

1 BNF definition of PDDL 3.1

Hereby a complete BNF syntax definition of the PDDL 3.1 language is presented (completely corrected) based on the originally published articles and information about PDDL 1.0, 2.1, 2.2, 3.0 and 3.1 [1-5].

1.1 Domain description

```

<domain> ::= (define (domain <name>)
               [<require-def>]
               [<types-def>]:typing
               [<constants-def>]
               [<predicates-def>]
               [<functions-def>]:fluents
               [<constraints>]
               <structure-def>*)

<require-def> ::= (:requirements <require-key>+)
<require-key> ::= See Section 3
<types-def> ::= (:types <typed list (name)>+)
<constants-def> ::= (:constants <typed list (name)>+)
<predicates-def> ::= (:predicates <atomic formula skeleton>+)
<atomic formula skeleton> ::= (<predicate> <typed list (variable)>+)
<predicate> ::= <name>
<variable> ::= ?<name>
<atomic function skeleton> ::= (<function-symbol> <typed list (variable)>+)
<function-symbol> ::= <name>
<functions-def> ::= :fluents (:functions <function typed list (atomic function
skeleton)>+)
<function typed list (x)> ::= x+ - <function type> <function typed list(x)>
<function typed list (x)> ::=
<function typed list (x)> ::= :numeric-fluents x+
This is deprecated since PDDL 3.1, where the default fluent type is number.
<function type> ::= :numeric-fluents number
<function type> ::= :typing + :object-fluents <type>
<constraints> ::= :constraints (:constraints <con-GD>)
<structure-def> ::= <action-def>
<structure-def> ::= :durative-actions <durative-action-def>
<structure-def> ::= :derived-predicates <derived-def>
<typed list (x)> ::= x*
<typed list (x)> ::= :typing x+ - <type> <typed list(x)>
<primitive-type> ::= <name>
<primitive-type> ::= object
<type> ::= (either <primitive-type>+)
<type> ::= <primitive-type>
<emptyOr (x)> ::= ()
<emptyOr (x)> ::= x
<action-def> ::= (:action <action-symbol>
               :parameters (<typed list (variable)>+)
               <action-def body>)

<action-symbol> ::= <name>
<action-def body> ::= [:precondition <emptyOr (pre-GD)>]
               [:effect <emptyOr (effect)>]

<pre-GD> ::= <pref-GD>
<pre-GD> ::= (and <pre-GD>*)
<pre-GD> ::= :universal-preconditions (forall (<typed list(variable)>) <pre-GD>)
<pref-GD> ::= :preferences (preference [<pref-name>] <GD>)
<pref-GD> ::= <GD>
<pref-name> ::= <name>
<GD> ::= <atomic formula(term)>
<GD> ::= :negative-preconditions <literal(term)>
<GD> ::= (and <GD>*)
<GD> ::= :disjunctive-preconditions (or <GD>*)
<GD> ::= :disjunctive-preconditions (not <GD>)
<GD> ::= :disjunctive-preconditions (imply <GD> <GD>)
<GD> ::= :existential-preconditions (exists (<typed list(variable)>) <GD>)
<GD> ::= :universal-preconditions (forall (<typed list(variable)>) <GD>)
<GD> ::= :numeric-fluents <f-comp>
<f-comp> ::= (<binary-comp> <f-exp> <f-exp>)
<literal(t)> ::= <atomic formula(t)>
<literal(t)> ::= (not <atomic formula(t)>)
<atomic formula(t)> ::= (<predicate> t*)
<atomic formula(t)> ::= :equality (= t t)
<term> ::= <name>

```

```

<term> ::= <variable>
<term> ::= :object-fluents <function-term>
<function-term> ::= :object-fluents (<function-symbol> <term>*)
<f-exp> ::= :numeric-fluents <number>
<f-exp> ::= :numeric-fluents (<binary-op> <f-exp> <f-exp>)
<f-exp> ::= :numeric-fluents (<multi-op> <f-exp> <f-exp>')
<f-exp> ::= :numeric-fluents (- <f-exp>)
<f-exp> ::= :numeric-fluents <f-head>
<f-head> ::= (<function-symbol> <term>*)
<f-head> ::= <function-symbol>
<binary-op> ::= -
<binary-op> ::= /
<multi-op> ::= *
<multi-op> ::= +
<binary-comp> ::= >
<binary-comp> ::= <
<binary-comp> ::= =
<binary-comp> ::= >=
<binary-comp> ::= <=
<name> ::= Any string of characters.
<number> ::= Any numeric literal (integers and floats of form n.n).
<effect> ::= (and <c-effect>*)
<effect> ::= <c-effect>
<c-effect> ::= :conditional-effects (forall (<typed list (variable)>) <effect>)
<c-effect> ::= :conditional-effects (when <GD> <cond-effect>)
<c-effect> ::= <p-effect>
<p-effect> ::= (not <atomic formula(term)>)
<p-effect> ::= <atomic formula(term)>
<p-effect> ::= :numeric-fluents (<assign-op> <f-head> <f-exp>)
<p-effect> ::= :object-fluents (assign <function-term> <term>)
<p-effect> ::= :object-fluents (assign <function-term> undefined)
<cond-effect> ::= (and <p-effect>*)
<cond-effect> ::= <p-effect>
<assign-op> ::= assign
<assign-op> ::= scale-up
<assign-op> ::= scale-down
<assign-op> ::= increase
<assign-op> ::= decrease
<durative-action-def> ::= (:durative-action <da-symbol>
:parameters (<typed list (variable)>)
<da-def body>))

<da-symbol> ::= <name>
<da-def body> ::= :duration <duration-constraint>
:condition <emptyOr (da-GD)>
:effect <emptyOr (da-effect)>

<da-GD> ::= <pref-timed-GD>
<da-GD> ::= (and <da-GD>*)
<da-GD> ::= :universal-preconditions (forall (<typed-list (variable)>) <da-GD>)
<pref-timed-GD> ::= <timed-GD>
<pref-timed-GD> ::= :preferences (preference [<pref-name>] <timed-GD>)
<timed-GD> ::= (at <time-specifier> <GD>)
<timed-GD> ::= (over <interval> <GD>)
<time-specifier> ::= start
<time-specifier> ::= end
<interval> ::= all
<duration-constraint> ::= :duration-inequalities (and <simple-duration-constraint>*)
<duration-constraint> ::= ()
<duration-constraint> ::= <simple-duration-constraint>
<simple-duration-constraint> ::= (<d-op> ?duration <d-value>)
<simple-duration-constraint> ::= (at <time-specifier> <simple-duration-constraint>)
<d-op> ::= :duration-inequalities <=
<d-op> ::= :duration-inequalities >=
<d-op> ::= =
<d-value> ::= <number>
<d-value> ::= :numeric-fluents <f-exp>
<da-effect> ::= (and <da-effect>*)
<da-effect> ::= <timed-effect>
<da-effect> ::= :conditional-effects (forall (<typed list (variable)>) <da-effect>)
<da-effect> ::= :conditional-effects (when <da-GD> <timed-effect>)
<da-effect> ::= :numeric-fluents (<assign-op> <f-head> <f-exp-da>)
<da-effect> ::= :object-fluents (assign <function-term> <term>)
<da-effect> ::= :object-fluents (assign <function-term> undefined)
<timed-effect> ::= (at <time-specifier> <da-effect>)
<timed-effect> ::= :continuous-effects + :numeric-fluents (<assign-op-t> <f-head> <f-exp-t>)
<f-exp-da> ::= (<binary-op> <f-exp-da> <f-exp-da>)
<f-exp-da> ::= (- <f-exp-da>)
<f-exp-da> ::= :duration-inequalities ?duration
<f-exp-da> ::= <f-exp>
<f-exp-da> ::= increase
<f-exp-da> ::= decrease
<f-exp-t> ::= (* <f-exp> #t)
<f-exp-t> ::= (* #t <f-exp>)
<f-exp-t> ::= #t
<derived-def> ::= (:derived <typed list (variable)> <GD>)

```

1.2 Problem description

```

<problem> ::= (define (problem <name>)
              (:domain <name>)
              [require-def]
              [object declaration]
              <init>
              <goal>
              [<constraints>]:constraints
              [<metric-spec>]:numeric-fluents
              [<length-spec>])

<object declaration> ::= (:objects <typed list (name)>))
<init> ::= (:init <init-el>*)
<init-el> ::= <literal (name)>
<init-el> ::= :timed-initial-literals (at <number> <literal (name)>))
<init-el> ::= :numeric-fluents (= <f-head> <number>)
<init-el> ::= :object-fluents (= <basic-function-term> <name>)
<basic-function-term> ::= <function-symbol>
<basic-function-term> ::= (<function-symbol> <name>*)
<goal> ::= (:goal <pre-GD>)
<constraints> ::= :constraints (<constraints <pref-con-GD>)
<pref-con-GD> ::= (and <pref-con-GD>*)
<pref-con-GD> ::= :universal-preconditions (forall (<typed list (variable)>) <pref-con-GD>)
<pref-con-GD> ::= :preferences (preference [<pref-name>] <con-GD>)
<pref-con-GD> ::= <con-GD>
<con-GD> ::= (and <con-GD>*)
<con-GD> ::= (forall (<typed list (variable)>) <con-GD>)
<con-GD> ::= (at end <GD>)
<con-GD> ::= (always <GD>)
<con-GD> ::= (sometime <GD>)
<con-GD> ::= (within <number> <GD>)
<con-GD> ::= (at-most-once <GD>)
<con-GD> ::= (sometime-after <GD> <GD>)
<con-GD> ::= (sometime-before <GD> <GD>)
<con-GD> ::= (always-within <number> <GD> <GD>)
<con-GD> ::= (hold-during <number> <number> <GD>)
<con-GD> ::= (hold-after <number> <GD>)
<metric-spec> ::= :numeric-fluents (:metric <optimization> <metric-f-exp>)
<optimization> ::= minimize
<optimization> ::= maximize
<metric-f-exp> ::= (<binary-op> <metric-f-exp> <metric-f-exp>)
<metric-f-exp> ::= (<multi-op> <metric-f-exp> <metric-f-exp>*)
<metric-f-exp> ::= (- <metric-f-exp>)
<metric-f-exp> ::= <number>
<metric-f-exp> ::= (<function-symbol> <name>*)
<metric-f-exp> ::= <function-symbol>
<metric-f-exp> ::= total-time
<metric-f-exp> ::= :preferences (is-violated <pref-name>)
<length-spec> ::= (:length [(:serial <integer>)] [(:parallel <integer>)])
                  The length-spec is deprecated since PDDL 2.1.

```

1.2.1 Lifting restrictions (from constraint declaration)

If we wish to embed modal operators into each other, then we should use these rules instead of those in section 1.2 respectively.

```

<con-GD> ::= (always <con2-GD>)
<con-GD> ::= (sometime <con2-GD>)
<con-GD> ::= (within <number> <con2-GD>)
<con-GD> ::= (at-most-once <con2-GD>)
<con-GD> ::= (sometime-after <con2-GD> <con2-GD>)
<con-GD> ::= (sometime-before <con2-GD> <con2-GD>)
<con-GD> ::= (always-within <number> <con2-GD> <con2-GD>)
<con-GD> ::= (hold-during <number> <number> <con2-GD>)
<con-GD> ::= (hold-after <number> <con2-GD>)
<con2-GD> ::= <con-GD>
<con2-GD> ::= <GD>

```

1.3 Requirements

Here is a table of all requirements in PDDL3.1. Some requirements imply others; some are abbreviations for common sets of requirements. If a domain stipulates no requirements, it is assumed to declare a requirement for `:strips`.

<code>:strips</code>	Basic STRIPS-style adds and deletes
<code>:typing</code>	Allow type names in declarations of variables
<code>:negative-preconditions</code>	Allow <code>not</code> in goal descriptions
<code>:disjunctive-preconditions</code>	Allow <code>or</code> in goal descriptions
<code>:equality</code>	Support <code>=</code> as built-in predicate
<code>:existential-preconditions</code>	Allow <code>exists</code> in goal descriptions
<code>:universal-preconditions</code>	Allow <code>forall</code> in goal descriptions
<code>:quantified-preconditions</code>	<code>= :existential-preconditions</code> <code>+ :universal-preconditions</code>
<code>:conditional-effects</code>	Allow <code>when</code> in action effects
<code>:fluents</code>	<code>= :numeric-fluents</code> <code>+ :object-fluents</code>
<code>:numeric-fluents</code>	Allow numeric function definitions and use of effects using assignment operators and arithmetic preconditions.
<code>:adl</code>	<code>= :strips + :typing</code> <code>+ :negative-preconditions</code> <code>+ :disjunctive-preconditions</code> <code>+ :equality</code> <code>+ :quantified-preconditions</code> <code>+ :conditional-effects</code>
<code>:durative-actions</code>	Allows durative actions. Note that this does not imply <code>:numeric-fluents</code> .
<code>:duration-inequalities</code>	Allows duration constraints in durative actions using inequalities.
<code>:continuous-effects</code>	Allows durative actions to affect fluents continuously over the duration of the actions.
<code>:derived-predicates</code>	Allows predicates whose truth value is defined by a formula
<code>:timed-initial-literals</code>	Allows the initial state to specify literals that will become true at a specified time point. Implies <code>:durative-actions</code>
<code>:preferences</code>	Allows use of preferences in action preconditions and goals.
<code>:constraints</code>	Allows use of constraints fields in domain and problem files. These may contain modal operators supporting trajectory constraints.
<code>:action-costs</code>	If this requirement is included in a PDDL specification, the use of numeric fluents is enabled (similar to the <code>:numeric-fluents</code> requirement). However, numeric fluents may only be used in certain very limited ways: <ol style="list-style-type: none"> 1. Numeric fluents may not be used in any conditions (preconditions, goal conditions, conditions of conditional effects, etc.). 2. A numeric fluent may only be used as the target of an effect if it is 0-ary and called <code>total-cost</code>. If such an effect is used, then the <code>total-cost</code> fluent must be explicitly initialized to 0 in the initial state. 3. The only allowable use of numeric fluents in effects is in effects of the form <code>(increase (total-cost) <numeric-term>)</code>, where the <code><numeric-term></code> is either a non-negative numeric constant or of the form <code>(<function-symbol> <term>*)</code>. (The <code><term></code> here is interpreted as shown in the PDDL grammar, i.e., it is a variable symbol or an object constant. Note that this <code><term></code> cannot be a <code><function-term></code>, even if the object fluents requirement is used.) 4. No numeric fluent may be initialized to a negative value. 5. If the problem contains a <code>:metric</code> specification, the objective must be <code>(minimize (total-cost))</code>, or - only if the <code>:durative-actions</code> requirement is also set - to minimize a linear combination of <code>total-cost</code> and <code>total-time</code>, with non-negative coefficients. <p>Note that an action can have multiple effects that increase <code>(total-cost)</code>, which is particularly useful in the context of conditional effects.</p> <p>Also note that these restrictions imply that <code>(total-cost)</code> never decreases throughout plan execution, i.e., action costs are never negative.</p>

References

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- [2] Fox M., Long D. (2003). *PDDL2.1: An Extension to pddl for Expressing Temporal Planning Domains*, Journal of Artificial Intelligence Research 20: 61-124.
- [3] Edelkamp S., Hoffmann J. (2003). *PDDL2.2: The Language for the Classical Part of the 4th International planning Competition*, Technical Report No. 195, Institut für Informatik.
- [4] Gerevini, A. Long D. (2005). *BNF Description of PDDL3.0*. Unpublished manuscript from the IPC-5 website.
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