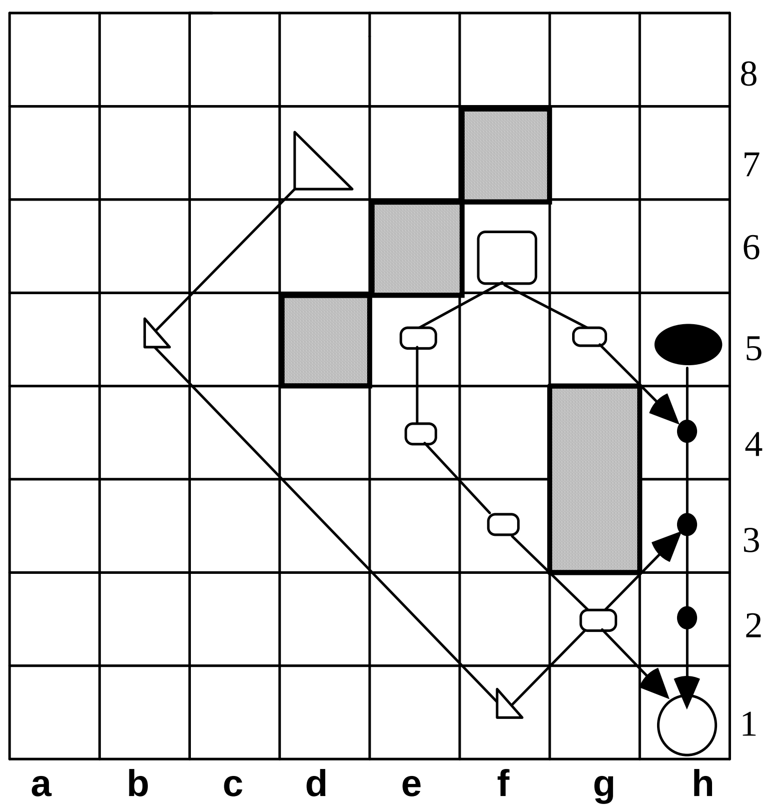
Interpretation of the Language of Zones for the robot control model

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

where

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



Grammar of Zones G_Z

L	Q	Kernel, π_k $(\forall z \in X)$	π_n $(\forall z \in X)$	F_T	F_F
1	Q_1	$S(u, v, w) \to A(u, v, w)$		*two*	$\varnothing$
2_i	Q_2	$A(u, v, w) \to t(h_i^o(u), l_o+1)$ $A((0, 0, 0), g(h_i^o(u),w), zero)$	$TIME(z) = DIST(z,h_i^o(u))$	3	$\varnothing$
3	Q_3	$A(u, v, w) \to A(f(u, v), v, w)$	$NEXTTIME(z) = init(u, NEXTTIME(z))$	*four*	5
4_j	Q_4	$A(u, v, w) \to t(h_j(u), TIME(y)))$ $A(u, v, g(h_j(u), w))$	$NEXTTIME(z) = ALPHA(z, h_j(u), TIME(y) - l+1)$	3	3
5	Q_5	$A(u, v, w) \to A((0, 0, 0), w, zero)$	$TIME(z) = NEXTTIME(z)$	3	6
6	Q_6	$A(u, v, w) \to \varepsilon$		$\varnothing$	$\varnothing$

$V_T = \{t\}$, $V_N = \{S, A\}$,

V_{PR}

Pred $=\{Q_1,Q_2,Q_3,Q_4,Q_5,Q_6\}$

$Q_1(u) = (ON(p_o) = x) \wedge (MAP_{x,p_o}(y) \le l \le l_o) \wedge$
$(\exists q\ ((ON(q) = y) \wedge (OPPOSE(p_o, q))))$

$Q_2(u) = T$

$Q_3(u) = (x \ne n) \vee (y \ne n)$

$Q_4(u) = (\exists p\ ((ON(p) = x) \wedge (l > 0) \wedge (x \ne x_o) \wedge (x \ne y_o)) \wedge$
$((\neg OPPOSE(p_o, p) \wedge (MAP_{x,p}(y) = 1)) \vee$
$(OPPOSE(p_o, p) \wedge (MAP_{x,p}(y) \le l)))$

$Q_5(w) = (w \ne zero)$

$Q_6 = T$

$Var = \{x, y, l, \tau, \theta, v_1, v_2, ..., v_n, w_1, w_2, ..., w_n\}$; for the sake of brevity:
$u = (x, y, l)$, $v = (v_1, v_2, ..., v_n)$, $w = (w_1, w_2, ..., w_n)$, $zero = (0, 0,..., 0)$

$Con = \{x_o,y_o,l_o,p_o\}$; $Func = Fcon \cup Fvar$;

$Fcon = \{f_x,f_y,f_l, g_1,g_2,...,g_n, h_1,h_2,...,h_M,$
$h_1^o, h_2^o, ... , h_M^o, DIST, init, ALPHA\}$, $f = (f_x, f_y, f_l)$, $g = (g_{x1}, g_{x2}, ... , g_{xn})$,
$M = |\mathbf{L}_t^{l_o}(S)|$ is the number of trajectories in $\mathbf{L}_t^{l_o}(S)$

$Fvar = \{x_o,y_o,l_o,p_o, TIME, NEXTTIME\}$

$E = \mathbf{Z}_+ \cup X \cup P \cup \mathbf{L}_t^{l_o}(S)$ is the subject domain;

Parm: $S \to Var$, $A \to \{u, v, w\}$, $t \to \{p, \tau, \theta\}$;

$L = \{1,3,5,6\} \cup two \cup four$, $two = \{2_1,2_2,...,2_M\}$, $four = \{4_1,4_2,...,4_M\}$

Definition of functions of the Grammar of Zones G_Z

$D(init) = X \times X \times \mathbf{Z}_+ \times \mathbf{Z}_+$

$$\boldsymbol{init}\ (u, r) = \begin{cases} 2n, & \text{if } u = (0,0,0), \\ r, & \text{if } u \neq (0,0,0). \end{cases}$$

$D(\boldsymbol{f}) = (X \times X \times \mathbf{Z}_+ \cup \{0, 0, 0\}) \times \mathbf{Z}_+^n$

$$f(u, v) = \begin{cases} (x+1, y, l), & \text{if } ((x \neq n) \wedge (l > 0)) \vee ((y = n) \wedge (l \leq 0)) \\ (1,\ y+1,\ TIME(y+1) \times v_{y+1}), & \text{if } (x = n) \vee ((l \leq 0) \wedge (y \neq n)). \end{cases}$$

$D(DIST) = X \times P \times \mathbf{L_t}^{\boldsymbol{l_o}}(S)$.

Let $t_o \in L_t^{l_o}(S)$, $t_o = \boldsymbol{a}(z_o)\boldsymbol{a}(z_1)...\boldsymbol{a}(z_m)$, $t_o \in t_{p_o}(z_o, z_m, m)$;

If $((z_m = y_o) \wedge (p = p_o) \wedge (\exists\, k\ (1 \leq k \leq m) \wedge (x = z_k))) \vee$

$(((z_m \neq y_o) \vee (p \neq p_o)) \wedge (\exists\, k\ (1 \leq k \leq m - 1) \wedge (x = z_k)))$

then $DIST(x, p_o, t_o) = k+1$

else $DIST(x, p_o, t_o) = 2n$

$D(ALPHA) = X \times P \times \mathbf{L_t}^{\boldsymbol{l_o}}(S) \times \mathbf{Z}_+$

$$ALPHA\ (x, p_o, t_o, k) = \begin{cases} max\ (NEXTTIME\ (x), k), & \text{if } (DIST\ (x, p_o, t_o) \neq 2n) \\ & \wedge\ (NEXTTIME\ (x) \neq 2n); \\ k, & \text{if } DIST\ (x, p_o, t_o) \neq 2n) \\ & \wedge\ (NEXTTIME\ (x) = 2n); \\ NEXTTIME\ (x), & \text{if } DIST\ (x, p_o, t_o) = 2n). \end{cases}$$

$D(g_r) = P \times \mathbf{L_t}^{\boldsymbol{l_o}}(S) \times \mathbf{Z}_+^n$, $r \in X$.

$$g_{\mathbf{r}}(p_o, t_o, w) = \begin{cases} 1, & \text{if } DIST(r, p_o, t_o) < 2n, \\ w_r, & \text{if } DIST(r, p_o, t_o) = 2n. \end{cases}$$

$D\ (h_i^o) = X \times X \times \mathbf{Z}_+$; Let $TRACKS_{p_o} = \{p_o\} \times \left(\bigcup_{1 \leq k \leq l} L[\mathbf{G_t}^{(2)}(x, y, k, p_o)] \right)$

If $TRACKS_{p_o} = \varnothing$

then $h_i^o(u) = \varepsilon$

else $TRACKS_{p_o} = \{(p_o, t_1), (p_o, t_2), \ldots, (p_o, t_b)\}, (b \leq M)$ **and**

$$h_i^o(u) = \begin{cases} (p_o, t_i), & \textbf{if } i \leq b, \\ (p_o, t_b), & \textbf{if } i > b. \end{cases}$$

$D(h_i) = X \times X \times \mathbf{Z}_+$; Let $TRACKS_p = \{p\} \times \left(\bigcup_{1 \leq k \leq l} L[\mathbf{G_t}^{(2)}(x, y, k, p)] \right)$

If $TRACKS_p = \varnothing$

then $h_i(u) = \varepsilon$

else $TRACKS_p = \{(p_1, t_1), (p_1, t_2), \ldots, (p_m, t_m)\},\ (m \leq M)$ **and**

$$h_i(u) = \begin{cases} (p_i, t_i), & \textbf{if } i \leq m, \\ (p_m, t_m), & \textbf{if } i > m. \end{cases}$$

Trajectories should not be embedded (as sub-trajectories) in the trajectories of the same negation.

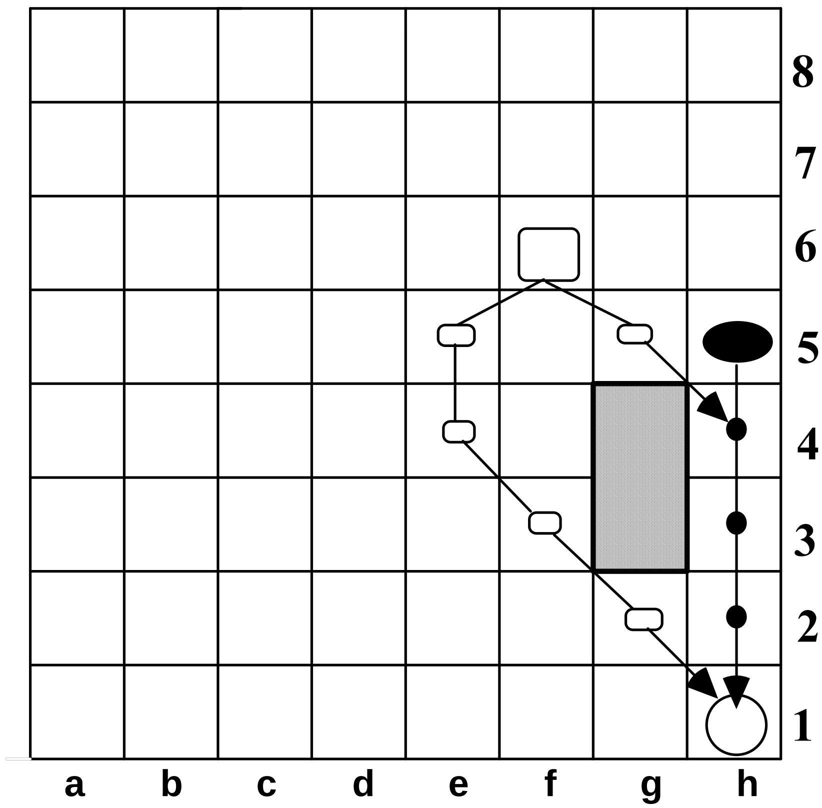
At the beginning of generation:

$u = (x_o, y_o, l_o)$, $w = zero$, $v = zero$, $x_o \in X$, $y_o \in X$, $l_o \in \mathbf{Z}_+$, $p_o \in P$,

$TIME\ (z) = 2n$, $NEXTTIME\ (z) = 2n$ for all z from X.

Generation of the Language of Zones for robot control model
(simplified version)

***t*(BOMBER, t_B, 5)*t*(FIGHTER, t_F, 5)*t*(FIGHTER, t_F^1, 2)**



——STEP 1——

$$u = (h5, h1, 4) = (38, 8, 4), \quad l = l_0 = 4 \text{ because}$$

$$Q_1(u) = (ON(BOMBER) = h5) \wedge (MAP_{h5,BOMBER}(h1) \leq 4 \leq 4) \wedge$$

$$((ON(Target) = h1) \wedge (OPPOSE(BOMBER, TARGET))) = T.$$

$$S(u, zero, zero) \overset{1}{\Rightarrow} A(u, zero, zero)$$

$$A(u, zero, zero) \overset{2i}{\Rightarrow} t(h_i^0(u), 5)\, A((0, 0, 0), g(h_i^0(u), zero), zero)$$

Computation of $h_i^0(u)$ $(l = 4)$.

$$TRACKS_{BOMBER} = \{BOMBER\} \times \Big(\bigcup_{1 \leq k \leq 4} L\,[G_t^{(2)}(h5, h1, k, BOMBER)].$$

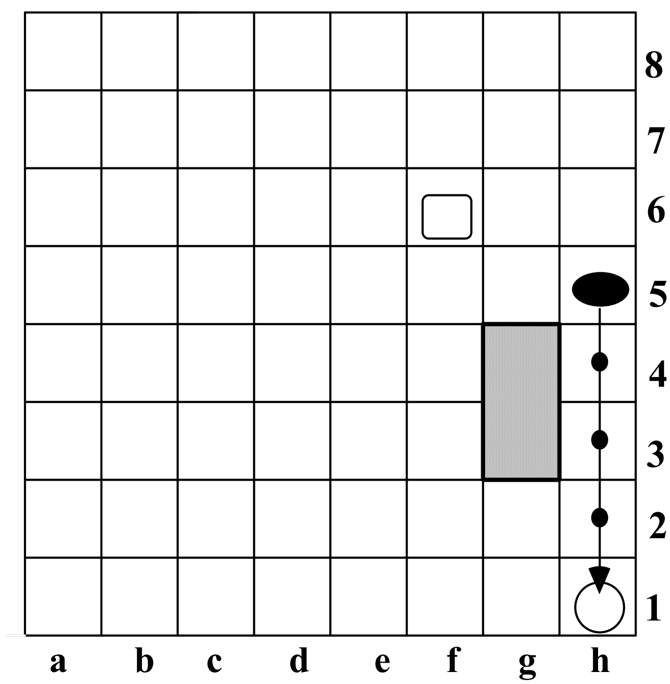
Only one such trajectory t_1 exists, and it is generated by this grammar:

$$t_B = a(h5)a(h4)a(h3)a(h2)a(h1).$$

Thus TRACKS = {(BOMBER, t_B)}, the number of trajectories b = 1 and

$$h_1^0(u) = (BOMBER, t_B).$$

$$t(BOMBER, t_B, 5).$$



––STEP 2––

Computation of $g(h_1{}^{0}(u), zero)$

$g(h_1{}^{0}(u), zero) = g$ (BOMBER, t_B, $zero$).

$$g_r(\mathrm{BOMBER}, t_B, zero) = \begin{cases} 1, & \text{if } DIST(r, \mathrm{BOMBER}, t_B) < 2n, \\ 0, & \text{if } DIST(r, \mathrm{BOMBER}, t_B) = 2n, \end{cases}$$

$DIST$ (x, BOMBER, t_B) = k+1, where k is the number of symbol of the trajectory t_B, whose parameter value is equal to x.

$DIST$ (h4, BOMBER, t_B) = 2
$DIST$ (h3, BOMBER, t_B) = 3
$DIST$ (h2, BOMBER, t_B) = 4
$DIST$ (h1, BOMBER, t_B) = 5

For the rest of x from X $DIST$ (x, BOMBER, t_B) = 2 × 62 =124.

For r ∈ {h1, h2, h3, h4} = {8, 16, 23, 30}

g_r(BOMBER, t_B, $zero$) = 1, for the rest of r g_r = 0.

$A(u, zero, zero)$ => t(BOMBER, t_B, 5)

A((0, 0, 0), g(BOMBER, t_B, $zero$), $zero$).

TIME(z) = $DIST$(z, BOMBER, t_B).

Symbol "=" in these formulas should be considered as an assignment, i.e., the current value of the right side expression should be assigned to the left side.

TIME(z) is equal to 124 for all z ∈ X except {h1, h2, h3, h4}, where TIME(z) is equal to 5, 4, 3, 2, respectively.

A representation of values of v (left) and TIME(z) (right) after generating trajectory a(h5)a(h4)a(h3)a(h2)a(h1)

							1
							1
							1
							1

							2
							3
							4
							5

-----STEP 3——

Q_3 ((0, 0, 0)) = (0 ≠ 62) ∧ (0 ≠ 62).

t(BOMBER, t_1, 5)A((0, 0, 0), v, *zero*) ^{3}=>

t(BOMBER, t_1, 5) A(f ((0, 0, 0), v), v, *zero*).

Computation of f

u = (x, y, l) = (0, 0, 0) and $v_{y+1} = v_1 = 0$:

$f(u, v)$ = (1, y+1, TIME(y+1) × v_{y+1}) = (1, 1, 0).

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^{3}=>t(BOMBER, t_B, 5) A((1, 1, 0), v, *zero*)

NEXTTIME(z) = init((0, 0, 0), NEXTTIME(z)) = 2n = 124

for all z from X.

Try 4j u = (x, y, l) = (1, 1, 0), i.e., l = 0 and Q_4 = F.

Try 3 u = (x, y, l) = (1, 1, 0), v is in Table, and w = *zero*.

Q_3(1, 1, 0) = T

^{3}=> t(BOMBER, t_B, 5) A(f ((1, 1, 0), v), v, *zero*).

Computation of f

As far as (l = 0) ∧ (y =1) and $v_{y+1} = v_2 = 0$,

$f(u, v)$ = (1, y+1, TIME(y+1) × v_{y+1}) = (1, 2, 0).

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^{3}=> t(BOMBER, t_B, 5) A((1, 2, 0), v, *zero*)

NEXTTIME(z) = init((1, 1, 0), NEXTTIME(z)).

NEXTTIME(z) = 124 for all z from X.

Values of v (left) and TIME(z) (right)

							1
							1
							1
							1

							2
							3
							4
							5

——STEP 4——

Try 4*j* $\quad Q_4(1, 2, 0) = F$

Try 3 $\quad Q_3(1, 2, 0) = T$

Try 4*j* $\quad Q_4(1, 3, 0) = F$

....

Loop continues until *u* changes either way:

$l = \mathrm{TIME}(y{+}1) \times v_{y+1} \neq 0$ **or** $y = 124.$

In our case $v_{7+1} = 1$ $(\neq 0)$.

8-th application of production 3 will result

$\overset{3}{\Rightarrow}$ $t(\mathrm{BOMBER}, t_B, 5)\ A((1, 8, 5), v, zero)$

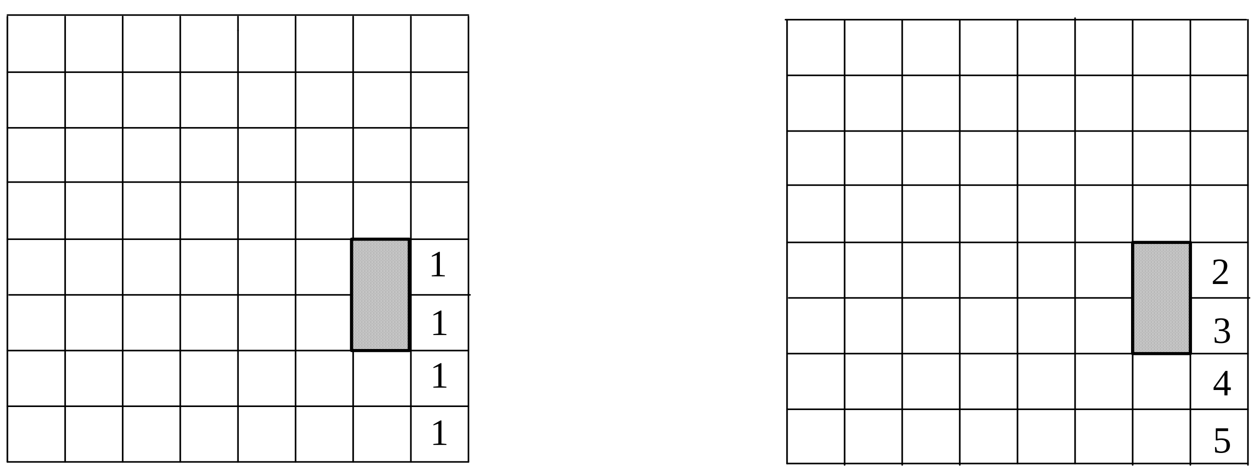
because

$u = (1, 7, 0)$

y+1 corresponds to h1, $\mathrm{TIME}(y{+}1) \times v_{y+1} = \mathrm{TIME}(h1) \times 1 = 5.$

This means that point h1 is determined as the ending point for generating trajectories of robots, which intercept motion of the BOMBER. The following derivation steps would allow us to find possible starting points of such trajectories.

Values of *v* (left) and TIME(z) (right)



——STEP 5——

Try 4j $Q_4(1, 8, 5) = F$

Try 3 with $l > 0$ and $x \neq 62$.

This means the beginning of a new loop which consists of multiple applications of production 3 after failures of attempts to apply one of productions 4j .

$$\overset{3}{=>} t(\text{BOMBER}, t_B, 5)\ A((2, 8, 5), v, zero)$$

$$\overset{3}{=>} t(\text{BOMBER}, t_B, 5)\ A((3, 8, 5), v, zero)$$

....

$$\overset{3}{=>} t(\text{BOMBER}, t_B, 5)\ A((44, 8, 5), v, zero)$$

With u = (44, 8, 5) this loop will be terminated because

$$Q_4(44, 8, 5) = (\text{ON(FIGHTER)} = 44) \wedge (5 > 0) \wedge$$

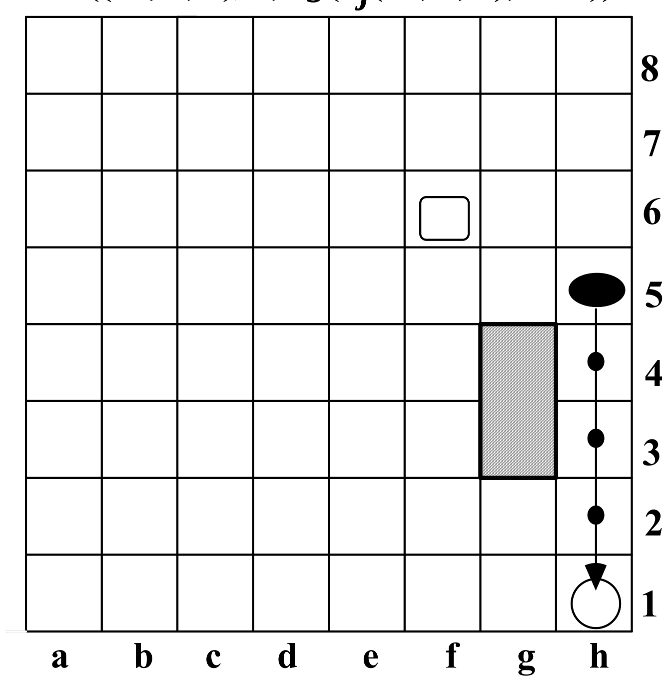
$$(\chi(\text{BOMBER, FIGHTER}) = 0) \wedge (\text{MAP}_{f6,\text{FIGHTER}}(h1) = 5) = T,$$

which means that productions 4j are applicable.

These productions will generate intercepting trajectories from f6 to h1.

$$\overset{4j}{=>} t(\text{BOMBER}, t_B, 5)\, t(h_j(44, 8, 5), \text{TIME}(8))$$

$$A((44, 8, 5), v,\ \ g(h_j(44, 8, 5), zero))$$



—– STEP 5 (continued) ---

$$4_j \Rightarrow t(\text{BOMBER}, t_B, 5)\, t(h_j(44, 8, 5), \text{TIME}(8))$$
$$A((44, 8, 5), v, g(h_j(44, 8, 5), zero))$$

Computation of $h_j(44, 8, 5)$

We have to generate all the shortest trajectories from point f6 to h1 for robot FIGHTER. The length of these trajectories should be less or equal 5.

$$\text{TRACKS}_{\text{FIGHTER}} = \{\text{FIGHTER}\} \times \bigcup_{1 \le k \le 5} L\,[G_t^{(2)}(\text{f6}, \text{h1}, k, \text{FIGHTER})]$$

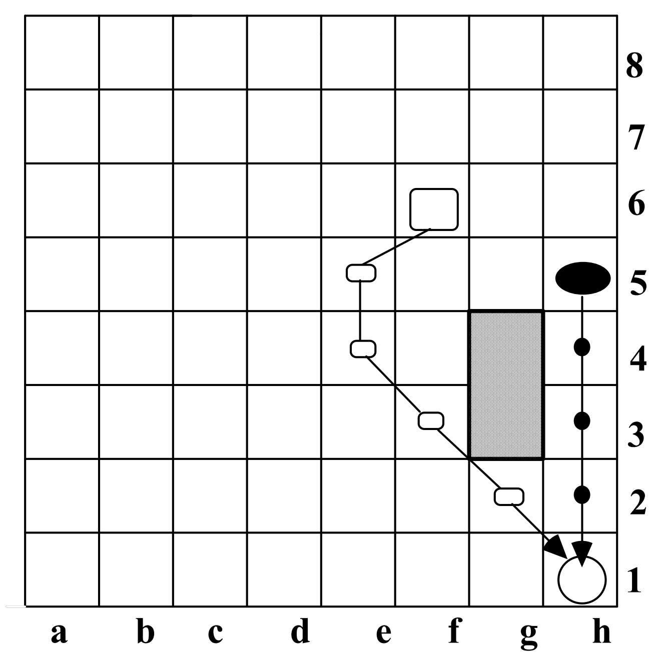
$$\text{TRACKS} = \{(\text{FIGHTER}, t_1), (\text{FIGHTER}, t_2), (\text{FIGHTER}, t_3)\}, \ m = 3 \text{ and}$$
$$h_1(44, 8, 5) = (\text{FIGHTER}, t_1)$$
$$h_2(44, 8, 5) = (\text{FIGHTER}, t_2)$$
$$h_3(44, 8, 5) = (\text{FIGHTER}, t_3)$$

There are three such trajectories t_1, t_2 and t_3, and they are generated by the grammar $G_t^{(2)}$. (Of course, there is one more trajectory, a(f6)a(g5)a(h4)a(h3)a(h2)a(h1), which partially coincides with the main trajectory of the Zone and thus should be rejected.)

$$t_F = t_1 = a(\text{f6})a(\text{e5})a(\text{e4})a(\text{f3})a(\text{g2})a(\text{h1}).$$

Taking into account that TIME(8) = 5, we have

$$4_1 \Rightarrow t(\text{BOMBER}, t_B, 5)\, t((\text{FIGHTER}, t_F), 5)$$
$$A((44, 8, 5), v, g(\text{FIGHTER}, t_F, zero))$$



——STEP 6——

$4_1 \Rightarrow t(\text{BOMBER}, t_B, 5)t((\text{FIGHTER}, t_F), 5)$
$A((44, 8, 5), v, g(\text{FIGHTER}, t_F, zero))$

Computation of g(FIGHTER, t_F, *zero*)

For all r ∈ X the r-th component of function g is as follows:

$$g_r(\text{FIGHTER}, t_F, zero) = \begin{cases} 1, & \text{if } DIST(r, \text{FIGHTER}, t_F) < 2n, \\ 0, & \text{if } DIST(r, \text{FIGHTER}, t_F) = 2n, \end{cases}$$

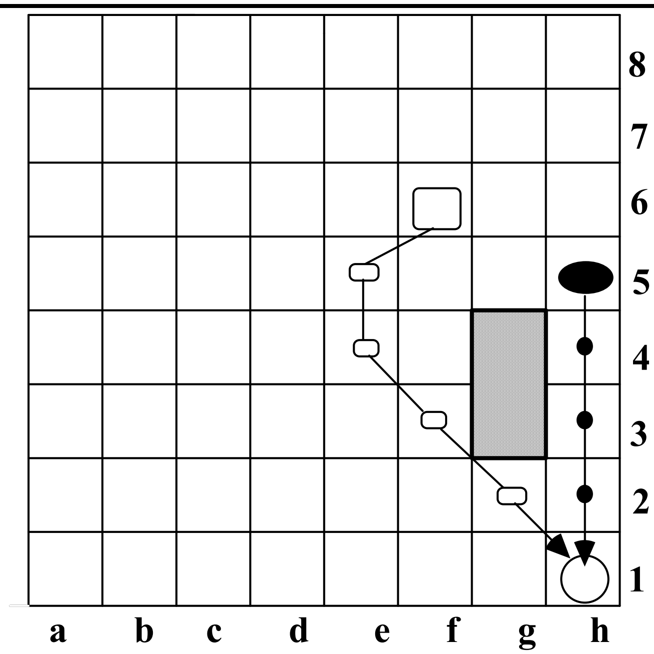
DIST **(x, FIGHTER, t_F) = k+1, where k is the number of symbol of the trajectory t_F, whose parameter value equals x.**

DIST **(e5, FIGHTER, t_F) = 2**
DIST **(e4, FIGHTER, t_F) = 3**
DIST **(f3, FIGHTER, t_F) = 4**
DIST **(g2, FIGHTER, t_F) = 5**
DIST **(h1, FIGHTER, t_F) = 6**

For the rest of x from X *DIST* (x, FIGHTER, t_F) = 2 x 62 = 124.

Thus for r ∈{e5, e4, f3, g2, h1} = {35, 28, 21, 15, 8}

g_r(FIGHTER, t_F, *zero*) = 1, for the rest of r g_r = 0.



——STEP 7——

Computation of NEXTTIME

NEXTTIME(z) = ALPHA(z, (FIGHTER, t_F), 5 – 5 +1).

From previous steps NEXTTIME(x) = 124 for all x from X.

$$ALPHA(x, p_o, t_o, k) = \begin{cases} \max(NEXTTIME(x), k), & \text{if } (DIST(x, p_o, t_o) \neq 2n) \\ & \wedge\ (NEXTTIME(x) \neq 2n); \\ k, & \text{if } DIST(x, p_o, t_o) \neq 2n) \\ & \wedge\ (NEXTTIME(x) = 2n); \\ NEXTTIME(x), & \text{if } DIST(x, p_o, t_o) = 2n). \end{cases}$$

For x $\in$ {e5, e4, f3, g2, h1} *ALPHA*(x, FIGHTER, t_F, 1) = 1,
while for other x *ALPHA*(x, FIGHTER, t_F, 1) = 124.

The same values should be assigned to NEXTTIME(z).

A representation of values of *w* (left) and NEXTTIME(z) (right) after generating trajectory *a*(f6)*a*(e5)*a*(e4)*a*(f3)*a*(g2)*a*(h1).

				1			
				1			
					1		
						1	
							1

				1			
				1			
					1		
						1	
							1

——STEP 8——

Try 3 with u =(44, 8, 5), i.e., with $l > 0$ and $x \neq 62$.

New loop consists of multiple applications of production 3 after failures of attempts to apply one of productions 4*j* .

$$\stackrel{3}{\Rightarrow} t(\mathrm{BOMBER}, t_B, 5)t(\mathrm{FIGHTER}, t_F, 5)\ A(45, 8, 5), v, w)$$

$$\stackrel{3}{\Rightarrow} t(\mathrm{BOMBER}, t_B, 5)t((\mathrm{FIGHTER}, t_F, 5)\ A(46, 8, 5), v, w)$$

....

$$\stackrel{3}{\Rightarrow} t(\mathrm{BOMBER}, t_B, 5)t(\mathrm{FIGHTER}, t_F, 5)\ A(62, 8, 5), v, w).$$

Computations of NEXTTIME(z) in production 3 will not change its values.
With *u* = (62, 8, 5) this loop is terminated which means that no other starting points are found.

New loop begins. The grammar changes ending point of prospective trajectories:

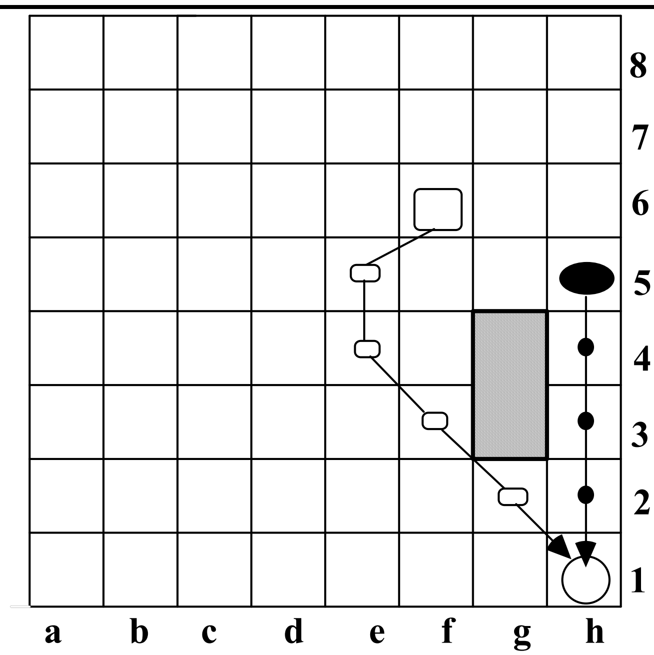
$$\stackrel{3}{\Rightarrow} t(\mathrm{BOMBER}, t_B, 5)t(\mathrm{FIGHTER}, t_F, 5)\ A(1, 9, 0), v, w)$$

$$\stackrel{3}{\Rightarrow} t(\mathrm{BOMBER}, t_B, 5)t((\mathrm{FIGHTER}, t_F, 5)\ A(1, 10, 0), v, w)$$

....

$$\stackrel{3}{\Rightarrow} t(\mathrm{BOMBER}, t_B, 5)t(\mathrm{FIGHTER}, t_F, 5)\ A(1, 16, 4), v, w),$$

With *u* = (1, 15, 0) this loop is terminated;
y+1 corresponds to h2, TIME(y+1) * v_{y+1} = TIME(h2) * 1 = 4.



——STEP 9——

Point h2 is determined as the next ending point for generating trajectories of robots, which can intercept motion of the BOMBER. The following derivation steps would allow us to look for possible starting points of such trajectories. Obviously, nothing will be found, except

$$a(\mathrm{f6})a(\mathrm{g5})a(\mathrm{h4})a(\mathrm{h3})a(\mathrm{h2}),$$

which will be rejected.

The same negative result will be achieved with the next ending point, h3. The only intercepting trajectory to be found and accepted is as follows:

$$t_F{}^1 = t_1 = a(\mathrm{f6})a(\mathrm{g5})a(\mathrm{h4})$$

$$4_1 \Rightarrow t(\mathrm{BOMBER}, t_B, 5)t(\mathrm{FIGHTER}, t_F, 5)t(\mathrm{FIGHTER}, t_F{}^1, 2)$$
$$A((44,30,2), v, g(\mathrm{FIGHTER}, t_F{}^1, w)),$$

$$\mathrm{NEXTTIME}(z) = ALPHA(z, \mathrm{FIGHTER}, t_F{}^1, 2–2+1).$$

A representation of values of *w* (left) and NEXTTIME(z) (right) after generating trajectory *a*(f6)*a*(g5)*a*(h4).

				1		1	
				1			1
					1		
						1	
							1

				1		1	
				1			1
					1		
						1	
							1

Try 3 returning to it each time after unsuccessful attempt of applying production 4_j. This loop will be terminated when $Q_3(u) = F$

$$Q_3(u) = (x \neq 62) \vee (y \neq 62) = F \text{ (in our case } x = 62 \text{ and } y = 62).$$

$$\text{Try 5: } Q_5(w) = (w \neq 0) = T\ .$$

$$5 \Rightarrow t(\mathrm{BOMBER}, t_B, 5)t(\mathrm{FIGHTER}, t_F, 5)t(\mathrm{FIGHTER}, t_F{}^1, 2)$$
$$A((0, 0, 0), w, zero)$$
$$\mathrm{TIME}(z) = \mathrm{NEXTTIME}(z)$$

This is the completion of generation of the 1-st negation trajectories

——STEP 10——

All the steps, 3 and 4*j*, which have been executed (or tried) for generating 1-st negation trajectories, will be repeated for generating 2-nd negation. No one such trajectory should be found.

The next return to production 5 will happen with *w* = *zero* (nothing is found). This means that production 5 is not applicable, and we complete derivation by applying production 6:

$$\overset{6}{\Rightarrow} t(\text{BOMBER}, t_B, 5)t(\text{FIGHTER}, t_F, 5)t(\text{FIGHTER}, t_F^1, 2).$$