Notes on the IEEE Std 1872-2015

"Ontologies for Robotics and Automation"

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What is the goal?

It provides a common set of term definitions aiming to unambiguous knowledge transfer across different agents.

It defines a core ontology to specify the most general concepts, relations, and axioms relevant for robotics and automation (R&A).

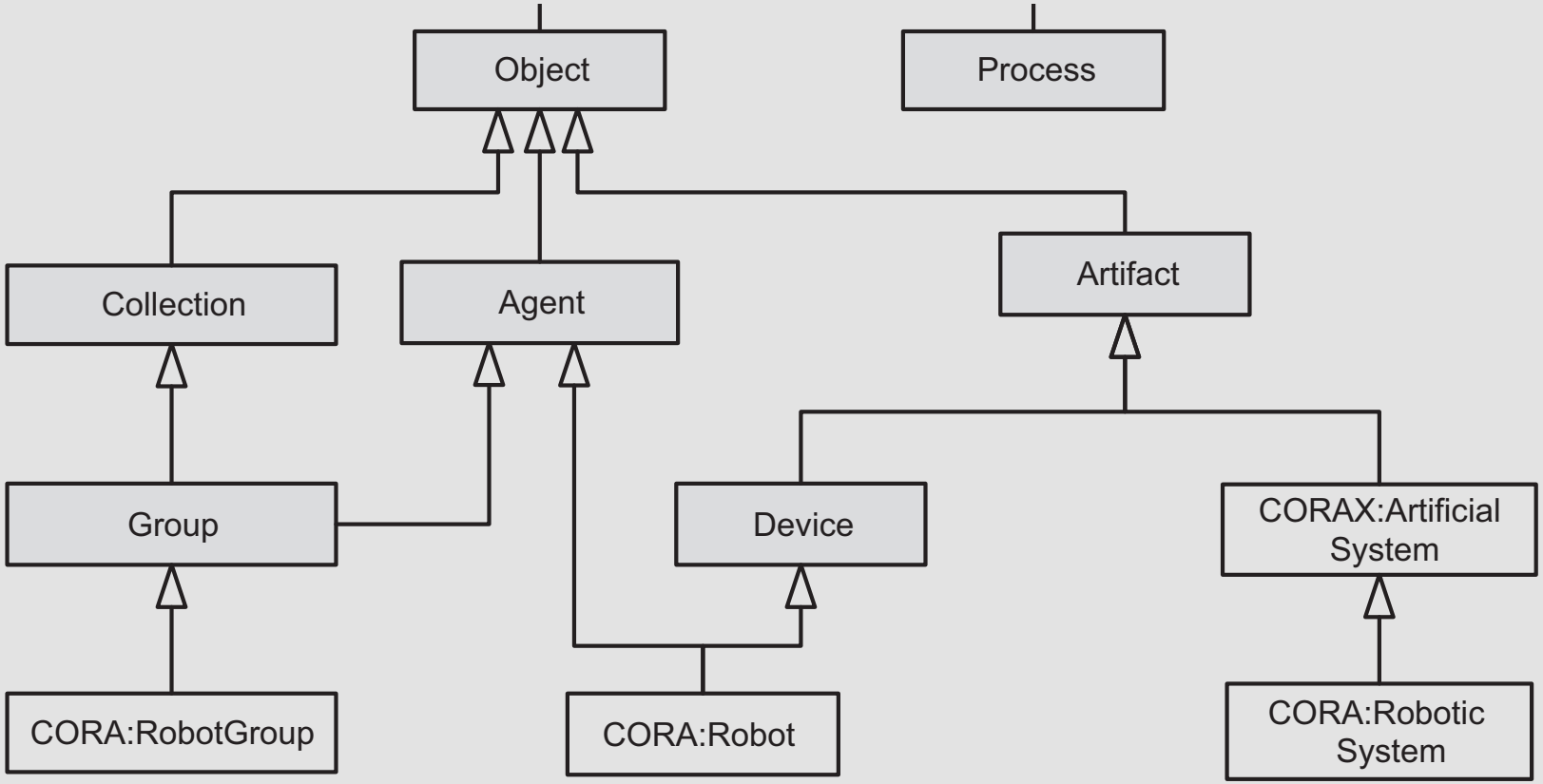
Result = a reference (a unified way) for knowledge representation and reasoning in robots; and
a formal reference vocabulary for communicating knowledge about R&A between robots and humans.

It includes a core ontology about R&A (CORA), together with some extensions covering hardware and software, activities and goals, environment, cause and effects of performing actions, and relationship among other robots and people.

How is it structured?

1. Overview
2. Normative references (other sources)
3. Definitions, abbreviations, and acronyms
4. Conventions
5. SUMO
6. CORAX axioms
7. CORA Axioms on Robot
8. RPARTS axioms
9. POS axioms

Which perspective does it take?



3. Definitions, abbreviations, and acronyms

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[6]

Some definitions refer to concepts and relations from the SUMO ontology.[7]

artificial system: An artifact (*Artifact* in SUMO) formed by various interacting devices (*Device* in SUMO) and other objects (*Object* in SUMO) in order to execute a function.

automated robot: A role for a robot performing a given task in which the robot acts as an automaton, not adapting to changes in the environment and/or following scripted plans. *Contrast:* **fully autonomous robot**; **remote-controlled robot**; **semi-autonomous robot**; **teleoperated robot**.

collective robotic system: A robotic system having a robot group as part. *See also:* **robot group**; **robotic system**. *Contrast:* **single robotic system**.

coordinate system: An abstract entity (*Abstract* in SUMO) used for specifying location and orientation that is defined in relation to a single reference object (*Object* in SUMO). Coordinate systems are related through hierarchies (i.e., trees). For instance, the local coordinate system of a robot is referenced by the robot itself. The reference object is not necessarily the origin of the coordinate system. A coordinate system defines at least one dimension in which points get their coordinate values. Points in a given coordinate system can be mapped to other coordinate systems by means of a transformation. *See also:* **global coordinate system**; **local coordinate system**; **transformation**.

design: A proposition (*Proposition* in SUMO) that abstracts the structure of one or more artifacts (*Artifact* in SUMO). A design is used to abstract information in contexts such as industrial robotics. A design is different from a blueprint; a blueprint represents a particular design.

fully autonomous robot: A role for a robot performing a given task in which the robot solves the task without human intervention while adapting to operational and environmental conditions. *Contrast:* **automated robot**; **remote-controlled robot**; **semi-autonomous robot**, **teleoperated robot**.

global coordinate system: An arbitrary coordinate system chosen by an agent as the global reference frame that constitutes the global coordinate system for that agent. In a hierarchy of local coordinate systems, the global coordinate system is the root of a tree of local coordinate systems. *See also:* **coordinate system**. *Contrast:* **local coordinate system**.

interaction: A process (*Process* in SUMO) in which two agents participate (*Agent* in SUMO). It is composed by two subprocesses defining action and reaction. The action subprocess initiated by agent X on a patient agent Y causes a reaction subprocess having Y as agent and X as patient.

local coordinate system: A coordinate system bounded to a hierarchical structure of coordinate systems and that is not at the root of the structure. *See also:* **coordinate system**. *Contrast:* **global coordinate system**.

orientation measure: Essentially a measure (*Measure* in SUMO) attributed to a (physical) object (*Object* in SUMO) concerning information regarding where the object is pointing to in relation to the reference object of the orientation coordinate system. *See also:* **coordinate system**; **orientation value**; **orientation region**; **pose**; **robot**.

orientation region: Defines a region or interval orientation in relation to a reference object (*Object* in SUMO). For instance, the "south" interval of a compass constitutes an orientation region in the one-dimensional, circular coordinate system of the compass. Eventually, position regions and orientation regions are referred by similar words. For instance, it is valid to say that a robot is at the north position, facing north. The former relates to a position region, i.e., the north region of a given country; the later relates to an orientation region, i.e., the orientation interval around north on the compass. *See also:* **orientation measure**; **position region**. *Contrast:* **orientation point**.

orientation value: A value in a coordinate system denoting a specific orientation. Orientation values in one coordinate system can be mapped to other coordinate systems. An example of use of orientation value is in "the robot is oriented 54° in relation to the reference object." *See also:* **orientation measure**. *Contrast:* **orientation region**.

physical environment: A physical environment is an object (*Object*, in SUMO) that has at least one specific part: a region (*Region* in SUMO) in which it is located. In addition, a physical environment relates to at least one reference object (*Object* in SUMO) based on which region is defined.

pose: A position and an orientation constitute a pose. The pose of an object is the description of any position and orientation measurements of that object. *See also:* **orientation measure**; **position measure**.

position measure: A measure (*Measure* in SUMO) attributed to a (physical) object (*Object* in SUMO) describing its position. A position can be described by a point or a region. For instance, one can describe a robot as positioned at coordinates (x, y) in the coordinate system, or at the front of the box, where "front" comprises a conical region centered on the box and pointed forward. *See also:* **coordinate system**; **pose**; **position point**; **position region**; **robot**.

position point: A point in a position coordinate system. It denotes a precise indication of position of a given object. Position points are always defined in a single coordinate system. *See also:* **position measure**. *Contrast:* **position region**.

position region: An abstract region in a position coordinate system. More specifically, a position region is defined by position points in a given coordinate system. It defines qualitative positions such as "left of," "in front of," "on top of," etc. These expressions define regions in relation to a reference object in which other objects are placed. A position region is always generated by a given spatial operator applied to a list of reference objects. *See also:* **position measure**. *Contrast:* **position point**.

processing device: An electric device (*Electric Device* in SUMO) whose purpose is to serve as an instrument in a subclass of computer process (*Computer Process* in SUMO).

remote-controlled robot: A role for a robot performing a given task in which the human operator controls the robot on a continuous basis, from a location off the robot, via only her/his direct observation. In this mode, the robot takes no initiative and relies on continuous or nearly continuous input from the human operator. *Contrast:* **automated robot**; **fully autonomous robot**; **semi-autonomous robot**; **teleoperated robot**.

robot actuating part: A role for devices (*Device* in SUMO) that allow for the robot to move and act in the surrounding environment. *Contrast:* **robot communicating part**; **robot processing part**; **robot sensing part**. *See also:* **robot part**.

robot communicating part: A role for devices (*Device* in SUMO) that serves as instruments in a robot-robot communication process or a human-robot communication process by allowing the robot to send (or receive) information to (or from) a robot or a human. *Contrast:* **robot actuating part**; **robot processing part**; **robot sensing part**. *See also:* **robot part**.

robot group: A group (*Group* in SUMO) of robots organized to achieve at least one common goal. *See also:* **robot**.

robot interface: A device (*Device* in SUMO) composed by the devices that play the roles of sensing parts, actuating parts, and communicating parts. Through the interface, the robot can sense and act on the environment as well as communicate with other agents. Therefore, the robot interface can be viewed as way to refer to all the devices that allow the robot to interact with the world. Each robot has one and only one robot interface. *See also:* **robot actuating part**; **robot communicating part**; **robot sensing part**.

robot part: A role played by any device (*Device* in SUMO) that is attached to the robot and serves in the functioning of the robot. Devices that are considered robot parts while attached to a robot are not necessarily always a robot part in an ontological sense, since they exist by themselves and, in most cases, they can be connected to other kinds of devices. For instance, a power source is essentially a device; however, a specific instance of a power source can be dynamically considered as a robot part during a specific time interval while connected to a robot. The parts of the devices that are considered robot parts are considered robot parts as well. *See also:* **robot**; **robot actuating part**; **robot communicating part**; **robot processing part**; **robot sensing part**.

robot processing part: A role played by processing devices which allows the robot to process information. *Contrast:* **robot actuating part**; **robot communicating part**; **robot sensing part**. *See also:* **processing device**; **robot part**.

robot sensing part: A role played by any measuring device (*MeasuringDevice* in SUMO) that allows the robot to acquire information about its environment. *Contrast:* **robot actuating part**; **robot communicating part**; **robot processing part**. *See also:* **robot part**.

robot: An agentive device (*Agent* and *Device* in SUMO) in a broad sense, purposed to act in the physical world in order to accomplish one or more tasks. In some cases, the actions of a robot might be subordinated to actions of other agents (*Agent* in SUMO), such as software agents (bots) or humans. A robot is composed of suitable mechanical and electronic parts. Robots might form social groups, where they interact to achieve a common goal. A robot (or a group of robots) can form robotic systems together with special environments geared to facilitate their work. *See also:* **automated robot**; **fully autonomous robot**; **remote-controlled robot**; **robot group**; **robotic system**; **semi-autonomous robot**; **teleoperated robot**.

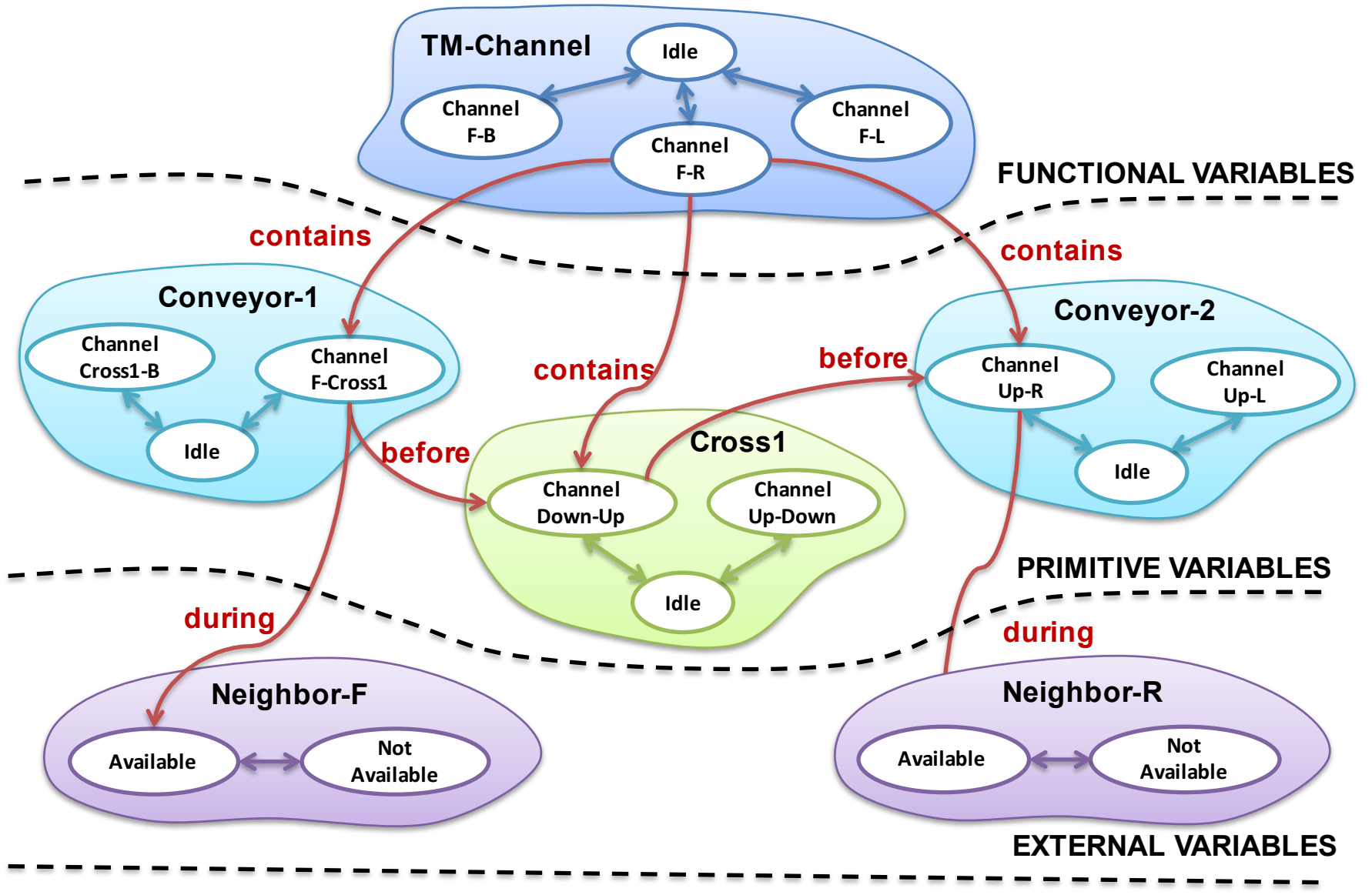
robotic environment: A physical environment equipped with a robotic system. *See also:* **physical environment**; **robotic system**.

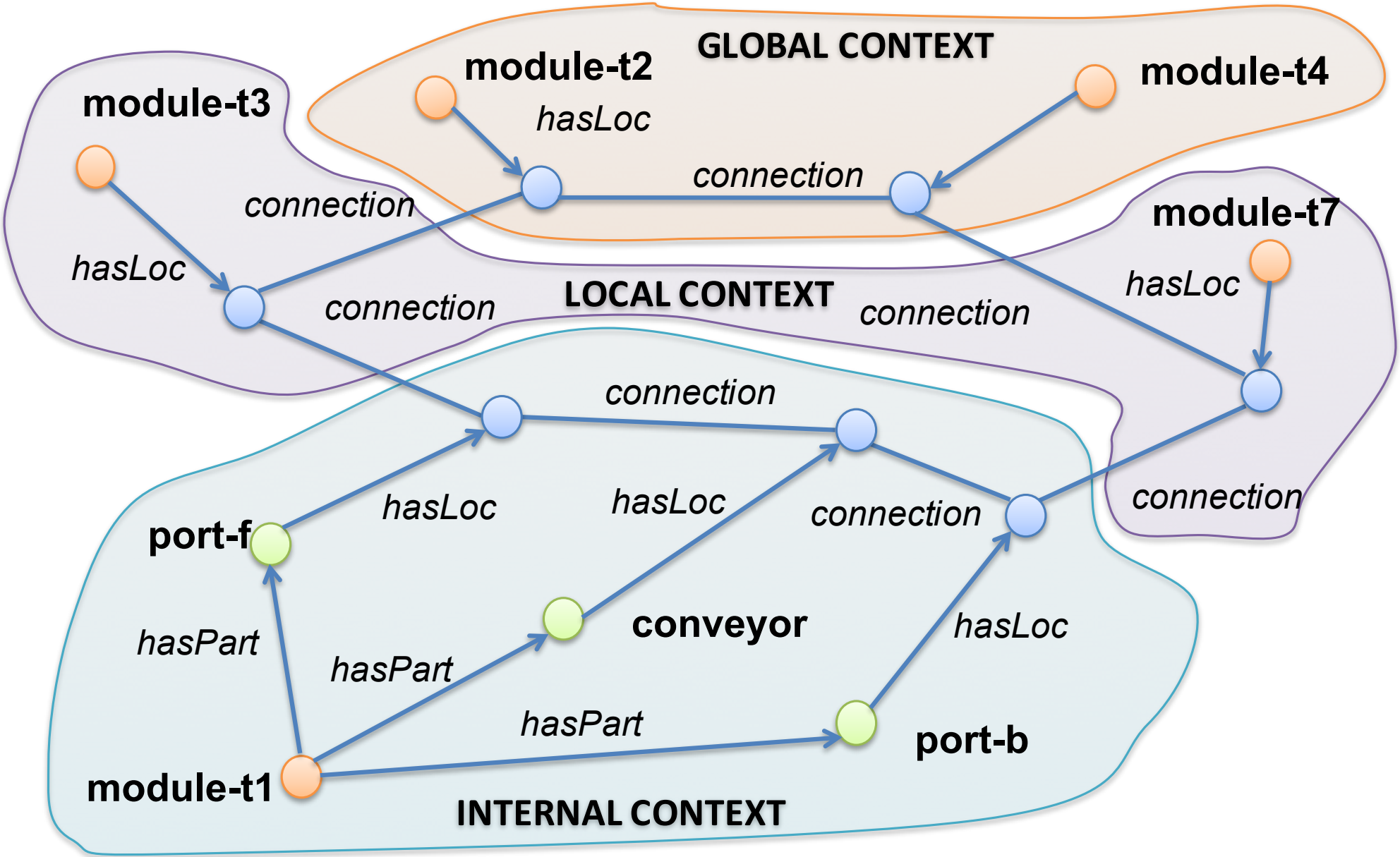
robotic system: An artificial system formed by one or more robots (single robots or groups of robots) and at least one device (*Device* in SUMO) supporting the operation of the robot(s). *See also:* **artificial system**; **collective robotic system**; **robot**; **single robotic system**.

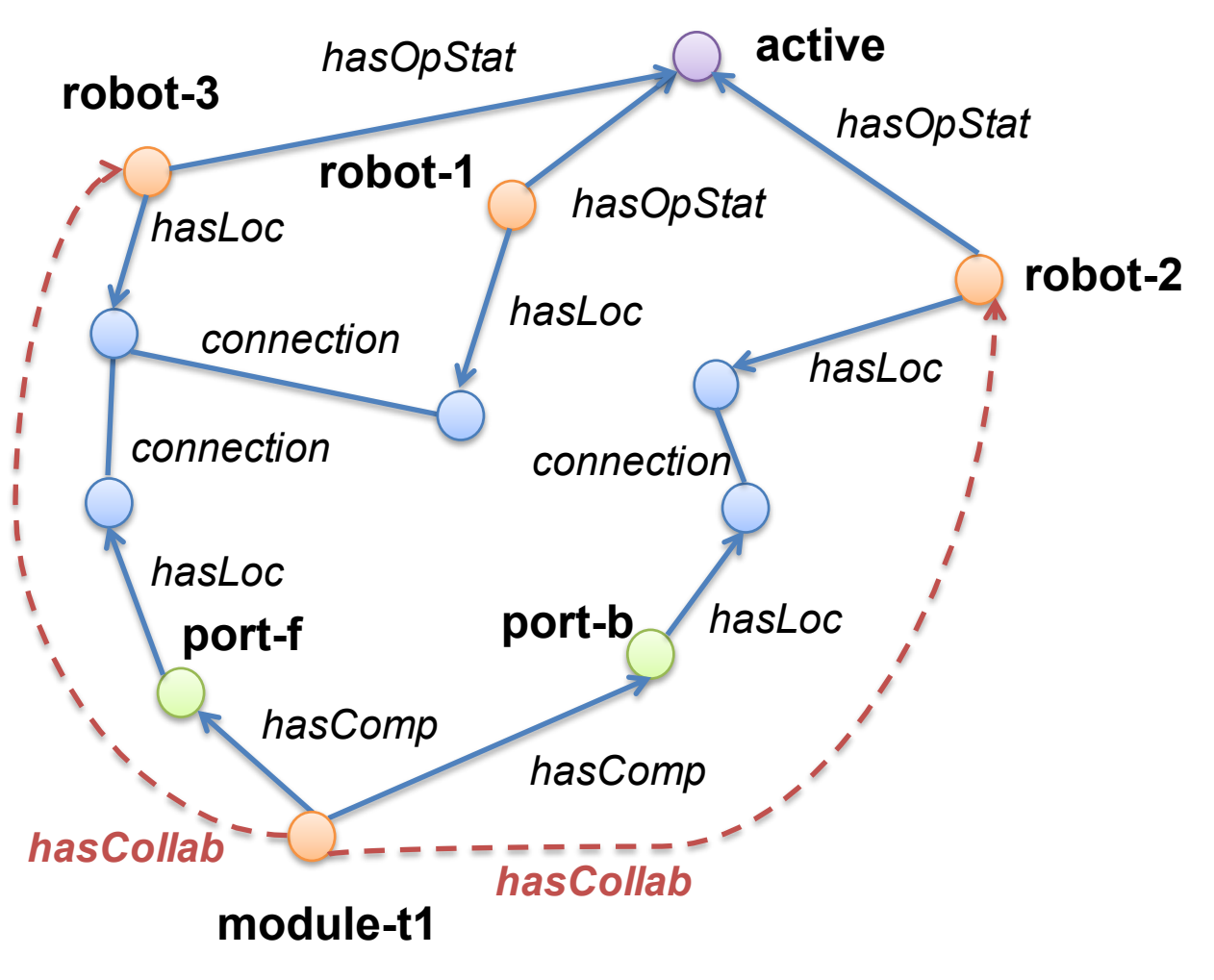
semi-autonomous robot: A role for a robot performing a given task in which the robot and a human operator plan and conduct the task, requiring various levels of human interaction. *Contrast:* **automated robot**; **fully autonomous robot**; **remote-controlled robot**; **teleoperated robot**.

single robotic system: A robotic system having one and only one robot as part and one or more supporting devices. *See also:* **robotic system**. *Contrast:* **collective robotic system**.

spatial operator: A mathematical function that can map reference objects (*Object* in SUMO) to regions in a coordinate system. *See also:* **coordinate system**.


TM-Channel
Idle
Channel F-B
Channel F-R
Channel F-L
FUNCTIONAL VARIABLES
contains
contains
contains
Conveyor-1
Channel Cross1-B
Channel F-Cross1
Idle
Conveyor-2
Channel Up-R
Channel Up-L
Idle
before
before
Cross1
Channel Down-Up
Channel Up-Down
Idle
PRIMITIVE VARIABLES
during
during
Neighbor-F
Available
Not Available
Neighbor-R
Available
Not Available
EXTERNAL VARIABLES


GLOBAL CONTEXT
module-t2
module-t4
hasLoc
connection
module-t3
connection
hasLoc
module-t7
hasLoc
LOCAL CONTEXT
connection
connection
connection
connection
hasLoc
hasLoc
connection
port-f
conveyor
hasPart
hasPart
hasLoc
hasPart
port-b
module-t1
INTERNAL CONTEXT

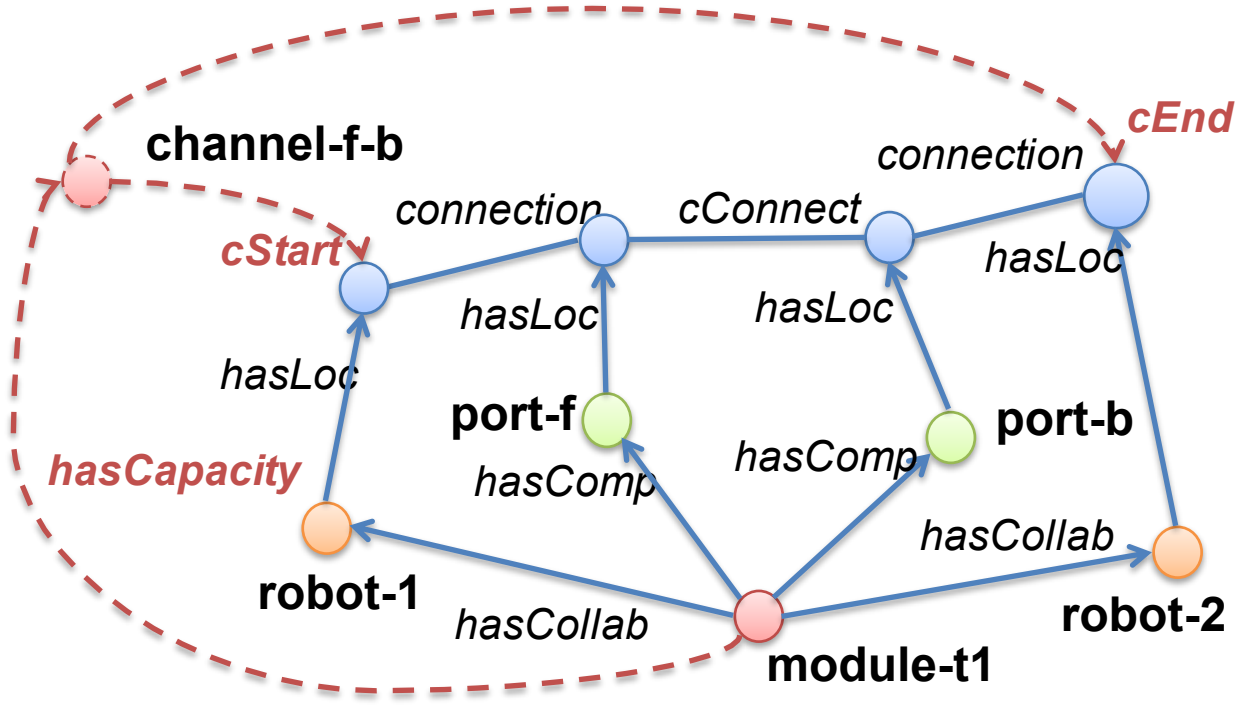

active
hasOpStat
robot-3
hasOpStat
robot-1
hasOpStat
hasLoc
robot-2
hasLoc
connection
hasLoc
connection
connection
hasLoc
port-f
port-b
hasLoc
hasComp
hasComp
hasCollab
hasCollab
module-t1

$$\text{ROBOT}(r) \wedge \text{PORT}(p) \wedge \text{hasLoc}(p, l_p) \wedge \text{P}(p,r) \wedge$$

$$\text{hasOpStat}(p, \text{active}) \wedge \text{ROBOT}(c) \wedge \text{hasLoc}(c, l_c) \wedge$$

$$\text{connection}(l_p, l_c)$$

$$\rightarrow \text{hasCollab}(r, c)$$


channel-f-b
cEnd
connection
connection
cConnect
cStart
hasLoc
hasLoc
hasLoc
hasLoc
hasLoc
port-f
port-b
hasCapacity
hasComp
hasComp
hasCollab
robot-1
hasCollab
robot-2
module-t1

$$\text{ROBOT}(r) \wedge \text{CONVEYOR}(c_1) \wedge \text{hasOpStat}(c_1, \text{active}) \wedge$$

$$\text{COMPONENT}(c_2) \wedge \text{COMPONENT}\,(c_3) \wedge$$

$$\text{hasLoc}(c_1, l_1) \wedge \text{hasLoc}(c_2, l_2) \wedge \text{hasLoc}(c_3, l_3) \wedge$$

$$\text{connection}(l_2,l_1) \wedge \text{connection}(l_1, l_3) \wedge$$

$$\rightarrow \text{hasCapacity}(r, f) \wedge \text{CHANNEL}(f) \wedge$$

$$\text{cStart}(f, l_2) \wedge \text{cEnd}(f, l_3) \wedge \text{cConnect}(l_2, l_3)$$