Agent-oriented modeling for social grocery shopping and other societal information systems

Prof. Kuldar Taveter, Tallinn University of Technology, Estonia

Who am I?

- Name: Kuldar Taveter
- Position: Professor, Chair in Software Engineering
- Education:
  - Dip.Eng., TUT, 1988
  - M.Sc., TUT, 1995
  - Ph.D., TUT, 2004
- Work experience:
  - 1985-1989: Institute of Cybernetics
  - 1989-1993: Private companies
  - 1993-1998: Department of Informatics of TUT
  - 1997-2005: Technical Research Centre of Finland
  - 2005-2008: The University of Melbourne, Australia
  - 2008- : Department of Informatics of TUT
  - 2011 : Department of Computer Science and Engineering of SCU
- Research areas: requirements elicitation and analysis, agent-oriented modelling, fast prototyping, agent-based simulation, ontologies

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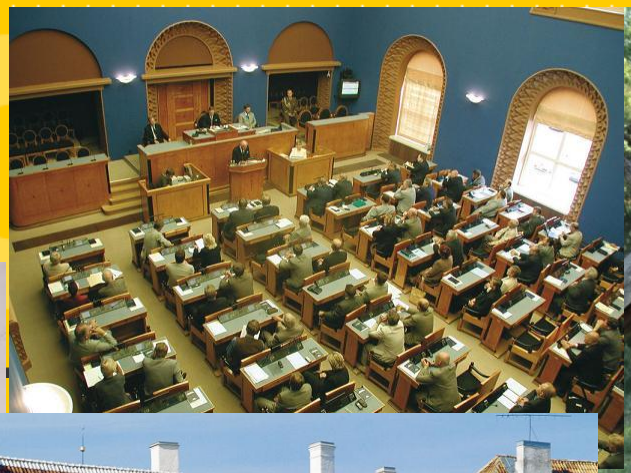
Basic Facts about Estonia

- North-East Europe
- Capital Tallinn
- Population 1,34 mio

- Area 45 000 km2, comparable to the Netherlands and Denmark
- Parliamentary republic, independence Feb 24 1918
- EU, May 1 2004
- Schengen treaty, Dec 21 2007
- Euro zone, Jan 1 2011

People and society



- Nordic mindset
- Peaceful and hard-working people
- Safe and stable society
- 70/30% of population native Estonian/Russian-speakers
- Foreign languages widely spoken: English, Russian, German, Finnish….
- 3 million tourists visit Estonia every year

Nature and country

- 4 seasons
- Well-preserved nature
- 1520 islands
- 1000 lakes…











e-Estonia

- Advanced IT society - free Internet access in many public areas, on coaches, trains, etc.
- ID-card, e-Government, e-Taxation, e-Voting, e-School, e-Signing, e-Business Register, e-Land Register, e-Banking (no bank cheques known!), etc.
- The headquarters of Skype lie in Tallinn

Higher Education in Estonia

smartEstonia.ee

- Higher (tertiary) education is offered at **universities** and **professional higher education institutions**
- Ca 2/3 of the age group study in higher education institutions - there are **ca 68 000 students** in Estonia
- There are **8 universities** in Estonia
- All institutions have introduced a **bachelor-master (3+2) structure** for most study programmes
- Growing number of **English taught programmes** are offered, especially at Master level.

Universities offering international academic programmes

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Public

Estonian Academy of Arts – www.artun.ee
Estonian Academy of Music and Theatre – www.ema.edu.ee
Estonian University of Life Sciences – www.emu.ee
Tallinn University – www.tlu.ee
Tallinn University of Technology – www.ttu.ee
University of Tartu – www.ut.ee

Private

Estonian Business School – www.ebs.ee
University Nord – www.nord.ee

Tallinn University of Technology

- Founded as an engineering college in 1918
- Acquired university status in 1936
- The second largest universityy in Estonia with about 14,200 students, 2,000 employees and with more than 54,000 graduates
- Courses taught in Estonian, English, and Russian
- International students ~5%
- 134 Bachelor's, Master's, and Doctoral degree programs
- The biggest faculty of economics and business administration in Estonia

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Faculties

- Civil Engineering
- Power Engineering
- Information Technology
- Chemistry and Materials Technology
- Mechanical Engineering
- Mathematics and Natural Sciences
- Social Sciences
- School of Economics and Business Administration

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International programs taught in English

- Bachelor´s:
  - International Business Administration
  - Law
  - International Relations
- Master´s:
  - MBA
  - Law
  - International Relations and European Studies
  - Technology Governance
  - Software Engineering
  - Cyber Security
  - Industrial Engineering and Management
  - Environmental Management and Cleaner Production
  - Materials and Processes of Sustainable Energetics
  - Health Care Technology
  - Design and Engineering

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Department of Informatics

- Department of Computer Mathematics (1967) → Department of Information Processing (1974) → Department of Informatics (1992)
- Faculty
  - 33 members
    - 4 professors
    - 6 associate professors
    - 6 lecturers
    - 7 assistant lecturers
    - 10 researchers
  - Qualifications:
    - PhD: 16 members
    - M.Sc.: 17 members, among them 10 PhD students

Department of Informatics: Composition

- Chair of Information Systems (ass. prof. E. Eessaar):
- Chair of Software Engineering (prof. K. Taveter)
- Chair of the Foundations of Informatics (prof. R. Kuusik)
- Chair of Knowledge-based Systems (prof. J. Tepandi)
- Chair of Information Security (prof. A. Buldas)
- Data Mining Laboratory
- Laboratory of Socio-Technical Systems
  - Evolutionary IS by agents
  - Agent-based simulation of asymmetric threats
  - Agent-based simulation of aircraft turnaround
- Laboratory of Web Services

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Department of Informatics: Teaching

- B.Sc. and M.Sc. in **Informatics**,
- B.Sc. and M.Sc. in **Business information technology**
- PhD in **Informatics**
- General informatics (8 ECP) in a majority of study programs offered by TTU
- An introductory course in information systems (5 ECP) for students at the faculties of information technology, social sciences, and economics and business administration
- Special courses in informatics (e.g., C++ and OOP, basic course in Internet, M.Sc. and PhD seminars, etc.)
- Further training in informatics (fee-charging courses)

Department of Informatics: Research

- Information systems (Government-funded project “Model-based Creation and Management of Evolutionary Information Systems”)
- Data mining (the method of monotone systems, used in several industry-oriented research projects)
- Web-services (application-oriented research projects in e-billing, power engineering, etc.)
- Intelligent systems and software agents (tactile feedback devices, methods of problem domain analysis and design of multiagent systems and agent-based simulation systems)

PhD studies

Year	Admissions	Defenses
2004	6	1
2005	8	2
2006	7	2
2007	7	1
2008	5	3
2009	7	1
2010	8	2
2011 (plan)		*4*

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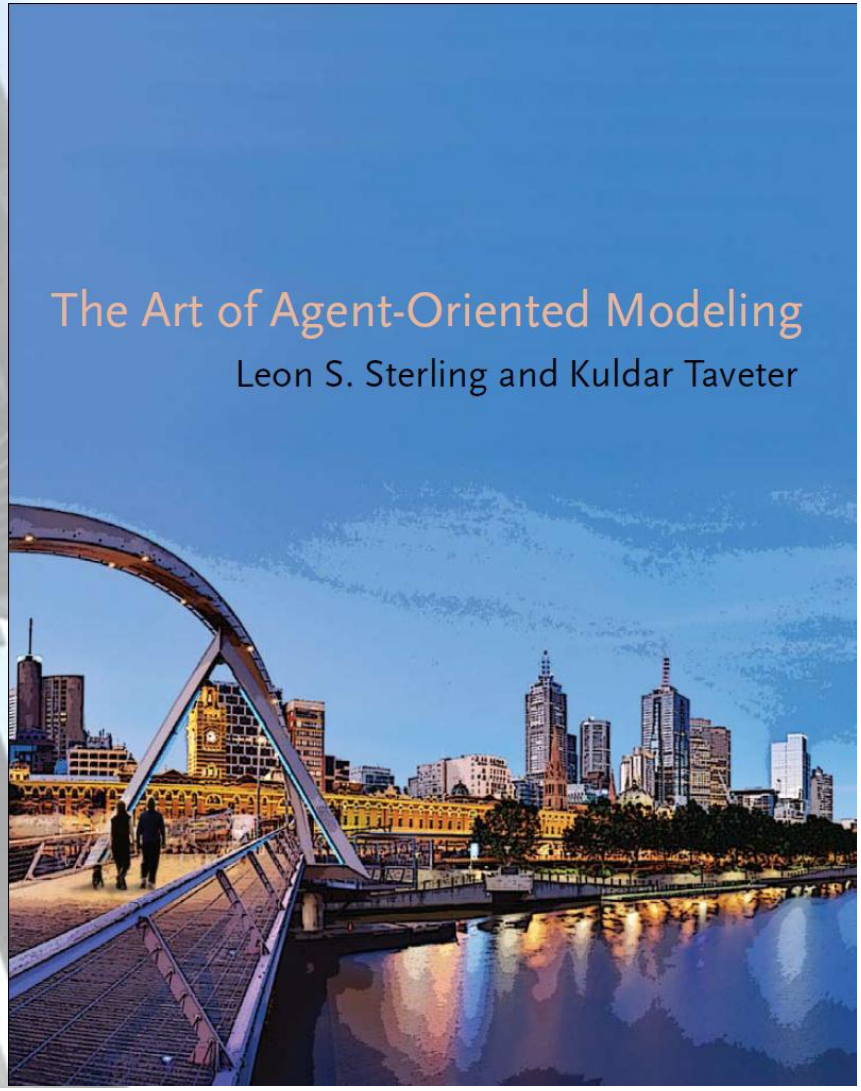
Agent-oriented modelling



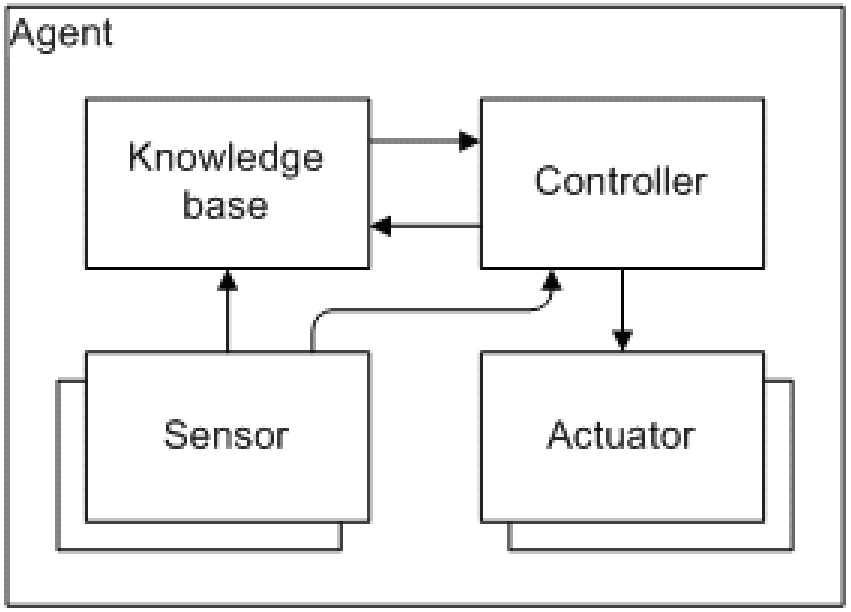
The book's mission

- To address how computing can support social organizations in the environment where the computing is:
  - Pervasive;
  - Deployed over a range of devices;
  - With multiplicity of users
- Approach for engineering software systems that are:
  - Open;
  - Intelligent;
  - Adaptive

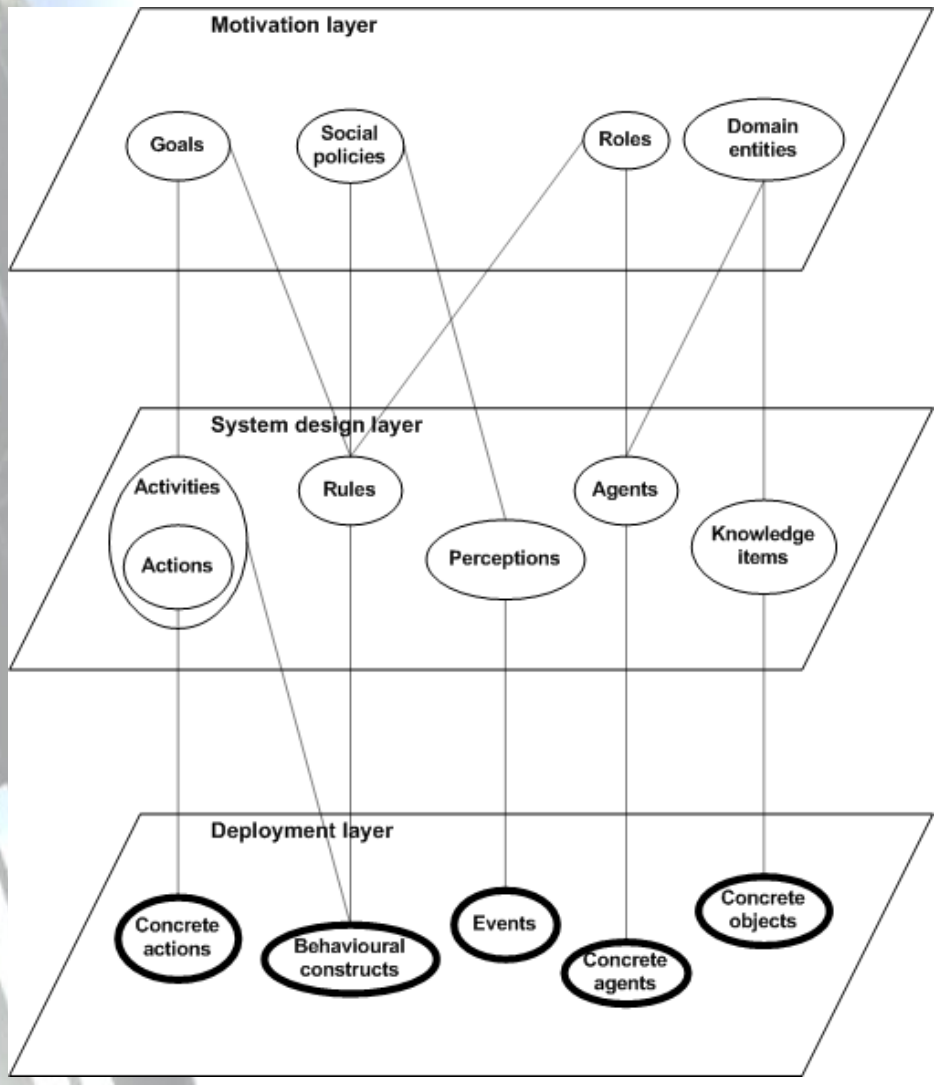
The “agent” metaphor

- An active entity as opposed to a passive entity
- An entity that can act in the environment, perceive events, and reason
- An entity that acts on behalf of someone or somebody

The abstract agent architecture



Concepts of AOM



Model types of AOM

Viewpoint models	***Viewpoint aspect***		
Abstraction layer	*Interaction*	*Information*	*Behavior*
Conceptual domain modeling	Role models and organisation models	Domain models	Goal models and motivational scenarios
Platform-independent computational design	Agent models and acquaintance models, interaction models	Knowledge models	Scenarios and behavior models
Platform-specific design and implementation	Agent interface and interaction specifications	Data models and service models	Agent behavior specifications

Mapping Prometheus to viewpoint framework

Viewpoint models	***Viewpoint aspect***		
Abstraction layer	*Interaction*	*Information*	*Behavior*
Conceptual domain modeling	Analysis Overview Diagram, System Roles Diagram		Goal Overview Diagram, Initial Role Descriptors, Scenarios
Platform-independent computational design	Agent Acquaintance Diagram, Interaction Diagrams, Protocol Diagrams, System Overview Diagram	Knowledge Coupling Diagrams	Agent Descriptors
Platform-specific design and implementation	Event Descriptors	Data Descriptors	Agent Overview Diagrams, Process Specifications, Capability Overview Diagrams

Mapping Tropos to viewpoint framework

Viewpoint models	***Viewpoint aspect***		
Abstraction layer	*Interaction*	*Information*	*Behavior*
Conceptual domain modeling	Actor Diagram	Actor Diagram	Goal Diagrams
Platform-independent computational design			Refined Goal Diagrams
Platform-specific design and implementation	Agent Interaction Diagrams	UML Class Diagrams	Capability Diagrams, Plan Diagrams

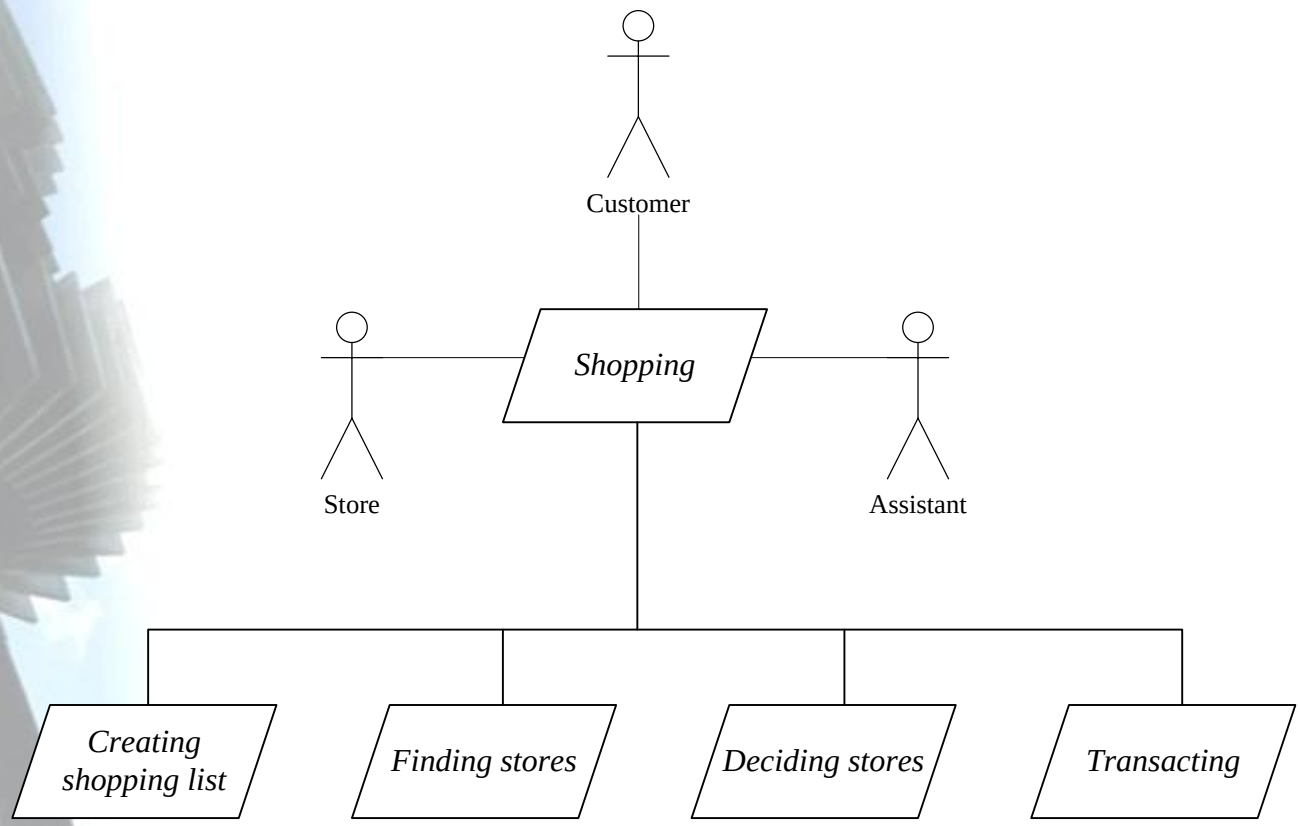
Mapping MaSE to viewpoint framework

Viewpoint models	***Viewpoint aspect***		
Abstraction layer	*Interaction*	*Information*	*Behavior*
Conceptual domain modeling	Sequence Diagrams, Role Model		Goal Diagram, Use Cases, Role Model
Platform-independent computational design	Protocol Diagrams, Agent Class Diagram		Concurrent Tasks, Agent Class Diagram
Platform-specific design and implementation			Plan Diagrams, Deployment Diagrams

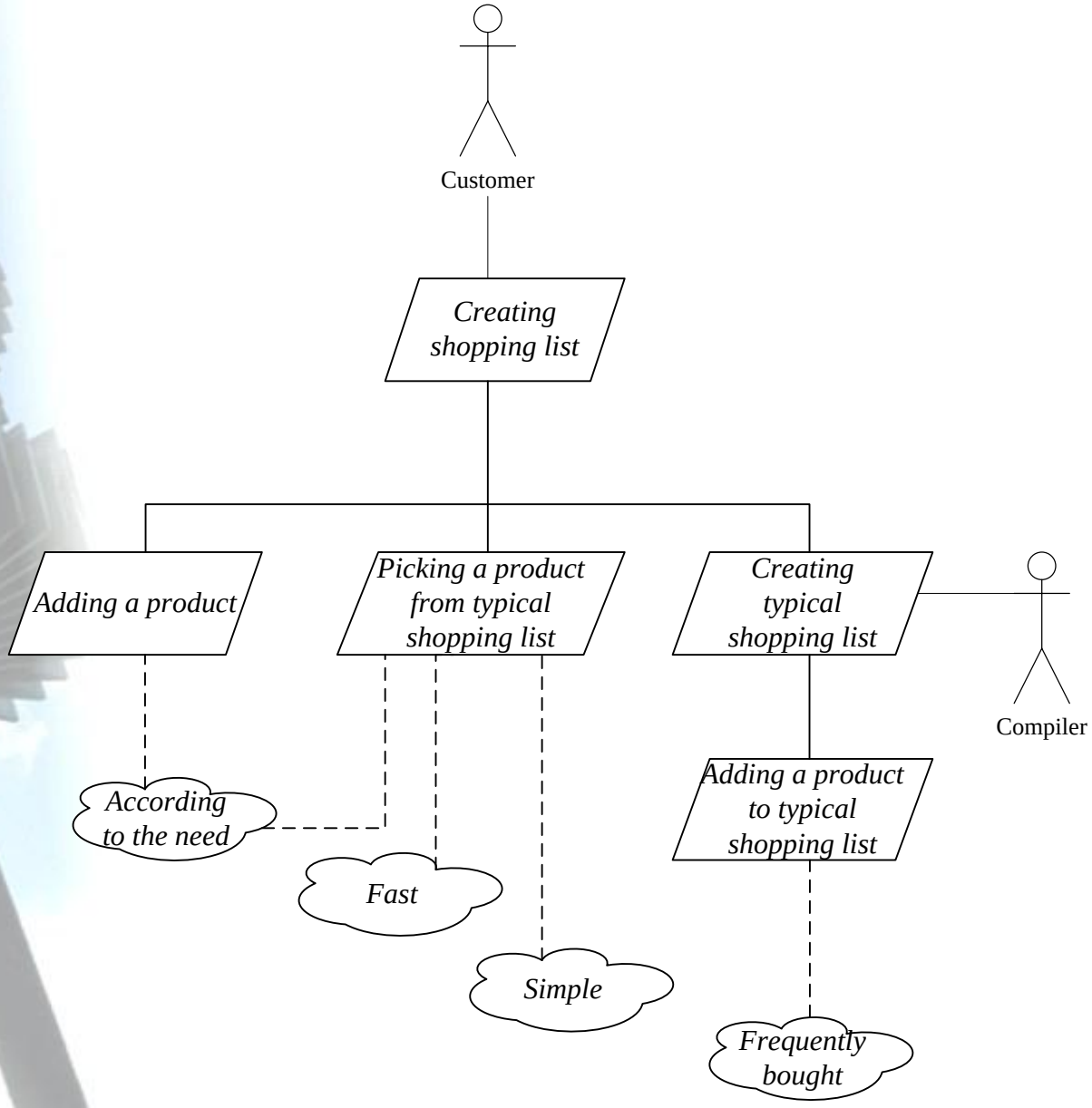
The case study of social grocery shopping

- Customers post the prices they paid for their groceries (this could be automated by querying the RFID tags of the items) and QoS information
- A prospective shopper enters a grocery list and obtains a pointer to the store(s) with the lowest total price (and best service)
- Each customer has an agent representing his/her interests and interacting with the agents of the other customers.

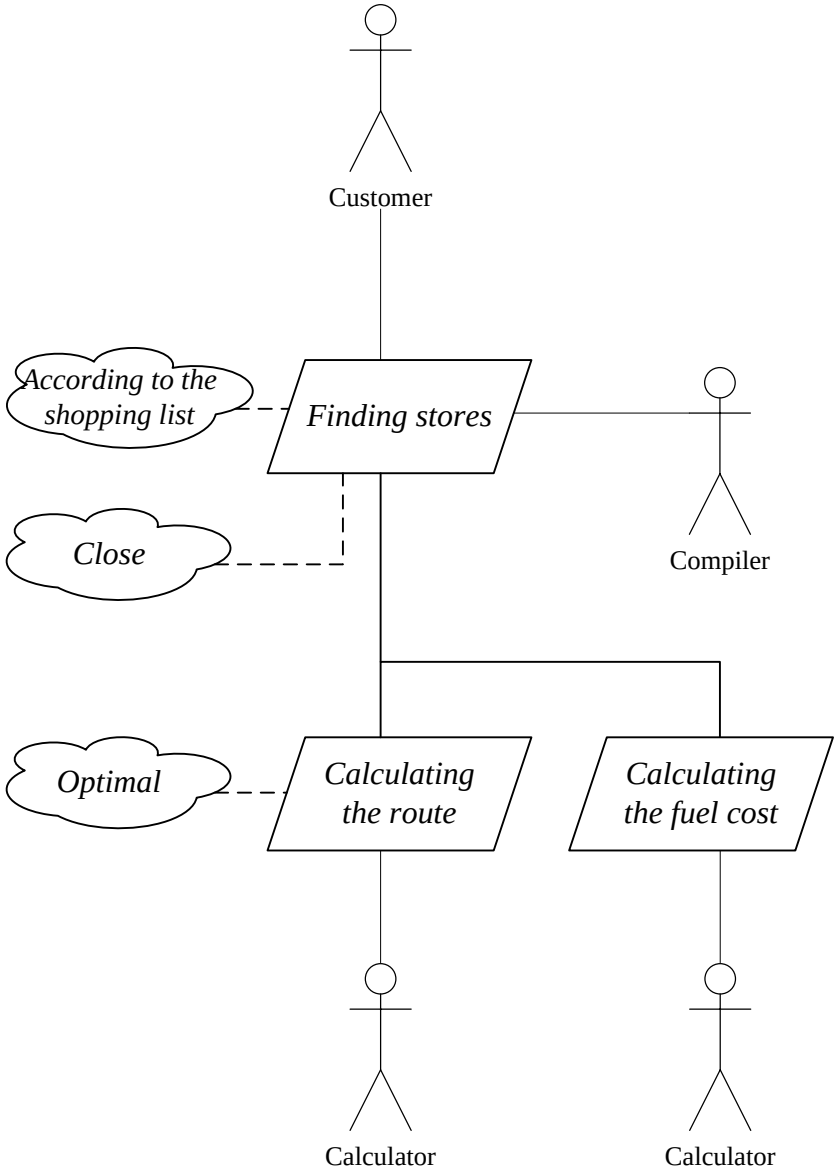
Overall goal model



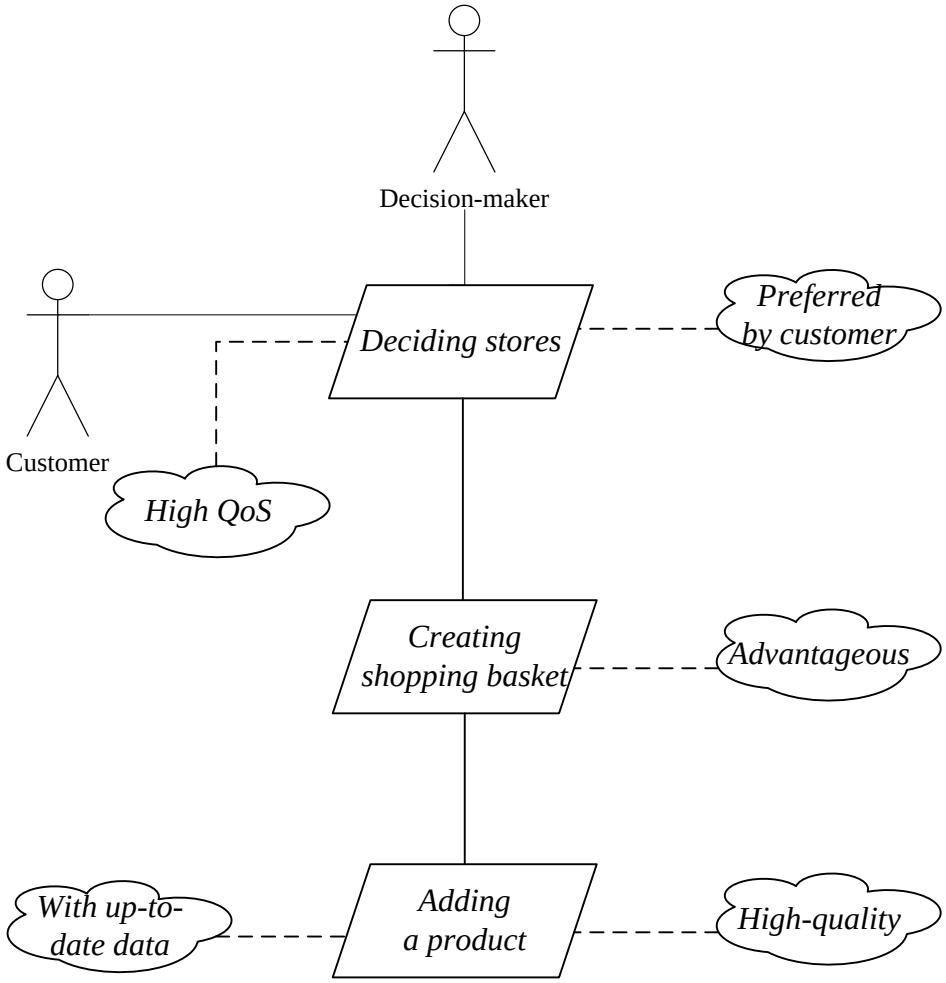
Creating shopping list



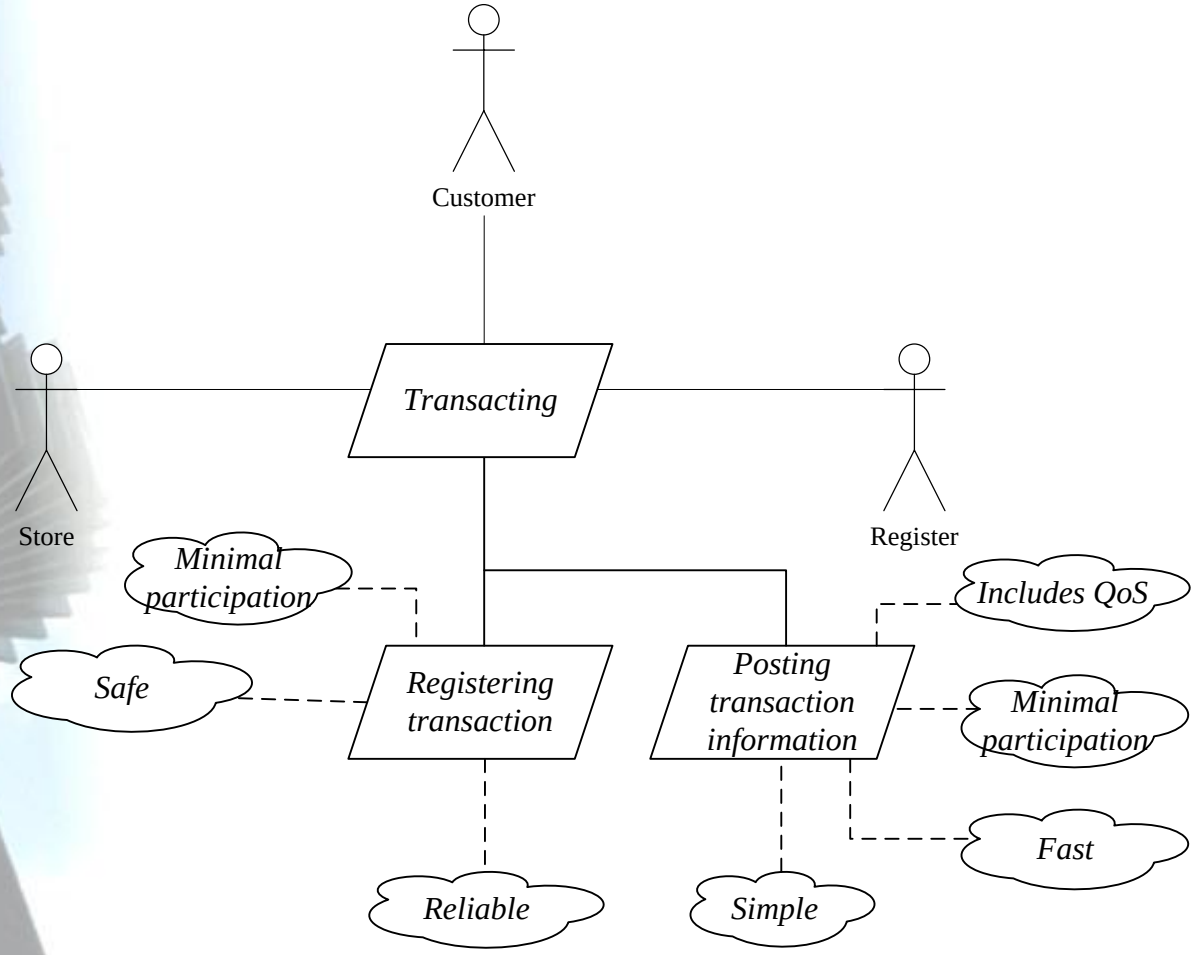
Finding stores



Deciding stores



Transacting



Role model for Customer

Role	Customer
Description	The role of a customer buying groceries
Responsi-bilities	Creating the shopping list - Adding a product to the shopping list - Picking a product from the typical shopping list Determining preferences Confirming the stores found by the Compiler Confirming the decisions made by the Decision-maker Driving to the stores Making transactions
Constraints	For picking products from the typical shopping list, the typical shopping list must have been created for the Customer To find the most advantageous shopping baskets, the Customer should consider the stores found by the Compiler and the decisions made by the Decision-maker To benefit from the transaction information posted by other customers, the Customer must authorize posting of his/her transaction information

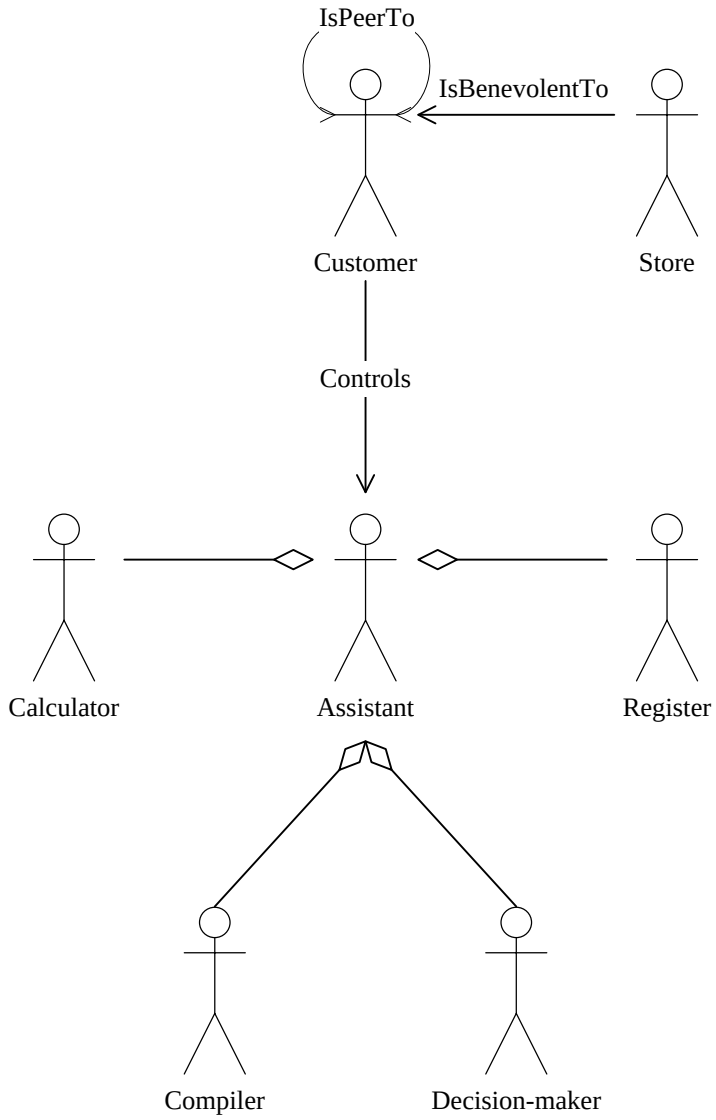
Role model for Compiler

Role	Compiler
Description	The role of shopping list and store list compiler
Responsi-bilities	Creating and managing the typical shopping list by the buyer - Add a product to the typical shopping list Storing shopping lists for statistics and data mining Finding potential stores with the help of the Calculator
Constraints	The shopping list by the Customer must be considered when finding potential stores The typical shopping list must be considered when finding potential stores The proximity of stores must be considered when finding potential stores For creating the typical shopping list, the Customer must have created shopping list(s) before.

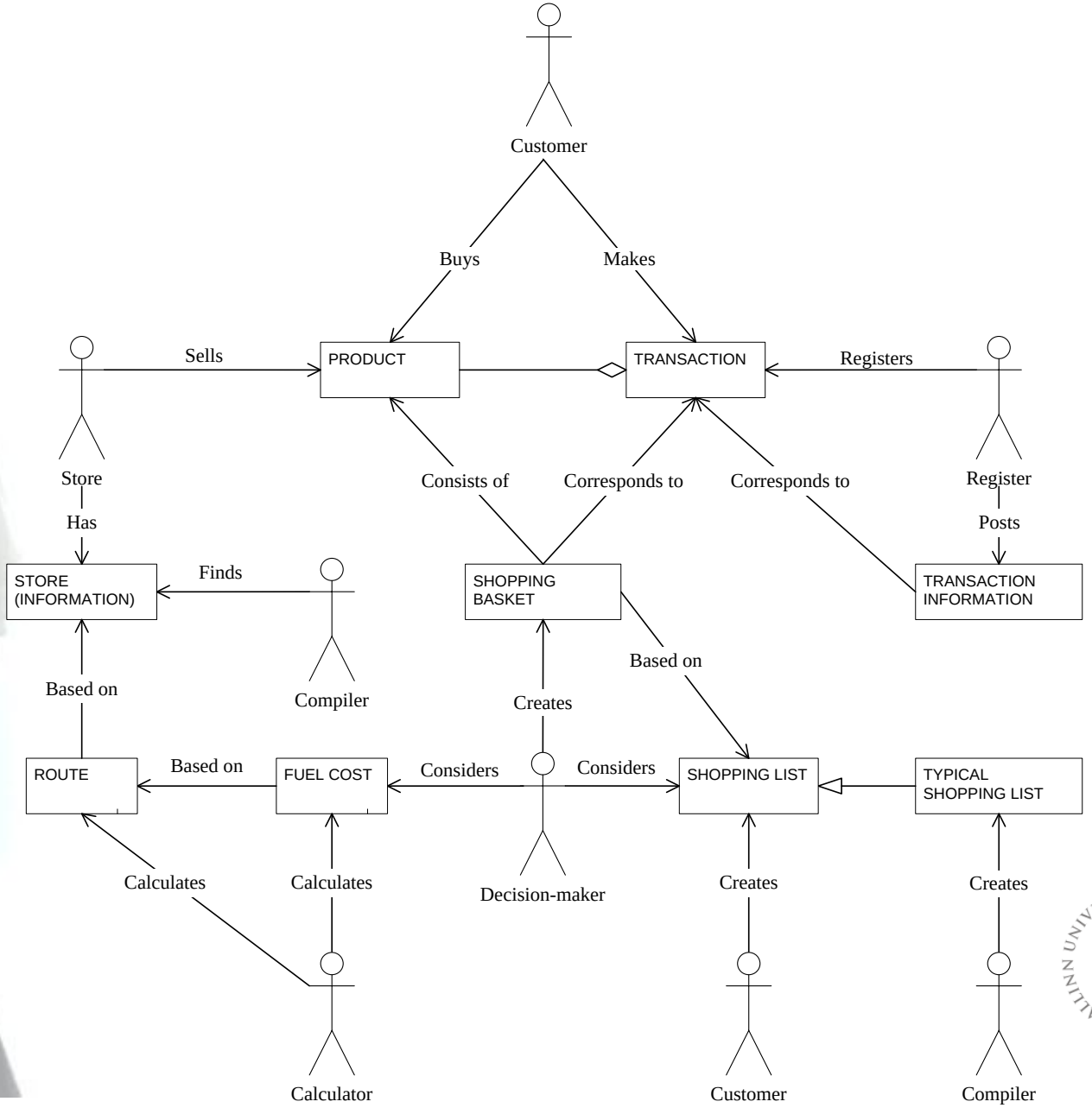
Role model for Decision-maker

Role	Decision-maker
Description	The role of decision-maker about the stores and their shopping baskets
Responsi-bilities	Comparing potential shopping baskets for the stores found by the Compiler Deciding the stores Deciding the shopping basket for each store selected
Constraints	The preferences by the Customer must be honored when deciding about the stores and their shopping baskets The transaction information posted by other customers, including QoS, must be considered when deciding about the stores and their shopping baskets The transaction information should be considered in the order of its age The fuel costs computed by the Calculator must be considered when deciding about the stores and their shopping baskets The shopping baskets created should be maximally advantageous for the Customer The shopping baskets should include high-quality products with up-to-date data

Organization model



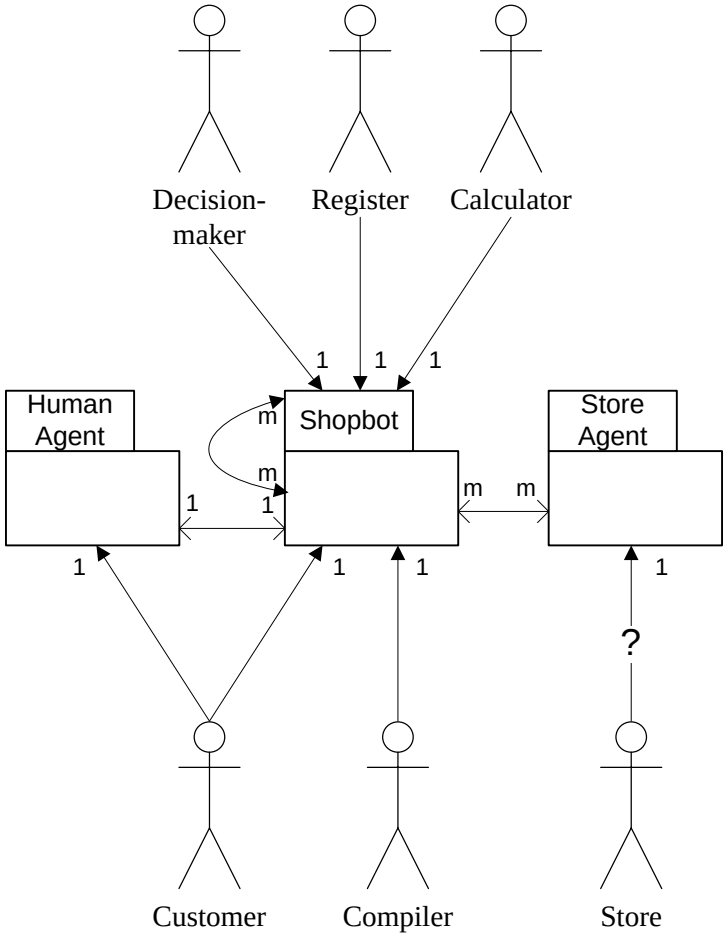
Domain model



Design models

- Agent and acquaintance models
- Interaction models
- Knowledge models
- Scenarios and behavior models

Agent and acquaintance model



Results from initial experiments by Prof Huhns and Hongying Du

- Savings up to 21% can be obtained by social grocery shopping!

Societal information systems

- Software agents represent members of the society
- The tasks:
  - Regulation (e.g., banking)
  - Allocation of scarce resources (e.g., energy, parking spaces, emergency care)
  - Distributed situation assessment (e.g., traffic jams)
  - Decentralized decision-making (e.g., grocery shopping, choosing healthcare providers)
- Open distributed systems

Conclusions

- AOM is appropriate for problem domain analysis for societal information systems
- Full potential of social networks has not been yet employed
- Further experiments required in different areas
- AOM -> NetLogo mapping?