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Advanced Topics in Software Engineering: Agent-Oriented Software Engineering

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Who am I?

- Name: Kuldar Taveter
- Position: Professor in Software Engineering, Head of the Laboratory of Sociotechnical Systems
- 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**
  - **Jan-Aug 2011: University of South Carolina, USA**
  - **Apr – May 2016: Shanghai University for Science and Technology, China**
- Research areas: Agent-oriented software engineering, engineering of sociotechnical systems, multiagent systems, intelligent systems

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

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-Parking (no parking meters known!), e-Business Register, e-Land Register, e-Banking (no bank checks known!), etc.
- The development centre of Skype lies in Tallinn
- The headquarters of the EU IT Agency are located in Tallinn

People and society

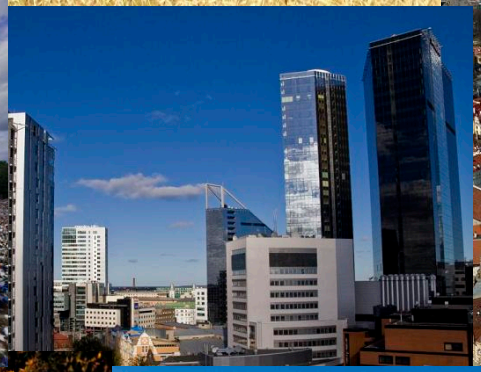
- Nordic mindset
- Peaceful and hard-working people
- Safe and stable society
- 70/30% of population native Estonian/Russian-speakers
- Foreign languages widely spoken: English, Russian, German, Finnish….
- 3 million tourists visit Estonia every year

Nature and country

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








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 ~7%
- 134 Bachelor's, Master's, and Doctoral degree programs
- The biggest faculty of economics and business administration in Estonia

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90
1918
2008

Faculty of Information Technology

- The number of students: approximately 2500
- The number of research and teaching staff: approximately 150
- Departments:
  - Thomas Johann Seebeck Department of Electronics
  - Radio and Communication Engineering
  - Computer Engineering
  - Computer Control
  - Computer Science
  - Informatics

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1918
2008

Department of Informatics

- Research and teaching staff 41 people
- Number of students in our study programs: approx. 1500
- Qualifications
  - PhD: 17 members
  - M.Sc.: 24 members, among them 12 PhD students

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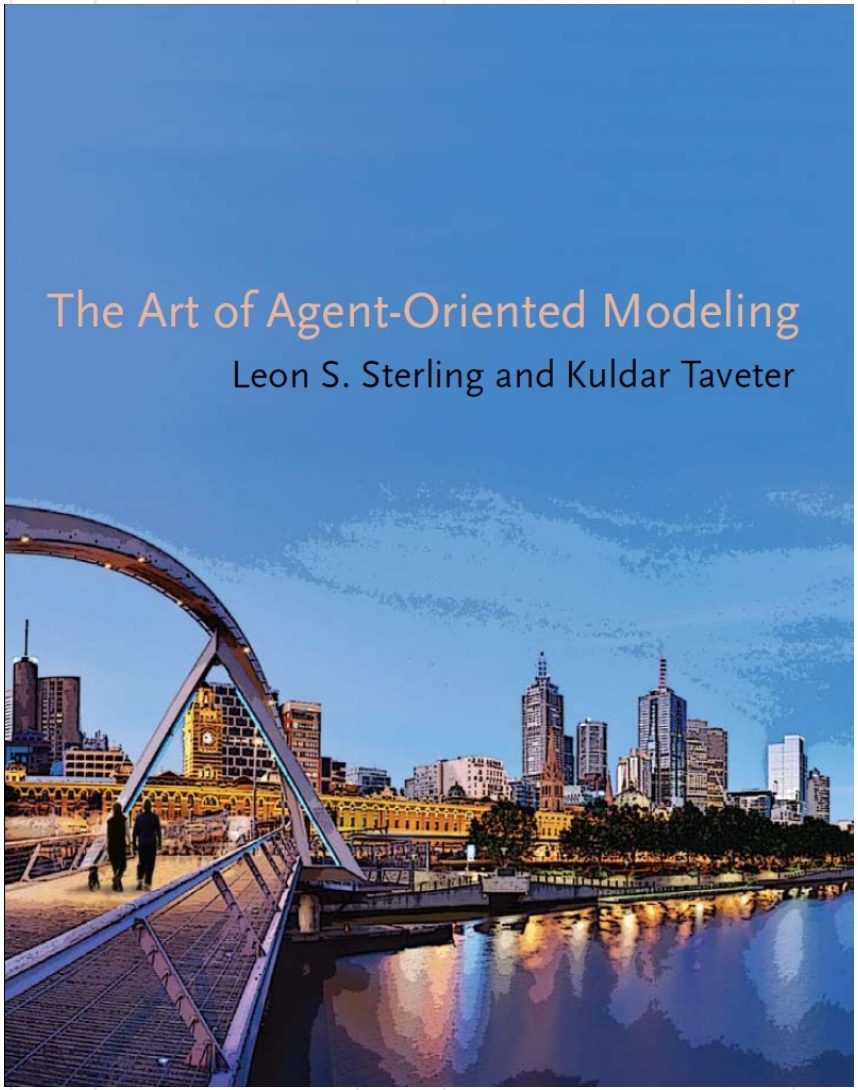
Agent-oriented modelling (AOM)



Why “agent-oriented”?

What is model?

- A hypothetical, simplified description of a complex entity or process
- “A model should be as complex as it needs, but not more complex”, David Lorge Parnas
- What features...
  - are important?
  - can be ignored?

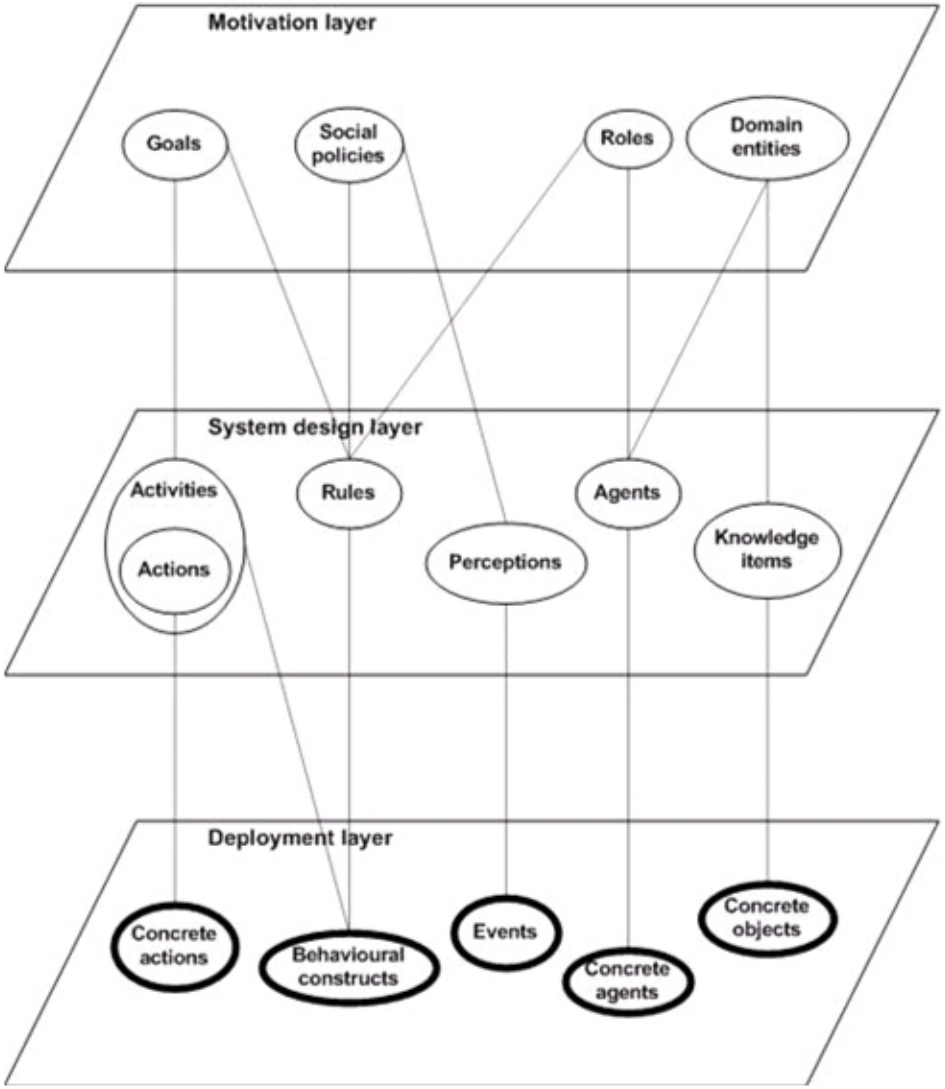
Examples of models

- A model of the solar system
- The model of a gold mine
- The model of a chemical plant
- Air traffic simulator:

Socio-technical system

- A software intensive system that has defined operational processes followed by human operators and which operates within an organization
- A system that contains both a social aspect, which may be a subsystem, and a technical aspect

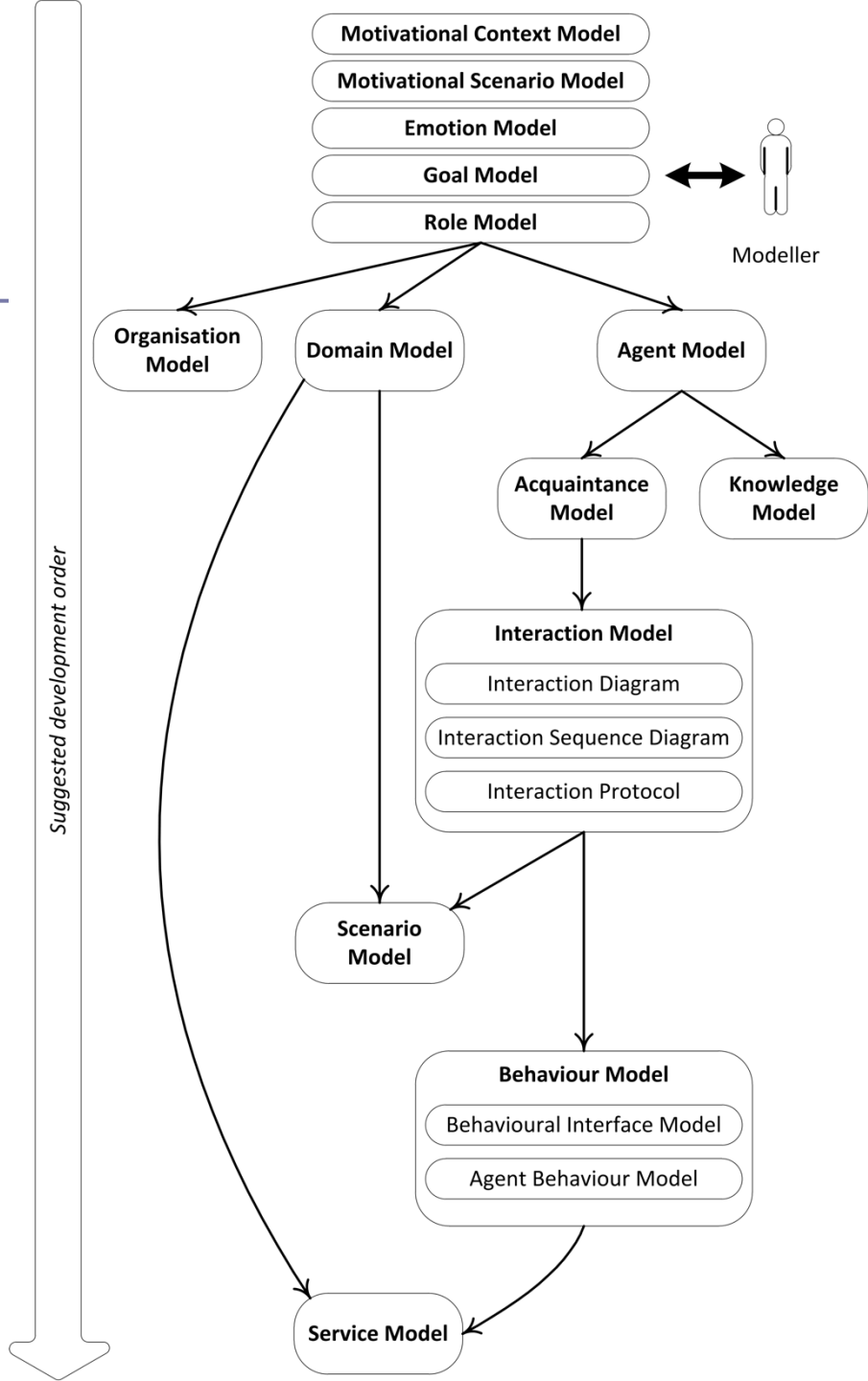
The conceptual space



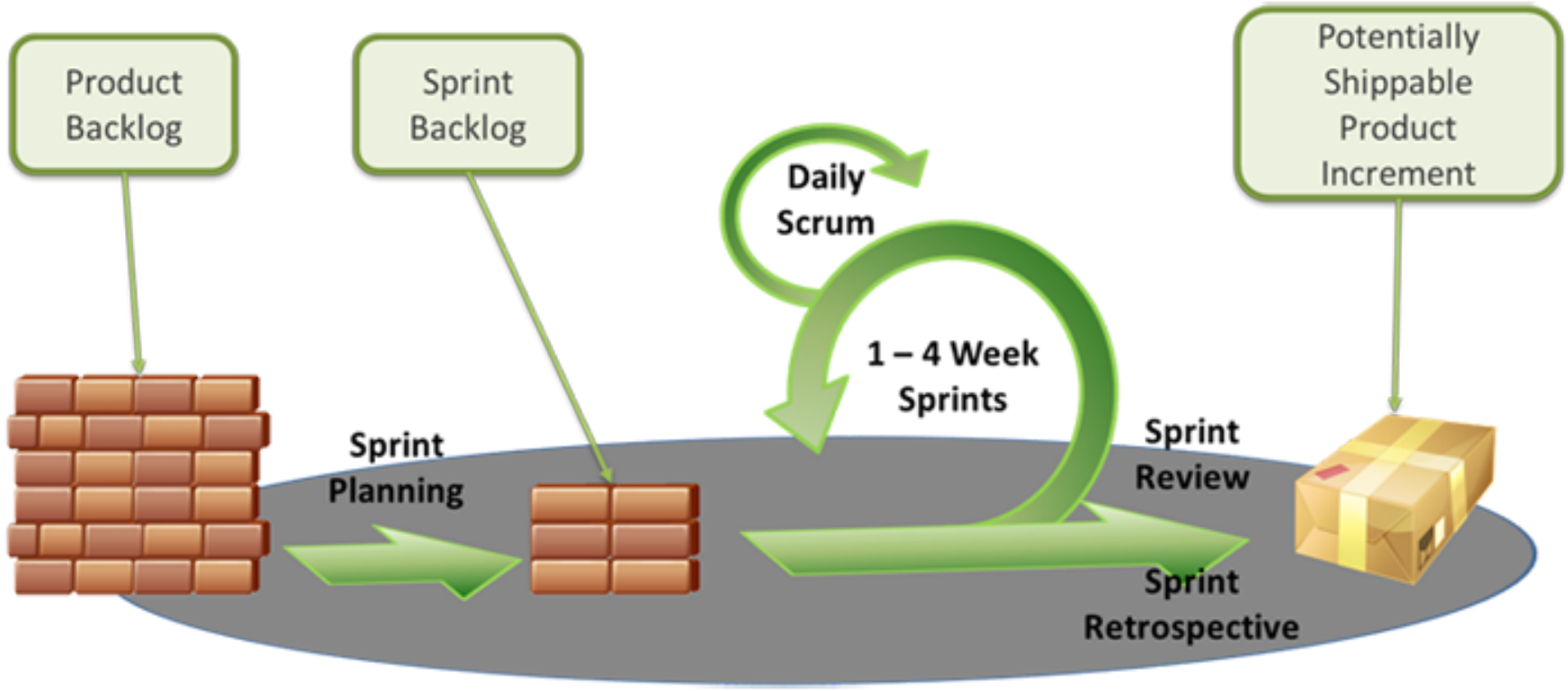
The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	Role models and organization model	Environment model and domain knowledge model	Goal models
Design	Agent models, acquaintance model, and interaction models	Agent knowledge model	Scenarios and agent behavior models
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

Modelling process:



Adding agility



Part III

GOAL MODELLING

The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	Role models and organization model	Environment model and domain knowledge model	**Goal models** and motivational scenarios
Design	Agent models, acquaintance model, and interaction models	Agent knowledge model	Scenarios and agent behavior models
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

Concepts for goal models

- Goal
  - Functional goal
  - Quality goal
- Role

What is goal?

- Dream with a deadline ☺
- A particular state of affairs intended by one or more agents

Two kinds of goals

- Functional goal: a goal that captures one or more desired scenarios. Example: attend the lecture
- Quality goal: quality requirement of the achievement of the functional goal. Example: attend the lecture *attentively*

What is role?

- Some capacity or position that the system requires in order to achieve its goals
- Examples

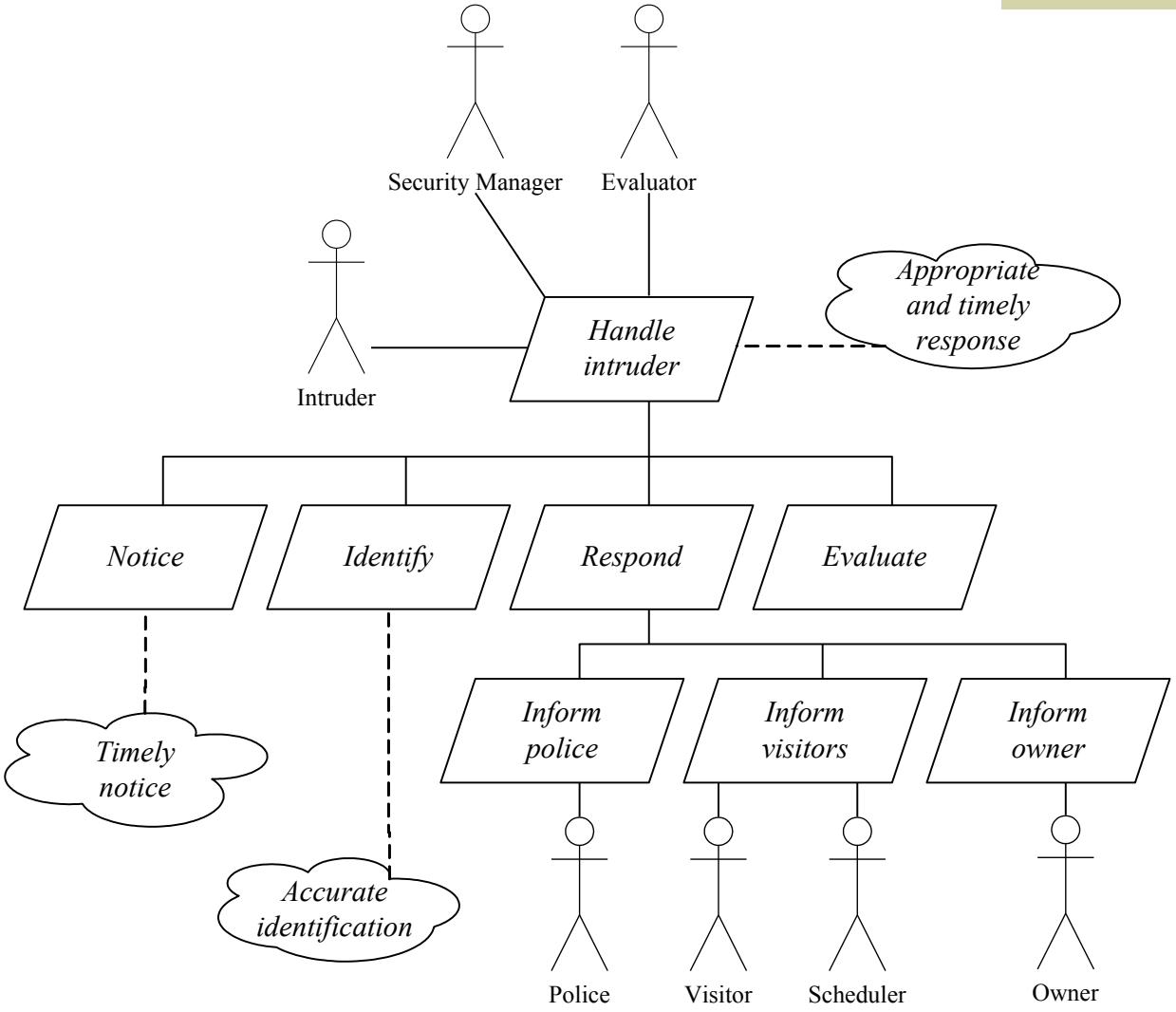
Goal model

- Hierarchy of goals
- Roles associated with goals
- Quality goals attached to goals

Notation for goal models

Symbol	Meaning
	**(Functional) Goal:** **To-Do goal**
	**Quality Goal:** **To-Be goal**
	**Quality Goal:** **To-Feel goal**
	**Role**
———	**Relationship between goals**
- - - - - - - - -	**Relationship between goals and quality goals**

Intruder detection system: Goal model



Part IV

ROLE AND ORGANIZATION MODELLING

The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	**Role models** and organization model	Environment model and domain knowledge model	Goal models and motivational scenarios
Design	Agent models, acquaintance model, and interaction models	Agent knowledge model	Scenarios and agent behavior models
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

Role model

- Role models are orthogonal to goal models
- A role model consists of the following four elements to describe the role:
  - Role name: A name identifying the role
  - Description: A textual description of the role
  - Responsibilities: A list of responsibilities that the agent playing the role must perform in order for a set of goals and their associated quality goals to be achieved
  - Constraints: A list of conditions that the agent playing the role must take into consideration when exercising its responsibilities

Intruder detection system: Role model for Security Manager

Role name	Security Manager
Description	The security Manager identifies and responds to an intruder detected in the house.
Responsibilities	Detect the presence of a person in the environment. Take an image of the person. Compare the image against the database of known people. Contact the police and send the image to them. Check the house schedule for planned visitors. Notify each visitor expected that day to stay away. Inform the owner that the police are on the way and the visitors have been warned not to enter the house.
Constraints	Photos of the owner and visitors need to be provided to the system in advance. A subject to be detected needs to be seen within the camera's image area. To receive messages, the owner and visitors must be accessible by electronic means of communication.

Intruder detection system: Role model for Visitor

Role name	Visitor
Description	The Visitor visits the owner
Responsibilities	Provide the owner with a recent photo. Register a visit with the owner Update the details of the visit with the owner, if necessary. Cancel the visit with the owner, if necessary. Receive from the security manager a request to stay away.
Constraints	To receive a request to stay away, must be accessible by electronic means of communication.

Intruder detection system: Role model for Owner

Role name	Owner
Description	The Owner owns the home
Responsibilities	Insert the photos of the visitors, family members, and himself/herself into the system.
	Register all scheduled visits.
	Update the details of a visit, if necessary.
	Cancel the visit, if needed.
	Receive from the security manager a request to stay away.
Constraints	The schedule must be kept up-to-date.
	To receive a request to stay away, the owner must be accessible by electronic means of communication.

Intruder detection system: Role model for Police

Role name	Police
Description	An institutional role for keeping law and order.
Responsibilities	Receive notification about the intrusion.
	Notify the staff on duty in the proximity of the intrusion site.
	Identify the intruder from the database of suspects.
Constraints	The staff on duty must be notified immediately.
	For identification, notification must be accompanied by a photo.

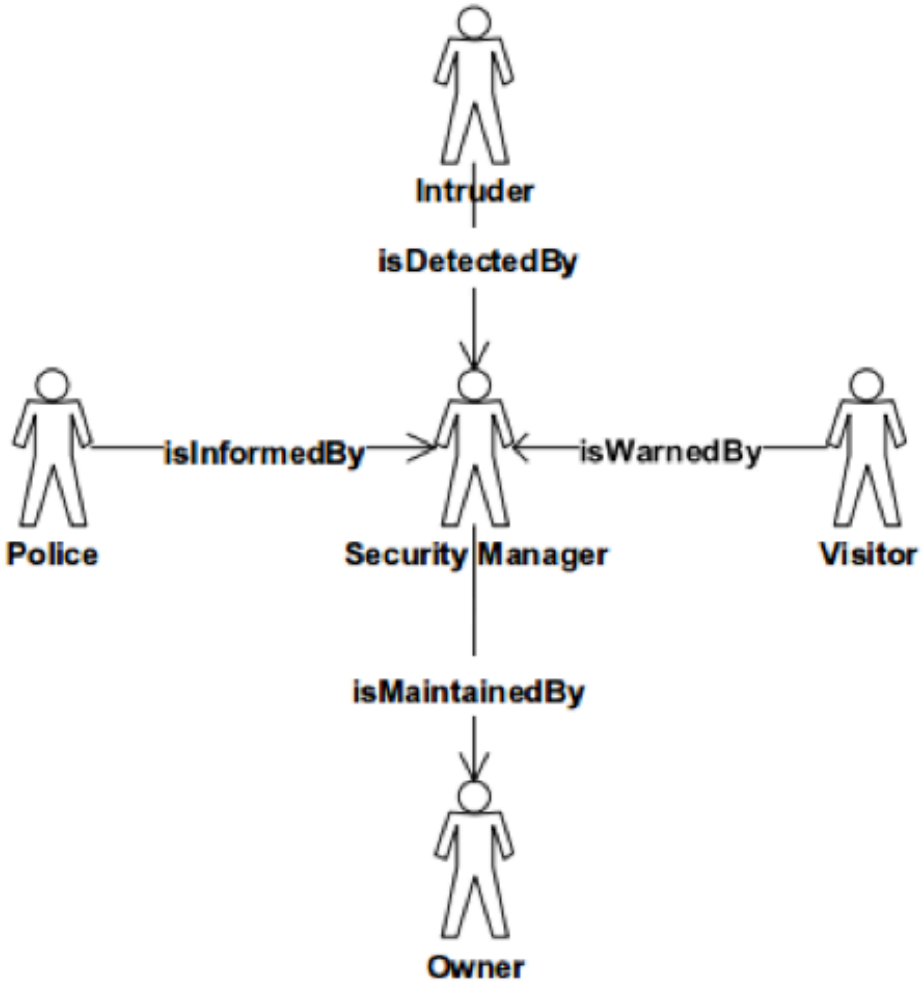
The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	Role models and **organization model**	Environment model and domain knowledge model	Goal models and motivational scenarios
Design	Agent models, acquaintance model, and interaction models	Agent knowledge model	Scenarios and agent behavior models
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

The organization model

- The model that represents relationships between the roles of the socio-technical system
- There can be different types of organizational relationships:
  - Is controlled by
    - Between a „boss“ and his subordinates
  - Is benevolent to
    - Between self interested roles
  - Is peer to
    - Between equal roles
  - Is dependent for resource
  - …

Intruder detection system: Organization model



Part V

MODELLING KNOWLEDGE OF THE SYSTEM

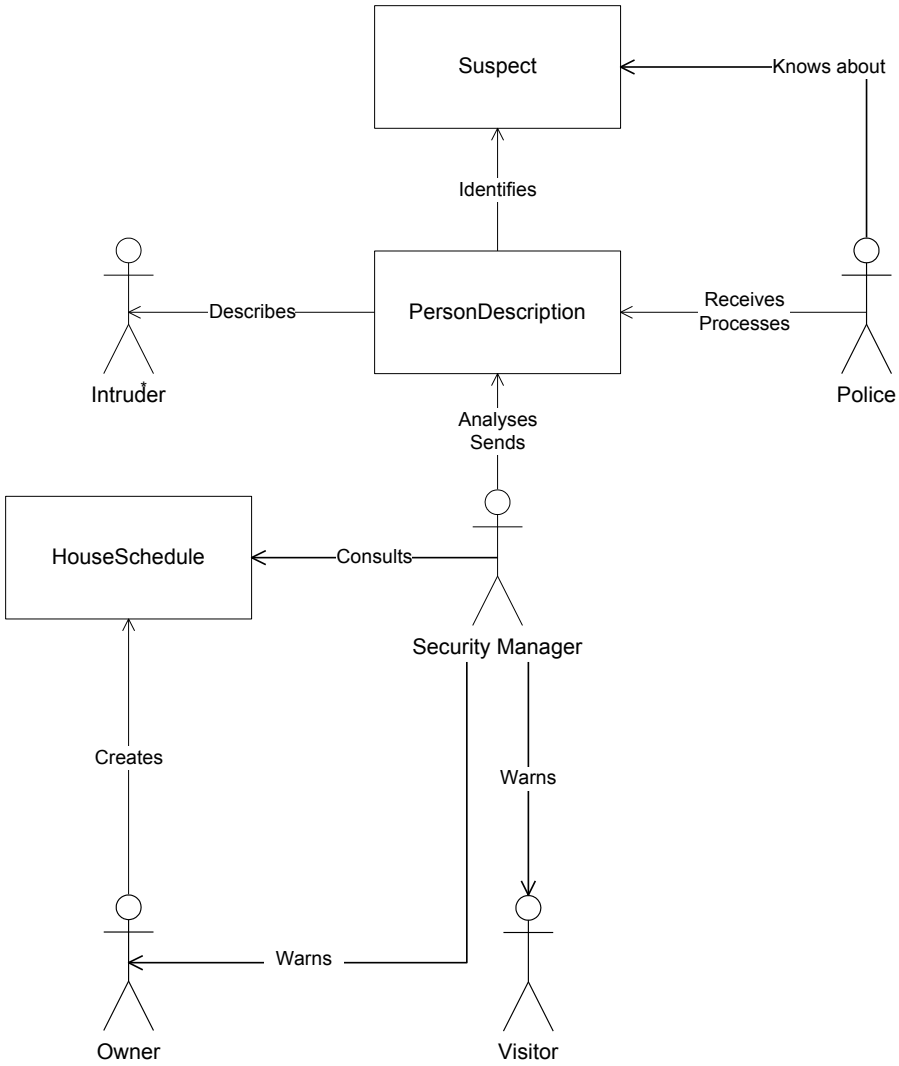
The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	Role models and organization model	Environment model and **domain knowledge model**	Goal models and motivational scenarios
Design	Agent models, acquaintance model, and interaction models	Agent knowledge model	Scenarios and agent behavior models
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

Domain knowledge model

- Domain knowledge model shows the knowledge to be represented within the system
- Domain knowledge model consists of domain knowledge entities, and relationships between them. Domain knowledge model also relates domain knowledge entities to roles

Intruder detection system: Domain knowledge model



Part VI

DECIDING SOFTWARE COMPONENTS

The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	Role models and organization model	Environment model and domain knowledge model	Goal models
Design	**Agent models**, acquaintance model, and interaction models	Agent knowledge model	Scenarios and agent behavior models
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

Agents

- We now need to decide the types of components – agents – of the sociotechnical system
- Why agents?
  - Proactivity
  - Reactivity
  - Social nature

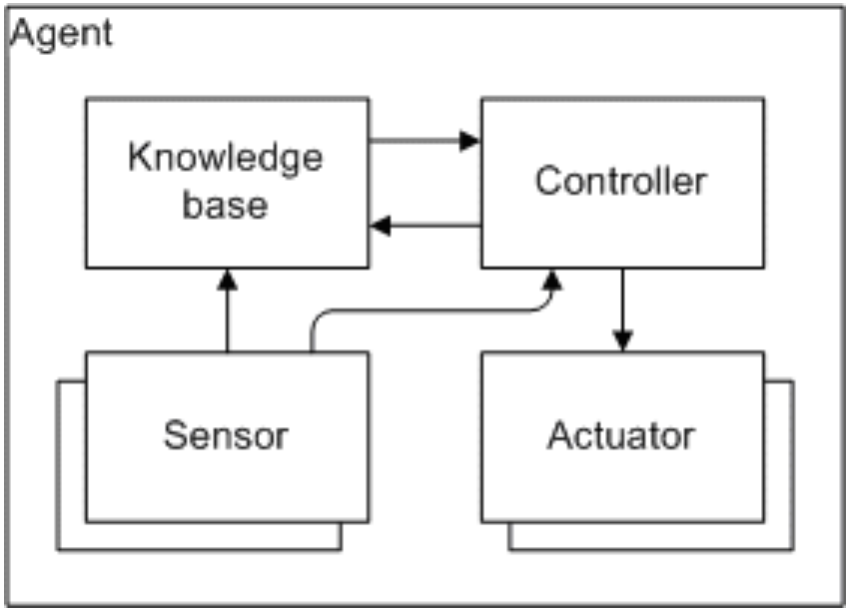
What is agent?

- 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

Agent

- Agent is an entity that perceives and affects its environment and performs reasoning
- Agent is:
  - reactive;
  - proactive;
  - social.
- Agent interacts in an asynchronous way

The abstract agent architecture



The execution loop of an abstract agent

while *the agent is unfulfilled* ***do***
sense the environment;
update the knowledge base;
reason;
choose actions;
act;
end while

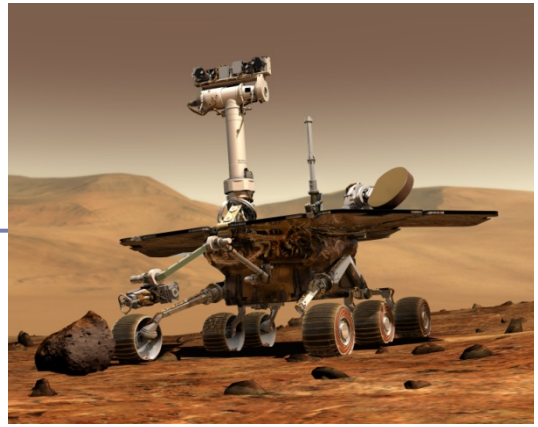
What is intelligent agent?

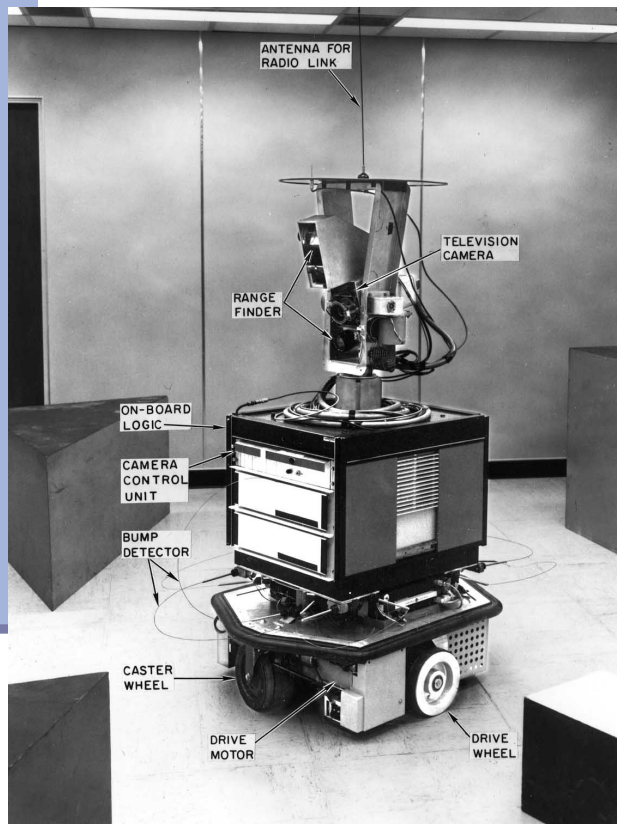
- An agent that is reactive, proactive, and social
- Examples

Anthropomorphic qualities

- Beliefs
- Responsibilities
- Expectations
- Capabilities
- Goals
- Desires
- Intentions

Example agents

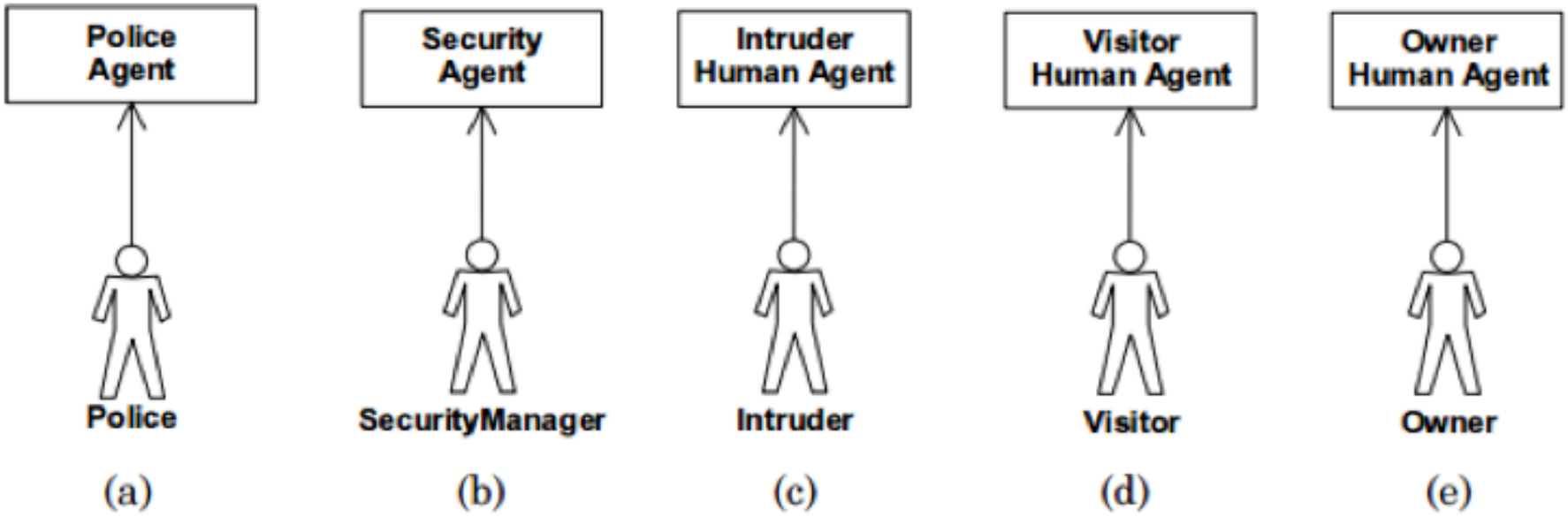




Agent model

- The purpose of an agent model is to map roles to agents of specific types

Intruder detection system: Agent model



Part III

MODELLING „WHO GOES WITH WHOM?“

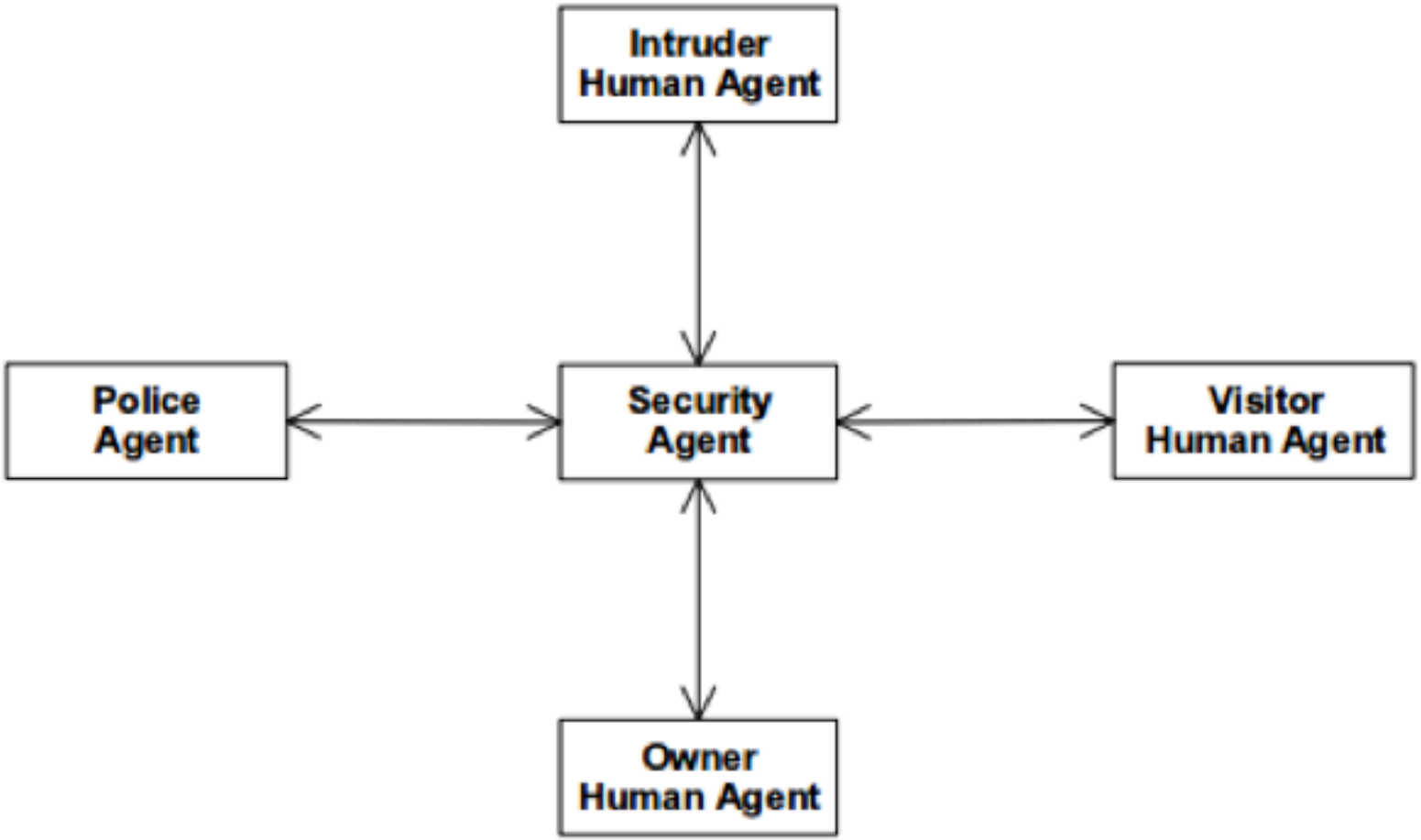
The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	Role models and organization model	Environment model and domain knowledge model	Goal models
Design	Agent models, **acquaintance model**, and interaction models	Agent knowledge model	Scenarios and agent behavior models
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

Acquaintance model

- The acquaintance model complements the agent model by outlining interaction pathways between the agents of the system

Intruder detection system: Acquaintance model



Part III

MODELLING AGENT INTERACTIONS

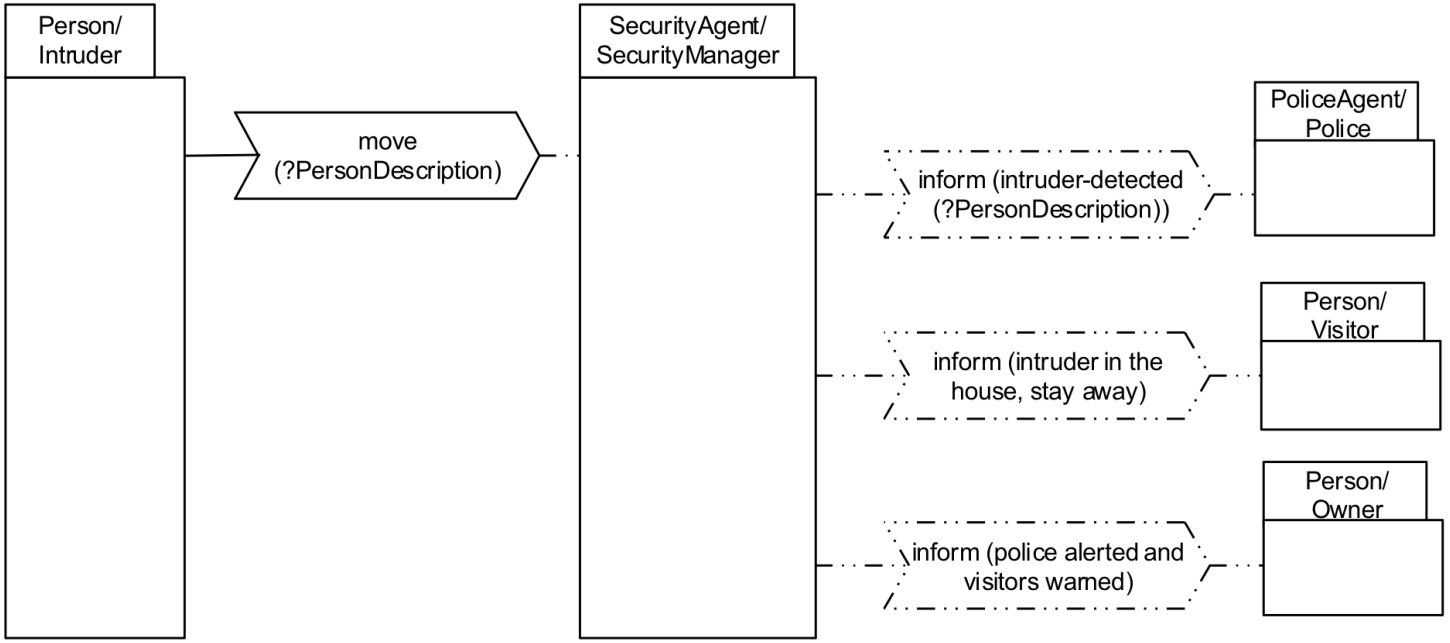
The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	Role models and organization model	Environment model and domain knowledge model	Goal models
Design	Agent models, acquaintance model, and **interaction models**	Agent knowledge model	Scenarios and agent behavior models
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

Interaction model

- Represents an interaction pattern between agents
- Is based on responsibilities defined for the corresponding roles

Intruder detection system: Interaction frame diagram



Part III

MODELLING THE KNOWLEDGE BY AGENTS

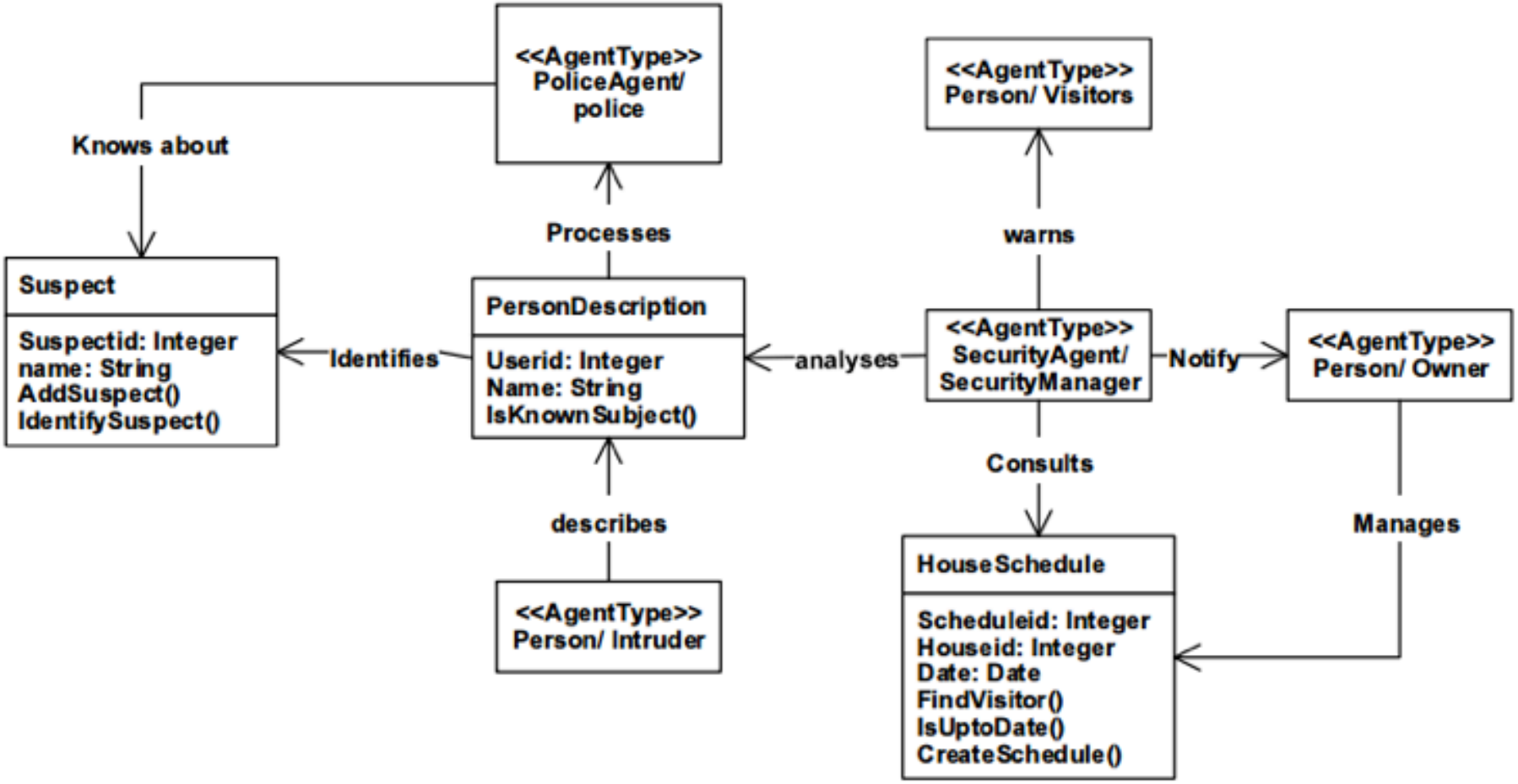
The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	Role models and organization model	Environment model and domain knowledge model	Goal models
Design	Agent models, acquaintance model, and interaction models	**Agent knowledge model**	Scenarios and agent behavior models
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

Agent knowledge model

- Elaboration of the domain knowledge model
- Represents the knowledge that agents have about their environments and about themselves
- Can be viewed as an ontology providing a framework of knowledge for the agents of the problem domain

Intruder detection system: Agent knowledge model



Part III

BEHAVIOUR MODELLING

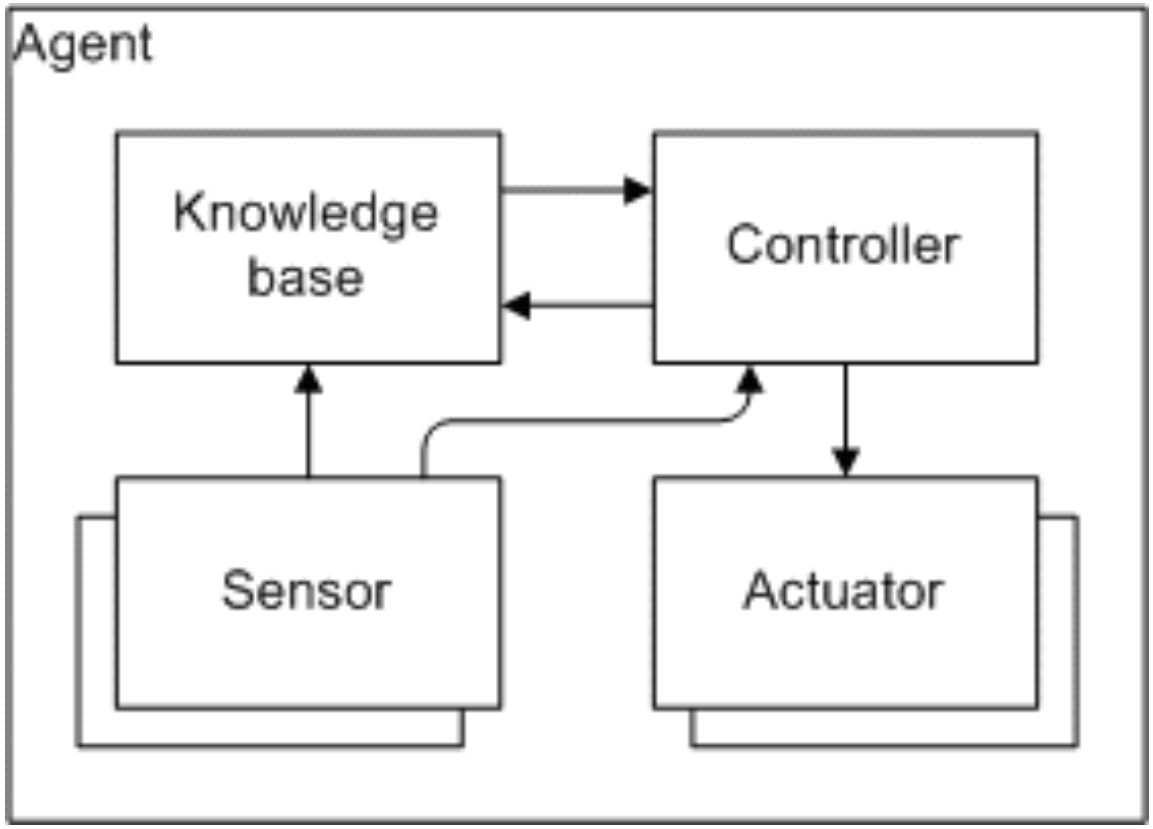
The Viewpoint Framework

	Viewpoint aspect		
Abstraction layer	Interaction	Information	Behavior
Analysis	Role models and organization model	Environment model and domain knowledge model	Goal models
Design	Agent models, acquaintance model, and interaction models	Knowledge model	Scenarios and **agent behavior models**
Prototyping	Interaction prototyping	Information prototyping	Behavior prototyping

Agent behaviour model

- Agent behaviour model addresses what an individual agent does

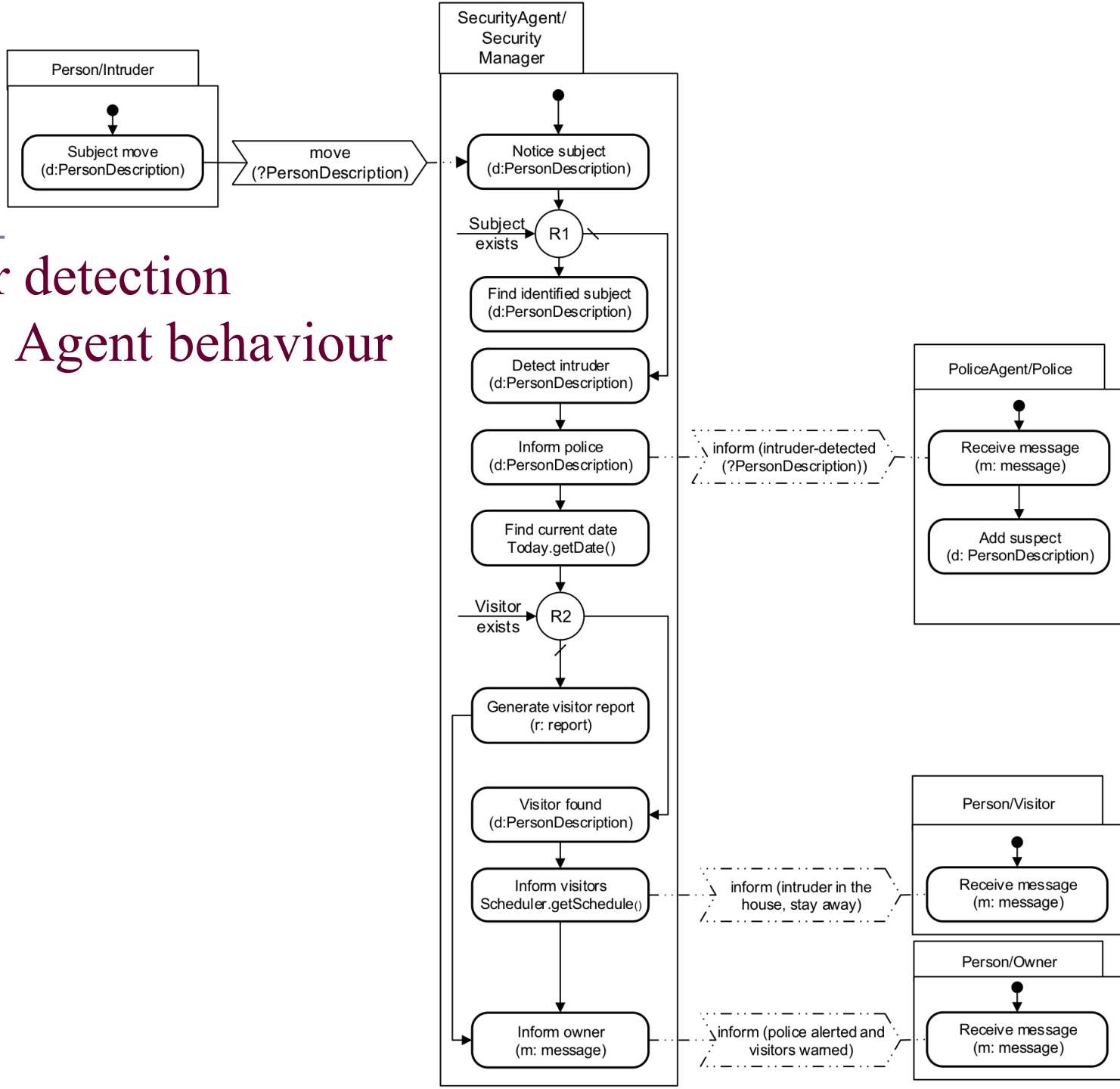
The abstract agent architecture revisited



The execution loop of an abstract agent

while *the agent is unfulfilled* ***do***
sense the environment;
update the knowledge base;
reason;
choose actions;
act;
end while

Intruder detection system: Agent behaviour model

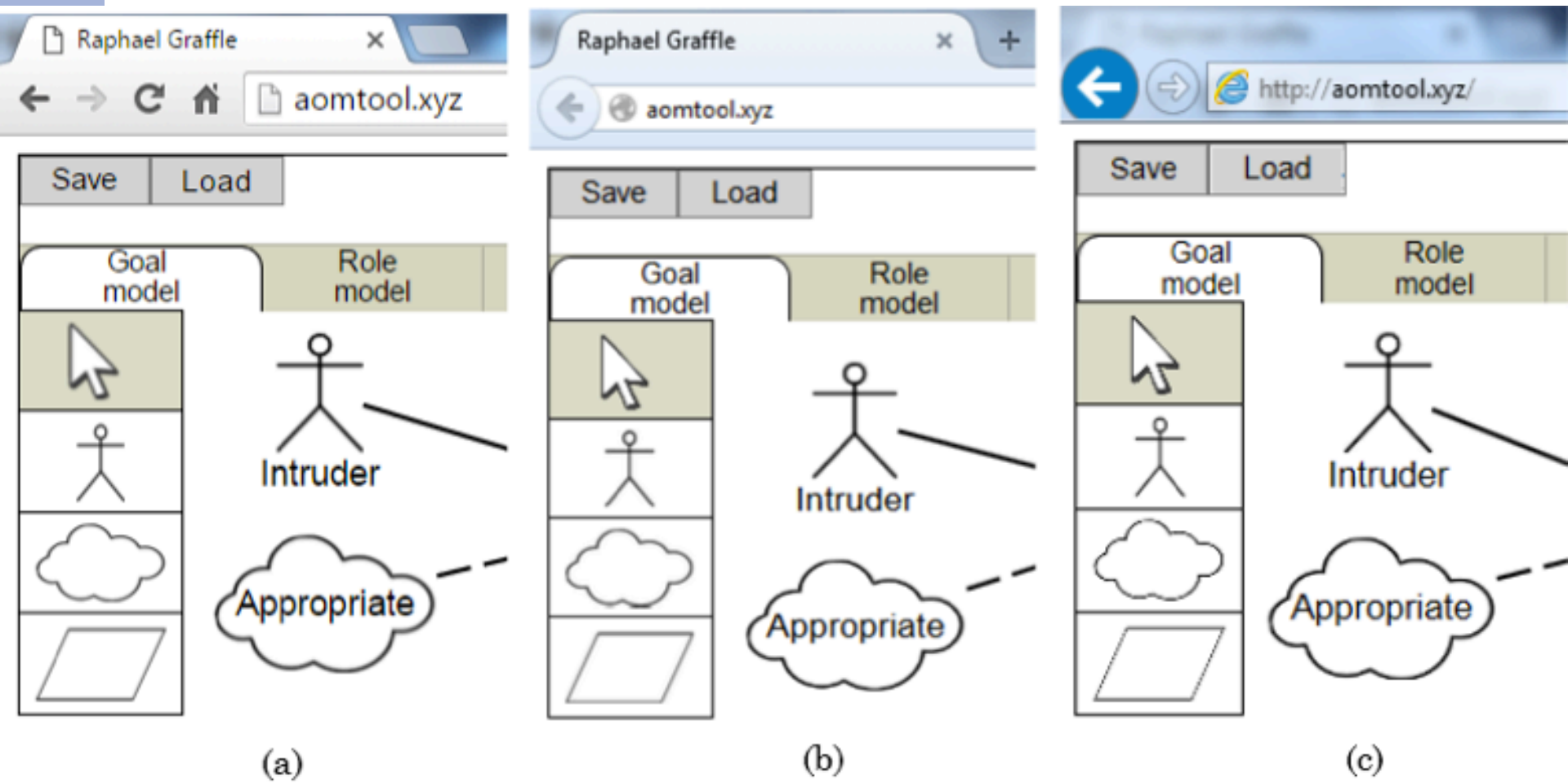


Fast prototyping

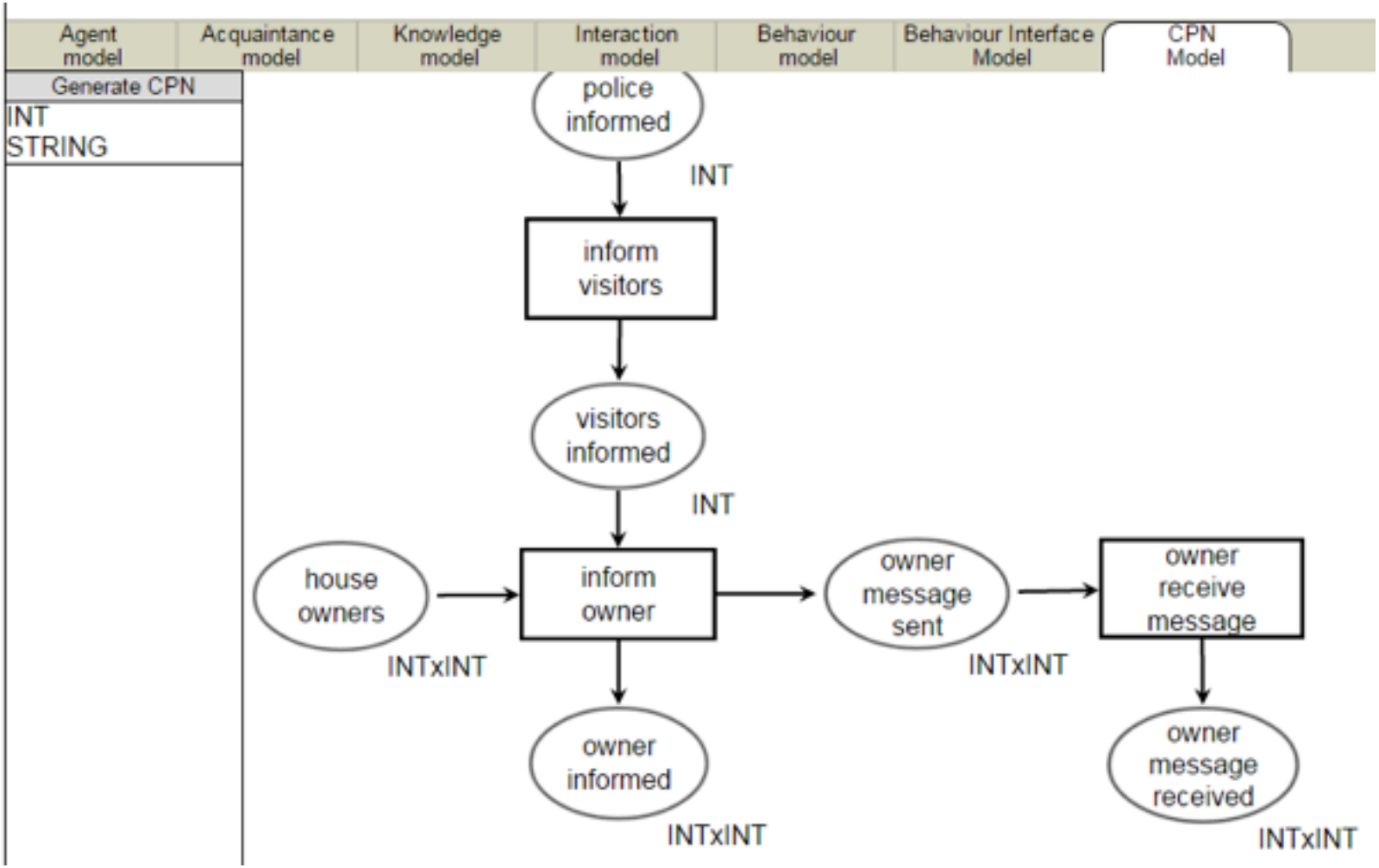
Intruder detection system: behavioural interface model

SNo	Pre-Condition(s)	Activity Name	Post-Condition(s)
1	Subject exist	Move	Subject moved
2	Subject moved Security agent exist	Notice	Subject noticed
3	Person Details DB	Find identified subject	Person Details DB Known subject
4	Subject noticed	Detect intruder	Intruder detected
5	Intruder detected	Inform police	Police msg sent Police informed
6	Police msg sent	Police receive msg	Received police msg
7	Police msg received	Add suspect	Suspect added
8	Police informed Dates	Find current date	Dates Current date
9	Current date	Generate visitor report	Visitor handled Generated report
10	Current date	Find visitor	Found visitor
11	Found visitor	Warn visitor	Visitor handled Visitor msg sent
12	Visitor msg sent	Visitor receive msg	Received visitor msg
13	Visitor informed House owner exist	Inform owner	Owner informed Owner msg sent
14	Owner msg sent	Owner receive msg	Received owner msg

AOM4STS web-based tool



Generation of CPN models for fast prototyping



Thank you! ☺ Any questions?