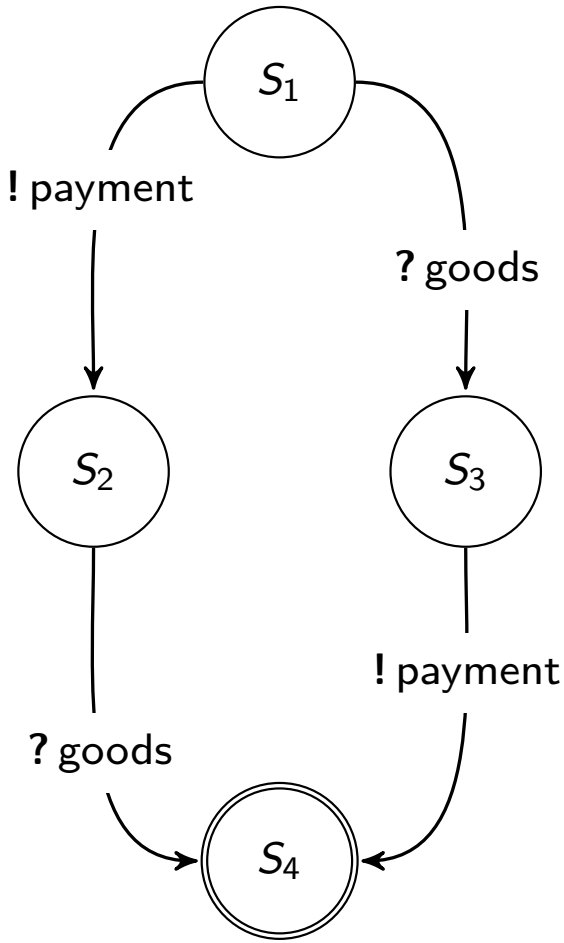
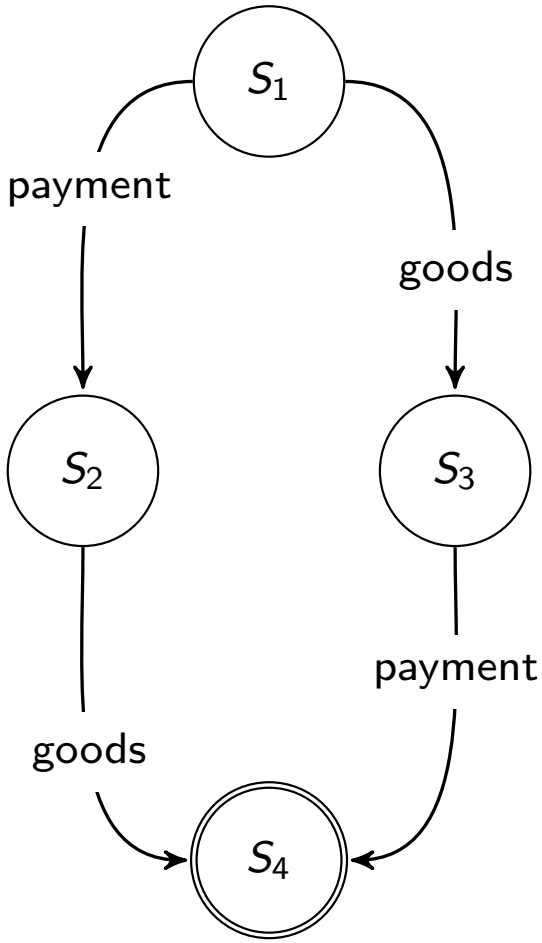
Protocols and Roles

Protocol: shared view; roles: each local view

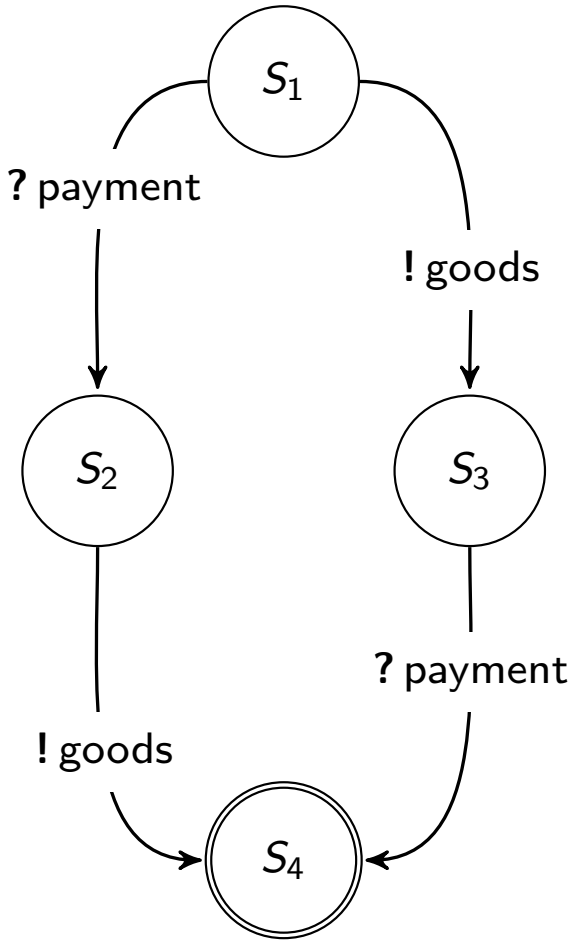
The Buyer Role



Trade Protocol



The Seller Role



Communication Protocols

Protocols define how the agents ought to communicate with one another

- A protocol is a modular, potentially reusable specification of the interactions between two or more entities
- Defining a protocol helps ensure *interoperability*, i.e., being able to work together
- Communities of practice define appropriate protocols
  - RosettaNet: manufacturing
  - Foreign exchange transactions: TWIST
  - Health care: HL7
- What are the main requirements for protocol specifications?
- How can we specify a communication protocol?

Exercise: Identify Agents and Communications Protocols

Setting: healthcare service engagement—an annual physical

Engineering with Agent Communication

- Begin from a protocol
- Generate role skeletons (or endpoints) from the protocol
- For each role skeleton, implement one or more agents who realize ("flesh out") it
  - Map each skeleton to a set of incoming and outgoing messages and the changes each message induces in the local state
  - Implement methods to process each incoming message
  - Send messages allowed by the protocol
- Challenge: Generating role skeletons that ensure interoperation
  - Not trivial when a protocol involves more than two roles
  - The protocol must be such that such skeletons are derivable from it

Protocols Promote Autonomy

A protocol should not constrain an agent's interactions beyond what is essential for the application

- Each agent is free to act as it pleases
- Protocols specify allowed ordering and occurrence of interactions
  - Should do so minimally
  - Control flow specifications unnecessarily limit agent autonomy

Protocols Promote Heterogeneity

- A protocol enables interoperation by specifying
  - Schemas of messages exchanged
  - Meanings of messages, which determine the *state* of the interaction
- Correctness cannot depend upon the agents' internal reasoning
- Intelligence of the agents is irrelevant for a communication protocol
- Control flow specifications unnecessarily couple agent designs at a low level
- A protocol
  - Becomes the standard to which agents are implemented
  - Defines the extent of heterogeneity: the agents can be heterogeneous with regard to everything else

Traditional Software Engineering Approaches

- Don't emphasize autonomy and heterogeneity
- Emphasize operational details
  - Leave open the formulation of the message syntax (good)
  - Disregard the meanings of the messages (bad)
- Traditional representations capture occurrence and ordering of messages, mostly in procedural terms
  - Finite state machines (procedural)
  - State diagrams or statecharts (procedural); generalize FSMs
  - Sequence diagrams (procedural)
  - Petri nets (procedural)
  - Pi-calculus (procedural)
  - Temporal logic (declarative)
- Dependence upon low-level details leads to interoperation being fragile to irrelevant modifications

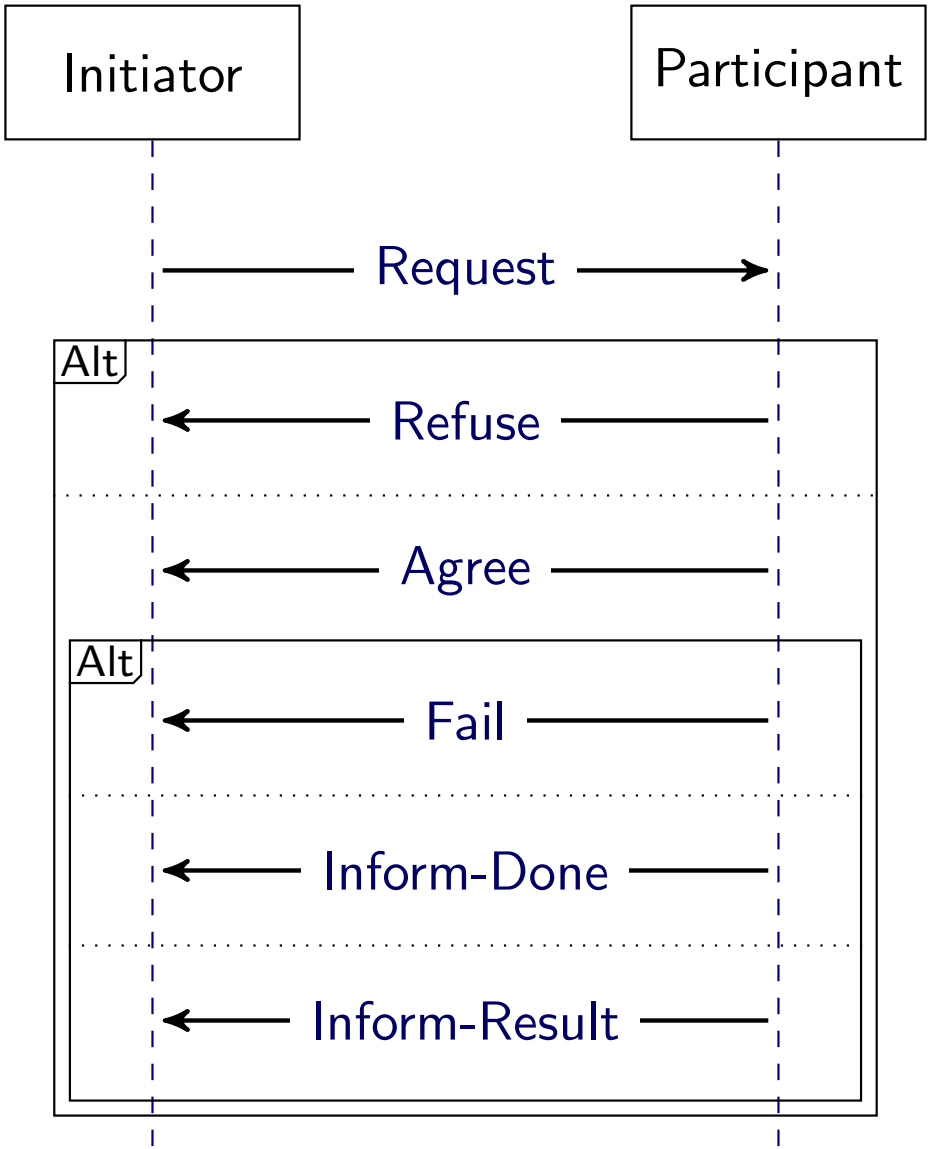
UML Sequence Diagrams

Used by FIPA (Foundation for Intelligent Physical Agents)

Combine constructs from Message Sequence Charts (MSCs) and FIPA

- Procedural constructs: sequencing (default), alternative, parallel, loop
- Highlights benefits of a protocol
  - Clear roles
  - Decouples agents from one another
- Ignores message meanings
  - FIPA offers a semantics for message types
  - But no application-specific meanings

FIPA Request Interaction Protocol



- Roles: INITIATOR and PARTICIPANT
- Messages
  - *request*, *agree*, *refuse*, *failure*, an *inform-done*, or an *inform-result*
- Ordering and occurrence
  - *refuse* or an *agree*
  - *agree* followed by a detailed response: *failure*, *inform-done*, or *inform-result*
  - *agree* is required only if the INITIATOR asked for a notification

Agent Programming for Protocols

Java Agent Development Framework or JADE is a leading platform

- *Behavior:* a specification of a role skeleton that characterizes important events such as the receipt of specified messages and the occurrence of timeouts
- Implement an agent according to a behavior by defining the methods it specifies as callbacks
  - Define the handlers for any incoming methods

Role Conformance

Developing an agent that conforms to a role specification

- Produce a role skeleton from a protocol specification
- Publish role skeletons along with the protocol specification
- An agent who plays (and hence implements) a role fleshes out the skeleton
- Challenge: determine constraints on the messages an agent playing a role can receive and send and constraints on how the local representation of the social state should progress
- Software vendors produce agent implementations
- An agent vendor does not reveal internal details but specifies what roles the agent can play
- Conformance means that an agent can play a particular protocol role
- Challenge: identifying formal languages for specifying roles along with algorithms for checking conformance

Protocol Refinement and Aggregation

Apply traditional conceptual modeling relations to communication

- Refinement: how a concept refines another (*is-a* hierarchy)
- Aggregation: how concepts are put together into composites (*part-whole* hierarchy)
- Well-understood for traditional object-oriented design and supported by programming languages (as type checking)
- Nontrivial for communication protocols (especially, refinement)
- Challenge: produce a generalized theory and associated languages and tools for refinement and aggregation of *meaning-based* protocols (to be introduced)

Choreography

A specification of the message flow among the participants from a neutral perspective

- Decentralized nature
- Contrasts with *orchestration*, a description of how one party controls all others
- Somewhat like a sequence diagram written textually
- Proposed approaches: WS-CDL and ebBP
- Shortcomings
  - No encoding of the meaning
  - Focus on ordering and occurrence
  - Make private actions of agents visible
  - Lack support for composition of choreographies