Protocols for Processes

Munindar P. Singh

(*Students:* Amit K. Chopra, Nirmit V. Desai, Ashok U. Mallya)

singh@ncsu.edu

Department of Computer Science

North Carolina State University

http://www.csc.ncsu.edu/faculty/mpsingh/

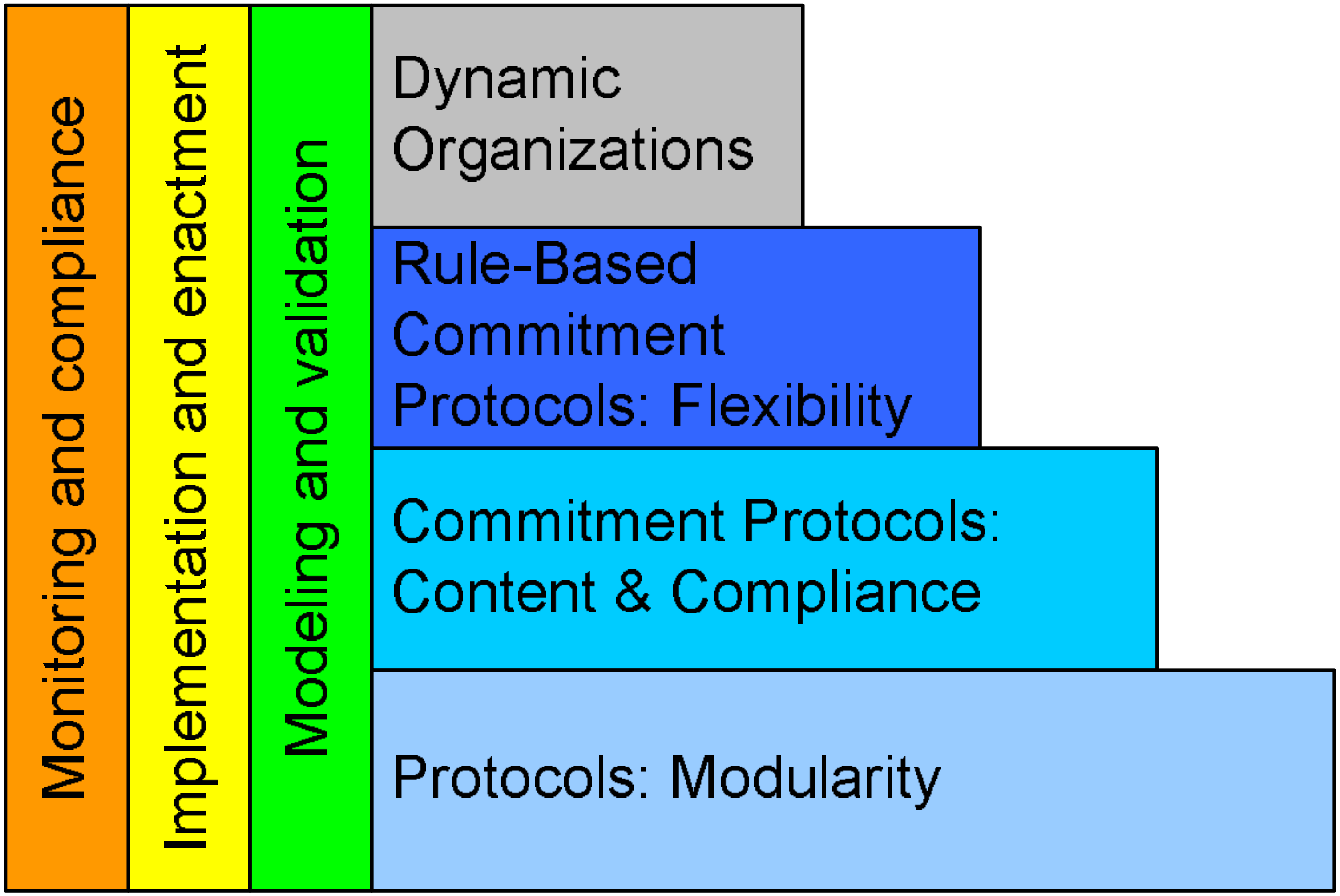
Why Processes and Protocols?

- Heavy interest from IT practitioners.
  - Standardization efforts.
  - Any number of products.
- Current industry approaches are impoverished: scripting languages.
  - No special abstractions for dealing with open systems: autonomy, heterogeneity, dynamism.
  - That is, not designed for SOAs.

A Process is . . .

- *Orchestration:* a partial order of actions under the control of a central conductor
  - Akin to a workflow or flow in BPEL.
- *Choreography:* an exchange of messages among participants
  - Akin to a conversation as described by WS-Chor.
- *Collaboration:* a joint set of activities among business partners.
  - Akin to real business; essential for SOAs.

Emphases of Collaboration

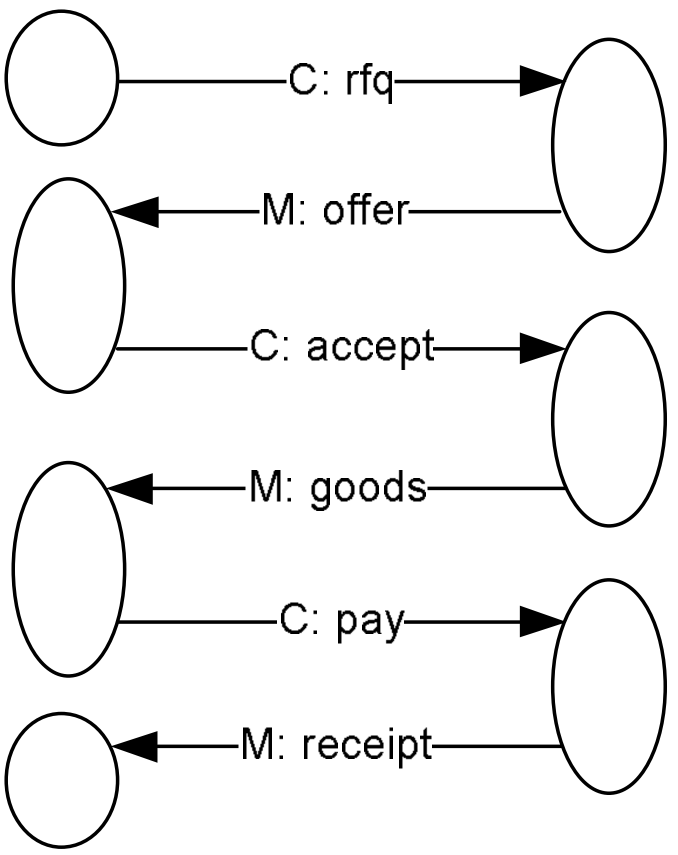


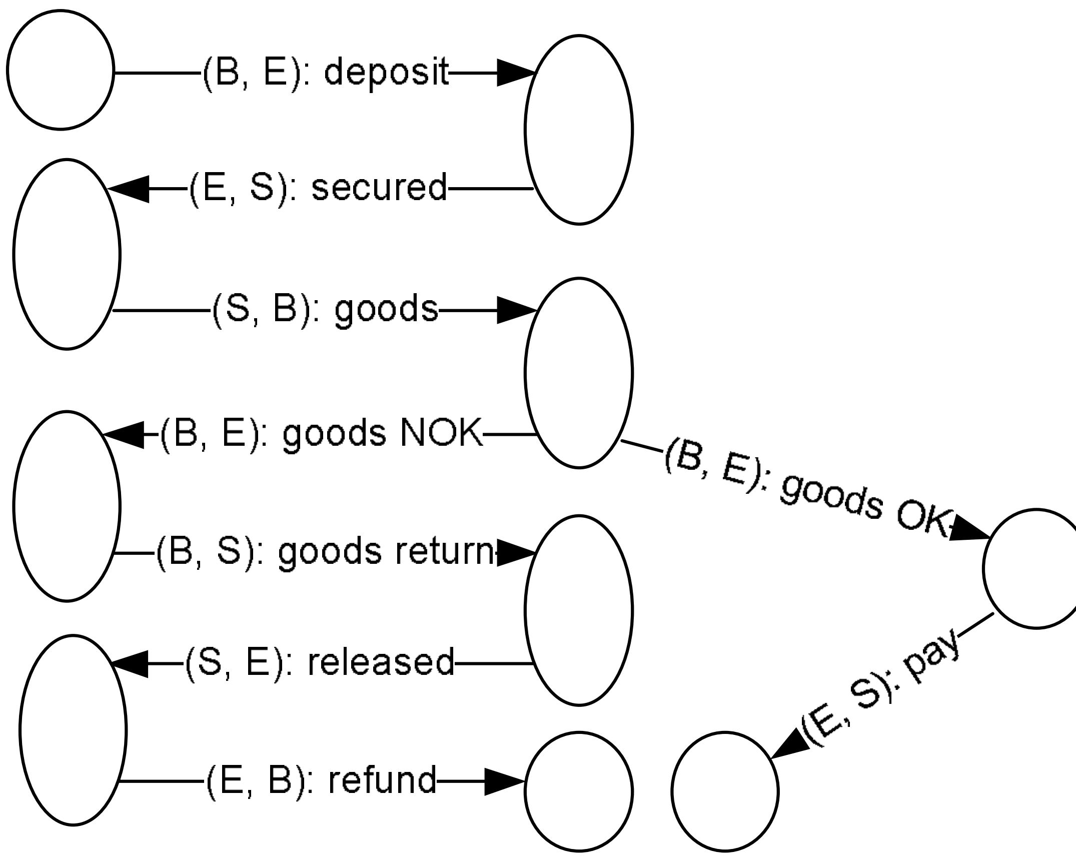
Monitoring and compliance
Implementation and enactment
Modeling and validation
Dynamic Organizations
Rule-Based Commitment Protocols: Flexibility
Commitment Protocols: Content & Compliance
Protocols: Modularity

Innovations: 1

- *Protocols:* Conceptually decentralized, reusable, encapsulations of processes.
- *Commitments:* Content for protocols.
  - Support reuse via abstractions for *refinement* and *aggregation* of protocols.
  - What the protocol should accomplish.
  - What deviations are legitimate and what aren't.
  - Operational semantics for commitments.

NetBill and Escrow Protocols



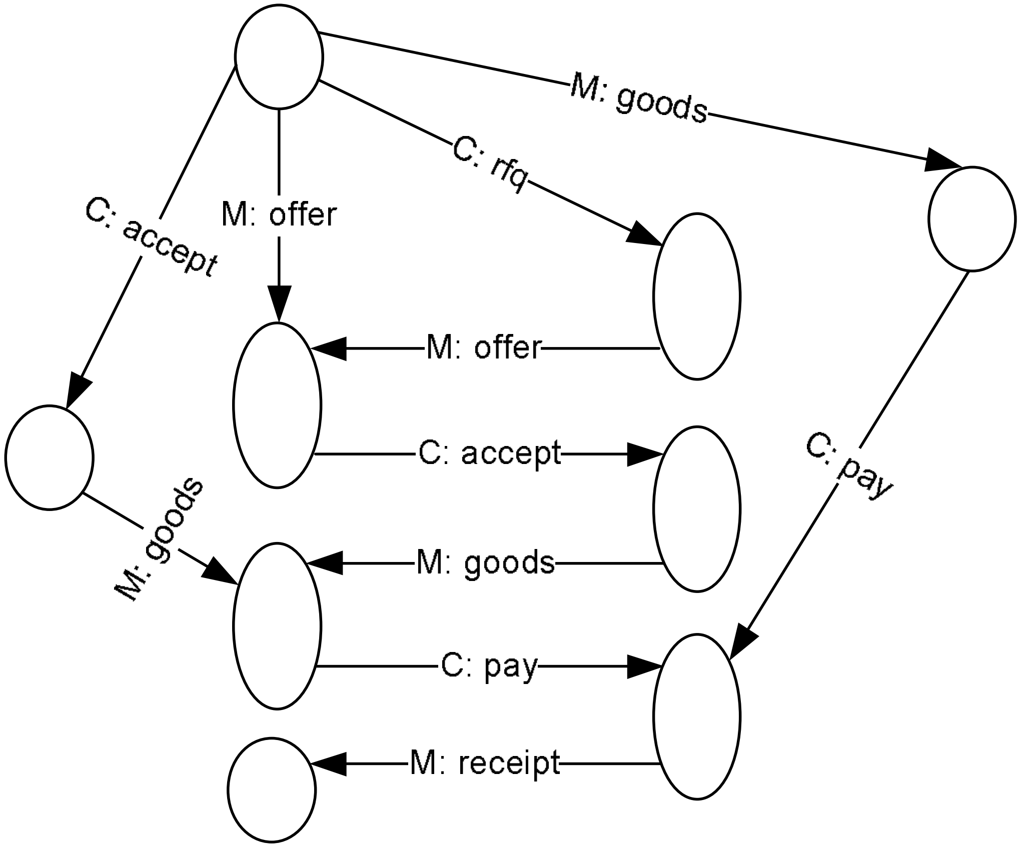


Innovations: 2

- *Rule-Based Reasoning:*
  - Expressing protocols flexibly.
  - Accommodating context.
  - Deciding specific actions by applying policies.
- *Spheres of Commitment:*
  - Modeling organizations.
  - Enacting protocols.
  - Monitoring and verifying compliance.
- Processes = Protocols + Policies.

Enhanced NetBill

Compiled from a commitment machine for NetBill.



Contributions (In Progress)

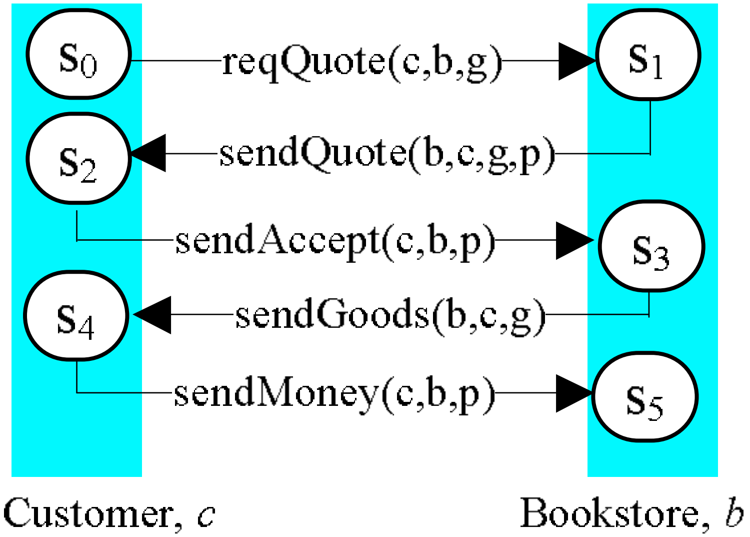
- Specification language for protocols.
- Formal semantics based on commitments.
- Protocol algebra to support refinement and aggregation.
- *Engineering:* not full automation, but tools for
  - Modeling and validation of protocols.
  - Modeling and validation of processes.
  - Enactment via Spheres of Commitment.
  - Monitoring and compliance.

Trends and Assessment

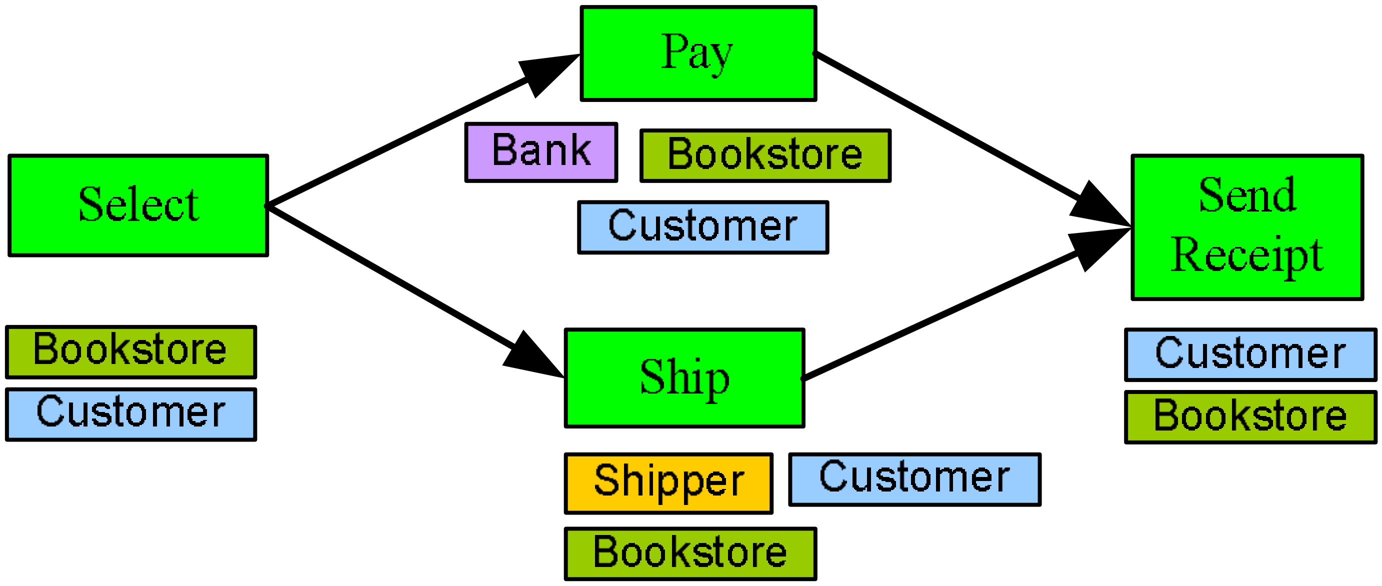
- Increasing # of business protocols.
  - IOTP, Escrow, SET, NetBill, . . .
  - RosettaNet: 107 Partner Interface Processes (PIPs).
  - ebXML Business Process Specification Schema (BPSS).
- Intended to be legally binding.
- Generally highly limited: two party, request-response protocols.
- No commitments; no formal semantics.
- Limited support for modeling or enactment.

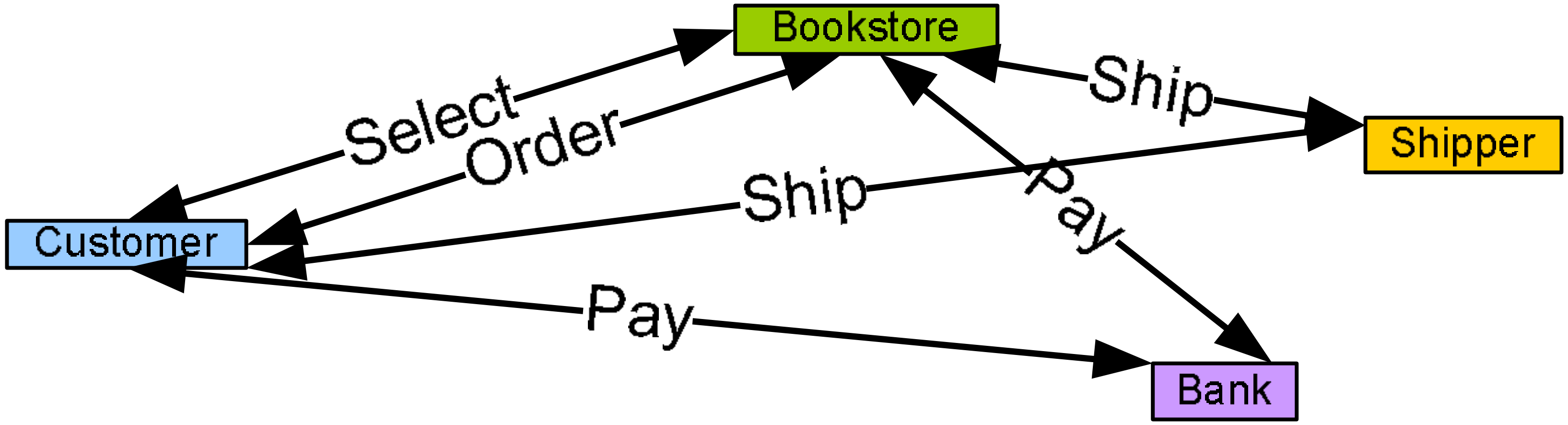
Simple Scenario and Example Run

- A customer (C) looks up a book at a vendor (B) and is quoted price and availability.
- C orders the book from B.
- B ships to C.
- C pays B.



Process View: Flow or Protocol





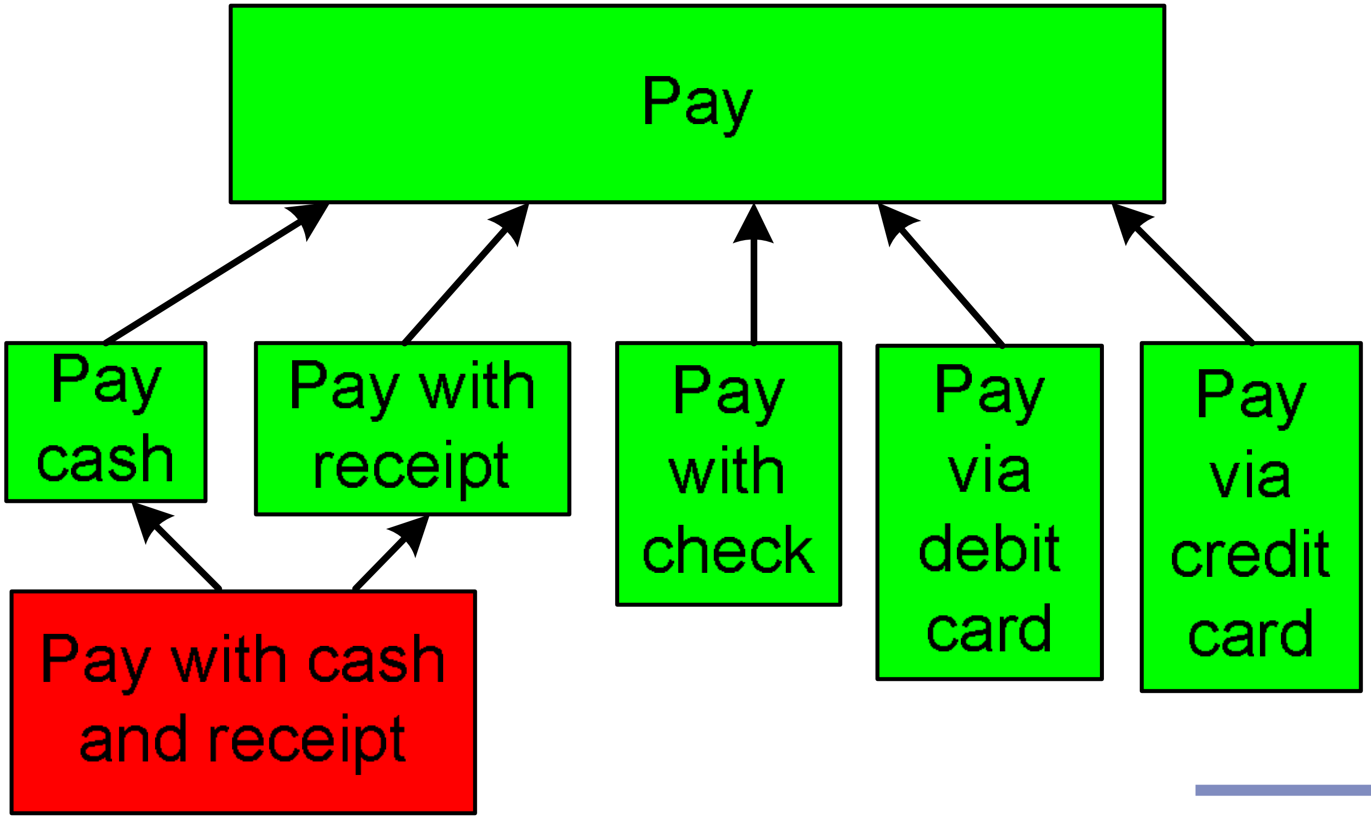
Challenges: Modeling

- *Refinement:* pay by credit card versus pay.
- *Extensibility:* verify C’s attributes, e.g., age.
- *Adjustment:* receive payment before shipping; receive book before paying.
- Alternative execution examples:
  - B arranges for a shipper (S) to deliver the book to C.
  - C pays via bank (K).
  - Compose a process from the above.

Refinement of Protocols

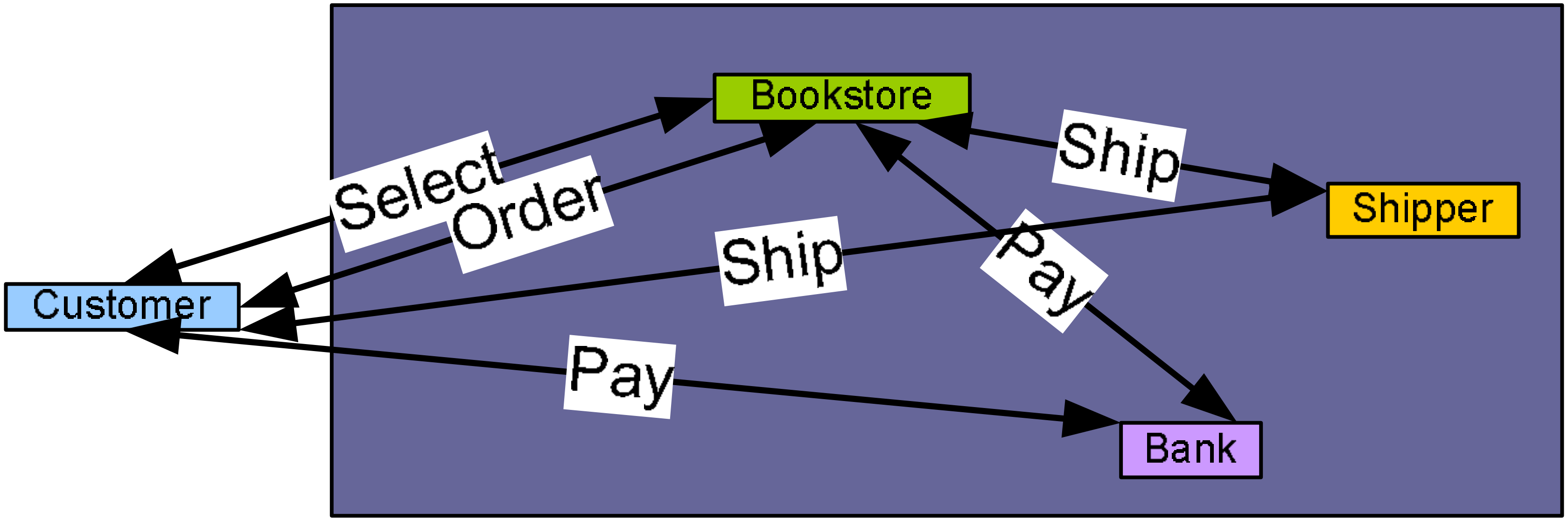
Selection criteria for protocols

- *Functional:* pay versus ship.
- *Nonfunctional:* payer trusts payee or not.

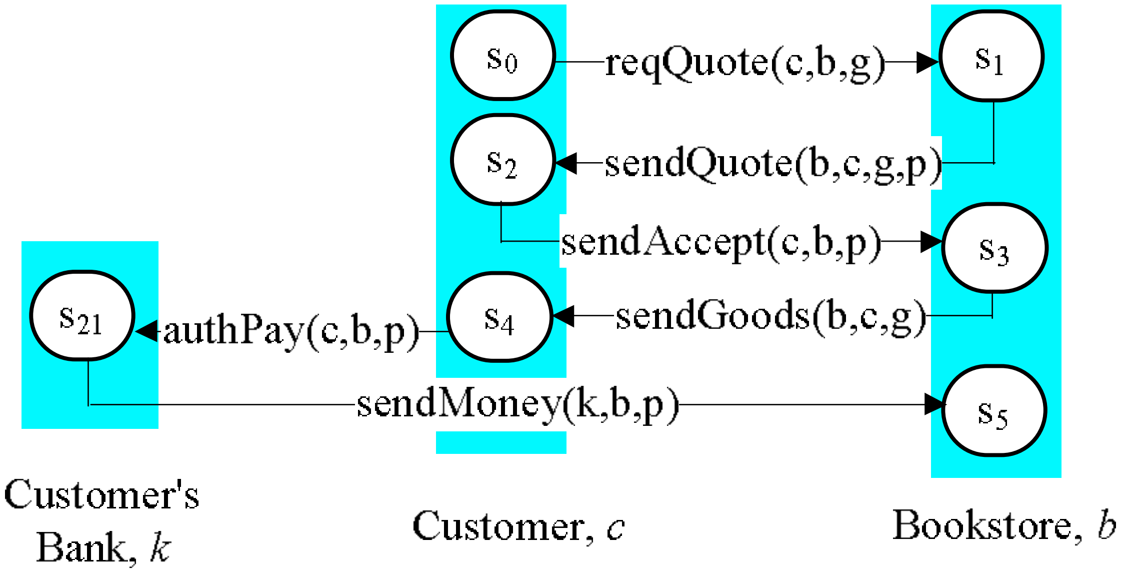


Aggregation of Protocols

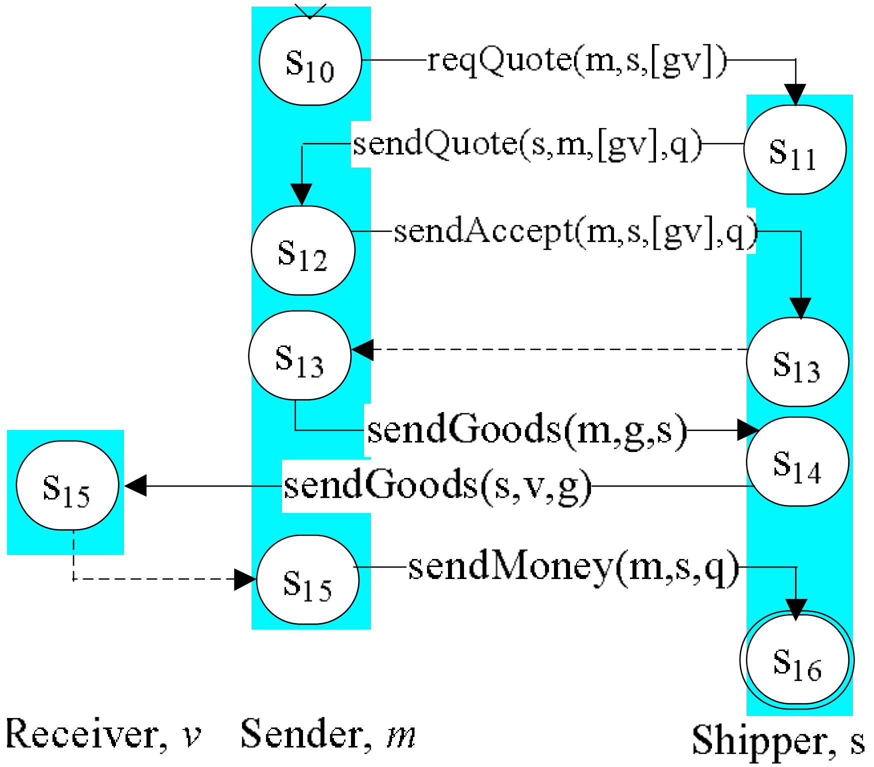
- A simplified protocol may be revealed to a give role.
- Decisions could be taken internally but not exposed.



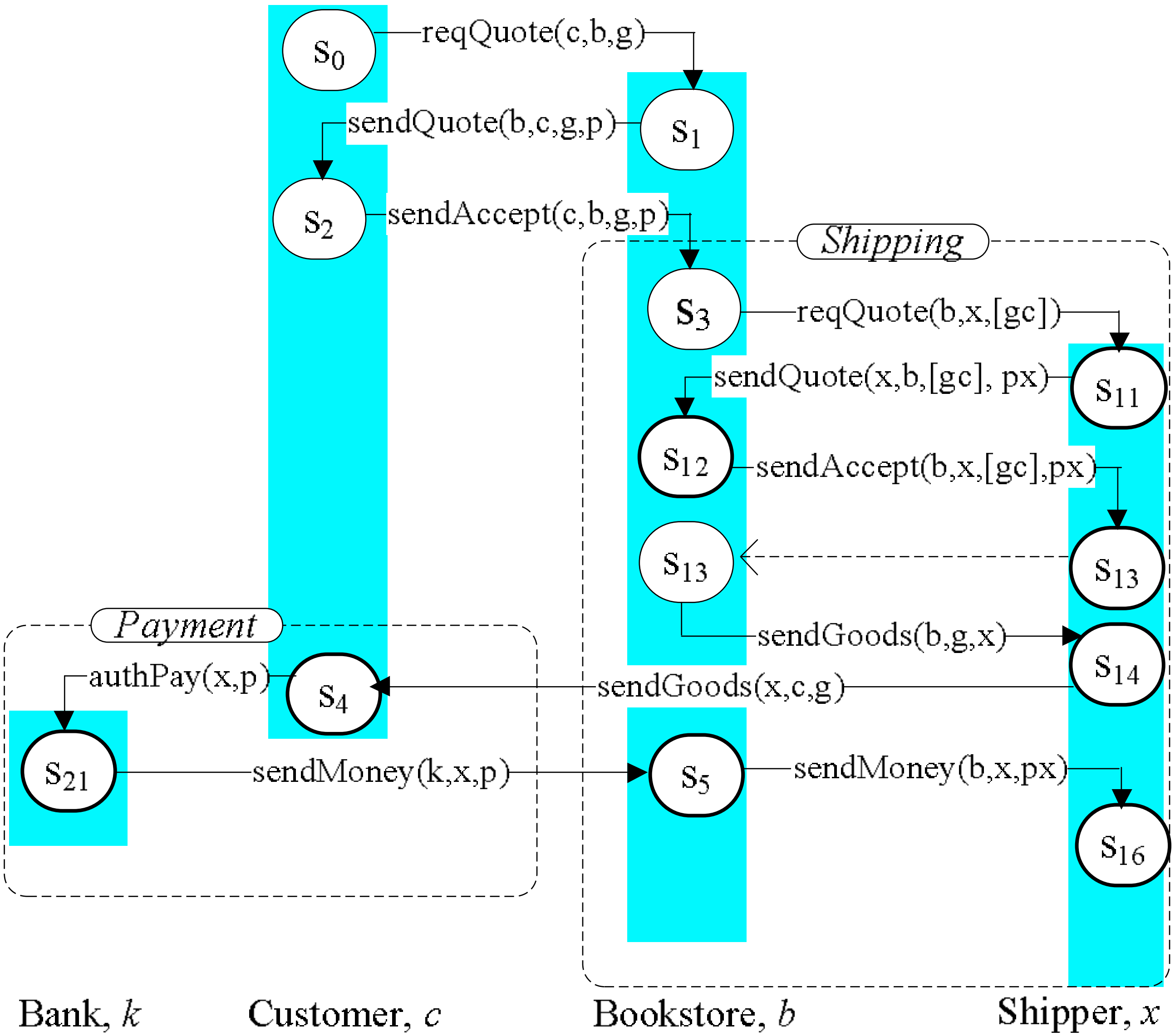
Example Run: Pay via Bank



Example Run: Shipper Protocol



Example Run: Composed Purchase

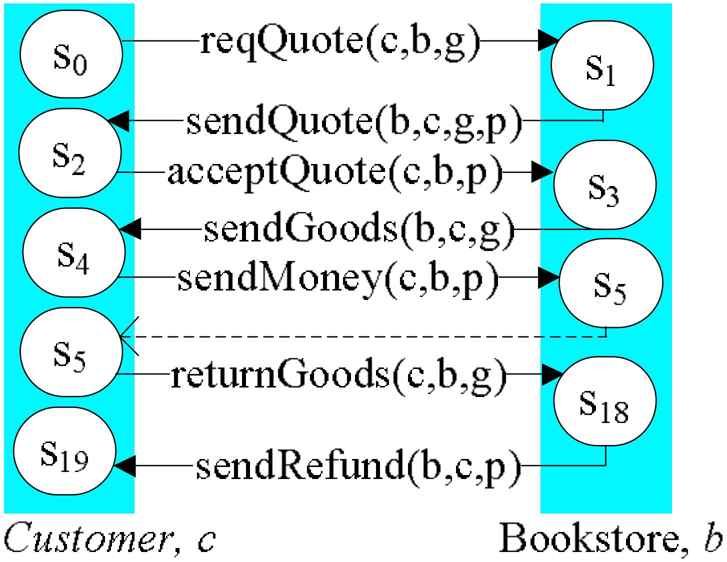


Challenges: Enactment

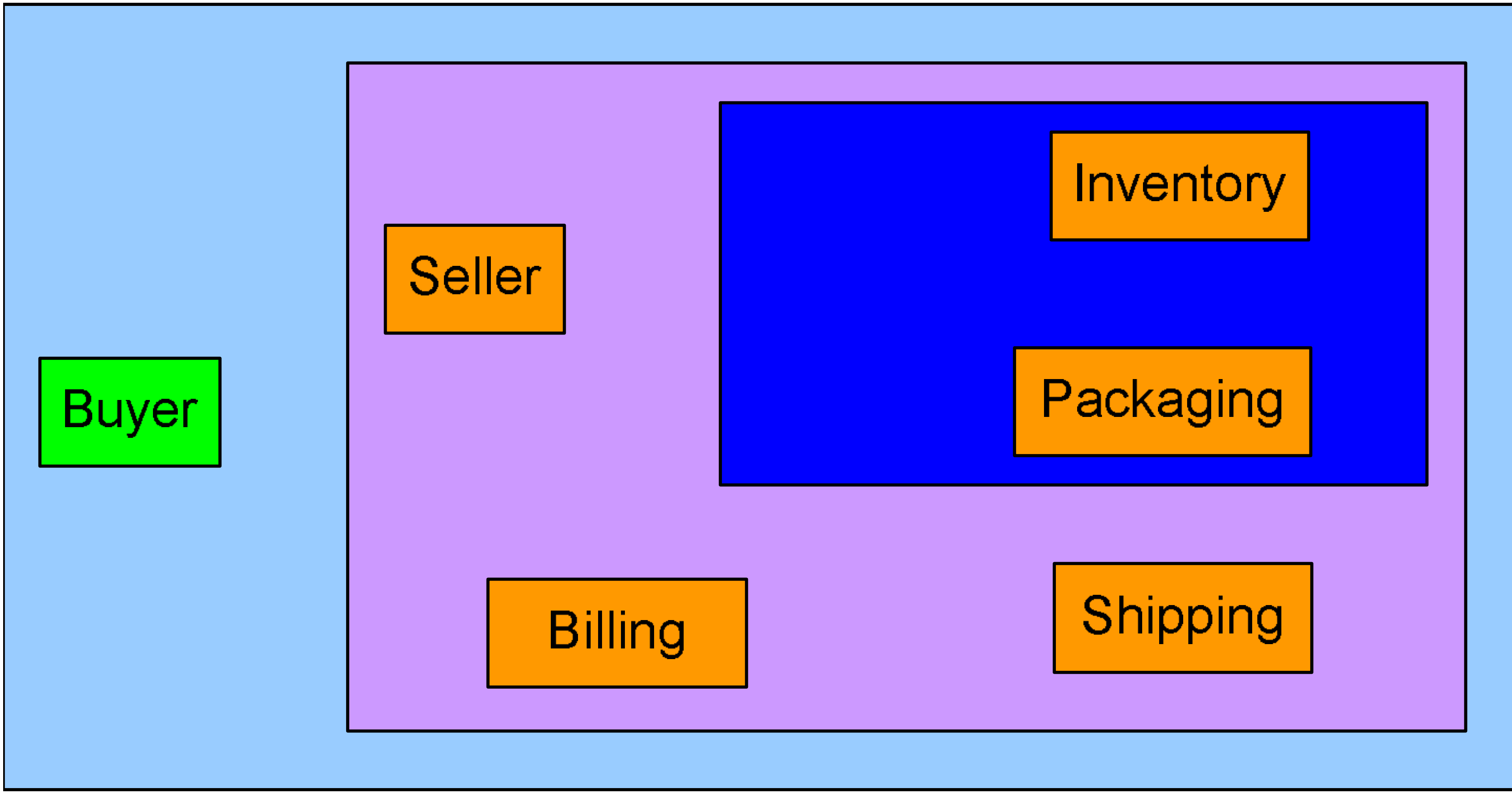
- *Behaving adaptively:* decide dynamically to ship before payment to trusted Cs.
- *Handling exceptions*.
  - External problems: cannot ship book.
  - Context-sensitivity: not legal for kids.
  - Detecting violations: no payment; book arrives damaged.
  - Correcting violations: remind, complain, refund, . . .
- *Exploiting opportunities:* combine orders from same C.

Example Run: Return and Refund

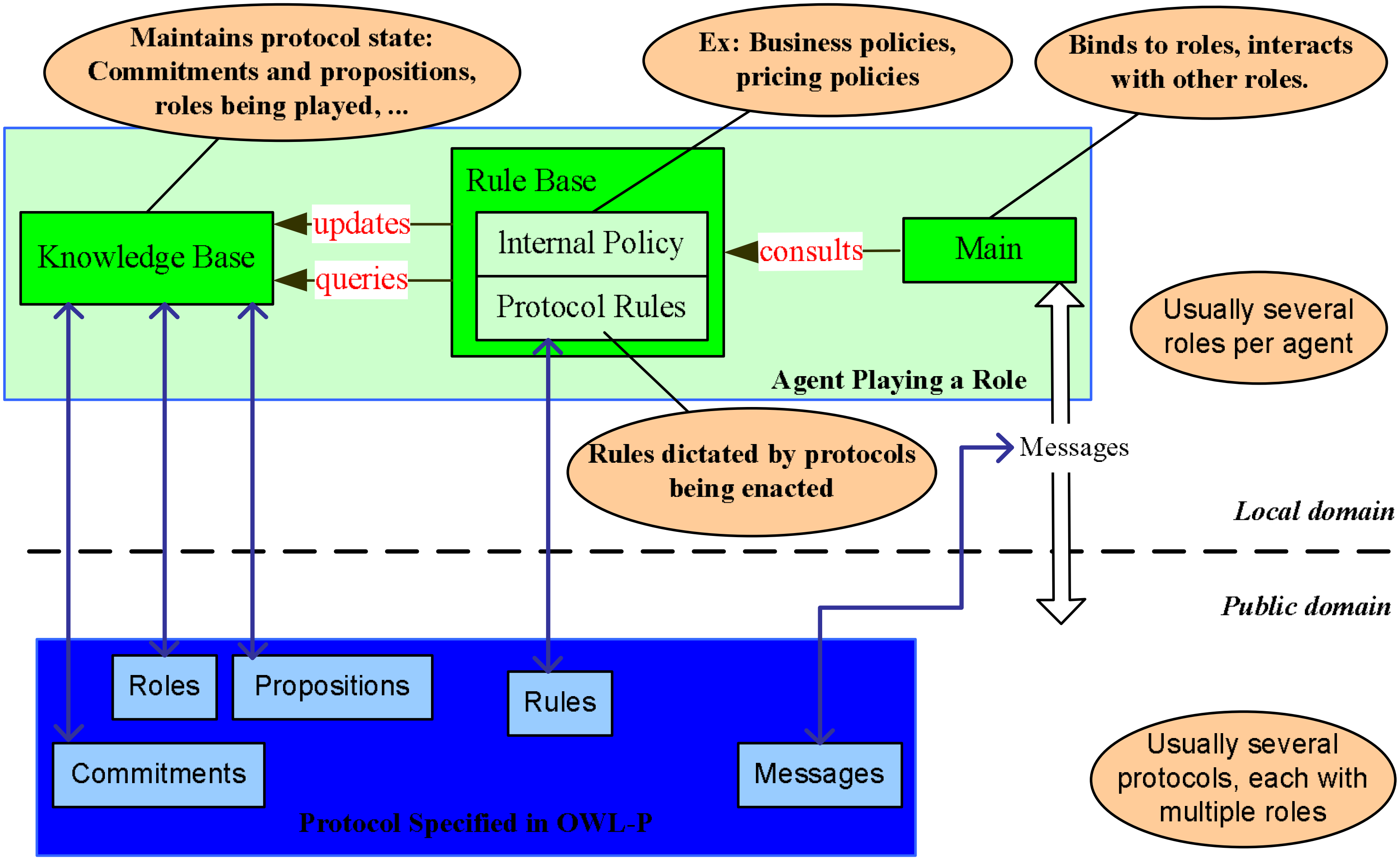
Example: Uniform Commercial Code (UCC) allows returns with refunds for goods that are received damaged.



Spheres of Commitment



Architecture


Maintains protocol state: Commitments and propositions, roles being played, ...
Ex: Business policies, pricing policies
Binds to roles, interacts with other roles.
Rule Base
Knowledge Base
updates
queries
Internal Policy
Protocol Rules
consults
Main
Usually several roles per agent
Agent Playing a Role
Rules dictated by protocols being enacted
Messages
Local domain
Public domain
Roles
Propositions
Rules
Commitments
Messages
Usually several protocols, each with multiple roles
Protocol Specified in OWL-P

Ongoing Work

- A language, OWL-P, OWL for Protocols.
  - Roles.
  - Messages: content as propositions and commitments.
  - Rules to describe messages and roles.
- Tool to generate skeletons from OWL-P.
- Operational semantics in π-calculus.
- Rule-based policies that help agents satisfy their protocol roles.
- Protocol algebra to support refinement and aggregation.

Processes = Protocols + Policies

- Operational patterns
  - Time outs, remind, garbage collect, ...
  - Decisions to manipulate: delegate, assign, . . .
  - Winograd & Flores and other such.
- Methodologies, e.g., enhancing Tropos:
  - Cover functional reqs via protocols.
  - Refine protocols for nonfunctional reqs.
  - Enact protocols dynamically based on agent policies and context.

Papers on this Topic

- "Protocols for Processes: Programming in the Large for Open Systems." *OOPSLA (Onward!)*, Oct 2004.
- "Agent Communication Languages: Rethinking the Principles." *IEEE Computer*, 31(12):40–47, Dec 1998.
- "Reasoning About Commitments in the Event Calculus: An Approach for Specifying and Executing Protocols." *Annals Math & AI*, 42(1-3), 2004.
- "Verifying Compliance with Commitment Protocols." *J. Autonomous Agents & MAS*, 2(3):217–236, Sep 1999.
- "An Ontology for Commitments in Multiagent Systems." *AI & Law*, 7:97–113, 1999.