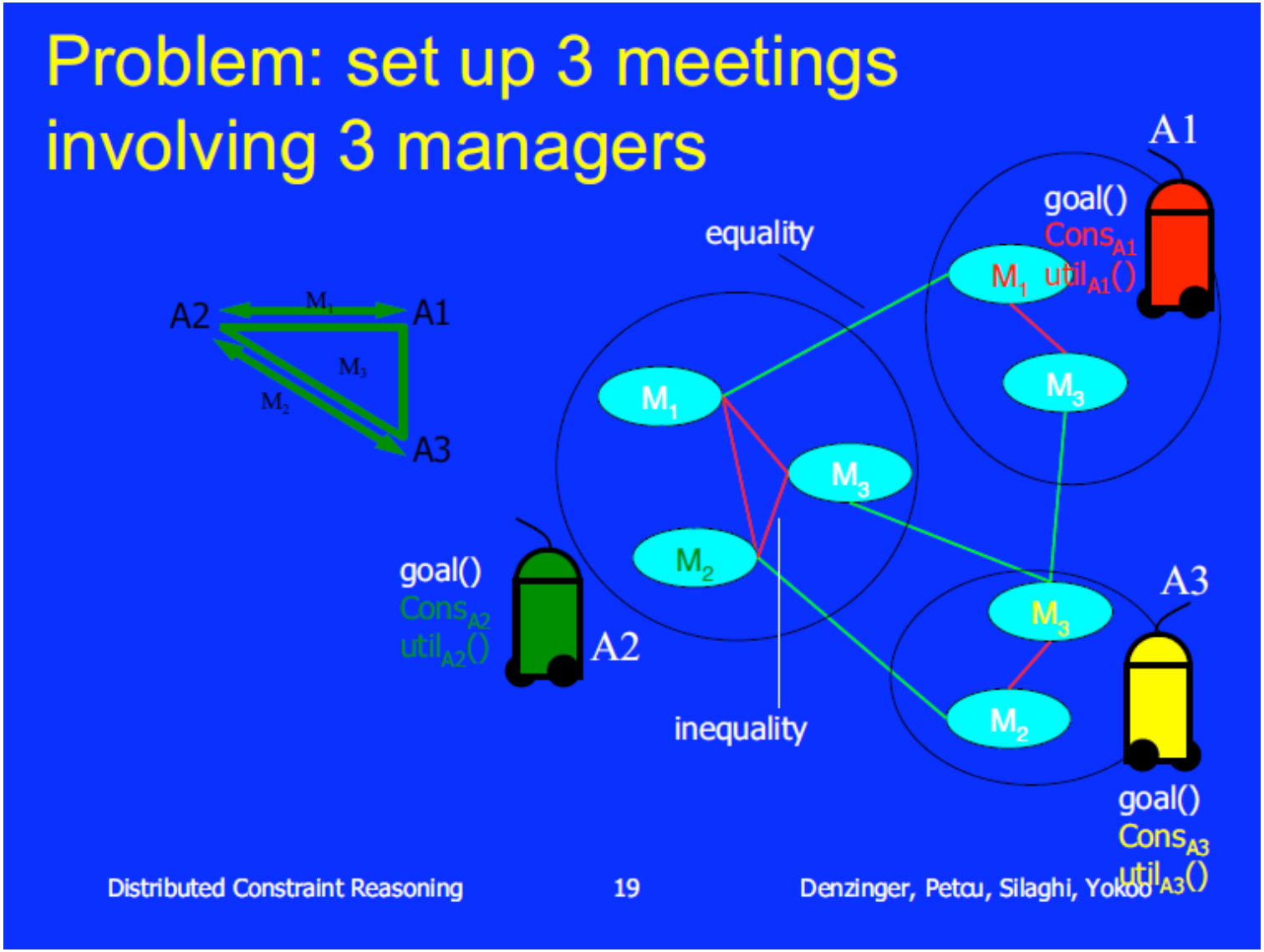
- Find a **non-conflicting assignment** of communication channels assuming **local communication only**

Meeting Scheduling



from http://cs.smu.ca/~pawan/wi07/petcu.pdf

Extension: Private constraints and preferences



from http://cs.smu.ca/~pawan/wi07/petcu.pdf

(Distributed) Constraint Reasoning

- Find an assignment to a set of variables such that
  1. **Boolean constraints** defined in terms of these variables are all fulfilled
  2. **Objective function** defined in terms of these variables is maximized

Constraint Satisfaction Problem

- Problem specification:
  - $X = \{x_i, \dots, x_m\}$ set of **variables**
  - $D = \{D_i, \dots, D_m\}$ set of **domains** for the variables, i.e. $x_i \in D_i$; if $D_i$is finite, let $D_i = \{v_{i,1}, \dots, v_{i,d(i)}\}$
  - $C = \{c_1, \dots, c_k\}$ set of **constraints** over X; the constraint c_i is represented as a **Boolean predicate** $P_i(y_1, \dots, y_j), \{y_1, \dots, y_j\} \subseteq X$ that determines whether a given value assignment combination for $y_1, \dots, y_j$ fulfill the particular constraint
- Solution:
  - find an **assignment** of variables $\{x_i, \dots, x_m\}$ such that **all constraints are satisfied**

Distributed Constraint Satisfaction Problem

- $A = \{A_1, \dots, A_n\}$ set of **agents**
- Each agent is responsible for one variable
  - extension to multiple variables per agent possible
- Agent can communicate by sending messages

When is Distributed Constraint Reasoning Needed?

- Additional individual goals of agents
  - privacy
  - individual interests / preferences
  - semi-cooperative agents
- Additional limits/restrictions on communication between agents
- Problem size?
- Dynamism?

Solution Algorithms

- Requirements on a good algorithm:
  - **terminates** in a finite number of steps
  - is **complete**: finds a solution if it exists
  - is **sound**: the solution returned is valid
- Top-Down
  - domain pruning: Filtering, Hyper-resolution
  - heuristic search : Asynchronous backtracking, Asynchronous weak-commitment search
- Bottom-Up
  - Distributed breakout

Conclusion

- Distributed constraint reasoning problem is a widely applicable model
- We distinguish between **constraint satisfaction** and **constraint optimization**
- **Top-down** and **bottom-up** techniques exist
  - top-down are complete but computationally more intensive on most problems
  - bottom-up are faster but can get stuck in local minima
- Very active areas of research with a lot of progress – new algorithms emerging frequently
- Reading: [Vidal] – Chapter 2 and [Shoham] – Chapter 1