An Anytime and Distributed Multi-Agent System

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Who am I?

- Claude Duvallet
  - Associate Professor in computer science since September 2003.
  - PhD obtained in October 2001 at the University of Le Havre, France
- Where do I com from? University of Le Havre (France).
- My topics of interest:
  - Teachings: Programming (Java, C/C++,...), Operating Systems (Linux, Unix), Distributed System (CORBA, RMI, RPC, EJB, LDAP, etc.), Network Protocols and Architecture, Network and System Administration.
  - Research: Real-Time Databases, Multimedia Systems, Quality of Service Management, Distributed Systems, etc.
- Current PhD supervising: Nizar Idoudi, Emna Bouazizi and Bechir Alaya.
- My homepage in English:

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Outline

- Introduction and context
- Real-time in Multi-Agent Systems
- ANYMAS model
- Distributed Multi-Agent Systems: DISMAS model
- Applications
- Conclusion

Decision System Support

- What is a Decision System Support
  - Goals: to help the users to take the good decisions.
  - Characteristics:
    - must give good information to the users.
    - must give response before deadlines.
    - need to use other systems like Databases, Case Based Reasoning,...
- Others constraints:
  - Many users in the system.
  - System is distributed.

$\Rightarrow$ Decision Systems Support are complex systems.

- Application for Decision Systems Support:
  - In the industry where it exists important risks like chemical industry or nuclear plants.
  - In the firm where it exists economics risk like commercial transaction management or bursaries systems.
  - In all systems which help users like expert systems in bank or insurance.

Problems

- Taking into account complexity of Decision Support Systems.
- Necessary to meet deadline to take the good decision.
- To extract the good information in Information Systems:
  - Information could be repeated, useless, ...
  - We must select the information.

Proposed solution

- To take into account complexity of Decision Support Systems, we use multi-agent systems (MAS):
  - advantage: possibility to take into account all the characteristics of the complex systems.
  - drawback: it is difficult to have predicted time behavior of MAS.
- Solution:
  - introduce real-time aspect in multi-agent systems.
  - in order to meet the deadlines: give some partial result to the users. It is not complete result but intermediary result that can be used.

Multi-Agent Systems

- It comes from the works on Distributed Artificial Intelligence.
- Mains goals:
  - Used to design complex systems.
  - Distribute the problem on many entities called agents.
- Definition:
  - A multi-agent system is composed of many agents which are organized in groups called organizations. These agents cooperate and communicate together in order to solve complex problems.
- Characteristics of an agent:
  - Reactivity: capacity to react to an event.
  - Proactivity: capacity to take its own decisions.
  - Sociability: capacity to communicate with others agents.
- Organization: group of agents which have a common goals
  - interacts and communicates a lot with each other.
  - create groups which grows up and adapt their behaviour to the environment.

Toward a solution to our problem

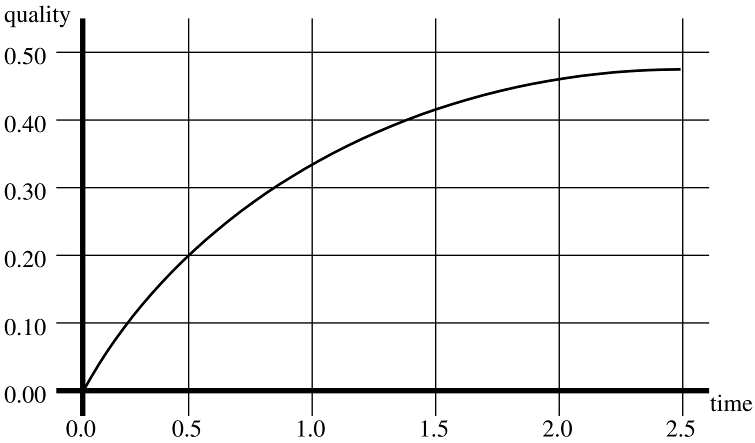
- Give more capacities to the classical Multi-Agent System:
  - uses of anytime algorithms to introduce real-time aspects.
  - distribute multi-agents systems in order to design systems with many users.

$\Rightarrow$ Toward a distributed and anytime multi-agent system.

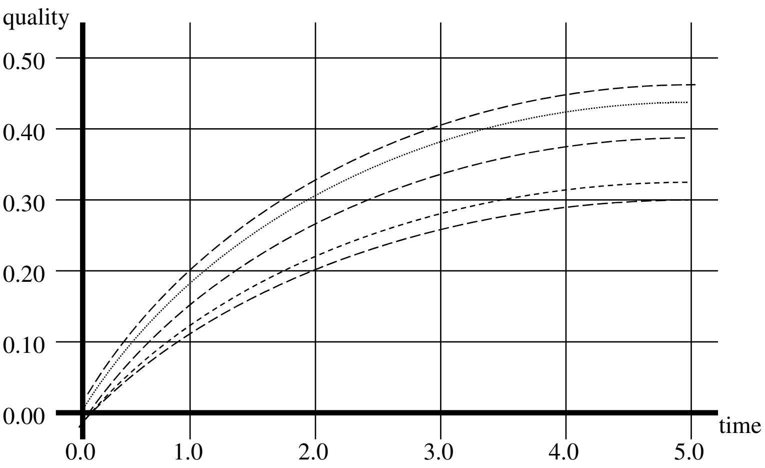
Anytime algorithms

- These algorithms provide some partial results but usable results provided on time.
- Characteristics of anytime algorithms:
  - Quality of the result is a function of the time allocated.
  - We could measure the quality of service of the result produced.
  - Predictability: anytime algorithms contains some statistical information on the measure of the quality of the result produced in function of the time allocated.
  - Interruptibility: it must be able to provide a result whatever the moment, it is stopped.
  - Monotonicity: quality of result always increases or stay at the same level but never decreases.
- How to measure performance?
  - thanks to performance profile,
  - and/or thanks to conditional performance profile.

Performance Profile



Conditional Performance Profile



Real-time in Multi-Agent Systems

- Real-time in classical systems
  - Tasks or transactions with deadlines, periods.
  - Result obtained late are wrong results.
  - Timely reaction rather than complete results
    $\Rightarrow$ tradeoff between timeliness and precision.
  - Incremental resolution of problems:
    rough solution $\longrightarrow$ optimization.
- Multi-agent systems : characterization
  - Distributed Artificial Intelligence.
  - Systems based on intelligent agents
  - Communications and cooperation between agents.
  - Autonomy of each agent.
- RT-MAS: Real-Time Multi-Agent Systems: Objectives
  - Control inter-agents communication times.
  - Used to build complex decision support systems.
  - Used to control multi-agent system execution times.

Our model: ANYMAS (1/2)

An ANYtime Multi-Agent Systems:

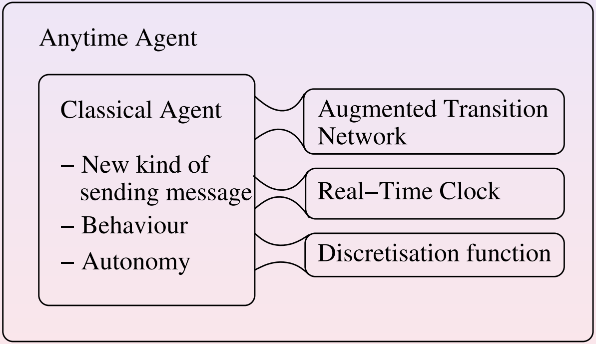
- Goals of our model:
  - To give anytime behavior to a Multi-Agent System.
- Two kinds of agents:
  - Anytime Agents: it is the main agents of the system.
  - Temporal agents: they decide which agents will be suspended.
- Two phases:
  - First phase=the learning period: it allows the calibration of the system.
  - Second phase=the real work: it allows the use of the system.

Our model: ANYMAS (2/2)

A model based on Anytime Agent and Anytime Multi-Agent Systems:

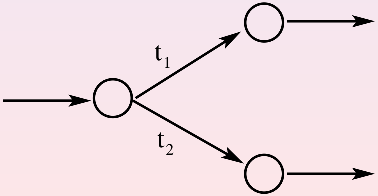
- Anytime Agent: Component
  - Clock $\longrightarrow$ time deviation measure.
  - Algorithm $\longrightarrow$ times discretization.
  - Capacity $\longrightarrow$ Time prediction needed to perform the next action.
  - An Augmented Transition Network (ATN) to represent states of an agent and to store information on the transition between states.
- ANYtime Multi-Agent System
  - The capacity to suspend actions of agent.
  - The capacity to arrange the different actions of agents.
  - Temporal agent decide which agents will be suspended.

ANYMAS model: anytime agent

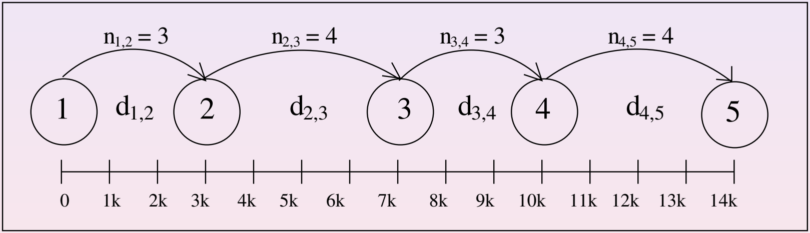


ANYMAS model: discretization function

- Input:
  - Elapsed time between two successive states of ATN.
- Output:
  - Average delay (discrete-time) elapsed between the statements of ATN (discretization algorithm).
  - Prediction of the time required to go from one state to an other one in the ATN (to perform a specific task).



ANYMAS model: an example of ATN



The ANYMAS model: Algorithm of discretization (1/2)

$n_{1,2} \leftarrow 1$
Increase $\leftarrow$ true
Last State $\leftarrow$ false
WHILE $((|d_{i,i+1} - k * n_{i,i+1}| > \varepsilon)$
    AND ((i+1) Not Last State))
    i $\leftarrow$ 1
    $n_{1,2} \leftarrow n_{1,2} + 1$
    k = round $(d_{i,i+1}, n_{i,i+1})$
    WHILE $(|d_{i,i+1} - k * n_{i,i+1}| < \varepsilon$
        AND (i+1) Not Last State))
        i $\leftarrow$ i + 1
        $d_{i,i+1} = d_{i,i+1} + d_{i-1,i} - k * n_{i-1,i}$
        $n_{i,i+1}$ = round $(d_{i,i+1} / k)$
    END WHILE
END WHILE

The ANYMAS model: Algorithm of discretization (2/2)

- Main step of the algorithm:
  (1) Initialize K,
  (2) Browse the statements of ATN,
  (3) Calculate $n_{i,i+1}$ and errors ($d_{i,i+1}$ modulo K);
  (4) Ensure that all errors are less than ε,
  (5) If error> ε then decrease K and go to step 2,
  (6) else continue until the complete statements.
- Goal: Allowing a fast recomputing of the execution time needed to finish the task and thus improving the quality of a solution.

Simulation of the algorithms

State i	State i+1	Time in ms	Time in K units
1	2	10556 ms	2640 K
2	3	20173 ms	5043 K
3	4	5443 ms	1361 K
4	5	34256 ms	8564 K
5	6	29654 ms	7413 K
6	7	32432 ms	8108 K
7	8	11284 ms	2821 K
8	9	27236 ms	6809 K
9	10	13255 ms	3314 K
10	11	34256	8564 K
11	12	11284	2821 K
Value of K : 4			

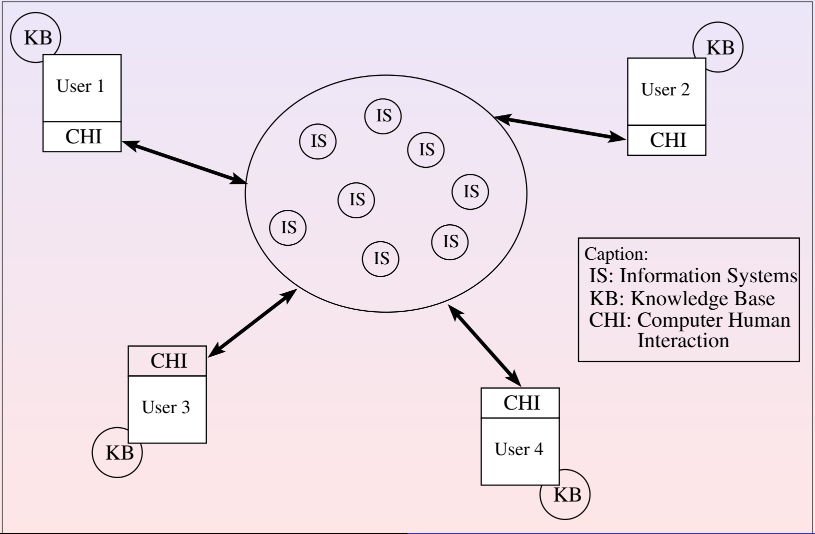
ANYMAS model: temporal agent

- Functions and goals:
  - To identify groups with high communication,
  - Assess the importance of the groups using statistics provided by the anytime agents,
  - Reinforcing the importance of certain groups according to their speed treatment.
- Characteristics:
  - Based on a lightweight structure of agents,
  - Created by agents anytime.
- Creation of an agent:
  - By the anytime agents when communication link between two agents exceeds a threshold,
  - Recording in its network of the agents who have created it, or are attached to it.
- Destruction:
  - Deleting in its network the "weak" communication links,
  - Self-destruction when its network is empty.

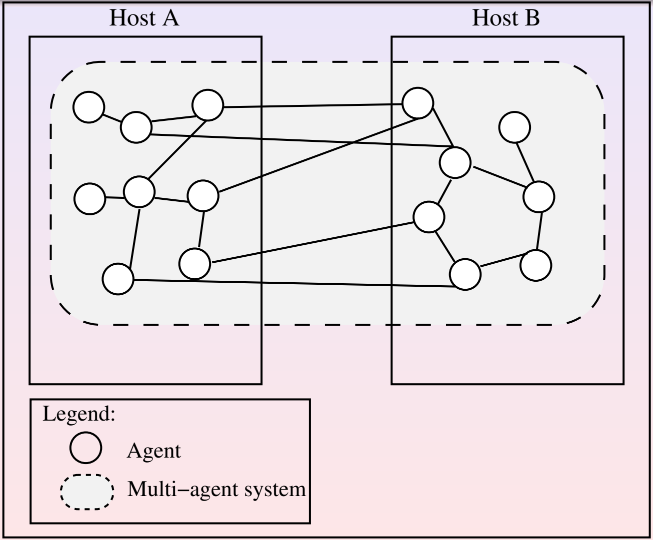
Applications: Validation

1. A first step of the validation of the ANYMAS model
   - A marketplace management
   - Utilization of Information Systems (IS)
   - Anytime algorithms and agents used to explore IS at different levels.
2. A second step of the validation of the ANYMAS model
   - Distribute the marketplace application according to the CORBA norm.

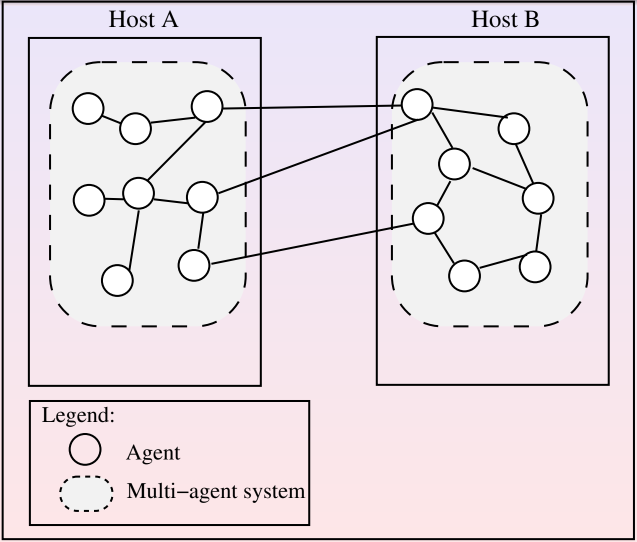
Applications: figure



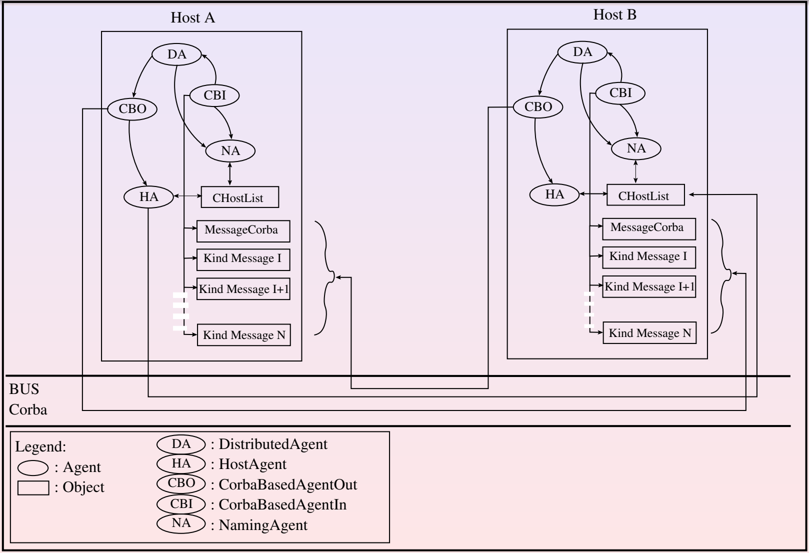
Distributed Multi-Agent Systems (1/2)



Distributed Multi-Agent Systems (2/2)



Distributed Multi-Agent Systems: our model



DISMAS model (1/2)

DIStributed Multi-Agent Systems:

- An implementation model for the distribution of MAS: application to the platform MadKit
- Using CORBA
- A full agent model
- Problem of the distribution:
  - Communications between agents.
  - The nature of the distribution: static / dynamic.
  - Knowledge of present platforms.
- A model of distributed agent:
  - Extending the functions of communications,
  - Extending the network of the agent,
  - Registration of agents on each machine.

DISMAS model (2/2)

- An agent model of the distribution:
  - An agents to transfer messages,
  - A namespace agent in order to identify each agent in an unique way,
  - A management agent for other machines to track the machines hosting a platform for distributed MAS according DISMAS model.
- Two kinds of transfer agents:
  - In output of a host (sending messages):
    - Transform message in CORBA object,
    - Add information to the message (name and position of the recipient).
  - In input of a host (receiving messages):
    - Recovery of CORBA object and extract message,
    - Transport to the local recipient.
- Agent of management of the hosts
  - Manages locally a list of machines achievable,
  - Get lists available on other machines and completes its own list.

Application to the management of anytime query

- Characteristics:
  - A system allowing management to commercial transactions.
  - User Help: to give the necessary information to make a decision.
  - Based on information systems organized to allow exploration at different levels of detail.
- Modeling:
  - The information could be public (all agents share this information) or private.
  - Multi-Agent Systems and extracting agents.
- Extracting information:
  - It is done by anytime and distributed agent,
  - Method:
    - Decomposing questions in simple SQL queries to the design,
    - Creating anytime agents that can perform simple queries at different depths in an information system.

Conclusion

- A model in order to take into account real-time in multi-agent systems.
- This model is base on anytime techniques and on progressive reasoning.
- A model to build distributed multi-agent systems.
- Implementation using an existing platform (MadKit) and the standard CORBA with the language JAVA.
- Designing an application for the management of business transactions.

Some publications

- Claude Duvallet, Bruno Sadeg, and Alain Cardon. An Anytime Multi-Agents Systems to Manage Electronic Commerce Transactions. In Proceedings of International Conference on Object Oriented Information System (OOIS'2000), pages 121-128, Springer, Londres, Grande-Bretagne, Décembre 2000.
- Claude Duvallet, Hadhoum Boukachour, and Alain Cardon. Intelligent and Self-Adaptive Interface. In Proceedings of International Conference on Industrial and Engineering Application of Artificial Intelligence and Expert System (IEA/AIE'2000), LNCS 1821, Springer Verlag, pages 711-716, New Orleans, United States, June 2000.
- Claude Duvallet, Bruno Sadeg, and Alain Cardon. How to build Real-Time Multi-Agent Systems using Anytime Techniques. In Proceedings of International Conference on Computer and their Applications (CATA'2000), ISCA, La Nouvelle Orleans, USA, pages 337-341, mars 2000.
- Claude Duvallet, Bruno Sadeg, and Alain Cardon. An anytime multiagent system to manage electronic marketplace. In Proceedings of Workshop on Artificial Intelligence in Electronic Commerce (AIEC-99), Sydney, Australia, 1999.
- Claude Duvallet, Bruno Sadeg, and Alain Cardon. Real-time in multiagents systems. In Proceedings of International Conference on Computer Applications in Industry and Engineering (CAINE'99), Atlanta, USA, pages 212-215, 1999.