

## DEMO2\_LIFT

**MACHINE** *Lift* ( *LFT* , *topfloor* , *bottomfloor* )

**CONSTRAINTS** *topfloor* > *bottomfloor*

**SETS** *DIR* = { *up* , *dn* } ; *DOR* = { *opn* , *clo* }

**CONSTANTS** *opp*

**PROPERTIES**

$opp \in DIR \rightarrow DIR \wedge$   
 $opp = \{ up \mapsto dn , dn \mapsto up \} \wedge$   
 $opp ( up ) = dn \wedge$   
 $opp ( dn ) = up$

**VARIABLES** *in* , *out* , *mov* , *dir* , *flr* , *dor*

**INVARIANT**

$in \in bottomfloor .. topfloor \leftrightarrow DIR \wedge$   
 $out \in LFT \leftrightarrow bottomfloor .. topfloor \wedge$   
 $mov \subseteq LFT \wedge$   
 $dir \in LFT \rightarrow DIR \wedge$   
 $flr \in LFT \rightarrow bottomfloor .. topfloor \wedge$   
 $dor \in LFT \rightarrow DOR \wedge$   
 $dor [ mov ] \subseteq \{ clo \}$

**INITIALISATION**

$in := \{ \} \parallel$   
 $out := \{ \} \parallel$   
 $mov := \{ \} \parallel$   
 $dir := LFT \times \{ up \} \parallel$   
 $flr := LFT \times \{ bottomfloor \} \parallel$   
 $dor := LFT \times \{ clo \}$

## OPERATIONS

**Request\_Lift** (  $fl$  ,  $dd$  )  $\hat{=}$

**PRE**

$fl \in \text{bottomfloor} \dots \text{topfloor} \wedge$   
 $dd \in \text{DIR}$

**THEN**

$in := in \cup \{ fl \mapsto dd \}$

**END** ;

**Request\_Floor** (  $ll$  ,  $fl$  )  $\hat{=}$

**PRE**

$fl \in \text{bottomfloor} \dots \text{topfloor} \wedge$   
 $ll \in \text{LFT}$

**THEN**

$out := out \cup \{ ll \mapsto fl \}$

**END** ;

**Continue\_Up** (  $ll$  )  $\hat{=}$

**PRE**

$ll \in \text{mov} \wedge$   
 $dir ( ll ) = \text{up} \wedge$   
 $ftr ( ll ) < \text{topfloor} \wedge$   
 $ll \mapsto ftr ( ll ) \notin out \wedge$   
 $ftr ( ll ) \mapsto \text{up} \notin in \wedge$   
 $attr\_up ( ll )$

**THEN**

$ftr ( ll ) := ftr ( ll ) + 1$

**END** ;

**Continue\_Down** (  $ll$  )  $\hat{=}$

**PRE**

$ll \in mov \wedge$   
 $dir ( ll ) = dn \wedge$   
 $ftr ( ll ) > bottomfloor \wedge$   
 $ll \mapsto ftr ( ll ) \notin out \wedge$   
 $ftr ( ll ) \mapsto dn \notin in \wedge$   
 $attr\_dn ( ll )$

**THEN**

$ftr ( ll ) := ftr ( ll ) - 1$

**END** ;

**Pickup\_Or\_Deliver\_And\_Continue** (  $ll$  )  $\hat{=}$

**PRE**

$ll \in mov \wedge$   
 $ftr ( ll ) \in in^{-1} [ \{ dir ( ll ) \} ] \cup out [ \{ ll \} ] \wedge$   
 $( dir ( ll ) = up \Rightarrow$   
 $attr\_up ( ll ) ) \wedge$   
 $( dir ( ll ) = dn \Rightarrow$   
 $attr\_dn ( ll ) )$

**THEN**

$mov := mov - \{ ll \} \parallel$   
 $dor ( ll ) := opn \parallel$   
 $out := out - \{ ll \mapsto ftr ( ll ) \} \parallel$   
 $in := in - \{ ftr ( ll ) \mapsto dir ( ll ) \}$

**END** ;

**Stop** (  $ll$  )  $\hat{=}$

**PRE**

$ll \in mov \wedge$   
 $( dir ( ll ) = up \Rightarrow \neg ( attr\_up ( ll ) ) ) \wedge$   
 $( dir ( ll ) = dn \Rightarrow \neg ( attr\_dn ( ll ) ) ) \wedge$   
 $ftr ( ll ) \notin dom ( in )$

**THEN**

$mov := mov - \{ ll \} \parallel$   
 $dor ( ll ) := opn \parallel$   
 $out := out - \{ ll \mapsto ftr ( ll ) \}$

**END** ;

**Pickup\_And\_Change\_Dir** ( $ll$ )  $\hat{=}$

**PRE**

$ll \in mov \wedge$   
 $(dir(ll) = up \Rightarrow$   
 $\neg(attr\_up(ll))) \wedge$   
 $(dir(ll) = dn \Rightarrow$   
 $\neg(attr\_dn(ll))) \wedge$   
 $ftr(ll) \mapsto dir(ll) \notin in \wedge$   
 $ftr(ll) \mapsto opp(dir(ll)) \in in$

**THEN**

$mov := mov - \{ll\} \parallel$   
 $dor(ll) := opn \parallel$   
 $out := out - \{ll \mapsto ftr(ll)\} \parallel$   
 $in := in - \{ftr(ll) \mapsto opp(dir(ll))\} \parallel$   
 $dir(ll) := opp(dir(ll))$

**END** ;

**Pickup\_And\_Same\_Dir** ( $ll$ )  $\hat{=}$

**PRE**

$ll \in mov \wedge$   
 $(dir(ll) = up \Rightarrow$   
 $\neg(attr\_up(ll))) \wedge$   
 $(dir(ll) = dn \Rightarrow$   
 $\neg(attr\_dn(ll))) \wedge$   
 $ftr(ll) \mapsto dir(ll) \in in$

**THEN**

$mov := mov - \{ll\} \parallel$   
 $dor(ll) := opn \parallel$   
 $out := out - \{ll \mapsto ftr(ll)\} \parallel$   
 $in := in - \{ftr(ll) \mapsto dir(ll)\}$

**END** ;

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Close_Door  $\hat{=}$ 
  PRE
     $dor^{-1} [ \{ opn \} ] \neq \{ \}$ 
  THEN
    ANY  $ll$  WHERE
       $ll \in dor^{-1} [ \{ opn \} ]$ 
    THEN
       $dor ( ll ) := clo$ 
    END
  END ;

Open_Door  $\hat{=}$ 
  PRE
     $dor^{-1} [ \{ clo \} ] \cap LFT - mov \neq \{ \}$ 
  THEN
    ANY  $ll$  WHERE
       $ll \in dor^{-1} [ \{ clo \} ] \wedge$ 
       $ll \notin mov$ 
    THEN
       $dor ( ll ) := opn$  ||
       $in := in - \{ flr ( ll ) \mapsto dir ( ll ) \}$ 
    END
  END ;

Depart_And_Move_Up (  $ll$  )  $\hat{=}$ 
  PRE
     $ll \in dor^{-1} [ \{ clo \} ] \wedge$ 
     $ll \notin mov \wedge$ 
     $attr\_up ( ll )$ 
  THEN
     $mov := mov \cup \{ ll \}$  ||
     $flr ( ll ) := flr ( ll ) + 1$  ||
     $dir ( ll ) := up$ 
  END ;

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**Depart\_And\_Move\_Down** (  $ll$  )  $\hat{=}$

**PRE**

$ll \in dor^{-1} [ \{ clo \} ] \wedge$

$ll \notin mov \wedge$

$attr\_dn ( ll )$

**THEN**

$mov := mov \cup \{ ll \} \parallel$

$ftr ( ll ) := ftr ( ll ) - 1 \parallel$

$dir ( ll ) := dn$

**END**

## DEFINITIONS

$attr\_up ( l ) \hat{=} out [ \{ l \} ] \cup dom ( in ) \cap ftr ( l ) + 1 .. topfloor \neq \{ \} ;$

$attr\_dn ( l ) \hat{=} out [ \{ l \} ] \cup dom ( in ) \cap bottomfloor .. ftr ( l ) - 1 \neq \{ \}$

**END**