

Issues in Agent Communication

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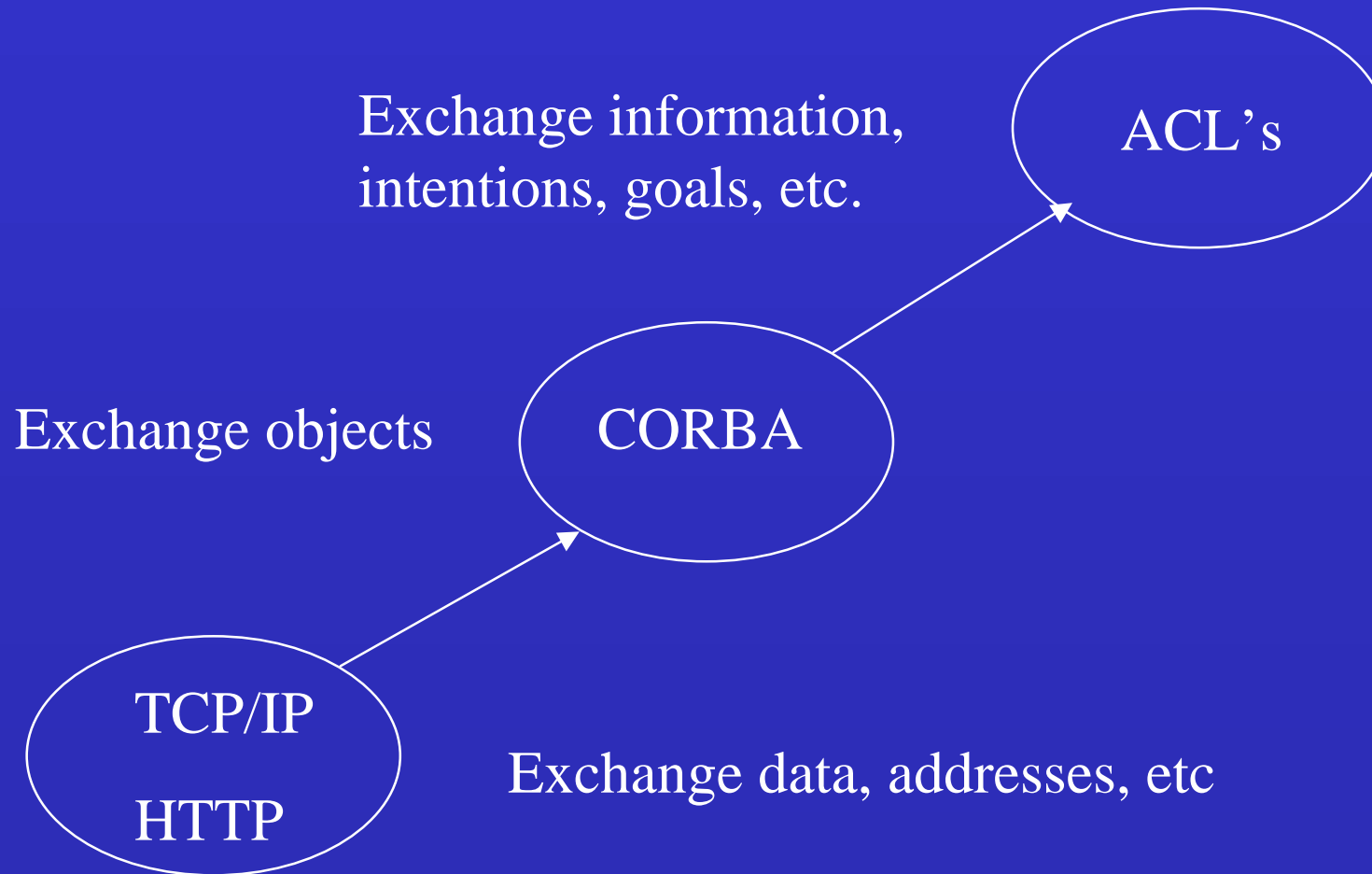
Overview

- Introduction
- Agent communication
- Current issues in agent communication
- Future developments
- Conclusion

Why an ACL?

- Communication is usually performed using a language
- It is richer and more efficient than observing changes in the world
- In open systems, an ACL is a useful interface to other agents

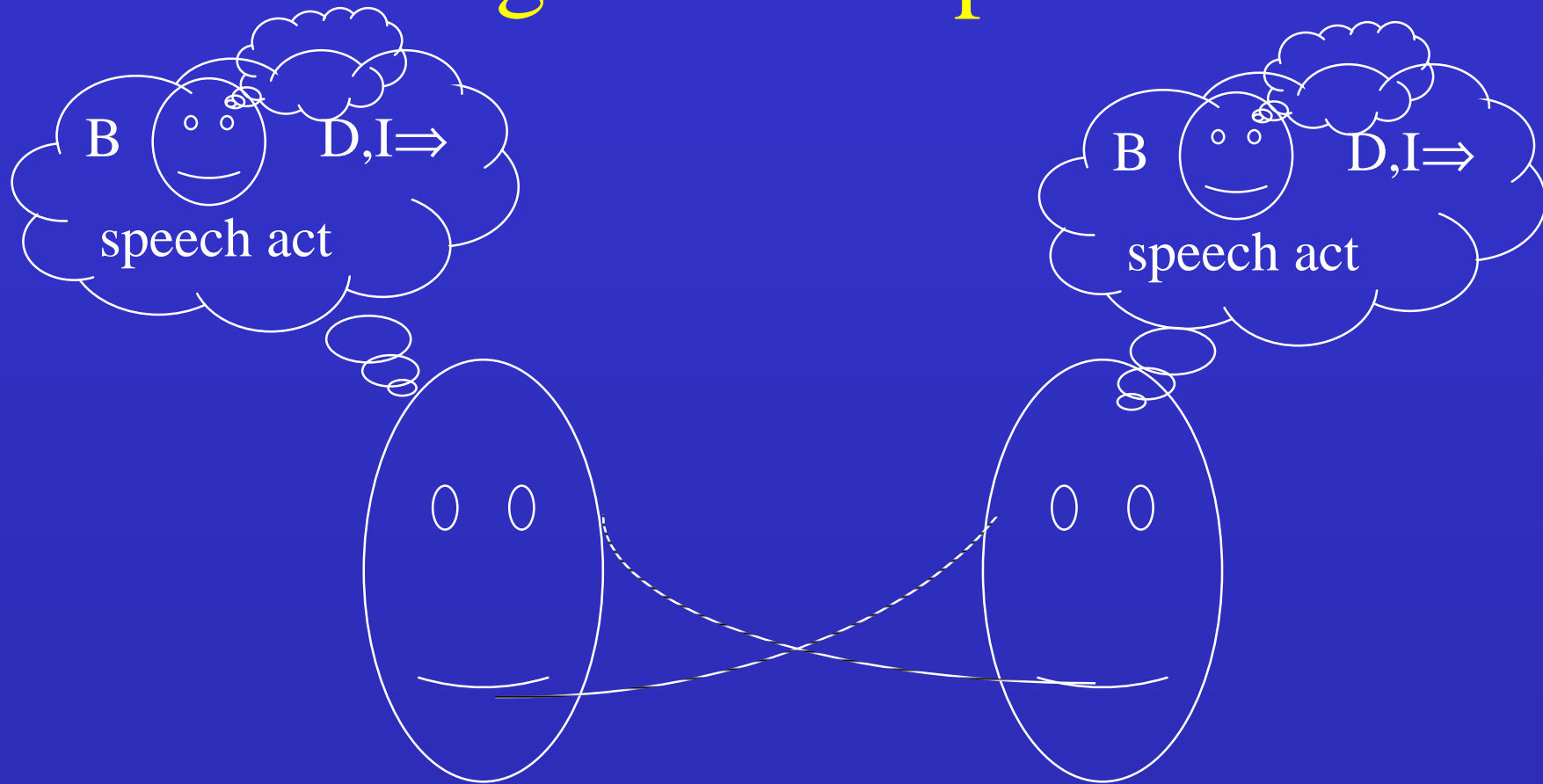
What is an ACL?



Agent communication and BDI agents

- ACL messages are usually modeled after **speech acts**.
- Speech acts are usually understood as intentional communicative acts.
- The intentional descriptions use concepts such as: **beliefs, goals, intentions, commitment**, etc.
- **BDI** agent frameworks describe agents in these terms as well.

BDI agents and speech acts



Speech Act Theory

- Speakers do not just utter true or false sentences.
- A speech act changes the world just as physical acts do!
- Most speech acts change the mental states of the participants of the conversation.

Speech Act Theory

Example: “Please, be quiet”

- **Locution**: the actual performance of the act
- **Illocution**: the purpose of the utterance; that the hearer is quiet.
- **Perlocution**: the consequences of the utterance: the hearer stops speaking.
- **Effect**: a.o. the hearer believes that the speaker *wants* it to be quiet.

Aspects of speech act semantics

- Pre- and postconditions of mental states
- Normative aspects of actions and reactions
- Social aspects of communication
- Pragmatics of speech acts

Example of speech act semantics

“Please, tell me the temperature in Melbourne.”

- Preconditions of mental state of speaker (a)
 - Desire(a, Know(a,temperature(Melbourne)))
 - Belief(a, Know(b,temperature(Melbourne)))
- Postconditions of mental states of speaker (a) and hearer (b)
 - Desire(a,Intend(b,Tell(b,a,temperature(Melbourne))))
 - Know(b, Desire(a,Know(a,temperature(Melbourne))))

Example of speech act semantics

“Please, tell me the temperature in Melbourne.”

- Normative aspects
 - $O(a, \text{Desire}(a, \text{Know}(a, \text{temperature}(\text{Melbourne}))))$
 - $O(b, \text{Tell}(b, a, \text{temperature}(\text{Melbourne})))$

Example of speech act semantics

“Please, tell me the temperature in Melbourne.”

- Social aspects
 - authority(a,b, request)
 - or
 - belief(a, cooperative(b))

Example of speech act semantics

“Please, tell me the temperature in Melbourne.”

- Pragmatic aspects
 - the speaker should really have a goal to know the temperature in Melbourne (sincerity)
 - the speaker “expects” some answer of the hearer
 - if the hearer wants to maintain a relationship with the speaker it has an obligation to respond

Two ACL implementations

- Knowledge Query and Manipulation Language
- FIPA ACL

KQML

- KQML is independent of
 - the transport mechanism
 - content language
 - ontology
- KQML can be extended with new message types. Therefore there are many dialects.

KQML message

Each message has exactly one
performative

(tell :sender CDagent
 :receiver Dignumagent
 :in-reply-to id9100.145
 :ontology EC.CD
 :language Prolog
 :content “price(cd263956,20)”)

Plus a list of
attribute/value pairs

KQML (facilitators)

- Facilitators are special agents who
 - Traffic in meta-information about other agents
 - Provide communication services such as:
 - Message forwarding
 - Matchmaking
 - Resource discovery
- Facilitators can be just yellow-pages or intelligent agents

FIPA ACL

- FIPA ACL is based on speech acts
- Communicative acts are described in both a narrative form and a formal semantics
- Syntax is similar to KQML
- Specification provides a normative description of high-level interaction protocols.

Major features of FIPA ACL

- Management and facilitation primitives are NOT part of the ACL!
- Primitives can be defined compositionally from “core” primitives
- Uses a multi-modal logic to define states (semantic language or SL)
- The semantics of primitives given in terms of Feasibility Preconditions (FP) and Rational Effect (RE)

FIPA ACL syntax

(inform	:sender	CDagent
	:receiver	Dignumagent
	:content	“price(cd263956,20)”
	:in-reply-to	reqoffer04
	:reply-with	offer2
	:language	Prolog
	:ontology	EC.CD)

Compose new primitives

$\langle i, \text{query-if}(j, X) \rangle \equiv \langle i, \text{request}(j, \langle j, \text{inform-if}(i, X) \rangle) \rangle$

FP: $\neg B_j X \wedge \neg B_j \neg X \wedge \neg U_j X \wedge \neg U_j \neg X \wedge$
 $\neg B_i I_j \text{Done}(\langle j, \text{inform-if}(i, X) \rangle)$

RE: $\text{Done}(\langle j, \text{inform}(i, X) \rangle | \langle j, \text{inform}(i, \neg X) \rangle)$

Agent i asks agent j if j is registered with server d1

(query-if_ :sender i
 :receiver j
 :content registered(j,d1)
 :language Prolog)

FIPA ACL vs KQML

- Different semantics; no easy mapping of primitives
- Different treatment of administration primitives (register, etc.)
- No facilitation primitives in FIPA ACL
- In FIPA ACL reserved content language necessary for some action messages

Issues in agent communication

- Semantics of messages and conversations
- Standard set of message types
- Ontologies for content of messages
- Conversation modelling, handling and verifying

ACL semantics necessary?

- No complete semantics for any ACL yet
- Semantics can help with standard implementation
- Semantics gives a framework for defining new performatives
- Semantics needed to make inferences over message exchanges
- In practice semantics is little used
- Gap between theory and practice too big
- Standardization maybe more important than semantics

Semantics of content (ontologies)

- Agents need to communicate many (high level) things
- Sensible communication is only possible if both sides have a common understanding about the content of the message
- Some shared ontology is a basic requirement
- Content language = Logic + Ontology

Ontologies

- An ontology is a common vocabulary and agreed upon meanings to describe a subject domain.
- Simply said: the ontology provides the meaning for all non-logical symbols of the content language.
- Ontologies for ACL are not different from dozens of other applications.

Ontologies

- Tools are needed to build ontologies.
- Example: Ontolingua
<http://ontolingua.stanford.edu/>
- Ontologies can be defined and translated into a number of content languages.
- Within WWW and EC domain the use of XML to describe ontologies is quickly gaining ground.

Ontologies

- In both KQML and FIPA ACL ontologies are referred to by a tag in the message
- Some general conditions on the message types are dependent on the ontology (e.g. time and action concepts).
- These conditions can therefore not easily be incorporated into a general message handler.

ACL shortcomings

- Semantic description; which primitives needed?
- Gap between theory and practice using mental attitudes
- What is a suitable set of performatives?
- A number of suppositions in the ACL's are not made explicit
- How can we test compliance with an ACL?
- Can ACL's be extended?

Conversation protocols (issues)

- What exactly is a conversation protocol (or policy)?
- How should conversation protocols be specified?
- Can conversation protocols be (de)composed?
- What can be said about the semantics of conversations?
- What formal properties do we want to prove for conversations?
- How are conversations interleaved with other agent actions?
- How do we check that a certain protocol is followed?
- Can agents learn/negotiate protocols?

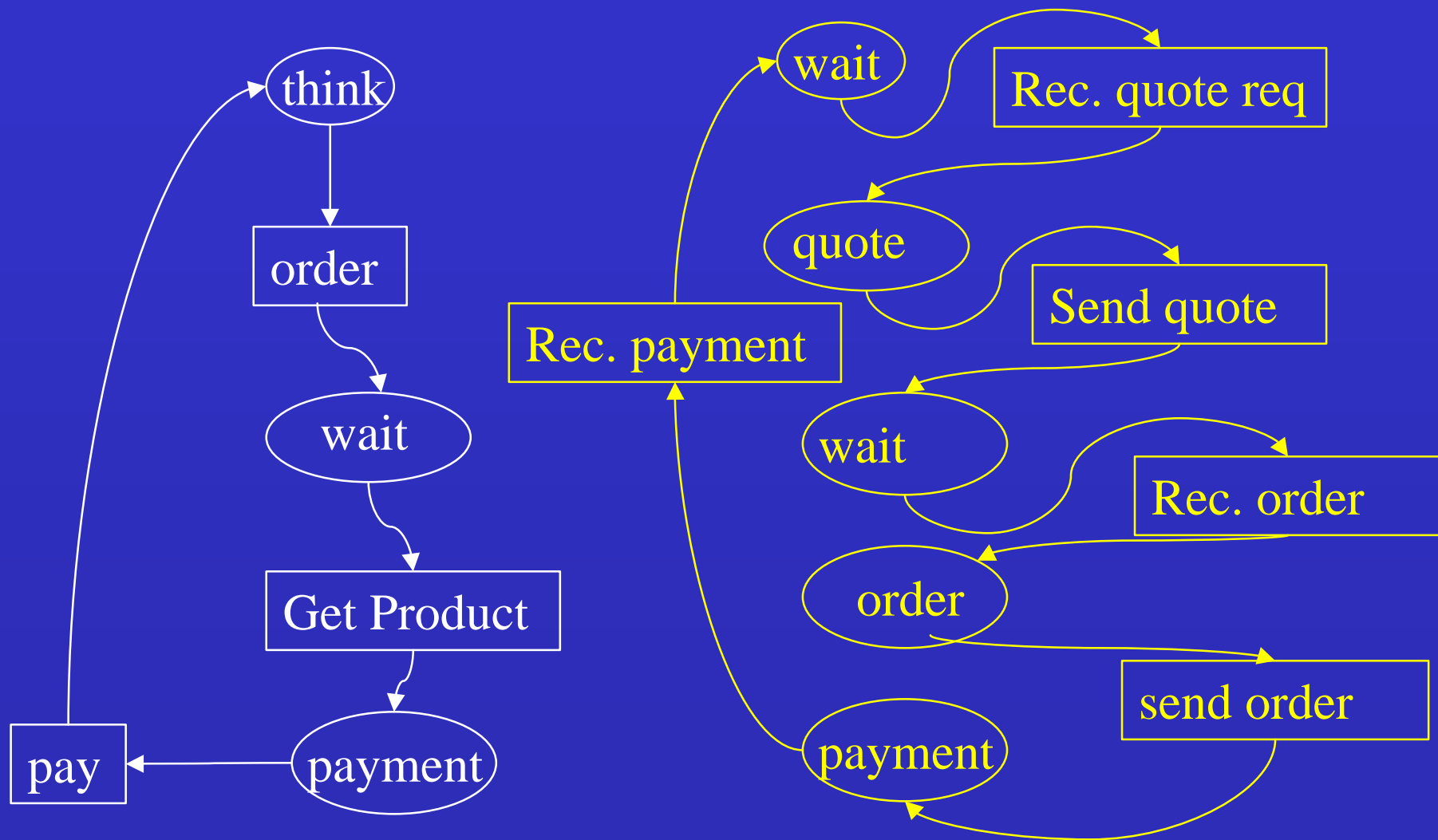
What is a conversation policy?

- A conversation policy includes some set of standard message sequences, **but also**
 - goal achievement policies
 - exception handling policies
 - uptake policies
 - termination policies
 - conversation management policies

Can conversation policies be (de)composed?

- How to link the protocols of two agents?
 - Can we check compatibility?
 - At which places are the protocols joined?
 - What are the properties of the resulting protocol?
- Can we build complex protocols from a number of simple ones?
- Possible but still very complex!

Connect two protocol halves



Properties of conversation protocols

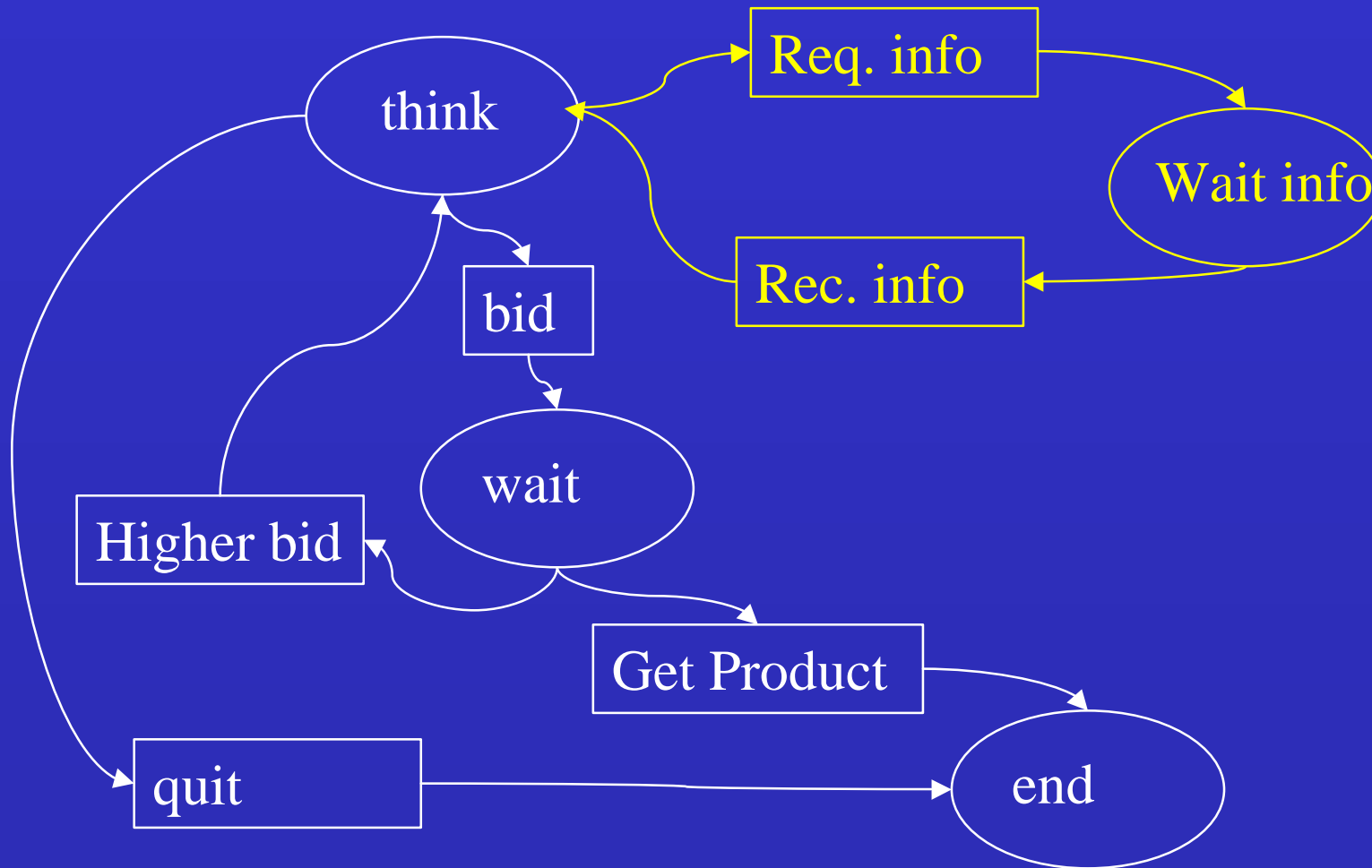
- Termination?
- Liveness, deadlock,...?
- Guaranteed termination in some type of mental or social state?
- Fairness in conversation?
- Other properties?

Constructing conversations

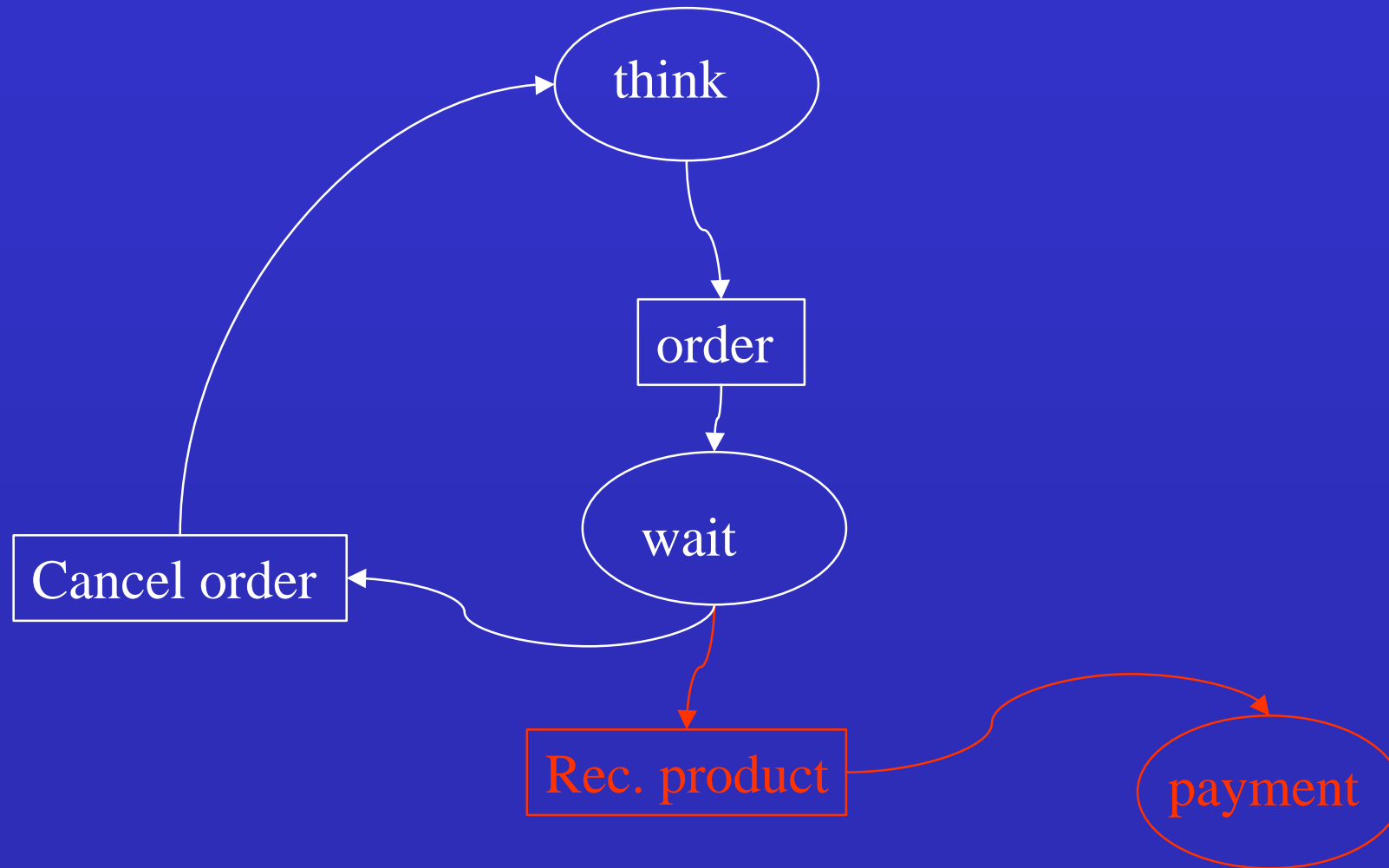
- Speech acts have to be planned as a means to reach a goal
- Therefore it should be possible to reason about consequences of conversations
- These should be combined with other agent tasks
- Thus conversations can be seen as joint tasks/intentions/goals!

Compliance to a protocol?

I. implement all possible sequences?



II. Implement subset



How to handle exceptions of a conversation policy

- Specify the conversation on a number of levels using small basic modules
- On each level the exceptions occurring on that level are specified
- Any exception that cannot be handled on a certain level is propagated to the level above

Future developments

- Simple standard set of messages
(influenced by practice!)
- Range of simple to complex ACL's
(subset relation?)
- Administration of agents important
- Content language plus ontology tools
needed

The role of XML in agent communication

- XML useful to specify content languages
- XML becomes universal standard
- Can XML be used to specify processes?
- Context dependencies difficult for XML

Conclusions

- Agent communication is important for MAS
- Many issues have still to be resolved in ACL's
- For MAS within company boundaries a general ACL is usually not needed
- Standard, simple ACL's plus support tools are needed
- Ontologies plus data integration are still important!