

Introduction to **STEP-NC**

Milling Operations

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- **Operations**
 - Describe what is to be done. May be referenced by several workingsteps if the operation is repeated in different places.
- **Questions**
 - What operations are possible?
 - How are strategies associated?
 - How are technology parameters associated?

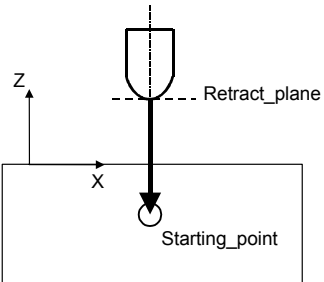
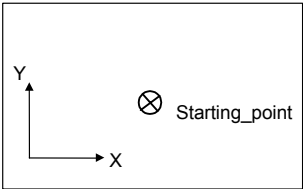
- **2.5D Machining Operations**
 - Plane and side milling.
 - Tool can move in the X-Y plane or along the Z axis, but not at the same time.
 - Set of strategies
- **Freeform Machining Operations**
 - For sculpted surfaces
 - 3, 4, and 5axis motion
 - Set of strategies
- **Drilling Operations**
 - Drilling, boring, back boring, tapping/threading
 - Tool moves in the Z axis only
 - Many strategy parameters

- **milling_type_operation**
 - **two5D_milling_operation**
 - » **bottom_and_side_milling**
 - B&S finish_milling
 - B&S rough_milling
 - » **side_milling**
 - side_finish_milling
 - side_rough_milling
 - » **plane_milling**
 - plane_finish_milling
 - plane_rough_milling
 - **freeform_operation**
- **drilling_type_operation**
 - **drilling_operation**
 - » **drilling**
 - » **center_drilling**
 - » **counter_sinking**
 - » **multistep_drilling**
 - **boring_operation**
 - » **boring**
 - » **reaming**
 - **back_boring**
 - **tapping**
 - **thread_drilling**

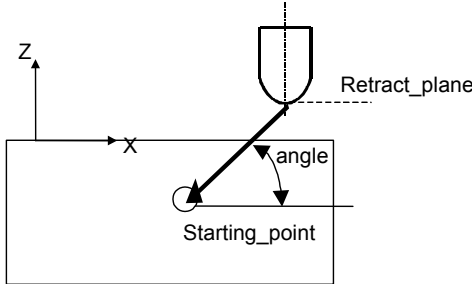
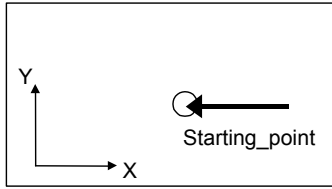
- **All Machining Operations can have:**
 - A cutting tool requirement
 - A start point and retract plane
 - Technology parameters, which are grouped and shared between operations
 - » Spindle speed, feedrate, feedrate per tooth, etc.
 - Machine function parameters, which are grouped and can be shared between operations
 - » Coolant, misting, chip removal, etc.
- **Operations can also have strategies**
 - All operations can have an associated machining strategy
 - All milling operations can also have an associated plunge strategy and a retract strategy

- **milling machining strategy**
 - **two5D_milling_strategy**
 - » **unidirectional**
 - » **bidirectional**
 - » **bidirectional_contour**
 - » **contour_parallel**
 - » **contour_bidirectional**
 - » **contour_spiral**
 - » **center_milling**
 - » **explicit**
 - **freeform_strategy**
 - » **uv_strategy**
 - » **plane_cc_strategy**
 - » **plane_cl_strategy**
 - » **leading_line_strategy**
 - **drilling_type_strategy**
- **approach_retract_strategy**
 - **plunge_strategy**
 - » **plunge_toolaxis**
 - » **plunge_ramp**
 - » **plunge_helix**
 - » **plunge_zigzag**
 - **air_strategy**
 - » **ap_retract_angle**
 - » **ap_retract_tangent**
 - **along_path**

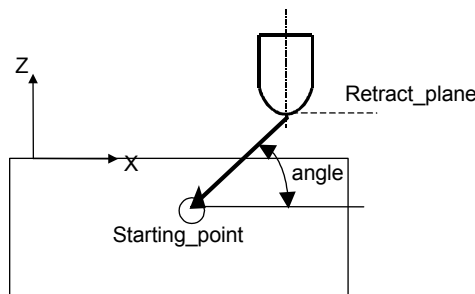
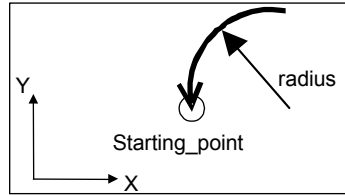
- Plunge strategies detail how the tool enters the material



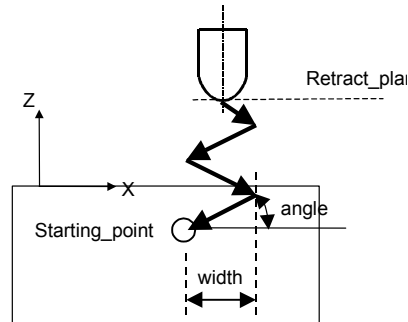
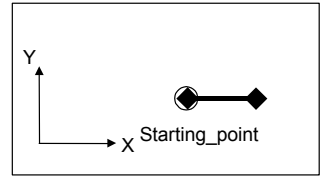
Toolaxis



Ramp

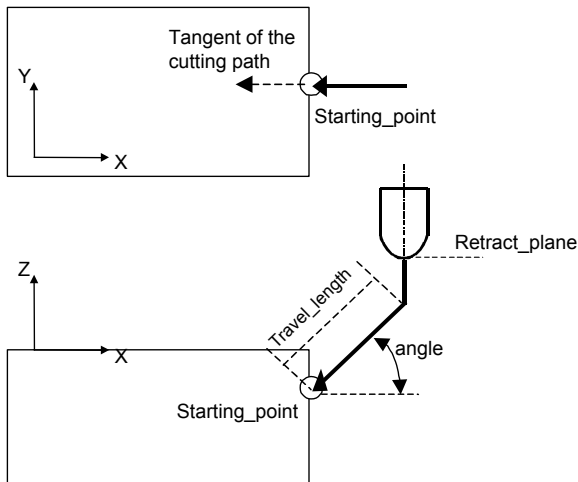


Helix

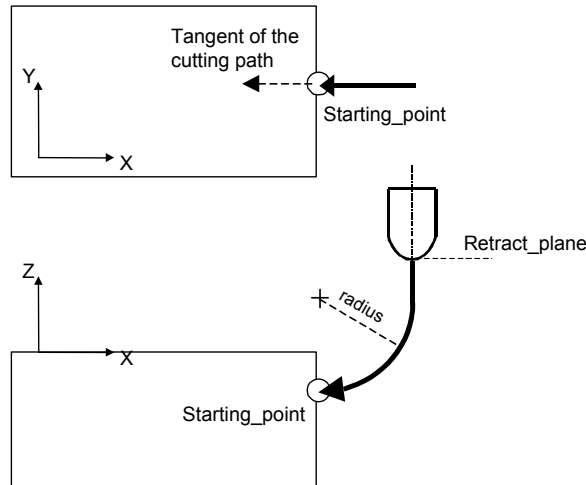


Zigzag

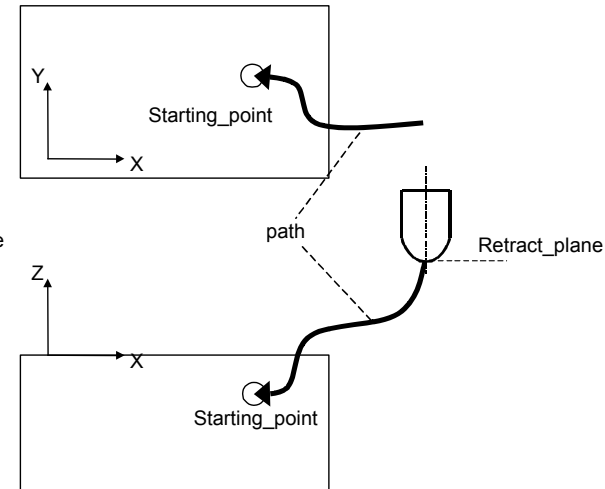
- Approach / Retract strategies detail how the tool moves through the air around the workpiece



Angle

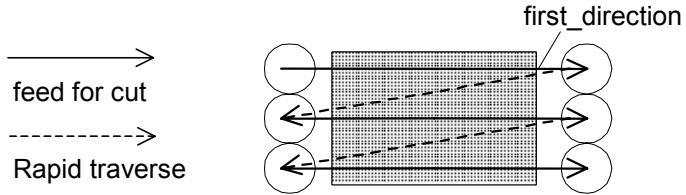


Tangent

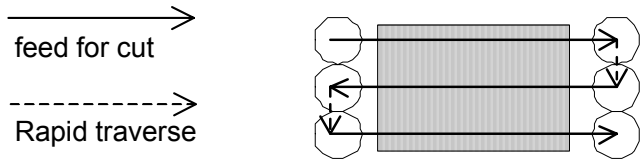


Along Path

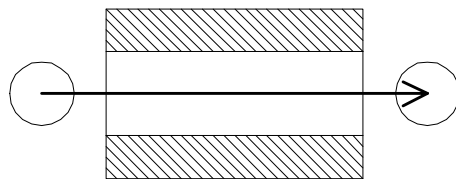
- **2.5D Machining Operations**
 - Plane and side milling.
 - Tool can move in the X-Y plane or along the Z axis, but not at the same time.
 - » `bottom_and_side_milling`
 - » `side_milling`
 - » `plane_milling`
- **All operations have rough and finish versions**
 - Rough milling leaves an allowance of material
 - Finish milling goes right to the feature boundaries



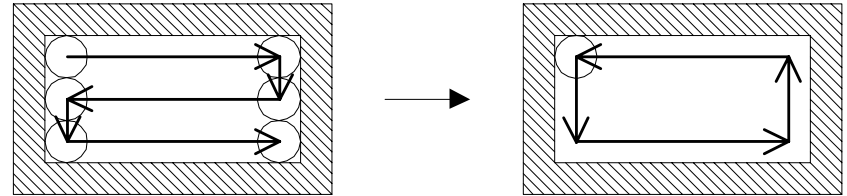
Unidirectional



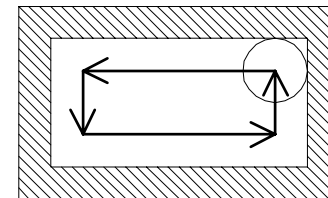
Bidirectional



Center Milling



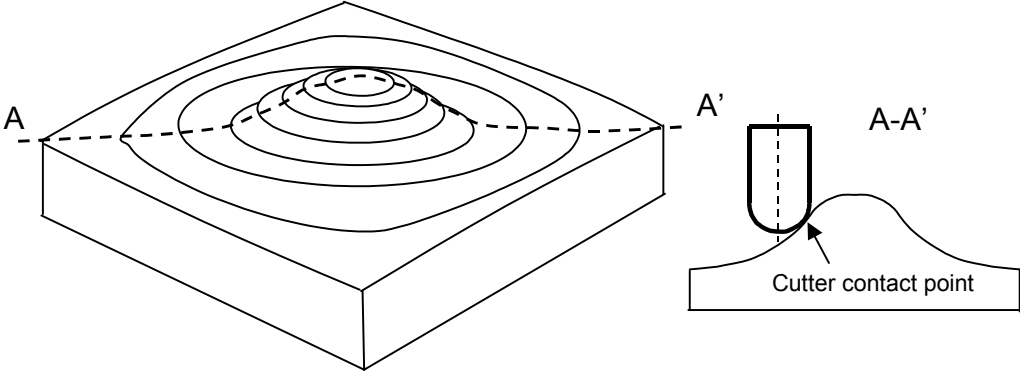
Bidirectional Contour & vice versa



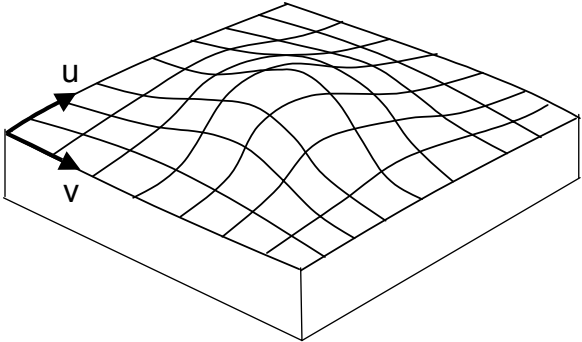
Contour Parallel & Spiral

- **Freeform Machining Operations**
 - For sculpted surfaces
 - 3, 4, and 5axis motion
 - No special subtypes

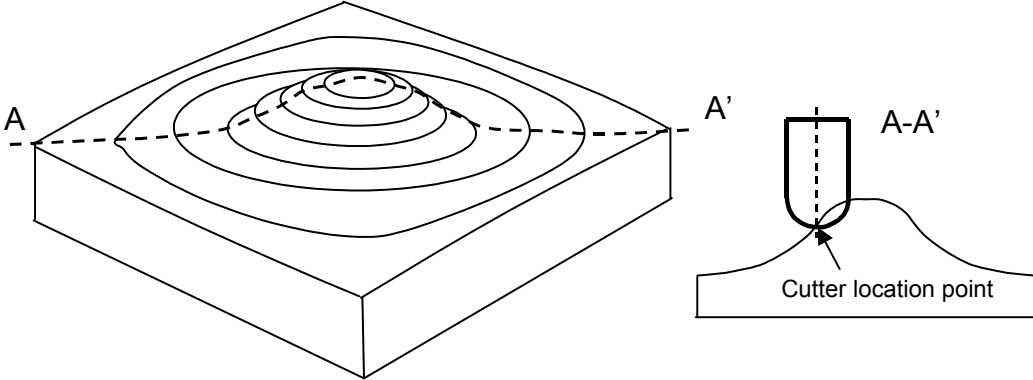
- **Usually for use with region feature or other explicit surface geometry**
 - Has a scallop height and chord parameters to help controllers decide how to generate toolpaths.



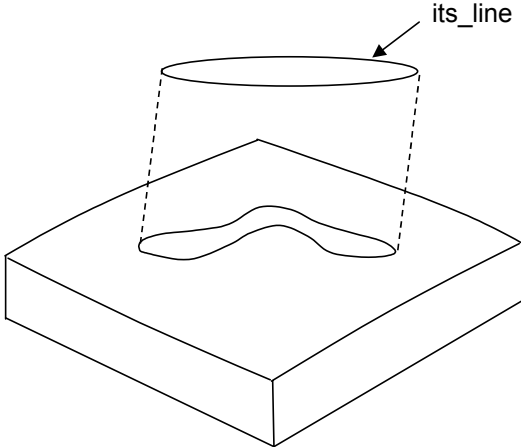
Cutter Contact Strategy



UV Strategy



Cutter Location Strategy



Leading Line Strategy

- **Drilling Operations**

- Drilling, boring, back boring, tapping/threading
- Tool moves in the Z axis only

- » **drilling_operation**

- drilling, center_drilling, counter_sinking, multistep_drilling

- » **boring_operation**

- boring, reaming

- » **back_boring**

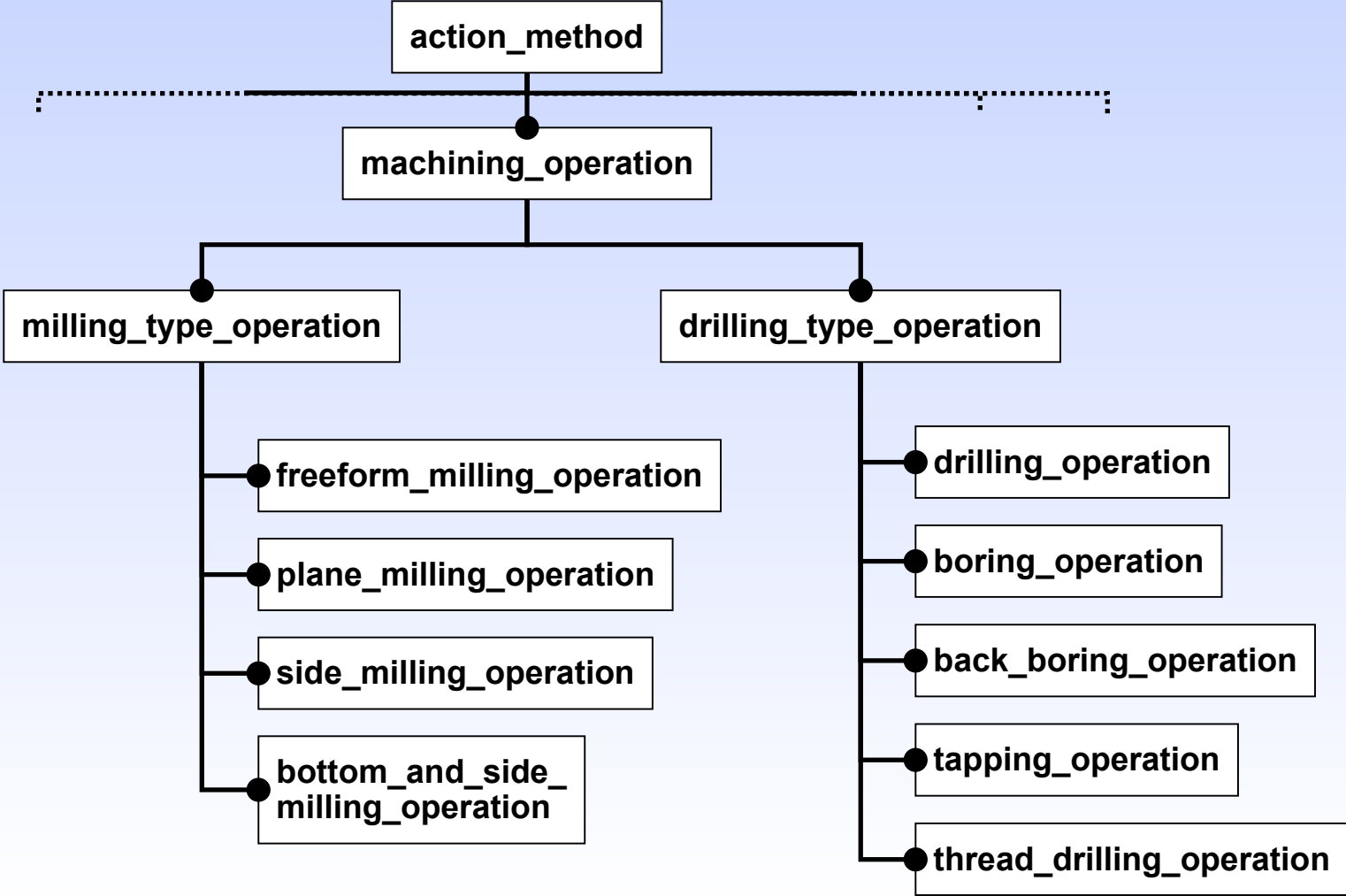
- » **tapping**

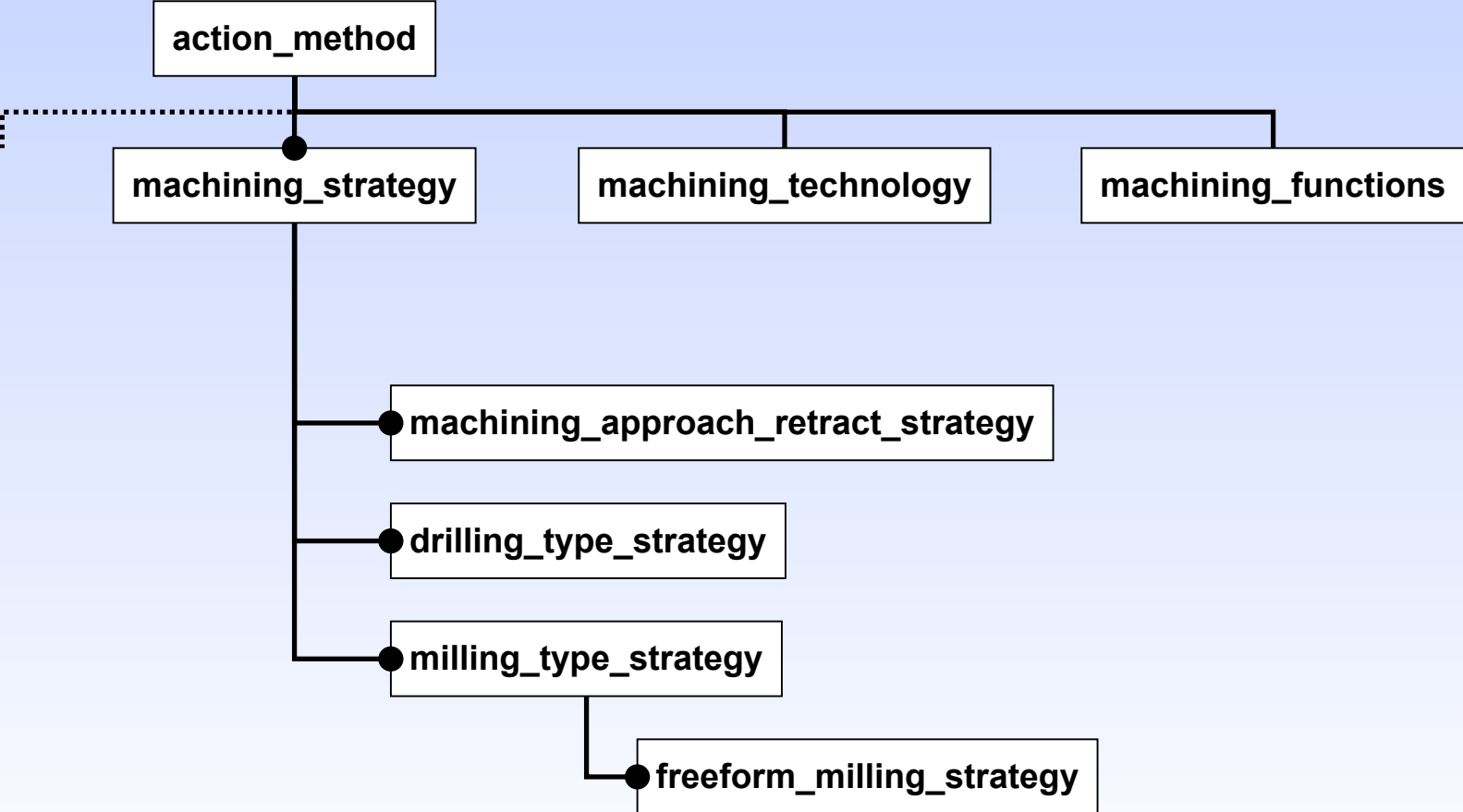
- » **thread_drilling**

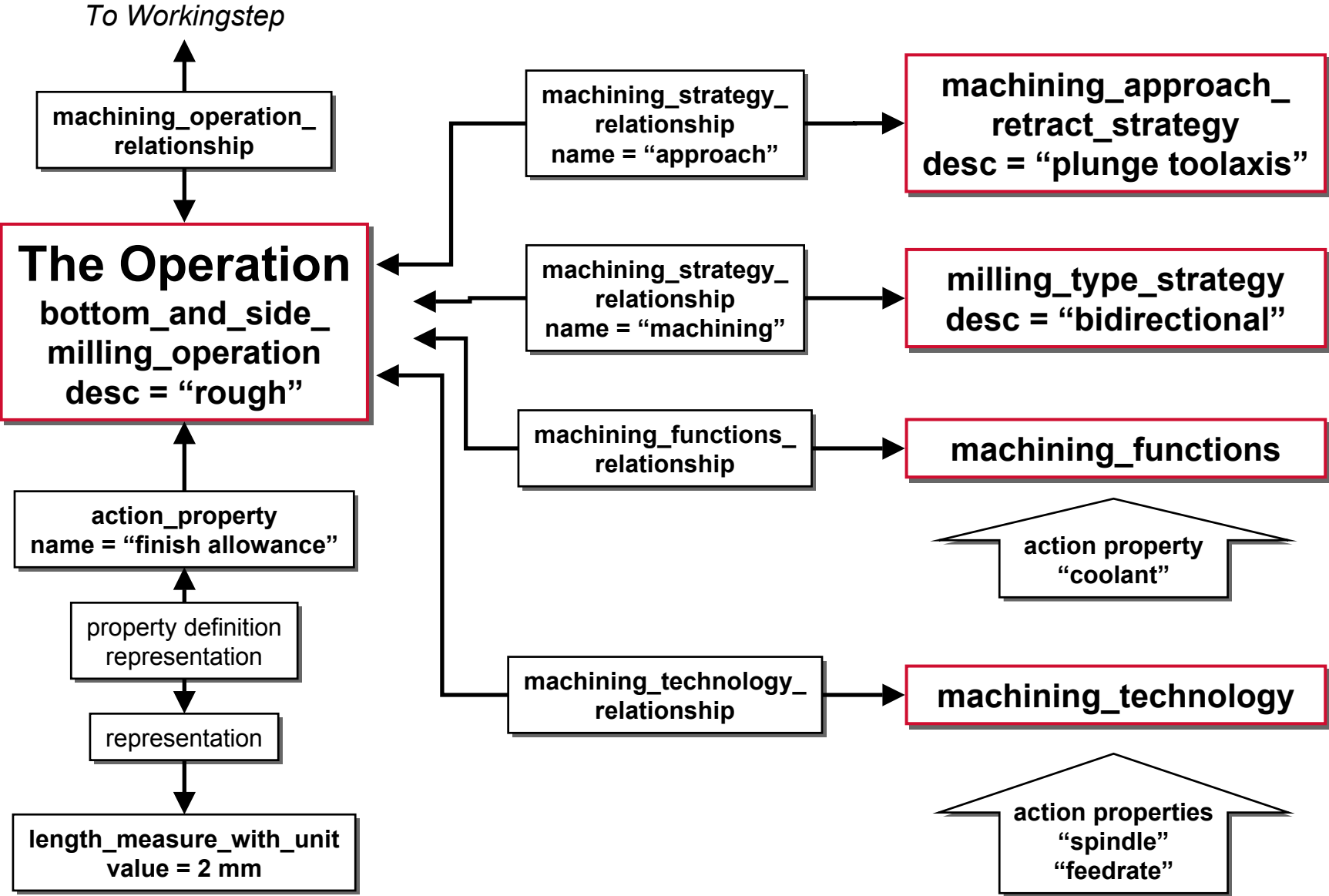
- **Only one drilling strategy, but with many parameters**

- Feed rates for starting, ending, and retract, dwell, depths, etc.

- **Operations are represented as action methods**
- **Strategies and other grouped parameters are also action methods**
 - Strategies, machine functions, technology
 - All are hooked to operation using action method relationships
 - Parameters are represented as action properties
- **Somewhat repetitive, but very straightforward**







- **Operations**
 - Describe what is to be done.
 - Currently supports 2.5D milling, freeform milling, drilling
 - With many strategies and parameters

- **Future editions will add operations for other machining technologies**
 - Turning
 - Grinding
 - EDM