LECTURE 1: INTRODUCTION

Multiagent Systems (CPT 302)
Based on "An Introduction to MultiAgent Systems, Second Edition" by Michael Wooldridge, John Wiley & Sons.

Module Information

- Lecturer: Ka Lok Man
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- Original teaching materials from Prof. Vasu Alagar, modified by Ka Lok Man
- Credits go to Prof. Vasu Alagar

Recommended Text Books

Title	Author	Publisher
READING IN AGENTS	**M. SINGH AND M. HUHNS**	**WILEY**
MULTI AGENT SYSTEMS	**J. FERBER**	**MIT PRESS**
MULTI AGENT SYSTEMS	**G. WEISS (EDITOR)**	**WILEY**
AN INTRODUCTION TO MULTIAGENT SYSTEMS	**M. WOOLDRIDGE**	**MORGAN KAUFMA**

Module Aims

- To introduce students to the concept of an agent and multi-agent systems, and the main applications for which they are appropriate.
- To introduce the main issues surrounding the design of intelligent agents.
- To introduce the main issues surrounding the design of a multi-agent society.
- To introduce a contemporary platform for implementing agents and multi-agent systems.

Intended Learning Outcomes

- To understand the notion of an agent, how agents are distinct from other software paradigms (e.g. objects) and understand the characteristics of applications that lend themselves to an agent-oriented solution.
- To understand the key issues associated with constructing agents capable of intelligent autonomous action, and the main approaches taken to developing such agents.
- To understand the key issues in designing societies of agents that can effectively cooperate in order to solve problems, including an understanding of the key types of multi-agent interactions possible in such systems.
- To understand the main application areas of agent-based solutions, and be able to develop a meaningful agent-based system using a contemporary agent development platform.

Method of Teaching and Learning

- Formal lectures:
  - Students will be expected to attend two hours of formal lectures and one hour of tutorial in a typical week.
- Private study:
  - In a typical week, students will be expected to devote a further seven or eight hours of unsupervised time to private study.
  - The time allowed for private study each week will typically include four hours of time for reflection and consideration of lecture material, and three to four hours of background reading.

Assessments and Examination

Type	Weight
Final Exam	80%
Assessment task I	10%
Assessment task II	10%

Overview

- Five ongoing trends have marked the history of computing:
  - *ubiquity*;
  - *interconnection*;
  - *intelligence*;
  - *delegation*; and
  - *human-orientation.*

Ubiquity

- The continual reduction in cost of computing capability has made it possible to introduce processing power into places and devices that would have once been uneconomic.
- As processing capability spreads, sophistication (and intelligence of a sort) becomes ubiquitous.
- What could benefit from having a processor embedded in it…?

Interconnection

- Computer systems today no longer stand alone, but are networked into large distributed systems.
- The internet is an obvious example, but networking is spreading its ever-growing tentacles…
- Since distributed and concurrent systems have become the norm, some researchers are putting forward theoretical models that portray computing as primarily a process of interaction.

Intelligence

- The complexity of tasks that we are capable of automating and delegating to computers has grown steadily.
- If you don’t feel comfortable with this definition of “intelligence”, it’s probably because you are a human.

Delegation

- Computers are doing more for us – without our intervention.
- We are *giving control* to computers, even in safety critical tasks.
- One example: fly-by-wire aircraft, where the machine's judgment may be trusted more than an experienced pilot.
- Already on the agenda: fly-by-wire cars (Toyota Prius problems), intelligent braking systems, cruise control that maintains distance from car in front.

Human Orientation

- The movement away from machine-oriented views of programming toward concepts and metaphors that more closely reflect the way we ourselves understand the world
- Programmers (and users!) relate to the machine differently.
- Programmers conceptualize and implement software in terms of higher-level – more human-oriented – abstractions.

Global Computing

- What techniques might be needed to deal with systems composed of 10^{10} processors?
- Don't be deterred by its seeming to be "science fiction".
- Billions of people connected by email once seemed to be "science fiction"…
- Let's assume that current software development models can't handle this…

Where does it bring us?

- Delegation and Intelligence imply the need to build computer systems that can act effectively on our behalf
- This implies:
  - The ability of computer systems to act *independently.*
  - The ability of computer systems to act in a way that *represents our best interests* while interacting with other humans or systems.

Interconnection and Distribution

- Interconnection and Distribution have become core motifs in *Computer Science.*
- But Interconnection and Distribution, coupled with the need for systems to represent our best interests, implies systems that can *cooperate* and *reach agreements* (or even *compete*) with other systems that have different interests (much as we do with other people).

So Computer Science expands…

- These issues were not studied in Computer Science until recently.
- All of these trends have led to the emergence of a new field in Computer Science: *multiagent systems.*

Agents, a Definition

- An agent is a computer system that is capable of *independent* action on behalf of its user or owner (figuring out what needs to be done to satisfy design objectives, rather than constantly being told).

Multiagent Systems, a definition

- A multiagent system is one that consists of a number of agents, which *interact* with one-another.
- In the most general case, agents will be acting on behalf of users with different goals and motivations.
- To successfully interact, they will require the ability to *cooperate*, *coordinate*, and *negotiate* with each other, much as people do.

Agent Design and Society Design

- The course covers two key problems:
  - How do we build agents capable of independent, autonomous action, so that they can successfully carry out tasks we delegate to them?
  - How do we build agents that are capable of interacting (cooperating, coordinating, negotiating) with other agents in order to successfully carry out those delegated tasks, especially when the other agents cannot be assumed to share the same interests/goals?
- The first problem is *agent design*, the second is *society design*.

Multiagent Systems

- In Multiagent Systems, we address questions such as:
  - How can cooperation emerge in societies of self-interested agents?
  - What kinds of languages can agents use to communicate?
  - How can self-interested agents recognize conflict, and how can they (nevertheless) reach agreement?
  - How can autonomous agents coordinate their activities so as to cooperatively achieve goals?

Multiagent Systems

- While these questions are all addressed in part by other disciplines (notably economics and social sciences), what makes the multiagent systems field unique is that it emphasizes that the agents in question are *computational & information processing* entities.

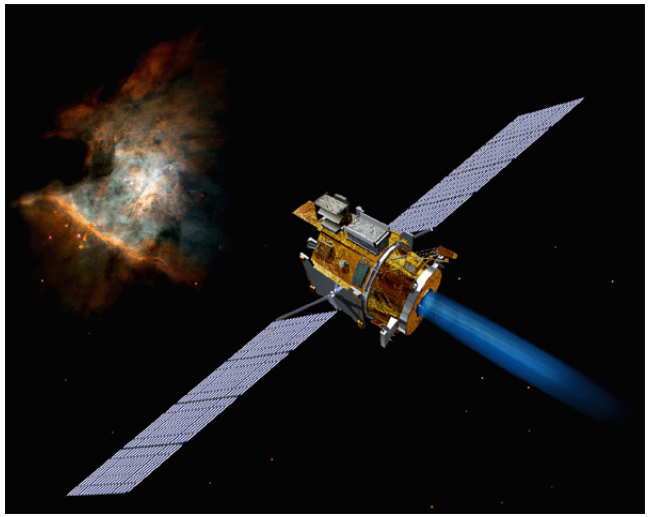
The Vision Thing

- It's easiest to understand the field of multiagent systems if you understand researchers' vision of the future.
- Fortunately, different researchers have different visions.
- The amalgamation of these visions (and research directions, and methodologies, and interests, and…) define the field.
- But the field's researchers clearly have enough in common to consider each other's work relevant to their own.

Spacecraft Control

- When a space probe makes its long flight from Earth to the outer planets, a ground crew is usually required to continually track its progress, and decide how to deal with unexpected eventualities. This is costly and, if decisions are required *quickly*, it is simply not practicable. For these reasons, organizations like NASA are seriously investigating the possibility of making probes more autonomous — giving them richer decision making capabilities and responsibilities.
- *This is not fiction:* NASA*'s DS1 has done it!*

Deep Space 1



- http://nmp.jpl.nasa.gov/ds1/
- "Deep Space 1 launched from Cape Canaveral on October 24, 1998. During a highly successful primary mission, it tested 12 advanced, high-risk technologies in space. In an extremely successful extended mission, it encountered comet Borrelly and returned the best images and other science data ever from a comet. During its fully successful hyperextended mission, it conducted further technology tests. The spacecraft was retired on December 18, 2001." – NASA Web site

Air Traffic Control

- “A key air-traffic control system…suddenly fails, leaving flights in the vicinity of the airport with no air-traffic control support. Fortunately, autonomous air-traffic control systems in nearby airports recognize the failure of their peer, and cooperate to track and deal with all affected flights.”
- Systems taking the initiative when necessary.
- Agents cooperating to solve problems beyond the capabilities of any individual agent.

Autonomous Agents for specialized tasks

- The DS1 example is one of a generic class.
- Agents (and their physical instantiation in robots) have a role to play in high-risk situations, unsuitable or impossible for humans.
- The degree of autonomy will differ depending on the situation (remote human control may be an alternative, but not always).

Internet Agents

- Searching the Internet for the answer to a specific query can be a long and tedious process. So, why not allow a computer program — an agent — do searches for us? The agent would typically be given a query that would require synthesizing pieces of information from various different Internet information sources.

Multiagent Systems is Interdisciplinary

- The field of Multiagent Systems is influenced and inspired by many other fields:
  - Economics
  - Philosophy
  - Game Theory
  - Logic
  - Ecology
  - Social Sciences
- This can be both a strength (infusing well-founded methodologies into the field) and a weakness (there are many different views as to what the field is about).
- This has analogies with artificial intelligence itself.