1. Requirements Analysis of Intruder Detection System (IDS)
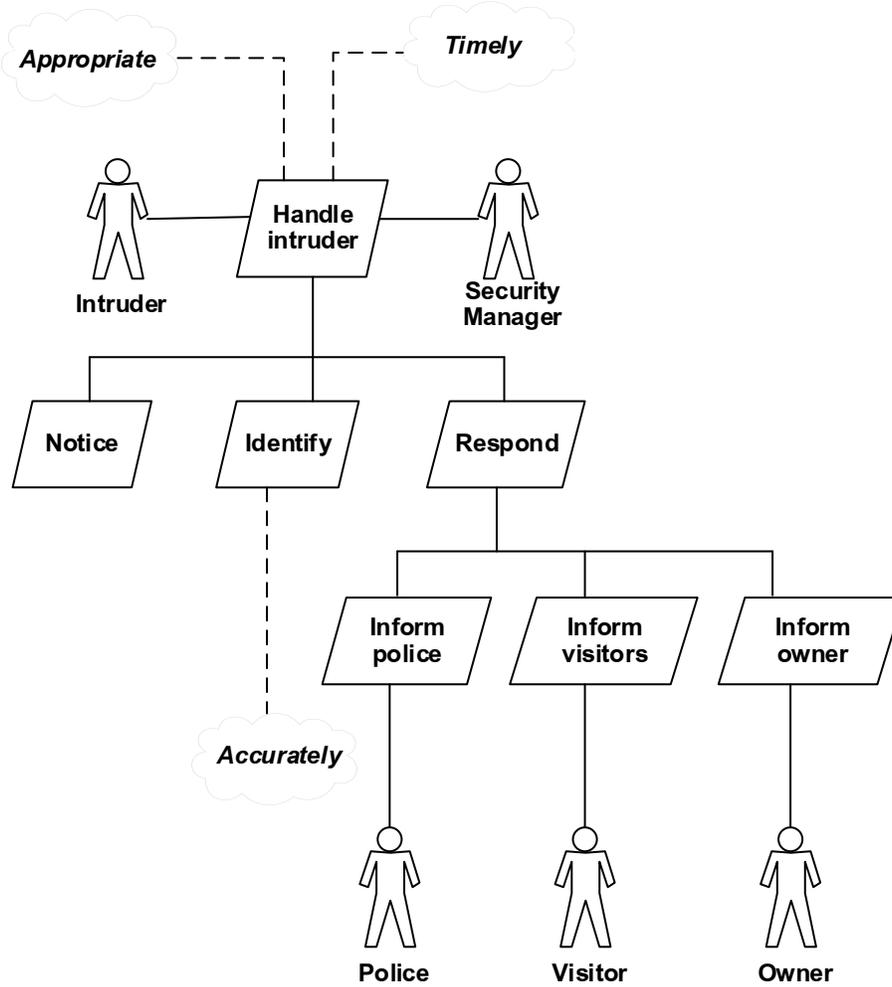
Figure 1: Main goal model of IDS

Table 1: The role Security Manager of intruder detection system

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.

Table 2: The Visitor visits the owner

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.

Table 3: The Owner owns the home

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.

Table 4: An institutional role for keeping law and order.

| 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.
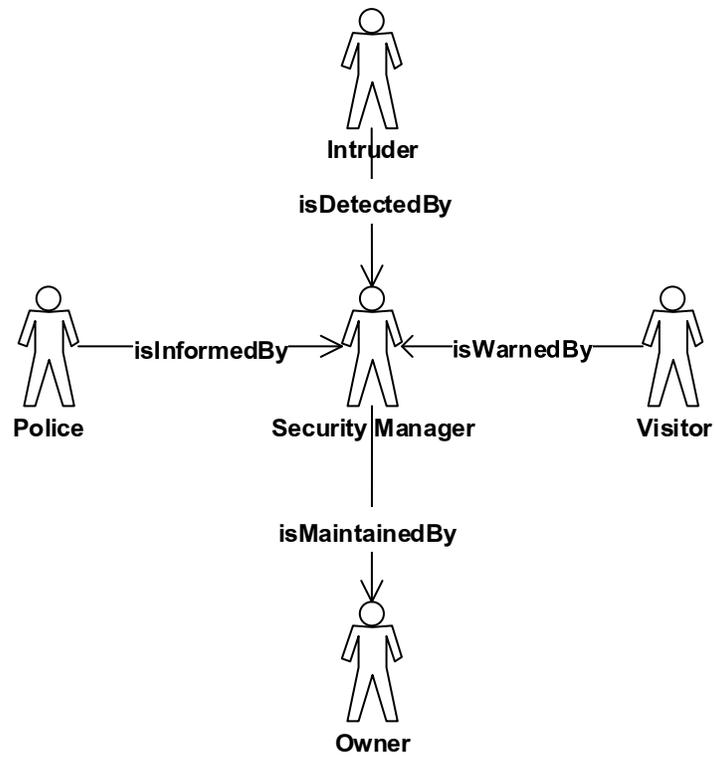
Figure 2: Organizational model of Intruder Detection System
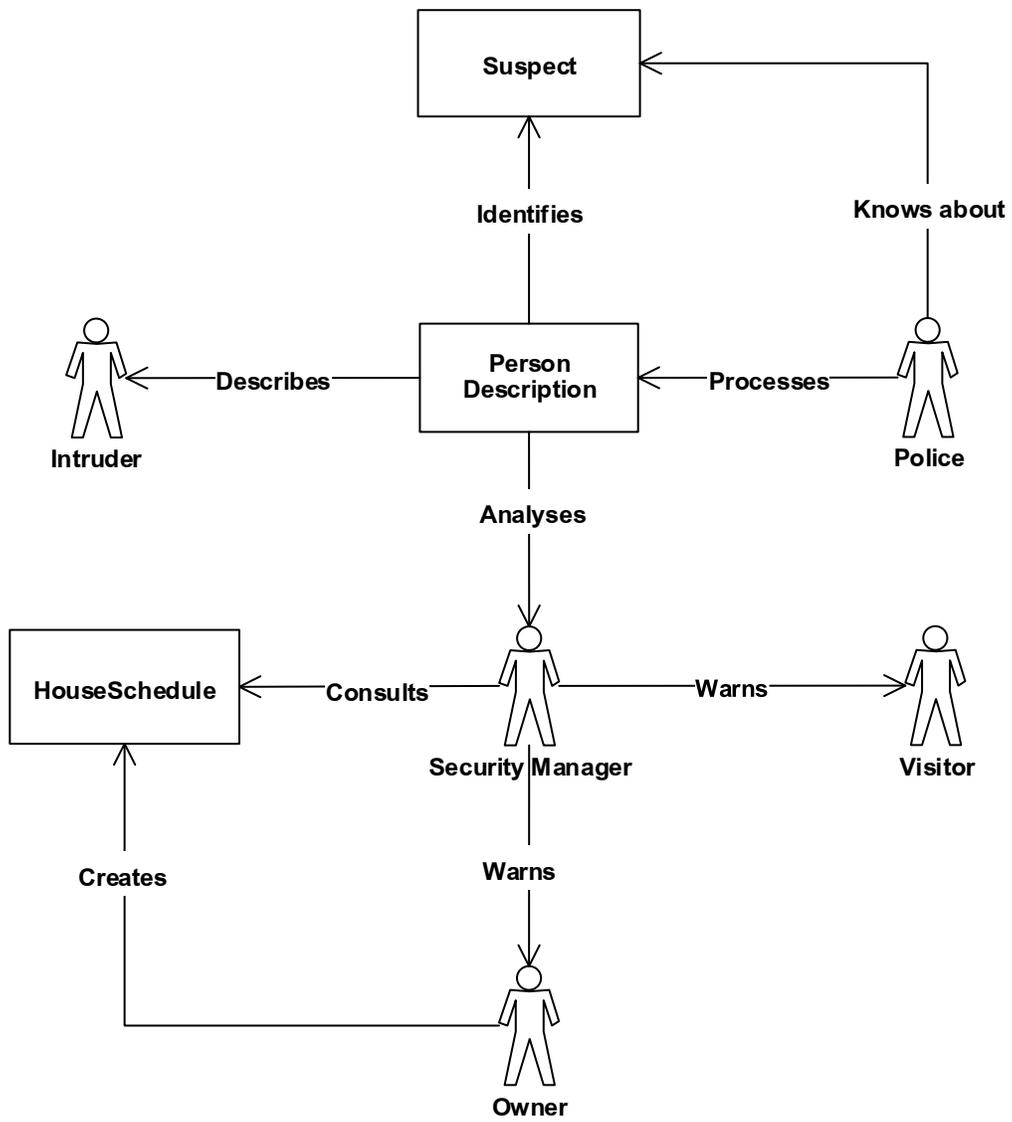
Figure 3: Domain model of Intruder Detetction System

2. Conceptual Design Models of Intruder Detection System (IDS)
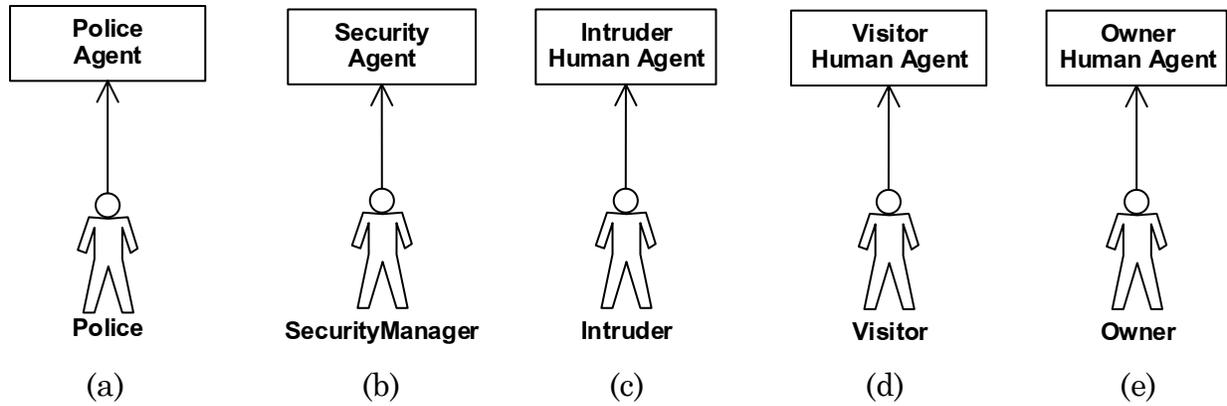

Figure 4: (a) Police agent model, (b) Security agent model (c) Intruder human agent model (d) Visitor human agent model and (e) Owner human agent of the Intruder Detection System
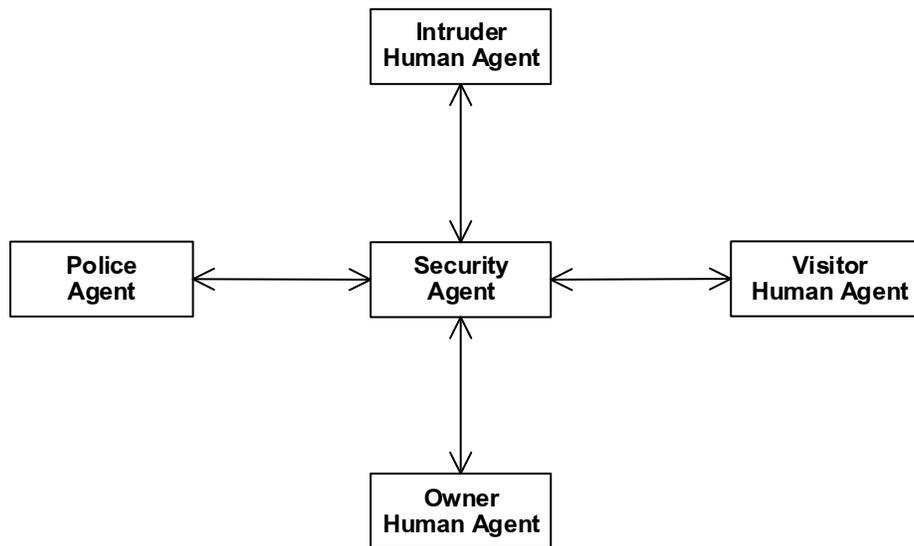
Figure 5: Acquaintance model of the Intruder Detection System
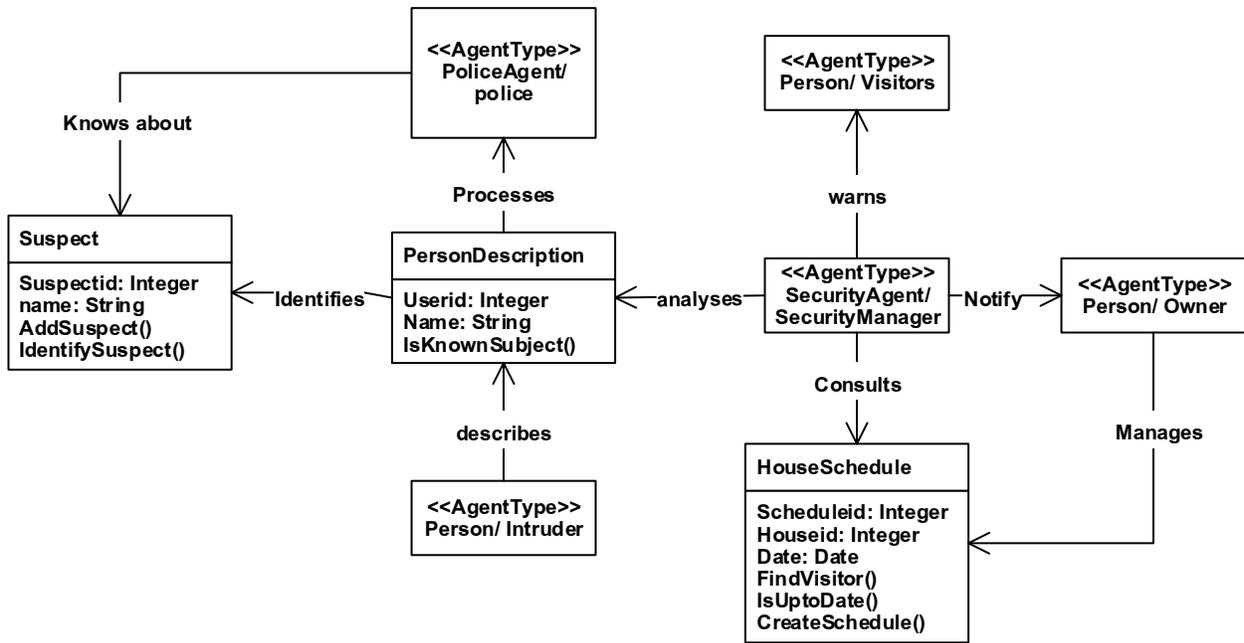
Figure 6: Knowledge model of the Intruder Detection System
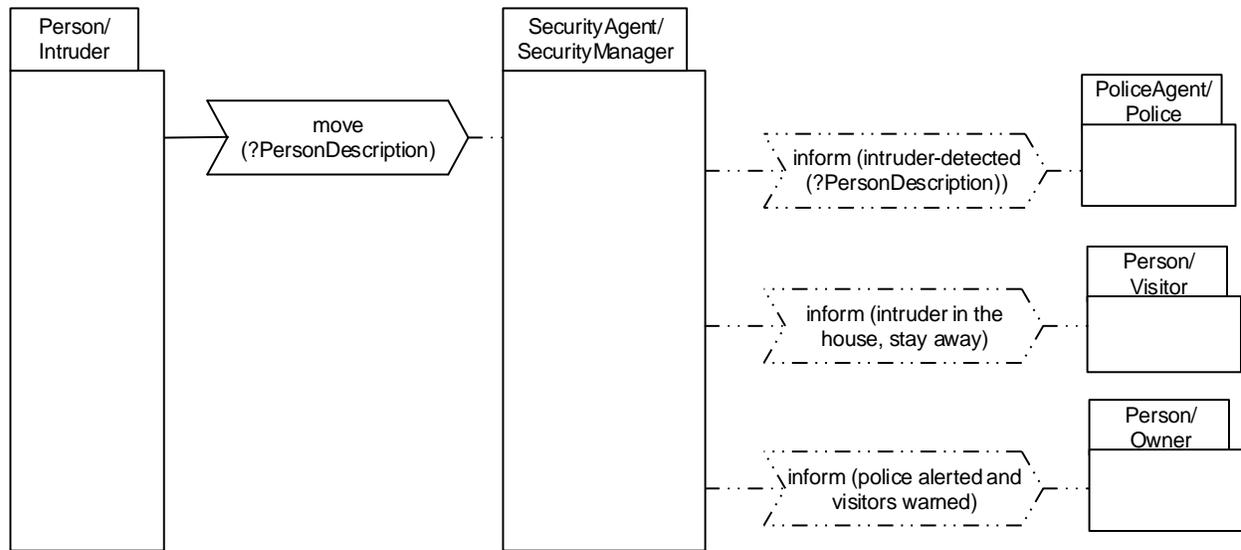
Figure 7: Interaction Frame Diagram of the Intruder Detection System
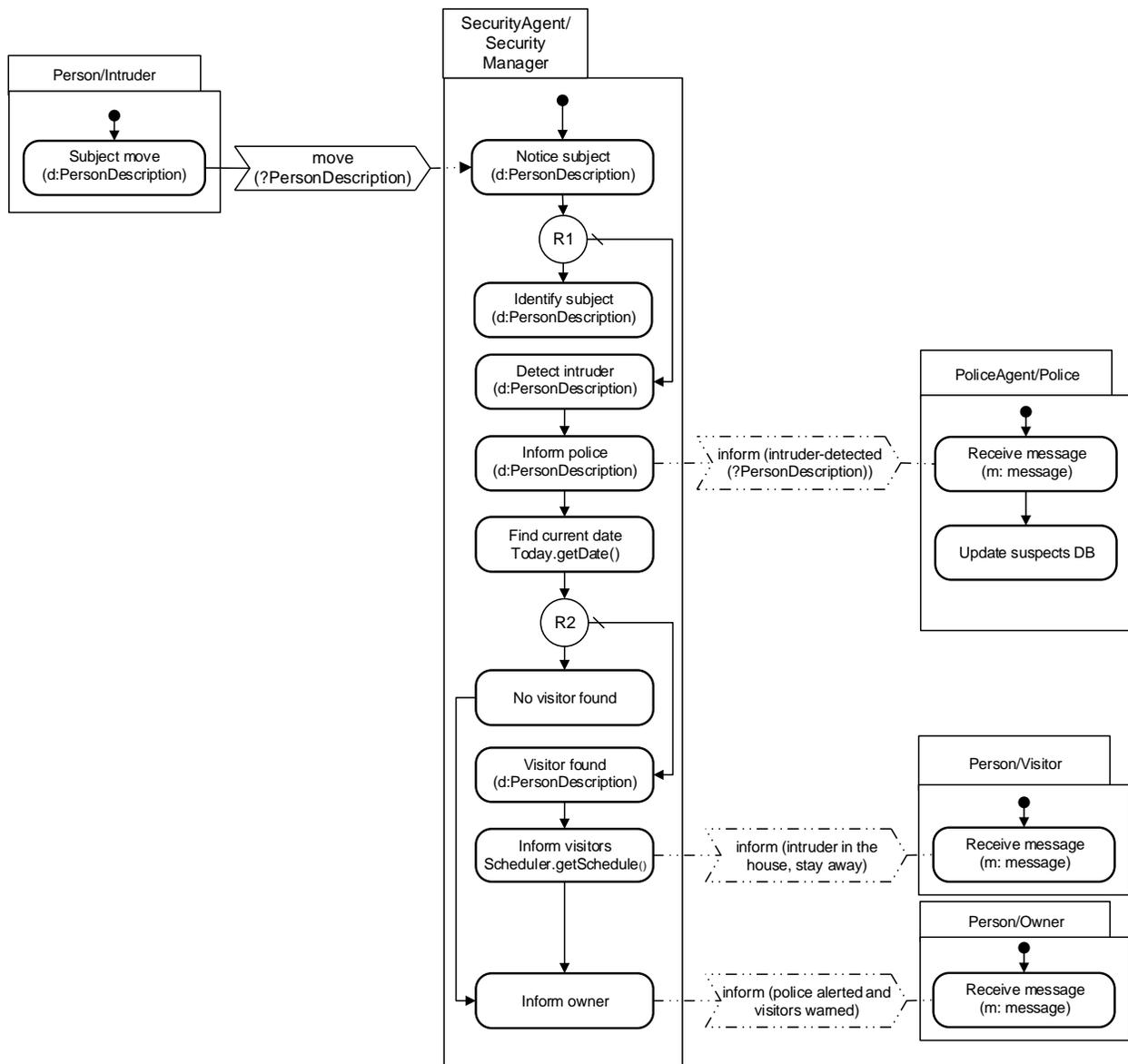
Figure 8: Behaviour Model of the Intruder Detection System

Table 5: Behavioral Interface Model of the Intruder Detection System

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	Identify subject	Person Details DB Subject known
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	Update suspect DB	Suspect added
8	Police informed Dates	Find current date	Dates Current date
9	Current date	Give no visitor alert	Visitor informed
10	Current date	Find visitor	Found visitor
11	Found visitor	Warn visitor	Visitor informed 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

3. Analysis Results of IDS in CPN Tools
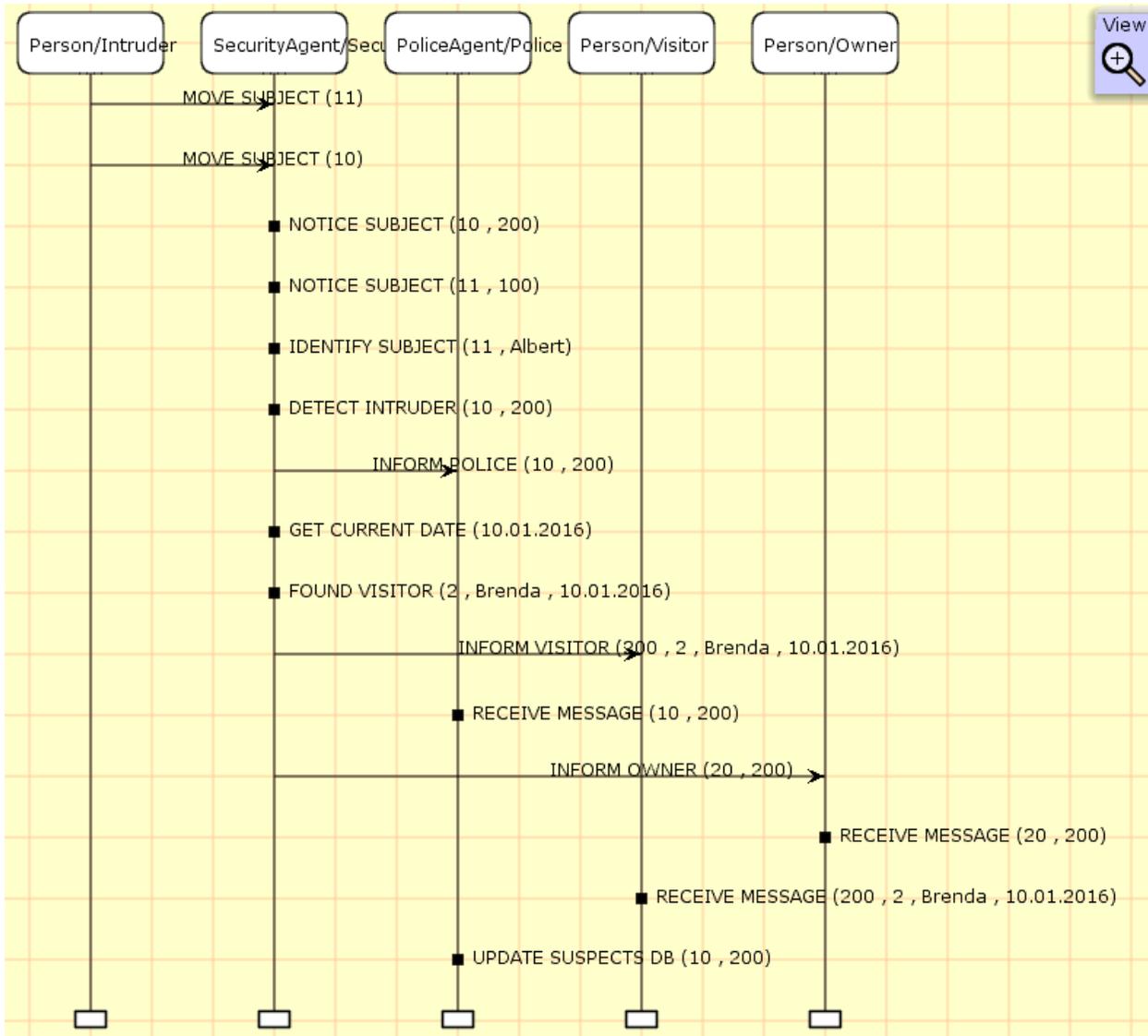
Figure 9: Sample Screenshot of IDS in CPN Tools

1`10++
1`11

move

subject
INT

input (sid);
action
move_subject(sid);

sid

sid

subject
moved
INT

sid

Notice

hid

security
agent
INT

1`(100)++
1`(200)

input (sid,hid);
action
notice_subject(sid,hid);

(sid,hid)

subject
noticed
INTxINT

suspects
updated
INTxINT

update
suspects DB

(sid,hid)

input (sid,hid);
output ();
action
update_suspects_db(sid,hid);

(sid,hid)

msg
received
INTxINT

(sid,hid)

1`(11,"Albert")++
1`(22,"Beata")

(sid,hid)

person
details
INTxSTRING

(pid,pn)

Identify
Intruder
Identify Intruder

(pid,pn)

known
subject
INTxSTRING

(sid,hid)

intruder
detected
INTxINT

(sid,hid)

inform
police

(sid,hid)

police
msg sent
INTxINT

(sid,hid)

police
receive
msg

input (sid,hid);
output ();
action
inform_police(sid,hid);

input (sid,hid);
output ();
action
police_receive_msg(sid,hid);

hid

police
informed
INT

hid

1`(1,"Andrew","11.01.2016")++
1`(2,"Brenda","12.01.2016")

visitors
INTxSTRINGxSTRING

(vid,vn,vd)

Inform
visitors
Get Visitors

(hid,vid,vn,vd)

visitors
msg sent
INTxINTxSTRINGxSTRING

(hid,vid,vn,vd)

visitors
receive
msg

input (hid,vid,vn,vd);
output ();
action
visitor_receive_msg(hid,vid,vn,vd);

(hid,vid,vn,vd)

visitors
msgs
INTxINTxSTRINGxSTRING

hid

visitors
informed
INT

hid

1`(10,100)++
1`(20,200)

house
owners
INTxINT

(oid,hid)

inform
owner

(oid,hid)

Owner
msg sent
INTxINT

(oid,hid)

owner
receive
msg

input (oid,hid);
output ();
action
inform_owner(oid,hid);

input (oid,hid);
output ();
action
owner_receive_msg(oid,hid);

(oid,hid)

(oid,hid)

owner
informed
INTxINT

owners
msgs
INTxINT

Figure 10: A representation of IDS Case Study in CPN Tools

Figure 11: Inform Visitors Module of IDS in CPN Tools
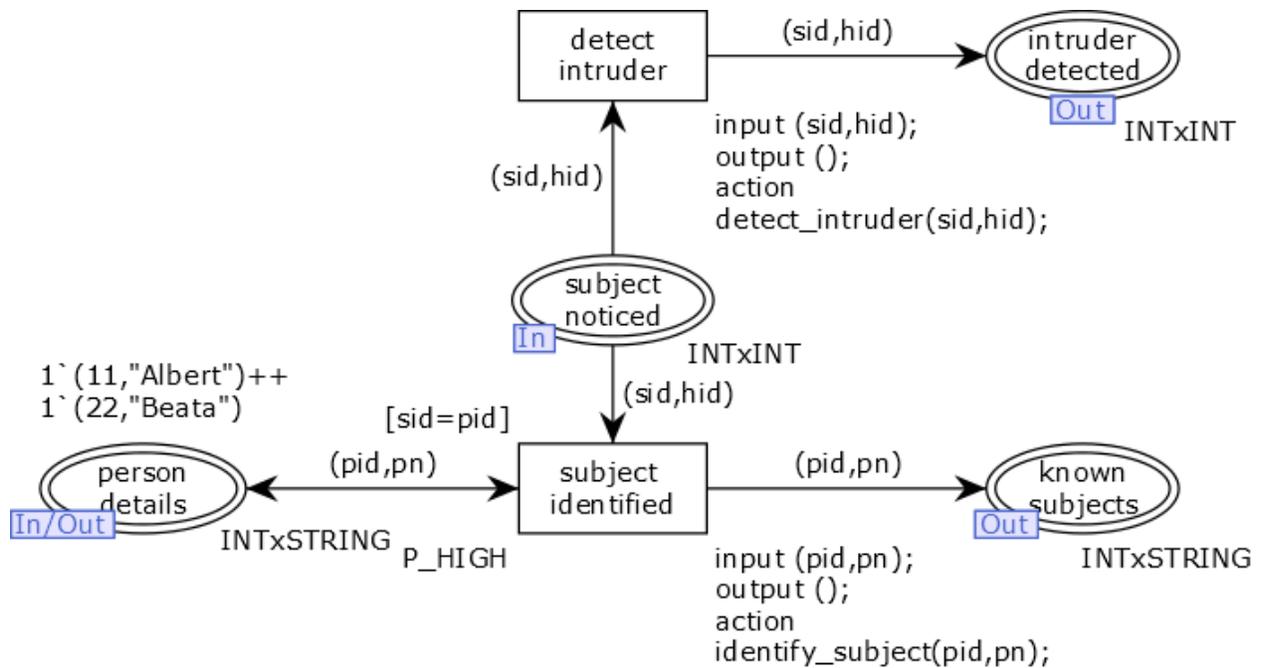
Figure 12: Identify Intruder Module of IDS in CPN Tools

4. Validation Results of Intruder Detection System

IDS Scenario 1

Sno.	Place Name	Initial token(s)	Final token(s)
1	Subject	(10), (11)	(10)
2	Security agent	(100), (200)	(200)
3	Person details	(11,"Albert"), (12,"beata")	(11,"Albert"), (12,"beata")
4	Known subject	—	(11,"Albert")
5	Suspects updated	—	—
6	Dates	("10.01.2016"), ("11.01.2016")	("10.01.2016"), ("11.01.2016")
7	Visitors	(1,"Andrew","11.01.2016), (2,"Brenda","12.01.2016)	(1,"Andrew","11.01.2016), (2,"Brenda","12.01.2016)
8	Visitors msg	—	—

9	House owners	(1000,100), (2000,200)	(10,100), (20,200)
10	Owners msg	—	—
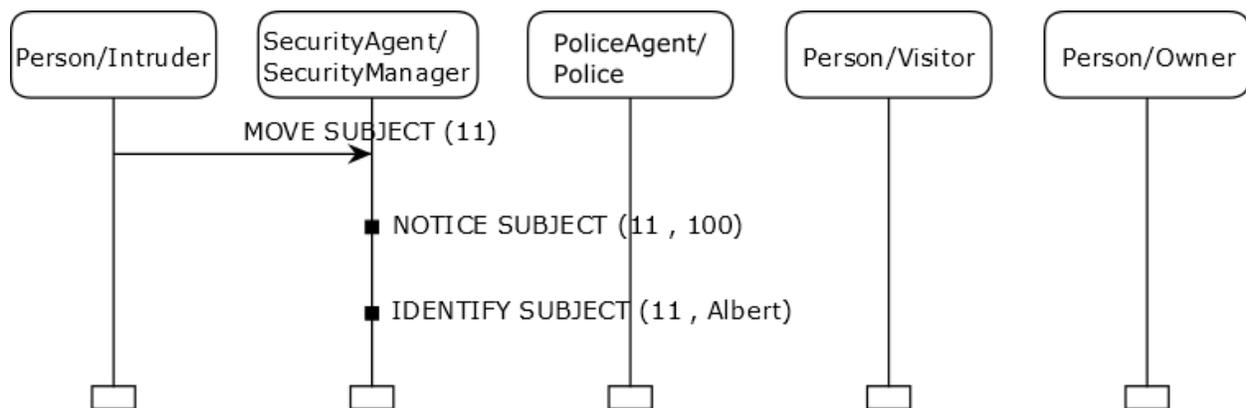
IDS Scenario 2

Sno.	Place Name	Initial token(s)	Final token(s)
1	Subject	(10), (11)	(11)
2	Security agent	(100), (200)	(100)
3	Person details	(11,"Albert"), (12,"beata")	(11,"Albert"), (12,"beata")
4	Known subject	—	—
5	Suspects updated	—	(10,200)

6	Dates	("10.01.2016"), ("11.01.2016")	("10,01.2016")
7	Visitors	(1,"Andrew","11.01.2016), (2,"Brenda","12.01.2016)	(1,"Andrew","11.01.2016), (2,"Brenda","12.01.2016)
8	Visitors msg	—	(200,1,"Andrew","11.01.2016")
9	House owners	(1000,100), (2000,200)	(1000,100), (2000,200)
10	Owners msg	—	(2000,200)
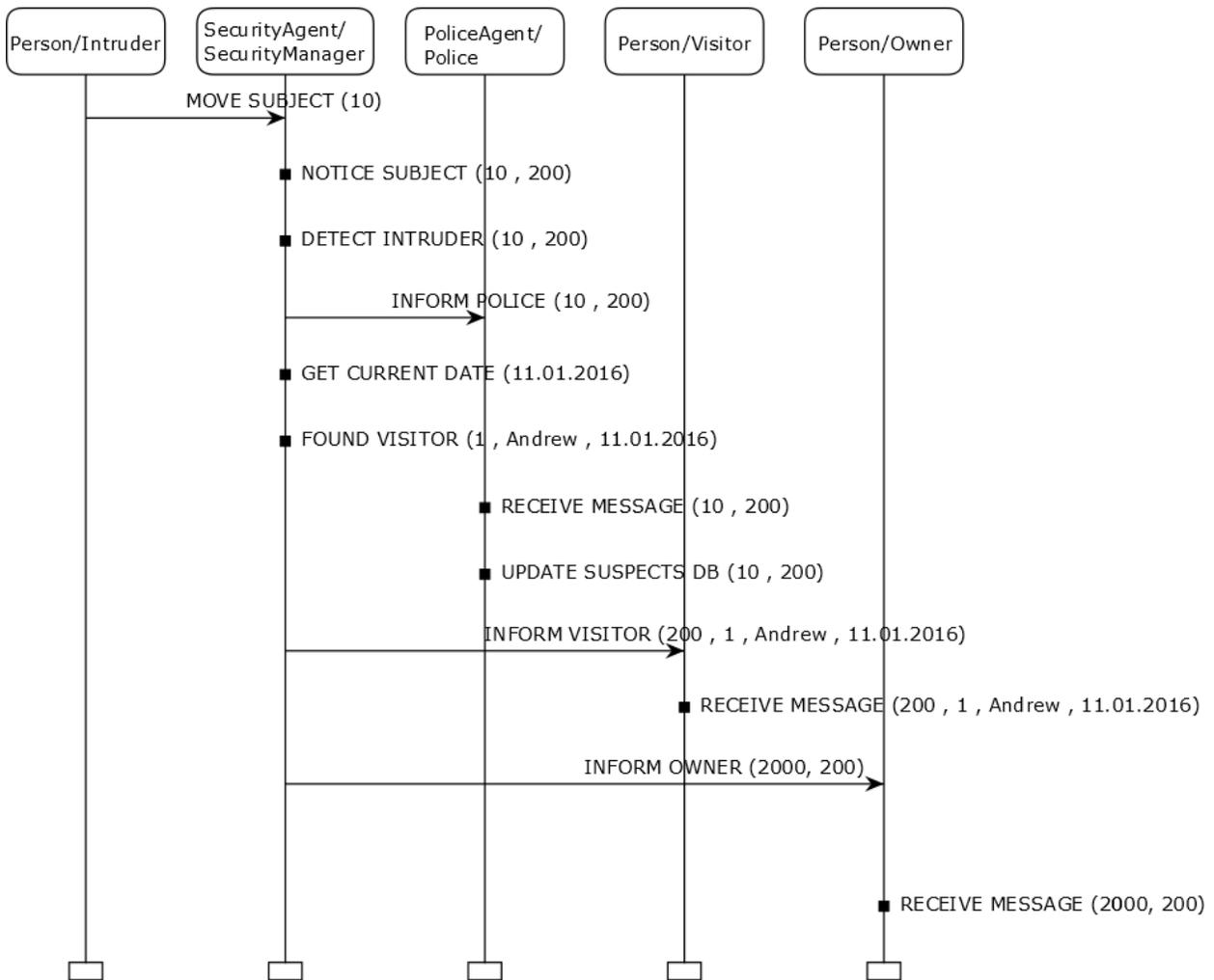
IDS Scenario 3

| Sno.	Place Name	Initial token(s)	Final token(s)
1	Subject	(10), (11)	(11)
2	Security agent	(100), (200)	(200)
3	Person details	(11,"Albert"), (12,"beata")	(11,"Albert"), (12,"beata")
4	Known subject	—	—
5	Suspects updated	—	(10,100)
6	Dates	("10.01.2016"), ("11.01.2016")	("11,01.2016")
7	Visitors	(1,"Andrew","11.01.2016), (2,"Brenda","12.01.2016)	(1,"Andrew","11.01.2016), (2,"Brenda","12.01.2016)
8	Visitors msg	—	—
9	House owners	(1000,100), (2000,200)	(1000,100), (2000,200)
10	Owners msg	—	(1000,100)
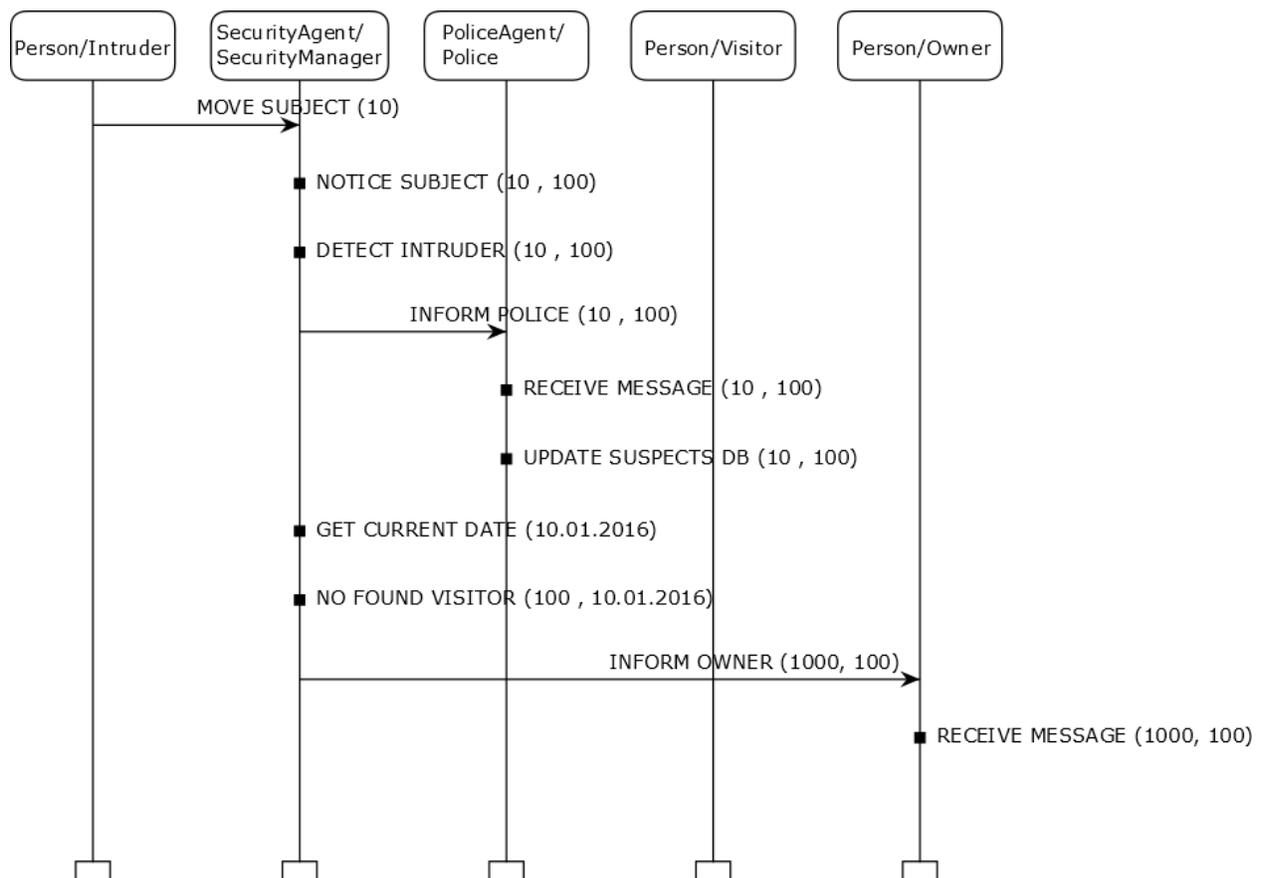
5. Verification Results of Intruder Detection System

Scenario	Subject	Dates
Case 1	(10)	(10.01.2016), (11.01.2016)
Case 2	(11)	(10.01.2016), (11.01.2016)
Case 3	(10,11)	(10.01.2016), (11.01.2016)
Case 4	(10,11)	(10.01.2016)
Case 5	(10,11)	(11.01.2016)

SS Analysis Case 1

```
Home Properties
-----------------------------------------------------------------------

  Home Markings
     None


 Liveness Properties
-----------------------------------------------------------------------

  Dead Markings
     [65,71,83,84]

  Dead Transition Instances
```

```
      Identify_Intruder'subject_identified 1

  Live Transition Instances
     None


 Fairness Properties
-------------------------------------------------------------------------
     No infinite occurrence sequences.
```

SS Analysis Report Case 2

```
Home Properties
-------------------------------------------------------------------------

  Home Markings
     None


 Liveness Properties
-------------------------------------------------------------------------

  Dead Markings
     [65,71,83,84]

  Dead Transition Instances
     Identify_Intruder'subject_identified 1

  Live Transition Instances
     None


 Fairness Properties
-------------------------------------------------------------------------
     No infinite occurrence sequences.
```

SS Analysis Report Case 3

```
Home Properties
-------------------------------------------------------------------------

  Home Markings
     None


 Liveness Properties
-------------------------------------------------------------------------

  Dead Markings
     [305,320,333,334]
```

```
   Dead Transition Instances
      None

   Live Transition Instances
      None


 Fairness Properties
 ------------------------------------------------------------------------
      No infinite occurrence sequences.
```

SS Analysis Report Case 4

```
Home Properties
 ------------------------------------------------------------------------

   Home Markings
      None


 Liveness Properties
 ------------------------------------------------------------------------

   Dead Markings
      [147,148]

   Dead Transition Instances
      Get_Visitors'visitor_found 1
      Get_Visitors'warn_visitors 1
      New_Page'visitors_receive_msg 1

   Live Transition Instances
      None


 Fairness Properties
 ------------------------------------------------------------------------
      No infinite occurrence sequences.
```

SS Analysis Report Case 5

```
Home Properties
 ------------------------------------------------------------------------

   Home Markings
      None


 Liveness Properties
```

  Dead Markings
     [237,238]

  Dead Transition Instances
     Get_Visitors'no_visitor_found 1

  Live Transition Instances
     None

 Fairness Properties

     No infinite occurrence sequences.