



What is It — and Why Do I Care?

Chair, OMG A&D "UML" Task Force
 Chair, FIPA Agent Modeling Technical Committee
 OMG-Certified UML Advanced Professional

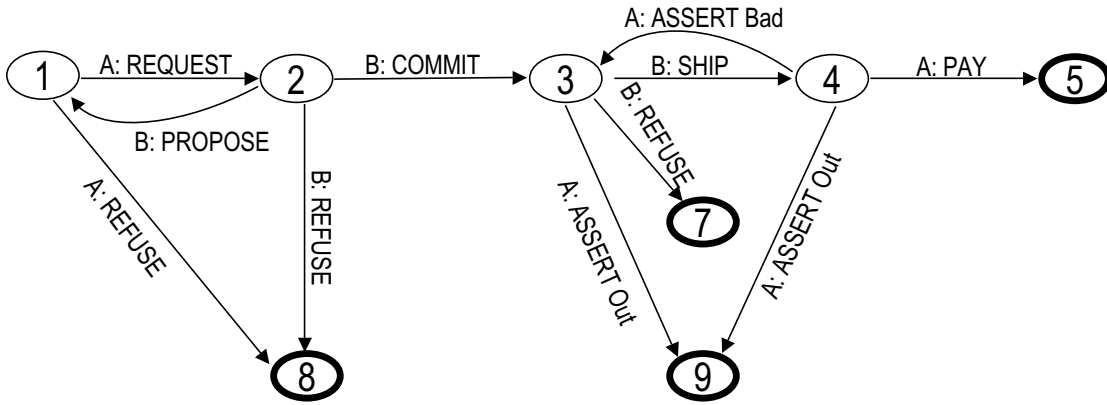
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AN AGENT CONVERSATION

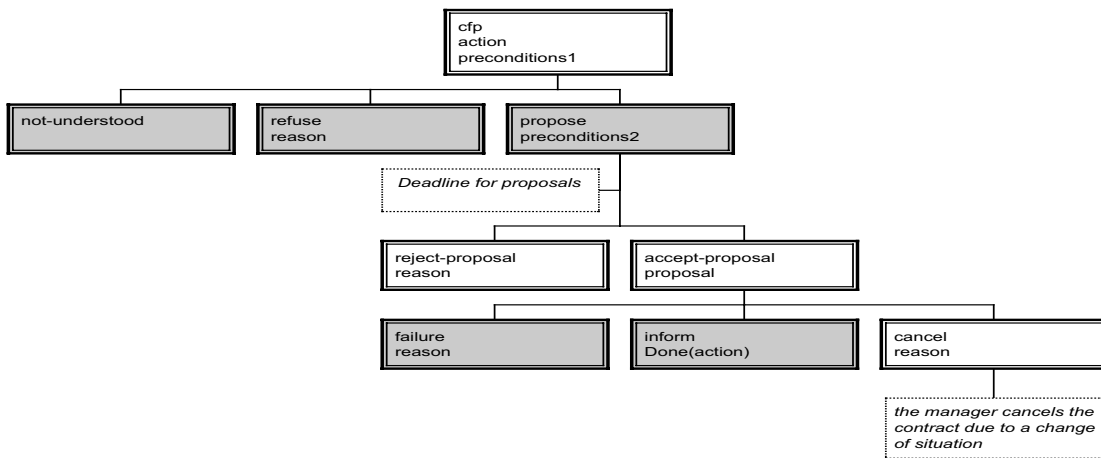
Seq	Sndr	Rcvr	Utterance	Rspnds to	Replies to	Re-solves	Com-pletes
1.	A	B,C,D	REQUEST: Please send me 50 widgets at your catalog price by next Thursday.				
2.	B	C	QUESTION: Are you bidding on A's RFQ?	1			
3.	C	B	INFORM: Yes, I am.	2	2	2	
4.	B	A	REFUSE	3	1	1	
5.	C	A	PROPOSE (INFORM + REQUEST): How about 40 widgets at catalog price by next Friday?	1	1		
6.	A	C	REQUEST: Please send me 40 widgets at catalog price by next Friday.	5	5	5	
7.	C	A	COMMIT: I plan to send you 40 widgets at catalog price by next Friday.	6	6	6	
8.	D	A	COMMIT: I plan to send you 50 widgets at catalog price by next Thursday.	1	1	1	
9.	A	C	ASSERT: I've found a better supplier, and am not relying on your COMMIT.	7,8	7		
10.	C	A	REFUSE: I'm abandoning my COMMIT.	9	9		7
11.	D	A	SHIP: Here are your widgets. Please pay me.	1	1		8
12.	A	D	ASSERT + REQUEST: You're five short. Please send the difference.	11	11		
13.	D	A	SHIP: Here are five more widgets. Please pay me.	12	12	12	
14.	A	D	PAY	13	13	13	

WINOGRAD-FLORES VERSION OF AN AGENT INTERACTION PROTOCOL (AIP)



After Smith and Cohen 1995

1997 FIPA-STYLE AGENT INTERACTION PROTOCOL (AIP)



FIPA 97 Specification, Version 2.0, Part 2, Agent Communication Language

AGENTS STANDARDIZATION AND AGENT UML (AUML)

- ❑ **OMG Agent Special Interest Group** recommends standards for agent technology where appropriate. (www.omg.org)
- ❑ **FIPA* Modeling Technical Committee** - now tasked with developing an AUML standard (www.auml.org)
- ❑ **Others** - MESSAGE, PASSI, Tropos, Prometheus, MaSE, ...

*FIPA (**Federated Intelligent Physical Agents**) has been working to develop and promote standardization in the area of agent interoperability since 1996. It has an on-going work program, meeting around the globe on a quarterly basis, with excess of 50 member organizations. (www.fipa.org)

THE FIPA AUML APPROACH

- ❑ Instead of reliance on the OMG's UML, we intend to reuse of UML *wherever it makes sense*.
- ❑ AUML is not restricted to using UML. Other approaches should be used *wherever it makes sense*.



<http://www.auml.org>

The general philosophy, then, is:

When it makes sense to reuse/extend portions of UML, then do it.

When it doesn't make sense to use UML, use something else or create something new.

SOFTWARE TECHNOLOGY AND AGENTS

Software history is one of increasing localization and encapsulation.

	Monolithic Programming	Modular Programming	Object-Oriented Programming	Agent Programming
Unit Behavior	Nonmodular	Modular	Modular	Modular
Unit State	External	External	Internal	Internal
Unit Invocation	External	External (CALLED)	External (message)	Internal (rules, goals)

Inspired by: Parunak, H. Van Dyke, *Autonomous Agent Architectures: A Non-technical Introduction*, Industrial Technology Institute, 10/13/95.

OO AND AGENTS

UML OO

UML Definition of *active object*:

- ❑ “An object that may execute its own behavior without requiring method invocation.”
- ❑ “The points at which an active object responds to communications from other objects are determined solely by the behavior of the active object and not by the invoking object.”
- ❑ “This implies that an active object is both autonomous and interactive to some degree.”

– UML 2.0 Superstructure document

OO and the agent-based approach seem to be converging.

UML 2.0 DIAGRAMS

Structure Diagrams

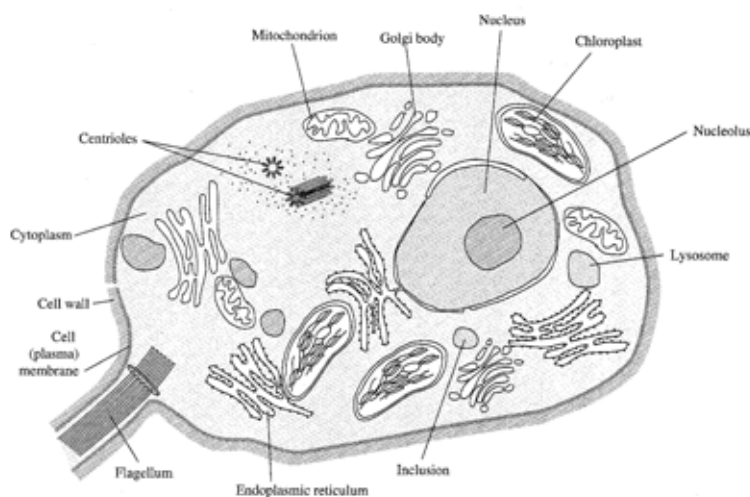
- Class diagrams
- Composite structure diagrams
- Component diagrams
- Packages
- Deployment diagrams

Behavior Diagrams

- Sequence diagrams
- Communication diagrams
- Activity diagrams
- State Machine
- Use Case diagrams

FIRST: A MAJOR DIFFERENCE BETWEEN OBJECT AND AGENT STRUCTURE

With agents, nature a source of analogies.



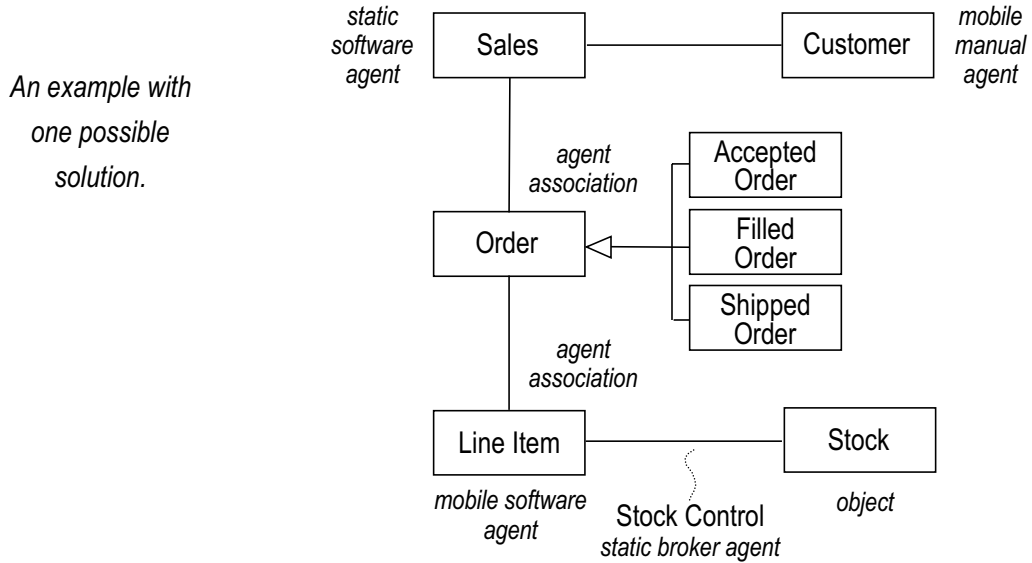
- symbiosis
- parasitism
- mimicry
- niche formation
- speciation
- sexual and asexual reproduction
- eukaryotic versus prokaryotic cells
- Darwinian evolution
- Lamarckian evolution
- neuron-based systems
- ...

These analogies mark some of the differences with conventional objects.

CLASS DIAGRAM

Agents and/or objects for order processing

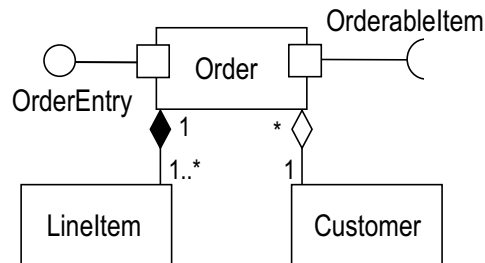
Start with a conceptual-level class diagram and identify which objects and links are candidates for agent-hood.



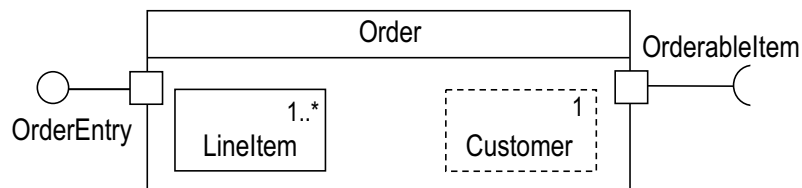
COMPOSITE STRUCTURE DIAGRAMS

A composition of interconnected elements that can collaborate.

This:

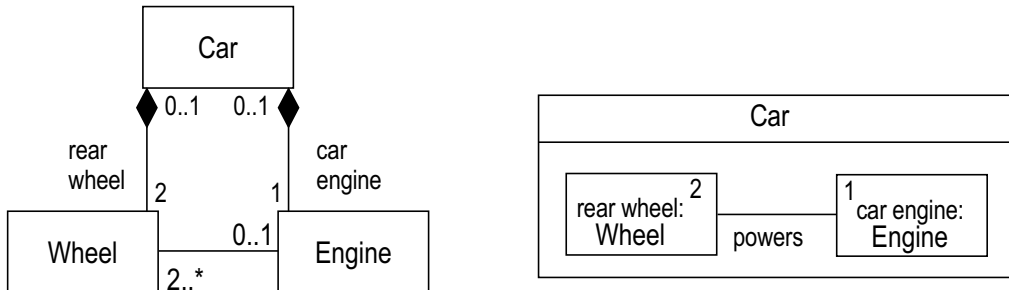


Can be represented as:



COMPOSITE STRUCTURE DIAGRAMS

Collaborating parts example

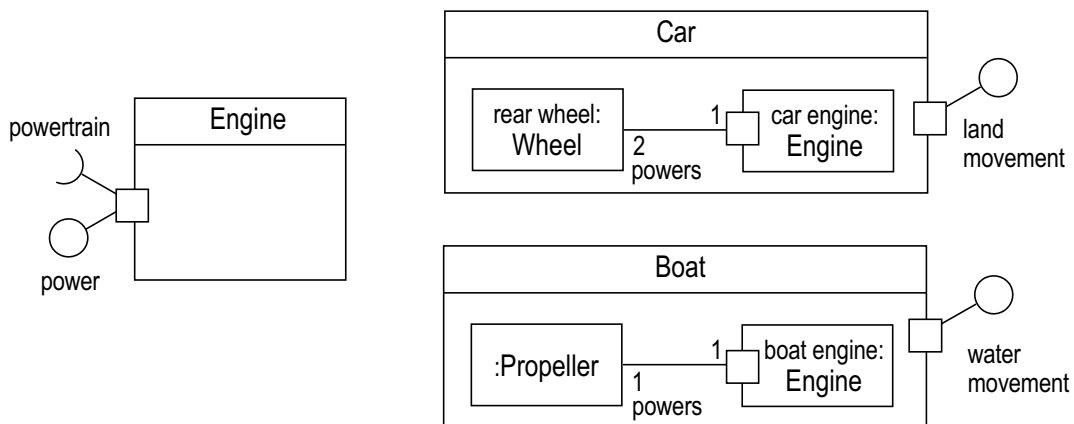


With class diagram only:

- Graphically less intuitive
- No context. Can imply:
 - "My engine on your wheels."
 - "Requires boats to have wheels"

COMPOSITE STRUCTURE DIAGRAMS

Collaborating parts with ports and interfaces



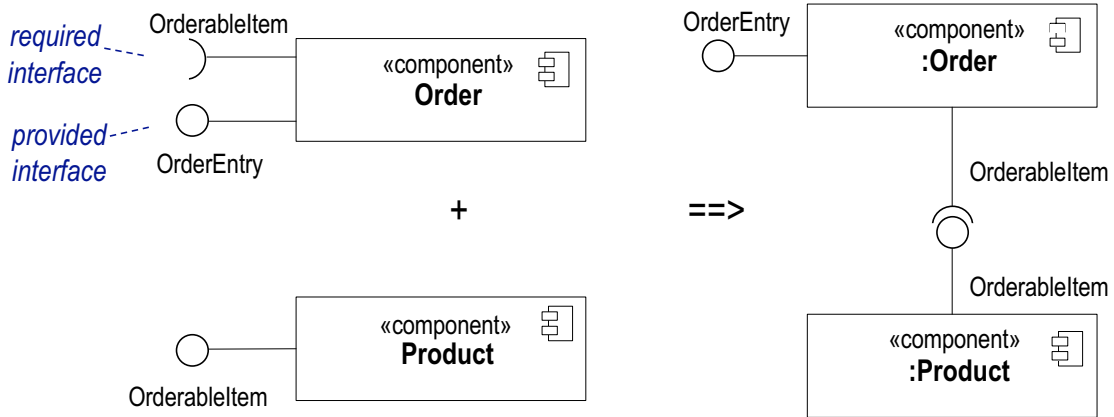
Innovations:

- Composite structures can be instantiated in their own right.
- Agents can be either *on* or *within* "cell membranes"
- Replace interface *methods* with interface *agents* (and their responsibilities)

COMPONENTS IN UML 2.0

Provided and required interfaces

Specifies a modular unit with well-defined interfaces that is replaceable within its environment.

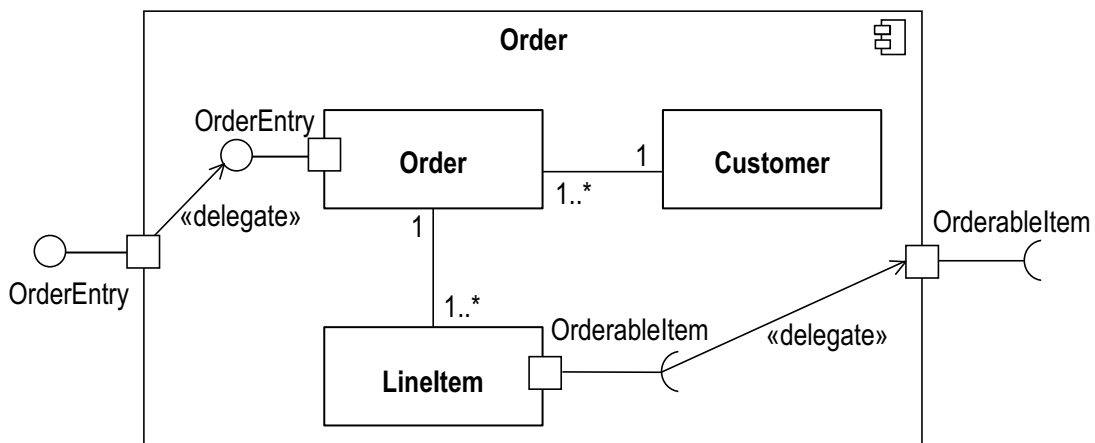


Component "wiring" symbols provide a more intuitive representation in UML 2.0.

COMPONENTS IN UML 2.0

Component internals

White-box view depicts internal assembly and physical containment.



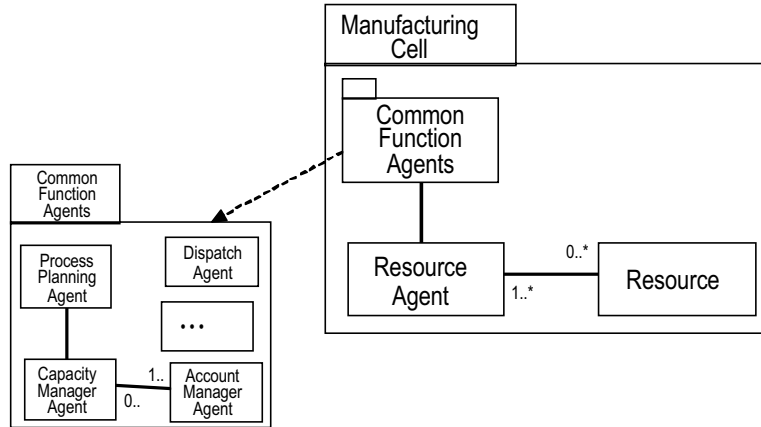
However, this does not fully provide the intuition needed for a composite structure for agents.

The component **Order** and the class **Order** are not equivalent.

For example, what does it mean to "create an instance of **Order**"?

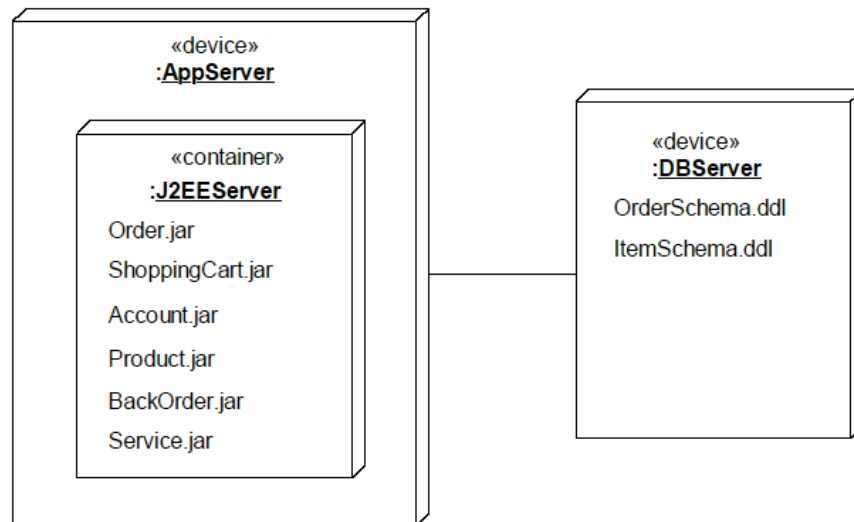
PACKAGES

Packages can specify agent aggregate hierarchies.



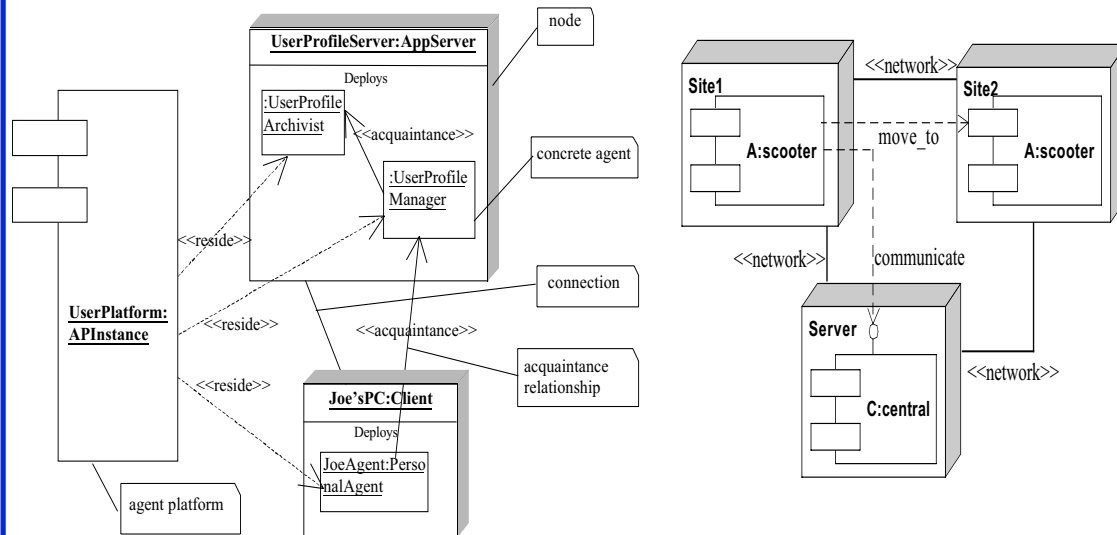
- With UML 2.0, composite structure diagrams are generally better for aggregation.
- Packages could be used to express agent environments and subsystems.

DEPLOYMENT DIAGRAMS



DEPLOYMENT DIAGRAMS

For agents



From PASSI

UML DIAGRAMS

Structure Diagrams

- Class diagrams
- Composite structure diagrams
- Component diagrams
- Packages
- Deployment diagrams

Behavior Diagrams

- Sequence diagrams
- Communication diagrams
- Activity diagrams
- State Machine
- Use Case diagrams

FIRST: A MAJOR DIFFERENCE BETWEEN OBJECT AND AGENT BEHAVIOR

Using nature a source of analogies



"Digital Dealmakers Meet in the Middle"
New York Times, 10 September, 2003

- Interaction
- Collaboration
- Cooperation
- Competition
- ...

These analogies mark some of the differences with conventional objects.

SEQUENCE DIAGRAMS

Two standards support them



INTERNATIONAL TELECOMMUNICATION UNION

Z.120
(11/1999)

SERIES Z: LANGUAGES AND GENERAL SOFTWARE
ASPECTS FOR TELECOMMUNICATION SYSTEMS
Formal description techniques (FDT) – Message
Sequence Chart

Message Sequence Chart (MSC)

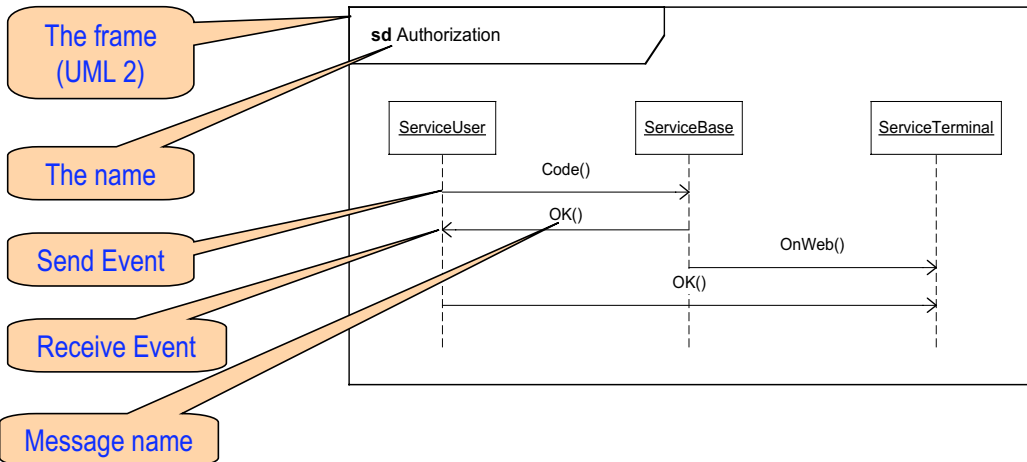


UML 2.0 Superstructure Specification

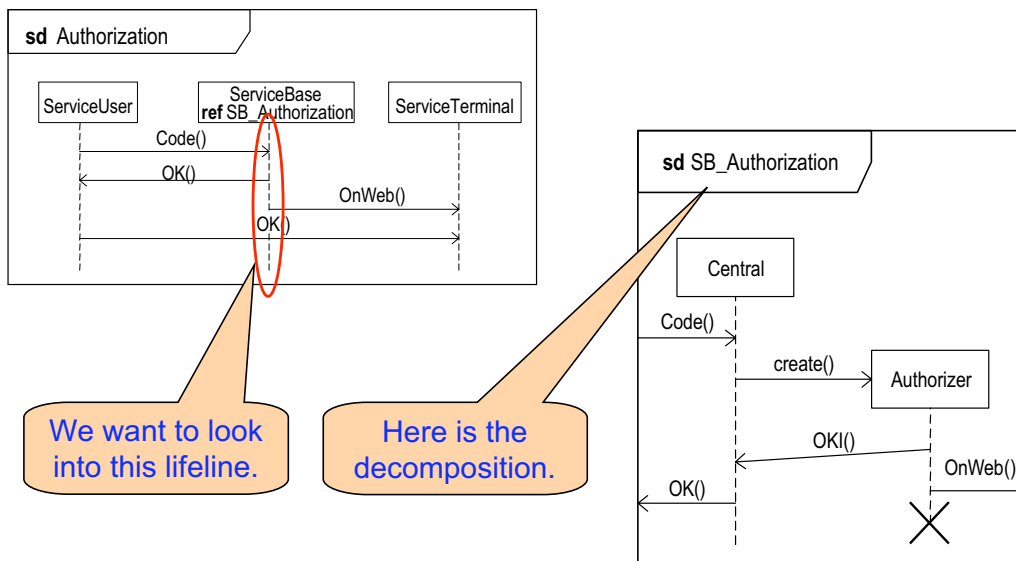
OMG Adopted Specification
ptc/03-08-02

(SIMPLE) SEQUENCE DIAGRAM

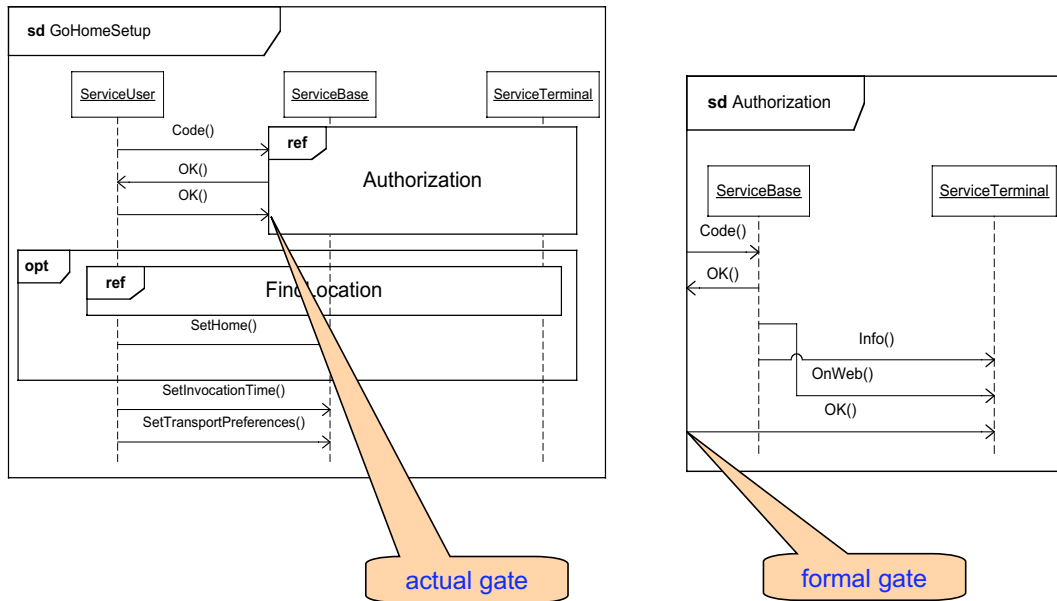
- ❑ Messages have one send event, and one receive event.
 - The send event must occur before the receive event.
 - The send event is the result of an Action
- ❑ Events are strictly ordered along a lifeline from top to bottom



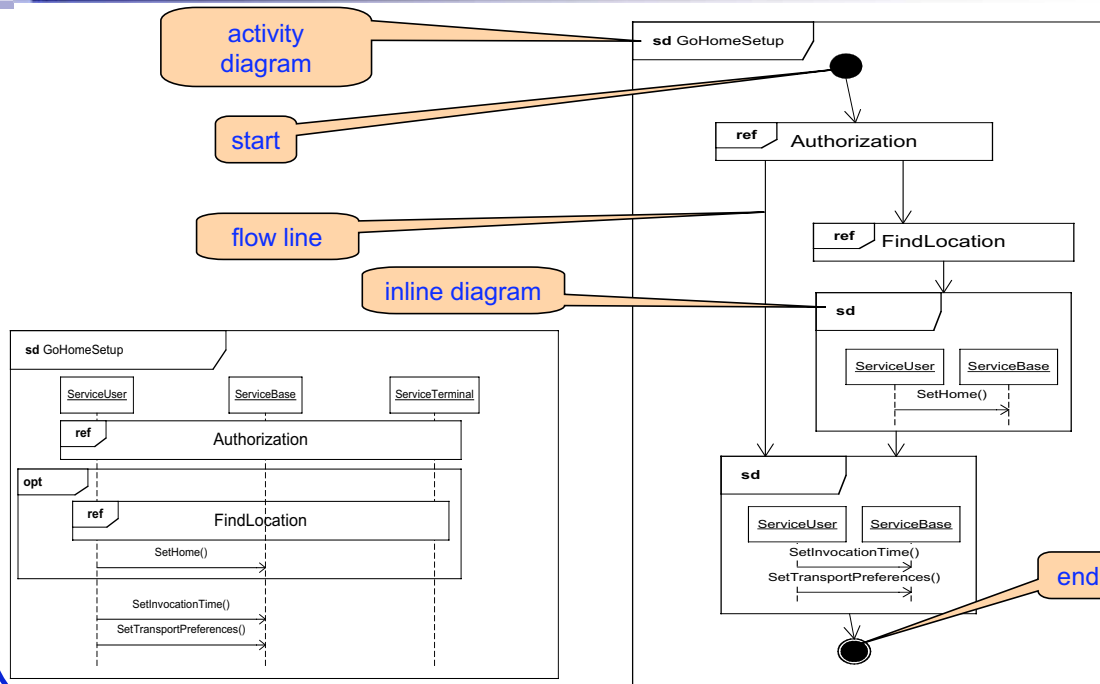
DECOMPOSING A LIFELINE



REFERENCES AND GATES

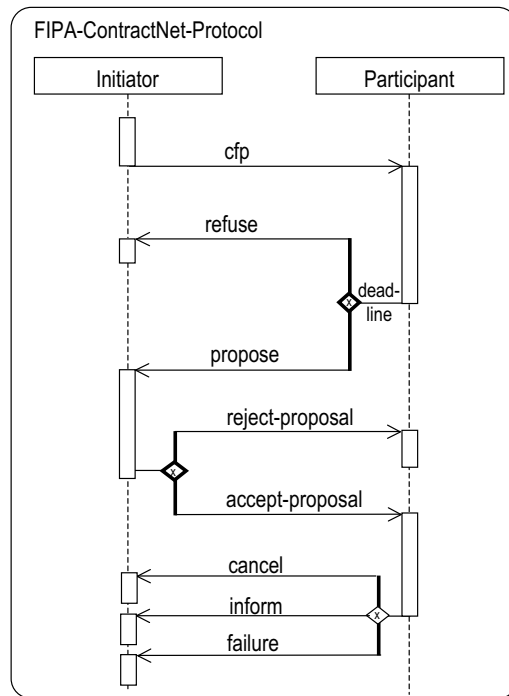


INTERACTION OVERVIEW



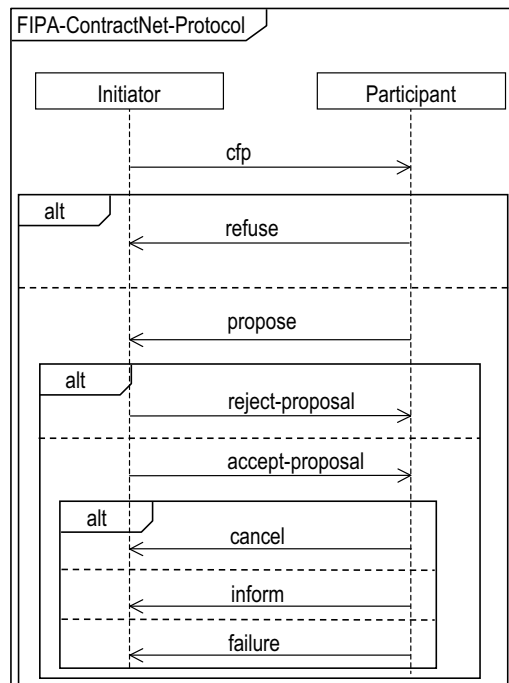
INTERACTION DIAGRAMS IN EARLY AUML

Minor extensions to UML 1.x



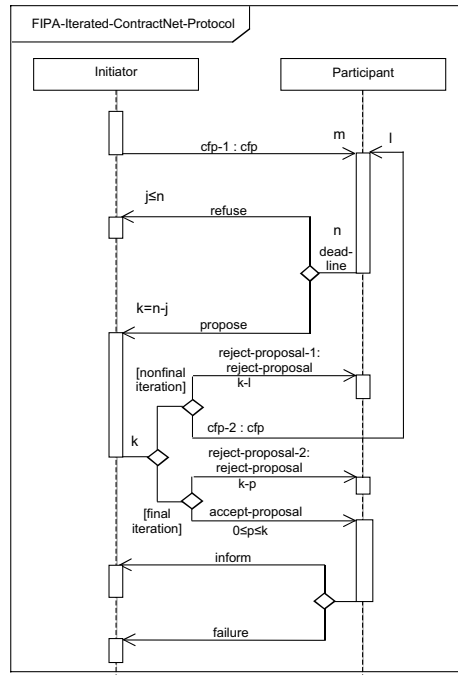
INTERACTION DIAGRAMS IN CURRENT AUML

Early AUML extensions have influenced UML 2.0



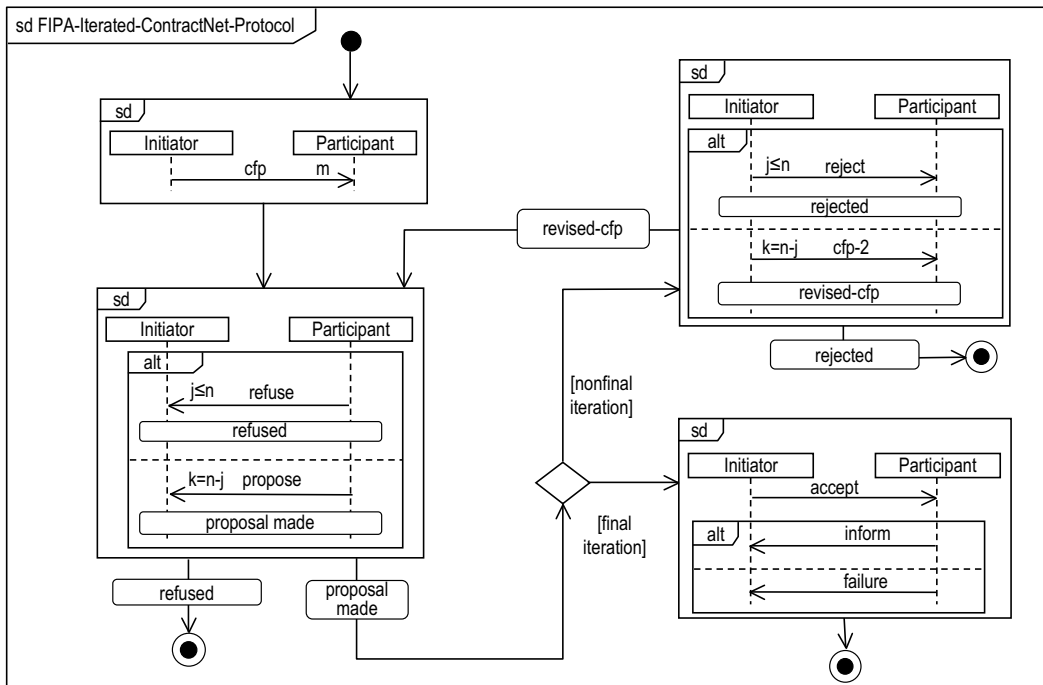
INTERACTION DIAGRAMS IN UML 1.X

Using sequence diagram approach

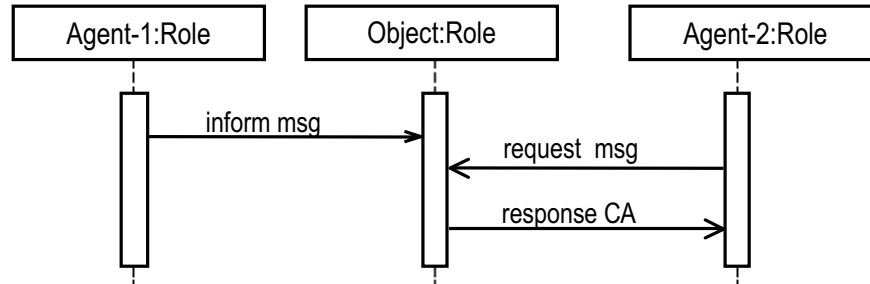


INTERACTION DIAGRAMS IN UML 2.0

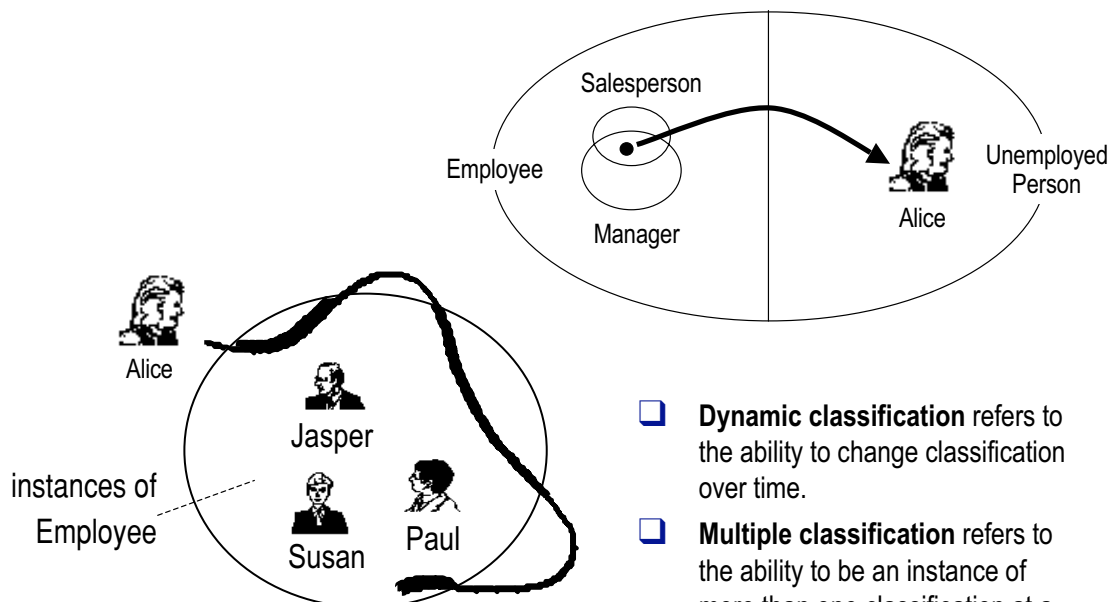
Using interaction overview approach



OBJECTS MAY PLAY A PART IN AGENT COMMUNICATION



DYNAMIC AND MULTIPLE CLASSIFICATION AND ROLE “CHANGES”

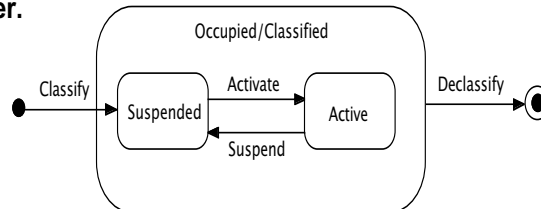


- ❑ **Dynamic classification** refers to the ability to change classification over time.
- ❑ **Multiple classification** refers to the ability to be an instance of more than one classification at a given moment.

ROLE “CHANGES”

Six scenarios are considered to be “changes,” yet semantically they all have a different meaning.

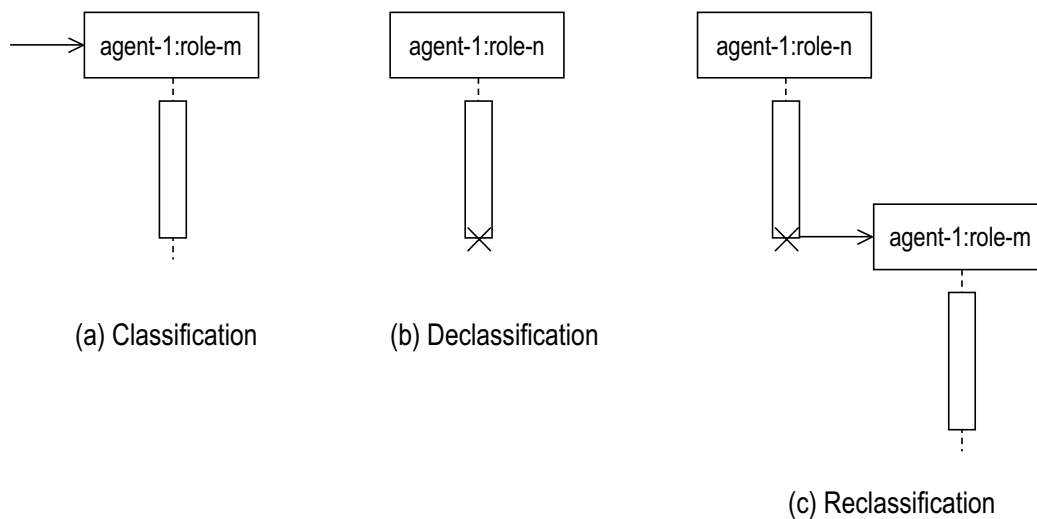
- ❑ **Classify** – Add the role of manager to the role of Employee as the result of a promotion.
- ❑ **Declassify** - Remove the role of Manager as the result of a demotion.
- ❑ ***Reclassify** - Change from the role of Employee to the role of Unemployed Person.
- ❑ **Activate** - Take up the behaviors of the Manager role as part of the day-to-day business activity.
- ❑ **Suspend** – Stop any Manager behavior and take on just those of the Employee role as part of the day-to-day business activity.
- ❑ ***Shift** - Change from an Employee role to a Pet Owner role, where neither is played at the same time as the other. This is a combination of activating one role while suspending another.



*composite operations

AUML ROLE-CHANGE NOTATION

Classification, declassification, and reclassification



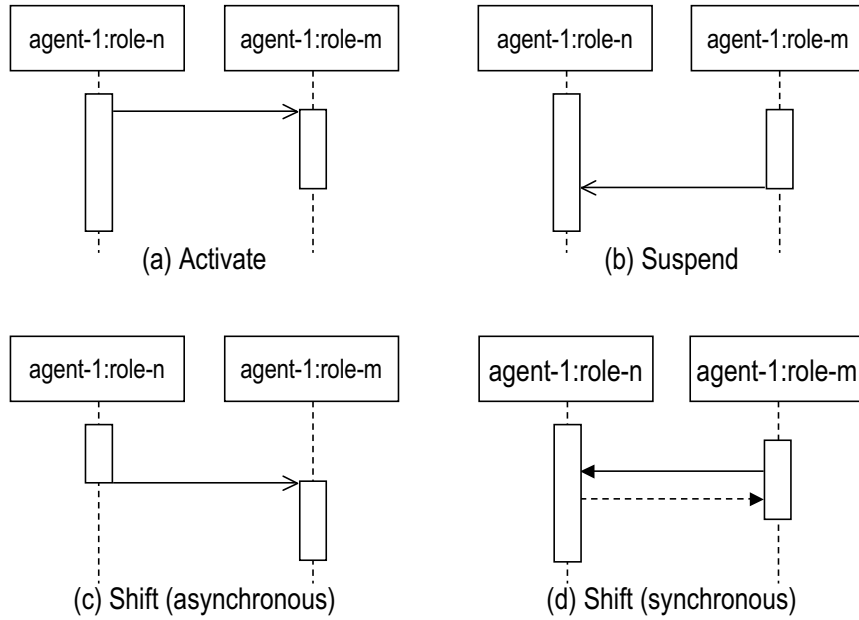
(a) Classification

(b) Declassification

(c) Reclassification

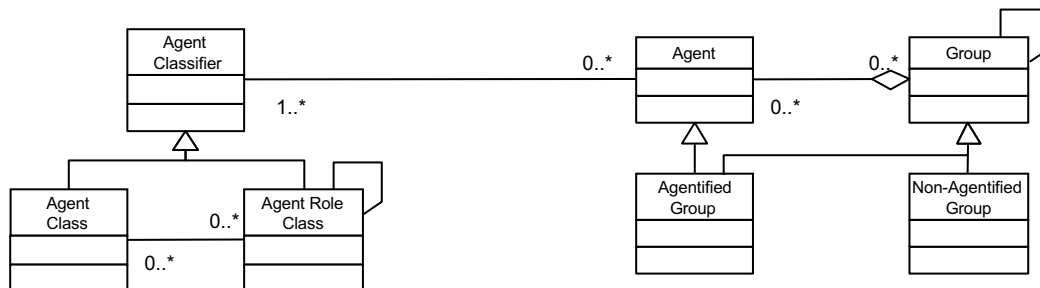
AUML ROLE-CHANGE NOTATION

UML and AUML notation for expressing activate, suspend, and shift



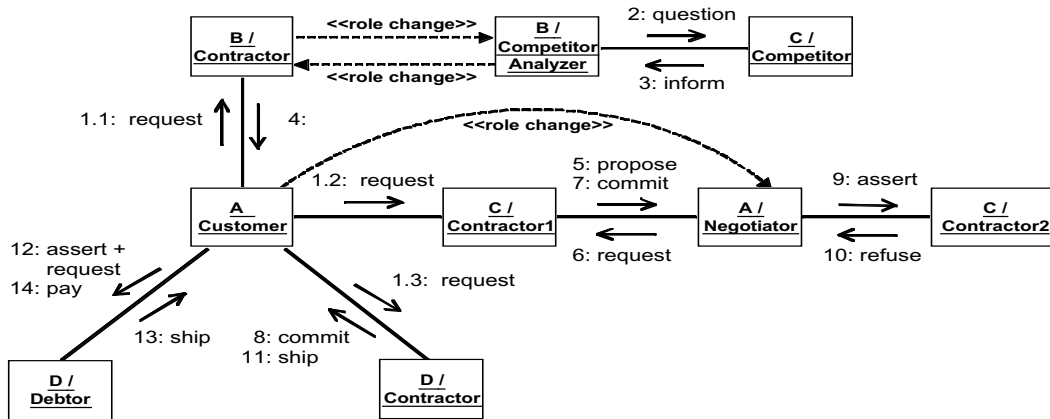
Or, use the stereotypes: «activates», «suspends», and «shifts».

AUML METAMODEL EXCERPT



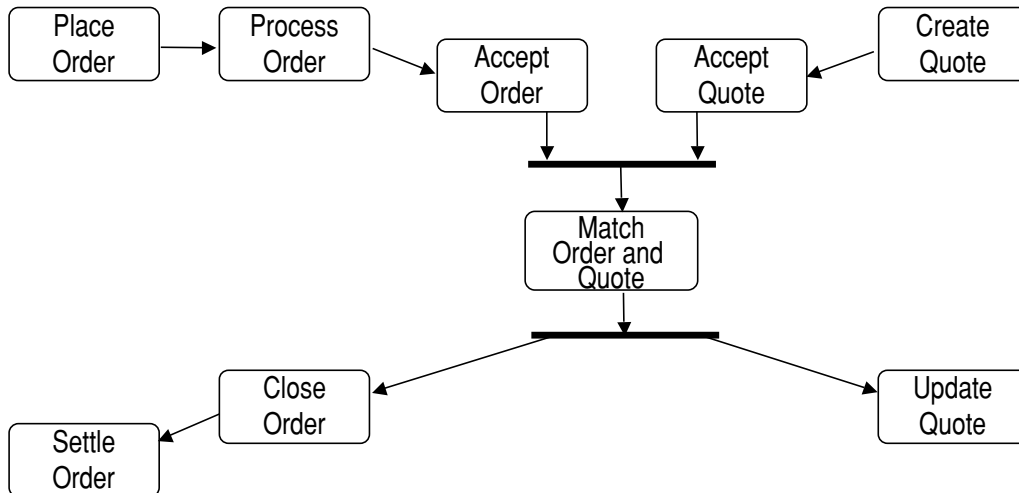
COMMUNICATION DIAGRAM

An alternative representation



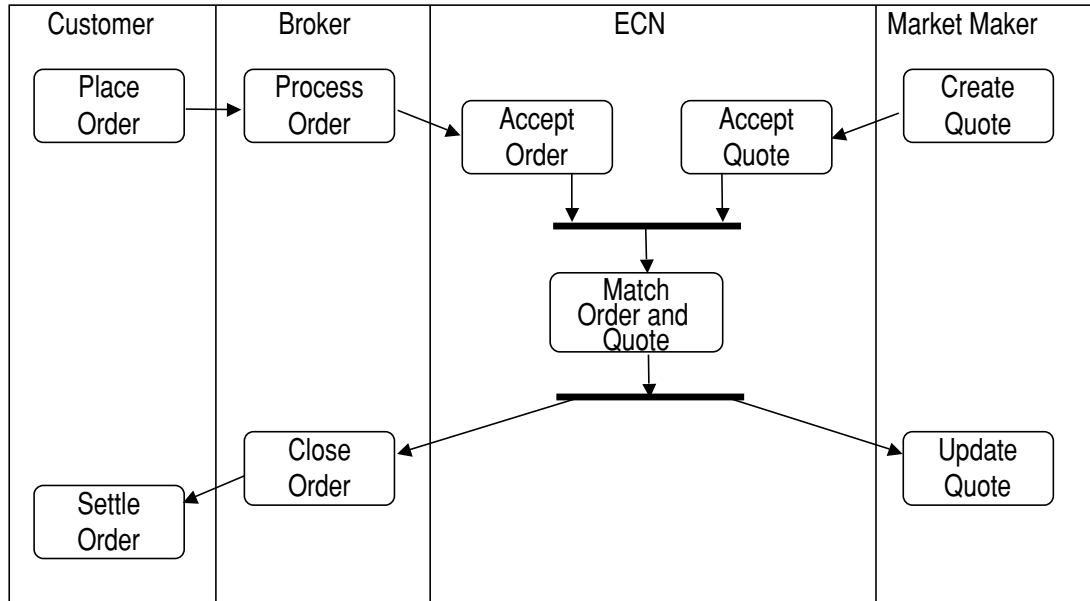
ACTIVITY DIAGRAMS

Another alternative representation



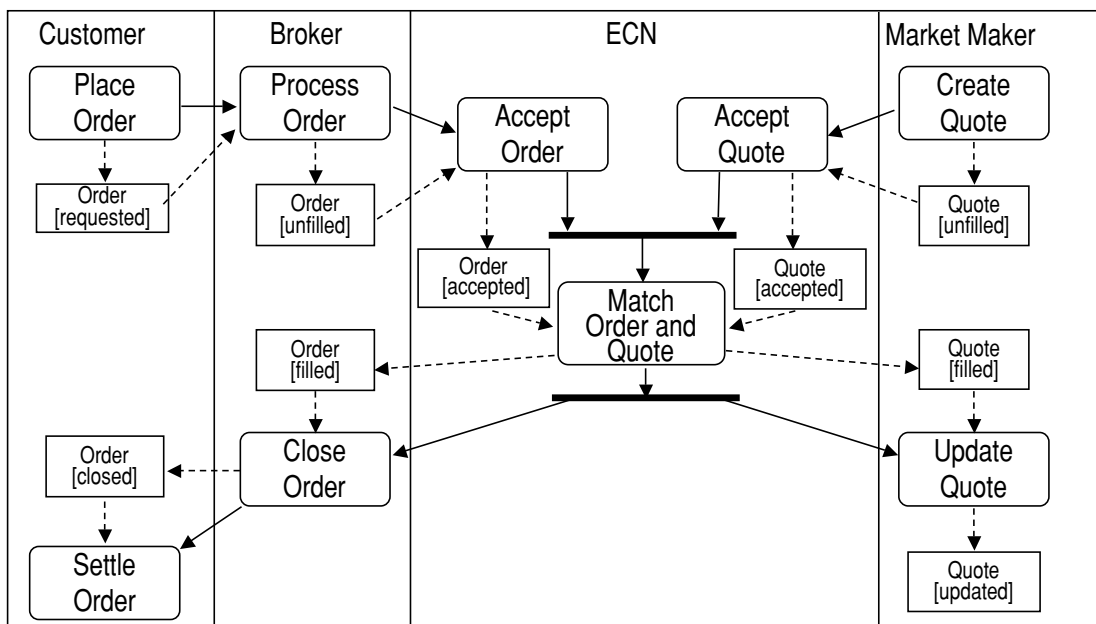
ORDER PROCESSING:

Activity diagrams with role-based partitions



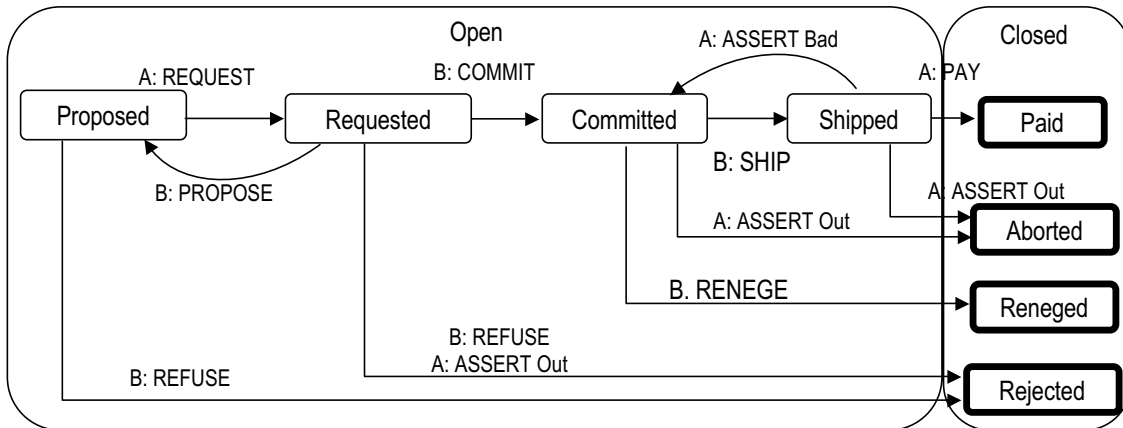
ORDER PROCESSING:

Activity diagrams with partitions and object flow



STATECHART NOTATION

Yet another alternative



*A state-based speech-act version
of the Winograd-Flores protocol
in UML statechart notation*

UML 2.0 DIAGRAMS

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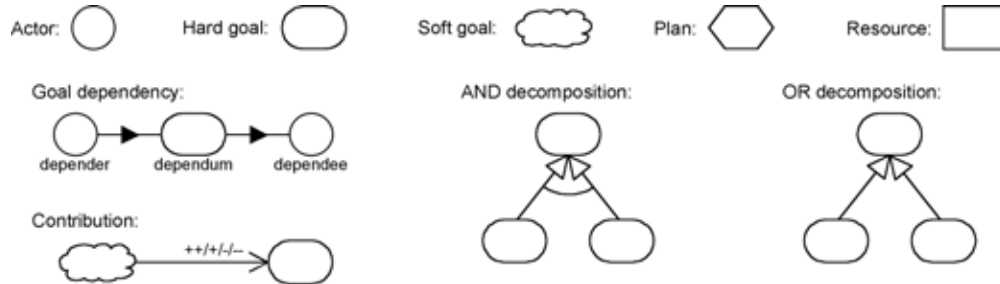
SOME DEFICIENCIES OF UML DIAGRAMS FOR AGENTS

UML has no “off-the-shelf” constructs to express:

- goals
- agent
- group
- multicasting
- generative functions, such as cloning, birthing, reproduction
- parasitism and symbiosis
- emergent phenomena
- ...

TROPOS

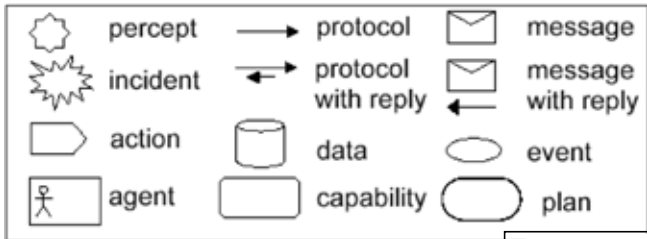
Symbols



Actor diagram

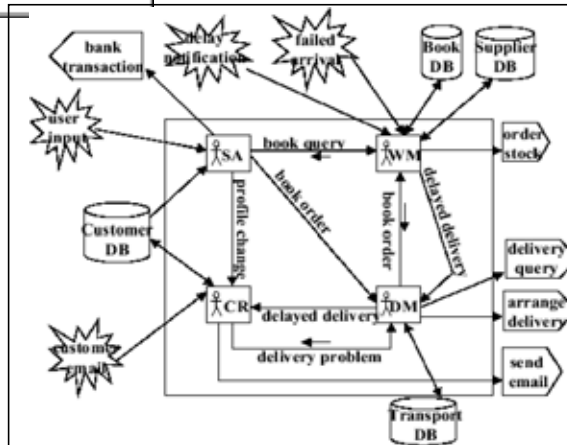


PROMETHEUS

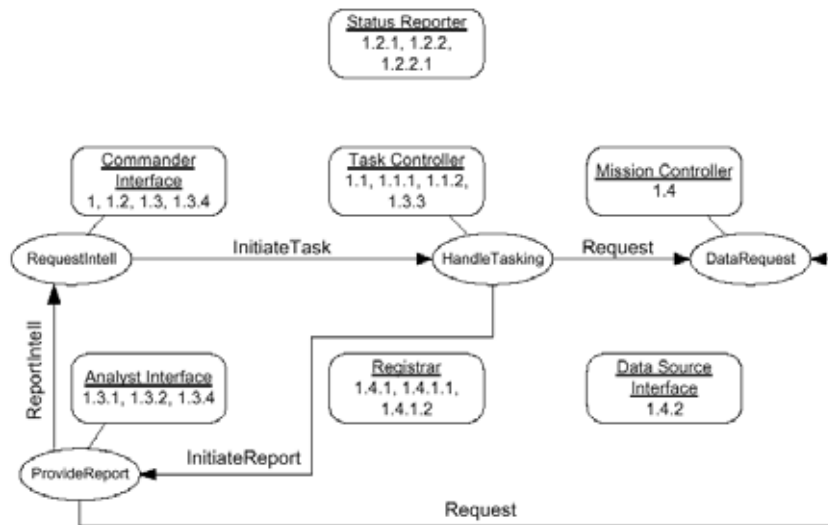


Symbols

System overview diagram



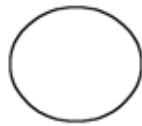
MaSE



Role model diagram

MESSAGE

Symbols



Agent



Role



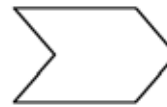
Organization



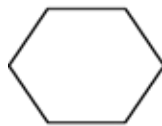
Goal



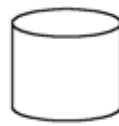
Task



Service



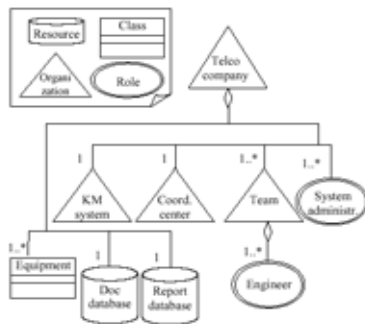
Interaction



Resource

MESSAGE

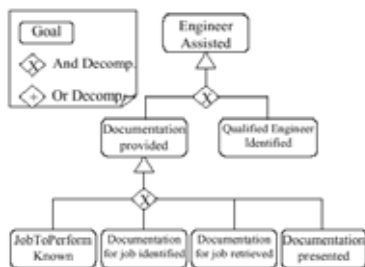
Diagram examples



Structural relationship diagram



Acquaintance diagrams



Goal implication diagram

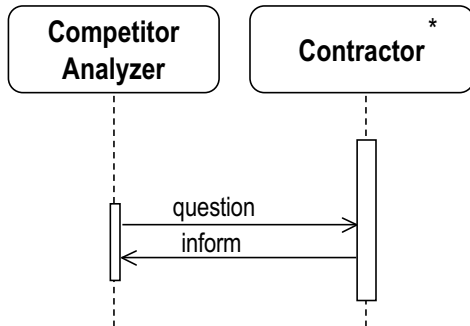


Agent diagram

AND, HOW CAN FIPA ACL AND UML HANDLE 1:M and M:M COMMUNICATIONS?

In FIPA ACL, the sender is often required to believe something about the receivers:
e.g., “If an agent performs an inform act with ... three agents as receiver, it denotes that the sender intends each of these agent to come to believe the content of the message.”

Also, “the sending agent intends that the receiving agent also comes to believe that the proposition is true” and “does not already believe that the receiver has any knowledge of the truth of the proposition”



However, in a broadcast, you cannot know who the hearer is:

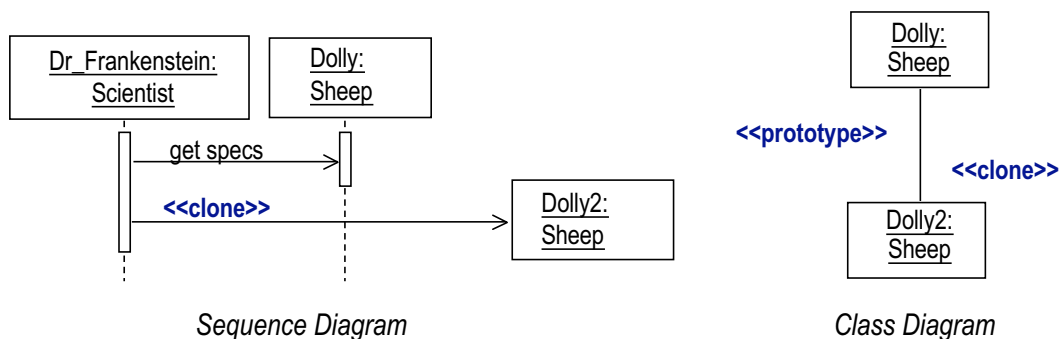
- "Beware of dog."
- "Bob, take attendance."
- "One of you, get a slice of pie."
- "John & Betty request the pleasure of your company."

We need more precise group semantics.

(Phil Cohen, Oregon Graduate Institute)

GENERATIVE FUNCTIONS:

Cloning

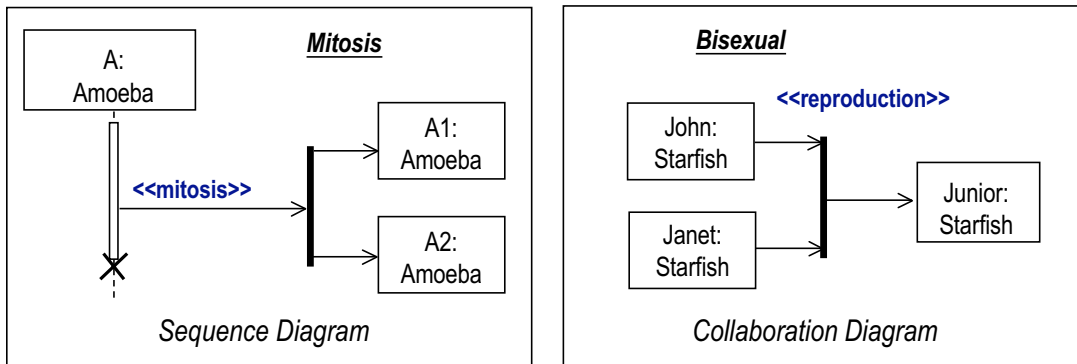


Sequence Diagram

Class Diagram

GENERATIVE FUNCTIONS:

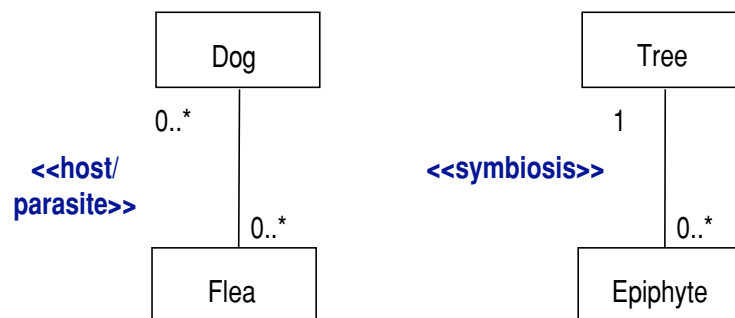
Mitosis and bisexual



Innovations:

- stereotypes
- synchronization bars (native to Activity Diagrams) on Sequence and Collaboration Diagrams

EXTENDING CLASS DIAGRAMS TO EXPRESS PARASITISM AND SYMBIOSIS



AUML APPROACH

- Instead of reliance on the OMG's UML, we intend to reuse of UML *wherever it makes sense*.
 - We need to capitalize on the current knowledge and momentum of the IT industry is a major consideration.
- AUML is not restricted to using UML. Other approaches should be used *wherever it makes sense*.
 - We need to work with other agent-modeling efforts now — before much more work has been done.



What is It — and Why Do I Care?

Chair, OMG A&D "UML" Task Force
Chair, FIPA Agent Modeling Technical Committee
OMG-Certified UML Advanced Professional

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