Intelligent Agent Societies

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Overview

- Multi-agent systems
- Multi-agent societies
- Methods of coordination

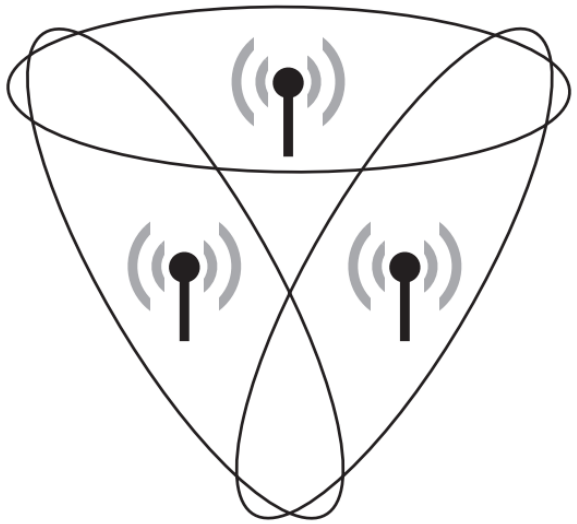
Multi-agent systems

What is a MAS?

- Agents have incomplete information/abilities
- There is no system global control
- Data is decentralized
- Computation is asynchronous

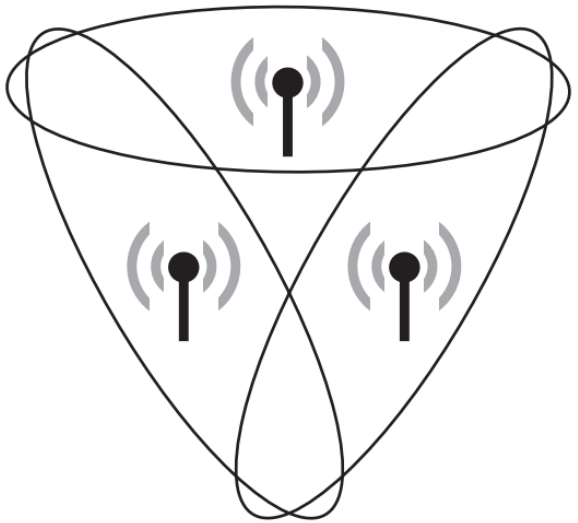
”MultiAgent Systems” by Sycara K. (1998)

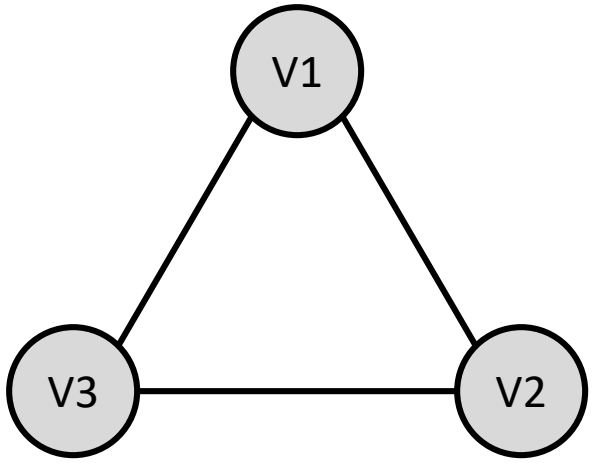
Distributed problem solving



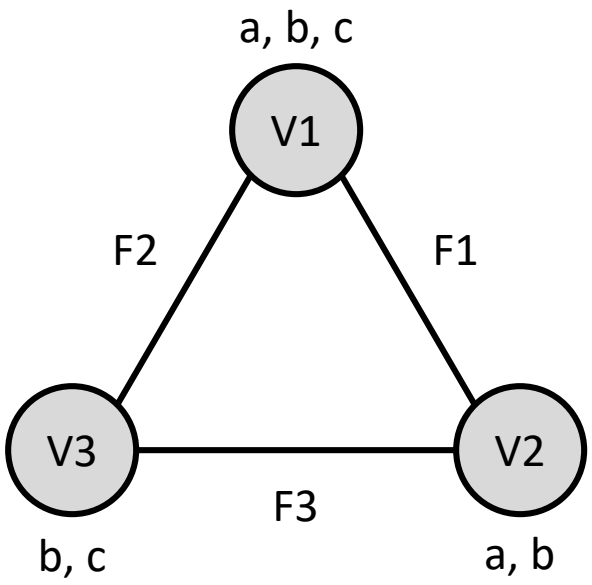
Adapted from example in: *“Distributed Problem Solving”* by Yeoh W. & Yokoo M. (2012)

Distributed problem solving





Distributed problem solving



V1	V2
~~a~~	~~a~~
a	b
b	a
~~b~~	~~b~~
c	a
c	b

F1

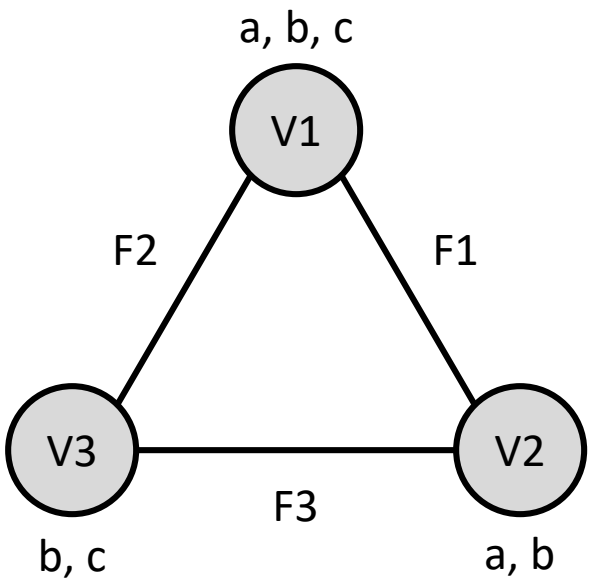
V1	V3
a	b
a	c
~~b~~	~~b~~
b	c
c	b
~~c~~	~~c~~

F2

V2	V3
a	b
a	c
~~b~~	~~b~~
b	c

F3

Distributed problem solving



V1	V2
a	b
b	a
c	a
c	b

F1

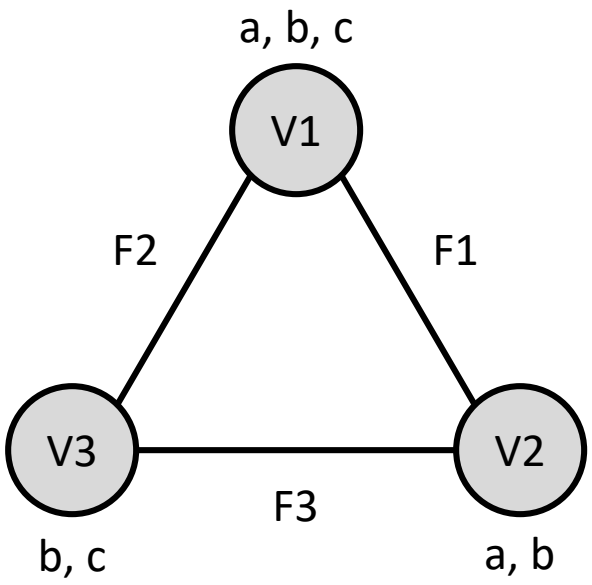
V1	V3
a	b
a	c
b	c
c	b

F2

V2	V3
a	b
a	c
b	c

F3

Centralized constraint reasoning: bucket elimination



V1	V2
a	b
b	a
c	a
c	b

F1

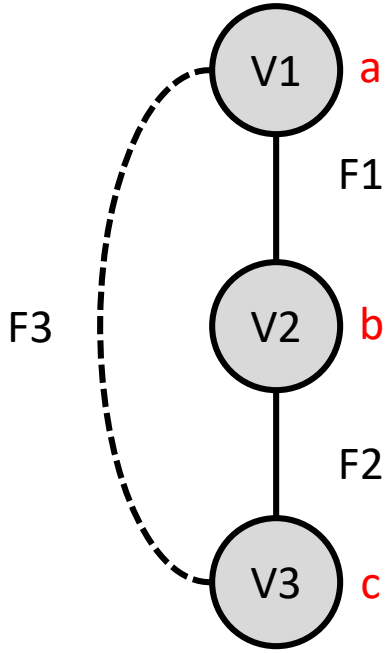
V1	V3
a	b
a	c
b	c
c	b

F2

V2	V3
a	b
a	c
b	c

F3

Centralized constraint reasoning: bucket elimination



V1	V2
a	b
b	a
c	a
c	b

F1

V1	V3
a	b
a	c
b	c
c	b

F2

V2	V3
a	b
a	c
b	c

F3

V1	V2	V3
a	a	b
a	a	c
a	b	c
b	a	c
b	b	c
c	a	b

F2 ⋈ F3

V1	V2
a	a
a	b
b	a
b	b
c	a

(F2 ⋈ F3) ⇓ V3

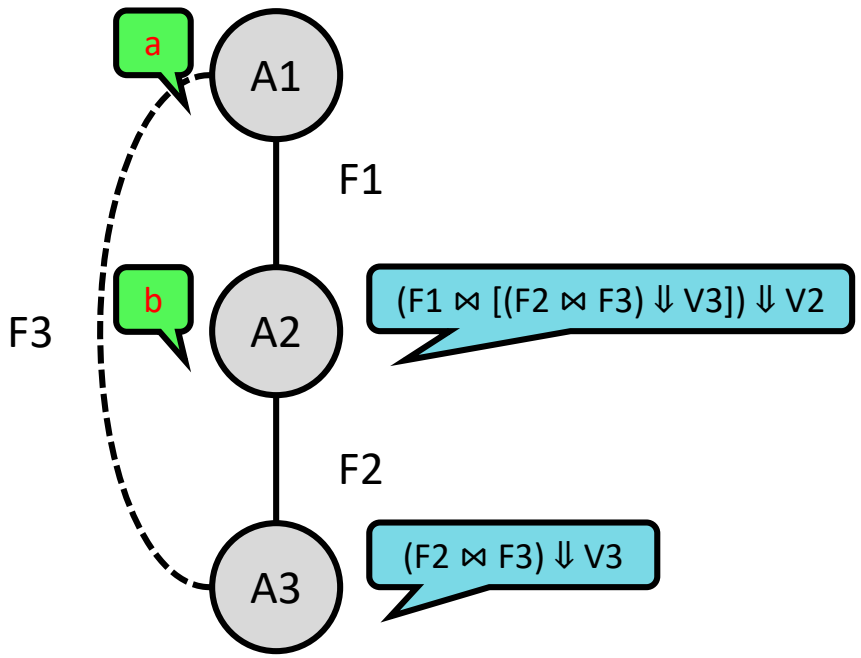
V1	V2
a	b
b	a
c	a

F1 ⋈ [(F2 ⋈ F3) ⇓ V3]

V1
a
b
c

(F1 ⋈ [(F2 ⋈ F3) ⇓ V3]) ⇓ V2

Distributed constraint reasoning



V1	V2
a	b
b	a
c	a
c	b

F1

V1	V3
a	b
a	c
b	c
c	b

F2

V2	V3
a	b
a	c
b	c

F3

V1	V2	V3
a	a	b
a	a	c
a	b	c
b	a	c
b	b	c
c	a	b

F2 ⋈ F3

V1	V2
a	a
a	b
b	a
b	b
c	a

(F2 ⋈ F3) ⇓ V3

V1	V2
a	b
b	a
c	a

F1 ⋈ [(F2 ⋈ F3) ⇓ V3]

V1
a
b
c

(F1 ⋈ [(F2 ⋈ F3) ⇓ V3]) ⇓ V2

Advantages

- Minimal communication
- Parallelism
- Robust (no central server)
- Privacy

Socially rational agents

“Principle of Social Rationality: If a socially rational agent can perform an action whose joint benefit is greater than its joint loss, then it may select that action.”

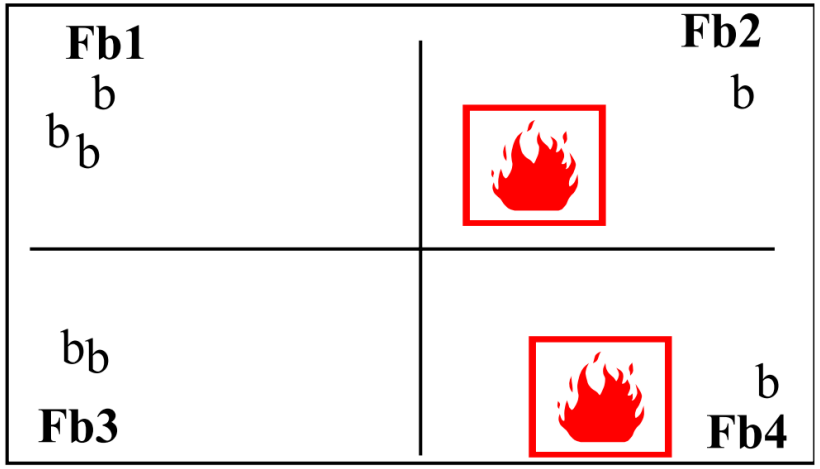
- Hogg & Jennings, “Socially Rational Agents”

- Distinct individual and system goals

Multi-agent societies

- Driven (at least partially) by self-interest
  - Free market
  - Crowd behavior modelling
  - Traffic simulation

Example: socially rational fire-fighting



Example: traffic simulation

- Driver-vehicle agents
  - Car following models
  - Driver behavior variability
  - Discrete decisions
    - Lane changing
    - When to break for stop lights
- Results
  - Emergent collective dynamics
  - Moving forward fast can lead to stop-and-go waves

"Multi-Agent Systems Simulation and Applications" by Uhrmacher A. & Weyns D.

Coordinating agents in an MAS

- Blackboard system
- Societal structures
  - Alliances
  - Teams
  - Coalitions

Applications & benefits

- Simulations
- Autonomous robot groups
- Video game AI