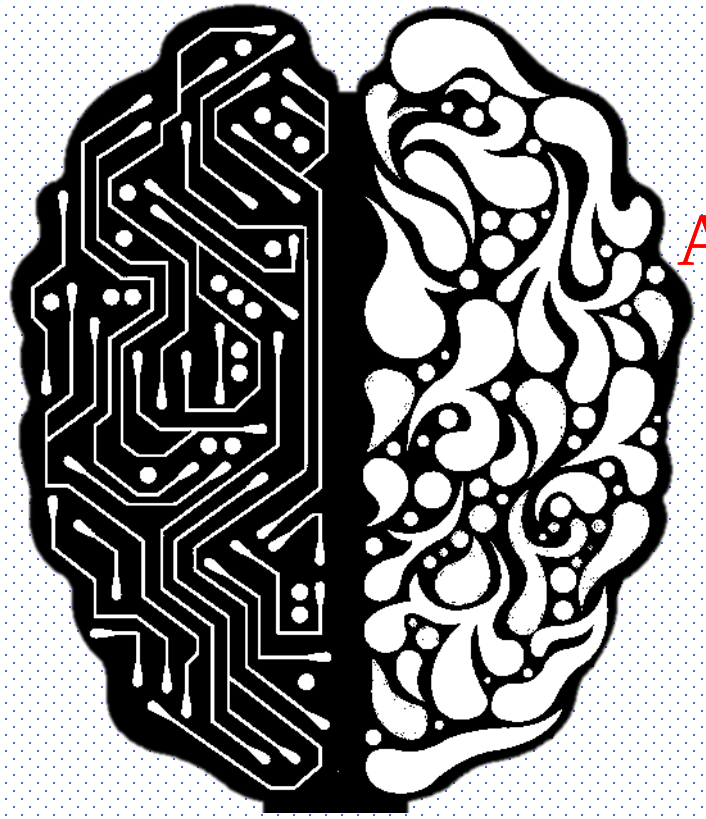

Multi-Agent Systems

Lecture III

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Lecture III Learning Objectives

- To understand the elements and principles of Agent Coordination.
- To understand the p[illegible]erative Problem Solving.
- To understand the common fo[illegible]ordination.
- Review the formalization of coordination.
- Identify the elements of the Contract Net Protocol

Coordination

"The process by which an agent reasons about its local actions of othe e (anticipated) actions of the community acts in a co nsure that the manner."

Nick Jennings,1996

Why Coordinate?

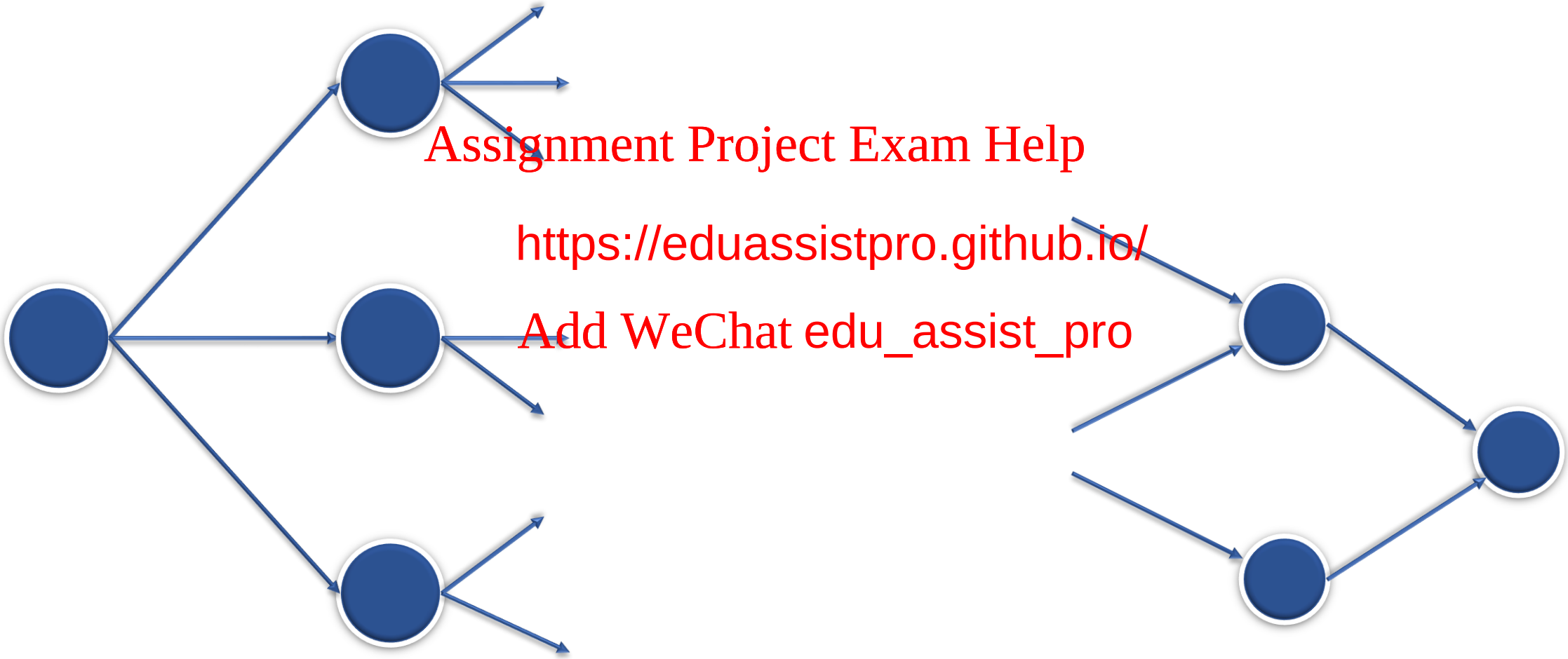
- Prevent anarchy or chaos.
- Dependencies between agents' actions.
- Need to meet global cons
- Achieve agents' goals
- No individual has sufficient competence, resources or information to solve the entire problem.
- Efficiency

Coordination Elements

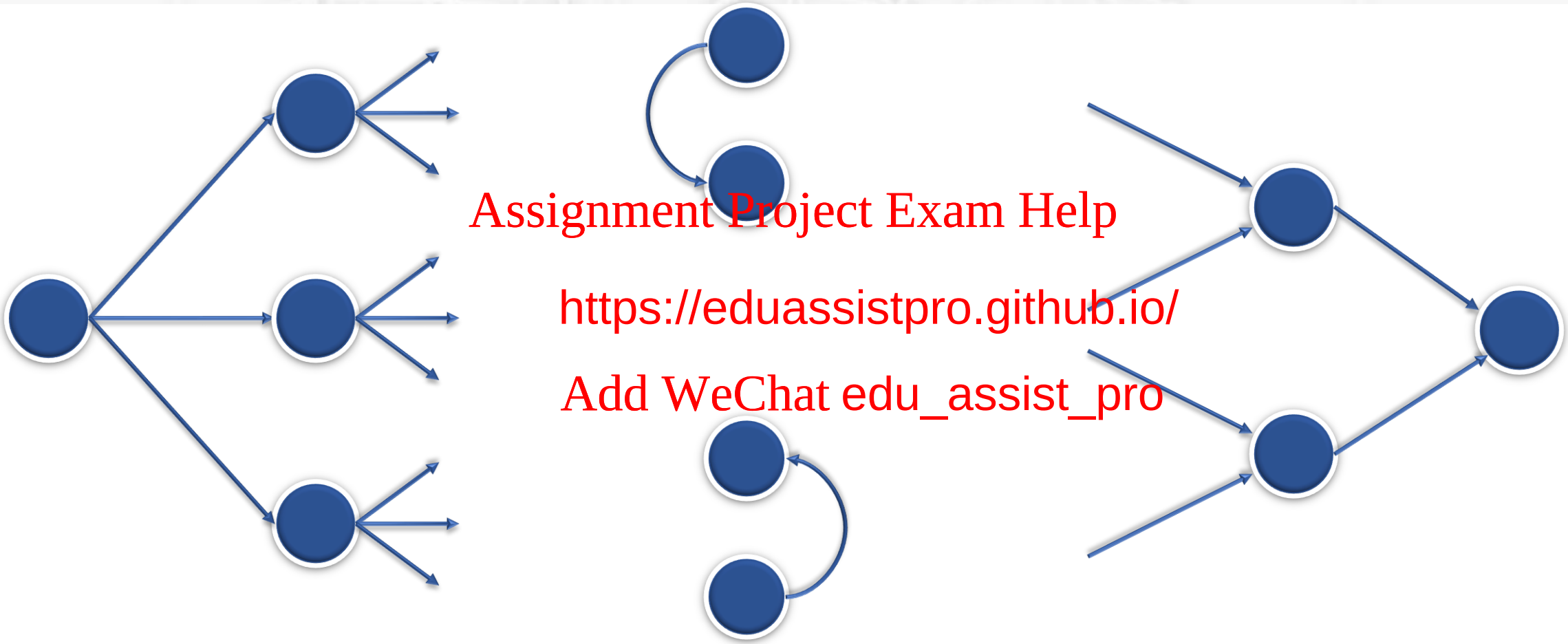
- The act of coordinating;
- Achieving proper order or a working relationship;
- Harmonious interaction as a function or part thereof;
- Autonomy;

Chess vs Robocup

Cooperative Problem Solving



Cooperative Problem Solving



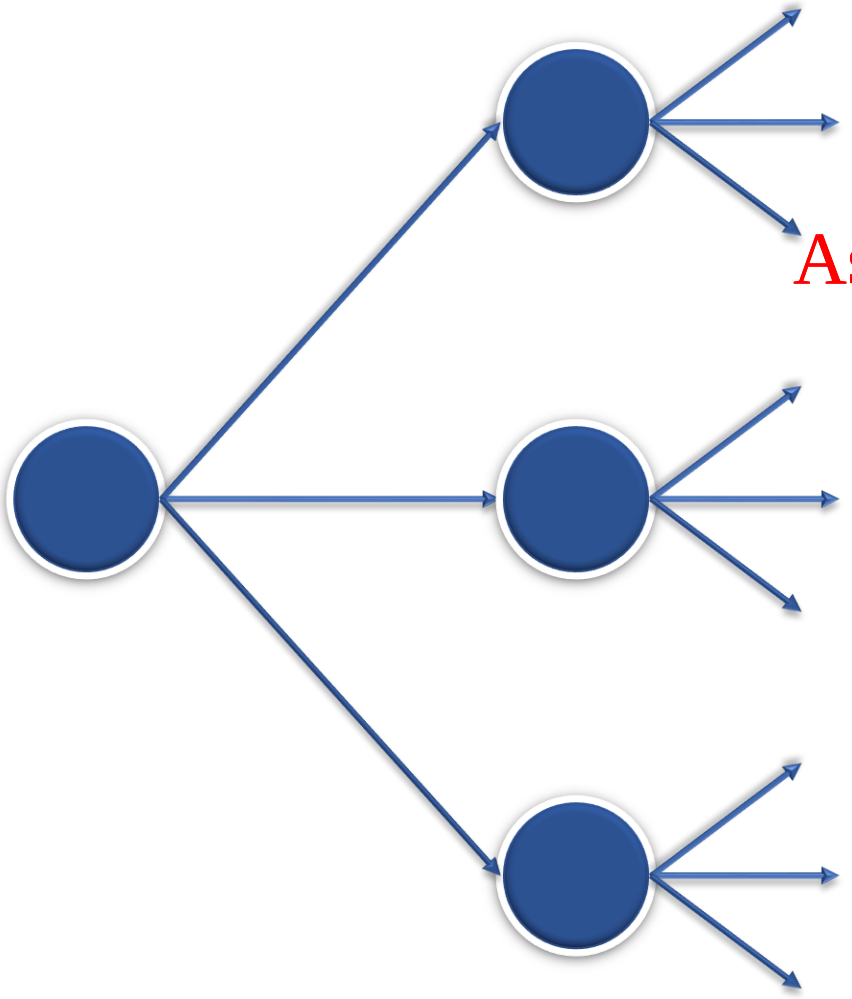
1
Problem decomposition

2
Subproblem solution

3
Answer synthesis

Cooperative Problem Solving

1. Problem decomposition

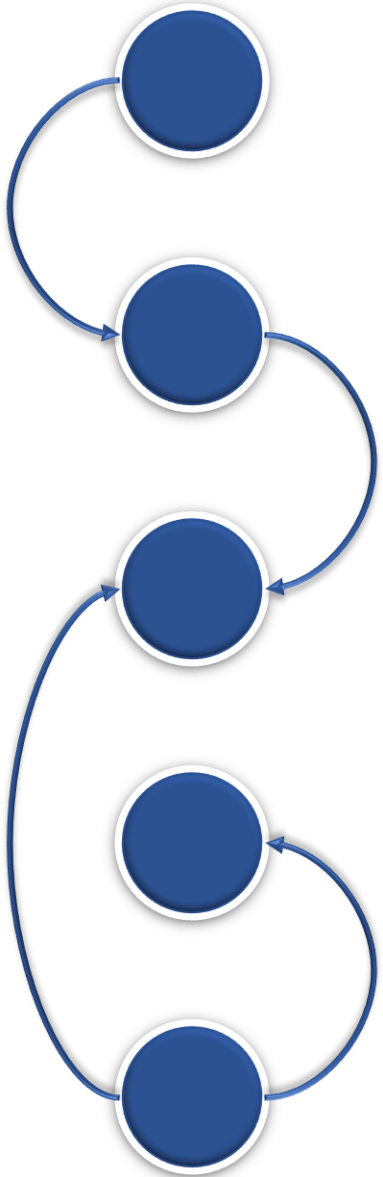


- How to break a problem down into a set of atomic sub-problems:
  - Identify a minimal set of **atomic operations** that can be performed by **individual agents**.
  - pose the initial problem.

- Issues:
  - What is an appropriate level of granularity?
  - How to decompose the problem? Recursively?
  - Who should decompose the problem? (user, agents)
  - Who should solve the sub problems?

Cooperative Problem Solving

2. Subprobem solution

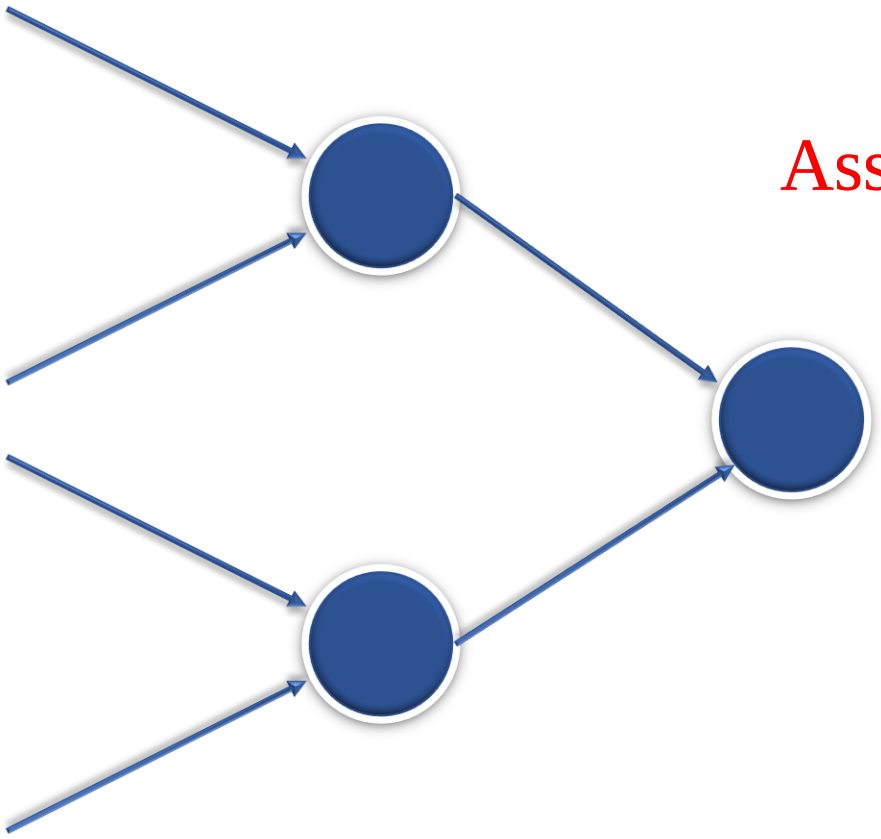


- Solving individual sub-problems.
- Sub-problems are allocated in the previous phase.
- Sub-problems may have dependencies.
- Sub-problems may need sub-problem solution.

- Issues:
  - How to get help?
  - Who to share information with others?
  - What information to share?
  - Static / Dynamic decomposition.

Cooperative Problem Solving

3. Answer Synthesis

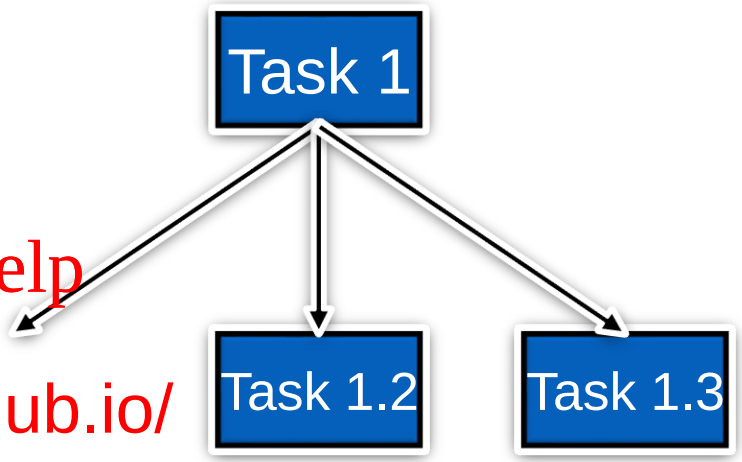


- Combining the results.
- Solutions to atomic sub-problems are combined to provide solutions to higher-level problems.
- Solutions to atomic sub-problems are assembled during this process.

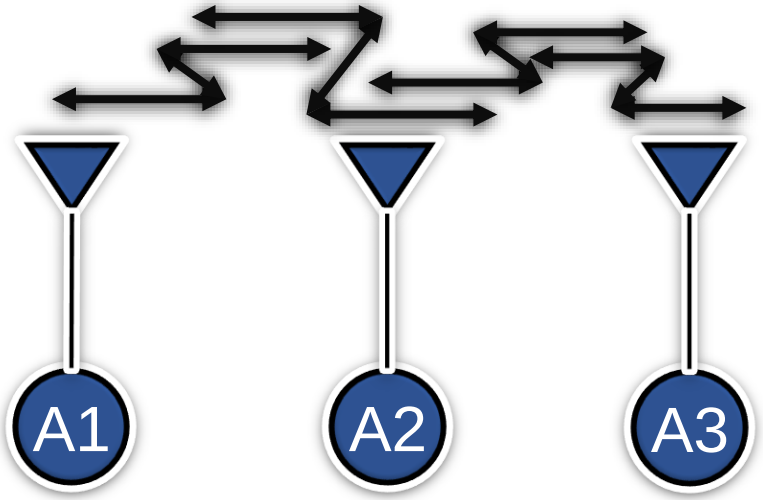
- Issues:
  - Who does the solution synthesis?
  - How are the sub-problems combined?
  - Where are the sub-problems combined?

How to Coordinate?

- There are two common forms of coordination:
- **Task sharing:**
  - When a problem is decomposed into subproblems an to different agents.



- **Result sharing:**
  - When agents share information relevant to their subproblems.



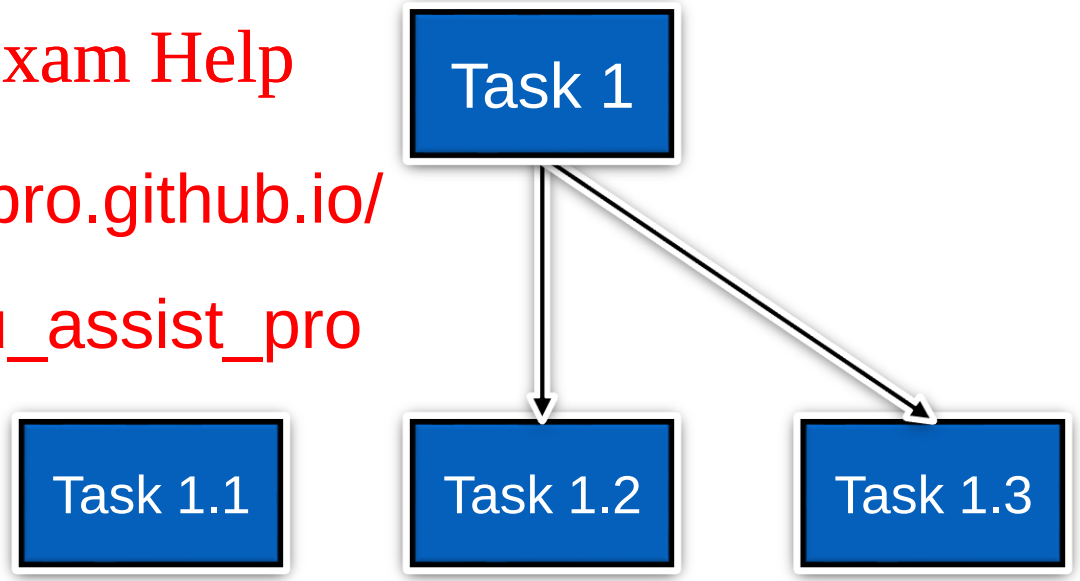
Task Sharing

The agent decomposes the task into a set of sub-tasks that are assigned to agents:

- The tasks are assigned dynamically at run-time based on agents capabilities.

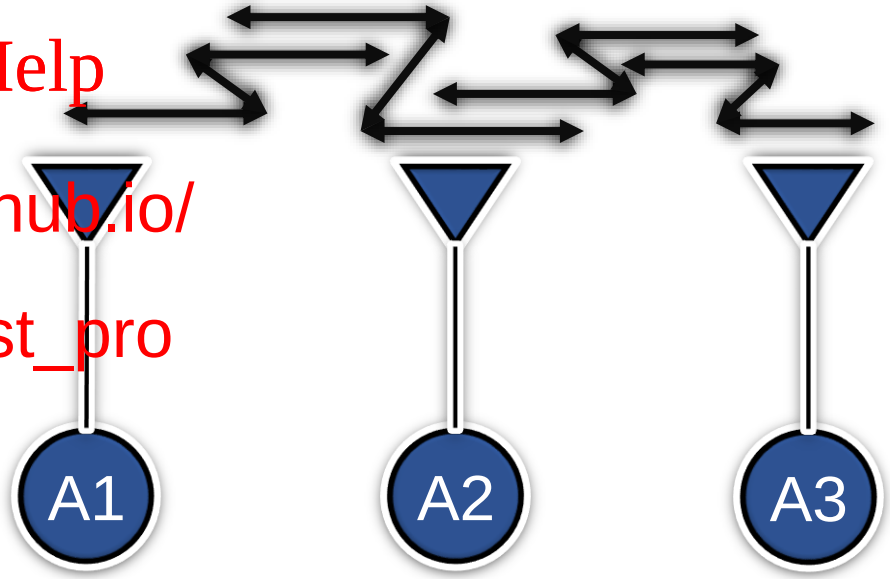
The task allocation proce

- through a central coordinator (manager is authorised to assign tasks to worker agents.
- through some form of coordination mechanism that allows peers to reach agreement as to who will do what (e.g. negotiation, distributed planning, ...).



Result Sharing

- Problem solving proceeds by agents cooperatively exchanging information as the solution is developed.
  - The set of tasks are pre-assigned at design time
- Results may be share
  - **proactively** - one agent sends an agent some information because it believes that the other will be interested in it.
  - r**eactively** – an agent sends information to another in response to a request.



Result Sharing

- A Result Sharing system's performance can take advantage of:

- **Confidence**: Higher confidence in a result if multiple agents independently derive it.
- **Completeness**: Sharing ***local*** can help to achieve a better ***global view***.
- **Precision**: Individual agents can refine their result based upon the results of the other agents.
- **Timeliness**: If the agents work together to formulate the solution in parallel, the result can be attained quicker.