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**Algorithm 1: Hierarchical Paradigm with *Fuzzy C-means* (H1) in CMOMMT-URBAN3D**

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```

input : Perceptions of agents.
output : Decision making of the organization.
1 while  $t < \Delta t$  do
2   if general coordinator then
3     if  $t \bmod \gamma = 0$  then
4       Receives the message from the UAVs
        with their positions and their
        targets observed ;
5       Execute FCM(iterations=10,dist =
        "euclidean",weights = 1,
        centers=UAV positions);
6       Send a message to the UAVs with
        the new centers requested;
7     end
8   else
9     if  $t \bmod \gamma = 0$  then
10      Sends a message to the general
        coordinator informing its position
        and targets observed;
11      Receives from the general
        coordinator the action requested
        with the new centres;
12      Moves in straight line to the new
        center nearest received;
13    else
14      Moves to the nearest center;
15    end
16  end
17 end

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**Algorithm 2: Hierarchical Paradigm with Kohonen Maps (H2) in CMOMMT-URBAN3D**

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```

input : Perceptions of agents.
output : Decision making of the organization.
1 while  $t < \Delta t$  do
2   if general coordinator then
3     if  $t \bmod \gamma = 0$  then
4       Receives the message from the UAVs
        with their positions and their
        targets observed ;
5       Execute Kohonen(xdim = 4,
        ydim=3, iterations=1500, alpha =
        0.08, top=hexagonal);
6       Send a message to the UAVs with
        the new centers requested;
7     end
8   else
9     if  $t \bmod \gamma = 0$  then
10      Sends a message to the general
        coordinator informing its position
        and targets observed;
11      Receives from the general
        coordinator the action requested
        with the new centres;
12      Moves in straight line to the new
        center nearest received;
13    else
14      Moves to the nearest center;
15    end
16  end
17 end

```

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### Algorithm 3: Dual Holarchy Paradigm (H3) in CMOMMT-URBAN3D

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```

input : Perceptions of agents.
output : Decision making of the organization.
1  while  $t < \Delta t$  do
2      if coordinator then
3          if  $t \bmod \gamma = 0$  then
4              if general coordinator then
5                  Receives the message from the UAVs with their positions and their targets observed ;
6                  Send a message propagating the information to the coordinators Kohonen and FCM ;
7              else
8                  if Kohonen holon coordinator then
9                      Receives the message from the general coordinator; Execute Kohonen( $x_{dim} = 3$ ,
10                      $y_{dim} = 2$ , iterations=1500,  $\alpha = 0.08$ , top=hexagonal);
11                     Send a message to the UAVs Kohonen with the new centers requested;
12                 else if FCM holon coordinator then
13                     Receives the message from the general coordinator; Execute FCM(iterations=10, dist =
14                     "euclidean", weights = 1, centers=UAV positions);
15                     Send a message to the UAVs FCM with the new centers requested;
16                 end
17             end
18         else
19             if  $t \bmod \gamma = 0$  then
20                 if Kohonen UAVs then
21                     Sends a message to the general coordinator informing its position and targets observed;
22                     Receives from the coordinator of the holon Kohonen the action requested with the new
23                     centres;
24                     Moves in a straight line to the new center Kohonen nearest received;
25                 else if FCM VANTs then
26                     Sends a message to the general coordinator informing its position and targets observed;
27                     Receives from the coordinator of the holon FCM the action requested with the new
28                     centres;
29                     Moves in a straight line to the new center FCM nearest received;
30                 else
31                     Move to the center closest of your holon;
32                 end
33             end
34         end
35     end
36 end

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#### Algorithm 4: Triple Holarchy Paradigm (H4) in CMOMMT-URBAN3D

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```

input : Perceptions of agents.
output: Decision making of the organization.
1  while  $t < \Delta t$  do
2      if coordinator then
3          if  $t \bmod \gamma = 0$  then
4              if general coordinator then
5                  Receives the message from the UAVs with their positions and their targets observed ;
6                  Send a message propagating the information to the coordinators Kohonen, FCM and DBSk;
7              else
8                  if Kohonen holon coordinator then
9                      Receives the message from the general coordinator; Execute Kohonen( $x_{dim} = 2$ ,
10                      $y_{dim} = 2$ , iterations=1500,  $\alpha = 0.08$ , top=hexagonal);
11                     Send a message to the UAVs Kohonen with the new centers requested;
12                 else if FCM holon coordinator then
13                     Receives the message from the general coordinator; Execute FCM(iterations=10,dist =
14                     "euclidean",weights = 1, centers=UAV positions);
15                     Send a message to the UAVs FCM with the new centers requested;
16                 else if DBSk holon coordinator then
17                     Receives the message from the general coordinator; Execute DBSk( $\epsilon = r/1.5$ , MinPts =
18                     2, K = 4, iterationsKM=10) ;
19                     Send a message to the UAVs DBSk with the new centers requested;
20                 end
21             end
22         else
23             if  $t \bmod \gamma = 0$  then
24                 if Kohonen UAVs then
25                     Sends a message to the general coordinator informing its position and targets observed;
26                     Receives from the coordinator of the holon Kohonen the action requested with the new
27                     centres;
28                     Moves in a straight line to the new center Kohonen nearest received;
29                 else if FCM VANTs then
30                     Sends a message to the general coordinator informing its position and targets observed;
31                     Receives from the coordinator of the holon FCM the action requested with the new
32                     centres;
33                     Moves in a straight line to the new center FCM nearest received;
34                 else if DBSk UAVs then
35                     Sends a message to the general coordinator informing its position and targets observed;
36                     Receives from the coordinator of the holon DBSk the action requested with the new
37                     centres;
38                     Moves in a straight line to the new center nearest received DBSk;
39                 else
40                     Move to the center nearest of your holon;
41                 end
42             end
43         end
44     end
45 end

```

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**Algorithm 5: Double Coalition Paradigm (C1) in CMOMMT-URBAN3D**

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```

input : Perceptions of agents.
output : Decision making of the organization.
1  while  $t < \Delta t$  do
2      if position X of UAV between 0 and 75 then
3          receive messages from coalition 1;
4      else if position X of UAV between 76 and 150 then
5          receive messages from coalition 2;
6      if VANT belong the coalition1 then
7          coalition1 leader  $\leftarrow$  draw(coalition1 UAVs) ;
8          if coalition leader1 then
9              if  $t \bmod \gamma = 0$  then
10                 Receives the message from the UAVs of the coalition1 with their positions
11                    and their targets observed;
12                  $q \leftarrow$  Number of UAVs in coalition1;
13                 Execute Kohonen( $x_{dim} = q/2$ ,  $y_{dim}=2$ , iterations=1500,  $\alpha = 0.08$ ,
14                    top=hexagonal);
15                 Sends a message to the UAVs of the coalition1 with the new centers
16                    requested;
17             end
18         else
19             Receives the message from the UAVs of the coalition1 with their positions and
20             their targets observed;
21             Send a message to the VANTs of coalition1 informing its position and targets observed;
22             Moves in a straight line to the new center Kohonen nearest received;
23         end
24     else if VANT belong the coalition2 then
25         coalition leader2  $\leftarrow$  draw(coalition UAVs2) ;
26         if coalition leader2 then
27             if  $t \bmod \gamma = 0$  then
28                 Receives the message from the UAVs of the coalition2 with their positions and
29                    their targets observed;
30                  $q \leftarrow$  Number of UAVs in coalition2;
31                 Execute Kohonen( $x_{dim} = q/2$ ,  $y_{dim}=2$ , iterations=1500,  $\alpha = 0.08$ ,
32                    top=hexagonal);
33                 Sends a message to the UAVs of the coalition2 with the new centers
34                    requested;
35             end
36         else
37             Receives the message from the UAVs of the coalition2 with their positions and
38             their targets observed;
39             Send a message to the VANTs of the coalition2 informing its position and targets
40             observed;
41             Moves in a straight line to the new center Kohonen nearest received;
42         end
43     end
44 end

```

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### Algorithm 6: Quadruple Coalition Paradigm (C2) in CMOMMT-URBAN3D

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```

input : Perceptions of agents.
output : Decision making of the organization.
1  while  $t < \Delta t$  do
2      if position X of UAV between 0 and 75 and position Y of UAV between 0 and 75 then
3          receive messages from coalition 1;
4      else if position X of UAV between 76 and 150 and position Y of UAV between 76 and 150 then
5          receive messages from coalition 2;
6      else if position X of UAV between 76 and 150 and position Y of UAV between 0 and 75 then
7          receive messages from coalition 3;
8      else if position X of UAV between 0 and 75 and position Y of UAV between 76 and 150 then
9          receive messages from coalition 4;
10     if VANT belong the coalition1 then
11         coalition1 leader  $\leftarrow$  draw(coalition1 UAVs) ;
12         if coalition leader1 then
13             if  $t \bmod \gamma = 0$  then
14                 Receives the message from the UAVs of the coalition1 with their positions and their
15                 targets observed;
16                  $q \leftarrow$  Number of UAVs in coalition1;
17                 Execute Kohonen( $x_{dim} = q/2$ ,  $y_{dim}=2$ , iterations=1500,  $\alpha = 0.08$ , top=hexagonal);
18                 Sends a message to the UAVs of the coalition1 with the new centers requested;
19             end
20         else
21             Receives the message from the UAVs of the coalition1 with their positions and their
22             targets observed;
23             Send a message to the UAVs of coalition1 informing its position and targets observed;
24             Moves in a straight line to the new center Kohonen nearest received;
25         end
26     else if VANT belong the coalition2 then
27         coalition leader2  $\leftarrow$  draw(coalition UAVs2) ;
28         if coalition leader2 then
29             if  $t \bmod \gamma = 0$  then
30                 Receives the message from the UAVs of the coalition2 with their positions and their
31                 targets observed;
32                  $q \leftarrow$  Number of UAVs in coalition2;
33                 Execute Kohonen( $x_{dim} = q/2$ ,  $y_{dim}=2$ , iterations=1500,  $\alpha = 0.08$ , top=hexagonal);
34                 Sends a message to the UAVs of the coalition2 with the new centers requested;
35             end
36         else
37             Receives the message from the UAVs of the coalition2 with their positions and their
38             targets observed;
39             Send a message to the UAVs of the coalition2 informing its position and targets observed;
40             Moves in a straight line to the new center Kohonen nearest received;
41         end
42     else if VANT belong a coalition3 then
43         coalition leader3  $\leftarrow$  draw(coalition UAVs3) ;
44         if coalition leader3 then
45             if  $t \bmod \gamma = 0$  then
46                 Receives the message from the UAVs of the coalition3 with their positions and their
47                 targets observed;
48                 Execute FCM(iterations=10,  $dist = "euclidean"$ , weights = 1, centers=UAV positions);
49                 Send a message to the UAVs of the coalition3 with the new centers requested;
50             end
51         else
52             Receives the message from the UAVs of the coalition3 with their positions and their
53             targets observed;
54             Send a message to the UAVs of the coalition3 informing its position and targets observed;
55             Moves in a straight line to the new center FCM nearest received;
56         end
57     else if VANT belong the coalition4 then
58         coalition leader4  $\leftarrow$  draw(coalition UAVs4) ;
59         if coalition leader4 then
60             if  $t \bmod \gamma = 0$  then
61                 Receives the message from the UAVs of the coalition4 with their positions and their
62                 targets observed;
63                 Execute FCM(iterations=10,  $dist = "euclidean"$ , weights = 1, centers=UAV positions);
64                 Sends a message to the UAVs of the coalition3 with the new centers requested;
65             end
66         else
67             Receives the message from the UAVs of the coalition4 with their positions and their
68             targets observed;
69             Send a message to the UAVs of the coalition4 informing its position and targets observed;
70             Moves in a straight line to the new center FCM nearest received;
71         end
72     end
73 end

```

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### Algorithm 7: Dual Federation Paradigm (F1) in CMOMMT-URBAN3D

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```

input : Perceptions of agents.
output : Decision making of the organization.
1  while  $t < \Delta t$  do
2      if number of targets observed by UAV  $< 2$  then
3          receive messages from explorer federation;
4      else if number of targets observed by UAV  $> 1$  then
5          receive messages from federation observer;
6      if VANT belong the observer federation then
7          if  $t \bmod \gamma = 0$  then
8              if federation delegate then
9                  Receives the message from the UAVs of the federation and from the delegate of the
                    explorer federation with the positions and targets observed;
11                  $q \leftarrow$  Number of UAVs in the observer federation ;
12                 Execute Kohonen( $x_{dim} = q//2$ ,  $y_{dim}=2$ , iterations=1500,  $\alpha = 0.08$ , top=hexagonal);
                    Sends a message to the UAVs of the observer federation with the requested new
                    centres;
13             else
14                 Send a message to the delegate of the observing federation informing its position and
                    targets observed;
15                 Receives from the delegate of the observer federation the action requested with the
                    new centres;
16                 Moves in a straight line to the new center nearest Kohonen ;
17             end
18         end
19     else if VANT belong the explorer federation then
20         if  $t \bmod \gamma = 0$  then
21             if explorer federation delegate then
22                 Sends a message from the UAVs of the explorer federation with their positions and
                    their targets observed to the delegate of the explorer federation;
23             else
24                 Send a message to the delegate of the exploring federation informing its position and
                    targets observed;
25                 moves randomly exploring the environment;
26             end
27         end
28 end

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### Algorithm 8: Triple Federation Paradigm (F2) in CMOMMT-URBAN3D

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```

input : Perceptions of agents.
output : Decision making of the organization.
1  while  $t < \Delta t$  do
2      if number of targets observed by UAV  $< 2$  then
3          receive messages from explorer federation;
4      else if number of targets observed by UAV  $> 1$  and  $= < 3$  then
5          receive messages from observer federation;
6      else if number of targets observed by UAV  $> 4$  then
7          receive messages from federation guard;
8      if VANT belong the observer federation then
9          if  $t \bmod \gamma = 0$  then
10             if federation delegate then
11                 Receives the message from the UAVs of the federation and from the delegate of the
12                 explorer federation with the positions and targets observed;
13                  $q \leftarrow$  Number of UAVs in the observer federation ;
14                 Execute Kohonen( $x_{dim} = q/2$ ,  $y_{dim}=2$ , iterations=1500,  $\alpha = 0.08$ , top=hexagonal);
15                 Sends a message to the UAVs of the observer federation with the new centers
16                 requested;
17             else
18                 Send a message to the delegate of the observing federation informing its position and
19                 targets observed;
20                 Receives from the delegate of the observer federation the action requested with the
21                 new centres;
22                 Moves in a straight line to the new center nearest Kohonen ;
23             end
24             else
25                 move randomly;
26             end
27         end
28     else if VANT belong the explorer federation then
29         if  $t \bmod \gamma = 0$  then
30             if explorer federation delegate then
31                 Send the message from the UAVs of the explorer federation with their positions and
32                 their targets observed to the delegate of the explorer federation and guard ;
33             else
34                 Send a message to the delegate of the exploring federation informing its position and
35                 targets observed;
36                 moves randomly exploring the environment;
37             end
38         end
39     else if VANT belong the guard federation then
40         if  $t \bmod \gamma = 0$  then
41             if guard federation delegate then
42                 Sends a message from the UAVs of the federation guard with their positions and
43                 their targets observed to the delegate of the federation observer;
44             else
45                 Sends a message to the federation delegate guard informing its position and targets
46                 observed;
47                 does not move in the environment;
48             end
49         end
50     end
51 end

```

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### Algorithm 9: Collision Detection for UAVs in CMOMMT-URBAN3D

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```

input : Destination position of the UAV.
output : Position corrected if necessary.
1
2  for  $UAV \in UAVs$  do
3      if No destination position exists OR destination position is  $<$  UAV speed then
4          Calculate a new random destination.
5      end
6      if there is a block ahead then
7          Assign a new orientation between {North, South, East, West} that results in the smallest angular
8          orientation offset.
9      end
10     if there is no other UAV ahead then
11         advances to the destination point.
12     end
13 end

```

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