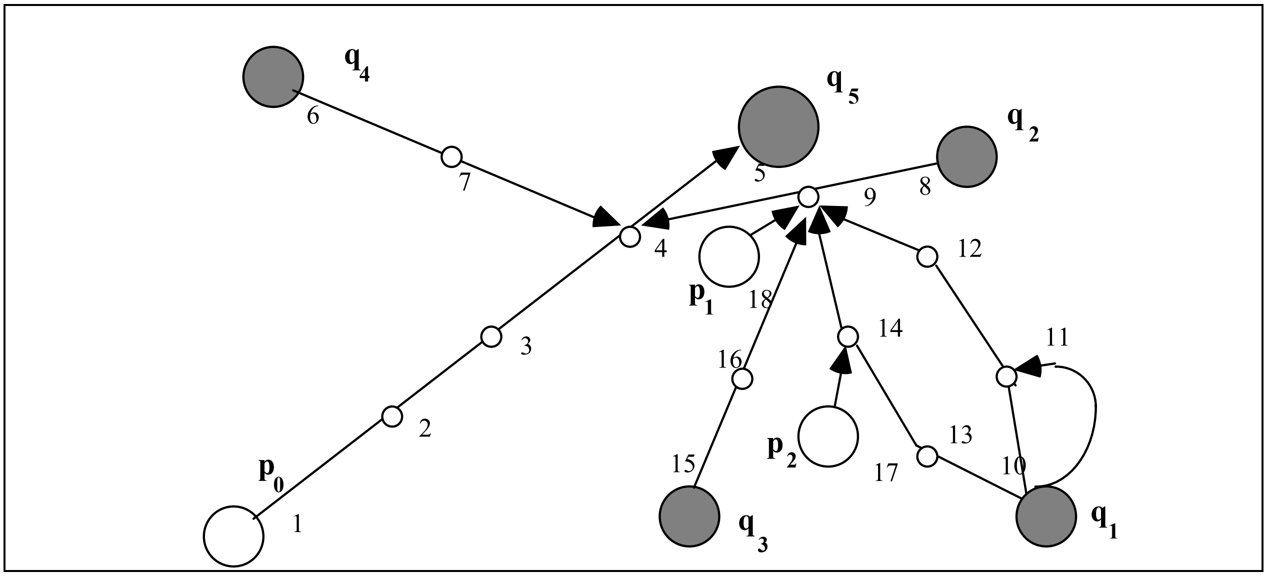


Zones trajectories (l, τ)	TRANSITION(p, x_o, x_1)					
	(q_1, 10, 11)	(p_o, 1, 2)	(q_1, 11, 12)	(p_o, 2, 3)	(q_2, 8, 9)	(p_o, 3, 4)
Z1, *a*(10)*a*(11*a*(12)*a*(9) (3, 3)	**(2,3)**	**(2, 2)**	**(1,2)**	**(1, 1)**	**Freeze**	
Z2, *a*(10)*a*(13)*a*(14)*a*(9) (3, 3)	**Freeze**					
Z2 *a*(17)*a*(14) (1, 1)	**Freeze**					
Z1, Z2 *a*(15)*a*(16)*a*(9) (2, 3)	**(2, 3)**	**(2, 2)**	**(2, 2)**	**(2, 1) Freeze**		
Z1, Z2 *a*(18)*a*(9) (1, 3)	**(1, 3)**	**(1, 2)**	**(1, 2)**	**(1, 1)**	**Freeze**	
Z1, Z2 *a*(8)*a*(9)*a*(4) (2, 4)	**(2, 4)**	**(2, 3)**	**(2, 3)**	**(2, 2)**	**(1, 2)**	**(1, 1)**
Z1, Z2 a(6)a(7)a(4) (2, 4)	**(2, 4)**	**(2, 3)**	**(2, 3)**	**(2, 2)**	**(2, 2)**	**(2, 1) Freeze**

Time distribution function $\boldsymbol{timer_\pi}$

Let $\pi_{Mo}(Z_1) = Z_2$ be a translation, with $Z_1 = \boldsymbol{t}(p_o, t_o, \tau_o)\boldsymbol{t}(p_1, t_1, \tau_1)\ldots\boldsymbol{t}(p_r, t_r, \tau_r)$, $Z_1 \in L_Z(S_1)$, $Z_2 \in L_Z(S_2)$. A mapping

$$\boldsymbol{timer_\pi}\colon \mathrm{Con}_\Pi(Z_1) \to \mathbf{Z},$$

where $\mathbf{Z}$ is the set of all integer numbers, is constructed as follows. We consider three cases:

(**1**) If $\Pi_{Mo}(t_o) = t_o'$, i.e., the main trajectory of Zone Z_1 is shortened, that is transformed into a substring with an excluded first symbol, then for all symbols $\boldsymbol{t}(p_c, t_c, \tau) \in \mathrm{Con}_\Pi(Z_1)$

$$\boldsymbol{timer_\pi}(\boldsymbol{t}(p_c, t_c, \tau)) = \tau - 1.$$

(**2**) If $\Pi_{Mo}(t_k) = t_k'$, i.e., some other trajectory t_k of Zone Z_1 is shortened ($k \neq 0$), then we define $\boldsymbol{timer_\pi}$ recursively.

(**a**) $\boldsymbol{timer_\pi}(\boldsymbol{t}(p_o, t_o, \tau_o)) = \tau_o$,
$\boldsymbol{timer_\pi}(\boldsymbol{t}(p_i, t_i, \tau_i)) = \tau_i$ (if $C_{TA(Z_1)}(t_i, t_o) = T$)

(**b**) Let $\boldsymbol{t}(p_c, t_c, \tau) \in \mathrm{Con}_\Pi(Z_1)$,
denote $CA(t_c) = \{t_i \in \mathrm{Con}_\Pi(Z_1) \mid C(t_c, t_i) = T\}$,
then $\boldsymbol{timer_\pi}(\boldsymbol{t}(p_c, t_c, \tau)) = \max\limits_{t_i \in CA(t_c)} \{TNEW(t_i)\}$, where

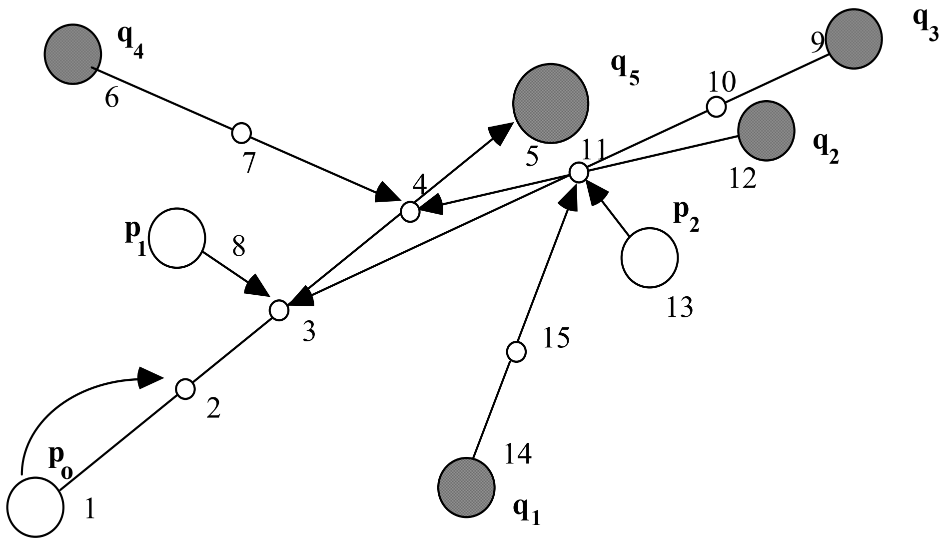
$$TNEW(t_i) = \begin{cases} \boldsymbol{timer_\pi}(\boldsymbol{t}(p_i, t_i, \tau_i)) - \boldsymbol{len}(p_i, t_i) + 1, & \text{if } t_i \neq t_k, \\ (\boldsymbol{timer_\pi}(\boldsymbol{t}(p_i, t_i, \tau_i)) + 1) - \boldsymbol{len}(p_i, t_i) + 1, & \text{if } t_i = t_k, \end{cases}$$

($\boldsymbol{len}(p_i, t_i)$ is the length of t_i).

---

(3) If $\Pi_{Mo}(t_m) = t_m$ for all $t_m \in TA(Z_1)$, then $\boldsymbol{timer_\pi}(\boldsymbol{t}(p_c, t_c, \tau)) = \tau$.

Interpretation of function *timer*π



(1) M_o = TRANSITION(p_o, 1, 2)

It means that function ***timer***π for all the symbols of $A(Z_1)$ yields the value of $\tau - 1$, where τ is the value the third parameter of each symbol. For example,

$$\boldsymbol{timer}_\pi(\boldsymbol{t}(q_3, t_{q_3}, \tau)) = \tau - 1,$$

$$\text{where } t_{q_3} = \boldsymbol{a}(9)\boldsymbol{a}(10)\boldsymbol{a}(11)\boldsymbol{a}(3),\ \tau = 3.$$

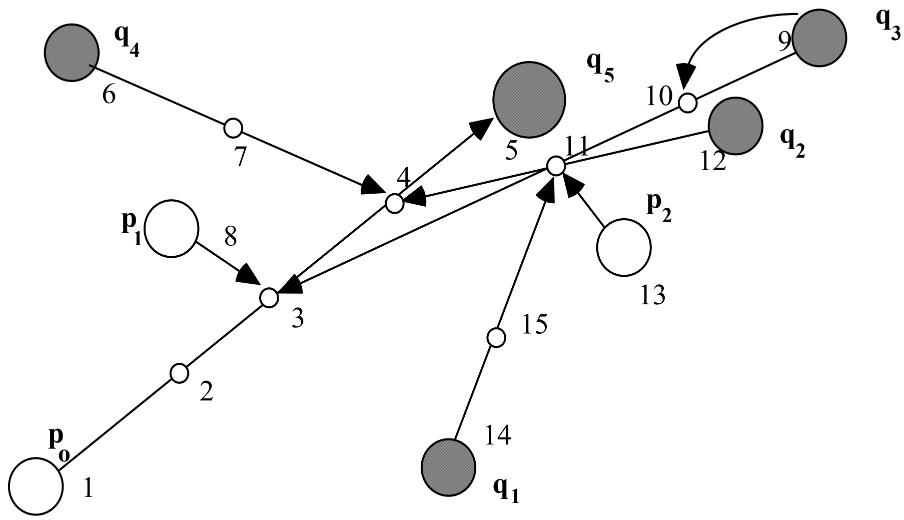
After TRANSITION(p_o, 1, 2) time allocated to the motion along trajectory t_{q_3} is less than the length of this trajectory (2 < 3) and, thus, trajectory t_{q_3} should not be included into the translation $\pi_{M_o}(Z_1)$ of Zone Z_1.

For the trajectory $t_{q_1} = \boldsymbol{a}(14)\boldsymbol{a}(15)\boldsymbol{a}(11)$ connected with t_{q_3}

$$\boldsymbol{timer}_\pi(\boldsymbol{t}(q_1, t_{q_1}, 3)) = 2.$$

It means that its length does not exceed the time allocated for the motion and, consequently, t_{q_1} should be included into Z_2. In spite of loosing the C^+ connection with t_o through t_{q_3} (which is not included), trajectory t_{q_1} keeps the C^+ connection with t_o through t_{q_2}.

Interpretation of function *timer*$_\pi$ (continued)



(**2**) M_o = TRANSITION(q_3, 9, 10)

(**a**) For the main trajectory $\boldsymbol{timer}_\pi(\boldsymbol{t}(p_o, t_o, \tau)) = 5$,

for the 1st negation trajectories:

$\boldsymbol{timer}_\pi(\boldsymbol{t}(p_1, t_{p_1}, \tau)) = 3$, $\boldsymbol{timer}_\pi(\boldsymbol{t}(q_2, t_{q_2}, \tau)) = 4$,

$\boldsymbol{timer}_\pi(\boldsymbol{t}(q_3, t_{q_3}, \tau)) = 3$, $\boldsymbol{timer}_\pi(\boldsymbol{t}(q_4, t_{q_4}, \tau)) = 4$.

After transition M_o elements q_2, q_3, q_4 still have enough time for interception of p_o.

For the 2nd negation trajectories t_{q_1} and t_{p_2} we have case

(**b**) for both trajectories $CA(t_{q_1}) = CA(t_{p_2}) = \{t_{q_2}, t_{q_3}\}$. Then

$\boldsymbol{timer}_\pi(\boldsymbol{t}(q_1, t_{q_1}, \tau)) = \max\{TNEW(t_{q_2}), TNEW(t_{q_3})\} = \max\{3, 2\} = 3$,

where

$TNEW(t_{q_2}) = \boldsymbol{timer}_\pi(\boldsymbol{t}(q_2, t_{q_2}, \tau)) - 2 + 1 = 4 - 2 + 1 = 3$,

$TNEW(t_{q_3}) = (\boldsymbol{timer}_\pi(\boldsymbol{t}(q_3, t_{q_3}, \tau)) + 1) - 3 + 1 = (3 + 1) - 3 + 1 = 2$

Consequently, $\boldsymbol{timer}_\pi(\boldsymbol{t}(q_1, t_{q_1}, \tau)) = 3$. Thus because the length of t_{q_1} does not exceed the value of $\boldsymbol{timer}_\pi$($2 < 3$) it should be included into the translation.

Theorem about Translations

THEOREM: ***Let for a translation*** $\pi_{Mo}(Z_1) = Z_2$. ***Under certain constraints for every symbol*** $t(p, t_i, \tau) \in Con_\Pi(Z_1)$, (***where*** $t_i \in t_p(x, y, l)$, $l > 1$)

$$\pi_o(t(p, t_i, \tau)) = t(p, \Pi_{Mo}(t_i), timer_p(t(p, t_i, \tau)))$$

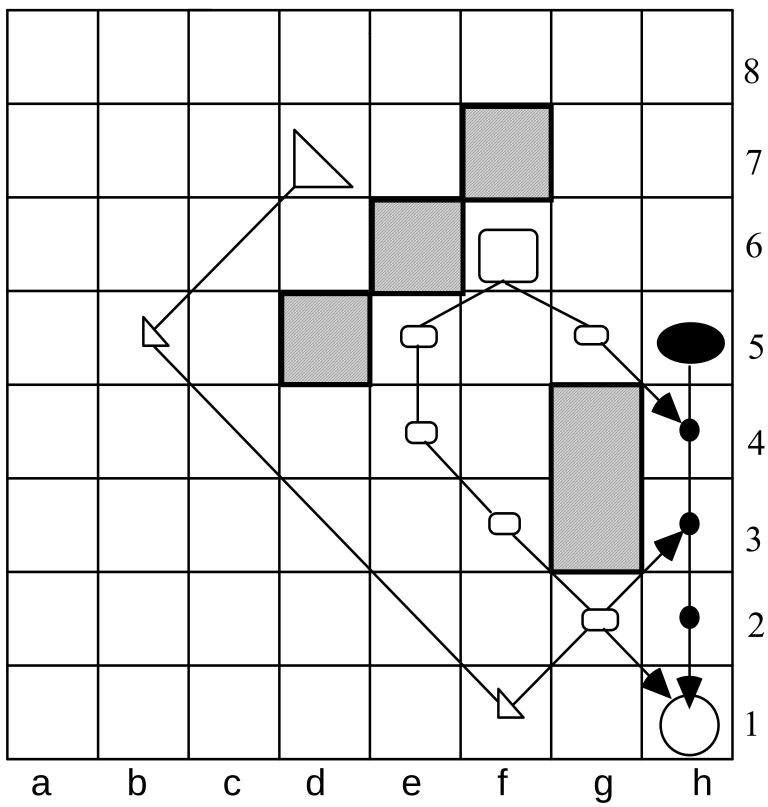
is a mapping onto $A(Z_2) \cap \Pi(Con_\Pi(Z_1))$, ***if and only if*** $l \le timer_\pi(t(p, t_i, \tau))$.

Interpretation of the trajectory network language for the robot control model

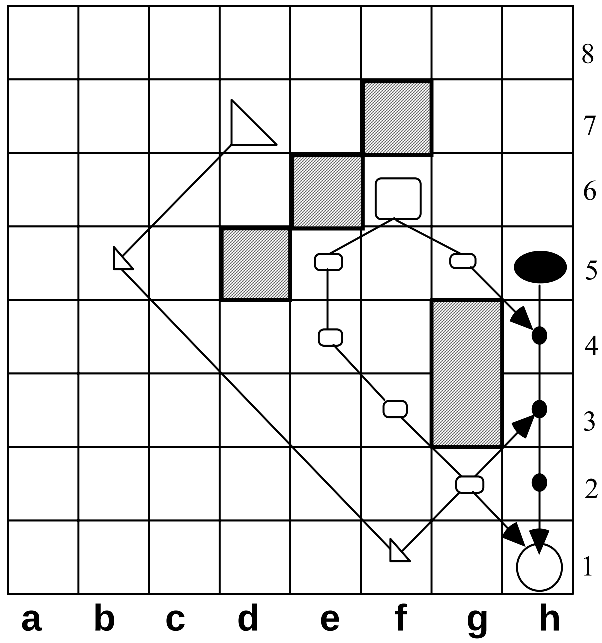
$$\boldsymbol{t}(\text{BOMBER}, t_B, 5)\boldsymbol{t}(\text{FIGHTER}, t_F, 5)\boldsymbol{t}(\text{MISSILE}, t_M, 5)\boldsymbol{t}(\text{MISSILE}, t_M{}^1, 3)$$
$$\boldsymbol{t}(\text{FIGHTER}, t_F{}^1, 2),$$

where

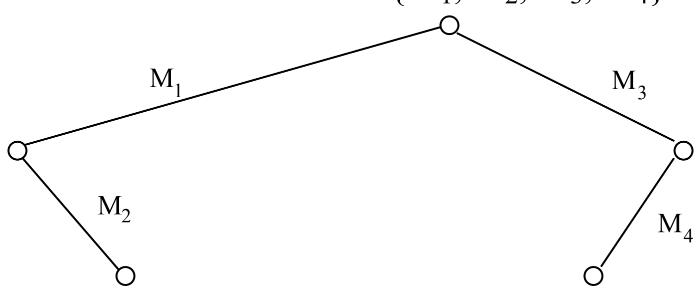
$$t_B=\boldsymbol{a}(h5)\boldsymbol{a}(h4)\boldsymbol{a}(h3)\boldsymbol{a}(h2)\boldsymbol{a}(h1),$$
$$t_F=\boldsymbol{a}(f6)\boldsymbol{a}(e5)\boldsymbol{a}(e4)\boldsymbol{a}(f3)\boldsymbol{a}(g2)\boldsymbol{a}(h1),$$
$$t_M=\boldsymbol{a}(d7)\boldsymbol{a}(b5)\boldsymbol{a}(f1)\boldsymbol{a}(g2)\boldsymbol{a}(h1),$$
$$t_M{}^1=\boldsymbol{a}(d7)\boldsymbol{a}(b5)\boldsymbol{a}(f1)\boldsymbol{a}(h3),$$
$$t_F{}^1=\boldsymbol{a}(f6)\boldsymbol{a}(g5)\boldsymbol{a}(h4)$$



Translations for Robot Control Model



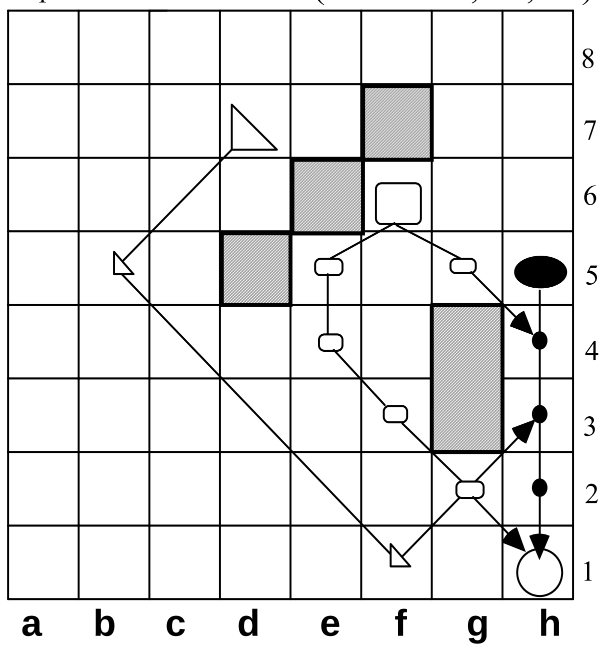
TRANSITIONS = {M_1, M_2, M_3, M_4}.



M_1 = TRANSITION(MISSILE, d7, b5)
M_2 = TRANSITION(BOMBER, h5, h4)
M_3 = TRANSITION(FIGHTER, f6, e5)
M_4 = TRANSITION(BOMBER, h5, h4)

Translations

M_1 = TRANSITION(MISSILE, d7, b5)



$$\pi_o(\boldsymbol{t}(\text{BOMBER}, t_B, 5)) = \boldsymbol{t}(\text{BOMBER}, \Pi_{M_1}(t_B), \boldsymbol{timer}_\pi(\boldsymbol{t}(\text{BOMBER}, t_B, 5)) = \boldsymbol{t}(\text{BOMBER}, t_B, 5)$$

$$\pi_o(\boldsymbol{t}(\text{FIGHTER}, t_F, 5)) = \boldsymbol{t}(\text{FIGHTER}, t_F, 5),$$
$$\pi_o(\boldsymbol{t}(\text{FIGHTER}, t_F{}^1, 2)) = \boldsymbol{t}(\text{FIGHTER}, t_F{}^1, 2),$$
$$\pi_o(\boldsymbol{t}(\text{MISSILE}, t_M, 5) = \boldsymbol{t}(\text{MISSILE}, \boldsymbol{\Pi_{M_1}(t_M)}, 5),$$
$$\pi_o(\boldsymbol{t}(\text{MISSILE}, t_M{}^1, 3) = \boldsymbol{t}(\text{MISSILE}, \boldsymbol{\Pi_{M_1}(t_M{}^1)}, 3),$$

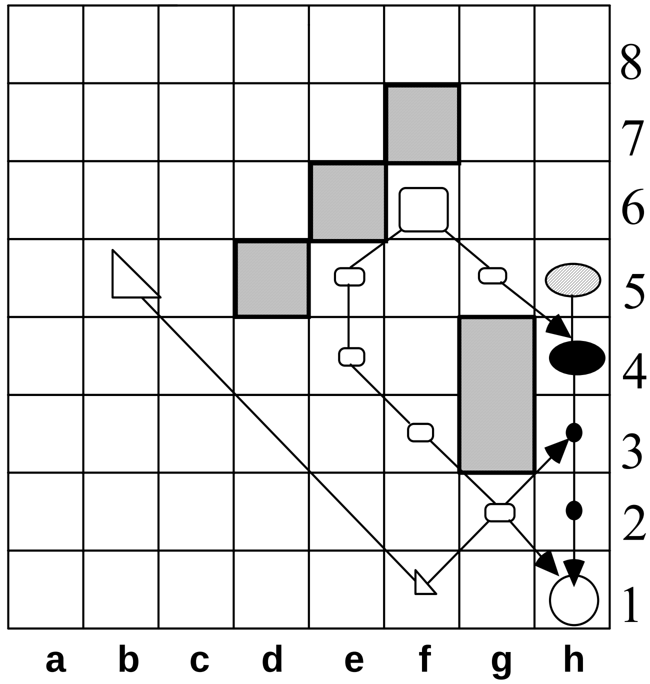
where $\Pi_{M_1}(t_M)$ and $\Pi_{M_1}(t_M{}^1)$ are shortened trajectories with excluded first symbol, i.e.,

$$\Pi_{M_1}(t_M) = t_{M,s} = \boldsymbol{a}(b5)\boldsymbol{a}(f1)\boldsymbol{a}(g2)\boldsymbol{a}(h1),$$
$$\Pi_{M_1}(t_M{}^1) = t_{M,s}{}^1 = \boldsymbol{a}(b5)\boldsymbol{a}(f1)\boldsymbol{a}(h3).$$

Lengths of all the 1-st negation trajectories of this Zone after the translation do not exceed values of $\boldsymbol{timer}_\pi$, consequently, according to Theorem, all these trajectories should be included into the new Zone $Z_1 = \pi_{M_1}(Z_o)$.

Translations (continued)

M_2 = TRANSITION(BOMBER, h5, h4).



$\pi_o(\boldsymbol{t}(\text{BOMBER}, t_B, 5)) = \boldsymbol{t}(\text{BOMBER}, \Pi_{M_2}(t_B), 4)$

$\pi_o(\boldsymbol{t}(\text{MISSILE}, t_{M,s}, 5) = \boldsymbol{t}(\text{MISSILE}, t_{M,s}, 4)$,

$\pi_o(\boldsymbol{t}(\text{MISSILE}, t_{M,s}{}^1 , 3) = \boldsymbol{t}(\text{MISSILE}, t_{M,s}{}^1 , 2)$,

where $\Pi_{M_2}(t_B) = t_{B,s} = \boldsymbol{a}(h4)\boldsymbol{a}(h3)\boldsymbol{a}(h2)\boldsymbol{a}(h1)$ is a shortened trajectory.

For BOMBER and MISSILE the following inequalities hold

$\boldsymbol{len}(\text{BOMBER}, \ t_{B,s}) = 3 < 4$,

$\boldsymbol{len}(\text{MISSILE}, \ t_{M,s}) = 3 < 4$,

$\boldsymbol{len}(\text{MISSILE}, \ t_{M,s}{}^1) = 2 \le 2$.

According to Theorem it means that trajectories $t_{B,s}$, $t_{M,s}$, $t_{M,s}{}^1$ of BOMBER and MISSILE should be included into the new Zone $Z_2 = \pi_{M_2}(Z_1)$., i.e., MISSILE has enough time to intercept BOMBER at h3 or h1.

$\boldsymbol{t}(\text{FIGHTER}, t_F, \boldsymbol{timer}_\pi(\boldsymbol{t}(\text{FIGHTER}, t_F, \ 5)) = \boldsymbol{t}(\text{FIGHTER}, t_F, 4)$,

$\boldsymbol{t}(\text{FIGHTER}, t_F{}^1, \boldsymbol{timer}_\pi(\boldsymbol{t}(\text{FIGHTER}, t_F{}^1, \ 2)) = \boldsymbol{t}(\text{FIGHTER}, t_F{}^1, 1)$,

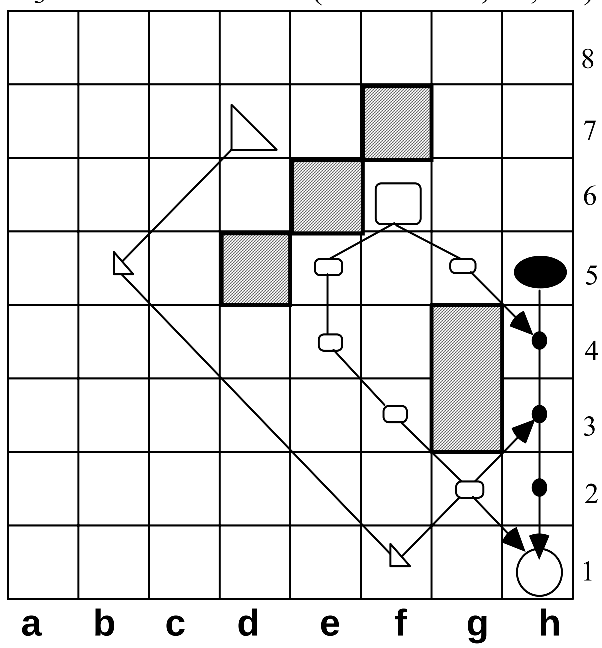
$\boldsymbol{len}(\text{FIGHTER}, \ t_F{}^1) = 2 > 1$,

$\boldsymbol{len}(\text{FIGHTER}, \ t_F) = 5 > 4$,

which means that trajectories $t_F{}^1$, t_F of FIGHTER are not included into the new Zone Z_2. Indeed, after transition M_2 FIGHTER does not have enough time for interception of BOMBER at h4 or at h1. In addition $t_F{}^1$ looses connection to $t_{B,s}$.

Translations (continued)

M_3 = TRANSITION(FIGHTER, f6, e5)



$$\pi_o(\boldsymbol{t}(\text{BOMBER}, t_B, 5)) = \boldsymbol{t}(\text{BOMBER}, t_B, 5)$$

For all the 1-st negation trajectories we obtain

$$\pi_o(\boldsymbol{t}(\text{FIGHTER}, t_F, 5)) = \boldsymbol{t}(\text{FIGHTER}, \Pi_{M_3}(t_F), 5),$$

$$\pi_o(\boldsymbol{t}(\text{MISSILE}, t_M, 5) = \boldsymbol{t}(\text{MISSILE}, t_M, 5),$$

$$\pi_o(\boldsymbol{t}(\text{MISSILE}, t_M{}^1, 3) = \boldsymbol{t}(\text{MISSILE}, t_M{}^1, 3),$$

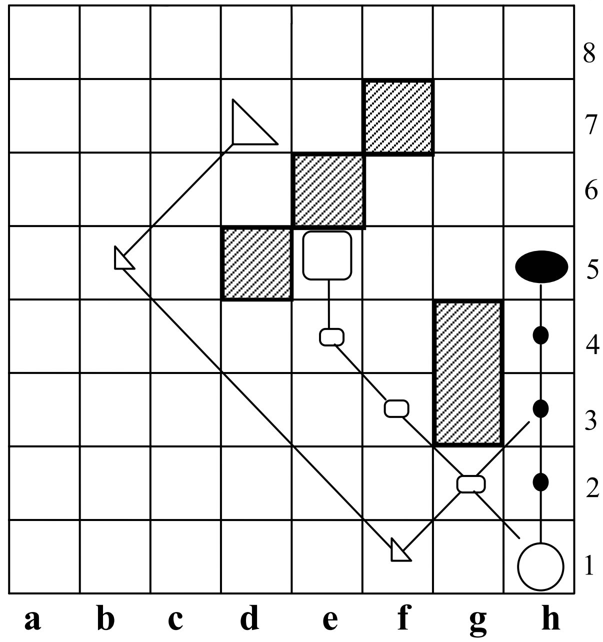
where $\Pi_{M_3}(t_F)$ is a shortened trajectory with excluded first symbol, i.e.,

$$\Pi_{M_3}(t_F) = t_{F,s} = \boldsymbol{a}(e5)\boldsymbol{a}(e4)\boldsymbol{a}(f3)\boldsymbol{a}(g2)\boldsymbol{a}(h1).$$

Concerning $\Pi_{M_3}(t_F{}^1)$, we conclude that after transition M_3 $t_F{}^1$ looses the connection with the main trajectory t_B, $\Pi_{M_3}(t_F{}^1) = e$, hence $t_F{}^1 \notin Con_\Pi(Z_o)$. Lengths of the 1-st negation trajectories of this Zone, accept for $t_F{}^1$, after translation Π_{M_3} do not exceed values of ***timer***$_\pi$, consequently, according to the Theorem, all these trajectories should be included into the new Zone $Z_3 = \pi_{M_3}(Z_o)$. It means that both FIGHTER and MISSILE have enough time for interception.

Translations (continued)

M_4 = TRANSITION(BOMBER, h5, h4)



$$\pi_o(\boldsymbol{t}(\text{BOMBER}, t_B, 5)) = \boldsymbol{t}(\text{BOMBER}, \Pi_{M4}(t_B), 4)$$

$$\pi_o(\boldsymbol{t}(\text{FIGHTER}, t_{F,s}, 5)) = \boldsymbol{t}(\text{FIGHTER}, t_{F,s}, 4),$$

$$\pi_o(\boldsymbol{t}(\text{MISSILE}, t_M, 5) = \boldsymbol{t}(\text{MISSILE}, t_M, 4),$$

where $\Pi_{M4}(t_B) = t_{B,s} = \boldsymbol{a}(h4)\boldsymbol{a}(h3)\boldsymbol{a}(h2)\boldsymbol{a}(h1)$ is a shortened trajectory. For BOMBER, FIGHTER and MISSILE the following inequalities hold

$$\boldsymbol{len}(\text{BOMBER}, \; t_{B,s}) = 3 < 4,$$

$$\boldsymbol{len}(\text{FIGHTER}, \; t_{F,s}) = 4 \le 4,$$

$$\boldsymbol{len}(\text{MISSILE}, \; t_M) = 4 \le 4.$$

According to Theorem it means that trajectories $t_{B,s}$, $t_{F,s}$, t_M of BOMBER, FIGHTER and MISSILE should be included in the new Zone $Z_4 = \pi_{M4}(Z_3)$., i.e., FIGHTER and MISSILE have enough time to intercept BOMBER at h1. But, considering trajectory $t_M{}^1$ of MISSILE, we have

$$\boldsymbol{t}(\text{MISSILE}, t_M{}^1, \boldsymbol{timer}_\pi(\boldsymbol{t}(\text{MISSILE}, t_M{}^1, \; 3)) = \boldsymbol{t}(\text{MISSILE}, t_M{}^1, 2),$$

$$\boldsymbol{len}(\text{MISSILE}, \; t_M{}^1) = 3 > 2,$$

which means that this trajectory is not included in the new Zone Z_4. Indeed, after transition M_4 MISSILE does not have enough time for interception of BOMBER at h3.

Translations for Robot Control Model
New Example