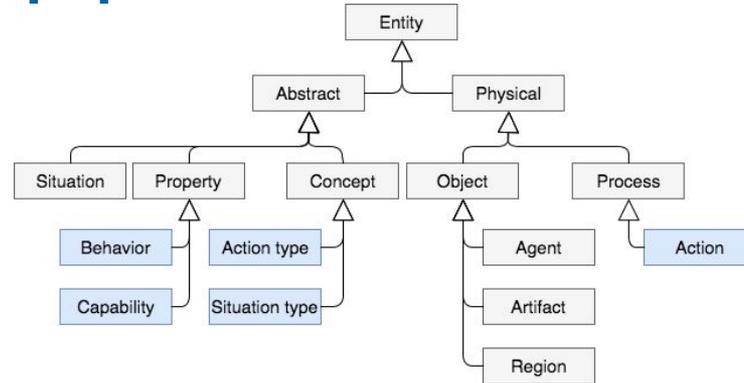# IEEE SA - 1872.2
Standard for Autonomous Robotics (AuR) Ontology

Working group committee:
Paulo Goncalves, Alberto Olivares-Alarcos, Veera Ragavan, Howard Li

Cloud Robotics' paper - Definitions

We focus on three terms: Capability, Behaviour and Action. Of course, all of them are built upon SUMO and CORA.

Definition 1. An action is a process performed by an agent

Definition 2. A capability is a property of an agent that allows it to perform or to participate in a certain type of action

Definition 3. A behavior is a property of an agent that makes it perform certain types of actions when it faces certain types of situations

Cloud Robotics' paper - Definitions: Action

Definition 1. An action is a process performed by an agent

$$\forall x \; Action(x) \rightarrow Process(x) \, \wedge$$

$$(\exists a \; Agent(a) \, \wedge \, performs(a, x))$$

Cloud Robotics' paper - Definitions: Capability

Definition 2. A capability is a property of an agent that allows it to perform or to participate in a certain type of action

[**Stefano**] Capability: an individual quality of an entity to maintain a state or realize some determined change in a given situation.

Stefano says that his definition for Capability is still a weak definition. But still, he provided some notes to be considered.

- ○ [Alberto, gathering Stefano's comments] One important difference between his definition and the one we propose is the use of **'quality'** instead of **'property'** (he proposes to use the first). The best example to see the difference between them is as follows: *let's consider we have an object, if we say that the object is red, 'red' is a property (general characteristic of an object), however, if we say that the object has a red color, 'red' is a quality (individual characteristic of that specific object). In the first case, we talk about the color red in general, while in the second, we talk about the red color which is manifested in the object (e.g. the specific red in the spectrum of 'red colors').* Another concern about the definition proposed in the CR paper is that we do not specified that the agent participates in a process with a specific role.

Cloud Robotics' paper - Definitions: Capability

Definition 2. A capability is a property of an agent that allows it to perform or to participate in a certain type of action

$$\forall c \; Capability(c) \; \rightarrow Property(c) \; \wedge$$
$$\exists a, t \; Agent(a) \; \wedge$$
$$capabilityOf(c, a) \; \wedge \qquad (2)$$
$$ActionType(t) \; \wedge$$
$$allowsPerforming(c, t),$$

where

$$\forall a \; Action(a) \; \rightarrow \exists t \; ActionType(t) \; \wedge$$
$$isClassifiedBy(a, t) \qquad (3)$$

and

$$\forall t \; ActionType(t) \; \rightarrow Concept(t). \qquad (4)$$

Besides that, if an agent performs a given action (Eq. 5), this means that it has the capability to do so:

$$\forall a, x \; performs(a, x) \rightarrow Agent(a) \; \wedge \; Action(x) \; \wedge$$
$$(\exists c \; Capability(c) \; \wedge$$
$$capabilityOf(c, a) \; \wedge$$
$$allowsPerforming(c, t) \; \wedge \qquad (5)$$
$$ActionType(t) \; \wedge$$
$$isClassifiedBy(x, t)).$$

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Cloud Robotics' paper - Definitions: Capability (discussion)

Definition 2. A capability is a property of an agent that allows it to perform or to participate in a certain type of action

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- ○ [Marcos E. Barreto] we assume agent = entity, but we should bear in mind that agent is frequently associated with an object or "something" with some autonomy and "intelligence" to take or respond to actions, while entity is frequently associated with an static representation of a given set of information and functions.
- ○ [Marcos E. Barreto] an entity can maintain a state or perform some change in a given situation => we are assuming the entity is not responsible to create any state but only perform changes in an existing state/situation or keep it? I mean, to what extent the entity will have an active or passive behaviour? Maybe we can mix both definitions in terms of 'performing actions' and 'keeping states' as desirable (or most frequent) capabilities.

Cloud Robotics' paper - Definitions: Behavior

Definition 3. A behavior is a property of an agent that makes it perform certain types of actions when it faces certain types of situations

*[**Stefano**] Behavior of a robot: the behavior of a robot is the way the robot interacts with its environment as well as the way its environment interacts with the robot.

Note 1: a behavior is a relational quality of the robot (i.e., it inheres in the robot only) whose manifestation depends on the environment in which the robot is. The manifestation of the behavior is an event. When the robot affects (part of) its environment, the event is an interaction.

Example: The event "the robot moved from point A to point B" is a event (a movement) which manifests the robot's behavior related to the robot's capacity to move. The manifested behavior (the quality as manifested in that event) can be said to be "smooth", "fast", "precise" etc. as well as "socially acceptable", "dangerous", "appropriate to the situation" etc.

Note 2: the definition aims to be object-centred but interpretation-independent.

Source: S. Borgo et al. "A formal ontological perspective on the behaviors and functions of technical artifacts." AI EDAM, 23:3–21, 1 2009.

Definition 3. A behavior is a property of an agent that makes it perform certain types of actions when it faces certain types of situations

$$\forall b \ Behavior(b) \ \rightarrow \ Property(b) \ \wedge$$

$$(\exists a, p, s \ Agent(a) \ \wedge \ hasBehavior(a, b) \ \wedge$$

$$ActionType(p) \ \wedge \ triggers(b, p) \ \wedge$$

$$SituationType(s) \ \wedge \ activates(s, b)),$$

(6)

where

$$\forall c \ Situation(c) \ \rightarrow \exists t \ SituationType(t)$$

$$\wedge \ isClassifiedBy(c, t),$$

(7)

and

$$\forall t \ SituationType(t) \ \rightarrow \ Concept(t).$$

(8)

s with its environment as well as the way its environment interacts with the

whose manifestation depends on the environment in which the robot is. The ~~nent, the event is an interaction~~

In order to have a given behavior b, an agent a should have the capabilities of performing the kinds of actions that are triggered by the behavior b, as follows:

$$\forall a, b \ hasBehavior(a, b) \ \rightarrow$$

$$(\forall t \ ActionType(t) \ \wedge \ triggers(b, t) \ \rightarrow$$

$$(\exists c \ Capability(c) \ \wedge \ hasCapability(a, c) \ \wedge$$

$$allowsPerforming(c, t))).$$

(9)

Cloud Robotics' paper - Definitions: Behavior (discussion)

Definition 3. A behavior is a property of an agent that makes it perform certain types of actions when it faces certain types of situations

*[**Stefano**] Behavior of a robot: the behavior of a robot is the way the robot interacts with its environment as well as the way its environment interacts with the robot.

- ○ [Marcos E. Barreto] I think Stefano's definition is more precise except from the part that the environment also interacts with the robot. I think we must associate behaviour to the robot itself and bear in mind that the environment is much more complex and dynamic, presenting different behaviours etc. Maybe we can incorporate, in a near future, some concept related to adaptability, to map how entity (or agents) can adapt its behaviour and capabilities to new environments. Our previous definition (CR paper) is a bit similar to CAPABILITY if we think on a property of an agent to make certain types of actions.

Cloud Robotics' paper - Definitions: General discussion

Definition 2. A capability is a property of an agent that allows it to perform or to participate in a certain type of action

Definition 3. A behavior is a property of an agent that makes it perform certain types of actions when it faces certain types of situations

[contribution from Signe, from the Task Ontology Group, to be discussed]

I've been thinking that capability is what sits at the interface of task and behavior.

- A task can specify a provided capability and can require other sub-capabiilties.
- A behavior is a specific instantiation of a capability, so "avoid" in the general sense is a capability, while the VFH+ algorithm would be an abstract behavior providing an instantiation of that capability, and a robot that is using the VFH+ algorithm to avoid obstacles would be a concrete example of a behavior.

A task specification can define a specific capability: task = do not get closer than X to obstacles; capability provided = avoid<no-contact,distance-threshold>. A capability can be used to define how a task should be accomplished: task = pick up the red cup; capability required = identify red objects; capability required = identify cups; capability required = grasp cup; capability required = lift object.

Example

- task: "mix the contents of this container until they reach homogeneity X" (If the task specifier wants, they could include "mix with homogeneity threshold as evaluation metric or exit condition" as a required capability)
- Capability: "mix"
- Behavior: robot A: "stir"; robot B: "shake"; robot C: "drive over bumpy ground while holding it"

Does this mesh with the definition you're proposing in these slides, or are you trying to get at a different concept?

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