

# Simulating a Human Cooperative Problem Solving

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# Introduction (1/3)

## Cognitive modelling and MAS

### *Design efficient heterogeneous MAS*

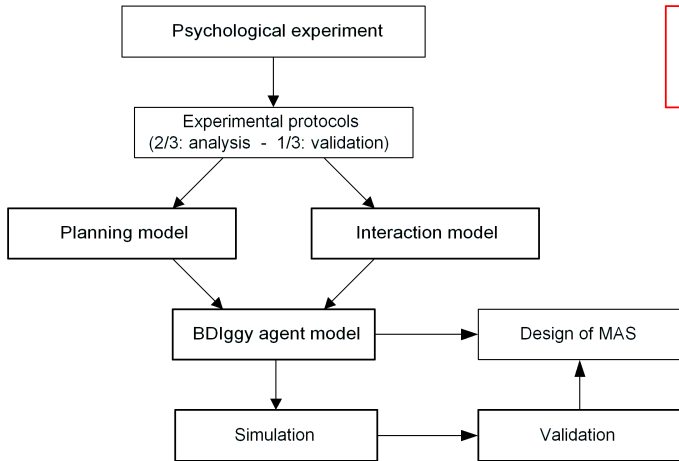
- **Cognitive modelling**: used to study human communication and reasoning, to improve the design of MAS
- **MAS**: simulation tool used to validate the cognitive models

#### Goal

**analyze, model** and **simulate** human capabilities of planning and interaction in a multiagent planning framework

# Introduction (2/3)

## Methodology



**Travel  
Agency  
Project**

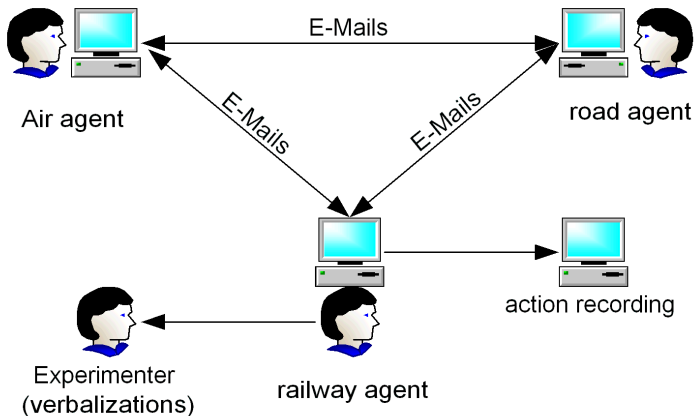
# Introduction (3/3)

## Plan

- Introduction
- The travel agency project
- The human planning model
- The human interaction model
- Simulation and validation
- Conclusion and future work

# Travel Agency Project (1/3)

## Psychological Experiment



# Travel Agency Project (2/3)

## Interface

**Propositions**

Car : ChateauNeuf - Orleans(gare)  
 train : Orleans - Paris  
 avion : Paris - Montpellier

avion : Paris - Montpellier  
 Depart le Demain a 11h45  
 Arrivee le Demain a 12h40  
 4 personne(s). Prix : 720 F.

Depl. vers le haut  
 Prix total : 3224  
 Depl. vers le bas  
 Supprimer Tester

**Horaires/Prix**

Depart : Nantes  
 Arrivee : Paris  
 Compagnie : Pigeon Vol

Afficher

08h40@9h35 - 595 F  
 18h45@17h45 - 595 F  
 18h52@19h05 - 595 F  
 19h55@20h50 - 595 F

Date : Demain  
 Nb places : 1  
 Memoriser

**Zone de travail**

Mon probleme  Pb. ag. routier  
 Pb. ag. ferroviaire

ChateauNeuf-Orleans(gare) (car)  
 Paris-Montpellier (avion)  
 Orleans-Paris (train)

Paris-Montpellier (avion PachtAR)  
 Date: Demain - 4 personnes  
 11h45@12h40 - 720 F

Reserver/Annuler Supprimer  
 Insérer proposition Envoyer

**Messagerie**

Agent routier : 1  
 Agent ferroviaire : 1  
 (Agent aerien : 1)  
 Agent aerien : 2  
 Agent ferroviaire : 2

List of messages (sent and received)

De: Agent routier A. Agent aerien  
 Vuilà !  
 =====HORAJRE=====  
 ChateauNeuf-Orleans(gare) ( car)  
 Date: Demain - 1 personne  
 08h10@9h45 - 24 F

Memoriser horaire Supprimer  
 Nouveau Message Repondre

**Timetable/price panel: consult the database**

**Workspace panel: memorize some stages**

**Message panel: send/receive messages**

**Proposition panel: design and test a solution**

# Travel Agency Project (3/3)

## An experimental protocol

Action record	Verbalization
<p>[09:31:52] Sujet: alexandre            [09:31:52] Rôle: Agent aérien            [09:31:52] Problème: Aller            [09:31:52] Date: Mardi 5 Mai 1998 17:32:43            [09:31:52] 1, Demande horaires Annecy-Annecy (Pach'AIR)            [09:31:55] 2, Demande horaires Annecy-Annecy (Pigeon Vol)            [09:31:59] 3, Demande horaires Annecy-Brest (Pigeon Vol)            [09:32:03] 4, Demande horaires Annecy-Brest (Pach'AIR)            [09:33:45] 5, Nouveau message            [09:34:21] 6, Reçoit message 1 de Agent ferroviaire            [09:34:53] 7, Envoie message 1                  De: Agent aérien A: Agent ferroviaire                  Y a-t-il une gare à Château-Neuf ?            [09:34:57] 8, Affiche message numero 1 de Agent ferroviaire                  De: Agent ferroviaire A: Agent aérien                  Salut, j'aimerais connaître les prix et les horaires du premier            vol NANTES-PARIS pour demain pour 1 personne. merci            [09:35:12] 9, Demande horaires Nantes-Paris (Pach'AIR)            [09:35:15] 10, Demande horaires Nantes-Paris (Pigeon Vol)            [09:35:39] 11, Mémorise horaire            [09:35:39] 12, Ajoute horaire dans panneau Mon problème                  Nantes-Paris (avion Pigeon Vol)                  Date: Demain -- 1 personne                  08h40/09h35 - 595 F            [09:35:43] 13, Envoie horaire Nantes-Paris (avion)            [09:36:05] 14, Reçoit message 1 de Agent routier            [09:36:43] 15, Envoie message 2                  De: Agent aérien A: Agent ferroviaire                  C'est le plus tôt, le dernier arrive à 20h50, tous à 595F                  =====HORAIRE=====                  Nantes-Paris (avion Pigeon Vol)                  Date: Demain -- 1 personne                  08h40/09h35 - 595 F            ...</p>	<p>"Si, je mets 4 est-ce qu'il va me mettre le prix..... "</p> <p>"Alors Château-Neuf départ et arrivée Maguelone... Donc Château-Neuf/Orléans en.... en... Château-Neuf/Orléans... Donc là... Je me demande si je l'envoie en train directement à Maguelone ou en avion depuis Paris... 3000 F... Donc ils iront en train..."            "Ah! Il faut que je demande s'il y une gare à Château-Neuf, on ne sait jamais.... "</p> <p>"Il est drôle lui... Je vais lui envoyer l'horaire le plus tôt."</p> <p>...</p>

# The human planning model

## IGGY system

- Sequential/parallel planning
- Plans built: prospective, retrospective, centrifugal, centripetal
- Previous individual human planning model extended to cooperative human planning

### IGGY

⇒ IGGY System (*phase, state of mind, strategy, tactic, observation and personality*)



## The human interaction model (1/6)

List of observed performatives (KQML, FIPA-ACL)

Performatives	Speech acts	%
<i>query</i>	directive	474 (42,97%)
<i>reply</i>	descriptive	437 (39,62%)
<i>refine</i>	directive	60 (5,44%)
<i>thank</i>	descriptive	30 (2,72%)
<i>propose</i>	commissive	29 (2,63%)
<i>inform</i>	descriptive	26 (2,36%)
<i>cancel</i>	directive	18 (1,63%)
<i>acceptProposal</i>	directive	10 (0,91%)
<i>notUnderstood</i>	descriptive	9 (0,82%)
<i>refuseProposal</i>	directive	3 (0,27%)
total		1103 (100%)

# The human interaction model (2/6)

## Utterance model

Speech act theory:  $F(P) \rightarrow \text{performative}(\text{mental state})$

directive(desire of the locutor)

air→railway

query(pD(air pStage(Orleans Paris ? <(10h30) train \* ? false)))

descriptive(belief)

railway→air

reply(pB(pStage(Orleans Paris 08h25 09h30 train 1 80 false)))

commissive(desire of the interlocutor)

railway→air

propose(pD(air pStage(Orleans Paris ? ? train ? ? false)))

# The human interaction model (3/6)

## Discourse model

### *Vanderveken theory*

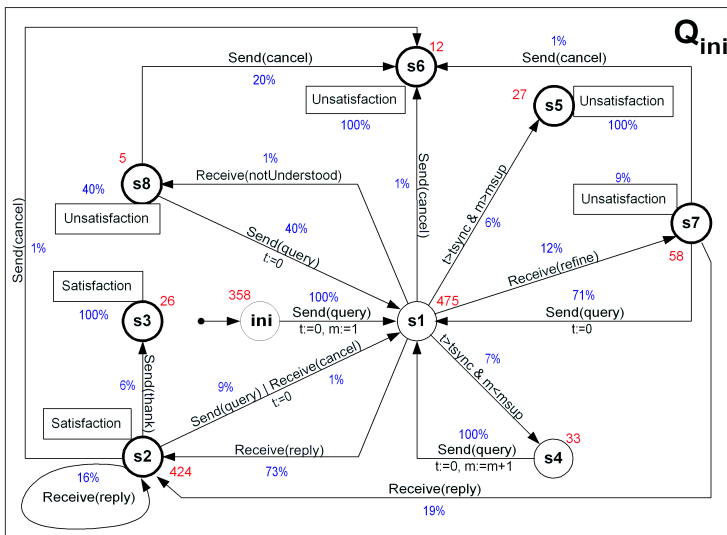
**Exchange:** series of utterances guided by the discourse goal

Types of exchange	Discourse goal	Initial performative	Closing performative	%
Information queries	Directive	query	reply	86,1%
Information proposals	Commissive	propose	reply	6,7%
Spontaneous sendings	Descriptive	inform	inform	6,3%
Error processings	Directive	-	cancel	0,2%

Representation: an exchange = a pair of timed automata

# The human interaction model (4/6)

## Example of timed automaton



# The human interaction model (5/6)

## Timed automata

- 4 pairs of timed automata cover the whole dialogs  
⇒ **Low complexity**
  - In MAS, automata used to:
    - Generate messages
    - Interpret received messages
- ⇒ **Timed automata are used to represent the expected messages in the dialogs**

# The human interaction model (6/6)

## Semantics of performatives

$$M = pMessage(A_S \ A_R \ query \ pD(A_S \ S))$$

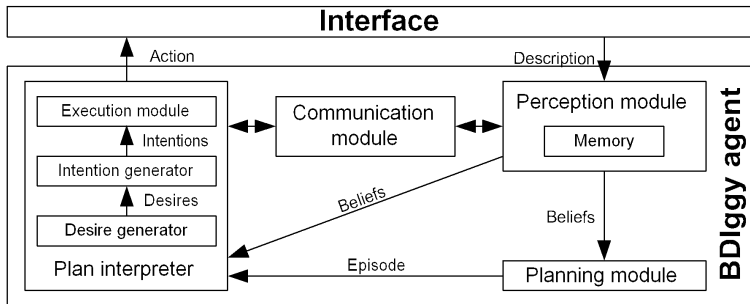
$$\left[ \begin{array}{l} pD(A_S \ S) \\ pB(!pMeans(S)) \\ !pB(S) \\ !pB(!S) \end{array} \right] \frac{Q_{ini}(ini, s2, s4, s7, s8) \xrightarrow{Send(query)} Q_{ini}(s1)}{aAdd(pB(pSent(M))); aUpdateTA(M)}$$

$$\frac{Q_{int}(ini, s1, s2, s4, s5) \xrightarrow{Receive(query)} Q_{int}(s1)}{aAdd(pB(pD(A_S \ S))); aUpdateTA(M)}$$

# Simulation and validation (1/3)

## The BDI<sub>IGGY</sub> architecture

- Planning model
- Interaction model (performatives/automata/semantics)
- BDI concepts



# Simulation and validation (2/3)

## Simulation

### Simulation of the travel agency problem

- 3 BDI<sub>GGY</sub> agents run simultaneously
- Connexion with the experimental interface
- Input: a personality for each agent
- Output: a generated protocol for each agent



# Simulation and validation (3/3)

## Validation

### *Turing-like test*

Generated protocols | Experimental protocols | Mixed protocols → Experts ?

	Set 1		Set 2		Total
	Human	BDI <sub>ggy</sub>	Human	BDI <sub>ggy</sub>	
<b>Expert 1</b>	2/3	1/3	1/2	2/4	6/12
<b>Expert 2</b>	1/3	1/3	-	-	2/6
<b>Expert 3</b>	-	-	0/2	2/4	2/6
<b>Expert 4</b>	-	-	2/2	2/4	4/6

## Conclusions...

- Psychological experiment
- Analysis of the experimental protocols
- Cooperative human planning model (IGGY)
- Human interaction model
  - Performatives applied to mental states
  - Timed automata
  - Semantics of performatives
- Planning and interaction are homogeneously integrated to a new agent architecture: BDIGGY
- Validation of the cognitive models and of the architecture:
  - Simulation thanks to BDIGGY agents
  - Experimental protocols and generated protocols are compared with a *Turing-like* test

## ... And future work

- Include Natural Language Processing
  - NLP Modules
  - Indirect speech acts
- Learning stage in the timed automata
  - Supervised learning
  - Unsupervised learning
- Extension to other kinds of problem (collaboration, negociation)
- Extension to other kinds of interaction (ECA, multimodal interaction)
- Heterogeneous MAS

Thank you ! Questions ?

# Plan interpreter

**Iggy2** : prospective, ... ,(Paris, optimized, cheapest)

**Pile de desirs** : [  
pD(railway pProblem(railway true))  
]

**Pile d'intentions** : [ ]

# Plan interpreter

**Iggy2** : prospective, ..., (Paris, optimized, cheapest)

**Pile de desirs** : [

pD(railway pTravel(pStage(Beaupreau Baisieux \*  $\leq$ (11:00) \*  
1  $\leq$ (1310) true))

pD(railway pProblem(railway true))

]

**Pile d'intentions** : [ ]

# Plan interpreter

**Iggy2** : prospective, ..., (Paris, optimized, cheapest)

**Pile de desirs** : [

pD(railway pStage(Beaupreau Nantes \* \* coach \* \* \*))

pD(railway pTravel(pStage(Beaupreau Nantes \* \* coach \* \* \*)

pStage(Nantes Baisieux \* \* \* \* \* \*))

pD(railway pProblem(railway true))

]

**Pile d'intentions** : [ ]

## Plan interpreter

**Iggy2** : prospective, ..., (Paris, optimized, cheapest)

**Pile de desirs** : [

pD(railway pStage(Baisieux Nantes \* \* coach \* \* \*))

pD(railway pTravel(pStage(Beaupreau Nantes \* \* coach \* \* \*)  
pStage(Nantes Baisieux \* \* \* \* \* \*))

pD(railway pProblem(railway true))

]

**Pile d'intentions** : [

pl(AskForStage,road,pStage(Beaupreau Nantes \* \* coach \* \* \*))

— sendMessage,%agent,pD(%role %stage)

— waitMessage,%agent,pMessage(%agent %role reply pB(%stage))  
OR pMessage(%agent %role reply pB(!%stage))

— memorize,pMessage(%agent %role reply %stage)

]



## Plan interpreter

**Iggy2** : prospective, ..., (Paris, optimized, cheapest)

**Pile de desirs** : [

pD(railway pStage(Baisieux Nantes \* \* coach \* \* \*))

pD(railway pTravel(pStage(Beaupreau Nantes \* \* coach \* \* \*))

pStage(Nantes Baisieux \* \* \* \* \* \*))

pD(railway pProblem(railway true))

]

**Pile d'intentions** : [

pI(AskForStage,road,pStage(Beaupreau Nantes \* \* coach \* \* \*))

— waitMessage,%agent,pMessage(%agent %role reply pB(%stage))

OR pMessage(%agent %role reply pB(!%stage))

— memorize,pMessage(%agent %role reply %stage)

]