USD

Odense
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MAS Course 5

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SCHEDULE OF THE COURSE + EXAMINATION

MAS 01	04 Aug.	Introduction, Methodology, Agents
MAS 02	05 Aug.	Agents, Environments, Interactions
MAS 03	06 Aug.	Dynamics, Organisations, Example
MAS 04	09 Aug.	Development, Deployment, Example
MAS 05	10 Aug.	Reactive and Cognitive Applications
MAS 06	11 Aug.	

attendance ; handouts ; individual work
[Ferber 95] [HERMES 01] [OFTA 04]

MAS Ex. 13 Aug. Written Control and Oral Delivery

KBS-Ship (ESPRIT I II projects 1074 & 2163)

Shipboard Installation of Knowledge-Based Systems Danish Maritime Institute (DK), East Asia Co (DK), Krupp Atlas (D), Nat'l Tech. Univ. Athens (G), Soren T. Lyngso A/S (DK), Lloyd's Register of Shipping (UK), Instituto Superior Technico (P)

Assist bridge and engine-room operators in duties ranging from voyage planning to diagnosis

Approach

- development of (few) KBS handling important functions (voyage planning, maintenance scheduling, alarm handling, loading planning) incorporating shipping regulations
- framework for communication and integration of these KBS

ARCHON (ESPRIT II project 2256)

Architecture for Cooperative Heterogeneous Online Systems Krupp Atlas (D), Amber Computer Systems (G), Electricity R&D Ctr (UK), Framentec (F), Iberduero (E), Queen Mary & Westfield College (UK), Univ. do Porto (P), Volmac (NL), Univ. Amsterdam (NL), CERN (CH), Ispra (I), Nat'l Tech. Univ. Athens (G), Univ. Libre de Bruxelles (B), Labein (E)

Architecture for Cooperative Expert Systems for Industrial Applications

Approach

- development environment implementing concepts of cooperation and interaction on virtual machine
- application in two large-scale demonstrators (domain of managing electrical power grids)

IMAGINE (ESPRIT III project 5362)

Integrated Multi-Agent INteractive Environment
Siemens (D), Steria (F), Intrasoft (G), Roke Manor Research (UK), Imperial College (UK), Univ. Amsterdam (NL), Univ. Keele (UK)

Environment for building complex MAS

Approach
- broad conceptual analysis
- specification of *Multi-Agent Implementation Language*
- prototype implementation on *Parlog+Prolog* Platform
- full implementation on C++
- test in application areas : air traffic control simulation, telecommunication management networks

The industrial impact of MAS

LES THEMES DES APPLICATIONS INDUSTRIELLES

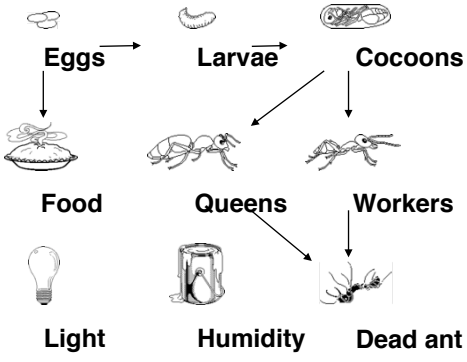
L'IA a passé le flambeau à la modélisation multi-agent, IA distribuée, vie artificielle. L'approche multi-agent est au coeur de la conception de services et applications distribuées

Extrait du Rapport de Synthèse "Recherche Publique et Coopérations Industrielles dans le Secteur Informatique " établi par SPECIF, pour la Direction de la Technologie du MENRT - Juin 1999

BOID

The Manta project (academic project)

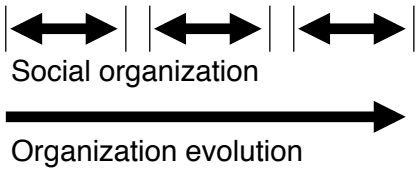
Behavioral modeling of a society of ants Ectatomma ruidum and emergence of social structures

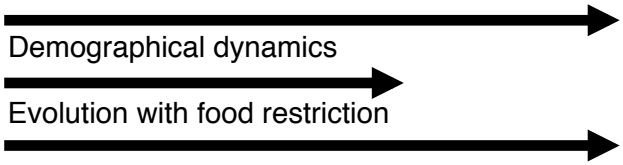


Developped by Drogoul / Ferber at U. Paris 6, in cooperation with Fresneau / Corbara, U. Paris 13

Manta : experiments

300 artificial societies of ants (from foundation to adulthood)



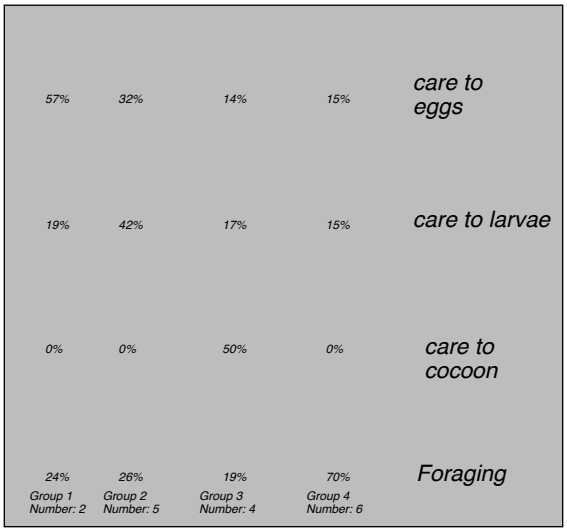


Manta : social organization and division of labor

Closest ants are attracted by sources stimuli (eggs, food, ..)

Reinforcement causes specialization of ants

Distribution into functional groups



Elastic Patterns (academic project)

The PACO resolution LIFIA-CNRS (F), VUB (B)

Feature extraction and tracking in 2D environments

Approach

- following the PACO approach
- simple agents with perception, communication, and action scopes
- implicit linking to extract complex image features
- full implementation on C/Parrallel Fortran - Sun WS / DAP (SIMD architecture)
- application to image feature extraction
- application to robot path planning

EPs : Intelligent Contour Detection

Environment

- {Yj} set of contrast points

Agents Xi

- PSi : infinite or fixed
- CSi : $1 \leq$ Card(Xj/Xi perceives Xj according CSi) ≤ 2
- DSi : in coherence with the contrast

Interactions with the environment

- $\sum j$ (PSi |Xi - Yj| + 1)**(-k), k=1, 2
- $\sum j$ exp -(PSi ln |Xi-Yj| -f(PS))**2

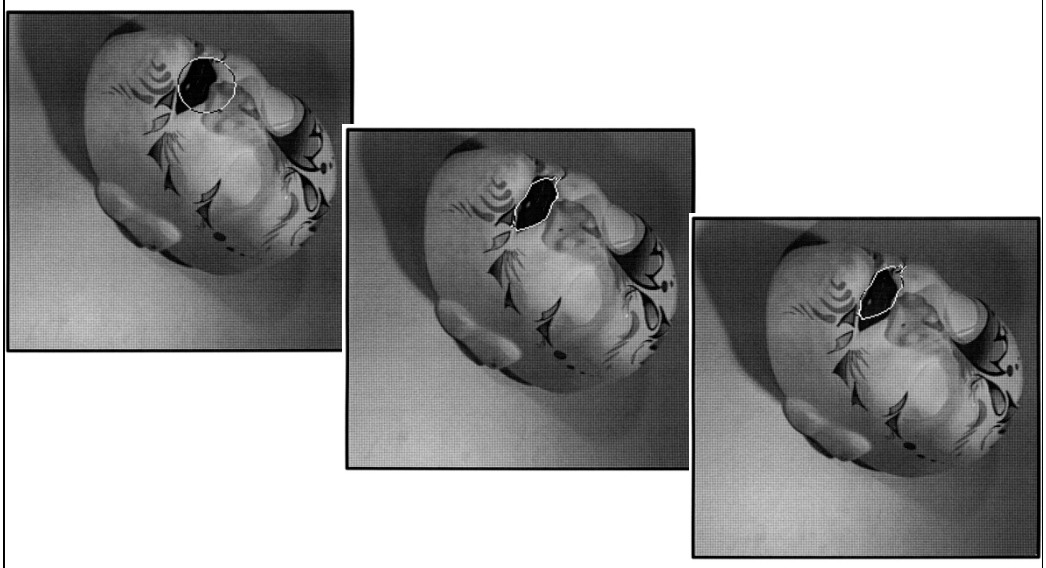
Interactions between agents

- $\sum j$ //CSi(j)// sign (|Xi-Xj| - μ) [ß(|Xi-Xj| - μ]**k, k=1, 3

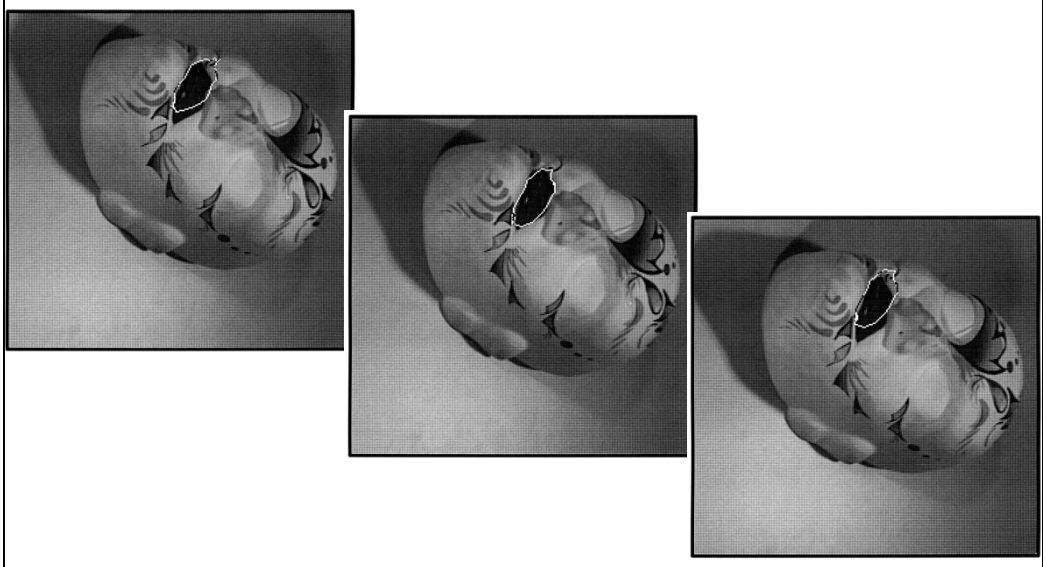
Getting the solution (by an external operator)

- Visualising the links between agents which mutually perceive each other

EPs : Intelligent Contour Tracking (mask)



EPs : Intelligent Contour Tracking (mask)



EPs : Planning trajectories

Environnement
- {Yj} set of heights

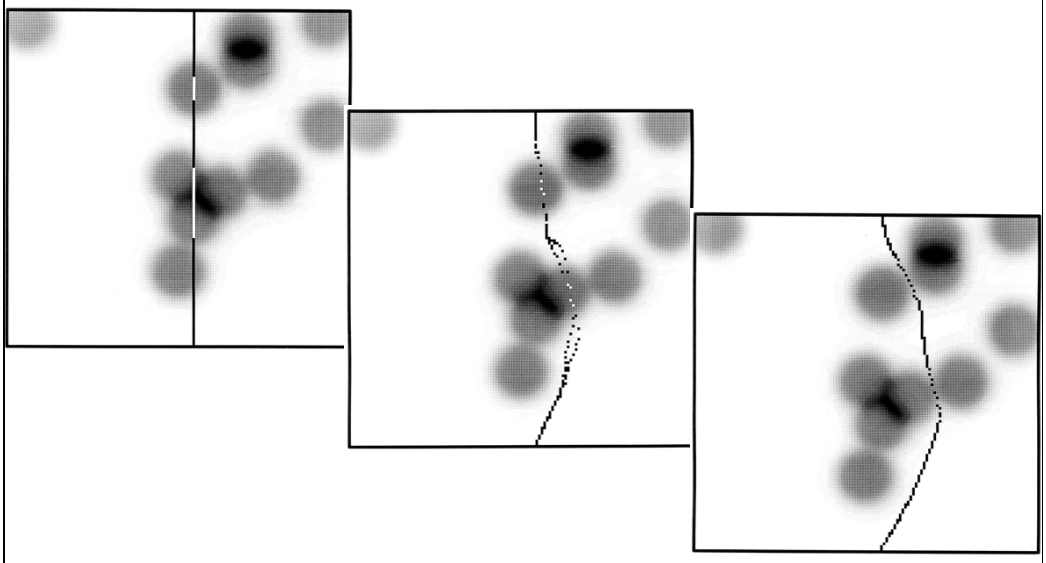
Agents Xi
- PSi : infinite or fixed
- CSi : 1 ≤ Card(Xj/Xi perceives Xj according CSi) ≤ 2
- DSi : in coherence with the height

Interaction with the environment
- gravity forces

Interactions between agents
- ∑j //CSi(j)// sign (|Xi-Xj| - μ) [ß(|Xi-Xj| - μ]**k, k=1, 3

Getting the solution (by an external operator)
- Visualising the links between agents which mutually perceive each other

EPs : Planning trajectories (desert)



PacoVision (industrial project)

A Reactive Multi Agent Approach to Image Feature Abstraction LIFIA-INPG (F), ELF Aquitaine Production (F)

Extraction of complex image features in 2D dense images

Approach

- simplified Demazeau's PACO agent model
- agents : one per column of the image
- determination of the best neighbours for each agent
- implicit linking to extract complex image features
- validation by human expert
- full implementation on C++/C - Sun WS

SMAALA (academic project)

A reactive multi-agent approach to over-constrained optimization; application to linear planning LEIBNIZ-UJF (F), CERREP (F)

Interacting reactive agents and global dynamics for distributed spatialized problem solving

Approach

- extends the PACO approach (+ formal model)
- supports expert analysis of a spatial project
- explores tool for spatial alternatives, with environmental, structural and social constraints
- allows hypothesis tests and dynamic add of constraints
- implementation on C++ on Sun WS - LAN
- parallelism is simulated : synchronous or asynchronous

SIGMA (academic project)

A reactive multi-agent approach to cartographic generalization LIFIA-INPG (F), IGN (F)

Interaction and organisation modelling to study their reciprocal interdependencies

Approach

- following the PACO approach (multiple types + organizational knowledge)
- reaching the relative importance of data types according to a desired global goal
- operators to transforms the representations of the data and the possible changes of scale
- interactive validation
- Implementation on C/C++ on Sun WS - LAN/XENOOPS

AGENT Project (CEC 24939) (1) [Lamy 1999]

Automated generalisation to provide maps from cartographic databases

Automatic GEneralisation New Technology IGN (F), LaserScan Ltd. (UK), LEIBNIZ-INPG (F), U. Zürich (CH), U. Edinburgh (UK)

Approach

- COHIA agents, micro agents (independent generalisation), meso agents (contextual generalisation), macro agents
- Simple IL interaction mechanisms but sophisticated generalisation operators
- Recursive organisations between agents
- Full implementation on GOTHIC/LAMPS2 - Sun WS and PC - LAN & WWW – Commercialized

S. Lamy, A. Ruas, Y. Demazeau, M. Jackson, W. Mackaness, & Robert Weibel, "The Application of Agents in Automated Map Generalisation", 19th International Cartographic Conference, Vol 2, pp. 1225-1234, August 1999.

FRIENDS (industrial project)

A joint project between INPG and France Telecom

Agents behaviour
- *« qui se ressemble, s'assemble »*

MAS behaviour
- *Size of a closed SMAM is constant over time*
- *Equilibrium of a closed SMAM is maximizing over time*
- *Entropy of a closed SMAM is maximizing over time*

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

FRIENDS : Applications

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)

FRIENDS : Numbercruncher

QuiQuoiOù Data (France Telecom)

- 4997 services
- 146674 keywords, 16384 being different
- 70337 seconds (19.5 hours)
- 128 identified groups at level 7, and 18 at level 6

Identified Groups at level 6

RELIGION	LINGUISTIQUE	SPORT	POLITIQUE
ALIMENTATION	ZOOLOGIE	LITTERATURE	MUSIQUE
COMMERCE	MEDIA	DROIT	MEDECINE
ART	TRANSPORTS	EDUCATION	TELECOM
INFORMATIQUE	GEOGRAPHIE		

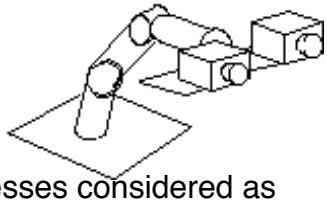
Example of the GEOGRAPHIE subgroups

CANADA	FRANCE	BELGIQUE	AGRICULTURE
TRANSPORTS	...		

VAP (EU project - ESPRIT III BR-3038)

Vision as Process Aalborg University (DK), University of Surrey (GB), Royal Institute of Technology (S), Linköping University (S), LTIRF (F), LIFIA-INPG (F)

An active, real-time, vision architecture to control the perceptual processes



Approach

- Four cooperative vision processes considered as concurrent and cooperative agents.
- Implementation using a central controller (VAP), using a multi-agent approach (VAP')
- Implementation on C/CLIPS on Sun WS / LAN

MAGIC (academic project - PRC-CHM)

Un système Multi-AGents pour l'Interprétation et la Compréhension de scènes LIFIA-CNRS (F), Crin-Inria (F)

Integration of low level vision modules to build 3D features

Approach

- simplified Boissier's agent model (individual/social)
- agents : "approximation polygonale", "segmentation en régions", "facettes-2D", "Facettes 3-D", "Arêtes 3-D"
- interaction messages : <comm.> <m.a.s.> <appl.>
- interaction protocols to regulate exchanges between modules and to implement the integration strategy
- full implementation on C/C++ - Sun WS - LAN/DPSK

TALISMAN (academic project)

Traitement Automatique des Langues par un Système Multi-Agents Crisstal (F), LIFIA-CNRS (F)

Multi-level morpho-syntactic analysis of the written french minimizing ambiguities by interactions

Approach

- simplified Demazeau's COHIA agent model
- agents : preprocessing, morphological analysis, syntactical anaysis, segmentation into propositions, transformations, ellipses, coordinations, negations
- Sian's interaction protocols to initialize, to regulate communication exchanges, to realize agent control
- full implementation on Bim/Prolog - Sun WS

ATRONS Project (with USD - Henrik Lund)

High level Programming language for reconfigurable modular robotics

VOWELS approach

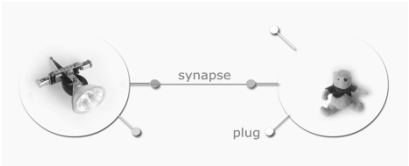
- ATRONS as A, evolving in a 3D environment
- I given IR sensors and physical grippers
- O as a problem to solve
- or a function to emerge

Applications

- Technological :
- to demonstrate modular robotics
- Scientific : to support emergence engineering

eGADGETS : Project [Mavrommati 03]

The project extends the notion of component-based software architectures to the world of tangible objects; transforming objects in peoples' everyday environment into autonomous artefacts (the eGadgets), which can be used as building blocks of larger pervasive computing systems



These systems can be accessed, composed and otherwise manipulated by application designers and end-users, using appropriate tools.

eGADGETS : Agents

GAS (Gadgetware Architectural Style), a conceptual and technological framework for describing and manipulating Gadgetworlds.

GAS consists of

- **A vocabulary and layers of semantic associations between terms**
- **A set of configuration rules**
- **A technical infrastructure to support it**

GAS serves as a common referent between Pervasive computing systems, designers, and people

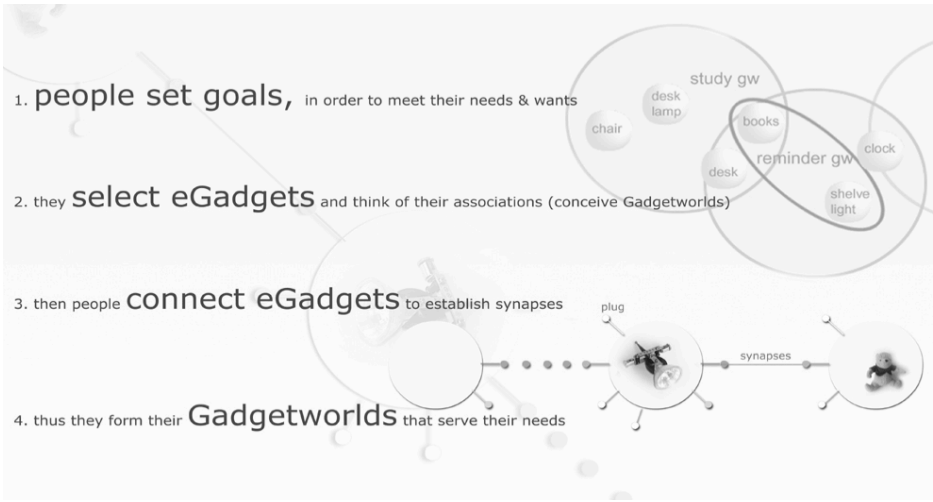
eGADGETS : Interactions

The eGadgets capabilities (Plugs) can be associated together via invisible links (Synapses) in many possible ways

A collection of objects functioning together in this way to serve one specific purpose, is a Gadgetworld

The Plug/Synapse model is a high level programming model that provides a conceptual abstraction that allows end users to describe Pervasive scenarios

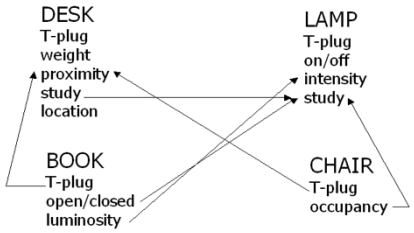
eGADGETS : Perspectives

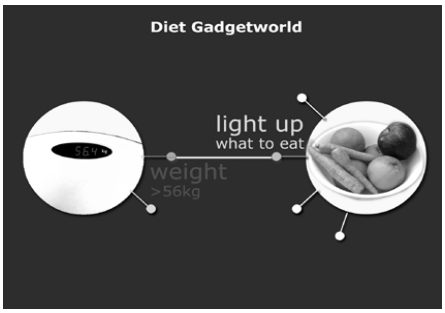


eGADGETS : Testing

12+ Gadgets & a living space (idorm)
2 working editors: PClaptop and PDA
Several Live hands-on interactive demos
User Evaluation activities in the iDorm

eGADGETS : Target applications





GROCER

Agentcities : Project [Willmott 03]

100+ organizations involved worldwide

- Including Industry giants such as HP, Fujitsu, Motorola and many others
- Participating in an open test environment
- Long term deployment, evolution and integration of technologies

Key technology issues

- Service interaction / semantics
- Service composition
- Automating service components

Concrete terms most groups work on:

- Particular technology trials
- Particular application focus

Agentcities : Network

160 nodes registered

- 70 or so active
- 30-50 "up" at any moment

Each service platform is connected live to the internet

- FIPA Agent standard implementation
- DAML-OIL/OWL processing
- Local directories and services
- HTTP / XML communication

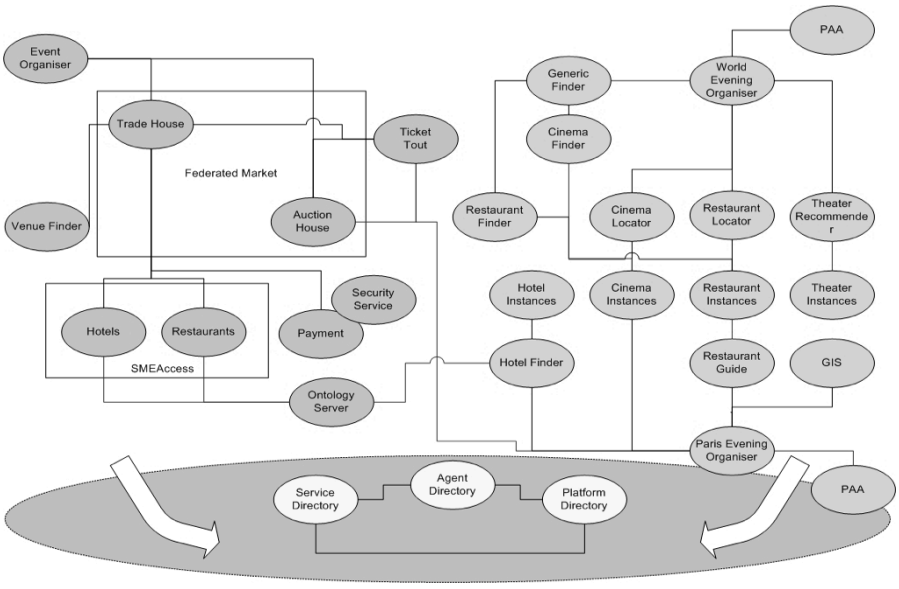
Now moving towards use by some major projects

- Each working on different applications

Agentcities : World

Agentcities : Europe

Agentcities : Demo [Jul. 03] (1)



Agentcities : Demo [Jul. 03] (2)

Agent Based Service Components

- From simple representatives to personal agents to complex federated markets, hosting and infrastructure
- More than 25 service types, nearly 200 agents

Hosted by 14 companies and Universities

- Deployed, Managed, Discoverable across Europe (and the World)

Business as Usual?

- Dynamic application creation
- Fully specified communication interfaces
- Coherent frameworks for all aspects of the environment
- Automated process in many areas
- Deployment on at least 5 different platform (JADE, FIPA-OS, AAP, ATOMIK Agent Shell, ZEUS)

Citizen Agents (MAGMA project)

To support everyday's life of every citizen

VOWELS approach

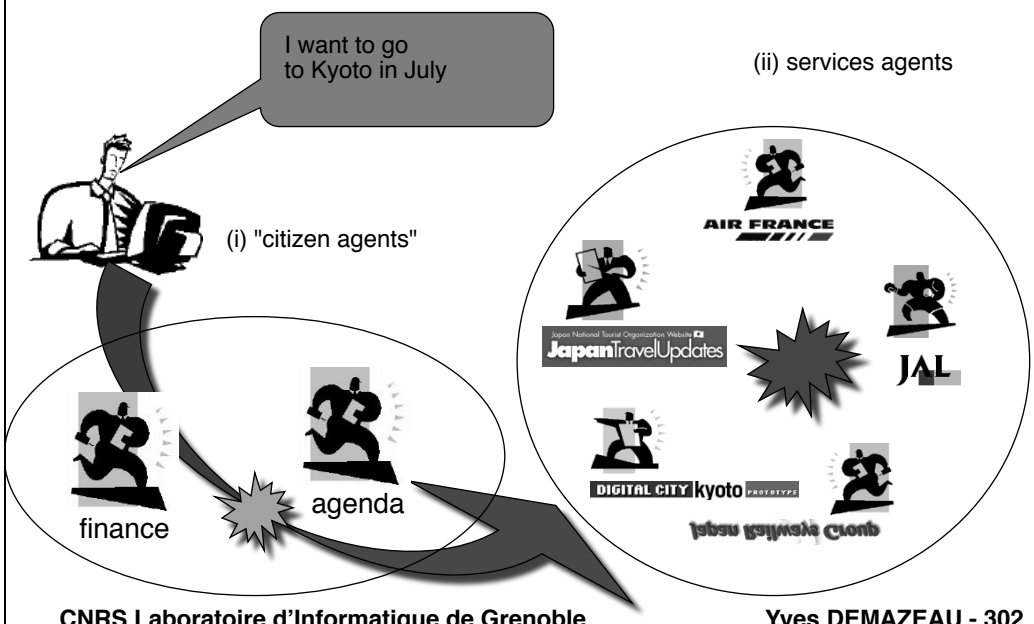
- One personal assistant per life domain, being the A
- E: Importance and urgency
- I : Sharing, Trusting, Negociating
- O : Family, Team, Consortium

Applications

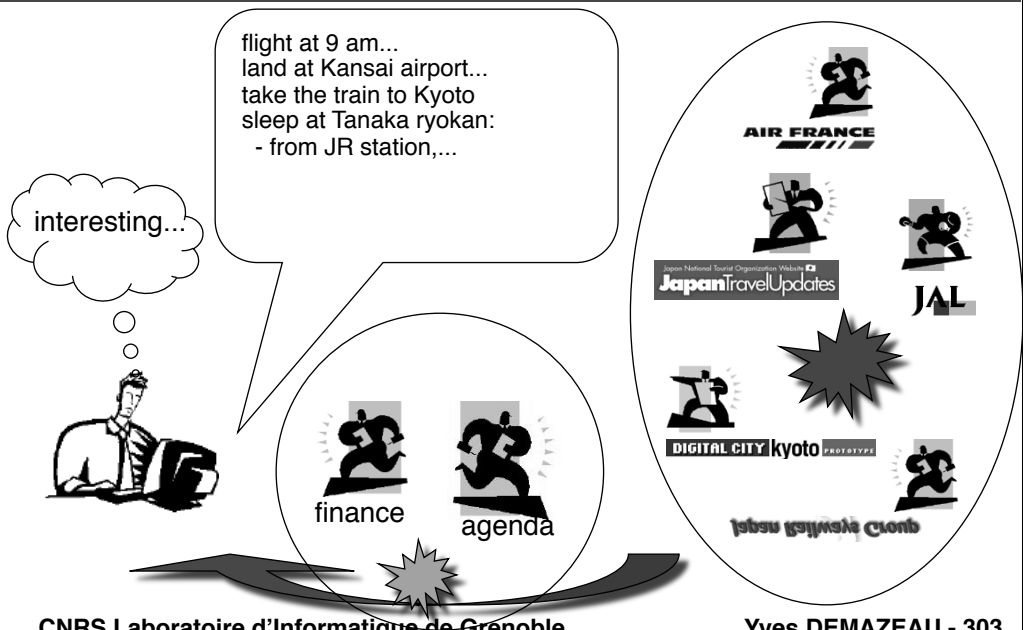
- Leisure : citizen as a consumer
- Finance : citizen as a partner
- Administration : citizen as a provider

Y. Demazeau, D. Melaye, M.-H. Verrons, "A Decentralized Calendar System Featuring Sharing, Trusting and Negotiating ", 19th International Conference on Industrial, Engineering & Other Applications of Applied Intelligent Systems, IEA/AIE'06, Annecy, June 2006.

Citizen Agents : Towards Complex Requests



Citizen Agents : Towards Global Answers



DECENTRALIZED CALENDARS (academic project)

An internal project , to support everyday's life of every citizen.

VOWELS approach

- One personal assistant per life domain, being the A
- Importance and urgence as subjective E
- Interactions I : Sharing, Trusting, Negociating
- Possible groups O : Family, Team, Consortium

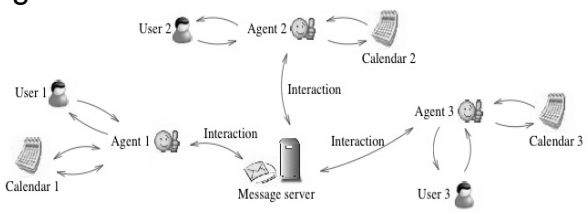
Applications

- Leisure : citizen as a consumer
- Finance : citizen as a partner
- Administration : citizen as a provider

Decentralized Calendars

Decentralized Calendars

- Negotating meetings and sharing events
- Importance and urgence as subjective features
- Local storage of the calendars and partial mutual knowledge



Approach

- Individual interactions : Sharing, Trusting, Negociating
  - ✓ Full sharing: CSP-like solution
  - ✓ Partial sharing: introduction of trust
  - ✓ No sharing: negotiation is necessary!
- Broadcasting to groups : Family, Team, Consortium

Importance and Urgence

Addition of an event

- Importance and urgency: two common dimensions of time handling, used by all agents,
- Each agent has a subjective vision of the combined priorities. Usually:

	High urgency	Low urgency
High importance	I	II
Low importance	III	IV

Checking consistency

- A higher priority task cannot be scheduled after a less priority one
- This is the responsibility of the user! The system only checks the constraint

Sharing Timetables

When timetables are shared, the meetings can be scheduled by well-known CSP techniques...

Groups

- Social organization of the agents
- Groups are structured in a hierarchy with subsumation relation

Sharing and groups

- An event can be public or private or...
- ...shared by several agents, but not all of them
- Sharing information or not according to the groups the agent belongs to
- If an agent belongs to several groups, its sharing capability is the logical combination of the sharing capability of its groups

Trust in Agents

Why trust?

- Trust is a central mechanism of coordination in situation of ignorance
- Trust can compensate the absence of information due to absence of sharing
- Individual trust supports dynamics

Sharing with trust

- A trust model calculates a trust capability in an agent permitting the sharing with this agent
- The trust model is based on several sources of trust (reputation, experiences, categorization, etc.)
- Which sources of trust to choose? It depends to the context, all sources are not necessarily at disposal

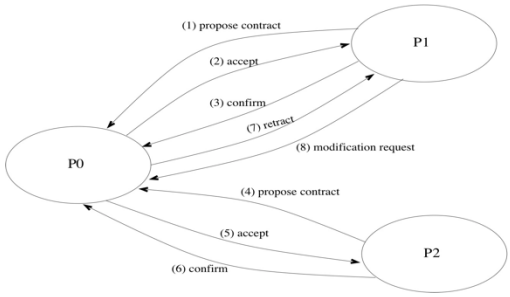
Negotiating a meeting (1)

Negotiation

- Absence of sharing: a system of negotiation is necessary
- GeNCA: a general negotiation API

GeNCA: negotiation level

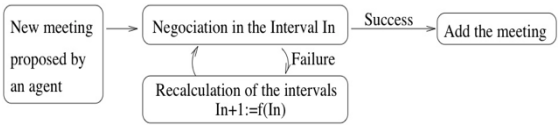
- Several rounds of negotiation
- Proposition, counter-proposition, confirmation and retractation of meetings



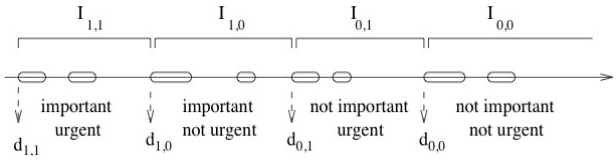
Negotiating a meeting (2)

GeNCA: strategic level

- Negotiation a meeting inside a time interval of possible solutions



- These intervals are built from the tasks and according to the different importance/urgency priorities



GEOMED (EU project - Telematics IE-194)

GEOgraphical MEDiation systems GMD (D), TNO (NL), VUB (B), LIFIA-UJF (F)

A agent-based tool to support mediation between actors through the telematic network

Approach

- no specific agent architecture, but personal assistants, library agents, mediation agents, migrating agents
- interaction mechanisms from active messages to interaction protocols to implement the communication exchanges between actors
- open environments and dynamic organisations
- full implementation on Java/HotJava - Sun WS - LAN & WWW - demonstrator "Le Salon"

SANPA (industrial project)

A Decision Support System for Actors in Town and Country Development LIFIA-UJF (F), Cerrep (F)

Agent, interaction, and organisation modelling to simulate negociations and to reach consensus

Approach

- A tool to support decentralized negotiation, asynchronously, and unconstrained
- Guarantees spatial coherency, global spatial consuensual search through negociation
- Maintains in time a project with its actors and events
- Manages access of all actors to all functions
- Makes use of personal assistants for actors and the project
- Implementation on C++/JAVA - Sun WS - LAN & WWW

PLAYWARE Project (with USD - Henrik Lund)

An interactive playground that recognizes and adapts to children

VOWELS approach

- Children as A, evolving in a 2D Environment
- I given tactile sensor and visual actuators
- O as a dynamic structure arising during time

Applications

- Societal : to train children
- Scientific : to assist heathcare

F. Hammer, A. Derakhshan, Y. Demazeau & H. Lund, “A Multi-Agent Approach to Social Human Behaviour in Children’s Play”, 6th International Conference on Agent Technology, IAT’06, pp. 403-406, IEEE/WIC/ACM, Hong-Kong, December 2006.

PLAYWARE Project (with USD - Henrik Lund)

Which applications are better handled by MAS ?

MAS methods cater for distributed intelligence applications : Network based, Human involved, Physically distributed, Decentralized controlled, ...

It suits when only local computational models are available whilst global ones are unknown

- Telecoms, Internet Applications, Vision, NLP, ...

It is adequate for application domains and kinds of problem as soon as non-determinism is acceptable

- Vision, Robotics, NLP, GIS, Societies Simulation, ...

It suits when the human is involved in the life cycle of a distributed system

- Internet Applications, Groupware, CSCW, GIS, ...

How MAS Methodology is specific ?

= Approach + Model + Tools + Problem + Domain
= Analysis + Design + Development + Deployment

It provides a new analysis and design approach

It is supported by existing formalisms,

It integrates existing programming paradigms,

It is striving towards industrial quality,

It caters for distributed intelligence applications,