Coordination Tasks and Agent Cooperation

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Self-Interested Agents

Work independently to further their own interests

Sometimes at the expense of others

Self-Interested Agents

Discrete MAS	**MAS with emergent behaviour**
Agents work independently	Agents work independently
No relation or cooperation	Can end up unintentionally cooperating

Self-Interested Agents

Application to garbage scouting

ScoutAgents' only goal is to find garbage

Reactively search, no organised cooperation

Possible, but suboptimal

Assumptions

Agents are benevolent

Explicitly cooperate
(with communication)

Coordination Tasks

A Scouting Coordination

B Harvesting Coordination

C Vehicle Coordination

Cooperation Mechanisms

Deliberative

1 PGP / GPGP

2 Coalitions

Negotiators

3 Contract Net

4 Auctions

5 Voting

PGP

Each agent creates a local plan

Agents exchange local plans and generate
PGP by combining local partial plans

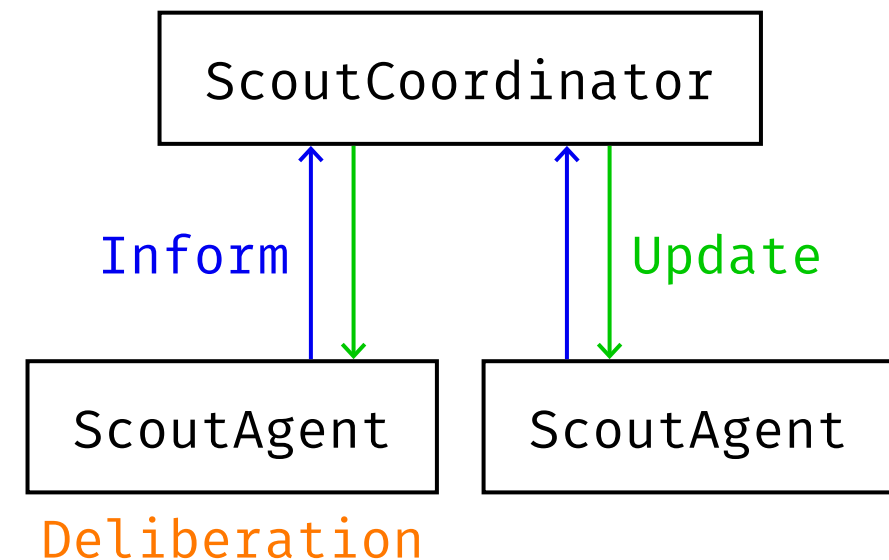Optimise PGP: analyse received information

GPGP
Domain-independent extension

Scouting Coordination

1 ScoutAgents decide their own paths (local plans)

2 ScoutCoordinator collects local plans and builds PGP

3 ScoutCoordinator checks for conflicts, returns modified PGP

PGP / GPGP — Advantages and Disadvantages

+ Flexibility in a dynamic environment

+ Efficiency: elimination of conflicts and redundancy

– Complexity

Coalitions

Several agents work together in a coalition

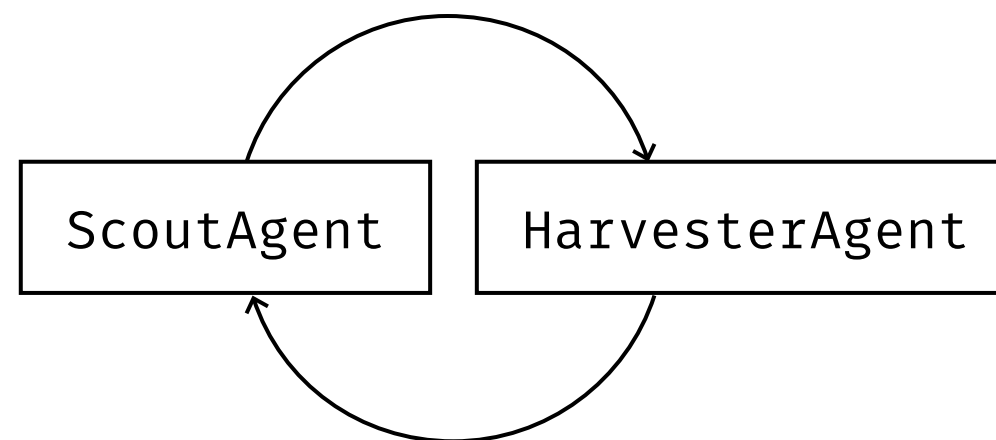Achieve tasks that could not be achieved individually

Complete tasks more efficiently

Coalitions — Applicability

Vehicle Coordination

Vehicles, that come close to each other, enter in a coalition

Objective is to move on fast and efficiently without colliding

Coalitions — Pros and Cons

+ Coalitions can prevent collisions

– A lot of communication

– When to form a coalition?

– Which mechanism to use?

Contract Net

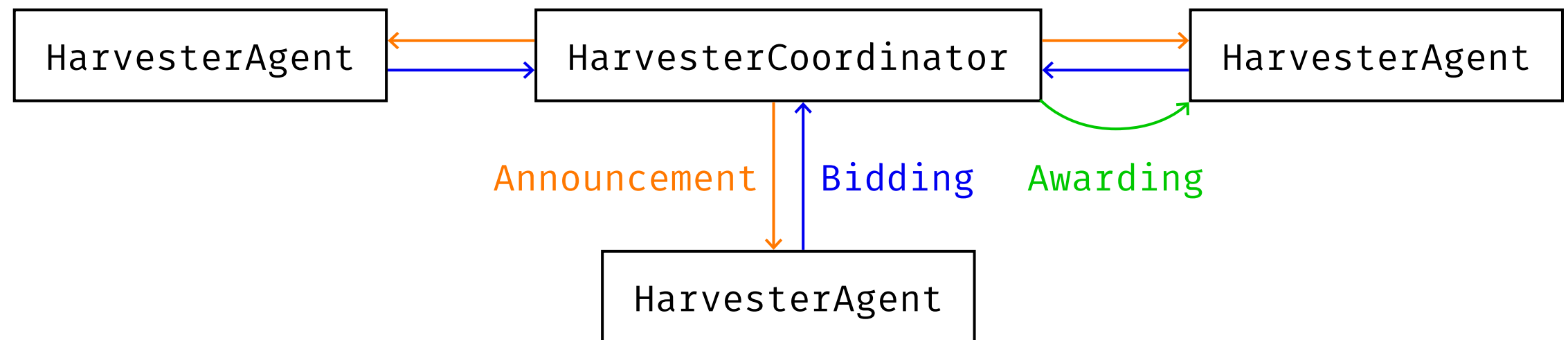Based on the way in which companies put contracts out to tender

Five phases:

1 Recognition
2 Announcement
3 Bidding
4 Awarding
5 Expediting

Harvesting Coordination

1. HarvesterCoordinator announces garbage
2. HarvesterAgents submit tenders
3. HarvesterCoordinator assigns task to one or more

Contract Net — Pros and Cons

+ Garbage collection is dividable into subgoals

+ Garbage collection subgoals are complex, it makes sense to distribute them efficiently

− Computational effort (deliberation)

− Time delay (exchange of messages)

Auctions

Allocate goods/resources among competing self-interested parties

English

Dutch

First price sealed bid (FPSB)
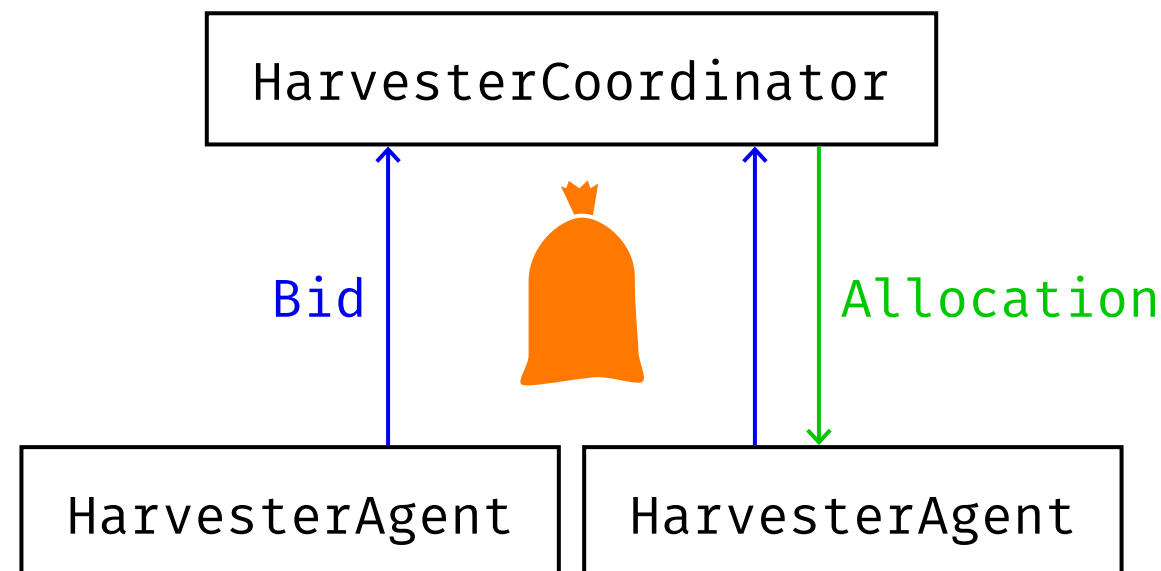
Vickrey

Multi-unit

Multi-attribute

Combinatorial

Harvesting Coordination: FPSB

1. Auctions of each group of garbage
2. HavesterAgents bid (based on their current state, load, distance from garbage)
3. HarvesterAgent allocates tasks to one or more

Auctions — Pros and Cons

+ Multi-attribute auctions would allow for allocation based on additional attributes/ information

– Agents are not self-interested and competitive, but want to reach a common goal together

Voting

Distributed deliberation process,
decisions are taken collectively

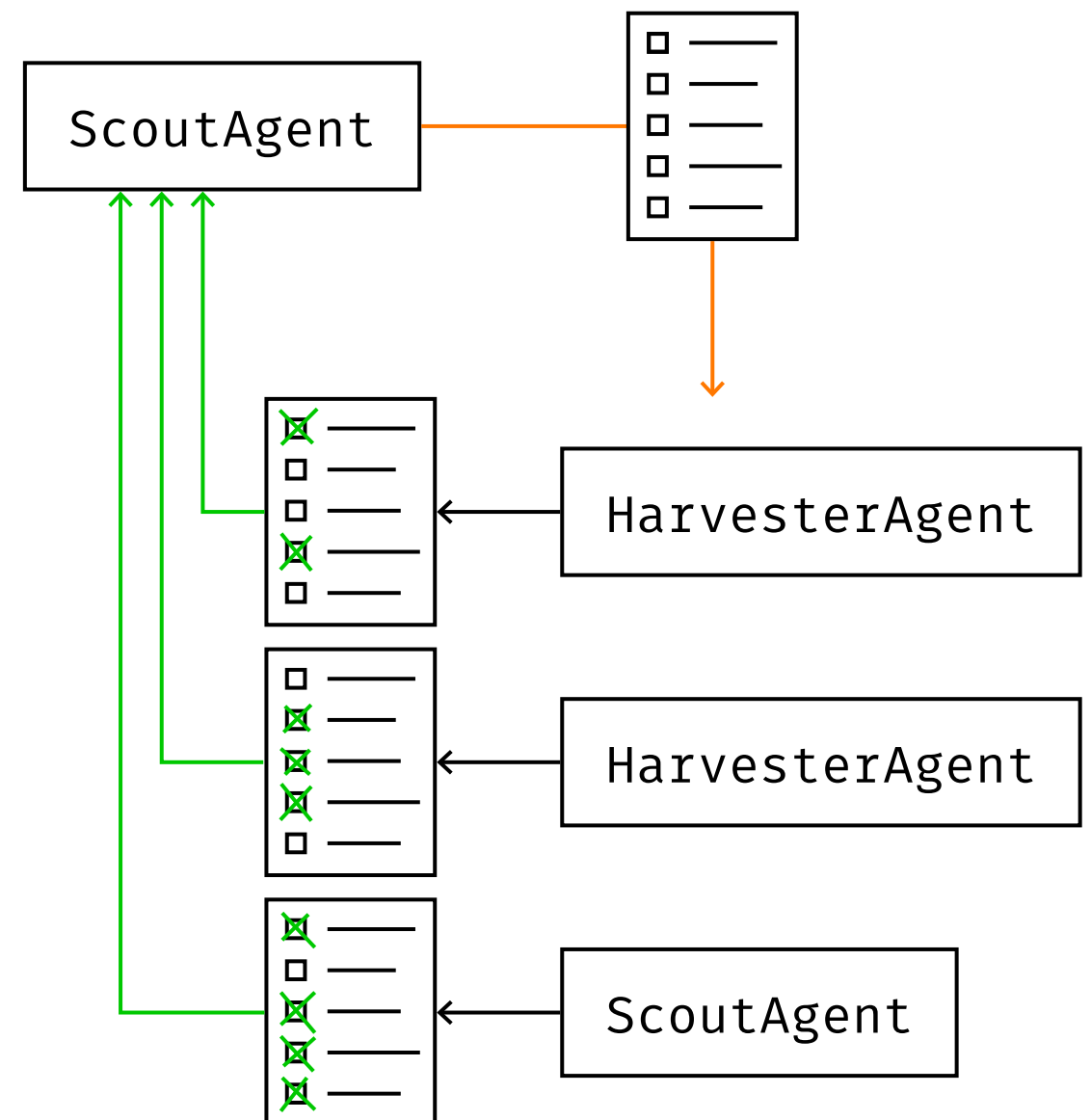Simple voting
Plurality, Anti-plurality, Best-worst, Approval

Total order voting
Binary, Borda, Condorcet

Vehicle Coordination: Approval Voting

1 Each vehicle puts a list of possible routes to a public vote

2 Other vehicles approve those paths that do not interfere with their own route

Voting — Pros and Cons

+ Agents have different destinations (objectives), and their decisions affect others

+ Equality principle: each vote has same weight

– Many vehicles have to determine their route at the same time: we need an order

– Unnecessary high computational cost to calculate alternative routes

Coordination Tasks

A Scouting Coordination

B Harvesting Coordination

C Vehicle Coordination

Scouting Coordination

Problem
Multi-agent patrolling problem

Solution
TSP-based single cycle approach

ScoutAgents patrol along a round-trip through all important cells on the map, within equal distance from each other

GPGP is used to achieve and uphold equidistance (e.g. after collisions)

Harvesting Coordination

Subproblem	Solution
Priorities of pending unassigned garbage	Approval voting
Assign garbage to HarvesterAgents	Contract Net
Idle HarvesterAgents	Coalition

Approval Voting

1   HarvesterCoordinator announces list of pending unassigned garbage

2   HarvesterAgents vote, returning list ordered by their preference
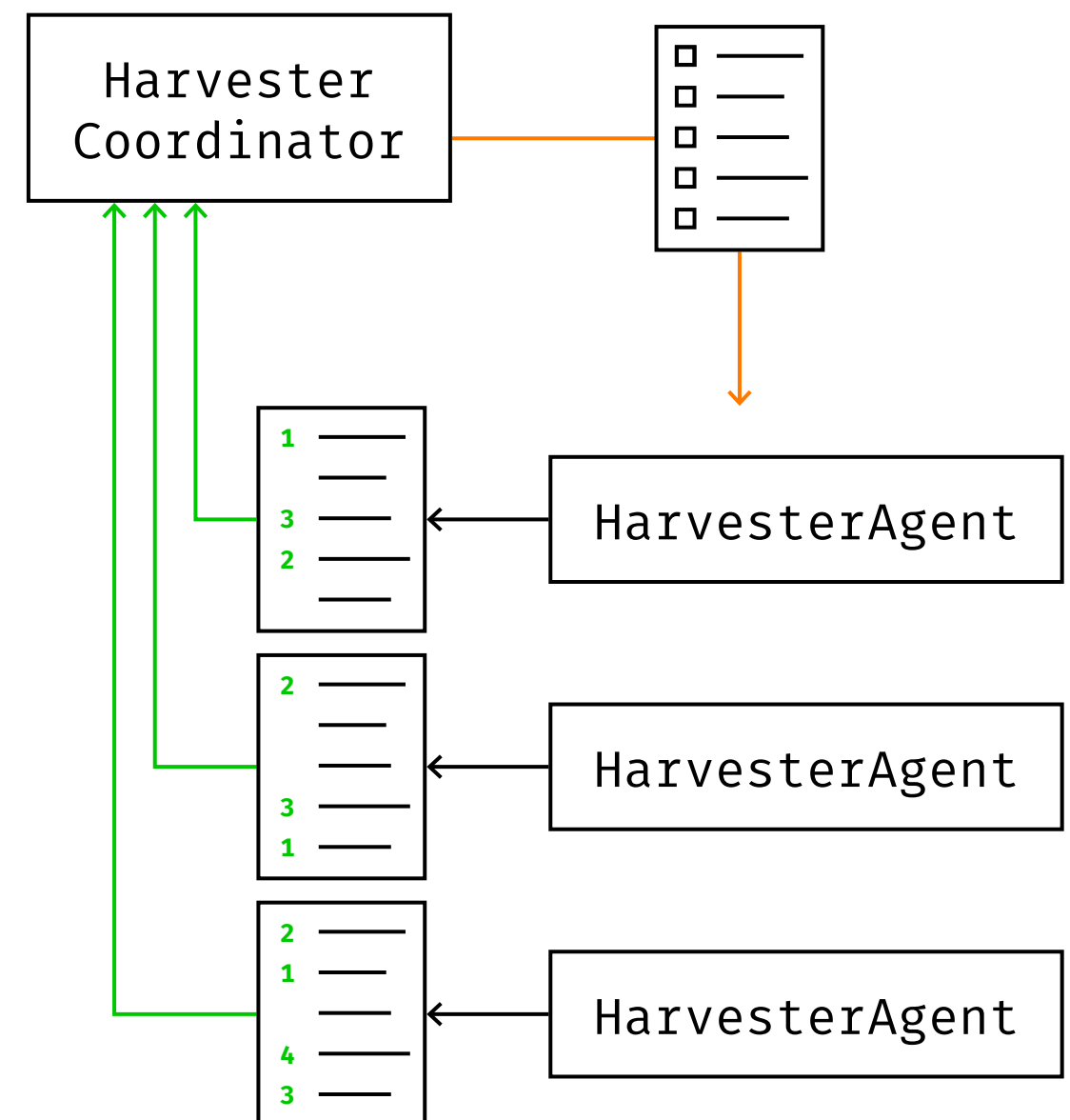
Contract Net

1 Each garbage (in previously determined order) is separately announced
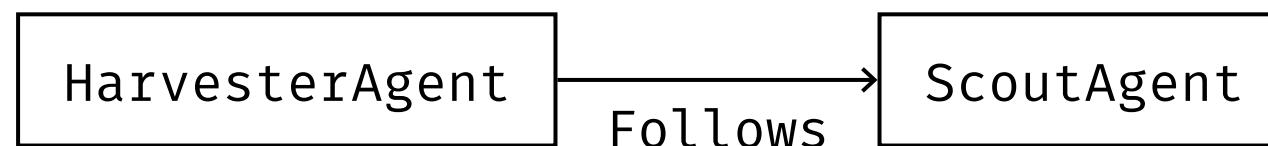2 HarvesterAgents submit tenders
3 HarvesterCoordinator assigns garbage
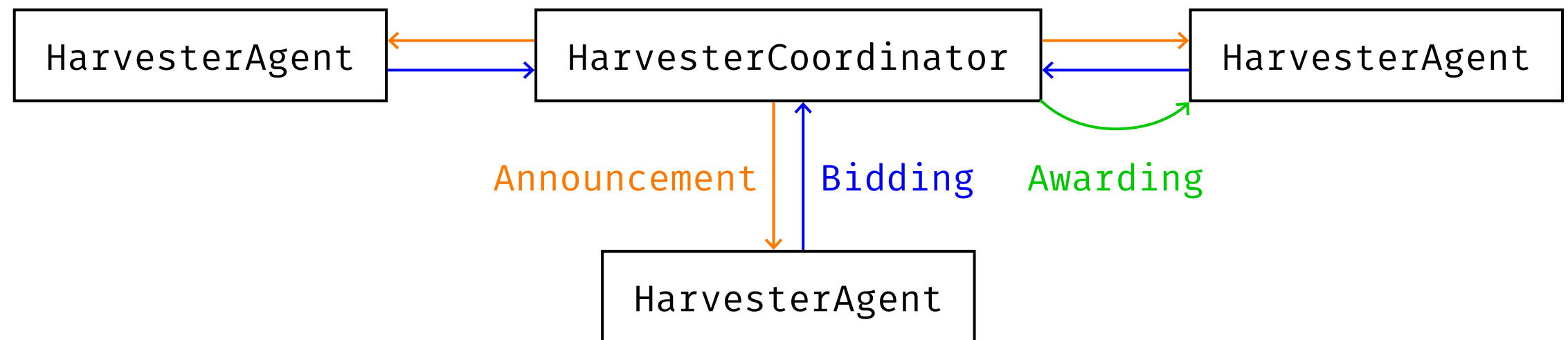
Coalition

Idle HarvesterAgents

Form a coalition with a ScoutAgent

Follow them around, to be closer to newly detected garbage

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┌──────────────────┐                    ┌─────────────────┐
│  HarvesterAgent  │───────────────────▶│   ScoutAgent    │
└──────────────────┘      Follows       └─────────────────┘
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Vehicle Coordination

Problem
Avoid vehicle collision

Solution
CoordinatorAgent administers GPGP

Has partial plan of all vehicles' paths and actions

Resolves possible collisions and returns updated plans to respective vehicles

Vehicle Coordination

Solution

P Hierarchy of vehicle priorities

1 Vehicle already moving to avoid collision
2 HarvesterAgent moving to recycling centre (to recycle garbage)
3 HarvesterAgent moving to garbage location (to harvest garbage)
4 ScoutAgent
5 HarvesterAgent idle

Vehicle Coordination

Solution
For each vehicle:

Max P (Vehicle 1, Vehicle 2)
Continue moving on current path

¬Max P (Vehicle 1, Vehicle 2)
Go back on previous path taken until no longer in current path of prioritised vehicle. Remain stationary until prioritised vehicle is out of path. Move again on original path.

Group 7

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