CHAPTER 3

AGENT ORIENTED FRAMEWORK

3.1 PRIMARY COMPONENTS OF AOP SYSTEM

1. **Formal Language:** A restricted formal language with strict semantics and syntax which will describe the mental state of the agent in terms of beliefs, commitments etc.

2. **A interpreted programming language:** A language in which one can define and program agents. The semantics comply with the semantics of formal language. This has basic constructs like INFORM, REQUEST etc.

3. **Agentifier:** This converts neutral devices into programmable agents

3.2 COMPONENTS OF MENTAL STATE

At any point of time, the future is determined by two factors: the past history and the current actions of the agent. Actions of the agent are determined by its decision or choice. Decisions are logically constrained by agent’s beliefs. These beliefs refer to:

- State of the world in past, present and future
- Mental state of the other agent
- Capabilities of this and other agents
Decisions are also constrained by past decisions. e.g. Agent can not decide to be in room 5 if he has already decided to be in room 3 at the same time.

Above discussion leads to three basic mental categories namely beliefs, decisions (choice) and capabilities. From this stage onwards we define the notion of obligation or commitments as basic category rather than choice and treat decision as simply obligation to oneself.

3.3 MODALITIES

1. **Time (t)**
   - holding (robot, cup)t
   - Meaning the robot is holding the cup at time t.

2. **Action**
   - Actions take place at different time and depending upon the circumstances at that time it has certain effects. We can represent actions as facts i.e. an action corresponds to a fact holding. For example, rather than saying robot took action raise arm at time t, we say the fact raise arm (robot) t is true. We will not distinguish between action and facts here onwards.

3. **Belief (b)**
   - An agent believes certain things both at certain time and about certain time.

A belief is represented as:

\[ B^t \varphi \]
where $a$ is agent and it believes fact $\phi$ at time $t$. e.g.

$B^3_a \ (\text{water is cold})$

states, at time 3, $a$ believes that at time 7 water will be cold.

4. **Obligation (OBL)**

We define obligation as

$OBL^{t}_{a,b} \phi$

states, at time $t$, agent $a$ is obliged or committed to agent $b$ about $\phi$

5. **Decisions (DEC)**

Agents are free to choose amongst several possible actions. This is the central notion of agenthood. With obligations defined, decisions can be viewed as simply obligations to oneself.

$DEC^{t}_{a} \phi = \text{def} \ OBL^{t}_{a,a} \phi$

states that decision $\phi$ of agent $a$ at time $t$ can be defined as obligation of agent $a$ to itself at time $t$.

6. **Capability (CAN)**

Capability is also an important notion of agenthood. An agent will not take any decision it believes it is not capable of. For example, Agent will not decide to be in room 3 at time $t$, if it is not in its capability to reach there at time $t$. or one agent won’t ask a child agent to climb the ladder as it believes that it is beyond the agents capability to do so.

$CAN^{t}_{a} \phi$

states that at time $t$, agent $a$ is capable of $\phi$
For example,
\[ \text{CAN}^3_a (\text{open(door)})^5 \]
states, at time 3, agent a believes that it is capable of ensuring that at time 5 the door will be open. But at time 4, it might no longer have that capability. Hence we define ABLE to be “immediate” notion of CAN.

\[ \text{ABLE}^t_a \varphi = \text{def} \text{CAN}^{\text{time(}\varphi\text{)}} \varphi \]

where time(\(\varphi\)) is the outermost time. e.g. time(open(\text{door})t) = t

For example,
\[ \text{ABLE}^t_a (\text{open(door)})^5 = \text{CAN}^5_a (\text{open(door)})^5 \]

### 3.4 PROPERTIES OF VARIOUS COMPONENTS

We need to place some constraints on the modalities defined previously so as to ensure resemblance with their real world counterparts. The correspondence will not be exact. Below are the properties of the modalities defined in previous section, which prove sufficient to justify the terminology.

- Internal Consistency
  - Obligations and beliefs are internally consistent. i.e.
    - for any t, a : \(\varphi\) : Bt \(\varphi\) is consistent
    - for any t, a : \(\varphi\) : OBLt \(\varphi\) for some b, is consistent

states that if agent a believes a fact \(\varphi\) at time t then it should not believe any fact \(\pi\) which conflicts with \(\varphi\) at the same time. Similarly if agent a is obliged to have lunch with agent b at time 5 then it should not also be obliged to be at agent c’s place at the same time.
• Good Faith

Agents commit only what they believe they are capable of.

\[
\text{for any } t,a,b,\phi: \text{OB}_a L^t_{b} = B_a^t((\text{ABLE}_a \phi) \land \phi)
\]

states that agent \(a\) is obliged to agent \(b\) about a fact \(\phi\) at time \(t\) only if agent \(a\) believes that at time \(t\) it is capable of \(\phi\) and \(\phi\) is true at time \(t\).

• Introspection We assume that agents are aware of their obligations. for any \(t,a,b,\phi\):

\[
\text{OBL}_a^t \phi \equiv B_a^t \text{OBL}_a^t \phi
\]

\[
\text{for any } t,a,b,\phi: \text{←OBL}_a^t \phi \equiv B_a^t \text{←OBL}_a^t \phi
\]

states that, at time \(t\) if agent \(a\) is obliged to fact \(\phi\) then it is also equivalent of saying that agent \(a\) believes at time \(t\) that it is obliged to fact \(\phi\) at time \(t\). On the other hand, we DO NOT assume that agents are necessarily aware of about commitments made TO them.

• Persistence of mental state

Till now we have put restrictions on the mental modalities only for a instance of time. Consider the case of belief, at one time the agent does not believe anything, then shortly after that it believes all the facts at that time and then again after that time it does not believe anything. This is not how a real world counterpart of belief works. Hence now we need to put a strong constraint that agents have perfect memory and faith in their beliefs and they let go of these beliefs only when they learn a contradictory fact. Hence we can say beliefs persist by default. This also implies that absence of belief persists by default.
Obligations also by default persists, however the persistence is not absolute. There might be conditions under which obligations are revoked. E.g. agent being released by other agents to it was obliged or agent realizing that it can no more fulfill the obligation.

Since decisions are defined in terms of obligation, it inherits the default persistence.

An agent is free to cancel any obligations made, including obligations made towards itself (i.e. decisions) that is, agent is free to modify any existing decision.

- **Introspection** We assume that agents are aware of their obligations. for any $t, a, b, \varphi$: $\text{OBL}_t^a \varphi \equiv \text{B}_t^a \text{OBL}_t^a \varphi$

  for any $t, a, b, \varphi$: $\text{OB}_t^a \varphi \equiv \text{B}_t^a \text{OB}_t^a \varphi$

states that, at time $t$ if agent $a$ is obliged to fact $\varphi$ then it is also equivalent of saying that agent $a$ believes at time $t$ that it is obliged to fact $\varphi$ at time $t$. On the other hand, we DO NOT assume that agents are necessarily aware of about commitments made TO them.

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Also capabilities do not tend to change frequently. Here we assume that capabilities are fixed.