ASAI '2000

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Next Agents' World

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Evolution of Programming Paradigms

1950's
- Machine and assembly language

1960's
- Procedural programming

1970's
- Structured programming

1980's
- Object-Based programming, Declarative programming

1990's
- Frameworks, design patterns, scenarios, and protocols

2000's
- Agents… Multi-Agent Systems…

…

What's next ?

Evolution of Agents and Multi-Agent Systems

Robotics Agents	Artificial Intelligence
Mobile Agents	Telecommunications
Software Agents	Software Engineering
Interface Agents	HC Interfaces
WWW Agents	Internet Computing
…	

MAS assuming Closed Environments
MAS integrating Open Environments
MAS including Human Agents (CSCW, ITS)
…

Who's next ?

Evolution of Technology and Perspectives

Network Capacity	78%
Processor performance	48%
Software Language and Tool Power	11%

How long ?

Availability of hardware and software
Reality of distributed and open systems
Reality of physical distributed entities
Existence of multiple knowledge domains
Need of accurate conceptual modeling
Wish of modelling natural or social systems

What's for ?

Motivations of this lecture

What's next ? Who's next ? How long ? What's for ?

1998 : an interview from the European Commission
1998 : the Agents' World multiconference
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2001 : a scheduled evolution of my research group
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The PhD thesis by Francis Van Aeken

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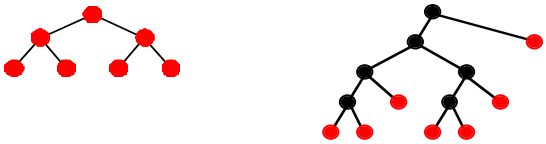
Minimal Multi-Agent Systems (1)

A joint project between INPG and France Telecom

Atomic agents and more complex agents
Λ = { S | S = Δ or S = (G D) = (D G) with G, D $\in$ Λ }



Minimal Multi-Agent Systems (2)

Measuring SMAMs

- size
- equilibrium
- entropy

$$EQ(S) = \frac{E(S)}{\log_2(TR(S))}$$

$$EQ(\Delta) = 1$$

$$E(S) = \sum \frac{N(A)}{2^{N(A)}}$$

Minimal Multi-Agent Systems (3)

Natural evolution of a closed SMAM

- Macroscopic view
- *The size of a closed SMAM is constant over time*
- *The equilibrium of a closed SMAM is maximizing over time*
- *The entopy of a closed SMAM is maximizing over time*

Agents behaviour

- Microscopic view
- *« qui se ressemble, s'assemble »*

Applications

- Augmented SMAMs vs. pure SMAMs
  - introduction of symbols
  - Adding attributes
- Friends (Off-Line, On-Line, Final, Numbercruncher)

Minimal Multi-Agent Systems (4)

FRIENDS Offline

- Atomic agents : users
- Complex agents : groups
- Attributes : key-words

FRIENDS Online

- Community Ware for the WWW
- Programmed in Java
- Evaluated at ICMAS'98

FRIENDS

- Mobile Heterogeneous Agents
- Programmed with Aglets
- Experimental System

FRIENDS Numbercruncher

- Hierarchical clustering
- Applied on QuiQuoiOù data (France Telecom)

Future Agents ' World

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Fusion of Virtual Reality & Real Virtuality (1)

The hype of Virtual Reality

- 3-D capabilities of personal computers are improving
- Chat systems are evolving into VR systems and feature elements like avatars (Canal+ Deuxième Monde)

The future of Virtual Reality

- Virtual agents will be increasingly present in the physical world
- Animal-like and human-like robots, connected to the network, will interact with humans (and each other) in a physical way

The emergence of Real Virtuality

- Already toys exist that are based on this philosophy.
- Some work on humanoid robots also fits in quite well (Honda Humanoid)

Fusion of Virtual Reality & Real Virtuality (2)

Prospective and Research issues

The physical world and the virtual world will merge

How to incorporate a social dimension in VR and in RV ?

(Extending the Social Dependence Theory ?)

Related to the O (also E) dimension of VOWELS

Acceptance of Human and Artificial Agents (1)

The increasing impact of artificial agents

- Artificial agents will take on an increasingly role in MAS systems (Citizen Agents)

The probable adaptation of human agents

- Human agents will adapt quickly to these agents that play a peripheral, assisting role
- If agents obey certain rules, they might be taken for granted (believable agents)

The problematic adaptation of virtual agents

- Artificial agents have hard time understanding our world
- Our social world might make more sense to them since they will live in a social world themselves
- The isolated agents of today will have no choice but to socially organise themselves (SMAMs)

Acceptance of Human and Artificial Agents (2)

Prospective and Research issues

Human and artificial agents will accept or at least tolerate each other (Sony Dog)
In certain contexts, one might not care to deal with a real or an artificial agent

The correspondence between real social worlds and virtual social worlds will help to bridge the gap between natural and artificial agents

(Reversing the Turing test ?)

Related to the A dimension of VOWELS

Transparency of HC Agent Interfaces (1)

Interactions between human agents
- Much work done in Natural Language Processing

Interactions between human and artificial agents
- How to represent ourselves to artificial agents ? (mutual representations)
- Man-Machine Interfaces are usually trying to reach the level of natural language

Interactions between artificial agents
- Interaction Languages between artificial agents are based on Speech Acts (IL, KQML, ACL)

Transparency of HC Agent Interfaces (2)

Prospective and Research issues

A unique interaction language between agents will arise to subsume these interests

How this language will look like ? Particularly at semantics and pragmatics levels ?

(Extending Speech Acts to Dialogism?)

Related to the I dimension of VOWELS

Management of the Social Space (1)

Traditional Real World social space

- Buildings not only provide shelter, but also organise physical space.
- Sophisticated transportation technology serves to overcome the constraints of physical space.
- To interact with somebody, one had to be physically close.

Future Real World social space

- Telephony allows to interact far away in physical space.
- Until the Internet, people did not change their social space through technology
- Using chat rooms, people can make friends / ennemies without physically meeting (Friends Numbercruncher)

The mirror evolution in the Virtual World

Management of the Social Space (2)

Prospective and Research issues

Social space will have to be organised and this is actually too much usually done in an ad hoc fashion

How to manage social space dynamically as it exists in physical space ?

(Investigating further IBM's model of the WWW ?)

Related to the E (also O) dimension of VOWELS

From Productivity to Creativity Tools (1)

The disappearing intermediates

- As barriers disappear, the need for middlemen will gradually disappear
- Finding somoneone else will become easy, interacting through social space and the transparency of interfaces.

Productivity vs. Creativity

- Using networks, the product will find its way to consumer
- As production becomes smoother, the importance of creativity will increase

Towards creativity tools

- Creation of original content will be a main activity
- Agents will want tools to assist in this process
- People will build quick prototypes, using virtual agents to try out ideas (Movies)

From Productivity to Creativity Tools (2)

Prospective and Research issues

We will see an evolution from productivity tools to creativity tools

How to move from productivity to creativity ?

(Generating High-Level License Free Products ?)

Related to the MAS dimension of VOWELS

Real-time and Interactive Applications (1)

The decreasing value of information

- Static information become no value due to copying and distribution through the Internet (Music)

The increasing value of processing

- People want the information to be interactive, to follow them wherever they go
- Information will not only have to be original, it will have to be live and to adapt real time (Baghera)
- Producers will have to return to the live production of their material

Joint teams of Artificial Agents and Human Agents

- Producers will be assisted by interactive real-time agents
- Virtual agents and Human agents will join in production/creation teams

Real-time and Interactive Applications (2)

Prospective and Research issues

There will be a new focus on highly interactive real-time applications

How to construct interactive real-time agent-like technology ? How to let agents interact with their tutors and their peers ?

(investigating more real-time applications ?)

Related to the Applications dimension of VOWELS

Summary of the lecture

MAS Research issues

The problem lays in the relations between mental issues and coordination theories, between micro and macro issues.

- Mutual representations
- Coordination models
- Organisations
- Methodologies

Multi-agent systems are in the near future what object oriented systems are today: a set of well defined techniques

- Multi-Agent Oriented Programming
- Testbeds and Benchmarks
- Standards
- Available industrial platforms

Future of this lecture

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