

```

1   T<- (desig-action-grounding ?action-designator (close-container ?arm
2   7gripper-opening
3   ?distance
4   ?left-reach-poses
5   ?left-grasp-poses
6   ?right-grasp-poses
7   ?left-lift-poses)
8   ?right-lift-poses
9   ?left-2nd-lift-poses)
10  ?right-2nd-lift-poses)
11  ?cont-name
12  ?environment-ob))
13
14  (spec-property ?action-designator (type ?closing))
15  (spec-property ?action-designator (object ?closed-object-designator))
16  (spec-property ?container-designator (type ?container-type))
17  (obj-int-object-type-subtype ?container ?container-type)
18  (spec-property ?container-designator (script ?script-environment))
19  (> (spec-property ?action-designator (arm ?arm))
20  (true)
21  (and (cran-robot-interfaces:robot ?robot)
22  (cran-robot-interfaces:arm ?robot ?arm)))
23
24  (spec-property ?action-designator (?distance ?distance))
25  (lisp-fun man-int get-connecting-point ?connecting-point ?connecting-joint)
26  (lisp-fun cl-robot:cl-arm ?arm)
27  (lisp-fun btr:btr-world ?world)
28  (lisp-fun btr:btr-object ?world ?btr-environment ?environment-ob)
29
30
31
32  (lisp-fun obj-int get-object-type-gripper-opening ?container-type ?gripper-opening)
33  (lisp-fun get-container-pose-and-transform ?container-name ?btr-environment
34  ?container-pose ?container-transform)
35
36
37
38  (lisp-fun obj-int get-object-grasping-poses ?container-name
39  :container-prismatic ?left :close ?container-transform ?left-poses)
40  (lisp-fun obj-int get-object-grasping-poses ?container-name
41  :container-prismatic ?right :close ?container-transform ?right-poses)
42  (lisp-fun cran-mobile-pick-place:plane extract-pick-up-manipulation-poses
43
44
45
46
47  ?arm ?left-poses ?right-poses
48  (?left-reach-poses ?right-reach-poses
49  ?left-grasp-poses ?right-grasp-poses
50  ?left-lift-poses ?right-lift-poses))
51
52  (> (lisp-pred identity ?left-poses)
53  (equal ?left-lift-poses ?left-lift-poses ?left-2nd-lift-poses))
54  (equal (NIL NIL) ?left-lift-poses ?left-2nd-lift-poses))
55
56
57
58
59
60
61
62
63
64  (> (lisp-pred identity ?right-lift-poses)
65  (equal ?right-lift-poses ?right-lift-poses ?right-2nd-lift-poses))
66  (equal (NIL NIL) ?right-lift-poses ?right-2nd-lift-poses))
67
68

```



```

1   T<- (desig-action-grounding ?action-designator (close-container ?resolved-action-designator))
2
3
4
5
6
7
8
9
10
11
12
13
14
15  (spec-property ?action-designator (type ?closing))
16  (spec-property ?action-designator (object ?closed-object-designator))
17  (spec-current-designator ?object-designator ?current-object-design)
18
19  (spec-property ?current-object-design (type ?object-type))
20  (spec-property ?current-object-design (name ?object-name))
21  (> (spec-property ?action-designator (arm ?arm))
22  (true)
23  (lisp-fun man-int get-object-obt-transform ?current-object-design ?object-transform)
24  (lisp-fun man-int calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face))
25
26  (> (spec-property ?action-designator (grasp ?grasp))
27  (true)
28  (and (lisp-fun man-int get-action-grasps ?object-type ?arm ?object-transform ?grasps)
29  (member ?grasp ?grasps)))
30  (> (spec-property ?action-designator (object-half-pose ?object-half-pose))
31  (true)
32  (lisp-fun "Please infer where to close the container, or less the query system to infer it here"))
33  (lisp-fun man-int get-action-gripping-effort ?object-type ?effort)
34  (lisp-fun man-int get-action-gripper-opening ?object-type ?gripper-opening)
35  (equal ?objects ?current-object-design)
36  (> (equal ?arm ?left)
37  (and (lisp-fun man-int get-action-trajectory :closing ?arm ?grasp T ?objects
38  ?right-poses)
39  (lisp-fun man-int get-fra-poses-by-label ?left-closing-poses :closing-up
40  ?left-closing-up-poses)
41  (lisp-fun man-int get-fra-poses-by-label ?left-closing-poses :closing-down
42  ?left-closing-down-poses))
43  (and (equal ?left-closing-up-poses NIL)
44  (equal ?left-closing-down-poses NIL)))
45  (> (equal ?arm ?right)
46  (and (lisp-fun man-int get-action-trajectory :closing ?arm ?grasp T ?objects
47  ?right-poses)
48  (lisp-fun man-int get-fra-poses-by-label ?right-closing-poses :closing-up
49  ?right-closing-up-poses)
50  (lisp-fun man-int get-fra-poses-by-label ?right-closing-poses :closing-down
51  ?right-closing-down-poses))
52  (and (equal ?right-closing-up-poses NIL)
53  (equal ?right-closing-down-poses NIL)))
54  (> (design-prop ?action-designator :collision-mode ?collision-mode))
55  (true)
56  (equal ?collision-mode NIL)
57  (design-designator :action (type ?closing)
58  (object ?current-object-design)
59  (object-name ?object-name)
60  (arm ?arm)
61  (grasp ?grasp)
62  (effort ?effort)
63  (left-closing-up-poses ?left-closing-up-poses)
64  (right-closing-up-poses ?right-closing-up-poses)
65  (left-closing-down-poses ?left-closing-down-poses)
66  (right-closing-down-poses ?right-closing-down-poses)
67  (collision-mode ?collision-mode))
68  ?resolved-action-designator)

```

Figure 1: Left: Manual designator for the action *Closing* (47 lines). Right: Generated designator based on *Halving* (55 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
40	32	12	3

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *object* instead of *container*)
- adds variables and their handling from the example designator, despite being unnecessary for the use case (here: *?object-half-pose*)
- generated designator ends by mapping variables to designator "parts"

```

1  | <- (desig-action-grounding ?action-designator (?close-container ?arm
2  |   | gripper-opening
3  |   | ?distance
4  |   | ?left-reach-poses
5  |   | ?right-reach-poses
6  |   | ?left-poses
7  |   | ?right-grasp-poses
8  |   | ?left-lift-poses
9  |   | ?right-lift-poses
10 |   | ?left-2nd-lift-poses
11 |   | ?right-2nd-lift-poses
12 |   | ?joint-name
13 |   | ?environment-obj)
14 |
15 |   (spec:property ?action-designator (type :closing))
16 |   (spec:property ?action-designator (object ?container-designator))
17 |   (spec:property ?container-designator (type ?container-type))
18 |   (obj-int-object-type-subtype ?container ?container-type)
19 |   (spec:property ?container-designator (part-of ?bsr-environment))
20 |   (> spec:property ?action-designator (?arm ?arm))
21 |   (true)
22 |   (and)
23 |     (cram-robot-interfaces:robot ?bsr)
24 |     (cram-robot-interfaces:arm ?bsr ?arm))
25 |   (spec:property ?action-designator (distance ?distance))
26 |   (lisp-fun get-container-link ?container-name ?bsr-environment ?container-link)
27 |   (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
28 |   (lisp-fun get-connecting-joint ?connecting-joint ?joint-name)
29 |   (bsr-world ?world)
30 |   (lisp-fun bsr-object ?world ?bsr-environment ?environment-obj)
31 |   (lisp-fun get-container-poses-and-transform ?container-name ?bsr-environment
32 |     ?Container-poses ?Container-transform)
33 |   (lisp-fun get-object-grasping-poses ?Container-name
34 |     ?Container-poses ?Container-transform ?left-poses)
35 |   (lisp-fun get-object-grasping-poses ?Container-name ?Container-transform
36 |     ?right-poses)
37 |   (lisp-fun cram-mobile-pick-place-plans: extract-pick-up-manipulation-poses
38 |     ?arm ?left-poses ?right-poses
39 |     ?left-reach-poses ?right-reach-poses
40 |     ?left-grasp-poses ?right-grasp-poses
41 |     ?left-lift-poses ?right-lift-poses)
42 |   (> lisp-pred identity ?left-poses)
43 |   (equal ?left-poses ?left-poses ?left-lift-poses)
44 |   (equal (NIL NIL) ?left-poses ?left-2nd-lift-poses)
45 |   (> lisp-pred identity ?right-poses)
46 |   (equal ?right-poses ?right-lift-poses ?right-2nd-lift-poses)
47 |   (equal (NIL NIL) ?right-lift-poses ?right-2nd-lift-poses)))

```



```

1  | <- (desig-action-grounding ?action-designator (?p-plans:close-container ?resolved-action-designator))
2  |   | gripper-opening
3  |   | ?distance
4  |   | ?left-reach-poses
5  |   | ?right-reach-poses
6  |   | ?left-poses
7  |   | ?right-grasp-poses
8  |   | ?left-lift-poses
9  |   | ?right-lift-poses
10 |   | ?left-2nd-lift-poses
11 |   | ?right-2nd-lift-poses
12 |   | ?joint-name
13 |   | ?environment-obj)
14 |
15 |   (spec:property ?action-designator (type :closing))
16 |   (spec:property ?action-designator (object ?object-designator))
17 |   (desig-current-designator ?object-designator ?current-object-design)
18 |   (spec:property ?current-object-design (name ?object-name))
19 |   (lisp-fun man-int-get-object-transform ?current-object-design ?object-transform)
20 |   (lisp-fun man-int-calculate-object-faces ?object-transform ?flacing-robot-face ?bottom-face)
21 |   (lisp-fun man-int-get-action-gripping-effort ?current-object-design ?effort)
22 |
23 |
24 |
25 |
26 |
27 |
28 |
29 |
30 |   (lisp-fun man-int-get-action-gripper-opening ?current-object-design ?gripper-opening)
31 |   (equal ?objects ?current-object-design)
32 |   (> (lisp-fun man-int-get-action-trajectory ?closing ?object-transform ?objects
33 |     ?trajectory)
34 |       (lisp-fun man-int-get-traj-poses-by-label ?trajectory ?reaching ?reach-poses)
35 |       (lisp-fun man-int-get-traj-poses-by-label ?trajectory ?grasping ?grasp-poses))
36 |   (desig-designator ?action (type :closing)
37 |     (object ?current-object-design)
38 |     (name ?object-name)
39 |     (gripper-opening ?gripper-opening)
40 |     (effort ?effort)
41 |     (reach-poses ?reach-poses)
42 |
43 |
44 |
45 |
46 |   (grasp-poses ?grasp-poses))
47 |   ?resolved-action-designator)

```

Figure 2: Left: Manual designator for the action *Closing* (47 lines). Right: Generated designator based on *Holding* (23 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
16	40	6	1

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *object* instead of *container*)
- generated designator ends by mapping variables to designator "parts"

```

1  (<- (design-action-grounding ?action-designator (close-container ?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    (?left-lift-pose)
9    (?right-lift-pose)
10   (?left-2nd-lift-pose)
11   (?right-2nd-lift-pose)
12   ?joint-name
13   ?environment-obj)))
14 (spec:property ?action-designator (:type :closing))
15 (spec:property ?action-designator (:object ?container-designator))
16 (spec:property ?container-designator (:type ?container-type))
17 (obj:into:object-type-subtype :container ?container-type)
18 (spec:property ?container-designator (:urdf-name ?container-name))
19 (spec:property ?container-designator (:part-of ?btr-environment))
20 (- (spec:property ?action-designator (:arm ?arm))
21   (true)
22   (and (cram-robot-interfaces:robot ?robot)
23         (cram-robot-interfaces:arm ?robot ?arm)))
24 (spec:property ?action-designator (:distance ?distance))
25 (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
26 (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
27 (lisp-fun cl-urdf:name ?connecting-joint ?joint-name)
28 (btr:bullet-world ?world)
29 (lisp-fun btr:object ?world ?btr-environment ?environment-obj)
30 (lisp-fun obj:int-get-object-type-gripper-opening ?container-type ?gripper-opening)
31 (lisp-fun get-container-pose-and-transform ?container-name ?btr-environment
32   ?container-pose ?container-transform)
33 (lisp-fun obj:int-get-object-grasping-poses ?container-name
34   :container-prismatic :left :close ?container-transform ?left-poses)
35 (lisp-fun obj:int-get-object-grasping-poses ?container-name
36   :container-prismatic :right :close ?container-transform ?right-poses)
37 (lisp-fun cram-mobile:pick-place-plans::extract:pick-up-manipulation-poses
38   ?arm ?left-poses ?right-poses
39   ?left-reach-poses ?right-reach-poses
40   ?left-grasp-poses ?right-grasp-poses
41   ?left-lift-poses ?right-lift-poses))
42 (> (lisp-pred identity ?left-lift-poses)
43   (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose)))
44   (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
45 (> (lisp-pred identity ?right-lift-poses)
46   (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose)))
47   (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))
```



```

1  (<- (design-action-grounding ?action-designator (close-container ?arm
2    ?gripper-closing
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    (?left-lift-pose)
9    (?right-lift-pose)
10   (?left-2nd-lift-pose)
11   (?right-2nd-lift-pose)
12   ?joint-name ?environment-obj)))
13
14 (spec:property ?action-designator (:type :closing))
15 (spec:property ?action-designator (:object ?container-designator))
16 (spec:property ?container-designator (:type ?container-type))
17 (obj:into:object-type-subtype :container ?container-type)
18 (spec:property ?container-designator (:urdf-name ?container-name))
19 (spec:property ?container-designator (:part-of ?btr-environment))
20 (- (spec:property ?action-designator (:arm ?arm))
21   (true)
22   (and (cram-robot-interfaces:robot ?robot)
23         (cram-robot-interfaces:arm ?robot ?arm)))
24 (spec:property ?action-designator (:distance ?distance))
25 (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
26 (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
27 (lisp-fun cl-urdf:name ?connecting-joint ?joint-name)
28 (btr:bullet-world ?world)
29 (lisp-fun btr:object ?world ?btr-environment ?environment-obj)
30 (lisp-fun obj:int-get-object-type-gripper-closing ?container-type ?gripper-closing)
31 (lisp-fun get-container-pose-and-transform ?container-name ?btr-environment
32   ?container-pose ?container-transform)
33 (lisp-fun obj:int-get-object-grasping-poses ?container-name
34   :container-prismatic :left :closed ?container-transform ?left-poses)
35 (lisp-fun obj:int-get-object-grasping-poses ?container-name
36   :container-prismatic :right :closed ?container-transform ?right-poses)
37 (lisp-fun cram-mobile:pick-place-plans::extract:pick-up-manipulation-poses
38   ?arm ?left-poses ?right-poses
39   ?left-reach-poses ?right-reach-poses
40   ?left-grasp-poses ?right-grasp-poses
41   ?left-lift-poses ?right-lift-poses))
42 (> (lisp-pred identity ?left-lift-poses)
43   (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose)))
44   (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
45 (> (lisp-pred identity ?right-lift-poses)
46   (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose)))
47   (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))
```

Figure 3: Left: Manual designator for the action *Closing* (47 lines). Right: Generated designator based on *Opening* (46 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
1	2	5	40

Findings:

- added / deleted lines are due to different spacing in generated designator
- 4 / 5 changes are names / descriptors (*opening -i closing*) that are changed wrong, since its about the gripper opening during the manipulation process, which is still necessary
- last change is due to one missing parentheses

```

1  (<- (design-action-grounding ?action-designator (close-container ?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    (?left-lift-pose)
9    (?right-lift-pose)
10   (?left-2nd-lift-pose)
11   (?right-2nd-lift-pose)
12   ?joint-name
13   ?environment-obj)))
14 (spec:property ?action-designator (:type :closing))
15 (spec:property ?action-designator (:object ?container-designator))
16 (spec:property ?container-designator (:type ?container-type))
17 (obj-int-object-type-subtype :container ?container-type)
18 (spec:property ?container-designator (:urdf-name ?container-name))
19 (spec:property ?container-designator (:part-of ?btr-environment))
20 (> (spec:property ?action-designator (:arm ?arm))
21   (true)
22   (and (cram-robot-interfaces:robot ?robot)
23         (cram-robot-interfaces:arm ?robot ?arm)))
24 (spec:property ?action-designator (:distance ?distance))
25 (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
26 (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
27 (lisp-fun cl-urdfname ?connecting-joint ?joint-name)
28 (btr:bullet-world ?world)
29 (lisp-fun btr-object ?world ?btr-environment ?environment-obj)
30 (lisp-fun obj-int-get-object-type-gripper-opening ?container-type ?gripper-opening)
31 (lisp-fun get-container-pose-and-transform ?container-name ?btr-environment
32   (?container-pose ?container-transform))
33 (lisp-fun obj-int-get-object-grasping-poses ?container-name
34   :container-prismatic :left :close ?container-transform ?left-poses)
35 (lisp-fun obj-int-get-object-grasping-poses ?container-name
36   :container-prismatic :right :close ?container-transform ?right-poses)
37 (lisp-fun cram-mobile-pick-place-plans:extract-pick-up-manipulation-poses
38   ?arm ?left-poses ?right-poses
39   (?left-reach-poses ?right-reach-poses
40     ?left-grasp-poses ?right-grasp-poses
41     ?left-lift-poses ?right-lift-poses))
42 (> (lisp-pred identity ?left-lift-poses)
43   (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose)))
44   (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
45 (> (lisp-pred identity ?right-lift-poses)
46   (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose)))
47   (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))
```



```

1  (<- (design-action-grounding ?action-designator (close-container ?arm
2    ?gripper-closing
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    (?left-lift-pose)
9    (?right-lift-pose)
10   (?left-2nd-lift-pose)
11   (?right-2nd-lift-pose)
12   ?joint-name ?environment-obj)))
13 (spec:property ?action-designator (:type :closing))
14 (spec:property ?action-designator (:object ?container-designator))
15 (spec:property ?container-designator (:type ?container-type))
16 (obj-int-object-type-subtype :container ?container-type)
17 (spec:property ?container-designator (:urdf-name ?container-name))
18 (spec:property ?container-designator (:part-of ?btr-environment))
19 (> (spec:property ?action-designator (:arm ?arm))
20   (true)
21   (and (cram-robot-interfaces:robot ?robot)
22         (cram-robot-interfaces:arm ?robot ?arm)))
23 (spec:property ?action-designator (:distance ?distance))
24 (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
25 (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
26 (lisp-fun cl-urdfname ?connecting-joint ?joint-name)
27 (btr:bullet-world ?world)
28 (lisp-fun btr-object ?world ?btr-environment ?environment-obj)
29 (lisp-fun obj-int-get-object-type-gripper-closing ?container-type ?gripper-closing)
30 (lisp-fun get-container-pose-and-transform ?container-name ?btr-environment
31   (?container-pose ?container-transform))
32 (lisp-fun obj-int-get-object-grasping-poses ?container-name
33   :container-prismatic :left :closed ?container-transform ?left-poses)
34 (lisp-fun obj-int-get-object-grasping-poses ?container-name
35   :container-prismatic :right :closed ?container-transform ?right-poses)
36 (lisp-fun cram-mobile-pick-place-plans:extract-pick-up-manipulation-poses
37   ?arm ?left-poses ?right-poses
38   (?left-reach-poses ?right-reach-poses
39     ?left-grasp-poses ?right-grasp-poses
40     ?left-lift-poses ?right-lift-poses))
41 (> (lisp-pred identity ?left-lift-poses)
42   (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose)))
43   (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
44 (> (lisp-pred identity ?right-lift-poses)
45   (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose)))
46   (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))
```

Figure 4: Left: Manual designator for the action *Closing* (47 lines). Right: Generated designator based on *Picking Up* (46 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
1	2	5	40

Findings:

- added / deleted lines are due to different spacing in generated designator
- 4 / 5 changes are names / descriptors (*opening -> closing*) that are changed wrong, since its about the gripper opening during the manipulation process, which is still necessary
- last change is due to one missing parentheses

```

1  :- (<- (desig.action-grounding ?action-designator (close-container ?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    (?left-lift-pose)
9    (?right-lift-pose)
10   (?left-2nd-lift-pose)
11   (?right-2nd-lift-pose)
12   ?joint-name
13   ?environment-obj))
14   (spec:property ?action-designator (:type :closing))
15   (spec:property ?action-designator (:object ?container-designator))
16   (spec:property ?container-designator (:type ?container-type))
17   (obj-int-to-object-type-subtype :container ?container-type)
18   (spec:property ?container-designator (:urdf-name ?container-name))
19   (spec:property ?container-designator (:part-of ?btr-environment))
20   (-> (spec:property ?action-designator (:arm ?arm))
21     (true)
22     (and (cram-robot-interfaces:robot ?robot)
23       (cram-robot-interfaces:arm ?robot ?arm)))
24     (spec:property ?action-designator (:distance ?distance))
25     (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
26     (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
27     (lisp-fun cl-urdf:name ?connecting-joint ?joint-name)
28     (btr-bullet-world ?world)
29     (lisp-fun btr-object ?world ?btr-environment ?environment-obj)
30     (lisp-fun obj-int-get-object-type-gripper-opening ?gripper-opening)
31     (lisp-fun get-container-pose-and-transform ?container-name ?btr-environment
32     (?container-pose ?container-transform))
33     (lisp-fun obj-int-get-object-grasping-poses ?container-name
34     :container-prismatic :left :close ?container-transform ?left-poses)
35     (lisp-fun obj-int-get-object-grasping-poses ?container-name
36     :container-prismatic :right :close ?container-transform ?right-poses)
37     (lisp-fun cram-mobile-pick-place-plan extract-pick-up-manipulation-poses
38     ?arm ?left-poses ?right-poses
39     (?left-reach-poses ?right-reach-poses
40     ?left-grasp-poses ?right-grasp-poses
41     ?left-lift-poses ?right-lift-poses))
42     (-> (lisp-pred identity ?left-lift-poses)
43       (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose))
44       (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
45     (-> (lisp-pred identity ?right-lift-poses)
46       (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose))
47       (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose)))))

1  :- (<- (desig.action-grounding ?action-designator (close ?container-designator))
2
3
4
5
6
7
8
9
10
11
12
13
14   (spec:property ?action-designator (:type :closing))
15   (spec:property ?action-designator (:object ?container-designator))
16   (spec:property ?container-designator (:type :container))
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33   (-> (lisp-fun obj-int-get-container-closing-poses ?container-name ?container-designator
34     ?closing-poses)
35     (lisp-fun extract-closing-manipulation-poses ?closing-poses ?left-reach-poses
36
37
38
39
40     ?right-reach-poses ?left-grasp-poses ?right-grasp-poses
41     ?left-retract-poses ?right-retract-poses)
42   (or (and (cram-robot-interfaces:robot ?robot)
43     (cram-robot-interfaces:arm ?robot :left)
44     (cram-robot-interfaces:arm ?robot :right))
45     (format "WARNING: Could not find robot or arms for closing container ~a.~%" ?container-designator)))

```

Figure 5: Left: Manual designator for the action *Closing* (47 lines). Right: Generated designator based on *Placing Down* (15 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
5	37	8	2

Findings:

- designator definition contains only one variable instead of 13
- generated designator focuses on the necessary poses but nothing else
- generation adds block about `cram-robot-interfaces` (3 lines)

```

1  [+< (design-action-grounding ?action-designator (close-container ?arm)
2    ?grpper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    (?left-lift-pose)
9    (?right-lift-pose)
10   (?left-2nd-lift-pose)
11   (?right-2nd-lift-pose)
12   ?cont-name
13   ?environment-obj)]
14   (
  


```

1 [+< (design-action-grounding ?action-designator (close-container ?resolved-action-designator))
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
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21
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63
64
65
66
67
68
69
70
71
72

```


```

Figure 6: Left: Manual designator for the action *Closing* (47 lines). Right: Generated designator based on *Pouring* (45 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
35	37	8	2

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *object* instead of *container*)
- high focus on finding the fitting (gripping) poses for two robot arms
- generated designator ends by mapping variables to designator "parts"

```

1  | <- (design-action-grounding ?action-designator (close-container ?arm
2  |   ?gripper-opening
3  |   ?distance
4  |   ?left-reach-poses
5  |   ?right-reach-poses
6  |   ?left-grasp-poses
7  |   ?left-lift-poses)
8  |   ?right-lift-poses)
9  |   ?joint-name
10 |   ?environment-obj)
11 |
12 |   (spec-property ?action-designator :type :closing)
13 |   (spec-property ?action-designator :object ?resolved-action-designator)
14 |   (spec-property ?container-designator :type ?container-type)
15 |   (obj-int-object-type-subtype ?container ?container-type)
16 |   (spec-property ?container-designator :current-name ?container-name)
17 |   (spec-property ?container-designator :part-of ?btr-environment)
18 |   (-> (spec-property ?action-designator :arm ?arm))
19 |   (true)
20 |
21 |
22 |
23 |
24 |
25 |
26 |
27 |   (and (cram-robot-interfaces:robot ?robot)
28 |         (cram-robot-interfaces:robot ?arm))
29 |   (spec-property ?action-designator :distance ?distance)
30 |   (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
31 |   (lisp-fun cl-urdf:name ?connecting-joint ?connecting-pint)
32 |   (lisp-fun btr:btr-object ?world ?btr-environment)
33 |   (lisp-fun cl-int:get-object-type gripper-opening ?container-type ?gripper-opening)
34 |   (lisp-fun cl-int:get-container-poses-and-transform ?container-name ?btr-environment
35 |     (cl-int:object-get-prismatic-poses ?container-name
36 |       :container-prismatic :right ?close ?container-transform ?left-poses)
37 |     (lisp-fun cl-int:get-object-grasping-poses ?container-name
38 |       :container-prismatic :right ?close ?container-transform ?right-poses)
39 |     (lisp-fun cram:mobile:pick-place-plans :extract-pick-up-manipulation-poses
40 |       ?arm ?left-poses)
41 |     (lisp-fun cl-int:reach-poses ?left-reach-poses
42 |       ?right-reach-poses)
43 |     (lisp-fun cl-int:grasp-poses ?left-grasp-poses
44 |       ?right-grasp-poses)
45 |     (lisp-fun cl-int:lift-poses ?left-lift-poses)
46 |     (lisp-fun cl-int:2nd-lift-poses ?left-2nd-lift-poses)
47 |     (-> (spec-pred identity ?left-lift-poses)
48 |           (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose)))
49 |
50 |           (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
51 |           (-> (spec-pred identity ?right-lift-poses)
52 |               (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose)))
53 |               (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose)))
54 |
55 |
56 |
57 |
58 |
59 |
60 |
61 )

```



```

1  | <- (design-action-grounding ?action-designator (close-container ?resolved-action-designator))
2  |   (spec-property ?action-designator :type :closing)
3  |   (spec-property ?action-designator :object ?resolved-action-designator)
4  |   (spec-property ?current-object-designator :type ?container)
5  |   (spec-property ?current-object-designator :name ?object-name)
6  |   (-> (spec-property ?action-designator :arm ?arm))
7  |   (true)
8  |
9  |   (man-int:robot-free-hand ?, ?arm)
10 |   (lisp-fun man-int:get-object-old-transform ?current-object-designator ?object-transform)
11 |   (man-int:calculate-object-face ?object-transform (facing-robot-face) ?bottom-face)
12 |   (-> (spec-property ?action-designator :grasp ?grasp)
13 |       (true)
14 |       (and (lisp-fun man-int:get-action-grasps ?container ?arm ?object-transform ?grasps)
15 |             (member ?grasp ?grasps)))
16 |       (lisp-fun man-int:get-action-gripping-effort ?container ?effort)
17 |
18 |
19 |
20 |
21 |
22 |
23 |
24 |
25 |
26 |
27 |
28 |
29 |
30 |
31 |
32 |
33 |
34 |
35 |
36 |
37 |
38 |
39 |
40 |
41 |   (and (lisp-fun man-int:get-action-gripper-opening ?container ?gripper-opening)
42 |         (spec-property ?objects (?current-object-designator))
43 |         (-> (equal ?arm ?left)
44 |
45 |
46 |
47 |
48 |
49 |
50 |         (and (lisp-fun man-int:get-action-trajectory :closing ?arm ?grasp T ?objects
51 |               (?left-closing-poses))
52 |             (equal ?left-closing-poses NIL))
53 |             (-> (equal ?right-closing-poses NIL))
54 |             (and (lisp-fun man-int:get-action-trajectory :closing ?arm ?grasp T ?objects
55 |                   (?right-closing-poses))
56 |                     (equal ?right-closing-poses NIL))
57 |                     (-> (spec-design-prop ?action-designator :collision-mode ?collision-mode)
58 |                         (equal ?collision-mode NIL))
59 |                         (design-designator :action (:type :closing)
60 |                           (spec-property ?current-object-designator :object-name ?object-name)
61 |                           (spec-property ?current-object-designator :name ?arm)
62 |                           (spec-property ?current-object-designator :gripper-opening ?gripper-opening)
63 |                           (spec-property ?current-object-designator :effort ?effort)
64 |                           (spec-property ?current-object-designator :grasp ?grasp)
65 |                           (spec-property ?current-object-designator :left-closing-poses ?left-closing-poses)
66 |                           (spec-property ?current-object-designator :right-closing-poses ?right-closing-poses)
67 |                           (spec-property ?current-object-designator :collision-mode ?collision-mode)
68 |                           (?resolved-action-designator)))
69 |
70 |
71 )

```

Figure 7: Left: Manual designator for the action *Closing* (47 lines). Right: Generated designator based on *Slicing* (40 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
29	36	8	3

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *object* instead of *container*)
- high focus on finding the fitting (gripping) poses for two robot arms
- generated designator ends by mapping variables to designator "parts"

```

1  |<- (design-action-grounding ?action-designator (close-container ?arm
2  |  |?gripper-opening
3  |  |?distance
4  |  |?left-reach-poses
5  |  |?right-reach-poses
6  |  |?left-grasp-poses
7  |  |?right-grasp-poses
8  |  |(?left-lift-poses)
9  |  |(?right-lift-poses)
10 |  |(?left-2nd-lift-poses)
11 |  |(?right-2nd-lift-poses)
12 |  |?point-name
13 |  |?environment-object)
14 |  |(spec:property ?action-designator :type :closing-container)
15 |  |(spec:property ?action-designator :object ?container-designator)
16 |  |(spec:property ?container-designator :type ?container-type))
17 |  |(obj-int:property ?container-designator :current-name ?container-name)
18 |  |(spec:property ?container-designator :parent ?left-environment)
19 |  |(spec:property ?container-designator :arm ?arm))
20 |  |(> (spec:property ?action-designator :arm ?arm))
21 |  |(true)
22 |  |(and (cram-robot-interfaces:robot ?robot)
23 |  |(cram-robot-interfaces:arm ?arm)
24 |  |(spec:property ?action-designator :collision-distance ?distance)
25 |  |(lisp-fun get-container-link ?container-name ?distance ?container-link)
26 |  |(lisp-fun get-connecting-joint ?container-link ?connecting-joint)
27 |  |(lisp-fun c-lift:name ?connecting-joint ?point-name)
28 |  |(lisp-fun btr:btr ?btr-environment ?environment-object)
29 |  |(lisp-fun obj-int:get-object-type ?gripper-opening ?container-type ?gripper-opening)
30 |  |(lisp-fun get-container-poses-and-transform ?container-name ?btr-environment
31 |  |(lisp-fun get-container-link ?container-link ?container-transform))
32 |  |(lisp-fun obj-int:get-object-type ?container-name ?container-name)
33 |  |(lisp-fun obj-int:get-object-poses ?container-name ?container-name)
34 |  |(lisp-fun obj-int:get-object-grasping-poses ?container-name
35 |  |(lisp-fun container-prismatic ?left-close ?container-transform ?left-poses)
36 |  |(lisp-fun container-prismatic ?right-close ?container-transform ?right-poses)
37 |  |(lisp-fun crm:mobile-pick-place-plan :extract:pick-up-manipulation-poses
38 |  |?arm ?left-poses ?right-poses
39 |  |?left-reach-poses ?right-reach-poses
40 |  |?left-grasp-poses ?right-grasp-poses
41 |  |?left-lift-poses ?right-lift-poses)
42 |  |(> (isp-pred identity ?left-poses))
43 |  |(> (isp-pred identity ?left-lift-poses))
44 |  |(equal ?left-poses (?left-lift-poses ?left-2nd-lift-poses))
45 |  |(equal ?left-poses (?left-lift-poses ?left-2nd-lift-poses)))
46 |  |(equal ?left-poses (?left-lift-poses ?left-2nd-lift-poses)))
47 |  |(equal ?right-poses (?right-lift-poses ?right-2nd-lift-poses))
48 |  |(equal ?right-poses (?right-lift-poses ?right-2nd-lift-poses)))
49 |  |(equal ?Nil ?Nil) (?right-lift-poses ?right-2nd-lift-poses))

1  |<- (design-action-grounding ?action-designator (close-container ?resolved-action-designator))
2  |  |(spec:property ?action-designator :type :closing-container)
3  |  |(spec:property ?action-designator :grasp ?grasp))
4  |  |(spec:property ?action-designator :arm ?arm))
5  |  |(spec:design-prop ?action-designator ?container ?container-designator)
6  |  |(design-current-designator ?container-designator ?current-container-designator)
7  |  |(spec:property ?current-container-designator :type ?container-type))
8  |  |(spec:property ?current-container-designator :current-container-designator)
9  |  |(equal ?container ?current-container-designator))

10 |  |(design-design-prop ?action-designator :collision-mode ?collision-mode)
11 |  |(lisp-fun (equal ?arm ?left)
12 |  |(and (lisp-fun get-trajectory ?closing-container ?arm ?current-grasp T ?container ?lists)
13 |  |(lisp-fun man-int:get-traj-poses-by-label ?lists ?closing-container
14 |  |?left-closing-poses)
15 |  |(lisp-fun man-int:get-traj-poses-by-label ?lists :initial
16 |  |?left-initial-poses)
17 |  |(and (eq ?left ?left-closing-poses NIL)
18 |  |(equal ?left ?left-initial-poses NIL)))
19 |  |(lisp-fun (equal ?arm ?right)
20 |  |(and (lisp-fun get-trajectory ?closing-container ?arm ?current-grasp T ?container ?lists)
21 |  |(lisp-fun man-int:get-traj-poses-by-label ?lists ?closing-container
22 |  |?right-closing-poses)
23 |  |(lisp-fun man-int:get-traj-poses-by-label ?lists :initial
24 |  |?right-initial-poses)
25 |  |(and (eq ?right ?right-closing-poses NIL)
26 |  |(equal ?right ?right-initial-poses NIL)))
27 |  |(design-designator ?action-designator ?closing-container)
28 |  |(collision-mode ?closing-container)
29 |  |(left-closing-poses ?left-closing-poses)
30 |  |(right-closing-poses ?right-closing-poses)
31 |  |(left-initial-poses ?left-initial-poses)
32 |  |(right-initial-poses ?right-initial-poses))
33 |  |(equal ?Nil ?Nil) ?resolved-action-designator)

```

Figure 8: Left: Manual designator for the action *Closing* (47 lines). Right: Generated designator based on *Wiping* (32 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
20	35	12	0

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *designator* instead of *type*)
- generated designator focuses on the necessary poses and trajectories
- generated designator ends by mapping variables to designator "parts"

```

1  :-> (design action-grounding ?action-designator (slice-in-half ?resolved-action-designator))
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
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21
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61
62
63
64
65
66
67
68
69
70
71
72
73

```

```

1  :-> (design action-grounding ?action-designator (halve ?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    ?left-lift-poses
9    ?right-lift-poses
10   ?left-2nd-lift-poses
11   ?right-2nd-lift-poses
12   ?joint-name
13   ?environment-obj))
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
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69
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71
72
73

```

Figure 9: Left: Manual designator for the action *Halving* (58 lines). Right: Generated designator based on *Closing* (47 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
31	42	14	2

Findings:

- designator definition contains 13 variables instead of only one
- some minor renaming (e.g. *cutting* instead of *halving*)
- generated designator does not cover the "cutting" part but focuses mainly on poses
- generated designator does not end by mapping variables to designator "parts"
- generation adds block about **cram-robot-interfaces** (2 lines)

```

1  ;< (design-action-grounding ?action-designator (slice-in-half ?resolved-action-designator))
2  (spec:property ?action-designator (:type :shaving))
3  (spec:property ?action-designator (?object ?object-designator))
4  (design-current-designator ?object-designator ?current-object-desig)
5  (spec:property ?current-object-desig (:type ?object-type))
6  (spec:property ?current-object-desig (:name ?object-name))
7
8
9
10
11
12
13
14
15
16
17
18
19
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21
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43
44
45
46
47
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49
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55
56
57
58
59
60

1  ;< (design-action-grounding ?action-designator (ip-plans-cut ?resolved-action-designator))
2  (spec:property ?action-designator (:type :shaving))
3  (spec:property ?action-designator (?object ?object-designator))
4  (design-current-designator ?object-designator ?current-object-desig)
5  (spec:property ?current-object-desig (:type ?object-type))
6  (spec:property ?current-object-desig (:name ?object-name))
7  (lisp-fun man-int-get-object-transform ?current-object-desig ?object-transform)
8  (lisp-fun man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
9  (> (man-int-object-rotationally-symmetric ?object-type)
10  (equal ?rotationally-symmetric nil))
11  (> (spec:property ?action-designator (grasp ?grasp))
12  (true))
13  (and (lisp-fun man-int-get-action-grasps ?object-type ?arm ?object-transform ?grasps)
14  (member ?grasp ?grasps)))
15  (> (spec:property ?action-designator (?object-half-pose ?object-half-pose))
16  (true))
17  (format "Please infer where to cut the object, or use the query system to infer it here")
18  (lisp-fun man-int-get-action-gripping-effort ?object-type ?effort)
19  (lisp-fun man-int-get-action-gripper-opening ?object-type ?gripper-opening)
20  (equal ?objects (?current-object-desig))
21  (> (equal ?arm ?left)
22  (and (lisp-fun man-int-get-action-trajectory :halving ?arm ?grasp ?objects
23  ?left-halving-poses)
24  (lisp-fun man-int-get-traj-poses-by-label ?left-halving-poses :halving-up
25  ?left-slice-up-poses)
26  (lisp-fun man-int-get-traj-poses-by-label ?left-halving-poses :halving-down
27  ?left-slice-down-poses))
28  (and (equal ?left-slice-up-poses NIL)
29  (equal ?left-slice-down-poses NIL)))
30  (> (equal ?arm ?right)
31  (and (lisp-fun man-int-get-action-trajectory :halving ?arm ?grasp ?objects
32  ?right-halving-poses)
33  (lisp-fun man-int-get-traj-poses-by-label ?right-halving-poses :halving-up
34  ?right-slice-up-poses)
35  (lisp-fun man-int-get-traj-poses-by-label ?right-halving-poses :slice-down
36  ?right-slice-down-poses))
37  (and (equal ?right-slice-up-poses NIL)
38  (equal ?right-slice-down-poses NIL)))
39  (> (design:desig-prop ?action-designator (collision-mode ?collision-mode))
40  (true))
41  (equal ?collision-mode nil))
42  (design:designator action (:type :shaving)
43  (?object ?current-object-desig)
44  (?object-name ?object-name)
45  (?arm ?arm)
46  (?gripper-opening ?gripper-opening)
47  (?effort ?effort)
48  (?grasp ?grasp)
49  (?left-slice-up-poses ?left-slice-up-poses)
50  (?right-slice-up-poses ?right-slice-up-poses)
51  (?left-slice-down-poses ?left-slice-down-poses)
52  (?right-slice-down-poses ?right-slice-down-poses)
53  (?collision-mode ?collision-mode))
54  (?resolved-action-designator))

1  ;< (design-action-grounding ?action-designator (ip-plans-cut ?resolved-action-designator))
2  (spec:property ?action-designator (:type :shaving))
3  (spec:property ?action-designator (?object ?object-designator))
4  (design-current-designator ?object-designator ?current-object-desig)
5  (spec:property ?current-object-desig (:type ?object-type))
6  (spec:property ?current-object-desig (:name ?object-name))
7  (lisp-fun man-int-get-object-transform ?current-object-desig ?object-transform)
8  (lisp-fun man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
9  (> (spec:property ?action-designator (?arm ?arm))
10  (true))
11  (man-int:robot-free-hand ?_ ?arm))
12
13
14
15
16
17
18
19
20
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22
23
24
25
26
27
28
29
30
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53
54
55
56
57
58
59
60
?resolved-action-designator)

```

Figure 10: Left: Manual designator for the action *Halving* (58 lines). Right: Generated designator based on *Holding* (48 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
3	13	29	16

Findings:

- some minor renaming (e.g. *cutting* instead of *halving*)
- generated designator does not cover the necessary poses for "halving" (*?object-half-pose*)

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1  :-> (desig.action-grounding ?action-designator (slice-in-half ?resolved-action-designator))
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13  | :-> (spec.property ?action-designator (:type :halving))
14  | :-> (spec.property ?action-designator (:object ?object-designator))
15  | :-> (design.current-designator ?object-designator ?current-object-design)
16  | :-> (spec.property ?current-object-desig (:type ?object-type))
17  | :-> (spec.property ?current-object-desig (:name ?object-name))
18  | :-> (> (spec.property ?action-designator (:arm ?arm))
19  |   (true)
20  |   (man-int:robot-free-hand ?, ?arm))
21  |   (lisp-fun man-int:get-object-old-transform ?current-object-design ?object-transform)
22  |   (lisp-fun man-int:calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face))
23  |   (equal ?rotationally-symmetric t)
24  |   (equal ?rotationally-symmetric nil))
25  |   (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
26  |   (member ?grasp ?grasps))
27  |   (spec.property ?action-designator (:grasp ?grasp))
28  |   (true)
29  |   (> (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
30  |     (member ?grasp ?grasps)))
31  |   (spec.property ?action-designator (:object-half-pose ?object-half-pose))
32  |   (true)
33  |   (format "Please infer where to cut the object, or use the query system to infer it here")
34  |   (> (lisp-fun man-int:get-action-grasping-effort ?object-type ?effort)
35  |     (lisp-fun man-int:cram-robot-interface-gripper-opening ?object-type ?gripper-opening)
36  |     (equal ?object ?current-object-design))
37  |     (=> (equal ?arm ?left)
38  |       (and (lisp-fun man-int:get-action-trajectory :halving ?arm ?grasp T ?objects
39  |         ?left-halving-pose)
40  |         (lisp-fun man-int:get-traj-poses-by-label ?left-halving-pose :halving-up
41  |           ?left-slice-up-poses)
42  |           (lisp-fun man-int:get-traj-poses-by-label ?left-halving-pose :halving-down
43  |             ?left-slice-down-poses))
44  |             (and ?left-slice-up-poses NIL)
45  |               (equal ?left-slice-down-poses NIL)))
46  |               (=> (equal ?arm ?right)
47  |                 (and (lisp-fun man-int:get-action-trajectory :halving ?arm ?grasp T ?objects
48  |                   ?right-halving-pose)
49  |                     (lisp-fun man-int:get-traj-poses-by-label ?right-halving-pose :halving-up
50  |                       ?right-slice-up-poses)
51  |                         (lisp-fun man-int:get-traj-poses-by-label ?right-halving-pose :slice-down
52  |                           ?right-slice-down-poses))
53  |                           (and ?equal ?right-slice-up-poses NIL)
54  |                             (equal ?right-slice-down-poses NIL)))
55  |                             (=> (design.desig-prop ?action-designator (:collision-mode ?collision-mode))
56  |                               (true)
57  |                               (equal ?collision-mode nil))
58  |                               (desig.designator ((type :halving)
59  |                                 (:object ?current-object-design)
60  |                                 (:object-name ?object-name)
61  |                                 (:arm ?arm)
62  |                                 (:gripper-opening ?gripper-opening)
63  |                                 (:effort ?effort)
64  |                                 (:grasp ?grasp)
65  |                                 (:left-slice-up-poses ?left-slice-up-poses)
66  |                                 (:right-slice-up-poses ?right-slice-up-poses)
67  |                                 (:left-slice-down-poses ?left-slice-down-poses)
68  |                                 (:right-slice-down-poses ?right-slice-down-poses)
69  |                                 (:collision-mode ?collision-mode))
70  |                                 ?resolved-action-designator)))
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1  :-(< (design.action-grounding ?action-designator (slice-in-half ?resolved-action-designator))
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Figure 12: Left: Manual designator for the action *Halving* (58 lines). Right: Generated designator based on *Picking Up* (45 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
29	42	13	3

Findings:

- designator definition contains 12 variables instead of only one
- some minor renaming (e.g. *cutting* instead of *halving*)
- generated designator does not cover the "cutting" part but focuses mainly on poses
- generated designator does not end by mapping variables to designator "parts"
- generation adds block about **cram-robot-interfaces** (2 lines)

```

1  | (spec:property ?action-designator (type :halving))
2  | (spec:property ?action-designator (object ?object-designator))
3  | (spec:property ?current-designator ?object-designator ?current-object-desig)
4  | (spec:property ?current-object-desig (type ?object-type))
5  | (spec:property ?current-object-desig (name ?object-name))
6  | (spec:property ?current-object-desig (name ?object-name))
7  | (true)
8  | (man-int:robot-free-hand ?, ?arm)
9  | (lisp-fun man-int:get-object-old-transform ?current-object-desig ?object-transform)
10 | (lisp-fun man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
11 | (man-int:object-rotationally-symmetric ?object-type)
12 | (and (man-int:object-rotationally-symmetric t)
13 |       (spec:property ?object-type nil))
14 | (spec:property ?action-designator (grasp ?grasp))
15 | (true)
16 | (and (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
17 |       (member ?grasp ?grasps)))
18 |
19 | (spec:property ?action-designator (object-half-pose ?object-half-pose))
20 | (true)
21 | (format "Please infer where to cut the object, or use the query system to infer it here")
22 | (lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
23 | (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
24 | (equal ?objects ?current-object-designator)
25 | (>= ?equal ?arm :left)
26 | (and (lisp-fun man-int:get-action-trajectory :halving ?arm ?grasp T ?objects
27 |           ?left-halving-pose)
28 |       (lisp-fun man-int:get-traj-poses-by-label ?left-halving-pose :halving-up
29 |           ?left-slice-up-poses)
30 |       (lisp-fun man-int:get-traj-poses-by-label ?left-halving-pose :halving-down
31 |           ?left-slice-down-poses))
32 |     (and (equal ?left-slice-up-poses NIL)
33 |           (equal ?left-slice-down-poses NIL)))
34 | (>= ?equal ?arm :right)
35 | (and (lisp-fun man-int:get-action-trajectory :halving ?arm ?grasp T ?objects
36 |           ?right-halving-pose)
37 |       (lisp-fun man-int:get-traj-poses-by-label ?right-halving-pose :slice-down
38 |           ?right-slice-down-poses))
39 |     (and (equal ?right-slice-up-poses NIL)
40 |           (equal ?right-slice-down-poses NIL)))
41 | (spec:design-prop ?action-designator (collision-mode ?collision-mode))
42 | (true)
43 | (equal ?collision-mode nil)
44 | (spec:designator ?action (type :halving)
45 |   (object ?current-object-designator)
46 |   (object-name ?object-name)
47 |   (arm ?arm)
48 |   (gripper-opening ?gripper-opening)
49 |   (effector ?effector)
50 |   (grasp ?grasp)
51 |   (left-slice-up-poses ?left-slice-up-poses)
52 |   (right-slice-up-poses ?right-slice-up-poses)
53 |   (left-slice-down-poses ?left-slice-down-poses)
54 |   (right-slice-down-poses ?right-slice-down-poses)
55 |   (collision-mode ?collision-mode))
56 | ?resolved-action-designator)
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```



```

1  | (spec:property ?action-designator (type :cutting))
2  | (spec:property ?action-designator (arm ?arm))
3  | (spec:property ?action-designator (object ?object-designator))
4  | (left-reach-poses ?left-reach-poses)
5  | (left-cut-poses ?left-cut-poses)
6  | (left-retract-poses ?left-retract-poses)
7  | (right-reach-poses ?right-reach-poses)
8  | (right-cut-poses ?right-cut-poses)
9  | (right-retract-poses ?right-retract-poses)
10 | (or (cpe:object-in-hand ?object-designator ?arm)
11 |      (and (format "WARNING: Wanted to cut an object ~a with an arm ~a, ~
12 |           but it's not in the arm, ~%" ?object-designator ?arm)
13 |            (cpe:object-in-hand ?object-designator ?arm)))
14 |      (spec:object-in-hand ?object-designator ?arm))
15 |
16 | (spec:property ?action-designator (object ?object-designator))
17 | (cpe:object-in-hand ?object-designator ?arm)
18 | (and (cram-robot-interfaces:robot ?robot)
19 |       (cpe:object-in-hand ?object-designator ?arm))
20 | (once (or (cpe:object-in-hand ?object-designator ?arm)
21 |           (spec:property ?action-designator (object ?object-designator)))
22 |           (spec:current-object-designator (type ?object-type)))
23 |           (spec:current-object-designator (name ?object-name)))
24 |           (obj-type ?object-type ?grasp ?object-type ?grasp))
25 |           (lisp-fun obj-int:get-object-transform ?current-object-designator ?object-transform)
26 |           (lisp-fun obj-int:get-object-poses ?current-object-designator ?object-poses)
27 |           (lisp-fun obj-int:get-object-bounding-box ?current-object-designator ?object-bbox)
28 |           (lisp-fun extract-cutting-poses ?arm ?object-poses ?object-bbox ?object-transform)
29 |
30 |           (lisp-fun extract-manipulation-poses ?arm ?left-cut-poses ?right-cut-poses
31 |               ?left-reach-poses ?right-reach-poses ?left-retract-poses ?right-retract-poses))
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44 |
45 | (spec:property ?left-cut-poses ?right-cut-poses)
46 | (lisp-fun extract-manipulation-poses ?arm ?left-cut-poses ?right-cut-poses
47 |     ?left-reach-poses ?right-reach-poses ?left-retract-poses ?right-retract-poses))
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```

Figure 13: Left: Manual designator for the action *Halving* (58 lines). Right: Generated designator based on *Placing Down* (30 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
21	49	8	1

Findings:

- designator definition contains 4 variables instead of only one
- generated designator does not cover the "cutting" part but focuses mainly on poses / trajectories
- generated designator does not end by mapping variables to designator "parts"
- generation adds block about **cram-robot-interfaces** (3 lines)

```

1  <- (design-action-grounding ?action-designator (slice-in-half ?resolved-action-designator))
2  (spec:property ?action-designator (:type :halving))
3  (spec:property ?action-designator (?object ?object-designator))
4  (design-current-designator ?object-designator ?current-object-design)
5  (spec:property ?current-object-design (:type ?object-type))
6  (spec:property ?current-object-design (?name ?object-name))
7
8  (> (spec:property ?action-designator (?arm ?arm))
9    (true)
10   (> (lisp-fun man-int-get-object-old-transform ?current-object-design ?object-transform)
11     (lisp-fun man-int-calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face)))
12   (> (man-int-object-rotationally-symmetric ?object-type)
13     (equal ?rotationally-symmetric t)
14   (> (spec:property ?action-designator (:grasp ?grasp))
15     (true)
16   (> (and (lisp-fun man-int-get-action-grasps ?object-type ?arm ?object-transform ?grasps)
17     (member ?grasp ?grasps)))
18   (> (spec:property ?action-designator (?object-half-pose ?object-half-pose))
19     (true)
20   (format "Please infer where to cut the object, or use the query system to infer it here")
21   (lisp-fun man-int-get-action-gripping-effort ?object-type ?effort)
22   (lisp-fun man-int-get-action-gripper-opening ?object-type ?gripper-opening)
23   (equal ?objects ?current-object-design)
24   (> (equal ?arm :left)
25     (and (lisp-fun man-int-get-action-trajectory :halving ?arm ?grasp T ?objects
26       ?effort)
27       (lisp-fun man-int-get-traj-poses-by-label ?left-halving-pose :halving-up
28         ?left-slice-up-poses)
29       (lisp-fun man-int-get-traj-poses-by-label ?left-halving-pose :halving-down
30         ?left-slice-down-poses)
31       (and (equal ?left-slice-up-poses NIL)
32         (equal ?left-slice-down-poses NIL)))
33   (> (equal ?arm :right)
34     (and (lisp-fun man-int-get-action-trajectory :halving ?arm ?grasp T ?objects
35       ?right-halving-pose)
36       (lisp-fun man-int-get-traj-poses-by-label ?right-halving-pose :halving-up
37         ?right-slice-up-poses)
38       (lisp-fun man-int-get-traj-poses-by-label ?right-halving-pose :halving-down
39         ?right-slice-down-poses)
40       (and (equal ?right-slice-up-poses NIL)
41         (equal ?right-slice-down-poses NIL)))
42   (> (design-desig-prop ?action-designator (:collision-mode ?collision-mode))
43     (true)
44   (> (equal ?collision-mode nil))
45   (> (design-designator :action (:type :halving)
46     (?object-name ?object-name)
47     (?arm ?arm)
48     (?gripper-opening ?gripper-opening)
49     (?effort ?effort)
50     (?grasp ?grasp)
51     (?left-slice-up-poses ?left-slice-up-poses)
52     (?right-slice-up-poses ?right-slice-up-poses)
53     (?left-slice-down-poses ?left-slice-down-poses)
54     (?right-slice-down-poses ?right-slice-down-poses)
55     (?collision-mode ?collision-mode))
56     ?resolved-action-designator)
57
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```



```

1  <- (design-action-grounding ?action-designator (halve ?resolved-action-designator))
2  (spec:property ?action-designator (:type :cutting))
3  (spec:property ?action-designator (?object ?object-designator))
4  (design-current-designator ?object-designator ?current-object-design)
5  (spec:property ?current-object-design (:type ?object-type))
6  (spec:property ?current-object-design (?name ?object-name))
7  (lisp-fun man-int-get-object-transform ?current-object-design ?object-transform)
8  (lisp-fun man-int-calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
9  (> (spec:property ?action-designator (?arms ?arms))
10    (true)
11   (> (and (man-int:robot-free-hand ?_ ?arm)
12     (equal ?arms (?arm))))
13
14
15
16
17
18  (> (spec:property ?action-designator (:grasp ?grasp))
19    (true)
20   (> (and (member ?arm ?arms)
21     (lisp-fun man-int-get-action-grasps ?object-type ?arm ?object-transform ?grasps)
22       (member ?grasp ?grasps)))
23
24
25
26  (lisp-fun man-int-get-action-gripping-effort ?object-type ?effort)
27  (lisp-fun man-int-get-action-gripper-opening ?object-type ?gripper-opening)
28  (equal ?objects ?current-object-design)
29  (> (member ?left ?arms)
30    (and (lisp-fun man-int-get-action-trajectory :cutting :left ?grasp T ?objects
31      ?effort)
32      (lisp-fun man-int-get-traj-poses-by-label ?left-cutting-pose :approach
33        ?left-approach-poses)
34      (lisp-fun man-int-get-traj-poses-by-label ?left-cutting-pose :cutting
35        ?left-cutting-poses)
36      (and (equal ?left-cutting-poses NIL)
37        (equal ?right-cutting-poses NIL)))
38  (> (member ?right ?arms)
39    (and (lisp-fun man-int-get-action-trajectory :cutting :right ?grasp T ?objects
40      ?right-cutting-pose)
41      (lisp-fun man-int-get-traj-poses-by-label ?right-cutting-pose :approach
42        ?right-approach-poses)
43      (lisp-fun man-int-get-traj-poses-by-label ?right-cutting-pose :cutting
44        ?right-cutting-poses)
45      (and (equal ?right-cutting-poses NIL)
46        (equal ?left-cutting-poses NIL)))
47  (> (design-desig-prop ?action-designator (:collision-mode ?collision-mode))
48    (true)
49  (> (equal ?collision-mode nil))
50  (> (design-designator :action (:type :cutting)
51    (?object ?current-object-design)
52    (?object-type ?object-type)
53    (?object-name ?object-name)
54    (?arms ?arms))
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?resolved-action-designator)

```

Figure 14: Left: Manual designator for the action *Halving* (58 lines). Right: Generated designator based on *Pouring* (53 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
5	10	29	19

Findings:

- mainly renaming (e.g. *cutting* instead of *halving*)
- generated designator does not cover the necessary poses for "halving" (*?object-half-pose*)
- generated designator shortens the mapping of variables to designator "parts" (misses the *:gripper-opening*)

Figure 15: Left: Manual designator for the action *Halving* (58 lines). Right: Generated designator based on *Slicing* (55 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
0	3	11	44

Findings:

- deleted lines describe block that is used for inferring the position / pose necessary for meeting the exact halve
 - deleted lines are the same that are added when the reference and generated action are swapped (Fig. 58)
 - remaining changes are places where the keyword *slicing* was not replaced by *halving*

```

1  | 1  | < (desig.action-grounding ?action-designator (slice-in-half ?resolved-action-designator))
2  | 2  |   (spec:property ?action-designator (:type :halving))
3  | 3  |   (spec:property ?action-designator ?object ?object-designator)
4  | 4  |   (spec:current-designator ?object-designator ?current-object-designator)
5  | 5  |   (spec:property ?current-object-designator (:type ?object-type))
6  | 6  |   (spec:property ?current-object-designator (:name ?object-name))
7  | 7  |   (spec:property ?action-designator (:arm ?arm))
8  | 8  |   (true)
9  | 9  |   (man-int:robot-free-hand 2 ?arm)
10 | 10 |   (lisp-fun:man-int:get-object-old-transform ?current-object-designator ?object-transform)
11 | 11 |   (lisp-fun:man-int:calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face)
12 | 12 |   (> (man-int:object-rotationally-symmetric ?object-type)
13 | 13 |     (equal ?rotationally-symmetric t)
14 | 14 |     (equal ?rotationally-symmetric nil))
15 | 15 |   (spec:property ?action-designator (:grasp ?grasp))
16 | 16 |   (true)
17 | 17 |   (and (lisp-fun:man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
18 | 18 |     (member ?grasp ?grasps))
19 | 19 |   (> (spec:property ?action-designator (:object-half-pose ?object-half-pose))
20 | 20 |     (true)
21 | 21 |     format "Please infer where to cut the object, or use the query system to infer it here")
22 | 22 |     (lisp-fun:man-int:get-action-gripping-effort ?object-type ?effort)
23 | 23 |     (lisp-fun:man-int:get-gripper-opening ?object-type ?gripper-opening)
24 | 24 |     (equal ?objects (?current-object ?designator))
25 | 25 |     (> (equal ?arm :left)
26 | 26 |       (and (lisp-fun:man-int:get-action-trajectory :halving) ?arm ?grasp T ?objects
27 | 27 |         ?left-halving-pose)
28 | 28 |         (lisp-fun:man-int:get-traj-poses-by-label ?left-halving-pose :halving-up)
29 | 29 |         (lisp-fun:man-int:get-traj-poses-by-label ?left-halving-pose :halving-down)
30 | 30 |         (lisp-fun:man-int:get-traj-poses-by-label ?left-halving-pose :halving-down-poses)
31 | 31 |         (lisp-fun:man-int:get-traj-poses-by-label ?left-slice-up-poses NIL)
32 | 32 |         (lisp-fun:man-int:get-traj-poses-by-label ?left-slice-down-poses NIL)
33 | 33 |       (> (equal ?arm :right)
34 | 34 |         (and (lisp-fun:man-int:get-action-trajectory :halving) ?arm ?grasp T ?objects
35 | 35 |           ?right-halving-pose)
36 | 36 |           (lisp-fun:man-int:get-traj-poses-by-label ?right-halving-pose :halving-up)
37 | 37 |           (lisp-fun:man-int:get-traj-poses-by-label ?right-halving-pose :slice-down)
38 | 38 |           (lisp-fun:man-int:get-traj-poses-by-label ?right-halving-pose :slice-down-poses)
39 | 39 |           (lisp-fun:man-int:get-traj-poses-by-label ?right-slice-up-poses NIL)
40 | 40 |           (lisp-fun:man-int:get-traj-poses-by-label ?right-slice-down-poses NIL)
41 | 41 |         (> (spec:design-prop ?action-designator (:collision-mode ?collision-mode))
42 | 42 |           (true)
43 | 43 |           (equal ?collision-mode nil))
44 | 44 |         (desig:designator :action (:type :halving)
45 | 45 |           (object ?current-object-designator)
46 | 46 |           (object-name ?object-name)
47 | 47 |           (arm ?arm)
48 | 48 |           (gripper-opening ?gripper-opening)
49 | 49 |           (effort ?effort)
50 | 50 |           (grasp ?grasp)
51 | 51 |           (left-slice-up-poses ?left-slice-up-poses)
52 | 52 |           (right-slice-up-poses ?right-slice-up-poses)
53 | 53 |           (left-slice-down-poses ?left-slice-down-poses)
54 | 54 |           (right-slice-down-poses ?right-slice-down-poses)
55 | 55 |           (collision-mode ?collision-mode)))
56 | 56 |         (?resolved-action-designator))
57 | 57 |
58 | 58 |

```



```

1  | 1  | < (desig.action-grounding ?action-designator (halve ?resolved-action-designator))
2  | 2  |   (spec:property ?action-designator (:type :cutting))
3  | 3  |   (spec:property ?action-designator (:grasp ?grasp))
4  | 4  |   (spec:property ?action-designator (:arm ?arm))
5  | 5  |   (spec:design-prop ?action-designator (:object ?object ?object-designator))
6  | 6  |   (spec:current-designator ?object-designator ?current-object-designator)
7  | 7  |   (spec:property ?current-object-designator (:type ?object-type))
8  | 8  |   (spec:property ?current-object-designator (?current-object-designator))
9  | 9  |   (equal ?object (?current-object-designator))
10 | 10 |   (> (equal ?grasp :pinching)
11 | 11 |     (and (lisp-fun:differentiate-object-types ?grasp ?object ?current-grasp)
12 | 12 |       (equal ?grasp ?current-grasp))
13 | 13 |       (spec:design-prop ?action-designator (:collision-mode ?collision-mode)))
14 | 14 |
15 | 15 |   (> (equal ?arm :left)
16 | 16 |     (and (lisp-fun:get-trajectory :cutting) ?arm ?current-grasp T ?object ?lists)
17 | 17 |       (lisp-fun:man-int:get-traj-poses-by-label ?lists :cutting
18 | 18 |         ?left-cutting-poses)
19 | 19 |       (lisp-fun:man-int:get-traj-poses-by-label ?lists :initial
20 | 20 |         ?left-initial-poses))
21 | 21 |       (and (equal ?left-cutting-poses NIL)
22 | 22 |         (equal ?left-initial-poses NIL))
23 | 23 |       (> (equal ?arm :right)
24 | 24 |         (and (lisp-fun:get-trajectory :cutting) ?arm ?current-grasp T ?object ?lists)
25 | 25 |           (lisp-fun:man-int:get-traj-poses-by-label ?lists :cutting
26 | 26 |             ?right-cutting-poses)
27 | 27 |             (lisp-fun:man-int:get-traj-poses-by-label ?lists :initial
28 | 28 |               ?right-initial-poses))
29 | 29 |             (and (equal ?right-cutting-poses NIL)
30 | 30 |               (equal ?right-initial-poses NIL))
31 | 31 |             (desig:designator :action (:type :cutting)
32 | 32 |               (collision-mode ?collision-mode)))
33 | 33 |
34 | 34 |             (left-cutting-poses ?left-cutting-poses)
35 | 35 |             (right-cutting-poses ?right-cutting-poses)
36 | 36 |             (left-initial-poses ?left-initial-poses)
37 | 37 |             (right-initial-poses ?right-initial-poses)))
38 | 38 |
39 | 39 |
40 | 40 |
41 | 41 |
42 | 42 |
43 | 43 |
44 | 44 |
45 | 45 |
46 | 46 |
47 | 47 |
48 | 48 |
49 | 49 |
50 | 50 |
51 | 51 |
52 | 52 |
53 | 53 |
54 | 54 |
55 | 55 |
56 | 56 |
57 | 57 |
58 | 58 |

```

Figure 16: Left: Manual designator for the action *Halving* (58 lines). Right: Generated designator based on *Wiping* (35 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
5	28	27	3

Findings:

- some minor renaming (e.g. *cutting* instead of *halving*)
- generated designator does not cover the necessary poses for "halving" (*?object-half-pose*)
- generated designator shortens the mapping of variables to designator "parts" (misses *:object*, *:object-name*, *:arm*, *:gripper-opening*, *:effort* and *:grasp*)

```

1  <- (desig.action-grounding ?action-designator (bp-plans:pick-up ?resolved-action-designator))
2
3   (spec:property ?action-designator (:type :holding))
4   (spec:property ?action-designator (?object ?object-designator))
5   (desig.current-designator ?object-designator ?current-object-desig)
6
7   (spec:property ?current-object-desig (:type ?object-type))
8   (spec:property ?current-object-desig (:name ?object-name))
9
10  (> (spec:property ?action-designator (:arm ?arm))
11    (true)
12
13  (lisp-fun man-int:get-object-transform ?current-object-desig ?object-transform)
14  (lisp-fun man-int:calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face)
15  (> (man-int:object-rotationally-symmetric ?object-type)
16    (equal ?rotationally-symmetric t)
17    (equal ?rotationally-symmetric nil))
18
19  (> (spec:property ?action-designator (grasp ?grasp))
20    (true)
21
22  (and (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
23
24  (> (lisp-fun man-int:get-action-grasps ?object-type ?effort)
25  (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
26  (equal ?objects (?current-object-design)))
27  (> (equal ?arm :left)
28
29  (and (lisp-fun man-int:get-action-trajectory :picking-up) ?arm ?grasp T ?objects
30
31  ?left-trajectory)
32  (lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :reaching
33  ?left-reach-poses)
34  (lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :grasping
35  ?left-grasp-poses))
36  (and (equal ?left-reach-poses NIL)
37  (equal ?left-grasp-poses NIL))
38
39  (> (equal ?arm :right)
40
41  (and (lisp-fun man-int:get-action-trajectory :picking-up) ?arm ?grasp T ?objects
42
43  ?right-trajectory)
44  (lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :reaching
45  ?right-reach-poses)
46  (lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :grasping
47  ?right-grasp-poses))
48  (and (equal ?right-reach-poses NIL)
49  (equal ?right-grasp-poses NIL))
50
51  (desig.designator :action (:type :picking-up)
52
53  (?object ?current-object-desig)
54
55  (?object-name ?object-name)
56  (?arm ?arm)
57  (?gripper-opening ?gripper-opening)
58  (?effort ?effort)
59  (?grasp ?grasp)
60  (?left-reach-poses ?left-reach-poses)
61  (?right-reach-poses ?right-reach-poses)
62  (?left-grasp-poses ?left-grasp-poses)
63  (?right-grasp-poses ?right-grasp-poses)
64
65  (?hold :holding))
66
67  ?resolved-action-designator)))

```



```

1  <- (desig.action-grounding ?action-designator (hold ?arm
2    ?gripper-opening
3    ?object-designator))
4
5   (spec:property ?action-designator (:type :holding))
6   (spec:property ?action-designator (?object ?object-designator))
7
8
9
10  (> (spec:property ?arm ?arm))
11  (true)
12
13  (and (cram-robot-interfaces:robot ?robot)
14  (cram-robot-interfaces:arm ?robot ?arm)))
15
16
17
18
19
20
21  (lisp-fun obj-int:get-object-type-gripper-opening
22  (spec:property ?object-designator (:type ?object-type))
23  (?gripper-opening)
24  (spec:property ?object-designator (:part-of ?environment))
25  (lisp-fun cram-robot-interfaces:object ?environment ?object-designator ?object)
26  (lisp-fun cram-robot-interfaces:grasp-object ?arm ?object ?gripper-opening)))
27
28
29
30
31
32
33
34
35
36
37
38
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41
42
43
44
45
46
47
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51
52
53
54

```

Figure 17: Left: Manual designator for the action *Holding* (52 lines). Right: Generated designator based on *Closing* (15 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
9	46	2	4

Findings:

- designator definition contains three variables instead of only one
- generated designator does not end by mapping variables to designator "parts"
- generation adds block about `cram-robot-interfaces` (2 lines)

```

1  :- (<- (design-action-grounding ?action-designator (hold ?resolved-action-designator))
2   | (spec:property ?action-designator :type :holding))
3   | (spec:property ?action-designator :object ?object-designator)
4   | (design current-designator ?object-designator ?current-object-design)
5   | (spec:property ?current-object-design :type ?object-type)
6   | (spec:property ?current-object-design :name ?object-name))
7   | (-> (spec:property ?action-designator :arm ?arm))
8   | (true)
9   | (man-int:robot-free-hand ?,?arm))
10  | (lisp-fun man-int:get-object-transform ?current-object-design ?object-transform)
11  | (lisp-fun man-int:calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face)
12  | (-> (man-int:object-rotationally-symmetric ?object-type)
13  | (equal ?rotationally-symmetric t)
14  | (equal ?rotationally-symmetric nil))
15  | (-> (spec:property ?action-designator :grasp ?gasp))
16  | (true)
17  | (and (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
18   | (member ?gasp ?grasps))
19  | (lisp-fun man-int:get-action-grapping-effort ?object-type ?effort)
20  | (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
21  | (equal ?objects (?current-object-design))
22  | (-> (equal ?arm :left)
23  | (and (lisp-fun man-int:get-action-trajectory :picking-up ?arm ?gasp T ?objects
24   | ?left-trajectory)
25  | (lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :reaching
26  | ?left-reach-poses)
27  | (lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :grasping
28  | ?left-grasp-poses))
29  | (and (equal ?left-grasp-poses NIL)
30  | (equal ?right-grasp-poses NIL)))
31  | (-> (equal ?arm :right)
32  | (and (lisp-fun man-int:get-action-trajectory :picking-up ?arm ?gasp T ?objects
33  | ?right-trajectory)
34  | (lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :reaching
35  | ?right-reach-poses)
36  | (lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :grasping
37  | ?right-grasp-poses))
38  | (and (equal ?right-reach-poses NIL)
39  | (equal ?right-grasp-poses NIL)))
40  | (design:designator :action ((type :picking-up)
41  | :object ?current-object-design)
42  | :object ?object-name)
43  | :object ?arm)
44  | :gripper-opening ?gripper-opening)
45  | :effort ?effort)
46  | :grasp ?gasp)
47  | (def-reach-poses ?left-reach-poses)
48  | (right-reach-poses ?right-reach-poses)
49  | (left-grasp-poses ?left-grasp-poses)
50  | (right-grasp-poses ?right-grasp-poses)
51  | (hold ?holding))
52  | ?resolved-action-designator))

1  :- (<- (design-action-grounding ?action-designator (hold ?resolved-action-designator))
2   | (spec:property ?action-designator :type :holding))
3   | (spec:property ?action-designator :object ?object-designator)
4   | (design current-designator ?object-designator ?current-object-design)
5   | (spec:property ?current-object-design :type ?object-type)
6   | (spec:property ?current-object-design :name ?object-name))
7   | (-> (spec:property ?action-designator :arm ?arm))
8   | (true)
9   | (man-int:robot-free-hand ?,?arm))
10  | (lisp-fun man-int:get-action-grasps ?object-type ?arm ?grasps)
11  | (member ?gasp ?grasps)
12  | (lisp-fun man-int:get-action-grapping-effort ?object-type ?effort)
13  | (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
14  | (equal ?objects (?current-object-design))
15  | (-> (equal ?arm :left)
16  | (and (lisp-fun man-int:get-action-trajectory :holding ?arm ?gasp T ?objects
17  | ?left-holding-poses)))
18  | (equal ?left-holding-poses NIL))
19  | (-> (equal ?arm :right)
20  | (and (lisp-fun man-int:get-action-trajectory :holding ?arm ?gasp T ?objects
21  | ?right-holding-poses))
22  | (equal ?right-holding-poses NIL)))
23  | (-> (design:designator :action ((type :holding)
24  | :object ?current-object-design)
25  | :object ?object-name)
26  | :object ?arm)
27  | :gripper-opening ?gripper-opening)
28  | :effort ?effort)
29  | :grasp ?gasp)
30  | (left-holding-poses ?left-holding-poses)
31  | (right-holding-poses ?right-holding-poses)
32  | (collision-mode ?collision-mode))
33  | (true)
34  | (equal ?collision-mode nil)))
35  | ?resolved-action-designator))

```

Figure 18: Left: Manual designator for the action *Holding* (52 lines). Right: Generated designator based on *Halving* (38 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
7	21	9	22

Findings:

- some minor renaming (e.g. *holding* instead of *picking up*)
- generated designator does not cover the necessary calculations regarding trajectories for reaching and/or grasping
- generated designator shortens the mapping of variables to designator "parts" (misses *:left-grasp-poses*, *:right-grasp-poses* and *:hold* but adds *:collision-mode*)

```

1  <- (design-action-grounding ?action-designator (np-plans:pick-up ?resolved-action-designator))
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54

```

```

1  <- (design-action-grounding ?action-designator (hold ?arm
2    ?gripper-closing
3    ?object-designator))
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54

```

Figure 19: Left: Manual designator for the action *Holding* (52 lines). Right: Generated designator based on *Opening* (10 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
4	46	2	4

Findings:

- designator definition contains three variables instead of only one
- generated designator does not end by mapping variables to designator "parts"
- generated designator contains almost no functionality (no trajectory calculations, etc.)
- generation adds block about `cram-robot-interfaces` (2 lines)

Figure 20: Left: Manual designator for the action *Holding* (52 lines). Right: Generated designator based on *Picking Up* (16 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
10	46	3	3

Findings:

- designator definition contains six variables instead of only one
 - generated designator does not end by mapping variables to designator "parts"
 - generated designator contains almost no functionality (no trajectory calculations, etc.)
 - generation adds block about `cram-robot-interfaces` (2 lines)

```

1  (-> (spec:property ?action-designator (:type :holding)))
2  (spec:property ?action-designator (:object ?object-designator))
3  (desig:current-designator ?object-designator ?current-object-desig)
4  (spec:property ?current-object-desig (:type ?object-type))
5  (spec:property ?current-object-desig (:name ?object-name))
6  (-> (spec:property ?action-designator (:arm ?arm)))
7
8  (true)
9
10 (-> (spec:property ?action-designator (:grasp ?grasp)))
11 (and (lisp-fun man-int: get-object-transform ?current-object-desig ?object-transform)
12 (lisp-fun man-int: calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
13 (<-> (man-int: object-rotationally-symmetric ?object-type)
14 (equal ?rotationally-symmetric t)
15 (equal ?rotationally-symmetric nil))
16 (-> (spec:property ?action-designator (:grasp ?grasp)))
17 (true)
18 (-> (spec:property ?action-designator (:member ?grasp ?grasps)))
19 (lisp-fun man-int: get-action-grasp-type ?object-type ?arm ?object-transform ?grasps)
20 (lisp-fun man-int: get-action-gripping-effort ?object-type ?effort)
21 (lisp-fun man-int: get-action-gripper-opening ?object-type ?gripper-opening)
22 (-> (spec:property ?objects (?current-object-desig)))
23 (-> (equal ?arm :left)
24 (and (lisp-fun man-int: get-action-trajectory :picking-up) ?arm ?grasp T ?objects
25 ?left-trajectory)
26 (lisp-fun man-int: get-traj-poses-by-label ?left-trajectory :reaching
27 ?left-reach-poses)
28 (lisp-fun man-int: get-traj-poses-by-label ?left-trajectory :grasping
29 ?left-grasp-poses))
30 (and (equal ?left-reach-poses NIL)
31 (equal ?left-grasp-poses NIL)))
32 (-> (equal ?arm :right)
33 (and (lisp-fun man-int: get-action-trajectory :picking-up) ?arm ?grasp T ?objects
34 ?right-trajectory)
35 (lisp-fun man-int: get-traj-poses-by-label ?right-trajectory :reaching
36 ?right-reach-poses)
37 (lisp-fun man-int: get-traj-poses-by-label ?right-trajectory :grasping
38 ?right-grasp-poses))
39 (and (equal ?right-reach-poses NIL)
40 (equal ?right-grasp-poses NIL)))
41 (desig:designator-action (:type :picking-up)
42 (object ?current-object-desig)
43 (object-name ?object-name)
44 (arm ?arm)
45 (gripper-opening ?gripper-opening)
46 (effort ?effort)
47 (grasp ?grasp)
48 (left-reach-poses ?left-reach-poses)
49 (right-reach-poses ?right-reach-poses)
50 (left-grasp-poses ?left-grasp-poses)
51 (right-grasp-poses ?right-grasp-poses)
52 (hold :holding))
?resolved-action-designator)))

```



```

1  (-> (spec:property ?action-designator (:type :holding)))
2  (spec:property ?action-designator (:object ?object-designator))
3
4
5
6
7  (-> (spec:property ?action-designator (:arm ?arm)))
8
9
10
11
12
13
14
15  (-> (spec:property ?action-designator (:object ?object-designator)))
16  (cpeo:object-in-hand ?object-designator ?arm))
17  (and (cram-robot-interfaces robot ?robot)
18  (cram-robot-interfaces arm ?robot ?arm))
19  (cpeo:object-in-hand ?object-designator ?arm)))
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52

```

Figure 21: Left: Manual designator for the action *Holding* (52 lines). Right: Generated designator based on *Placing Down* (8 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
4	48	2	2

Findings:

- generated designator does not end by mapping variables to designator "parts"
- generated designator contains almost no functionality (no trajectory calculations, etc.)
- generation adds block about `cram-robot-interfaces` (3 lines)

```

1  <- (design-action-grounding ?action-designator (ip-plans :pick-up ?resolved-action-designator))
2   (spec:property ?action-designator (:type :holding))
3   (spec:property ?action-designator (:object ?object-designator))
4   (design-current-designator ?object-designator ?current-object-design)
5   (spec:property ?current-object-design (:type ?object-type))
6   (spec:property ?current-object-design (:name ?object-name))
7   (-> (spec:property ?action-designator (:arm ?arm)))
8   (true)
9   (-> (man-int:robot-free-hand ?_ ?arm))
10  (lisp-fun man-int:get-object-faces ?current-object-design ?object-transform)
11  (lisp-fun man-int:calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face)
12  (-> (man-int:object-rotationally-symmetric ?object-type))
13  (equal ?rotationally-symmetric t)
14  (equal ?rotationally-symmetric nil)
15  (-> (spec:property ?action-designator (:grasp ?grasp)))
16  (true)
17
18  (-> (and (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
19   (member ?grasp ?grasps)))
20  (lisp-fun man-int:calc-grasping-effort ?object-type ?effort)
21  (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
22  (equal ?objects (?current-object-design))
23  (-> (equal ?arm :left))
24  (-> (and (lisp-fun man-int:get-action-trajectory :picking-up ?arm) ?grasp T ?objects
25   :left-trajectory))
26  (lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :reaching)
27  (-> (lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :grasping
28   ?left-grasp-poses))
29  (and (equal ?left-reach-poses NIL)
30  (equal ?left-grasp-poses NIL)))
31  (-> (equal ?arm :right))
32  (-> (and (lisp-fun man-int:get-action-trajectory :picking-up ?arm) ?grasp T ?objects
33   :right-trajectory))
34  (lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :reaching)
35  (-> (lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :grasping
36   ?right-grasp-poses))
37  (and (equal ?right-reach-poses NIL)
38  (equal ?right-grasp-poses NIL)))
39
40  (-> (design-designator :action (:type :picking-up)
41   :object ?current-object-design)
42
43   (:object-name ?object-name)
44   (:arm ?arm)
45   (:gripper-opening ?gripper-opening)
46   (:effort ?effort)
47   (:grasp ?grasp)
48   (:left-reach-poses ?left-reach-poses)
49   (:right-reach-poses ?right-reach-poses)
50   (:left-grasp-poses ?left-grasp-poses)
51   (:right-grasp-poses ?right-grasp-poses)
52   (:hold :holding))
53
54  ?resolved-action-designator))

```



```

1  <- (design-action-grounding ?action-designator (ip-plans :hold ?resolved-action-designator))
2   (spec:property ?action-designator (:type :holding))
3   (spec:property ?action-designator (:object ?object-designator))
4   (design-current-designator ?object-designator ?current-object-design)
5   (spec:property ?current-object-design (:type ?object-type))
6   (spec:property ?current-object-design (:name ?object-name))
7   (-> (spec:property ?action-designator (:arms ?arms)))
8   (true)
9   (-> (and (man-int:robot-free-hand ?_ ?arm)
10   (equal ?arms ?arm)))
11
12
13
14
15  (-> (spec:property ?action-designator (:grasp ?grasp)))
16  (true)
17  (+ (and (member ?arm ?arms)
18   (lisp-fun man-int:get-action-grasps ?object-type ?arm ?grasps)
19   (member ?grasp ?grasps)))
20  (lisp-fun man-int:calc-grasping-effort ?object-type ?effort)
21  (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
22  (equal ?objects (?current-object-design)))
23  (-> (member ?left ?arms))
24  (-> (and (lisp-fun man-int:get-action-trajectory :holding :left) ?grasp T ?objects
25   :left-holding-poses))
26  (lisp-fun man-int:get-traj-poses-by-label ?left-holding-poses :approach)
27
28
29
30  (-> (equal ?left-approach-poses))
31
32  (-> (member ?right ?arms))
33  (-> (and (lisp-fun man-int:get-action-trajectory :holding :right) ?grasp T ?objects
34   :right-holding-poses))
35  (lisp-fun man-int:get-traj-poses-by-label ?right-holding-poses :approach)
36
37
38  (-> (equal ?right-approach-poses))
39
40  (-> (design-designator :action (:type :holding)
41   :object ?current-object-design)
42
43   (:object-type ?object-type)
44   (:object-name ?object-name)
45   (:arms ?arms))
46
47
48  (:grasp ?grasp)
49  (:left-approach-poses ?left-approach-poses)
50  (:right-approach-poses ?right-approach-poses))
51
52
53
54  ?resolved-action-designator))

```

Figure 22: Left: Manual designator for the action *Holding* (52 lines). Right: Generated designator based on *Pouring* (39 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
4	17	20	15

Findings:

- some minor renaming (e.g. *approach* instead of *reach*)
- omits the rotational trajectory calculation
- generated designator shortens the mapping of variables to designator "parts" (misses *:arm*, *:gripper-opening*, *:effort*, *:left-grasp-poses*, *:right-grasp-poses* and *:hold* but adds *:object-type* and *:arms*)

```

1  |  [(<- (design-action-grounding ?action-designator (resplans:pick-up ?resolved-action-designator)))
2  |  |  [(spec:property ?action-designator :type :holding))
3  |  |  [(spec:property ?action-designator :object ?object-designator))
4  |  |  [(design-current-designator ?object-designator ?current-object-desig))
5  |  |  [(spec:property ?current-object-desig :type ?object-type))
6  |  |  [(spec:property ?current-object-desig :name ?object-name))
7  |  |  [(> (spec:property ?action-designator (:arm ?arm))))
8  |  |  [(true))
9  |  |  [(man-int:robot-free-hand ?_ ?arm)))
10 |  |  [(lisp-fun man-int:get-object-transform ?current-object-desig ?object-transform))
11 |  |  [(lisp-fun man-int:calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face)))
12 |  |  [(> (man-int:object-rotationally-symmetric ?object-type))
13 |  |  [(equal ?object-type ?rotationally-symmetric t))
14 |  |  [(equal ?rotationally-symmetric nil)))
15 |  |  [(> (spec:property ?action-designator (:grasp ?grasp))))
16 |  |  [(true))
17 |  |  [(lisp-fun man-int:get-action-grasp ?object-type ?arm ?object-transform ?grasps))
18 |  |  [(member ?grasp ?grasps)))
19 |  |  [(lisp-fun man-int:get-action-gripping-effort ?object-type ?effort))
20 |  |  [(lisp-fun man-int:get-action-grpper-opening ?object-type ?gripper-opening))
21 |  |  [(equal ?objects (?current-object-desig)))
22 |  |  [(> (equal ?arm :left)))
23 |  |  [(and (lisp-fun man-int:get-action-trajectory :picking-up ?arm ?grasp T ?objects)
24 |  |  [?left-trajectory))
25 |  |  [(lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :reaching)
26 |  |  [?left-reach-poses))
27 |  |  [(lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :grasping)
28 |  |  [?left-grasp-poses)))
29 |  |  [(and (equal ?left-reach-poses NIL))
30 |  |  [(equal ?left-grasp-poses NIL))))
31 |  |  [(> (equal ?arm :right)))
32 |  |  [(and (lisp-fun man-int:get-action-trajectory :picking-up ?arm ?grasp T ?objects)
33 |  |  [?right-trajectory))
34 |  |  [(lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :reaching)
35 |  |  [?right-reach-poses))
36 |  |  [(lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :grasping)
37 |  |  [?right-grasp-poses)))
38 |  |  [(and (equal ?right-reach-poses NIL))
39 |  |  [(equal ?right-grasp-poses NIL))))
40 |  |  [(design-designator :action ((:type :holding))
41 |  |  [(:object ?current-object-desig))
42 |  |  [(:object-name ?object-name))
43 |  |  [(:arm ?arm))
44 |  |  [(:gripper-opening ?gripper-opening))
45 |  |  [(:effort ?effort))
46 |  |  [(:grasp ?grasp))
47 |  |  [(:left-reach-poses ?left-reach-poses))
48 |  |  [(:right-reach-poses ?right-reach-poses))
49 |  |  [(:left-grasp-poses ?left-grasp-poses))
50 |  |  [(:right-grasp-poses ?right-grasp-poses))
51 |  |  [(:hold :holding)))
52 |  |  [(?resolved-action-designator)))

```



```

1  |  [(<- (design-action-grounding ?action-designator (:hold ?resolved-action-designator)))
2  |  |  [(spec:property ?action-designator :type :holding))
3  |  |  [(spec:property ?action-designator :object ?object-designator))
4  |  |  [(design-current-designator ?object-designator ?current-object-desig))
5  |  |  [(spec:property ?current-object-desig :type ?object-type))
6  |  |  [(spec:property ?current-object-desig :name ?object-name))
7  |  |  [(> (spec:property ?action-designator (:arm ?arm))))
8  |  |  [(true))
9  |  |  [(man-int:robot-free-hand ?_ ?arm)))
10 |  |  [(lisp-fun man-int:get-action-grasp ?object-type ?arm ?object-transform ?grasps))
11 |  |  [(member ?grasp ?grasps)))
12 |  |  [(lisp-fun man-int:get-action-gripping-effort ?object-type ?effort))
13 |  |  [(lisp-fun man-int:get-action-grpper-opening ?object-type ?gripper-opening))
14 |  |  [(equal ?objects (?current-object-desig)))
15 |  |  [(> (lisp-fun man-int:get-action-trajectory :holding ?arm ?grasp T ?objects)
16 |  |  [?holding-poses)))
17 |  |  [(design-designator :action ((:type :holding))
18 |  |  [(:object ?current-object-desig))
19 |  |  [(:object-name ?object-name))
20 |  |  [(:arm ?arm))
21 |  |  [(:gripper-opening ?gripper-opening))
22 |  |  [(:effort ?effort))
23 |  |  [(:grasp ?grasp))
24 |  |  [(:holding-poses ?holding-poses)))
25 |  |  [(?resolved-action-designator)))

```

Figure 23: Left: Manual designator for the action *Holding* (52 lines). Right: Generated designator based on *Slicing* (27 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
2	27	6	19

Findings:

- generated designator does not cover the necessary calculations regarding (rotational) trajectories for reaching and/or grasping
- generated designator shortens the mapping of variables to designator "parts" (misses *:left-reach-poses*, *:right-reach-poses*, *:left-grasp-poses*, *:right-grasp-poses* and *:hold* but adds a *:holding-poses*)

```

1  | (< (desig:action-grounding ?action-designator (pp-plans:pick-up ?resolved-action-designator)))
2  |   (spec:property ?action-designator (:type :holding))
3  |   (spec:property ?action-designator (:object ?object-designator))
4  |   (spec:current-designator ?object-designator ?current-object-desig)
5  |   (spec:property ?current-object-desig (:type ?object-type))
6  |   (spec:property ?current-object-desig (:name ?object-name))
7  |   (-> (spec:property ?action-designator (:arm ?arm))
8  |         (true)
9  |         (man-int:robot-free-hand ?_ ?arm))
10 |         (lisp-fun man-int:get-object-transform ?current-object-desig ?object-transform)
11 |         (lisp-fun man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
12 |         (-> (man-int:object-rotationally-symmetric ?object-type)
13 |             (equal ?rotationally-symmetric t)
14 |             (equal ?rotationally-symmetric nil))
15 |             (-> (spec:property ?action-designator (:grasp ?grasp))
16 |                   (true)
17 |                   (and (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
18 |                         (member ?grasp ?grasps)))
19 |                     (lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
20 |                     (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
21 |                     (equal ?objects (?current-object-desig)))
22 |                     (-> (equal ?arm :left)
23 |                           (and (lisp-fun man-int:get-action-trajectory :picking-up) ?arm ?grasp T ?objects
24 |                               ?left-trajectory)
25 |                               (lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :reaching)
26 |                               ?left-reach-poses)
27 |                               (lisp-fun man-int:get-traj-poses-by-label ?left-trajectory :grasping)
28 |                               ?left-grasp-poses)
29 |                               (and (equal ?left-reach-poses NIL)
30 |                                   (equal ?left-grasp-poses NIL)))
31 |                               (-> (equal ?arm :right)
32 |                                   (and (lisp-fun man-int:get-action-trajectory :picking-up) ?arm ?grasp T ?objects
33 |                                       ?right-trajectory)
34 |                                       (lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :reaching)
35 |                                       ?right-reach-poses)
36 |                                       (lisp-fun man-int:get-traj-poses-by-label ?right-trajectory :grasping)
37 |                                       ?right-grasp-poses)
38 |                                       (and (equal ?right-reach-poses NIL)
39 |                                           (equal ?right-grasp-poses NIL)))
40 |                                       (design:designator :action ((:type :picking-up)
41 |                                         (:object ?current-object-desig)
42 |                                         (:object-name ?object-name)
43 |                                         (:arm ?arm)
44 |                                         (:gripper-opening ?gripper-opening)
45 |                                         (:effort ?effort)
46 |                                         (:grasp ?grasp)
47 |                                         (:left-reach-poses ?left-reach-poses)
48 |                                         (:right-reach-poses ?right-reach-poses)
49 |                                         (:left-grasp-poses ?left-grasp-poses)
50 |                                         (:right-grasp-poses ?right-grasp-poses)
51 |                                         (:hold :holding)))
52 |                                         ?resolved-action-designator)))

```

Figure 24: Left: Manual designator for the action *Holding* (52 lines). Right: Generated designator based on *Wiping* (6 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
3	49	2	1

Findings:

- designator definition contains five variables instead of only one
- generated designator contains no functionality (no trajectory calculations, etc.)
- generated designator does not end by mapping variables to designator "parts"

```

1  (<- (design-action-grounding ?action-designator (open-container ?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-lift-poses
7    ?right-lift-poses
8    ?left-lift-pose)
9    (?right-lift-pose)
10   (?left-2nd-lift-pose)
11   (?right-2nd-lift-pose)
12   ?joint-name ?environment-obj))
13
14  (spec:property ?action-designator (:type :opening))
15  (spec:property ?action-designator (:object ?container-designator))
16  (spec:property ?container-designator (:type ?container-type))
17  (obj:int-object-type-subtype :container ?container-type)
18  (spec:property ?container-designator (:urdf-name ?container-name))
19  (spec:property ?container-designator (:part-of ?btr-environment))
20  (-> (spec:property ?action-designator (:arm ?arm))
21    (true)
22    (and (cram-robot-interfaces:robot ?robot)
23      (cram-robot-interfaces:arm ?robot ?arm)))
24  (spec:property ?action-designator (:distance ?distance))
25  (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
26  (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
27  (lisp-fun cl-urdfname ?connecting-joint ?joint-name)
28  (btr:bullet-world ?world)
29  (lisp-fun btr:object ?world ?btr-environment ?environment-obj)
30  (lisp-fun obj:int-get-object-type:gripper-opening ?container-type ?gripper-opening)
31  (lisp-fun get-container-poses-and-transform ?container-name ?btr-environment
32    (?container-prismatic ?left-open ?container-transform ?left-poses)
33    (?container-prismatic ?right-open ?container-transform ?right-poses)
34    (?lisp-fun cram:mobile:pick-place-plans:extract:pick-up-manipulation-poses
35      (?lisp-fun obj:int-get-object-grasping-poses ?container-name
36        :container-prismatic ?right :open ?container-transform ?right-poses)
37      (?lisp-fun obj:int-get-object-grasping-poses ?container-name
38        :left-poses ?right-poses
39        (?lisp-fun obj:int-get-object-grasping-poses ?right-poses
40          ?left-poses ?right-reach-poses
41          ?left-grasp-poses ?right-grasp-poses
42          ?left-lift-poses ?right-lift-poses)
43        (>- (lisp-pred identity ?left-lift-poses)
44          (equal) ?left-lift-poses ?left-lift-pose ?left-2nd-lift-pose)))
45        (-> (lisp-pred identity ?right-poses)
46          (equal) ?right-lift-poses ?right-lift-pose ?right-2nd-lift-pose)))
47          (equal) (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose)))))

```

Figure 25: Left: Manual designator for the action *Opening* (46 lines). Right: Generated designator based on *Closing* (36 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
1	11	5	30

Findings:

- ChatGPT replaces *grasping* and *picking up* with *release*, which has a different meaning
- additional line is due to a difference in formatting
- ChatGPT does not generate the necessary poses for lifting and how they are handled

```

1  | <- (design-action-grounding ?action-designator (open-container ?arm
2  |   ?gripper-opening
3  |   ?distance
4  |   ?left-reach-poses
5  |   ?right-reach-poses
6  |   ?left-grasp-poses
7  |   ?right-grasp-poses
8  |   ?left-lift-poses
9  |   ?right-lift-poses
10 |   ?left-2nd-lift-poses
11 |   ?right-2nd-lift-poses
12 |   ?joint-name ?environment-obj)
13 |
14 |   (spec:property ?action-designator (:type :opening))
15 |   (spec:property ?action-designator ?object ?container-designator)
16 |   (spec:property ?container-designator (:type ?container-type))
17 |   (obj-int:object-type-subtype ?container ?container-type)
18 |   (spec:property ?container-designator (curdf-name ?container-name))
19 |   (spec:property ?container-designator (part-of ?btr-environment))
20 |   (> (spec:property ?action-designator (?arm ?arm))
21 |     (true)
22 |     (and
23 |       (cram-robot-interfaces:robot ?robot)
24 |       (cram-robot-interfaces:arm ?robot ?arm)))
25 |
26 |   (spec:property ?action-designator (:distance ?distance))
27 |   (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
28 |   (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
29 |   (lisp-fun get-connecting-joint ?connecting-joint ?joint-name)
30 |   (bullet-world ?world)
31 |   (lisp-fun btr-object ?world ?btr-environment ?environment-obj)
32 |   (lisp-fun obj-int:get-object-type ?gripper-opening ?container-type ?gripper-opening)
33 |   (lisp-fun get-container-poses-and-transform ?container-name ?btr-environment
34 |     ?container-poses ?container-transform)
35 |
36 |   (lisp-fun obj-int:get-object-grasping-poses ?container-name
37 |     :container-prismatic ?right ?open ?container-transform ?right-poses)
38 |   (lisp-fun cram-mobile-pick-place-plans:extract-pick-up-manipulation-poses
39 |     ?arm ?left-poses ?right-poses
40 |     ?left-reach-poses ?right-reach-poses
41 |     ?left-grasp-poses ?right-grasp-poses
42 |     ?left-lift-poses ?right-lift-poses)
43 |
44 |   (> (lisp-pred identity ?left-lift-poses)
45 |     (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose))
46 |     (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
47 |
48 |   (> (lisp-pred identity ?right-lift-poses)
49 |     (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose))
50 |     (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose)))
51 |
52 |
53 |
54 |
55 |
56 |
57 |
58 |
59 |
60 |
61 |
62 |
63 |
64 |
65 |
66 |
67 |
68 )

```



```

1  | <- (design-action-grounding ?action-designator (open-container ?resolved-action-designator))
2  |   (spec:property ?action-designator (:type :opening))
3  |   (spec:property ?action-designator ?object ?object-designator)
4  |   (design-current-designator ?object-designator ?current-object-designator)
5  |   (true)
6  |   (spec:property ?current-object-designator (:type ?object-type))
7  |   (spec:property ?current-object-designator ?name ?object-name)
8  |   (> (spec:property ?action-designator (?arm ?arm))
9  |     (true)
10 |     (man-int:robot-free-hand ? ?arm))
11 |     (lisp-fun man-int:get-object-old-transform ?current-object-design ?object-transform)
12 |     (lisp-fun man-int:calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face))
13 |     (spec:property ?action-designator (?grasp ?grasp))
14 |     (true)
15 |     (and
16 |       (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
17 |         (member ?grasp ?grasps))
18 |       (spec:property ?action-designator (?object-half-pose ?object-half-pose))
19 |         (true)
20 |         (format "Please infer where to open the container, or use the query system to infer it here")
21 |         (lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
22 |         (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
23 |         (equal ?objects (?current-object-design))
24 |         (equal ?arm-left)
25 |         (and
26 |           (lisp-fun man-int:get-action-trajectory :opening ?arm ?grasp T ?objects)
27 |             (and
28 |               (lisp-fun man-int:get-traj-poses-by-label ?left-opening-pose :opening-up)
29 |                 (lisp-fun man-int:get-traj-poses-by-label ?left-opening-pose :opening-down)
30 |                   (lisp-fun man-int:get-traj-poses-by-label ?left-opening-down-poses)
31 |                     (and
32 |                       (equal ?left-opening-up-poses NIL)
33 |                         (equal ?left-opening-down-poses NIL))
34 |                       (equal ?arm-right)
35 |                         (and
36 |                           (lisp-fun man-int:get-action-trajectory :opening ?arm ?grasp T ?objects)
37 |                             (and
38 |                               (lisp-fun man-int:get-traj-poses-by-label ?right-opening-pose :opening-up)
39 |                                 (lisp-fun man-int:get-traj-poses-by-label ?right-opening-pose :opening-down)
40 |                                   (lisp-fun man-int:get-traj-poses-by-label ?right-opening-down-poses)
41 |                                     (and
42 |                                       (equal ?right-opening-up-poses NIL)
43 |                                         (equal ?right-opening-down-poses NIL))
44 |                                         (equal ?right-opening-down-poses NIL)))
45 |                                         (and
46 |                                           (lisp-fun man-int:get-traj-poses-by-label ?right-opening-pose :opening-up)
47 |                                             (lisp-fun man-int:get-traj-poses-by-label ?right-opening-pose :opening-down)
48 |                                               (lisp-fun man-int:get-traj-poses-by-label ?right-opening-down-poses)
49 |                                                 (and
50 |                                                   (equal ?right-opening-up-poses NIL)
51 |                                                     (equal ?right-opening-down-poses NIL)))
52 |
53 |                                         (and
54 |                                           (design-design-prop ?action ((?type :opening)
55 |                                             (?object ?current-object-design)
56 |                                             (?object-name ?object-name)
57 |                                             (?arm ?arm)
58 |                                             (?gripper-opening ?gripper-opening)
59 |                                             (?effort ?effort)
60 |                                             (?grasp ?grasp)
61 |                                             (?left-opening-up-poses ?left-opening-up-poses)
62 |                                               (lisp-fun man-int:get-traj-poses ?left-opening-up-poses)
63 |                                                 (lisp-fun man-int:get-traj-poses ?right-opening-up-poses)
64 |                                                   (lisp-fun man-int:get-traj-poses ?left-opening-down-poses)
65 |                                                     (lisp-fun man-int:get-traj-poses ?right-opening-down-poses)
66 |                                                       (collision-mode ?collision-mode))
67 |                                                       (resolved-action-designator)))
68 )

```

Figure 26: Left: Manual designator for the action *Opening* (46 lines). Right: Generated designator based on *Halving* (55 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
44	35	8	3

Findings:

- designator definition contains only one variable instead of 13
- designator performs unnecessary calculations (e.g. getting a *?object-half-pose*)
- designator calculates trajectories and poses in a different manner
- designator (falsely) ends by mapping the variables to designator "parts"

```

1  #:-(<- (design-action-grounding ?action-designator (open-container ?arm
2    ?upper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    ?left-1st-lift-poses
9    ?right-1st-lift-poses
10   ?left-2nd-lift-poses
11   ?right-2nd-lift-poses
12   ?joint-name ?environment-obj))
13   (spec-property ?action-designator (:type :opening))
14   (spec-property ?action-designator (:object ?container-designator))
15   (spec-property ?container-designator (:type ?container-type))
16   (obj-int-object-type-subtype :container ?container-type)
17   (spec-property ?container-designator (:url-name ?container-name))
18   (spec-property ?container-designator (:part-of ?btb-environment))
19
20  (> (spec-property ?action-designator (arm ?arm)
21    (true)
22    (and (cram-robot-interfaces:robot ?robot)
23      (cram-robot-interface:arm ?robot ?arm)))
24    (spec-property ?action-designator (?distance ?distance)
25      (spec-property ?distance (?bt-environment ?container-link)
26        (isp-fun get-connecting-joint ?container-link ?connecting-joint)
27        (isp-fun cl-urdf:name ?connecting-joint ?joint-name)
28        (btr:btr-world ?world)
29        (isp-fun btr:object ?world ?bt-environment ?environment-obj)
30
31    (lisp-fun obj-int:get-object-type? :gripper-opening ?container-type ?gripper-opening)
32    (lisp-fun get-container-pose-and-transform ?container-name ?bt-environment
33      (container-pose ?container-transform))
34
35    (lisp-fun obj-int:get-object-grasping-poses ?container-name
36      :container-prismatic-left :open ?container-transform ?left-poses)
37    (lisp-fun obj-int:get-object-grasping-poses ?container-name
38      :container-prismatic-right :open ?container-transform ?right-poses)
39    (lisp-fun cram-mobile-pick-place-plans:extract-pick-up-manipulation-poses
40      ?arm ?left-poses ?right-poses
41      (left-reach-poses ?right-reach-poses
42        ?left-grasp-poses ?right-grasp-poses
43
44      ?left-lift-poses ?right-lift-poses)
45    (> (isp-pred identity ?left-lift-poses
46      (equal ?left-lift-poses ?left-1st-lift-poses ?left-2nd-lift-poses)
47      (equal (nil nil) ?left-lift-poses ?left-2nd-lift-poses)))
48    (> (isp-pred identity ?right-lift-poses
49      (equal ?right-lift-poses ?right-lift-poses ?right-2nd-lift-poses)
50      (equal (nil nil) ?right-lift-poses ?right-2nd-lift-poses)))
51
52
53
54
55
56
57
58
59

```



```

1  #:-(<- (design-action-grounding ?action-designator (sp-plans:open-container ?resolved-action-designator))
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59

```

Figure 27: Left: Manual designator for the action *Opening* (46 lines). Right: Generated designator based on *Holding* (47 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
36	35	9	2

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *object* instead of *container*)
- designator calculates trajectories and poses in a different manner
- designator (falsely) ends by mapping the variables to designator "parts"

The figure shows two side-by-side code snippets. The left snippet is a manual designator for the action *Opening*, consisting of 46 lines of Lisp-like code. The right snippet is a generated designator based on *Picking Up*, consisting of 42 lines. Both snippets include line numbers and color-coded regions: pink for specific properties like gripper-opening, grey for general environment objects, green for container-related logic, and yellow for equality checks.

```

Left (Manual Designator for Opening):
1  <- (desig.action-grounding ?action-designator (open-container ?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    ?left-lift-poses)
9    (right-lift-poses)
10   (left-2nd-lift-poses)
11   (right-2nd-lift-poses)
12   ?joint-name ?environment-obj))
13   (spec.property ?action-designator (type :opening))
14   (spec.property ?action-designator (object ?container-designator))
15   (spec.property ?container-designator (type ?container-type))
16   (obj-int-object-type-subtype :container ?container-type)
17   (spec.property ?container-designator (urdf-name ?container-name))
18   (spec.property ?container-designator (part-of ?btr-environment))
19   (> (spec.property ?action-designator (arm ?arm))
20     (true)
21     (and (cram-robot-interfaces.robot ?robot)
22       (cram-robot-interfaces.arm ?robot ?arm)))
23     (spec.property ?action-designator (distance ?distance))
24     (llisp-fun get-container-link ?container-name ?btr-environment ?container-link)
25     (llisp-fun get-connecting-joint ?container-link ?connecting-joint)
26     (llisp-fun get-transform ?connecting-joint ?joint-name)
27     (btr-bullet-world ?world)
28     (llisp-fun btr-object ?world ?btr-environment ?environment-obj)
29     (llisp-fun obj-int-get-object-type-gripper-opening ?container-type ?gripper-opening)
30     (llisp-fun get-container-pose-and-transform ?container-name ?btr-environment
31     (container-pose ?container-transform))
32     (llisp-fun obj-int-get-object-grasping-poses ?container-name
33     :container-prismatic :left open) ?container-transform ?left-poses)
34     (llisp-fun obj-int-get-object-grasping-poses ?container-name
35     :container-prismatic :right open) ?container-transform ?right-poses)
36     (llisp-fun cram-mobile-pick-place-plans:extract-pick-up-manipulation-poses
37     ?arm ?left-poses ?right-poses
38     (?left-reach-poses ?right-reach-poses
39     ?left-grasp-poses ?right-grasp-poses
40     ?left-lift-poses ?right-lift-poses))
41     (> (llisp-pred identity ?left-lift-poses)
42       (equal (NIL NIL) (?left-lift-poses ?left-2nd-lift-poses)))
43       (> (llisp-pred identity ?right-lift-poses)
44         (equal ?right-lift-poses (right-lift-poses ?right-2nd-lift-poses)))
45       (equal (NIL NIL) (?right-lift-poses ?right-2nd-lift-poses))))
46

Right (Generated Designator for Picking Up):
1  <- (desig.action-grounding ?action-designator (open-container ?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    ?joint-name ?environment-obj))
9
10
11
12
13   (spec.property ?action-designator (type :opening))
14   (spec.property ?action-designator (object ?container-designator))
15   (spec.property ?container-designator (type ?container-type))
16   (obj-int-object-type-subtype :container ?container-type)
17   (spec.property ?container-designator (urdf-name ?container-name))
18   (spec.property ?container-designator (part-of ?btr-environment))
19   (> (spec.property ?action-designator (arm ?arm))
20     (true)
21     (and (cram-robot-interfaces.robot ?robot)
22       (cram-robot-interfaces.arm ?robot ?arm)))
23     (spec.property ?action-designator (distance ?distance))
24     (llisp-fun get-container-link ?container-name ?btr-environment ?container-link)
25     (llisp-fun get-connecting-joint ?container-link ?connecting-joint)
26     (llisp-fun get-transform ?connecting-joint ?joint-name)
27     (btr-bullet-world ?world)
28     (llisp-fun btr-object ?world ?btr-environment ?environment-obj)
29     (llisp-fun obj-int-get-object-type-gripper-opening ?container-type ?gripper-opening)
30     (llisp-fun get-container-pose-and-transform ?container-name ?btr-environment
31     (container-pose ?container-transform))
32     (llisp-fun obj-int-get-object-grasping-poses ?container-name
33     :container-prismatic :left open) ?container-transform ?left-poses)
34     (llisp-fun obj-int-get-object-grasping-poses ?container-name
35     :container-prismatic :right open) ?container-transform ?right-poses)
36     (llisp-fun cram-mobile-pick-place-plans:extract-pick-up-manipulation-poses
37     ?arm ?left-poses ?right-poses
38     (?left-reach-poses ?right-reach-poses
39     ?left-grasp-poses ?right-grasp-poses
40     ?left-lift-poses ?right-lift-poses))
41     (> (llisp-pred identity ?left-lift-poses)
42       (equal (NIL NIL) (?left-lift-poses NIL)))
43       (> (llisp-pred identity ?right-lift-poses)
44         (equal ?right-lift-poses NIL)))
45       (equal (NIL NIL) (?right-lift-poses NIL)))
46

```

Figure 28: Left: Manual designator for the action *Opening* (46 lines). Right: Generated designator based on *Picking Up* (42 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
1	5	3	38

Findings:

- ChatGPT does not define the necessary poses for lifting
- ChatGPT still uses these poses but in a simplified and wrong way

```

1  | (spec:property ?action-designator (:type :opening))
2  |   ?gripper-opening
3  |   ?distance
4  |   ?left-reach-poses
5  |   ?right-reach-poses
6  |   ?left-grasp-poses
7  |   ?right-grasp-poses
8  |   (?left-lift-poses)
9  |   (?right-lift-poses)
10 |   (?left-2nd-lift-poses)
11 |   (?right-2nd-lift-poses)
12 |   (?left-name ?environment-obj)
13 | 
14 |   (spec:property ?action-designator (:type :opening))
15 |   (spec:property ?action-designator (:object ?container-designator))
16 |   (spec:property ?container-designator (:type ?container-type))
17 |   (obj-int-object-type-subtype :container ?container-type)
18 |   (spec:property ?container-designator (:part-of ?btr-environment))
19 |   (> (spec:property ?action-designator (:arm ?arm))
20 |       (true)
21 |       (and (cram-robot-interface :robot ?robot)
22 |             (cram-robot-interface :arm ?robot ?arm)))
23 |   (spec:property ?action-designator (:distance ?distance))
24 |   (lisp:fun get-container-link ?container-name ?distance ?container-link)
25 |   (lisp:fun get-connecting-joint ?container-link ?connecting-joint)
26 |   (lisp:fun cl-urdf-name ?connecting-joint ?joint-name)
27 |   (lisp:fun br object-world ?btr-environment ?environment-obj)
28 |   (lisp:fun obj-int-get-object-type-gripper-opening ?container-type ?gripper-opening)
29 |   (lisp:fun get-container-pose-and-transform ?container-name ?btr-environment)
30 |   (lisp:fun get-container-pose-and-transform ?container-name ?btr-environment
31 |       (?container-pose ?pose ?transform))
32 |   (lisp:fun obj-int-get-prismatic-poses ?container-name)
33 |   (lisp:fun obj-int-get-object-grasping-poses ?container-name
34 |       :container-prismatic :left :open ?container-transform ?left-poses)
35 |   (lisp:fun obj-int-get-object-grasping-poses ?container-name
36 |       :container-prismatic :right :open ?container-transform ?right-poses)
37 |   (lisp:fun cram-mobile-pick-place-plans extract-pick-up-manipulation-poses
38 |       ?arm ?left-poses)
39 |   (?left-reach-poses ?right-reach-poses
40 |    ?left-grasp-poses ?right-grasp-poses
41 |    ?left-lift-poses ?right-lift-poses)
42 | 
43 |   (> (lisp:pred identity ?left-lift-poses)
44 |       (equal ?left-lift-poses ?right-lift-poses ?left-2nd-lift-poses)
45 |       (equal NIL NIL ?left-lift-poses ?right-2nd-lift-poses))
46 | 
47 |   (> (lisp:pred identity ?right-lift-poses)
48 |       (equal ?right-lift-poses ?right-lift-poses ?right-2nd-lift-poses)
49 |       (equal NIL NIL ?right-lift-poses ?right-2nd-lift-poses)))

```



```

1  | (spec:property ?action-designator (:type :opening))
2  |   (spec:property ?action-designator (:object ?container-designator))
3  |   (spec:property ?container-designator (:type ?container))
4  | 
5  |   (spec:property ?container-designator (:name ?container-name))
6  | 
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```

Figure 29: Left: Manual designator for the action *Opening* (46 lines). Right: Generated designator based on *Placing Down* (12 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
5	39	5	2

Findings:

- designator definition contains only one variable instead of 13
- designator contains only definitions, no assignments or calculations

```

1  #:(<- (desig:action-grounding ?action-designator (open-container ?arm
2    ?upper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    (?left-lift-pose)
8    (?right-lift-pose)
9    (?left-2nd-lift-pose)
10   (?right-2nd-lift-pose)
11   ?joint-name ?environment-object))
12 
13  (spec:property ?action-designator (:type :opening))
14  (spec:property ?action-designator (:object ?container-designator))
15  (spec:property ?container-designator (:type ?container-type))
16  (obj-int:object-type-subtype ?container ?container-type)
17  (spec:property ?container-designator (:uri-id ?name ?container-name))
18  (spec:property ?container-designator (:part-of ?btr-environment))
19 
20 
21 
22 
23 
24  (-> (spec:property ?action-designator (:arm ?arm)))
25 
26 
27 
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30 
31 
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40 
41 
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43 
44 
45 
46  (true)
47  (and)
48  (cram-robot-interfaces:robot ?robot)
49  (cram-robot-interfaces:arms ?robot ?arms)
50  (spec:property ?action-designator (:object ?object ?environment))
51  (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
52  (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
53  (lisp-fun cl-urdf:name ?connecting-joint ?joint-name)
54  (btr:bullet-world ?world)
55  (lisp-fun btr:object ?world ?btr-environment ?environment-object)
56  (lisp-fun obj-int:get-object-type:gripper-opening ?container-type ?gripper-opening)
57  (lisp-fun get-container-pose-and-transform ?container-name ?btr-environment
58  (?container-pose ?container-transform))
59  (lisp-fun obj-int:get-object-grasping-poses ?container-name
60  ?left-poses)
61  (lisp-fun cram-mobile:pick-place-plans:extract-pick-up-manipulation-poses
62  ?arm ?left-poses ?right-poses
63  ?left-reach-poses ?right-reach-poses
64  ?left-grasp-poses ?right-grasp-poses
65  ?left-lift-poses ?right-lift-poses)
66  (> (isp-pred identity ?left-poses)
67  (equal ?left-lift-poses ?left-poses ?left-2nd-lift-pose))
68  (equal (NIL NIL) ?left-lift-poses ?left-2nd-lift-pose))
69  (> (isp-pred identity ?right-poses)
70  (equal ?right-lift-poses ?right-lift-pose ?right-2nd-lift-pose))
71  (equal (NIL NIL) ?right-lift-poses ?right-2nd-lift-pose)))

```



```

1  #:(<- (desig:action-grounding ?action-designator (open-container ?resolved-action-designator))
2 
3 
4 
5 
6 
7 
8 
9 
10 
11 
12 
13  (spec:property ?action-designator (:type :opening))
14  (spec:property ?action-designator (:object ?object ?object-type))
15  (desig:current-designator ?object-designator ?current-object-design)
16  (spec:property ?current-object-design (:type ?object-type))
17  (spec:property ?current-object-design (:name ?object-name))
18  (spec:property ?action-designator (:arms ?arms))
19  (true)
20  (and)
21  (equal ?arms ?arm))
22  (lisp-fun man-int:get-object-transform ?current-object-design ?object-transform)
23  (lisp-fun man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
24  (-> (spec:property ?action-designator (:grasp ?grasp)))
25  (true)
26  (and)
27  (member ?arm ?arms)
28  (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
29  (member ?grasp ?grasps))
30  (lisp-fun man-int:get-left-gripping-effort ?object-type ?effort)
31  (lisp-fun man-int:left-action-gripper-opening ?object-type ?gripper-opening)
32  (equal ?objects ?current-object-design)
33  (> (member ?left ?arms)
34  (and)
35  (lisp-fun man-int:get-action-trajectory :opening :left ?grasp T ?objects)
36  (?left-opening-pose)
37  (lisp-fun man-int:get-traj-poses-by-label ?left-opening-pose :approach)
38  (?left-approach-poses))
39  (equal ?left-approach-poses NIL)
40  (> (member ?right ?arms)
41  (and)
42  (lisp-fun man-int:get-action-trajectory :opening :right ?grasp T ?objects)
43  (?right-opening-pose)
44  (lisp-fun man-int:get-traj-poses-by-label ?right-opening-pose :approach)
45  (?right-approach-poses))
46  (equal ?right-approach-poses NIL)
47  (-> (design-prop ?action-designator (:collision-mode ?collision-mode)))
48  (true)
49  (equal ?collision-mode nil)
50  (desig:designator action ((:type :opening)
51  (:object ?current-object-design)
52 
53  (?object-type ?object-type)
54 
55  (?object-name ?object-name)
56  (?arms ?arms)
57 
58  (?grasp ?grasp)
59  (?left-approach-poses ?left-approach-poses)
60  (?right-approach-poses ?right-approach-poses)
61  (?collision-mode ?collision-mode)))
62  (?resolved-action-designator))
63 
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```

Figure 30: Left: Manual designator for the action *Opening* (46 lines). Right: Generated designator based on *Pouring* (45 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
35	36	8	2

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *object* instead of *container*)
- designator calculates trajectories and poses in a different manner
- designator (falsely) ends by mapping the variables to designator "parts"

```
1  :- (<- (design-action-grounding ?action-designator (open-container ?arm
2    ?gripper-opening
3    ?distane
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    ?left-lift-poses)
9    ?left-lift-poses)
10   ?left-2nd-lift-poses)
11   ?right-2nd-lift-poses)
12   ?joint-name ?environment-obj))
13   (spec-property ?action-designator :type :opening)
14   (spec-property ?action-designator :object ?container-designator)
15   (spec-property ?container-designator :type :container-type)
16   (obj-int-object-type-subtype :container ?container-type)
17   (spec-property ?container-designator :urdf-name ?container-name)
18   (spec-property ?container-designator :part-of ?btr-environment))
19   (-> (spec-property ?action-designator :arm ?arm))
20   (true)
21   (and
22     (cram-robot-interfaces robot ?robot)
23     (cram-robot-interfaces arm ?robot ?arm)))
24   (spec-property ?action-designator :distance ?distance))
25   (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
26   (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
27   (lisp-fun cl-urdf.name ?connecting-joint ?joint-name)
28   (btr-bullet-world ?world)
29
30   (-> (lisp-fun btr-object ?world ?btr-environment ?environment-obj)
31   (lisp-fun obj-int-get-object-type-gripper-opening ?container-type ?gripper-opening)
32   (lisp-fun obj-int-get-container-object-transform ?container-name ?btr-environment
33   ?container-type ?container-transform))
34   (lisp-fun obj-int-get-object-grasping-poses ?container-name
35   :container-prismatic :left :open ?container-transform ?left-poses)
36
37   (-> (lisp-fun obj-int-get-object-grasping-poses ?container-name
38   :container-prismatic :right :open ?container-transform ?right-poses)
39   (lisp-fun cram-mobile-pick-place-plans :extract-pick-up-manipulation-poses
40   ?arm ?left-poses ?right-poses
41   (?left-reach-poses ?right-reach-poses
42   ?left-grasp-poses ?right-grasp-poses
43
44   ?left-poses ?right-lift-poses)))
45
46   (-> (lisp-pred identity ?left-lift-poses)
47   (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose))
48   (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
49
50   (-> (lisp-pred identity ?right-lift-poses)
51   (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose))
52   (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))
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Figure 31: Left: Manual designator for the action *Opening* (46 lines). Right: Generated designator based on *Slicing* (47 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
36	35	8	3

Findings:

- designator definition contains only one variable instead of 13
 - some minor renaming (e.g. *object* instead of *container*)
 - designator calculates trajectories and poses in a different manner
 - designator (falsely) ends by mapping the variables to designator "parts"

```

1  <- (desig.action-grounding ?action-designator (open-container ?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    ?left-lift-poses
9    ?right-lift-poses
10   ?left-2nd-lift-poses
11   ?right-2nd-lift-poses
12   ?joint-name ?environment-obj)
13   (spec:property ?action-designator (:type :opening))
14   (spec:property ?action-designator (:object ?container-designator))
15   (spec:property ?container-designator (:type ?container-type))
16   (obj-int:object-type-subtype ?container ?container-type)
17   (spec:property ?container-designator (:urdf-name ?container-name))
18   (spec:property ?container-designator (:part-of ?bitr-environment))
19   (-> (spec:property ?action-designator (:arm ?arm))
20     (true)
21     (and
22       (cram-robot-interfaces:robot ?robot)
23       (cram-robot-interfaces:arm ?robot ?arm)))
24   (spec:property ?action-designator (:distance ?distance))
25   (lisp-fun get-contain-link ?container-name ?bitr-environment ?container-link)
26   (lisp-fun get-connecting-joint ?container-link :connecting-joint)
27   (lisp-fun get-joint ?joint-name ?joint)
28   (lisp-fun bullet-world ?world)
29   (lisp-fun bitr:object ?world ?bitr-environment ?environment-obj)
30   (lisp-fun obj-int:get-object-type-gripper-opening ?container-type ?gripper-opening)
31   (lisp-fun get-container-pose-and-transform ?container-name ?bitr-environment
32     ?container-pose ?container-transform)
33   (lisp-fun obj-int:get-object-grasping-poses ?container-name
34     :container-prismatic ?left :open ?container-transform ?left-poses)
35   (lisp-fun obj-int:get-object-prismatic-robot :open ?container-transform ?right-poses)
36   (lisp-fun cram-motor-pick-place-poses :extract-pick-up-manipulation-poses
37     ?arm ?left-poses ?right-poses
38     ?left-reach-poses ?right-reach-poses
39     ?left-grasp-poses ?right-grasp-poses
40     ?left-lift-poses ?right-lift-poses)
41   (-> (lisp-pred identity ?left-lift-poses)
42     (equal ?left-lift-poses (?left-lift-poses ?left-2nd-lift-poses))
43     (equal (nil nil) (?left-lift-poses ?left-2nd-lift-poses)))
44   (-> (lisp-pred identity ?right-lift-poses)
45     (equal ?right-lift-poses (?right-lift-poses ?right-2nd-lift-poses))
46     (equal (nil nil) (?right-lift-poses ?right-2nd-lift-poses)))

```



```

1  <- (desig.action-grounding ?action-designator (open-container ?resolved-action-designator))
2
3
4
5
6
7
8
9
10
11
12
13   (spec:property ?action-designator (:type :opening-container))
14   (spec:property ?action-designator (:grasp ?grasp))
15   (spec:property ?action-designator (:arm ?arm))
16   (desig.current-designator ?container-designator ?current-container-designator)
17
18   (spec:property ?current-container-designator (:type ?container-type))
19   (-> (spec:property ?current-container-designator
20     (lisp-fun get-trajectory :opening-container ?arm ?grasp ?current-container-designator ?lists)
21     (lisp-fun man-int:get-traj-poses-by-label ?lists :opening-container ?poses))
22   (design designator :action (:type :opening-container)
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37   (spec:property ?arm ?arm)
38
39   (spec:property ?grasp ?grasp)
40   (spec:property ?poses ?poses)
41   (spec:property ?resolved-action-designator))
42
43
44
45
46

```

Figure 32: Left: Manual designator for the action *Opening* (46 lines). Right: Generated designator based on *Wiping* (14 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
6	38	8	0

Findings:

- designator definition contains only one variable instead of 13
- designator contains only definitions, no assignments or calculations
- designator (falsely) ends by mapping the variables to designator "parts"

```

1  <- (design-action-grounding ?action-designator (open-container ?arm
2    ?gripper-opening
3    ?distance
4    ?)
5    ?left-reach-poses
6    ?right-reach-poses
7    ?left-grasp-poses
8    ?right-grasp-poses
9    ?left-lift-poses
10   ?right-lift-poses
11   (?left-1st-lift-pose)
12   (?right-1st-lift-pose)
13   (?left-2nd-lift-pose)
14   (?right-2nd-lift-pose)
15   (?joint-name ?environment-obj))
16   (spec:property ?action-designator (:type :opening))
17   (spec:property ?action-designator (:object ?container-designator))
18   (spec:property ?container-designator (:type ?container-type))
19   (obj:int-object-type-subtype :container ?container-type)
20   (spec:property ?container-designator (:urdf-name ?container-name))
21   (spec:property ?container-designator (:part-of ?bt-environment))
22   (-> (spec:property ?action-designator (:arm ?arm))
23     (true)
24     (and (cram-robot-interfaces:robot ?robot)
25       (cram-robot-interfaces:arm ?robot ?arm)))
26     (spec:property ?action-designator (:distance ?distance))
27     (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
28     (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
29     (lisp-fun cl-urdf:name ?connecting-joint ?joint-name)
30     (btr:bullet-world ?world)
31     (lisp-fun btr:object ?world ?btr-environment ?environment-obj)
32     (lisp-fun obj-int:get-object-type-gripper-opening ?container-type ?gripper-opening)
33     (lisp-fun get-container-pose-and-transform ?container-name ?btr-environment
34       (?container-poses ?container-transform))
35     (lisp-fun obj-int:get-object-grasping-poses ?container-name
36       :container-prismatic :left :open ?container-transform ?left-poses)
37     (lisp-fun obj-int:get-object-grasping-poses ?container-name
38       :container-prismatic :right :open ?container-transform ?right-poses)
39     (lisp-fun cram-mobile:pick-place-plans:extract-pick-up-manipulation-poses
40       ?arm ?left-poses ?right-poses
41       (?left-reach-poses ?right-reach-poses
42         ?left-grasp-poses ?right-grasp-poses
43         ?left-lift-poses ?right-lift-poses))
44     (-> (lisp-pred identity ?left-poses)
45       (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose))
46       (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
47     (-> (lisp-pred identity ?right-poses)
48       (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose))
49     (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))))

1  <- (design-action-grounding ?action-designator (pick-up ?arm
2    ?gripper-opening
3    ?distance
4    ?)
5    ?left-reach-poses
6    ?right-reach-poses
7    ?left-grasp-poses
8    ?right-grasp-poses
9    ?left-lift-poses
10   ?right-lift-poses
11   (?left-1st-lift-pose)
12   (?right-1st-lift-pose)
13   (?left-2nd-lift-pose)
14   (?right-2nd-lift-pose)))
15   (spec:property ?action-designator (:type :picking))
16   (spec:property ?action-designator (:object ?object-designator))
17   (spec:property ?object-designator (:type ?object-type))
18   (obj:int-object-type-subtype :object ?object-type)
19   (spec:property ?object-designator (:urdf-name ?object-name))
20   (-> (spec:property ?action-designator (:arm ?arm))
21     (true)
22     (and (cram-robot-interfaces:robot ?robot)
23       (cram-robot-interfaces:arm ?robot ?arm)))
24     (spec:property ?action-designator (:distance ?distance)))

30   (lisp-fun obj-int:get-object-type-gripper-opening ?object-type ?gripper-opening)
31   (lisp-fun get-object-pose-and-transform ?object-name ?object-transform)

33   (lisp-fun obj-int:get-object-grasping-poses ?object-name
34     :object-prismatic :left :close ?object-transform ?left-poses)
35   (lisp-fun obj-int:get-object-grasping-poses ?object-name
36     :object-prismatic :right :close ?object-transform ?right-poses)
37   (lisp-fun cram-mobile:pick-place-plans:extract-pick-up-manipulation-poses
38     ?arm ?left-poses ?right-poses
39     (?left-reach-poses ?right-reach-poses
40       ?left-grasp-poses ?right-grasp-poses
41       ?left-lift-poses ?right-lift-poses))
42   (-> (lisp-pred identity ?left-poses)
43     (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose))
44     (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
45   (-> (lisp-pred identity ?right-poses)
46     (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose))
47     (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))))


```

Figure 33: Left: Manual designator for the action *Picking Up* (46 lines). Right: Generated designator based on *Closing* (39 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
1	8	14	24

Findings:

- designator definition contains 12 instead of 13 variables
- some minor renaming (e.g. *object* instead of *container*)
- no linking to joints and container

```

1  | <-(design-action-grounding ?action-designator (open-container ?arm
2  |   ?gripper-opening
3  |   ?distance
4  |   ?left-reach-poses
5  |   ?right-reach-poses
6  |   ?left-grasp-poses
7  |   ?right-grasp-poses
8  |   ?left-lift-poses
9  |   ?right-lift-poses
10 |   ?left-2nd-lift-poses
11 |   ?right-2nd-lift-poses
12 |   ?point-name ?environment-obj))
13 | 
14 | (spec:property ?action-designator :type :opening)
15 | (spec:property ?action-designator :object ?object)
16 | (spec:property ?container-designator :type ?container-type)
17 | (obj:object-type-subtype ?container ?container-type)
18 | (spec:property ?container-designator :name ?container-name)
19 | (spec:property ?container-designator :part-of ?m-environment)
20 | (-> (spec:property ?action-designator :arm ?arm))
21 | 
22 | 
23 | 
24 | 
25 | 
26 | 
27 | 
28 | 
29 | 
30 | 
31 | 
32 | 
33 | 
34 | 
35 | 
36 | 
37 | 
38 | 
39 | 
40 | 
41 | 
42 | 
43 | 
44 | 
45 | 
46 | 
47 | 
48 | 
49 | 
50 | 
51 | 
52 | 
53 | 
54 | 
55 | 
56 | 
57 | 

```



```

1  | <-(design-action-grounding ?action-designator (pick-up ?resolved-action-designator))
2  | 
3  | 
4  | 
5  | 
6  | 
7  | 
8  | 
9  | 
10 | 
11 | 
12 | 
13 | 
14 | 
15 | 
16 | 
17 | 
18 | 
19 | 
20 | 
21 | 
22 | 
23 | 
24 | 
25 | 
26 | 
27 | 
28 | 
29 | 
30 | 
31 | 
32 | 
33 | 
34 | 
35 | 
36 | 
37 | 
38 | 
39 | 
40 | 
41 | 
42 | 
43 | 
44 | 
45 | 
46 | 
47 | 
48 | 
49 | 
50 | 
51 | 
52 | 
53 | 
54 | 
55 | 
56 | 
57 | 

```

Figure 34: Left: Manual designator for the action *Picking Up* (46 lines). Right: Generated designator based on *Halving* (35 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
26	37	7	2

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *object* instead of *container*)
- designator calculates trajectories and poses in a different manner
- designator (falsely) ends by mapping the variables to designator "parts"

```

1  #:c (design.action-grounding ?action-designator (open-container ?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    ?left-lift-pose)
9    ?right-lift-pose)
10   ?left-2nd-lift-pose)
11   ?right-2nd-lift-pose)
12   ?joint-name ?environment-object)
13
14   (spec:property ?action-designator (type ?holding))
15   (spec:property ?action-designator (object ?current-object-designator))
16   (spec:property ?container-designator (type ?container-type))
17   (obj-int object-type-subtype ?container ?container-type)
18
19   (spec:property ?container-designator (url-id ?container-name))
20   (spec:property ?container-designator (part-of ?left-environment))
21
22   (-> (spec:property ?action-designator (arm ?arm))
23     (true)
24
25   (and (cram-robot-interfaces:robot ?robot)
26     (cram-robot-interfaces:object ?world ?left-environment ?environment-object)
27
28   (lisp-fun obj-int get-object-type-gripper-opening ?container-type ?gripper-opening)
29
30   (lisp-fun obj-int get-container-pose-and-transform ?container-name ?left-environment
31     ?left-robot-free-hand)
32
33   (lisp-fun obj-int get-object-grasping-poses ?container-name
34     ?left-robot-free-hand)
35
36
37   (lisp-fun obj-int get-object-grasping-poses ?container-name
38     ?left-robot-free-hand)
39
40   (lisp-fun obj-int get-object-grasping-poses ?container-name
41     ?left-robot-free-hand)
42
43
44   (lisp-fun cram-mobile-pick-place-plans: extract-pick-up-manipulation-poses
45     ?arm ?left-poses ?right-poses)
46
47
48   (lisp-fun obj-int get-object-grasping-poses ?container-name
49     ?left-reach-poses
50     ?left-grasp-poses ?right-grasp-poses
51     ?left-lift-poses)
52
53   (-> (lisp-pred identity ?left-lift-poses)
54     (equal NIL NIL) (?left-lift-poses ?left-2nd-lift-pose))
55
56   (-> (lisp-pred identity ?right-lift-poses)
57     (equal NIL NIL) (?right-lift-poses ?right-2nd-lift-pose)))
58
59
60
61
62
63

```



```

1  #:c (design.action-grounding ?action-designator (gp-plans:pick-up ?resolved-action-designator))
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63

```

Figure 35: Left: Manual designator for the action *Picking Up* (46 lines). Right: Generated designator based on *Holding* (51 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
39	34	10	2

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *object* instead of *container*)
- designator calculates trajectories and poses in a different manner
- designator (falsely) ends by mapping the variables to designator "parts"

```
1  |(< (design:action-grounding ?action-designator (open-container) ?arm
2  |  ?gripper-opening
3  |  ?distance
4  |
5  |    ?left-reach-poses
6  |    ?right-reach-poses
7  |    ?left-grasp-poses
8  |    ?right-grasp-poses
9  |    (?left-lift-pose)
10 |    (?right-lift-pose)
11 |    (?left-2nd-lift-pose)
12 |    (?right-2nd-lift-pose)
13 |    (?joint-name ?environment-obj))
14 |  (spec:property ?action-designator (:type :opening))
15 |  (spec:property ?action-designator (:object ?container-designator))
16 |  (spec:property ?container-designator (:type ?container-type))
17 |  (obj:int-object-type-subtype :container ?container-type)
18 |  (spec:property ?container-designator (:urdf-name ?container-name))
19 |  (spec:property ?container-designator (:part-of ?btr-environment))
20 |  (-> (spec:property ?action-designator (:arm ?arm))
21 |        (true)
22 |        (and (cram-robot-interfaces:robot ?robot)
23 |              (cram-robot-interfaces:arm ?robot ?arm)))
24 |  (spec:property ?action-designator (:distance ?distance))
25 |  (lisp-fun obj-int-get-link ?container-name ?btr-environment ?container-link)
26 |  (lisp-fun obj-int-get-connecting-joint ?container-link ?connecting-joint)
27 |  (lisp-fun obj-int-name ?connecting-joint ?joint-name)
28 |  (btr:bullet-world? ?world)
29 |  (lisp-fun btr:bolt ?world)
30 |  (lisp-fun btr:bolt ?world ?btr-environment ?environment-obj)
31 |  (lisp-fun btr:obj-int-get-object-type-gripper-opening ?container-type ?gripper-opening)
32 |  (lisp-fun get-container-pose-and-transform ?container-name ?btr-environment
33 |    (?container-poses ?container-transform)
34 |    (lisp-fun obj-int-get-object-grasping-poses ?container-name
35 |      :container-primitive :left :open ?container-transform) ?left-poses)
36 |    (lisp-fun obj-int-get-object-grasping-poses ?container-name
37 |      :container-primitive :right :open ?container-transform) ?right-poses)
38 |  (lisp-fun cram-mobile:pick-place-plans:extract-pick-up-manipulation-poses
39 |    ?arm ?left-poses ?right-poses
40 |    (?left-reach-poses ?right-reach-poses
41 |     ?left-grasp-poses ?right-grasp-poses
42 |     ?left-lift-poses ?right-lift-poses))
43 |  (-> (lisp-pred identity ?left-lift-poses)
44 |        (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose))
45 |        (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
46 |  (-> (lisp-pred identity ?right-lift-poses)
47 |        (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose))
48 |        (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))
```



```
1  |(< (design:action-grounding ?action-designator (pick-up) ?arm
2  |  ?gripper-opening
3  |  ?distance
4  |  ?object-designator
5  |
6  |    ?left-reach-poses
7  |    ?right-reach-poses
8  |    ?left-grasp-poses
9  |    ?right-grasp-poses
10 |    (?left-lift-pose)
11 |    (?right-lift-pose)
12 |    (?left-2nd-lift-pose)
13 |    (?right-2nd-lift-pose)))
14 |  (spec:property ?action-designator (:type :pick-up))
15 |  (spec:property ?action-designator (:object ?object-designator))
16 |  (spec:property ?object-designator (:type ?object-type))
17 |
18 |  (-> (spec:property ?action-designator (:arm ?arm))
19 |        (true)
20 |        (and (cram-robot-interfaces:robot ?robot)
21 |              (cram-robot-interfaces:arm ?robot ?arm)))
22 |  (spec:property ?action-designator (:distance ?distance))
23 |
24 |  (lisp-fun obj-int-get-object-type-gripper-opening ?object-type ?gripper-opening)
25 |
26 |  (lisp-fun obj-int-get-object-grasping-poses ?object-designator
27 |    :object ?left :open NIL) ?left-poses)
28 |  (lisp-fun obj-int-get-object-grasping-poses ?object-designator
29 |    :object ?right :open NIL) ?right-poses)
30 |  (lisp-fun cram-mobile:pick-place-plans:extract-pick-up-manipulation-poses
31 |    ?arm ?left-poses ?right-poses
32 |    (?left-reach-poses ?right-reach-poses
33 |     ?left-grasp-poses ?right-grasp-poses
34 |     ?left-lift-poses ?right-lift-poses))
35 |  (-> (lisp-pred identity ?left-lift-poses)
36 |        (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose))
37 |        (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
38 |  (-> (lisp-pred identity ?right-lift-poses)
39 |        (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose))
40 |        (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))
```

Figure 36: Left: Manual designator for the action *Picking Up* (46 lines). Right: Generated designator based on *Opening* (36 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
1	11	10	25

Findings:

- designator definition contains 12 instead of 13 variables
 - some minor renaming (e.g. *object* instead of *container*)
 - no linking to joints and container

```

1  <- (desig.action-grounding ?action-designator (open-container ?arm
2    ?upper-opening
3    ?disjoint
4    ?left-reach-poses
5    ?left-grasp-poses
6    ?right-grasp-poses
7    (?left-lift-pose)
8    (?right-lift-pose)
9    (?left-2nd-lift-pose)
10   (?right-2nd-lift-pose)
11   (?joint-name ?environment-obj))
12   (spec.property ?action-designator (:type :opening))
13   (spec.property ?action-designator (:object ?container-designator))
14   (spec.property ?container-designator (:type ?container-type))
15   (obj-int-object-type-subtype :container ?container-type)
16   (spec.property ?container-designator (:urdf-name ?container-name))
17   (spec.property ?container-designator (:part-of ?btr-environment))
18   (spec.property ?action-designator (:arm ?arm))
19   (true)
20   (and
21     (cram-robot-interfaces:robot ?robot)
22     (cram-robot-interfaces:arm ?robot ?arm)))
23   (spec.property ?action-designator (:instance ?instance))
24   (lisp-fun link ?container-name ?btr-environment ?container-link)
25   (lisp-fun get-connecting-joint ?container-link ?connecting-joint)
26   (lisp-fun cl-urdf-frame ?connecting-joint ?joint-name)
27   (btr:btr-world ?world)
28   (lisp-fun btr:object ?world ?btr-environment ?environment-obj)
29   (lisp-fun obj-int-get-object-type-gripper-opening ?container-type ?gripper-opening)
30   (lisp-fun obj-int-get-object-pose-and-transform ?container-name ?btr-environment
31     (?container-pose ?container-transform))
32   (lisp-fun obj-int-get-object-grasping-poses ?container-name
33     :container-prismatic :left (open ?container-transform ?left-poses)
34   (lisp-fun obj-int-get-object-grasping-poses ?container-name
35     :container-prismatic :right (open ?container-transform ?right-poses)
36   (lisp-fun cram-mobile:pick-place-plans:extract-pick-up-manipulation-poses
37     ?arm ?left-poses ?right-poses
38     (?left-reach-poses ?right-reach-poses
39       ?left-grasp-poses ?right-grasp-poses
40       ?left-lift-poses ?right-lift-poses))
41   (> (lisp-pred identity ?left-lift-poses)
42     (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose))
43     (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
44   (> (lisp-pred identity ?right-lift-poses)
45     (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose))
46     (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))

```



```

1  <- (desig.action-grounding ?action-designator (pick ?object-designator ?arm
2    ?left-reach-poses ?right-reach-poses
3    ?left-grasp-poses ?right-grasp-poses
4    ?left-retract-poses ?right-retract-poses))
5
6
7
8
9
10
11
12
13   (spec.property ?action-designator (:type :picking))
14
15
16
17
18
19   (-> (spec.property ?action-designator (:arm ?arm)))
20
21   (and
22     (cram-robot-interfaces:robot ?robot)
23     (cram-robot-interfaces:arm ?robot ?arm)))
24   (> (spec.property ?action-designator (:object ?object-designator))
25     (cproe:object-in-world ?object-designator))
26
27
28
29
30
31
32   (lisp-fun obj-int-get-object-grasping-poses
33     ?object-designator :left ?left-grasp-poses)
34   (lisp-fun obj-int-get-object-grasping-poses
35     ?object-designator :right ?right-grasp-poses)
36   (lisp-fun extract-pick-manipulation-poses ?arm ?left-grasp-poses ?right-grasp-poses
37     (?left-reach-poses ?right-reach-poses ?left-grasp-poses ?right-grasp-poses
38       ?left-retract-poses ?right-retract-poses)))
39
40
41
42
43
44
45
46

```

Figure 37: Left: Manual designator for the action *Picking Up* (46 lines). Right: Generated designator based on *Placing Down* (17 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
2	31	12	3

Findings:

- designator definition contains 8 instead of 13 variables
- some minor renaming (e.g. *picking* instead of *opening*)
- designator contains only definitions, no assignments or calculations
- no linking to joints and container

```

1  <- (design-action-grounding ?action-designator (?arm
2    ?gripper-opening
3    ?distance
4    ?left-reach-poses
5    ?right-reach-poses
6    ?left-grasp-poses
7    ?right-grasp-poses
8    ?left-lift-poses)
9    ?right-lift-poses)
10   ?right-2nd-lift-poses)
11   ?grip-name ?environment-obj)
12   (spec-property ?action-designator (type ?opening))
13   (spec-property ?action-designator (object ?container-designator))
14
15  (spec-property ?container-designator (type ?container-type))
16  (obj-int-object-type-subtype ?container ?container-type)
17  (spec-property ?container-designator (url-name ?container-name))
18  (spec-property ?container-designator (part-of ?btr-environment))
19
20
21
22
23
24
25
26
27  (> (spec-property ?action-designator (?arm ?arm))
28    (true)
29    (and (cram-robot-interfaces robot ?robot)
30      (cram-robot-interfaces arm ?arm)))
31    (spec-property ?action-designator (distance ?distance))
32    (lisp-fun get-container-link ?container-name ?btr-environment ?container-link)
33    (lisp-fun get-connecting-point ?container-link ?connecting-point)
34    (lisp-fun cl-url-name ?connecting-joint ?joint-name)
35
36    (btr-bullet-world ?world)
37    (lisp-fun btr-object ?world ?btr-environment ?environment-type)
38    (lisp-fun obs-int-get-object-type ?gripper-opening ?container-type ?gripper-opening)
39    (lisp-fun get-object-transform ?object-name ?btr-environment)
40    (lisp-fun get-object ?container-transform)
41    (lisp-fun get-object-grasping-poses ?container-name
42      :container-prismatic ?left-open ?container-transform ?left-poses)
43    (lisp-fun get-object-grasping-poses ?container-name
44      :container-prismatic ?right-open ?container-transform ?right-poses)
45    (lisp-fun cram-mobile-pick-place-plans-extract-pick-up-manipulation-poses
46      ?arm ?left-poses ?right-poses
47      (?left-reach-poses ?right-reach-poses)
48      (?left-grasp-poses ?right-grasp-poses
49      ?left-lift-poses ?right-lift-poses))
50    (> (lisp-pred identity ?left-lift-poses)
51      (equal ?left-lift-poses (?left-lift-poses ?left-2nd-lift-poses)))
52    (lisp-pred identity ?right-lift-poses)
53    (> (lisp-pred identity ?right-lift-poses)
54      (equal ?right-lift-poses (?right-lift-poses ?right-2nd-lift-poses)))

```



```

1  <- (design-action-grounding ?action-designator (?pick-up ?resolved-action-designator))
2  (spec-property ?action-designator (type ?picking))
3  (spec-property ?action-designator (object ?object-designator))
4  (design-current-designator ?object-designator ?current-object-desig)
5  (spec-property ?current-object-desig (type ?object-type))
6  (spec-property ?current-object-desig (name ?object-name))
7  (> (spec-property ?action-designator (arms ?arms))
8    (true)
9    (and (member ?arms ?arm))
10   (lisp-fun man-int-get-object-transform ?current-object-desig ?object-transform)
11   (lisp-fun man-int-calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face))
12   (> (man-int-object-rotationally-symmetric ?object-type)
13     (equal ?rotationally-symmetric t)
14     (not ?rotationally-symmetric nil))
15  (spec-property ?action-designator (grasp ?grasp))
16  (true)
17  (and (member ?arm ?arms))
18  (lisp-fun man-int-get-object-grasps ?object-type ?arm ?object-transform ?grasps)
19  (lisp-fun man-int-get-object-grasp ?object-type ?grasp)
20  (lisp-fun man-int-get-action-gripping-effort ?object-type ?effort)
21  (lisp-fun man-int-get-action-gripper-opening ?object-type ?gripper-opening)
22  (spec-property ?action-designator (collision-mode ?collision-mode))
23  (true)
24  (lisp-fun man-int-get-action-trajectory ?picking ?arm ?grasp t ?objects ?approach-poses)
25  (lisp-fun man-int-get-traj-poses-by-label ?approach-poses ?approach ?approach-poses))
26  (> (design-design-prop ?action-designator (Collision-mode ?collision-mode))
27    (true)
28    (equal ?collision-mode nil))
29  (design-designator action ((type ?picking)
30    (object ?current-object-desig)
31
32
33
34
35
36
37  (spec-property ?object-type ?object-type)
38
39
40  (spec-property ?object-name ?object-name)
41  (spec-property ?arms ?arms)
42
43
44
45
46
47  (spec-property ?grasp ?grasp)
48  (spec-property ?approach-poses ?approach-poses)
49  (spec-property ?collision-mode ?collision-mode))
50
51
52
53
54

```

Figure 38: Left: Manual designer for the action *Picking Up* (46 lines). Right: Generated designer based on *Pouring* (38 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
31	39	6	1

Findings:

- designer definition contains only one variable instead of 13
- designer calculates trajectories and poses in a different manner
- no linking to joints and container
- designer (falsely) ends by mapping the variables to designer "parts"

```

1  | 1  | 
2  | 2  | 
3  | 3  | 
4  | 4  | 
5  | 5  | 
6  | 6  | 
7  | 7  | 
8  | 8  | 
9  | 9  | 
10 | 10 | 
11 | 11 | 
12 | 12 | 
13 | 13 | 
14 | 14 | 
15 | 15 | 
16 | 16 | 
17 | 17 | 
18 | 18 | 
19 | 19 | 
20 | 20 | 
21 | 21 | 
22 | 22 | 
23 | 23 | 
24 | 24 | 
25 | 25 | 
26 | 26 | 
27 | 27 | 
28 | 28 | 
29 | 29 | 
30 | 30 | 
31 | 31 | 
32 | 32 | 
33 | 33 | 
34 | 34 | 
35 | 35 | 
36 | 36 | 
37 | 37 | 
38 | 38 | 
39 | 39 | 
40 | 40 | 
41 | 41 | 
42 | 42 | 
43 | 43 | 
44 | 44 | 
45 | 45 | 
46 | 46 | 
47 | 47 | 
48 | 48 | 
49 | 49 | 
50 | 50 | 
51 | 51 | 
52 | 52 | 

```

Figure 39: Left: Manual designator for the action *Picking Up* (46 lines). Right: Generated designator based on *Slicing* (33 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
22	35	9	2

Findings:

- designator definition contains only one variable instead of 13
- some minor renaming (e.g. *object* instead of *container*)
- designator calculates trajectories and poses in a different manner
- no linking to joints and container
- designator (falsely) ends by mapping the variables to designator "parts"

```

1  :-> (< design action-grounding ?action-designator (?open-container ?arm
2
3  	?gripper-opening
4  	?distance
5  	?left-reach-poses
6  	?right-reach-poses
7  	?left-grasp-poses
8  	?right-grasp-poses
9  	?left-lift-poses
10  ?right-lift-poses
11  ?left-2nd-lift-poses
12  ?right-2nd-lift-poses
13  ?open-name ?environment-object)
14
15  (spec:property ?action-designator :type :opening)
16  (spec:property ?action-designator :object ?container-designator)
17  (spec:property ?action-designator :value ?open-value)
18  (obj-int-object-type-pe-subtype ?container ?container-type)
19  (spec:property ?container-designator :uri-name ?Container-name)
20  (spec:property ?container-designator :part-of ?btr-environment)
21
22  (spec:property ?action-designator :arm ?arm)
23
24  (true)
25  (and (gram-robot-interfaces :robot ?robot)
26        (gram-robot-interfaces :arm ?robot ?arm))
27
28  (spec:property ?action-designator :distance ?distance)
29
30  (lisp-fun get-container-link ?Container-name ?btr-environment ?Container-link)
31  (lisp-fun get-connecting-joint ?Container-link ?connecting-joint)
32  (lisp-fun cl:and NAME ?connecting-joint ?Joint-name)
33  (lisp-fun cl:and NAME ?Joint-name)
34  (lisp-fun btr:object ?World ?btr-environment ?Environment-object)
35  (lisp-fun obj-int-get-object-type-gripper-opening ?Container-name ?gripper-opening)
36
37  (lisp-fun get-container-pose-and-transform ?Container-name ?btr-environment
38  	?Container-pose ?Container-transform)
39
40  (lisp-fun obj-int-get-object-grasping-poses ?Container-name
41  	?Container-prismatic-left ?open ?Container-transform ?Left-poses)
42
43  (lisp-fun obj-int-get-object-grasping-poses ?Container-name
44  	?Container-prismatic-right ?open ?Container-transform ?Right-poses)
45
46  (lisp-fun get-man-int-grab-poses ?Left-poses ?Extract-pick-up-maniulation-poses
47  	?Arm ?Left-poses ?Right-poses
48  	?Left-reach-poses ?Right-reach-poses
49  	?Left-grasp-poses ?Right-grasp-poses
50  	?Left-lift-poses ?Right-lift-poses)
51
52  (> (lisp-pred identity ?Left-lift-poses)
53  	(equal ?Left-lift-poses ?Left-lift-poses ?Left-2nd-lift-poses))
54
55  (equal (NIL NIL) ?Left-lift-poses ?Left-2nd-lift-poses))
56
57  (> (lisp-pred identity ?Right-lift-poses)
58  	(equal ?Right-lift-poses ?Right-lift-poses ?Right-2nd-lift-poses))
59
60  (equal (NIL NIL) ?Right-lift-poses ?Right-2nd-lift-poses))
61
62
63  :-> (< design action-grounding ?action-designator (pick-up ?resolved-action-designator))
64
65  (spec:property ?action-designator :type :picking)
66  (spec:property ?action-designator :grasp ?grasp)
67  (spec:property ?action-designator :arm ?arm)
68
69  (design:design-prop :action-designator :object ?object-designator)
70  (design:current-designator :object-designator ?current-object-designator)
71
72  (spec:property ?current-object-designator :type ?Object-type)
73  (equal ?object ?current-object-designator)
74
75
76  :-> (< design action-grounding ?action-designator (collision-mode ?collision-mode))
77
78  (> (equal ?arm ?left))
79
80  (lisp-fun man-int-get-trap-poses-by-label ?list ?Picks
81  	?Left-pose)
82
83  (lisp-fun man-int-get-trap-poses-by-label ?list ?Picks
84  	?Right-pose)
85
86  (lisp-fun man-int-get-trap-poses-by-label ?list ?Picks
87  	?Left-initial-pose)
88
89  (and (equal ?Left-pick-up-poses NIL)
90        (equal ?Right-pick-up-poses NIL))
91
92  (> (equal ?arm ?right))
93
94  (and (lisp-fun get-trajectory ?picking ?arm ?current-object-designator T NIL ?lists)
95        (lisp-fun man-int-get-trap-poses-by-label ?list ?Picks
96         ?Left-pick-up-poses))
97
98  (lisp-fun man-int-get-trap-poses-by-label ?list ?Picks
99  	?Right-pick-up-poses)
100
101  (and (equal ?Right-pick-up-poses NIL)
102        (equal ?Right-initial-pose NIL))
103
104  (desig:designator :action :type :picking)
105
106  (lisp-fun get-trajectory ?picking ?arm ?current-object-designator ?Collision-mode)
107
108  (lisp-fun pick-up-poses ?Left-pick-up-poses)
109
110  (lisp-fun pick-up-poses ?Right-pick-up-poses)
111
112  (lisp-fun initial-pose ?Left-initial-pose)
113
114
115  (lisp-fun initial-pose ?Right-initial-pose)
116
117  ?resolved-action-designator)

```

Figure 40: Left: Manual designator for the action *Picking Up* (46 lines). Right: Generated designator based on *Wiping* (32 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
21	35	11	0

Findings:

- designator definition contains only one variable instead of 13
 - some minor renaming (e.g. *picking* instead of *opening*)
 - designator calculates trajectories and poses in a different manner
 - designator (falsely) ends by mapping the variables to designator "parts"

```

1  | 1  | 
2  | 2  | 
3  | 3  | 
4  | 4  | 
5  | 5  | 
6  | 6  | 
7  | 7  | 
8  | 8  | 
9  | 9  | 
10 | 10 | 
11 | 11 | 
12 | 12 | 
13 | 13 | 
14 | 14 | 
15 | 15 | 
16 | 16 | 
17 | 17 | 
18 | 18 | 
19 | 19 | 
20 | 20 | 
21 | 21 | 
22 | 22 | 
23 | 23 | 
24 | 24 | 
25 | 25 | 
26 | 26 | 
27 | 27 | 
28 | 28 | 
29 | 29 | 
30 | 30 | 
31 | 31 | 
32 | 32 | 
33 | 33 | 
34 | 34 | 
35 | 35 | 
36 | 36 | 
37 | 37 | 
38 | 38 | 
39 | 39 | 
40 | 40 | 
41 | 41 | 
42 | 42 | 
43 | 43 | 
44 | 44 | 
45 | 45 | 
46 | 46 | 
47 | 47 | 
48 | 48 | 
49 | 49 | 
50 | 50 | 
51 | 51 | 
52 | 52 | 
53 | 53 | 
54 | 54 | 

```

Figure 41: Left: Manual designator for the action *Placing Down* (46 lines). Right: Generated designator based on *Closing* (31 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
14	29	14	3

Findings:

- designator definition contains eight instead of nine variables (2 overlap)
- some minor renaming (e.g. *held-object-name* instead of *object-name*)
- trajectories and poses are only defined and not calculated / used

```

1  ;<- (design:action-grounding ?action-designator (place ?current-object-designator ?arm
2    ?left-reach-poses ?right-reach-poses
3    ?left-put-poses ?right-put-poses
4    ?left-retract-poses ?right-retract-poses
5    ?location))
6  (spec:property ?action-designator (type :placing))
7
8  ;> (spec:property ?position-designator (arm ?arm))
9  ;> (spec:property ?action-designator (object ?object-designator))
10 ;> (or (cpe:object-in-hand ?object-designator ?arm)
11   (and (format "WARNING: Wanted to place an object ~a with a arm ~a, ~
12     but it's not in the arm.~%" ?object-designator ?arm)
13   ))
14
15 ;> (spec:property ?object-designator-in-hand ?arm)
16 ;> (spec:property ?action-designator (object ?object-designator))
17 ;> (cpe:object-in-hand ?object-designator ?arm)
18 ;> (and (cram:robot-interfaces robot ?robot)
19   (cram:robot-interfaces:arm ?robot ?arm)
20   (cpe:object-in-hand ?object-designator ?arm)
21   )
22
23 ;> (spec:property ?action-designator (object ?object-designator))
24 ;> (cpe:object-in-hand ?object-designator ?arm)
25 ;> (and (cram:robot-interfaces robot ?robot)
26   (cram:robot-interfaces:arm ?robot ?arm)
27   (cpe:object-in-hand ?object-designator ?arm))
28
29 ;(once (or (cpe:object-in-hand ?object-designator ?arm)
30   (spec:property ?current-object-designator (type :current-object-designator)))
31   (spec:property ?current-object-designator (type :object-type)))
32   (spec:property ?current-object-designator (name ?object-name))
33   (spec:object-type-grasp ?object-type ?grasp)
34   )
35 ;> (spec:property ?action-designator (target ?location))
36 ;> (and (desig:current-designator ?location ?current-location-designator)
37   (desig:designator-groundings ?current-location-designator ?poses)
38   (memes:pose ?poses))
39 ;(symbol-value cram:tf:ensure-pose-in-frame ?base-frame)
40 ;(lisp-fun cram:tf:ensure-pose-in-frame ?target-pose ?base-frame :use-zero-time t
41 ;  ?target-pose-in-base)
42 ;(lisp-fun roslib:utilities:rosify-underscores-lisp-name ?object-name ?if-name)
43 ;(lisp-fun cram:tf:pose-stamped>transform-stamped ?target-pose-in-base ?if-name
44 ;  ?target-transform)
45 ;(and (lisp-fun obj-int:get-object-transform ?current-object-designator ?target-transform)
46 ;  (lisp-fun obj-int:get-object-transform ?current-object-designator ?target-pose)
47 ;  (desig:designator ?location (pose ?target-pose) ?location))
48 ;(lisp-fun obj-int:get-object-grasping-poses
49 ;  ?object-name ?object-type :left ?grasp ?target-transform
50 ;  ?left-poses)
51 ;(lisp-fun obj-int:get-object-grasping-poses
52 ;  ?object-name ?object-type :right ?grasp ?target-transform
53 ;  ?right-poses)
54 ;(lisp-fun extract-place-manipulation-poses ?arm ?left-poses ?right-poses
55
56
57
58
59
60
61 ;(lisp-fun man-int:get-traj-poses-by-label ?left-placing-pose :placing-down
62 ;  ?left-reach-poses ?right-reach-poses ?left-put-poses ?right-put-poses
63 ;  ?left-retract-poses ?right-retract-poses)))

```



```

1  ;<- (design:action-grounding ?action-designator (place-down ?resolved-action-designator))
2
3
4
5
6
7  (spec:property ?action-designator (type :placing))
8  (spec:current-object-designator ?object ?object-designator)
9  (spec:property ?current-object-design ?type ?object-type)
10 (spec:property ?current-object-design (name ?object-name))
11 (spec:current-designator ?location-designator ?current-location-design)
12 (spec:property ?current-location-design (name ?location-name))
13 (lisp-fun man-int:get-location-pose ?current-location-design ?location-pose)
14 ;> (spec:property ?action-designator (arm ?arm))
15 ;> (true)
16 ;(man-int:robot-holding-object ?arm ?current-object-design)
17 ;(lisp-fun man-int:get-object-old-transform ?current-object-design ?object-transform)
18
19 ;> (lisp-fun man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
20 ;> (spec:property ?action-designator (grasp ?grasp))
21 ;> (true)
22 ;(and (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
23 ;  (member ?grasp ?grasps))
24 ;(lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
25
26
27
28
29
30
31
32 ;(lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
33 ;(equal ?objects ?current-object-design)
34 ;> (equal ?arm :left)
35 ;(and (lisp-fun man-int:get-action-trajectory :placing ?arm ?grasp T ?objects
36 ;  ?left-placing-down-poses)
37 ;  (lisp-fun man-int:get-drag-poses-by-label ?left-placing-pose :placing-down
38 ;  ?left-placing-down-poses)
39 ;  (equal ?left-placing-down-poses NIL))
40 ;> (equal ?arm :right)
41 ;(and (lisp-fun man-int:get-action-trajectory :placing ?arm ?grasp T ?objects
42 ;  ?right-placing-pose ?location-pose)
43
44 ;(lisp-fun man-int:get-traj-poses-by-label ?right-placing-pose :placing-down
45 ;  ?right-placing-down-poses)
46 ;(equal ?right-placing-down-poses NIL))
47 ;> (desig:design-prop ?action-designator (collision-mode ?collision-mode))
48 ;> (true)
49 ;(equal ?collision-mode NIL)
50 ;(desig:designator :action (type :placing)
51 ;  (object ?current-object-design)
52 ;  (name ?object-name ?object-type)
53 ;  (arm ?arm)
54 ;  (gripper-opening ?gripper-opening)
55 ;  (effort ?effort)
56 ;  (grasp ?grasp)
57 ;  (location ?current-location-design)
58 ;  (location ?location-name ?location-hand)
59 ;  (lisp-fun man-int:get-traj-poses ?left-placing-down-poses)
60 ;  (lisp-fun man-int:get-traj-poses ?right-placing-down-poses)
61 ;  (collision-mode ?collision-mode))
62 ;?resolved-action-designator)
63

```

Figure 42: Left: Manual designator for the action *Placing Down* (46 lines). Right: Generated designator based on *Halving* (51 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
43	38	6	2

Findings:

- designator definition contains only one instead of nine variables
- designator calculates trajectories and poses in a different manner
- designator (falsely) ends by mapping the variables to designator "parts"

```

1  <- (design-action-grounding ?action-designator (place ?current-object-designator ?arm
2    ?left-reach-poses ?right-reach-poses
3    ?left-put-poses ?right-put-poses
4    ?left-retract-poses ?right-retract-poses
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
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31
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34
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39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54

```

(spec property ?action-designator (type :placing-down))
 (spec: property ?action-designator (object ?object-designator))
 (or (spec: object-in-hand ?object-designator ?arm)
 (and (format "WARNING: Wanted to place an object ~a with an arm ~a, ~a
 but it's not in the arm.-%" ?object-designator ?arm))
 (spec: object-in-hand ?object-designator ?arm))
 (spec: object-in-hand ?object-designator ?object-type))
 (and (cram-robot-interfaces:robot ?robot)
 (cram-robot-interfaces:arm ?robot ?arm))
 (spec: object-in-hand ?object-designator ?arm))
 (once (or (cram-robot-interfaces:object-in-hand ?object-designator ?arm))
 (design-current-designator ?current-object-designator ?object-type)))
 (spec: current-object-designator ?type))
 (spec: property ?current-object-designator (name ?object-name))
 (obj-int:object-type-grasp ?object-type ?grasp))
 (> (spec: property ?action-designator (target ?location))
 (and (design-current-designator location ?current-location-designator)
 (design-current-designator ?current-object-designator ?poses)
 (symbol-value cramt:robot-base-frame) *base-frame*)
 (lisp-fun cramt:ensure-pose-in-frame ?target-pose ?base-frame :use-zero-time t
 ?target-pose-in-base))
 (lisp-fun roslib-utilities:rosify-undercores-lisp-name ?object-name ?t1-name)
 (lisp-fun cramt:pose-stamped->transform-stamped ?target-pose-in-base ?t1-name
 ?target-pose-in-base))
 (and (lisp-fun obj-int:get-object-transform ?current-object-designator ?target-transform)
 (lisp-fun obj-int:get-object-?pose ?current-object-designator ?target-pose))
 (design-designator location ((?pose ?target-pose) ?location)))
 (lisp-fun obj-int:get-object-grasping-poses
 ?object-name ?object-type ?left ?grasp ?target-transform
 ?right-poses)
 (lisp-fun extract-place-manipulation-poses ?arm ?left-poses ?right-poses
 ?left-reach-poses ?right-reach-poses ?left-put-poses ?right-put-poses
 ?left-retract-poses ?right-retract-poses)))

(lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
 (equal ?objects (?current-object-designator))
 (design-designator :action ((type :placing-down)
 (object ?current-object-designator)
 (object-name ?object-name)
 (location ?current-location-designator)
 (location-name ?location-name)
 (arm ?arm)
 (gripper-opening ?gripper-opening)
 (effort ?effort)
 (reach-poses ?reach-poses)
 (place-poses ?place-poses)))
 ?resolved-action-designator)

Figure 43: Left: Manual designator for the action *Placing Down* (46 lines). Right: Generated designator based on *Holding* (35 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
26	37	8	1

Findings:

- designator definition contains only one instead of nine variables
- designator sets high focus on definitions relevant for calculating trajectories / poses instead of using them
- designator (falsely) ends by mapping the variables to designator "parts"

```

1  :-> (design.action-grounding ?action-designator (place ?current-object-designator ?arm
2      ?left-reach-poses ?right-reach-poses
3
4      ?left-put-poses ?right-put-poses
5      ?left-retract-poses ?right-retract-poses
6
7      ?location))
8      (spec.property ?action-designator (:type :placing))
9
10
11
12
13
14
15  :-> (spec.property ?action-designator (:arm ?arm))
16      (-> (spec.property ?action-designator (:object ?object ?object-designator))
17          (cpose:object-in-hand ?object ?object-designator ?arm)
18          (and) (format "WARNING: Wanted to place an object ~a with arm ~a, ~
19          but it's not the arm - %~a" ?object-designator ?arm)
20
21      ) (cpose:object-in-hand ?object-designator ?arm)
22      (-> (spec.property ?action-designator (:object ?object ?object-designator))
23          (cpose:object-in-hand ?object ?object-designator ?arm)
24          (and) (cram:robot-interfaces:arm ?robot ?arm)
25          (cpose:object-in-hand ?object-designator ?arm)))
26
27  :-> (once (or (cpose:object-in-hand ?object ?object-designator ?arm)
28      (spec.property ?action-designator (:object ?object ?object-designator)))
29      (desig.current-designator ?object-designator ?current-object-designator)
30      (spec.property ?current-object-designator (:type ?object-type))
31      (spec.property ?current-object-designator (:name ?object-name))
32
33  :-> (spec.property ?action-designator (?target ?location))
34      (and) (desig.current-designator ?location ?current-location-designator)
35      (design.designator-groundings ?current-location-designator ?poses)
36      (member ?target-pose ?poses)
37      (symbol-value cram:if:robot-base-frame *base-frame*)
38      (lisp-fun cram:tf:ensure-pose-in-frame ?target-pose ?base-frame :use-zero-time t
39      ?target-pose-in-base)
40      (lisp-fun ros-lisp:utilities:rosify-underscores-lisp-name ?object-name ?tf-name)
41      (lisp-fun cram:if:pose-stamped->transform-stamped ?target-pose-in-base ?tf-name
42      ?target-transform)
43
44  :-> (and (lisp-fun obj:int-get-object-transform ?current-object-designator ?target-transform)
45      (lisp-fun obj:int-get-object-base-pose ?current-object-designator ?target-pose)
46      (lisp-fun obj:int-get-object-location (:pose ?target-pose) ?location))
47      (lisp-fun obj:int-get-object-grasping-poses
48      ?object-name ?object-type ?left ?grasp ?target-transform
49      ?left-poses)
50      (lisp-fun obj:int-get-object-grasping-poses
51      ?object-name ?object-type ?right ?grasp ?target-transform
52      ?right-poses)
53
54  :-> (lisp-fun extract-place-manipulation-poses ?arm ?left-poses ?right-poses
55      (?left-reach-poses ?right-reach-poses ?left-put-poses ?right-put-poses
56      ?left-retract-poses ?right-retract-poses)))

```



```

1  :-> (design.action-grounding ?action-designator (place-down ?arm
2      ?gripper-opening
3      ?distance
4      ?left-reach-poses
5      ?right-reach-poses
6      ?left-release-poses
7      ?right-release-poses
8      ?location-designator))
9
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```

Figure 44: Left: Manual designator for the action *Placing Down* (46 lines). Right: Generated designator based on *Opening* (33 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
19	32	11	3

Findings:

- designator definition contains eight instead of nine variables (2 overlap)
- designator sets high focus on definitions relevant for calculating trajectories / poses instead of using them

Figure 45: Left: Manual designator for the action *Placing Down* (46 lines). Right: Generated designator based on *Picking Up* (27 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
16	35	8	3

Findings:

- designator definition contains eight instead of nine variables (1 overlap)
 - designator sets high focus on definitions relevant for calculating trajectories / poses instead of using them

Figure 46: Left: Manual designator for the action *Placing Down* (46 lines). Right: Generated designator based on *Pouring* (44 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
30	32	13	1

Findings:

- designator definition contains only one instead of nine variables
 - some minor renaming (e.g. *approach* instead of *reach*)
 - designator calculates trajectories and poses in a different manner
 - designator (falsely) ends by mapping the variables to designator "parts"

```

1  ;<- (design.action-grounding ?action-designator (place ?current-object-designator ?arm
2   ;?left-reach-poses ?right-reach-poses
3   ;?left-put-poses ?right-put-poses
4   ;?left-retract-poses ?right-retract-poses
5   ;?location))
6   (spec property ?action-designator (:type :placing))
7
8
9
10
11  ;(> (spec property ?action-designator (:arm ?arm))
12   ;(> (spec property ?action-designator (?object ?object-designator))
13   ;(or (cpoe object-in-hand ?object-designator ?arm)
14   ;(and (format "WARNING: Wanted to place an object ~a with arm ~a, ~
15   ;but it's not in the arm.~%" ?object-designator ?arm)
16   ;)))
17   ;(> (spec property ?action-designator (?object ?object-designator))
18   ;(spec property ?action-designator (?object ?object-designator ?arm)
19   ;(and (cram:robot-interfaces:robot ?robot)
20   ;(cram:robot-interfaces:arm ?robot ?arm)
21   ;(cram:object-in-hand ?object-designator ?arm)))
22   ;(once (or (cram:object-in-hand ?object-designator ?arm)
23   ;(spec property ?action-designator (?object ?object-designator)))
24   ;(design current-designator ?object-designator ?current-object-designator)
25   ;(spec property ?current-object-designator (:type ?object-type))
26   ;(spec property ?current-object-designator (:name ?object-name))
27   ;(obj-int:object-type-grasp ?object-type ?grasp)
28   ;(> (spec property ?action-designator (?target ?location))
29   ;(and (cram:object-in-hand ?object-designator ?location ?current-location-designator)
30   ;(design designer-grounding ?current-location-designator ?poses)
31   ;(member ?target-poses ?poses)
32   ;(symbol-value cram-if:robot-base-frame ?base-frame)
33   ;(lisp-fun cram-if:ensure-pose-in-frame ?target-poses ?base-frame :use-zero-time t
34   ;?target-poses-in-base)
35   ;(lisp-fun roslib-unities:rosify-underscores-lisp-name ?object-name ?if-name)
36   ;(lisp-fun cram-if:pose-stamped->transform-stamped ?target-poses-in-base ?if-name
37   ;?target-transform)
38   ;(and (lisp-fun obj-int:get-object-transform ?current-object-designator ?target-transform)
39   ;(lisp-fun obj-int:get-object-pose ?current-object-designator ?target-poses)
40   ;(lisp-fun obj-int:get-object-pose ?current-object-designator ?target-poses)
41   ;(design designer :location ((cpose ?target-poses) ?location)))
42   ;(lisp-fun obj-int:get-object-grasping-poses
43   ;?object-name ?object-type :left ?grasp ?target-transform
44   ;?left-poses)
45   ;(lisp-fun obj-int:get-object-grasping-poses
46   ;?object-name ?object-type :right ?grasp ?target-transform
47   ;?right-poses)
48   ;(lisp-fun extract:place-manipulation-poses ?arm ?left-poses ?right-poses
49   ;(?left-reach-poses ?right-reach-poses ?left-put-poses ?right-put-poses
50   ;?left-retract-poses ?right-retract-poses)))
51
52
53
;
```



```

1  ;<- (design.action-grounding ?action-designator (place-down ?resolved-action-designator))
2
3
4
5
6   (spec property ?action-designator (:type :placing))
7   (spec property ?action-designator (?object ?object-designator))
8   (design current-object-designator ?current-object-design)
9   (spec property ?current-object-design (?name ?object-type))
10  (spec property ?current-object-design (?name ?object-name))
11   (> (spec property ?action-designator (arm ?arm))
12   ;(true)
13   ;(man-int:robot-holding-object ?_ ?arm ?current-object-design)
14   ;(lisp-fun man-int:get-object-old-transform ?current-object-design ?object-transform)
15   ;(lisp-fun man-int:calculate-object-faces ?object-transform ?facing-robot-face ?bottom-face))
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37   ;(lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
38   ;(> (lisp-fun man-int:get-action-trajectory :placing ?arm NIL NIL NIL ?place-down-pose)
39   ;(and
40   ;(design design-prop ?action-designator (:collision-mode ?collision-mode))
41   ;(equal ?collision-mode nil)
42   ;(design designator :action ((:type :placing)
43   ;(?object ?current-object-design)
44
45
46   ;(?object-name ?object-name)
47   ;(arm ?arm)
48   ;(:gripper-opening ?gripper-opening)
49   ;(effort ?effort)
50   ;(place-down-pose ?place-down-pose)
51   ;(:collision-mode ?collision-mode))
52
53
;
```

Figure 47: Left: Manual designator for the action *Placing Down* (46 lines). Right: Generated designator based on *Slicing* (27 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
21	40	4	2

Findings:

- designator definition contains only one instead of nine variables
- designator sets high focus on definitions relevant for calculating trajectories / poses instead of using them
- designator (falsely) ends by mapping the variables to designator "parts"

```

1  | <-(design-action-grounding ?action-designator (place ?current-object-designator ?arm
2  |   ?left-reach-poses ?right-reach-poses
3  |   ?left-put-poses ?right-put-poses
4  |   ?left-retract-poses ?right-retract-poses
5  |   ?location))
6  | 
7  |   (spec:property ?action-designator (:type :placing))
8  | 
9  |   (spec:property ?action-designator (:arm ?arm))
10 | 
11 |   (spec:property ?action-designator (:object ?object-designator))
12 | 
13 |   (or (cpeo:object-in-hand ?object-designator ?arm)
14 |       (and (format WARNING: Wanted to place an object ~a with arm ~a, ~
15 |             but it's not in the arm. ~% ?object-designator ?arm)
16 |           ))
17 | 
18 |   (cpeo:object-in-hand ?object-designator ?object ?object-designator)
19 | 
20 |   (cpeo:object-in-hand ?object-designator ?object ?object-designator)
21 | 
22 |   (and (cram-robot-interfaces:robot ?robot)
23 |         (cram-robot-interfaces:arm ?robot ?arm)
24 |         (cpeo:object-in-hand ?object-designator ?arm)))
25 | 
26 |   (once (spec:property ?action-designator (:type ?object-type)))
27 | 
28 |   (spec:property ?current-object-designator ?object ?object-designator)
29 | 
30 |   (spec:property ?current-object-designator ?name ?object-name)
31 | 
32 |   (obj-int:object-type:grasp ?object-type ?grasp)
33 | 
34 |   (spec:property ?action-designator (:target ?location))
35 | 
36 |   (and (desig:current-designator ?location ?current-location-designator)
37 |         (desig:current-designator ?location ?current-location-designator)
38 |         (member ?target-poses ?poses)
39 |         (symbol-value cram-tf::robot-base-frame* ?base-frame)
40 |         (lisp-fun cram-tf:ensure-pose-in-frame ?target-poses ?base-frame :use-zero-time t
41 |             ?target-pose-in-base)
42 |         (lisp-fun roslib-utilities:rosify-underscores-lisp-name ?object-name ?tf-name)
43 |         (lisp-fun cram-tf:pose-stamped->transform-stamped ?target-pose-in-base ?tf-name
44 |             ?target-transform)
45 |         (and (lisp-fun obj-int:get-object-transform ?current-object-designator ?target-transform)
46 |               (lisp-fun obj-int:get-object-pose ?current-object-designator ?target-pose)
47 |               (desig:current-designator ?location ((?poses ?target-pose) ?location)))
48 |               (lisp-fun obj-int:get-object-grasping-poses
49 |                   ?object-name ?object-type ?left ?grasp ?target-transform
50 |                   ?left-poses)
51 |               (lisp-fun obj-int:get-object-grasping-poses
52 |                   ?object-name ?object-type ?right ?grasp ?target-transform
53 |                   ?right-poses)
54 |               (lisp-fun extract-place-manipulation-poses ?arm ?left-poses ?right-poses
55 |                   (?left-reach-poses ?right-reach-poses ?left-put-poses ?right-put-poses
56 |                   ?left-retract-poses ?right-retract-poses)))))

```



```

1  | <-(design-action-grounding ?action-designator (place-down ?resolved-action-designator))
2  | 
3  | 
4  | 
5  | 
6  | 
7  | 
8  | 
9  | 
10 | 
11 | 
12 | 
13 | 
14 | 
15 | 
16 | 
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44 | 
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46 |

```

Figure 48: Left: Manual designator for the action *Placing Down* (46 lines). Right: Generated designator based on *Wiping* (13 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
1	34	11	1

Findings:

- designator definition contains only one instead of nine variables
- designator contains only (some) definitions and no usage / calculations
- designator (falsely) ends by mapping the variables to designator "parts"

```

1  (-> (design.action-grounding ?action-designator (pour ?resolved-action-designator))
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
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21
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71
72
73
74
75
76
77
78
79
80
81
82
83
84
85

```

(spec:property ?action-designator (:type ?pouring))
(spec:property ?action-designator ?object ?source-object-designator)
(spec:current-designator ?object-designator ?current-object-desig)
(spec:property ?current-object-desig (:type ?object-type))
(-> (spec:property ?action-designator (:arms ?arms))
(when
 (and (man-intro-trust-free-hand ?_ ?arm)
 (equal ?arms (?arm)))
 (lisp-fun man-int-get-object-transform ?current-object-desig ?object-transform)
 (lisp-fun man-int-calculate-object-faces ?object-transform (facing-robot-face ?bottom-face))
 (-> (spec:property ?current-object-desig (:symmetric ?object-type))
 (equal ?rotationally-symmetric nil))
 (-> (spec:property ?action-designator (:grasp ?grasp))
 (true))
 (and (member ?arm ?arms)
 (lisp-fun man-int-get-action-grasps ?object-type ?arm ?object-transform ?grasps)
 (member ?grasp ?grasps))
 (lisp-fun man-int-get-action-gripping-effort ?object-type ?effort)
 (lisp-fun man-int-get-action-gripper-opening ?object-type ?gripper-opening)
 (equal ?object ?current-object-desig))
 (-> (spec:property ?target ?arm))
 (and (lisp-fun man-int-get-action-trajectory :pouring :left ?grasp T ?objects
 ?left-pouring-pose)
 (lisp-fun man-int-get-traj-poses-by-label ?left-pouring-pose :approach
 ?right-approach-poses)
 (lisp-fun man-int-get-traj-poses-by-label ?left-pouring-pose :tilting
 ?right-tilt-poses))
 (and (equal ?left-approach-poses NIL))
 (equal ?left-tilt-poses NIL))
 (-> (spec:property ?target ?right))
 (and (lisp-fun man-int-get-action-trajectory :pouring :right ?grasp T ?objects
 ?right-pouring-pose)
 (lisp-fun man-int-get-traj-poses-by-label ?right-pouring-pose :approach
 ?right-approach-poses)
 (lisp-fun man-int-get-traj-poses-by-label ?right-pouring-pose :tilting
 ?right-tilt-poses))
 (and (equal ?right-approach-poses NIL))
 (equal ?right-tilt-poses NIL))
 (-> (spec:desig-prop ?action-designator (:collision-mode ?collision-mode)))
 (true))
 (equal ?collision-mode nil))
 (design:designator :action ((?object ?current-object-desig)
 (?object-type ?object-type))
 (?object-name ?object-name)
 (?arms ?arms)
 (?grasp ?grasp)
 (?left-approach-poses ?left-approach-poses)
 (?right-approach-poses ?right-approach-poses)
 (?left-tilt-poses ?left-tilt-poses)
 (?right-tilt-poses ?right-tilt-poses)
 (?collision-mode ?collision-mode))
 (?resolved-action-designator))


```

1  (-> (design.action-grounding ?action-designator (pour ?arm))
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
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```

(spec:property ?action-designator (:type ?pouring))
(spec:property ?action-designator ?target ?target-container-designator)
(spec:property ?source-container-designator (:type ?source-container-type))
(spec:property ?object-type-subtype ?container ?source-container-type)
(spec:property ?source-container-designator (:urdf-name ?source-container-name))
(spec:property ?source-container-designator (:part-of ?btr-environment))
(spec:property ?target-container-designator (:type ?target-container-type))
(spec:property ?target-container-designator (?name ?target-container-name))
(spec:property ?target-container-designator (:part-of ?btr-environment))
(-> (spec:property ?action-designator (:arm ?arm)))
(true))
(and (cram-robot-interfaces robot ?robot)
(cram-robot-interfaces arm ?robot ?arm))
(lisp-fun obj-int-get-object-type-gripper-opening ?source-container-type ?gripper-opening)
(spec:property ?action-designator (:distance ?distance))
(lisp-fun get-container-link ?source-container-name ?btr-environment ?source-container-link)
(lisp-fun get-connecting-joint ?source-container-link ?connecting-joint)
(lisp-fun el-strict-name ?connecting-joint ?part-name))
(btr:btr-world ?world)
(lisp-fun bl-object ?world ?btr-environment ?environment-obj)
(lisp-fun get-container-pose-and-transform ?target-container-name ?btr-environment
(?target-container-pose ?target-container-transform))
(lisp-fun get-container-pose-and-transform ?target-container-name ?btr-environment
(?target-container-pose ?target-container-transform))
(lisp-fun obj-int-get-object-grasping-pose ?source-container-name
?container-prismatic :left :close ?source-container-transform ?left-poses)
(lisp-fun obj-int-get-object-grasping-pose ?source-container-name
?container-prismatic :right :close ?source-container-transform ?right-poses)
(lisp-fun cram-mobile-pick-place-plans:extract-pick-up-manipulation-poses
?arm ?left-poses ?right-poses
?left-reach-poses ?right-reach-poses
?left-grasp-poses ?right-grasp-poses
?left-tilt-poses ?right-tilt-poses))
(-> (lisp-pred identity ?left-tilt-poses))
(equal ?left-tilt-poses ?left-tilt-poses ?left-2nd-lft-tilt-poses))
(equal (NIL NIL) ?left-tilt-poses ?left-2nd-lft-tilt-poses))
(-> (lisp-pred identity ?right-tilt-poses))
(equal ?right-tilt-poses ?right-tilt-poses ?right-2nd-lft-tilt-poses))
(equal (NIL NIL) ?right-tilt-poses ?right-2nd-lft-tilt-poses)))

Figure 49: Left: Manual designator for the action *Pouring* (56 lines). Right: Generated designator based on *Closing* (56 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
48	48	6	2

Findings:

- designator definition contains 15 instead of only one variable
- designator calculates trajectories and poses in a different manner
- generation adds block about **cram-robot-interfaces** (2 lines)
- designator does not end by mapping the variables to designator "parts"

```

1  <- (desig:action-grounding ?action-designator (pour ?resolved-action-designator))
2   (spec:property ?action-designator :type ?pouring)
3   (spec:property ?action-designator :object ?object-designator)
4   (spec:current-designator ?object-designator ?current-object-desig)
5   (spec:property ?current-object-desig :type ?object-type)
6   (spec:property ?current-object-desig :name ?object-name)
7
8   (> (spec:property ?action-designator :arms ?arms)
9    (true)
10   (and (man:int:robot-free-hand ?_ ?arm)
11     (equal ?arms ?arm)))
12
13   (lisp-fun-man-int-set-object-transform ?current-object-designator ?object-transform)
14   (lisp-fun-man-int-set-object-faces ?object-transform ?facing-robot-face ?bottom-face)
15
16   (> (man:int:object-rotationally-symmetric ?object-type)
17     (equal ?rotationally-symmetric nil))
18
19   (> (spec:property ?action-designator (grasp ?grasp)
20    (true)
21   (and (member ?arm ?arms)
22     (lisp-fun-man-int-get-action-grasps ?object-type ?arm ?object-transform ?grasps)
23     (member ?grasp ?grasps)))
24
25
26
27
28   (lisp-fun-man-int-get-action-gripping-effort ?object-type ?effort)
29   (lisp-fun-man-int-get-action-gripper-opening ?object-type ?gripper-opening)
30   (equal ?object-type ?current-object-designator)
31
32   (> (member ?left ?arms)
33     (and (lisp-fun-man-int-get-action-trajectory :pouring ?left ?grasp T ?objects
34       ?left-pouring-pose)
35       (lisp-fun-man-int-get-traj-poses-by-label ?left-pouring-pose :approach
36         ?left-approach-poses)
37       (lisp-fun-man-int-get-traj-poses-by-label ?left-pouring-pose :tilting
38         ?left-tilt-poses)
39       (and (equal ?left-tilt-poses NIL)
40         (equal ?left-tilt-poses NIL)))
41
42   (> (member ?right ?arms)
43     (and (lisp-fun-man-int-get-action-trajectory :pouring ?right ?grasp T ?objects
44       ?right-pouring-pose)
45       (lisp-fun-man-int-get-traj-poses-by-label ?right-pouring-pose :approach
46         ?right-approach-poses)
47       (lisp-fun-man-int-get-traj-poses-by-label ?right-pouring-pose :tilting
48         ?right-tilt-poses)
49
50   (> (desig:design-prop ?action-designator :collision-mode ?collision-mode)
51     (true)
52     (equal ?collision-mode nil))
53
54   (desig:designator :action :type ?pouring)
55   (desig:designator :object :current-object-designator)
56   (desig:designator :object-type :object-type)
57
58   (desig:designator :object-name :object-name)
59   (desig:designator :arms ?arms)
60
61   (desig:designator :grasp ?grasp)
62   (desig:designator :left-approach-poses ?left-approach-poses)
63   (desig:designator :right-approach-poses ?right-approach-poses)
64   (desig:designator :left-tilt-poses ?left-tilt-poses)
65   (desig:designator :right-tilt-poses ?right-tilt-poses)
66
67   (desig:designator :collision-mode ?collision-mode)
68
69   ?resolved-action-designator]

```



```

1  <- (desig:action-grounding ?action-designator (pour ?resolved-action-designator))
2   (spec:property ?action-designator :type ?pouring)
3   (spec:property ?action-designator :source ?source-designator)
4   (spec:property ?action-designator :destination ?destination-designator)
5   (spec:current-designator ?source-designator ?current-source-desig)
6   (spec:current-designator ?destination-designator ?current-destination-desig)
7
8   (spec:property ?current-source-desig :type ?source-type)
9   (spec:property ?current-source-desig :name ?source-name)
10  (spec:property ?current-destination-desig :type ?destination-type)
11  (spec:property ?current-destination-desig :name ?destination-name)
12
13  (> (spec:property ?action-designator :arm ?arm))
14
15  (man:int:robot-free-hand ?_ ?arm)
16  (lisp-fun-man-int-get-object-old-transform ?current-source-designator ?source-transform)
17  (lisp-fun-man-int-get-object-old-transform ?current-destination-designator ?destination-transform)
18  (lisp-fun-man-int-calculate-object-faces ?source-transform ?source-top-face ?source-bottom-face)
19  (lisp-fun-man-int-calculate-object-faces ?destination-transform ?destination-top-face ?destination-bottom-face)
20
21  (> (spec:property ?action-designator (grasp ?grasp)
22    (true)
23
24  (and (lisp-fun-man-int-get-action-grasps ?source-type ?arm ?source-transform ?grasps)
25    (member ?grasp ?grasps)))
26
27  (> (spec:property ?action-designator (:pouring-pose ?pouring-pose))
28    (true)
29
30  (lisp-fun-man-int-get-action-grinding-effort ?source-type ?effort)
31  (lisp-fun-man-int-get-action-gripper-opening ?source-type ?gripper-opening)
32  (equal ?objects ?current-source-desig ?current-destination-desig)
33
34  (> (equal ?left ?arm)
35    (and (lisp-fun-man-int-get-traj-poses-by-label ?left-pouring-pose :pouring-up
36      ?left-pouring-up-poses)
37      (lisp-fun-man-int-get-traj-poses-by-label ?left-pouring-pose :pouring-down
38        ?left-pouring-down-poses)
39      (and (equal ?left-pouring-up-poses NIL)
40        (equal ?left-pouring-down-poses NIL)))
41
42  (> (equal ?right ?arm)
43    (and (lisp-fun-man-int-get-traj-poses-by-label ?right-pouring-pose :pouring-up
44      ?right-pouring-up-poses)
45      (lisp-fun-man-int-get-traj-poses-by-label ?right-pouring-pose :pouring-down
46        ?right-pouring-down-poses)
47      (and (equal ?right-pouring-up-poses NIL)
48        (equal ?right-pouring-down-poses NIL)))
49
50  (> (desig:design-prop ?action-designator :collision-mode ?collision-mode)
51    (true)
52    (equal ?collision-mode nil))
53
54  (desig:designator :action :type ?pouring)
55  (desig:designator :object :current-object-designator)
56  (desig:designator :source-name :source-name)
57  (desig:designator :destination-name :destination-name)
58
59  (desig:designator :arm ?arm)
60  (desig:designator :gripper-opening ?gripper-opening)
61  (desig:designator :effort ?effort)
62  (desig:designator :grasp ?grasp)
63
64  (desig:designator :left-pouring-up-poses ?left-pouring-up-poses)
65  (desig:designator :right-pouring-up-poses ?right-pouring-up-poses)
66  (desig:designator :left-pouring-down-poses ?left-pouring-down-poses)
67  (desig:designator :right-pouring-down-poses ?right-pouring-down-poses)
68
69  (desig:designator :collision-mode ?collision-mode)
70
71  ?resolved-action-designator]

```

Figure 50: Left: Manual designator for the action *Pouring* (56 lines). Right: Generated designator based on *Halving* (63 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
14	7	34	15

Findings:

- some minor renaming (e.g. *source* instead of *object*)
- designator calculates a specific *pouring-pose*
- generated designator extends the mapping of variables to designator "parts" (misses *:object-type* and *:arms* but adds *:source-name*, *:destination*, *:gripper-opening*, *:effort* and *:arm*)

Figure 51: Left: Manual designator for the action *Pouring* (56 lines). Right: Generated designator based on *Holding* (37 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
18	37	15	4

Findings:

- designator sets high focus on definitions relevant for calculating trajectories / poses instead of using them
 - generated designator shortens the mapping of variables to designator "parts" (misses `:object-type`, `:grasp`, `:collision-mode`, `:right-approach-poses` and `:arms` but adds `:target`, `:target-name` and `:pour-direction`)

```

1  :-(< (design:action-grounding ?action-designator (pour ?resolved-action-designator))
2
3
4
5
6
7
8
9
10
11
12
13
14
15   (spec:property ?action-designator (:type :pouring))
16   (spec:property ?action-designator (:object ?object-designator))
17   (design:current-designator ?object-designator ?current-object-desig)
18   (spec:property ?current-object-desig (:type ?object-type))
19
20
21
22
23
24   (spec:property ?current-object-desig (:name ?object-name))
25
26   :-(> (spec:property ?action-designator (:arms ?arms))
27
28     (true)
29     (and (man-int:robot-free-hand ?_ ?arm)
30       (equal ?arms ?arm)))
31     (lisp-fun man-int:get-object-transform ?current-object-desig ?object-transform)
32     (lisp-fun man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
33     (> (man-int:object-rotationally-symmetric ?object-type)
34       (equal ?rotationally-symmetric nil))
35     (> (spec:property ?action-designator (:grasp ?grasp))
36       (true)
37       (and (member ?arm ?arms)
38         (+ (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
39             (member ?grasp ?grasps)))
40         (lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
41         (+ (lisp-fun obj-int:get-object-gripper-opening ?object-type ?gripper-opening)
42             (equal ?objects ?current-object-desig))
43         (> (member :left ?arms)
44           (and (lisp-fun man-int:get-action-trajectory :pouring :left ?grasp T ?objects
45             ?left-pouring-pose)
46             (lisp-fun man-int:get-traj-poses-by-label ?left-pouring-pose :approach
47               ?left-approach-poses)
48             (lisp-fun man-int:get-traj-poses-by-label ?left-pouring-pose :tilting
49               ?left-tilt-poses)
50             (and (equal ?left-approach-poses NIL)
51               (equal ?left-tilt-poses NIL)))
52         (> (member :right ?arms)
53           (and (lisp-fun man-int:get-action-trajectory :pouring :right ?grasp T ?objects
54             ?right-pouring-pose)
55               (lisp-fun man-int:get-traj-poses-by-label ?right-pouring-pose :approach
56                 ?right-approach-poses)
57               (lisp-fun man-int:get-traj-poses-by-label ?right-pouring-pose :tilting
58                 ?right-tilt-poses)
59               (and (equal ?right-approach-poses NIL)
60                 (equal ?right-tilt-poses NIL)))
61         (> (design:desig-prop ?action-designator (:collision-mode ?collision-mode))
62           (true)
63           (equal ?collision-mode nil))
64         (design:designator ?action (:type :pouring)
65           (:object ?current-object-desig)
66           (:object-type ?object-type)
67           (:object-name ?object-name)
68           (:arms ?arms)
69           (:grasp ?grasp)
70           (:left-approach-poses ?left-approach-poses)
71           (:right-approach-poses ?right-approach-poses)
72           (:left-tilt-poses ?left-tilt-poses)
73           (:right-tilt-poses ?right-tilt-poses)
74           (:collision-mode ?collision-mode))
75           ?resolved-action-designator)))
1  :-(< (design:action-grounding ?action-designator [pour ?arm]
2
3
4
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13
14
15   (spec:property ?action-designator (:type :pouring))
16   (spec:property ?action-designator (:source ?source-container-designator))
17   (spec:property ?action-designator (:target ?target-container-designator))
18   (spec:property ?source-container-designator (:type ?source-container-type))
19   (spec:property ?source-container-designator (?part-of ?btb-environment))
20   (spec:property ?source-container-designator (?part-of ?btb-environment))
21   (spec:property ?target-container-designator (?part-of ?btb-environment))
22   (spec:property ?target-container-designator (?part-of ?btb-environment))
23   (+ (spec:property ?action-designator (:arm ?arm))
24
25     (true)
26     (and (cram-robot-interfaces:robot ?robot)
27       (cram-robot-interfaces:arm ?robot ?arm)))
28     (spec:property ?action-designator (:distance ?distance))
29     (lisp-fun get-container-link ?source-container-name ?btb-environment ?source-container-link)
30     (lisp-fun get-connecting-joint ?source-container-link ?connecting-joint)
31     (lisp-fun cl-urdf:link-name ?connecting-joint ?joint-name)
32     (bt:bullet-world ?world)
33
34
35
36
37
38   (+ (lisp-fun btr:object ?world ?btr-environment ?environment-obj)
39
40
41   (+ (lisp-fun obj-int:get-object-type-gripper-opening ?source-container-type ?gripper-opening)
42     (lisp-fun obj-int:get-container-poses-and-transform ?source-container-name ?btr-environment
43       (?source-container-poses ?source-container-transform)))
44
45
46
47
48   (+ (lisp-fun obj-int:get-object-grasping-poses ?source-container-name
49     (:container-prismatic :left open ?source-container-transform ?left-poses)
50     (lisp-fun obj-int:get-object-grasping-poses ?source-container-name
51       (:container-prismatic :right open ?source-container-transform ?right-poses)
52       (lisp-fun cram-mobile:pick-place-plans::extract-pick-up-manipulation-poses
53
54
55
56   (+ ?arm ?left-poses ?right-poses
57     (?left-reach-poses ?right-reach-poses
58     ?left-grasp-poses ?right-grasp-poses)
59
60
61   (+ (lisp-pred identity ?left-lift-poses ?right-lift-poses))
62     (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose))
63     (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
64
65
66
67
68
69
70
71   (+ (lisp-pred identity ?right-lift-poses)
72     (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose))
73     (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose)))
74
75

```

Figure 52: Left: Manual designator for the action *Pouring* (56 lines). Right: Generated designator based on *Opening* (53 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
40	43	11	2

Findings:

- designator definition contains 15 instead of only one variable
- designator calculates trajectories and poses in a different manner
- some minor renaming (e.g. *source* instead of *object*)
- generation adds block about **cram-robot-interfaces** (2 lines)
- designator does not end by mapping the variables to designator "parts"

Figure 53: Left: Manual designator for the action *Pouring* (56 lines). Right: Generated designator based on *Picking Up* (49 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
40	47	7	2

Findings:

- designator definition contains 12 instead of only one variable
 - designator calculates trajectories and poses in a different manner
 - some minor renaming (e.g. *container* instead of *object*)
 - generation adds block about **cram-robot-interfaces** (2 lines)
 - designator does not end by mapping the variables to designator "parts"

```

1  | <- (desig.action-grounding ?action-designator [pour ?resolved-action-designator])
2  |   (spec property ?action-designator (:type :pouring))
3  |   (spec property ?action-designator [object ?object-designator])
4  |   (desig current-designator ?object-designator ?current-object-desig)
5  |   (spec property ?current-object-desig (:type ?object-type))
6  |   (spec property ?current-object-desig (:name ?object-name))
7  |   (-> (spec:property ?action-designator (:arms ?arms)))
8  |     (true)
9  |     (and (man-int:robot-free-hand ?_?arm)
10 |       (equal ?armc ?arm)))
11 |     (lisp-fun man-int:get-object-transform ?current-object-desig ?object-transform)
12 |     (lisp-fun man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
13 |     (-> (man-int:object-rotationally-symmetric ?object-type)
14 |       (equal ?rotationally-symmetric nil))
15 |     (-> (spec:property ?action-designator (:grasp ?grasp))
16 |       (true)
17 |       (and (member ?armc ?arms)
18 |         (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
19 |           (member ?grasp ?grasps)))
20 |         (lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
21 |         (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
22 |         (equal ?objects ?current-object-desig)
23 |         (-> (member ?left ?arms)
24 |           (and (lisp-fun man-int:get-action-trajectory :pouring :left) ?grasp T ?objects
25 |             ?left-pouring)
26 |             (lisp-fun man-int:get-traj-poses-by-label ?left-pouring-pose :approach
27 |               ?left-approach-poses)
28 |               (lisp-fun man-int:get-traj-poses-by-label ?left-pouring-pose :tilting
29 |                 ?left-tilt-poses)
30 |                 (and (equal ?left-approach-poses NIL)
31 |                   (equal ?left-tilt-poses NIL))
32 |                   (-> (member ?right ?arms)
33 |                     (and (lisp-fun man-int:get-action-trajectory :pouring :right) ?grasp T ?objects
34 |                       ?right-pouring)
35 |                         (lisp-fun man-int:get-traj-poses-by-label ?right-pouring-pose :approach
36 |                           ?right-approach-poses)
37 |                           (lisp-fun man-int:get-traj-poses-by-label ?right-pouring-pose :tilting
38 |                             ?right-tilt-poses)
39 |                             (and (equal ?right-approach-poses NIL)
40 |                               (equal ?right-tilt-poses NIL)))
41 |                               (-> (desig:design-prop ?action-designator (:collision-mode ?collision-mode))
42 |                                 (true)
43 |                                 (equal ?collision-mode nil))
44 |                                 (desig:designator :action ((:type :pouring)
45 |                                   (object ?current-object-desig)
46 |                                   (object-type ?object-type)
47 |                                   (object-name ?object-name)
48 |                                   (arms ?arms)
49 |                                   (grasp ?grasp)
50 |                                   (left-approach-poses ?left-approach-poses)
51 |                                   (right-approach-poses ?right-approach-poses)
52 |                                   (left-tilt-poses ?left-tilt-poses)
53 |                                   (right-tilt-poses ?right-tilt-poses)
54 |                                   (collision-mode ?collision-mode)))
55 |                                 ?resolved-action-designator)
56 |

```



```

1  | <- (desig.action-grounding ?action-designator [pour ?source-container ?target-container])
2  |   (spec property ?action-designator (:type :pouring))
3  |   (spec property ?current-target-container (:type ?target-type))
4  |   (spec property ?current-target-container [object ?source-container])
5  |   (cpeo:object-in-hand ?source-container ?arm))
6  |
7  |   (-> (spec property ?action-designator [target ?target-container])
8  |     (desig current-designator ?target-container ?current-target-container)
9  |     (spec property ?current-target-container (:type ?target-type))
10 |     (and (member ?target-type (:container :bottle :glass))
11 |       (not (cpeo:object-in-hand ?current-target-container ?arm))))
12 |       (lisp-fun obj-int:get-container-contents ?source-container ?contents)
13 |       (lisp-fun obj-int:empty-container ?source-container)
14 |       (lisp-fun obj-int:fill-container ?target-container ?contents)))
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56 |

```

Figure 54: Left: Manual designator for the action *Pouring* (56 lines). Right: Generated designator based on *Placing Down* (12 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
8	52	3	1

Findings:

- designator definition contains two instead of only one variable
- some minor renaming (e.g. *source-container* instead of *object*)
- designator contains only some definitions, no assignments or calculations
- designator does not end by mapping the variables to designator "parts"

```

1  <- (design-action-grounding ?action-designator (pour ?resolved-action-designator))
2   (spec:property ?action-designator (:type :pouring))
3   (spec:property ?action-designator (?object ?object-designator))
4   (spec:current-designator ?object-designator ?current-object-design)
5   (spec:property ?current-object-design (:type ?object-type))
6   (spec:property ?current-object-design (:name ?object-name))
7
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61
62
63
64

```

```

1  <- (design-action-grounding ?action-designator (pour ?resolved-action-designator))
2   (spec:property ?action-designator (:type :pouring))
3   (spec:property ?action-designator (?source ?source-designator))
4   (spec:current-designator ?source-designator ?current-source-design)
5   (spec:current-designator ?target-designator ?current-target-design)
6   (spec:property ?current-source-design (:type ?source-type))
7   (spec:property ?current-source-design (:name ?source-name))
8   (spec:property ?current-target-design (:type ?target-type))
9   (spec:property ?current-target-design (:name ?target-name))
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```

Figure 55: Left: Manual designator for the action *Pouring* (56 lines). Right: Generated designator based on *Slicing* (55 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
13	14	27	15

Findings:

- some minor renaming (e.g. *source* instead of *object*)
- designator calculates trajectories and poses in a different manner
- generated designator extends the mapping of variables to designator "parts" (misses *:object-type*, *:left-tilt-poses*, *:right-tilt-poses* and *:arms* but adds *:target*, *:source-name*, *:arm*, *:gripper-opening* and *:effort*)

```

1  <- (design-action-grounding ?action-designator (pour ?resolved-action-designator))
2    (spec-property ?action-designator :type :pouring)
3    (spec-property ?action-designator :object ?object-designator)
4
5    (spec-current-designator ?object-designator ?current-object-desig)
6    (spec-property ?current-object-desig :type ?object-type)
7    (spec-property ?current-object-desig :name ?object-name)
8    (spec-property ?action-designator :arms ?arms)
9      (true)
10   (and (man-int-robot-free-hand ?_?arm)
11     (equal ?arms ?arm)))
12   (lisp-fun man-int-get-object-transform ?current-object-desig ?object-transform)
13   (lisp-fun man-int-calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
14   (> (man-int-object-rotationally-symmetric ?object-type)
15     (equal ?rotationally-symmetric t))
16   (equal ?rotationally-symmetric nil)
17
18   (> (spec-property ?action-designator :grasp ?grasp))
19   (true)
20   (and (member ?arm ?arms)
21     (lisp-fun man-int-get-action-grasps ?object-type ?arm ?object-transform ?grasps)
22     (member ?grasp ?grasps)))
23
24   (lisp-fun man-int-get-action-gripping-effort ?object-type ?effort)
25   (lisp-fun man-int-get-action-gripper-opening ?object-type ?gripper-opening)
26   (equal ?objects (?current-object-desig))
27   (> (member ?left ?arms)
28     (and (lisp-fun man-int-get-action-trajectory :pouring ?left ?grasp T ?objects
29       ?left-pouring-pose)
30       (lisp-fun man-int-get-traj-poses-by-label ?left-pouring-pose :approach
31         ?left-approach-poses)
32       (lisp-fun man-int-get-traj-poses-by-label ?left-pouring-pose :tilting
33         ?left-tilt-poses)))
34     (and (equal ?left-approach-poses NIL)
35       (equal ?left-tilt-poses NIL)))
36   (> (member ?right ?arms)
37     (and (lisp-fun man-int-get-action-trajectory :pouring ?right ?grasp T ?objects
38       ?right-pouring-pose)
39       (lisp-fun man-int-get-traj-poses-by-label ?right-pouring-pose :approach
40         ?right-approach-poses)
41       (lisp-fun man-int-get-traj-poses-by-label ?right-pouring-pose :tilting
42         ?right-tilt-poses)))
43     (and (equal ?right-approach-poses NIL)
44       (equal ?right-tilt-poses NIL)))
45   (> (design-design-prop ?action-designator :collision-mode ?collision-mode))
46   (true)
47   (equal ?collision-mode nil))
48
49   (design-designator :action ((type :pouring)
50     (:object ?current-object-desig)
51     (:object-type ?object-type)
52     (:object-name ?object-name)
53     (:arms ?arms)
54     (:grasp ?grasp)
55     (:left-approach-poses ?left-approach-poses)
56     (:right-approach-poses ?right-approach-poses)
57     (:left-tilt-poses ?left-tilt-poses)
58     (:right-tilt-poses ?right-tilt-poses)
59     (:collision-mode ?collision-mode)))
60     ?resolved-action-designator))
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Figure 56: Left: Manual designator for the action *Pouring* (56 lines). Right: Generated designator based on *Wiping* (39 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
9	26	26	4

Findings:

- some minor renaming (e.g. *source* instead of *object*)
 - designator calculates trajectories and poses in a different manner
 - generated designator shortens the mapping of variables to designator "parts" (misses *:object*, *:object-type*, *:object-name*, *:grasp* and *:arms*

```

1  :- (<- (desig:action-grounding ?action-designator (slice ?resolved-action-designator))
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1  :- (<- (desig:action-grounding ?action-designator (slice ?arm
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Figure 57: Left: Manual designator for the action *Slicing* (55 lines). Right: Generated designator based on *Closing* (48 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
28	35	17	3

Findings:

- designator definition contains 14 instead of only one variable
- some minor renaming (e.g. *cutting* instead of *slicing*)
- designator calculates trajectories and poses in a different manner
- generation adds block about `cram-robot-interfaces` (2 lines)
- designator does not end by mapping the variables to designator "parts"

```

1  :-> (desig-action-grounding ?action-designator (slice ?resolved-action-designator))
2   | spec:property ?action-designator (:type :slicing)
3   | spec:property ?action-designator (?object ?object-designator)
4   | (design-current-designator ?object-designator ?current-object-design)
5   | (spec:property ?current-object-desig (?type ?object-type))
6   | (spec:property ?current-object-desig (?name ?object-name))
7   | (spec:property ?action-designator (:arm ?arm))
8   | (true)
9   | (man-int:robot-free-hand ?, ?arm)
10  | (lisp-fun:man-int:get-object-old-transform ?current-object-desig ?object-transform)
11  | (lisp-fun:man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
12  | (-> (man-int:object-rotationally-symmetric ?object-type)
13  | (equal ?rotationally-symmetric t)
14  | (equal ?rotationally-symmetric nil))
15  | (-> (spec:property ?action-designator (:grasp ?grasp))
16  | (true)
17  | (and (lisp-fun:man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
18  | (member ?grasp ?grasps)))
19
20
21
22  | (lisp-fun:man-int:get-action-gripping-effort ?object-type ?effort)
23  | (lisp-fun:man-int:get-action-gripper-opening ?object-type ?gripper-opening)
24  | (-> (equal ?objects ?current-object-design))
25  | (-> (equal ?arm ?left))
26  | (and (lisp-fun:man-int:get-action-trajectory :slicing) ?arm ?grasp T ?objects
27  | ?left-slicing-poses)
28  | (lisp-fun:man-int:get-traj-poses-by-label ?left-slicing-poses :slice-up)
29  | ?left-slice-up-poses)
30  | (lisp-fun:man-int:get-traj-poses-by-label ?left-slicing-poses :slice-down)
31  | ?left-slice-down-poses)
32  | (and (equal ?left-slice-up-poses NIL)
33  | (equal ?left-slice-down-poses NIL))
34  | (-> (equal ?arm ?right))
35  | (and (lisp-fun:man-int:get-action-trajectory :slicing) ?arm ?grasp T ?objects
36  | ?right-slicing-poses)
37  | (lisp-fun:man-int:get-traj-poses-by-label ?right-slicing-poses :slice-up)
38  | ?right-slice-up-poses)
39  | (lisp-fun:man-int:get-traj-poses-by-label ?right-slicing-poses :slice-down)
40  | ?right-slice-down-poses)
41  | (and (equal ?right-slice-up-poses NIL)
42  | (equal ?right-slice-down-poses NIL))
43  | (-> (desig:design-prop ?action-designator (:collision-mode ?collision-mode)))
44  | (true)
45  | (equal ?collision-mode nil))
46  | (desig:designator :action ((?type :slicing)
47  | (?object ?current-object-design)
48  | (?object-name ?object-name)
49  | (?arm ?arm)
50  | (?gripper-opening ?gripper-opening)
51  | (?effort ?effort)
52  | (?grasp ?grasp)
53  | (?left-slice-up-poses ?left-slice-up-poses)
54  | (?right-slice-up-poses ?right-slice-up-poses)
55  | (?left-slice-down-poses ?left-slice-down-poses)
56  | (?right-slice-down-poses ?right-slice-down-poses)
57  | (?collision-mode ?collision-mode)))
58  | (?resolved-action-designator))

1  :-> (desig-action-grounding ?action-designator (slice-into-two ?resolved-action-designator))
2   | spec:property ?action-designator (:type :slicing)
3   | spec:property ?action-designator (?object ?object-designator)
4   | (design-current-designator ?object-designator ?current-object-design)
5   | (spec:property ?current-object-desig (?type ?object-type))
6   | (spec:property ?current-object-desig (?name ?object-name))
7   | (spec:property ?action-designator (:arm ?arm))
8   | (true)
9   | (man-int:robot-free-hand ?, ?arm)
10  | (lisp-fun:man-int:get-object-old-transform ?current-object-design ?object-transform)
11  | (lisp-fun:man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
12  | (-> (man-int:object-rotationally-symmetric ?object-type)
13  | (equal ?rotationally-symmetric t)
14  | (equal ?rotationally-symmetric nil))
15  | (-> (spec:property ?action-designator (:grasp ?grasp))
16  | (true)
17  | (and (lisp-fun:man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
18  | (member ?grasp ?grasps)))
19
20
21  | (-> (spec:property ?action-designator (:object-half-pose ?object-half-pose)))
22  | (true)
23  | (format "Please infer where to cut the object, or use the query system to infer it here")
24  | (lisp-fun:man-int:get-action-gripping-effort ?object-type ?effort)
25  | (lisp-fun:man-int:get-action-gripper-opening ?object-type ?gripper-opening)
26  | (-> (equal ?arm ?left))
27  | (and (lisp-fun:man-int:get-action-trajectory :slicing) ?arm ?grasp T ?objects
28  | ?left-slice-poses)
29  | (lisp-fun:man-int:get-traj-poses-by-label ?left-slice-poses :slice-up)
30  | ?left-slice-up-poses)
31  | (lisp-fun:man-int:get-traj-poses-by-label ?left-slice-poses :slice-down)
32  | ?left-slice-down-poses)
33  | (and (equal ?left-slice-up-poses NIL)
34  | (equal ?left-slice-down-poses NIL))
35  | (-> (equal ?arm ?right))
36  | (and (lisp-fun:man-int:get-action-trajectory :slicing) ?arm ?grasp T ?objects
37  | ?right-slice-poses)
38  | (lisp-fun:man-int:get-traj-poses-by-label ?right-slice-poses :slice-up)
39  | ?right-slice-up-poses)
40  | (lisp-fun:man-int:get-traj-poses-by-label ?right-slice-poses :slice-down)
41  | ?right-slice-down-poses)
42  | (and (equal ?right-slice-up-poses NIL)
43  | (equal ?right-slice-down-poses NIL))
44  | (-> (desig:design-prop ?action-designator (:collision-mode ?collision-mode)))
45  | (true)
46  | (equal ?collision-mode nil))
47  | (desig:designator :action ((?type :slicing)
48  | (?object ?current-object-design)
49  | (?object-name ?object-name)
50  | (?arm ?arm)
51  | (?gripper-opening ?gripper-opening)
52  | (?effort ?effort)
53  | (?grasp ?grasp)
54  | (?left-slice-up-poses ?left-slice-up-poses)
55  | (?right-slice-up-poses ?right-slice-up-poses)
56  | (?left-slice-down-poses ?left-slice-down-poses)
57  | (?right-slice-down-poses ?right-slice-down-poses)
58  | (?collision-mode ?collision-mode)))
59  | (?resolved-action-designator))

```

Figure 58: Left: Manual designator for the action *Slicing* (55 lines). Right: Generated designator based on *Halving* (58 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
3	0	7	48

Findings:

- added lines describe block that is used for inferring the position / pose necessary for meeting the exact halve (not necessary for "normal" slicing)
- added lines are the same that are deleted when the reference and generated action are swapped (Fig. 15)
- remaining changes are places where the action verb is used in the "wrong" form (generated *slice* instead of *slicing*)

```

1  (-> (design-action-grounding ?action-designator (slice ?resolved-action-designator))
2    (spec:property ?action-designator :type :slicing))
3    (spec:property ?action-designator :object ?object-designator)
4      (desig:current-designator ?object-designator ?current-object-desig)
5        (spec:property ?current-object-desig :type ?object-type)
6          (spec:property ?current-object-desig :name ?object-name))
7
8    (-> (spec:property ?action-designator :arm ?arm))
9      (true)
10     (man-int:robot-free-hand ?_ ?arm))
11       (lisp-fun man-int:get-object-old-transform ?current-object-desig ?object-transform)
12         (lisp-fun man-int:calculate-object-face ?object-transform ?facing-robot-face ?bottom-face))
13           (-> (man-int:object-rotationally-symmetric ?object-type)
14             (equal ?rotationally-symmetric t)
15               (equal ?rotationally-symmetric nil)))
16
17   (-> (spec:property ?action-designator :grasp ?grasp))
18     (true)
19       (and (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
20         (member ?grasp ?grasps)))
21         (lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
22           (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
23             (equal ?objects ?current-object-desig))
24               (-> (equal ?arm :left)
25                 (and (lisp-fun man-int:get-action-trajectory :slicing ?arm ?grasp T ?objects
26                   ?left-slicing-poses)
27                     (lisp-fun man-int:get-traj-poses-by-label ?left-slicing-poses :slice-up
28                       ?left-slice-up-poses)
29                         (lisp-fun man-int:get-traj-poses-by-label ?left-slicing-poses :slice-down
30                           ?left-slice-down-poses)))
31               (and (equal ?left-slice-up-poses NIL)
32                 (equal ?left-slice-down-poses NIL)))
33                 (-> (equal ?arm :right)
34                   (and (lisp-fun man-int:get-action-trajectory :slicing ?arm ?grasp T ?objects
35                     ?right-slicing-poses)
36                       (lisp-fun man-int:get-traj-poses-by-label ?right-slicing-poses :slice-up
37                         ?right-slice-up-poses)
38                           (lisp-fun man-int:get-traj-poses-by-label ?right-slicing-poses :slice-down
39                             ?right-slice-down-poses)))
40               (and (equal ?right-slice-up-poses NIL)
41                 (equal ?right-slice-down-poses NIL)))
42                 (-> (design:desig-prop ?action-designator :collision-mode ?collision-mode)
43                   (true)
44                     (equal ?collision-mode nil))
45                     (desig:designator :action ((type :slicing)
46                       (object ?current-object-desig)
47                         (object-name ?object-name)
48                           (arm ?arm)
49                             (gripper-opening ?gripper-opening)
50                               (effort ?effort)
51                                 (grasp ?grasp)
52                                   (left-slice-up-poses ?left-slice-up-poses)
53                                     (right-slice-up-poses ?right-slice-up-poses)
54                                       (left-slice-down-poses ?left-slice-down-poses)
55                                         (right-slice-down-poses ?right-slice-down-poses)
56                                           (collision-mode ?collision-mode)
57                                             ?resolved-action-designator)))
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```

1  (-> (design:action-grounding ?action-designator (slice ?resolved-action-designator))
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1  (-> (design:action-grounding ?action-designator (slice ?resolved-action-designator))
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```

Figure 60: Left: Manual designator for the action *Slicing* (55 lines). Right: Generated designator based on *Opening* (47 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
32	40	13	2

Findings:

- designator definition contains 13 instead of only one variable
- some minor renaming (e.g. *cutting* instead of *slicing*)
- generation adds block about `cram-robot-interfaces` (2 lines)
- designator calculates trajectories and poses in a different manner
- designator does not end by mapping the variables to designator "parts"

```

1  :- (<- (design:action-grounding ?action-designator (slice ?resolved-action-designator)))
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```

```

1  :- (<- (design:action-grounding ?action-designator (slice ?arm
2      ?gripper-opening
3      ?distance
4      ?left-reach-poses
5      ?right-reach-poses
6      ?left-grasp-poses
7      ?right-grasp-poses
8      ?left-cut-poses
9      ?right-cut-poses
10     ?joint-name ?environment-obj)))
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```

Figure 61: Left: Manual designator for the action *Slicing* (55 lines). Right: Generated designator based on *Picking Up* (40 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
26	41	12	2

Findings:

- designator definition contains eleven instead of only one variable
- some minor renaming (e.g. *cutting* instead of *slicing*)
- generation adds block about **cram-robot-interfaces** (2 lines)
- designator calculates trajectories and poses in a different manner
- designator does not end by mapping the variables to designator "parts"

```

1  (+< (design-action-grounding :action-designator (slice ?resolved-action-designator))
2    (spec:property ?action-designator :type :slicing))
3    (spec:property ?action-designator :object ?object-designator)
4      (design-current-designator ?object-designator ?current-object-design)
5        (spec:property ?current-object-desig :type ?object-type))
6          (spec:property ?current-object-desig :name ?object-name))
7            (> (spec:property ?non-ion-designate (:arm ?am))
8              (true))
9                (impl-int:robot-free-hand ?_2?am))
10               (lisp-fun:man-int:get-object-old-transform ?current-object-design :object-transform)
11                 (lisp-fun:man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
12                   (> (equal ?rotationally-symmetric t)
13                     (equal ?rotationally-symmetric nil)))
14                       (> (spec:property ?non-ion-designate :grasp ?grasp))
15                         (true)
16                           (and (lisp-fun:man-int:get-action-grasps ?object-type ?am ?object-transform ?grasps)
17                             (member ?grasp ?grasps)))
18                               (lisp-fun:man-int:get-action-grasping-effort ?object-type ?effort)
19                                 (lisp-fun:man-int:get-action-gripper-opening ?object-type ?gripper-opening)
20                                   (equal ?objects ?current-object-design))
21                                       (> (equal ?am:left)
22                                         (and (lisp-fun:man-int:get-action-trajectory :slicing ?am ?grasp T ?objects
23                                           ?left-slicing-poses)
24                                             (lisp-fun:man-int:get-traj-poses-by-label ?left-slicing-poses :slice-up
25                                               ?left-slice-up-poses)
26                                                 (lisp-fun:man-int:get-traj-poses-by-label ?left-slicing-poses :slice-down
27                                                   ?left-slice-down-poses)))
28                                       (and (equal ?left-slice-up-poses NIL)
29                                         (equal ?left-slice-down-poses NIL)))
30                                           (> (equal ?am:right)
31                                             (and (lisp-fun:man-int:get-action-trajectory :slicing ?am ?grasp T ?objects
32                                               ?right-slicing-poses)
33                                                 (lisp-fun:man-int:get-traj-poses-by-label ?right-slicing-poses :slice-up
34                                                   ?right-slice-up-poses)
35                                                   (lisp-fun:man-int:get-traj-poses-by-label ?right-slicing-poses :slice-down
36                                                     ?right-slice-down-poses)))
37                                         (and (equal ?right-slice-up-poses NIL)
38                                           (equal ?right-slice-down-poses NIL)))
39                                               (> (defvar design-prop ?action-designator :collision-mode ?collision-mode)
40                                                 (true))
41                                                   (equal ?collision-mode nil))
42                                                       (design-designator :action ((?type :slicing)
43             :object ?current-object-design)
44               :object-name ?object-name)
45                 :arm ?am)
46                   :gripper-opening ?gripper-opening)
47                     :effort ?effort)
48                       :grasp ?grasp)
49                         (left-slice-up-poses ?left-slice-up-poses)
50                           (right-slice-up-poses ?right-slice-up-poses)
51                             (left-slice-down-poses ?left-slice-down-poses)
52                               (right-slice-down-poses ?right-slice-down-poses)
53                                 (collision-mode ?collision-mode)))
54                                     ?resolved-action-designator)
55

```



```

1  (+< (design-action-grounding :action-designator (slice ?object-designator ?knife-designator ?small-slice ?big-slice))
2    (spec:property ?action-designator :type :slicing))
3    (spec:property ?action-designator :object ?object-designator)
4      (cpose:object-in-hand ?object-designator ?hand))
5        (> (spec:property ?action-designator :tool ?knife-designator)
6          (cpose:object-in-hand ?knife-designator ?hand))
7            (design-current-designator ?object-designator ?current-object-designator)
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Figure 62: Left: Manual designator for the action *Slicing* (55 lines). Right: Generated designator based on *Placing Down* (11 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
5	49	5	1

Findings:

- designator definition contains four instead of only one variable
- designator does not calculate trajectories and poses
- designator does not end by mapping the variables to designator "parts"

```

1  (< design-action-grounding ?action-designator (?slice ?resolved-action-designator))
2  (spec-property ?action-designator (:type :slicing))
3  (spec-property ?action-designator (?object ?object-designator))
4  (design-current-designator ?object-designator ?current-object-desig)
5  (spec-property ?current-object-desig (:type ?object-type))
6  (spec-property ?current-object-desig (:name ?object-name))
7  (> (spec-property ?action-designator (?arm ?arm))
8    (true)
9    (man-int:robot-free-hand ?_?arm))
10
11  (> (lisp-fun man-int:get-object-old-transform ?current-object-desig ?object-transform)
12    (lisp-fun man-int:calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
13    (> (man-int:object-rotationally-symmetric ?object-type)
14      (equal ?rotationally-symmetric t)
15      (equal ?rotationally-symmetric nil))
16    (> (spec-property ?action-designator (:grasp ?grasp))
17      (true)
18
19      (and (lisp-fun man-int:get-action-grasps ?object-type ?arm ?object-transform ?grasps)
20        (member ?grasp ?grasps)))
21      (lisp-fun man-int:get-action-gripping-effort ?object-type ?effort)
22      (lisp-fun man-int:get-action-gripper-opening ?object-type ?gripper-opening)
23      (equal ?objects (Current-object-designator))
24      (> (equal ?left ?arm)
25        (and (lisp-fun man-int:get-action-trajectory :slicing ?arm) ?grasp T ?objects
26          ?left-slicing)
27          (lisp-fun man-int:get-traj-poses-by-label ?left-slicing-pose :slice-up)
28          ?left-slice-up-poses)
29          (lisp-fun man-int:get-traj-poses-by-label ?left-slicing-pose :slice-down)
30          ?left-slice-down-poses))
31      (and (equal ?left-slice-up-poses NIL)
32        (equal ?left-slice-down-poses NIL)))
33      (> (equal ?right ?right)
34        (and (lisp-fun man-int:get-action-trajectory :slicing ?arm) ?grasp T ?objects
35          ?right-slicing)
36          (lisp-fun man-int:get-traj-poses-by-label ?right-slicing-pose :slice-up)
37          ?right-slice-up-poses)
38          (lisp-fun man-int:get-traj-poses-by-label ?right-slicing-pose :slice-down)
39          ?right-slice-down-poses))
40      (and (equal ?right-slice-up-poses NIL)
41        (equal ?right-slice-down-poses NIL)))
42
43  (> (design-prop ?collision-mode ?action-designator (:collision-mode ?collision-mode))
44    (true)
45    (equal ?collision-mode nil))
46
47  (design-designator :action ((:type :slicing)
48    (?object ?current-object-designator)
49
50    (?object-name ?object-name)
51    (?arm ?arm)
52    (?gripper-opening ?gripper-opening)
53    (?effort ?effort)
54    (?grasp ?grasp)
55    (?left-slice-up-poses ?left-slice-up-poses)
56    (?right-slice-up-poses ?right-slice-up-poses)
57    (?left-slice-down-poses ?left-slice-down-poses)
58    (?right-slice-down-poses ?right-slice-down-poses)
59    (?collision-mode ?collision-mode)))
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62  |-----| resolved-action-designator |-----|
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Figure 63: Left: Manual designator for the action *Slicing* (55 lines). Right: Generated designator based on *Pouring* (55 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
6	6	29	20

Findings:

- some minor renaming (e.g. *cutting* instead of *slicing*)
 - generated designator extends the mapping of variables to designator "parts" (misses *:arm*, *:gripper-opening* and *:effort* but adds *:object-type*, *:arms*, *:num-slices* and *:slice-sizes*)

```

1  <- (desig:action-grounding ?action-designator (slice ?resolved-action-designator))
2   (spec:property ?action-designator (:type :slicing))
3   (spec:property ?action-designator (?object ?object-designator))
4   (desig:current-designator ?object-designator ?current-object-desig)
5   (spec:property ?current-object-desig (:type ?object-type))
6   (spec:property ?current-object-desig (?name ?object-name))
7   (-> (spec:property ?action-designator (:arm ?arm))
8     (true)
9     (man-int:robot-free-hand ?_ ?arm)))
10    (lisp-fun:man-int-get-object-old-transform ?current-object-desig ?object-transform)
11    (lisp-fun:man-int-calculate-object-faces ?object-transform (?facing-robot-face ?bottom-face))
12    (-> (man-int:object-rotationally-symmetric ?object-type)
13      (equal ?rotationally-symmetric t)
14      (equal ?rotationally-symmetric nil))
15    (-> (spec:property ?action-designator (:grasp ?grasp))
16      (true)
17      (and (lisp-fun:man-int-get-action-grasps ?object-type ?arm ?object-transform ?grasps)
18        (member ?grasp ?grasps)))
19      (lisp-fun:man-int-get-action-gripping-effort ?object-type ?effort)
20      (lisp-fun:man-int-get-action-gripper-opening ?object-type ?gripper-opening)
21      (equal ?objects (?current-object-designator))
22      (-> (equal ?arm :left)
23        (and (lisp-fun:man-int-get-action-trajectory :slicing ?arm ?grasp T ?objects
24          ?left-slicing-poses)
25          (lisp-fun:man-int-get-traj-poses-by-label ?left-slicing-poses :slice-up)
26          ?left-slice-up-poses)
27          (lisp-fun:man-int-get-traj-poses-by-label ?left-slicing-poses :slice-down)
28          ?left-slice-down-poses)))
29      (and (equal ?left-slice-up-poses nil)
30        (equal ?left-slice-down-poses nil)))
31      (-> (equal ?arm :right)
32        (and (lisp-fun:man-int-get-action-trajectory :slicing ?arm ?grasp T ?objects
33          ?right-slicing-poses)
34          (lisp-fun:man-int-get-traj-poses-by-label ?right-slicing-poses :slice-up)
35          ?right-slice-up-poses)
36          (lisp-fun:man-int-get-traj-poses-by-label ?right-slicing-poses :slice-down)
37          ?right-slice-down-poses)))
38      (and (equal ?right-slice-up-poses nil)
39        (equal ?right-slice-down-poses nil)))
40      (-> (desig:desig-prop ?action-designator (:collision-mode ?collision-mode))
41        (true)
42        (equal ?collision-mode nil)))
43      (desig:designator :action ((:type :slicing)
44        (?object ?current-object-desig)
45        (?object-name ?object-name)
46        (?arm ?arm)
47        (?gripper-opening ?gripper-opening)
48        (?effort ?effort)
49        (?grasp ?grasp)
50        (?left-slice-up-poses ?left-slice-up-poses)
51        (?right-slice-up-poses ?right-slice-up-poses)
52        (?left-slice-down-poses ?left-slice-down-poses)
53        (?right-slice-down-poses ?right-slice-down-poses)
54        (?collision-mode ?collision-mode)))
55        ?resolved-action-designator)))

```

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Figure 64: Left: Manual designator for the action *Slicing* (55 lines). Right: Generated designator based on *Wiping* (6 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
0	49	5	1

Findings:

- designator contains no definition and no calculations but just the mapping part
- generated designator shortens the mapping of variables to designator "parts" (misses :object, :arm, :gripper-opening, :grasp, :left-slice-down-poses, :right-slice-down-poses and :effort)

```

1  <- (desig:action-grounding ?action-designator (wipe ?resolved-action-designator))
2
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15
16  (spec:property ?action-designator (:type :wiping))
17  (spec:property ?action-designator (:grasp ?grasp))
18  (spec:property ?action-designator (?arm ?arm))
19  (desig:desig-prop ?action-designator (?surface ?surface-designator))
20  (desig:current-designator ?surface-designator ?current-surface-designator)
21  (spec:property ?current-surface-designator (type ?surface-type))
22  (equal ?surface ?current-surface-designator))
23  (> (equal ?grasp :scrubbing)
24  (lisp-fun different-surface-types ?grasp ?surface ?current-grasp)
25  (equal ?grasp ?current-grasp))
26  (desig:desig-prop ?action-designator (:collision-mode ?collision-mode))
27  (> (equal ?arm :left)
28  (and (lisp-fun get-trajectory :wiping) ?arm ?current-grasp T ?surface ?lists)
29
30
31
32  (lisp-fun man-int:get-traj-poses-by-label ?lists :wiping
33  ?left-wipe-poses)
34  (lisp-fun man-int:get-traj-poses-by-label ?lists :initial
35  ?left-initial-poses))
36  (and (equal ?left-wipe-poses NIL)
37  (equal ?left-initial-poses NIL))
38  (> (equal ?arm :right)
39  (and (lisp-fun get-trajectory :wiping) ?arm ?current-grasp T ?surface ?lists)
40  (lisp-fun man-int:get-traj-poses-by-label ?lists :wiping
41  ?right-wipe-poses)
42  (lisp-fun man-int:get-traj-poses-by-label ?lists :initial
43  ?right-initial-poses))
44  (and (equal ?right-wipe-poses NIL)
45  (equal ?right-initial-poses NIL))
46  (desig:designator :action ((:type :wiping)
47  (:collision-mode ?collision-mode)
48
49  (lisp-fun (left-wipe-poses ?left-wipe-poses)
50  (right-wipe-poses ?right-wipe-poses)
51  (left-initial-poses ?left-initial-poses)
52
53  (right-initial-poses ?right-initial-poses)
54
55  ?resolved-action-designator)))

```



```

1  <- (desig:action-grounding ?action-designator (wipe ?arm)
2  ?gripper-opening
3  ?distance
4  ?surface-designator
5  ?towel-designator
6  ?left-reach-poses
7  ?right-reach-poses
8  ?left-grasp-poses
9  ?right-grasp-poses
10  (?left-lift-pose)
11  (?right-lift-pose)
12  (?left-2nd-lift-pose)
13  (?right-2nd-lift-pose)
14  ?joint-name
15  ?environment-obj)
16  (spec:property ?action-designator (:type :cleaning))
17  (spec:property ?action-designator (:object ?surface-designator))
18  (spec:property ?surface-designator (type ?surface-type))
19  (obj-int:object-type-subtype ?surface ?surface-type)
20  (spec:property ?surface-designator (urdf-name ?surface-name))
21  (spec:property ?surface-designator (:part-of ?btr-environment))
22  (spec:property ?towel-designator (tool ?towel-designator))
23  (spec:property ?towel-designator (:type :towel))
24  (spec:property ?towel-designator (:part-of ?btr-environment))
25
26
27  (> (spec:property ?action-designator (:arm ?arm))
28  (true)
29  (and (cram-robot-interfaces:robot ?robot)
30  (cram-robot-interfaces:arm ?robot ?arm)))
31  (spec:property ?action-designator (:distance ?distance))
32  (lisp-fun obj-int:get-object-gripper-opening ?towel-designator ?gripper-opening)
33  (lisp-fun get-surface-link ?surface-name ?btr-environment ?surface-link)
34  (lisp-fun get-connecting-joint ?surface-link ?connecting-joint)
35  (lisp-fun cl-urdf:name ?connecting-joint ?joint-name)
36  (btr:btr-world ?world)
37  (lisp-fun btr:object ?world ?btr-environment ?environment-obj)
38  (lisp-fun get-surface-pose-and-transform ?surface-name ?btr-environment
39  ?surface-poses ?surface-transform)
40  (lisp-fun obj-int:get-object-grasping-poses ?towel-designator
41  :towel :left :close ?surface-transform ?left-poses)
42  (lisp-fun obj-int:get-object-grasping-poses ?towel-designator
43
44  :towel :right :close ?surface-transform ?right-poses)
45  (lisp-fun cram-mobile:pick-place-plans::extract-pick-up-manipulation-poses
46  ?arm ?left-poses ?right-poses
47  ?left-reach-poses ?right-reach-poses
48  ?left-grasp-poses ?right-grasp-poses
49  ?left-lift-poses ?right-lift-poses))
50  (> (lisp-pred identity ?left-lift-poses)
51  (equal ?left-lift-poses (?left-lift-pose ?left-2nd-lift-pose)))
52  (equal (NIL NIL) (?left-lift-pose ?left-2nd-lift-pose)))
53  (> (lisp-pred identity ?right-lift-poses)
54  (equal ?right-lift-poses (?right-lift-pose ?right-2nd-lift-pose)))
55  (equal (NIL NIL) (?right-lift-pose ?right-2nd-lift-pose))))|)

```

Figure 65: Left: Manual designator for the action *Wiping* (35 lines). Right: Generated designator based on *Closing* (52 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
36	19	16	0

Findings:

- designator definition contains 15 instead of only one variable
- some minor renaming (e.g. *cleaning* instead of *wiping*)
- designator calculates trajectories and poses in a different manner
- generation adds block about **cram-robot-interfaces** (2 lines)
- designator does not end by mapping the variables to designator "parts"

```

1  <- (design-action-grounding ?action-designator (wipe ?resolved-action-designator))
2   (spec:property ?action-designator (:type :wiping))
3   (spec:property ?action-designator (:grasp ?grasp))
4
5
6
7   (spec:property ?action-designator (:arm ?arm))
8   (design:desig-prop ?action-designator (:surface ?surface-designator))
9
10
11
12
13
14
15   (design:current-designator ?surface-designator ?current-surface-designator)
16   (spec:property ?current-surface-designator (:type ?surface-type))
17
18   (-> (equal ?surface (?current-surface-designator))
19     (lisp-fun:differentiate-surface-types ?grasp ?surface ?current-grasp)
20
21   (design:desig-prop ?action-designator (:collision-mode ?collision-mode))
22
23   (-> (equal ?arm :left)
24     (and (lisp-fun:get-trajectory :wiping ?arm ?current-grasp T ?surface ?lists)
25       (lisp-fun:man-int:get-traj-poses-by-label ?lists :wiping
26         ?left-wipe-poses)
27       (lisp-fun:man-int:get-traj-poses-by-label ?lists :initial
28         ?left-initial-poses)
29       (and (equal ?left-wipe-poses NIL)
30         (equal ?left-initial-poses NIL)))
31
32   (-> (equal ?arm :right)
33     (and (lisp-fun:get-trajectory :wiping ?arm ?current-grasp T ?surface ?lists)
34
35       (lisp-fun:man-int:get-traj-poses-by-label ?lists :wiping
36         ?right-wipe-poses)
37       (lisp-fun:man-int:get-traj-poses-by-label ?lists :initial
38         ?right-initial-poses)
39       (and (equal ?right-wipe-poses NIL)
40         (equal ?right-initial-poses NIL)))
41
42
43   (design:designator :action ((:type :wiping)
44     (:collision-mode ?collision-mode)
45
46
47
48
49
50
51
52     (:left-wipe-poses ?left-wipe-poses)
53     (:right-wipe-poses ?right-wipe-poses)
54     (:left-initial-poses ?left-initial-poses)
55     (:right-initial-poses ?right-initial-poses)))
56
57   ?resolved-action-designator)

```



```

1  <- (design-action-grounding ?action-designator (wipe-surface ?resolved-action-designator))
2   (spec:property ?action-designator (:type :cleaning))
3   (spec:property ?action-designator (:object ?object-designator))
4   (design:current-designator ?object-designator ?current-object-desig)
5   (spec:property ?current-object-desig (:type ?object-type))
6   (spec:property ?current-object-desig (:name ?object-name))
7
8   (-> (spec:property ?action-designator (:arm ?arm)))
9
10
11   (true)
12   (man-int:robot-free-hand ?_ ?arm))
13   (-> (spec:property ?action-designator (:grasp ?grasp)))
14
15   (and (lisp-fun:man-int:get-action-grasps ?object-type ?arm ?grasps)
16     (member ?grasp ?grasps)))
17
18   (-> (spec:property ?action-designator (:towel ?towel-designator)))
19   (design:current-designator ?towel-designator ?current-towel-desig)
20
21   (spec:property ?current-towel-desig (:type ?towel-type))
22
23   (spec:property ?current-towel-desig (:name ?towel-name))
24
25   (lisp-fun:man-int:get-action-gripping-effort ?object-type ?effort)
26   (lisp-fun:man-int:get-action-gripper-opening ?object-type ?gripper-opening)
27
28   (-> (equal ?objects ?objects))
29
30   (design:desig-prop ?current-object-desig ?current-towel-desig)
31
32   (-> (equal ?arm :left)
33     (and (lisp-fun:man-int:get-action-trajectory :wiping ?arm ?grasp T ?objects)
34       (lisp-fun:man-int:get-action-trajectory :wiping ?arm ?grasp-up ?objects)
35       (lisp-fun:man-int:get-traj-poses-by-label ?left-wiping-poses :wiping-up)
36       (lisp-fun:man-int:get-traj-poses-by-label ?left-wiping-poses :wiping-down)
37       (lisp-fun:man-int:get-traj-poses-by-label ?left-wiping-poses :wiping-down))
38
39   (and (equal ?left-wiping-poses NIL)
40     (equal ?left-wiping-down-poses NIL)))
41
42   (-> (equal ?arm :right)
43     (and (lisp-fun:man-int:get-action-trajectory :wiping ?arm ?grasp T ?objects)
44       (lisp-fun:man-int:get-action-trajectory :wiping ?arm ?grasp-up ?objects)
45       (lisp-fun:man-int:get-traj-poses-by-label ?right-wiping-poses :wiping-up)
46       (lisp-fun:man-int:get-traj-poses-by-label ?right-wiping-poses :wiping-down)
47       (lisp-fun:man-int:get-traj-poses-by-label ?right-wiping-down-poses))
48
49   (and (equal ?right-wiping-poses NIL)
50     (equal ?right-wiping-down-poses NIL)))
51
52
53   (-> (design:desig-prop ?action ((:type :cleaning)
54     (:object ?current-object-desig)
55     (:name ?object-name)
56     (:arm ?arm)
57     (:gripper-opening ?gripper-opening)
58     (:effort ?effort)
59     (:grasp ?grasp)
60     (:towel ?current-towel-design)
61     (:towel-name ?towel-name)
62     (:left-wipe-up-poses ?left-wipe-up-poses)
63     (:right-wipe-up-poses ?right-wipe-up-poses)
64     (:left-wipe-down-poses ?left-wipe-down-poses)
65     (:right-wipe-down-poses ?right-wipe-down-poses)
66     (:collision-mode ?collision-mode)))
67
68   ?resolved-action-designator)

```

Figure 66: Left: Manual designator for the action *Wiping* (35 lines). Right: Generated designator based on *Halving* (56 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
25	4	28	3

Findings:

- some minor renaming (e.g. *cleaning* instead of *wiping*)
- designator calculates trajectories and poses in a different manner
- generated designator extends the mapping of variables to designator "parts" (adds *:object*, *:object-name*, *:arm*, *:gripper-opening*, *:grasp*, *:towel*, *:towel-name* and *:effort*)

Diagram illustrating the design action-grounding process for a 'wiping' action across two columns of code snippets.

Left Column (Design Action-Designator):

```

1  <- (design-action-grounding :action-designator (wipe ?resolved-action-designator))
2  (spec:property ?action-designator (:type :wiping))
3  (spec:property ?action-designator (:grasp ?grasp))
4  (spec:property ?action-designator (:arm ?arm))
5
6  (design:desig-prop :action-designator (:surface ?surface-designator))
7  (design:current-designator ?surface-designator ?current-surface-designator)
8  (spec:property ?current-surface-designator (:type ?surface-type))
9  (equal ?surface ?current-surface-designator)
10 (>= (equal ?grasp :scrubbing)
11   (lisp-fun differentiate-surface-types ?grasp ?surface ?current-grasp)
12   (equal ?grasp ?current-grasp))
13
14 (design:desig-prop :action-designator (:collision-mode ?collision-mode))
15
16
17
18
19
20
21
22
23 (>= (equal ?arm :left)
24   (and (lisp-fun get-trajectory :wiping) ?arm ?current-grasp T ?surface ?lists)
25
26   (lisp-fun man-int-get-traj-poses-by-label ?lists :wiping
27     ?left-wipe-poses)
28   (lisp-fun man-int-get-traj-poses-by-label ?lists :initial
29     ?left-initial-poses))
30
31
32 (and (equal ?left-wipe-poses NIL)
33   (equal ?left-initial-poses NIL)))
34
35 (>= (equal ?arm :right)
36   (and (lisp-fun get-trajectory :wiping) ?arm ?current-grasp T ?surface ?lists)
37
38   (lisp-fun man-int-get-traj-poses-by-label ?lists :wiping
39     ?right-wipe-poses)
40   (lisp-fun man-int-get-traj-poses-by-label ?lists :initial
41     ?right-initial-poses))
42
43
44 (and (equal ?right-wipe-poses NIL)
45   (equal ?right-initial-poses NIL)))
46
47 (design:designator :action ((:type :wiping)
48   (:collision-mode ?collision-mode))
49
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59
60   (?left-wipe-poses ?left-wipe-poses)
61   (?right-wipe-poses ?right-wipe-poses)
62   (?left-initial-poses ?left-initial-poses)
63   (?right-initial-poses ?right-initial-poses))
64
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```

Figure 67: Left: Manual designator for the action *Wiping* (35 lines). Right: Generated designator based on *Holding* (63 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
36	8	21	6

Findings:

- some minor renaming (e.g. *cleaning* instead of *wiping*)
 - designator calculates trajectories and poses in a different manner
 - generated designator extends the mapping of variables to designator "parts" (misses *:collision-mode*, *:left-initial-pose* and *:right-initial-pose* but adds *:object*, *:object-name*, *:tool*, *:tool-name*, *:arm*, *:gripper-opening*, *:grasp*, *:cleaning*, *:left-reach-poses*, *:right-reach-poses*, *:left-grasp-poses*, *:right-grasp-poses* and *:effort*)

```

1  <- (design:action-grounding ?action-designator (wipe ?resolved-action-designator))
2
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```

```

1  <- (design:action-grounding ?action-designator (wipe ?arm
2    ?gripper-opening
3    ?distance
4    ?surface-designator
5    ?towel-designator
6    ?left-reach-poses
7    ?right-reach-poses
8    ?left-grasp-poses
9    ?right-grasp-poses
10   ?left-lift-poses
11   ?left-2nd-lift-poses
12   ?right-lift-poses
13   ?right-2nd-lift-poses
14   ?joint-name ?environment-obj))
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
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56

```

Figure 68: Left: Manual designator for the action *Wiping* (35 lines). Right: Generated designator based on *Opening* (52 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
37	20	15	0

Findings:

- designator definition contains 15 instead of only one variable
- some minor renaming (e.g. *cleaning* instead of *wiping*)
- designator calculates trajectories and poses in a different manner
- designator does not end by mapping the variables to designator "parts"

```

1  <- (desig:action-grounding ?action-designator (wipe ?resolved-action-designator))
2   (spec:property ?action-designator :type :wiping)
3   (spec:property ?action-designator :name ?wiping)
4   (spec:property ?action-designator :arm ?arm)
5   (spec:property ?action-designator :surface ?surface)
6   (spec:property ?action-designator :current-surface-designator)
7   (spec:property ?surface-designator :current-surface-type)
8   (spec:property ?current-surface-designator :type ?surface-type)
9   (spec:property ?grasp :scrubbing)
10  (spec:property ?grasp :current-grasp)
11  (spec:property ?current-grasp :type ?surface)
12  (spec:property ?action-designator :collision-mode ?collision-mode)
13  (spec:property ?action-designator :current-surface-type)
14  (> (equal ?arm :left)
15   (and (lisp-fun man-int: get-traj-poses-by-label ?lists :wiping
16   ?left-wipe-poses)
17   (lisp-fun man-int: get-traj-poses-by-label ?lists :initial
18   ?left-initial-poses)
19   (and (equal ?left-wipe-poses NIL)
20   (equal ?left-initial-poses NIL)))
21  (> (equal ?arm :right)
22  (and (lisp-fun man-int: get-traj-poses-by-label ?lists :wiping
23  ?right-wipe-poses)
24  (lisp-fun man-int: get-traj-poses-by-label ?lists :initial
25  ?right-initial-poses)
26  (and (equal ?right-wipe-poses NIL)
27  (equal ?right-initial-poses NIL)))
28  (spec:designator :action ((type wiping)
29   (spec:property :collision-mode ?collision-mode)
30   (spec:property :left-wipe-poses ?left-wipe-poses)
31   (spec:property :right-wipe-poses ?right-wipe-poses)
32   (spec:property :left-initial-pose ?left-initial-pose)
33   (spec:property :right-initial-pose ?right-initial-pose)
34   ?resolved-action-designator))
35

```



```

1  <- (desig:action-grounding ?action-designator (wipe ?arm ?towel-designator ?surface-designator))
2   (spec:property ?action-designator :type :cleaning)
3   (spec:property ?action-designator :object ?surface-designator)
4   (spec:property ?surface-designator :type ?surface-type)
5
6   (obj-int:object-type-subtype ?surface ?surface-type)
7   (spec:property ?surface-designator :surf-name ?surface-name)
8   (spec:property ?surface-designator :part-of ?btr-environment)
9
10  (spec:property ?action-designator :arm ?arm)
11  (true)
12  (and (cram-robot-interfaces:robot ?robot)
13   (cram-robot-interfaces:arm ?robot ?arm))
14  (spec:property ?action-designator :tool ?towel-designator)
15  (spec:property ?towel-designator :type ?towel)
16  (spec:property ?towel-designator :part-of ?btr-environment)
17  (spec:property ?towel-designator :name ?towel-name)
18  (lisp-fun get-surface-pose-and-transform ?surface-name ?btr-environment
19   ?surface-pose ?surface-transform)
20  (lisp-fun crm-mobile:pick-place-plans: extract-wipe-manipulation-poses
21   ?arm ?surface-pose ?surface-transform
22   ?towel-name)
23
24
25
26
27
28
29
30
31  (?reach-poses ?grasp-poses ?lift-poses)
32  (> (lisp-pred identity ?lift-poses)
33  (equal ?lift-poses NIL)
34  (true))
35

```

Figure 69: Left: Manual designator for the action *Wiping* (35 lines). Right: Generated designator based on *Picking Up* (24 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
16	27	8	0

Findings:

- designator definition contains three instead of only one variable
- some minor renaming (e.g. *cleaning* instead of *wiping*)
- generation adds block about **cram-robot-interfaces** (2 lines)
- designator does not end by mapping the variables to designator "parts"

```

1  <- (desig-action-grounding ?action-designator wipe ?resolved-action-designator)
2   (spec-property ?action-designator :type :wiping)
3   (spec-property ?action-designator :?grasp)
4   (spec-property ?action-designator :arm ?arm)
5   (design-desig-prop ?action-designator :surface ?surface-designator)
6   (design-current-designator ?surface-designator ?current-surface-designator)
7   (spec-property ?current-surface-designator :type ?surface-type)
8   (equal ?surface ?current-surface-designator)
9   (-> ?grasp :scrubbing)
10  (lisp-fun differentiate-surface-type ?grasp ?surface ?current-grasp)
11  (equal ?grasp ?current-grasp)
12  (design-desig-prop ?action-designator :collision-mode ?collision-mode)
13  (-> ?equal ?arm-left)
14  (and lisp-fun get-trajectory :wiping ?arm ?current-grasp T ?surface ?lists)
15  (lisp-fun man-int-get-traj-poses-by-label ?lists :wiping
16    ?left-wipe-poses)
17  (lisp-fun man-int-get-traj-poses-by-label ?lists :initial
18    ?left-initial-poses)
19  (and (equal ?left-wipe-poses NIL)
20    (equal ?left-initial-poses NIL))
21  (-> ?equal ?arm-right)
22  (and lisp-fun get-trajectory :wiping ?arm ?current-grasp T ?surface ?lists)
23  (lisp-fun man-int-get-traj-poses-by-label ?lists :wiping
24    ?right-wipe-poses)
25  (lisp-fun man-int-get-traj-poses-by-label ?lists :initial
26    ?right-initial-poses)
27  (and (equal ?right-wipe-poses NIL)
28    (equal ?right-initial-poses NIL))
29  (design-designator :action ((type :wiping)
30    (collision-mode ?collision-mode)
31    (left-wipe-poses ?left-wipe-poses)
32    (right-wipe-poses ?right-wipe-poses)
33    (left-initial-poses ?left-initial-poses)
34    (right-initial-poses ?right-initial-poses)))
35  ?resolved-action-designator)

1  <- (desig-action-grounding ?action-designator (wipe ?surface-designator ?towel-designator))
2   (spec-property ?action-designator :type :cleaning)
3   (spec-property ?action-designator :surface ?surface-designator)
4   (spec-property ?action-designator :tool ?towel-designator)
5
6   (design-current-designator ?surface-designator ?current-surface-designator)
7   (spec-property ?current-surface-designator :name ?surface-name)
8   (spec-property ?current-surface-designator :type ?surface-type)
9   (spec-property ?towel-designator ?current-towel-designator)
10  (spec-property ?current-towel-designator :type ?towel-type)
11
12  (spec-property ?current-towel-designator :name ?towel-name)
13  (and (cram-robot-interfaces:robot ?robot)
14    (cram-robot-interfaces:arm ?robot ?arm)
15    (cram-robot-interfaces:gripper ?robot ?gripper)
16    (cram-object-in-hand ?towel-designator ?gripper)
17    (cram-object-in-hand ?towel-designator ?arm))
18  (lisp-fun obj-int-get-surface-transform ?current-surface-designator ?surface-transform)
19  (lisp-fun obj-int-get-object-transform ?current-towel-designator ?towel-transform)
20  (lisp-fun obj-int-get-object-pose ?current-towel-designator ?towel-poses)
21  (lisp-fun cram-robot-interfaces:arm-k ?arm ?towel-poses ?towel-transform ?ik-solution)
22  (lisp-fun cram-robot-interfaces:arm-move ?arm ?ik-solution)
23  (lisp-fun cram-robot-interfaces:gripper-close ?gripper)
24  (lisp-fun cram-robot-interfaces:gripper-move ?gripper :position 0.1)
25  (lisp-fun cram-robot-interfaces:gripper-move ?gripper :position 0.0)
26  (lisp-fun cram-robot-interfaces:gripper-open ?gripper)
27
28
29
30
31
32
33
34
35

```

Figure 70: Left: Manual designator for the action *Wiping* (35 lines). Right: Generated designator based on *Placing Down* (25 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
17	27	6	2

Findings:

- designator definition contains two instead of only one variable
- some minor renaming (e.g. *cleaning* instead of *wiping*)
- generation adds block about **cram-robot-interfaces** (3 lines)
- designator contains only definitions but no calculations
- designator does not end by mapping the variables to designator "parts"

Figure 71: Left: Manual designator for the action *Wiping* (35 lines). Right: Generated designator based on *Pouring* (53 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
24	6	25	2

Findings:

- some minor renaming (e.g. *cleaning* instead of *wiping*)
 - designator calculates trajectories and poses in a different manner
 - generated designator extends the mapping of variables to designator "parts" (adds *:object*, *:object-type*, *:object-name*, *:arms* and *:grasp*)

```

1  (<- (desig.action-grounding ?action-designator (wipe ?resolved-action-designator))
2   |  (spec.property ?action-designator (:type :wiping))
3   |  (spec.property ?action-designator (:grasp ?grasp))
4   |  (spec.property ?action-designator (:arm ?arm))
5   |  (design.desig-prop ?action-designator (:surface ?surface-designator))
6   |  (spec.property ?surface-designator ?current-surface-designator)
7   |  (spec.property ?current-surface-designator (:type ?surface-type))
8   |  (equal ?surface (?current-surface-designator))
9
10
11
12  (> (equal ?grasp :scrubbing)
13    (lisp-fun differentiate-surface-types ?grasp ?surface ?current-grasp)
14    (equal ?grasp ?current-grasp))
15  (design.desig-prop ?action-designator (:collision-mode ?collision-mode))
16
17
18
19  (> (equal ?arm :left)
20    (and (lisp-fun get-trajectory :swiping ?arm ?current-grasp T ?surface ?lists)
21      (lisp-fun man-int-get-traj-poses-by-label ?lists :swiping
22        ?left-wipe-poses)
23      (lisp-fun man-int-get-traj-poses-by-label ?lists :initial
24        ?left-initial-poses))
25    (and (equal ?left-wipe-poses NIL)
26      (equal ?left-initial-poses NIL)))
27
28  (> (equal ?arm :right)
29    (and (lisp-fun get-trajectory :swiping ?arm ?current-grasp T ?surface ?lists)
30      (lisp-fun man-int-get-traj-poses-by-label ?lists :swiping
31        ?right-wipe-poses)
32      (lisp-fun man-int-get-traj-poses-by-label ?lists :initial
33        ?right-initial-poses))
34    (and (equal ?right-wipe-poses NIL)
35      (equal ?right-initial-poses NIL)))
36
37  (design.designator :action ((:type :swiping)
38    (:collision-mode ?collision-mode))
39
40
41
42
43
44  (:left-wipe-poses ?left-wipe-poses)
45  (:right-wipe-poses ?right-wipe-poses)
46  (:left-initial-poses ?left-initial-poses)
47  (:right-initial-poses ?right-initial-poses))
48  ?resolved-action-designator)

```



```

1  (<- (desig.action-grounding ?action-designator (wipe ?resolved-action-designator))
2   |  (spec.property ?action-designator (:object ?object-designator))
3   |  (spec.property ?current-object-designator ?object-designator ?current-object-desig)
4   |  (spec.property ?current-object-desig (:type ?object-type))
5   |  (spec.property ?current-object-desig (:name ?object-name))
6   |  (true)
7   |  (man-int:robot-free-hand ?_ ?arm))
8
9  (> (spec.property ?action-designator (:arm ?arm))
10  (true)
11
12  (> (spec.property ?action-designator (:grasp ?grasp))
13  (true)
14  (and (lisp-fun man-int-get-action-grasps ?object-type ?arm ?grasps)
15    (member ?grasp ?grasps)))
16  (lisp-fun man-int-get-action-gripping-effort ?object-type ?effort)
17  (lisp-fun man-int-get-action-gripper-opening ?object-type ?gripper-opening)
18  (equal ?objects (?current-object-desig))
19  (> (equal ?arm :left)
20    (and (lisp-fun man-int-get-action-trajectory :cleaning ?arm ?grasp T ?objects
21      ?left-wiping-poses)
22      (lisp-fun man-int-get-traj-poses-by-label ?left-wiping-poses :wipe
23        ?left-wipe-poses)))
24    (equal ?left-wipe-poses NIL))
25  (> (equal ?arm :right)
26    (and (lisp-fun man-int-get-action-trajectory :cleaning ?arm ?grasp T ?objects
27      ?right-wiping-poses)
28      (lisp-fun man-int-get-traj-poses-by-label ?right-wiping-poses :wipe
29        ?right-wipe-poses)))
30    (equal ?right-wipe-poses NIL))
31
32  (> (design.desig-prop ?action-designator (:collision-mode ?collision-mode))
33  (true)
34  (equal ?collision-mode NIL))
35  (design.designator :action ((:type :cleaning)
36    (:object ?current-object-design)
37    (:object-name ?object-name)
38    (:arm ?arm)
39    (:gripper-opening ?gripper-opening)
40    (:effort ?effort)
41    (:grasp ?grasp)
42    (:left-wipe-poses ?left-wipe-poses)
43    (:right-wipe-poses ?right-wipe-poses)
44    (:collision-mode ?collision-mode)))
45
46
47  ?resolved-action-designator)
48

```

Figure 72: Left: Manual designator for the action *Wiping* (35 lines). Right: Generated designator based on *Slicing* (42 lines).

Added Lines	Deleted Lines	Changed Lines	Unchanged Lines
19	12	17	6

Findings:

- some minor renaming (e.g. *cleaning* instead of *wiping*)
- designator calculates trajectories and poses in a different manner
- generated designator extends the mapping of variables to designator "parts" (misses *:left-initial-poses* and *:right-initial-poses* but adds *:object*, *:object-name*, *:arm*, *:gripper-opening*, *:effort* and *:grasp*)