Contents

Communication at Opportunity Sim -- Square Boundary Analysis

By: Patrick Ledzian Date: 10 April 2022 Last update: 24 April 2022

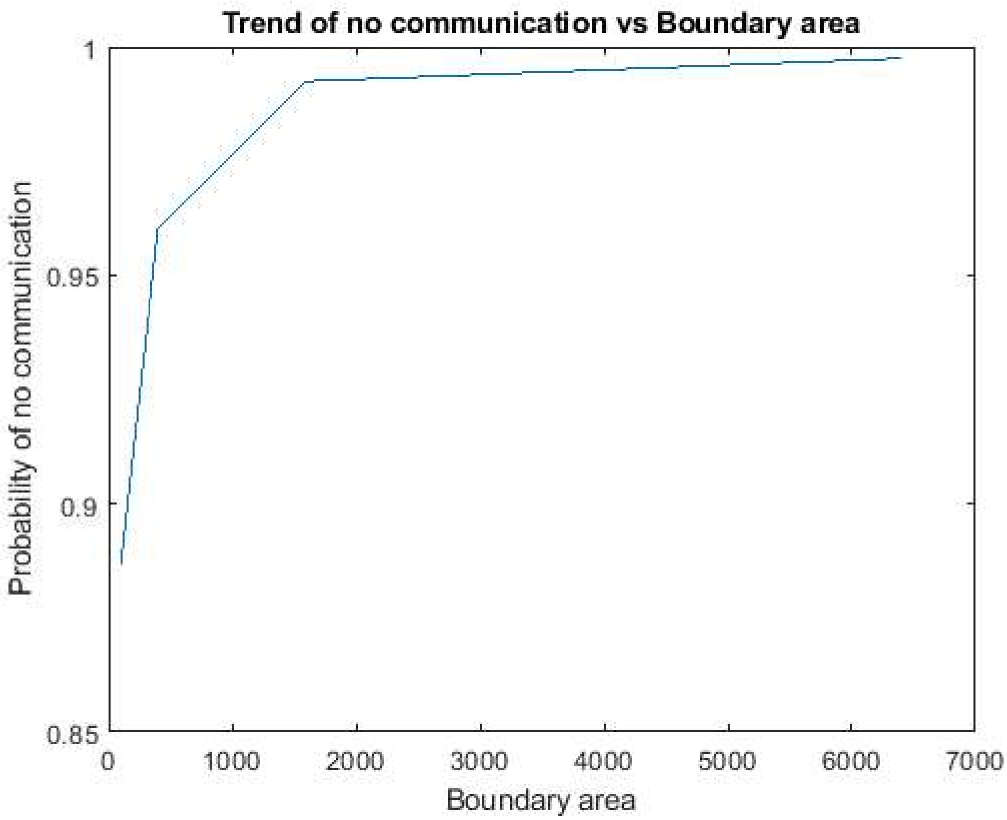
```
% Overview:
% Generate simulation data to provide insight as to how often agents
% interact when bouncing around in a closed, axis-aligned square boundary.
% Each agent chooses a new random heading (uniform distribution [0, pi)])
% whenever it intersects with a boundary. Longer-term goal is to determine
% what conditions result in reliably connected communications graphs
% between agents, independent of agent starting position. As well as to
% determine how long agents must randomly interact before said
% communication graphs are connected.
%

close all
clear all
clc

a = SimAnalysis();
```

General Analysis -- Infinite path length, single iteration simulations

With square axis-aligned boundaries the chance of random communication between non-coordinating agents appears to be stationary with-respect-to the number of agents. However, the transients behavior (rise-time) is shorter the more agents that are present. Also note that as the area of the boundaries increases the chance of communication goes down. A target for future work is to intelligently manipulate the distribution agents choose new random headings from, maybe from local interactions (comms). This should also be balanced with the transient (rise-time) behavior to meet mission needs (vehicle specs, on-scene time, power management, etc).

```
xgen = [100, 400, 1600, 6400];
ygen = [0.887, 0.96, 0.9925, 0.9975];

figure()
plot(xgen, ygen)
xlabel("Boundary area")
ylabel("Probability of no communication")
title("Trend of no communication vs Boundary area")
```

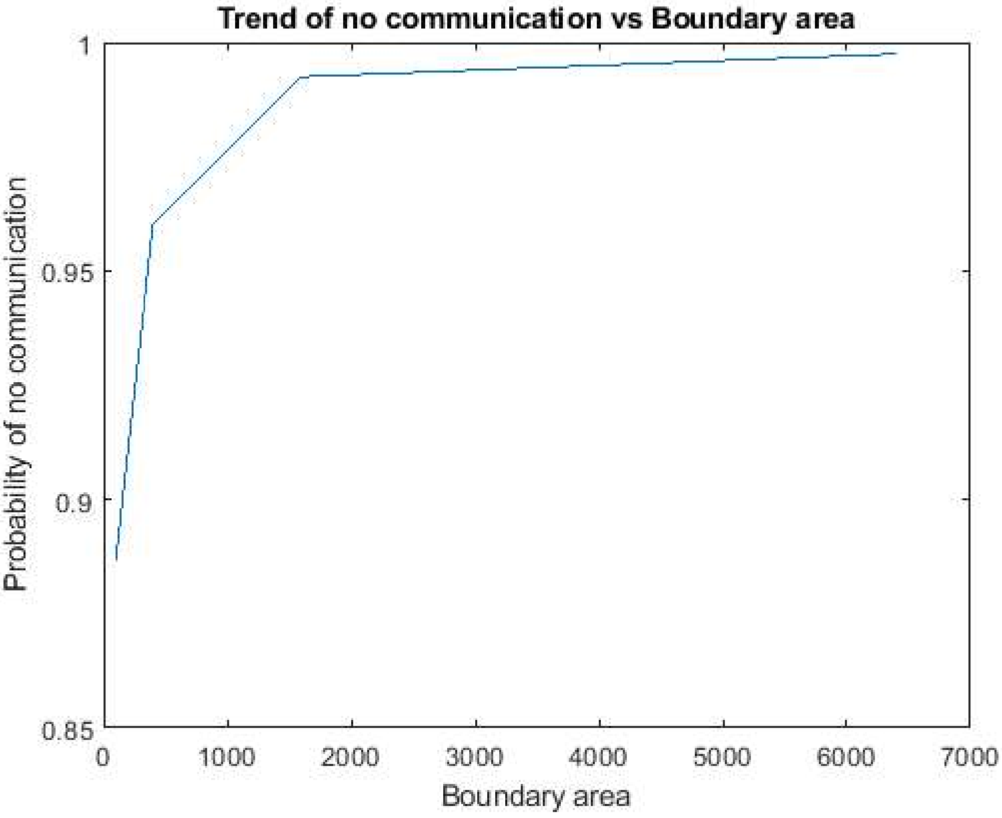
```
ylim([0.85 1.0])
```

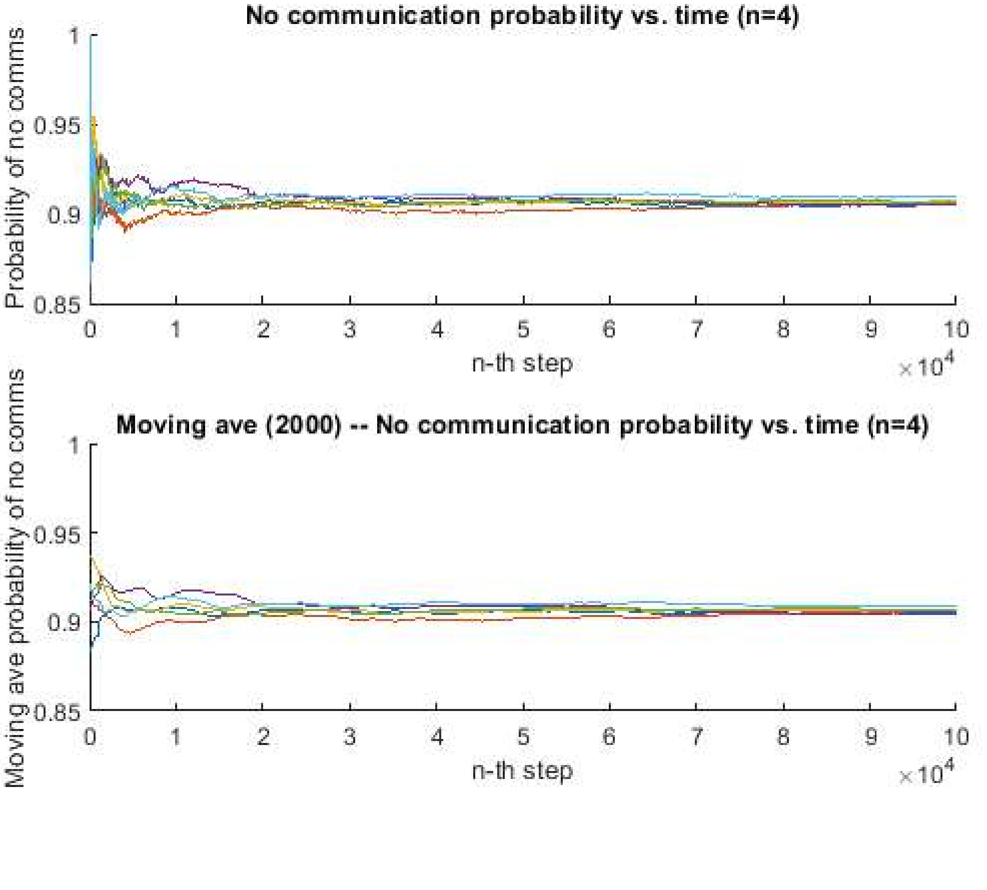


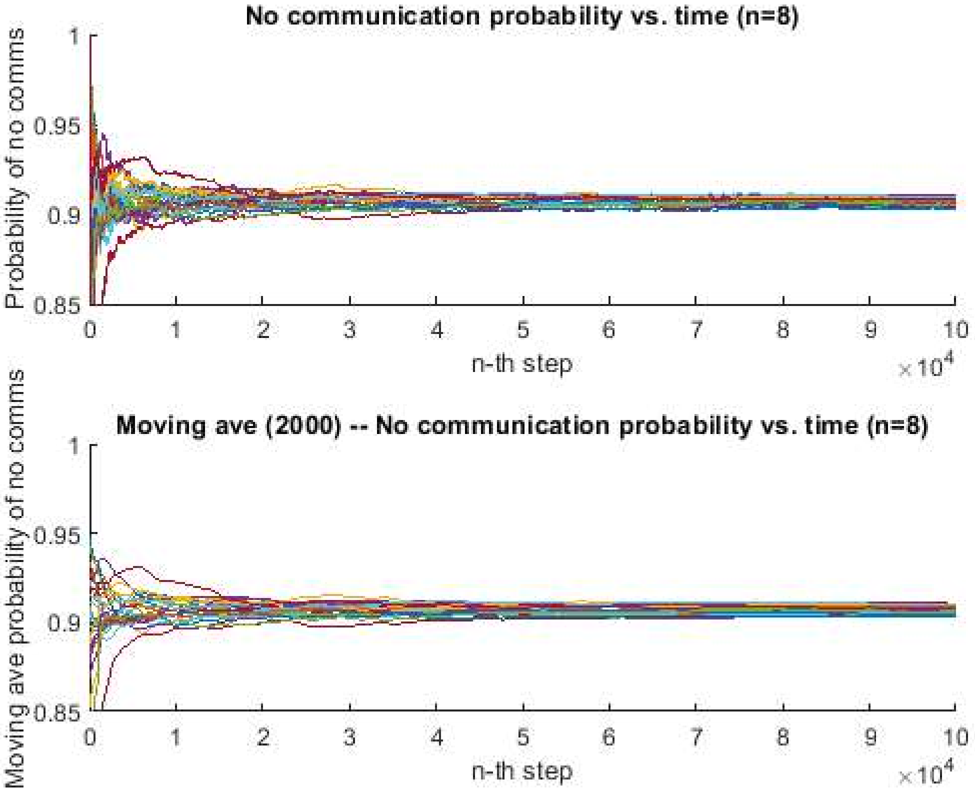
4, 8, 16, 32 Agent Inf Horizon Test in 10x10 Box

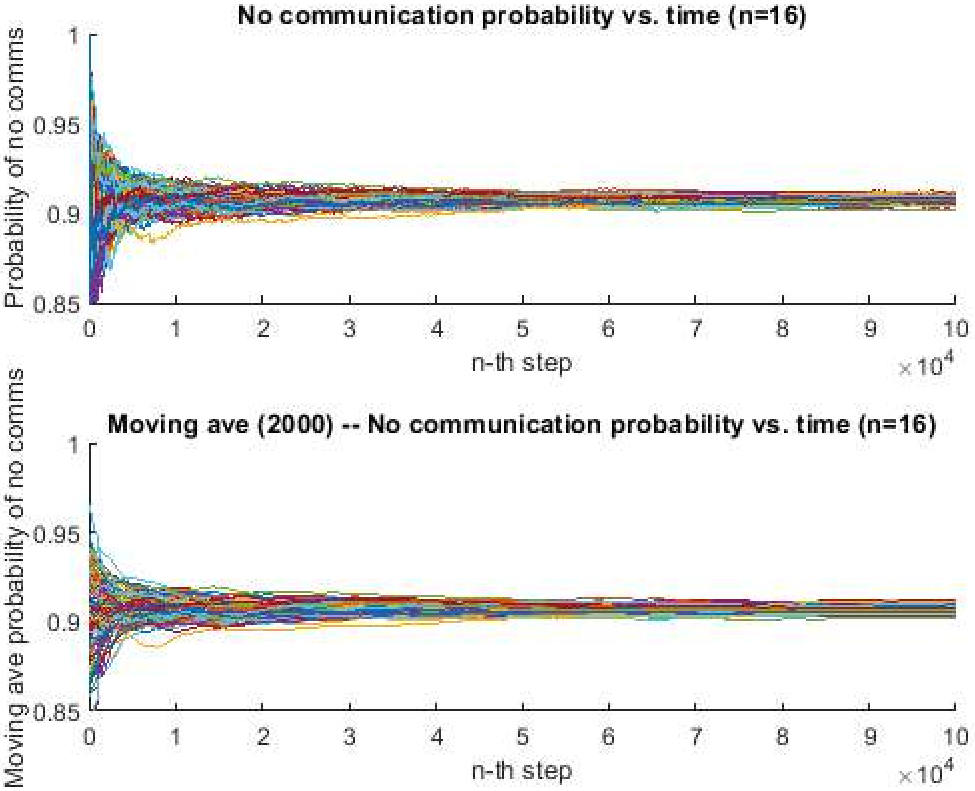
```
% Results:
% 4-Agent case: converges to [0.886, 0.888]
% 8-Agent case: converges to [0.886, 0.889]
% 16-Agent case: converges to [0.885, 0.890]
% 32-Agent case: converges to [0.884, 0.891]
%

bounds = [0 10 10 0; 0 0 10 10];

a.steadyStateCommProb(bounds, 4, 100000, 1);             % bounds, numAgents, N, sim_itrs
a.steadyStateCommProb(bounds, 8, 100000, 1);
a.steadyStateCommProb(bounds, 16, 100000, 1);
a.steadyStateCommProb(bounds, 32, 100000, 1);

SimAnalysis.clearEmptyFigs();                            % closes figures without titles (for empty ones!)
disp("Done: 10x10 inf horizon")
```

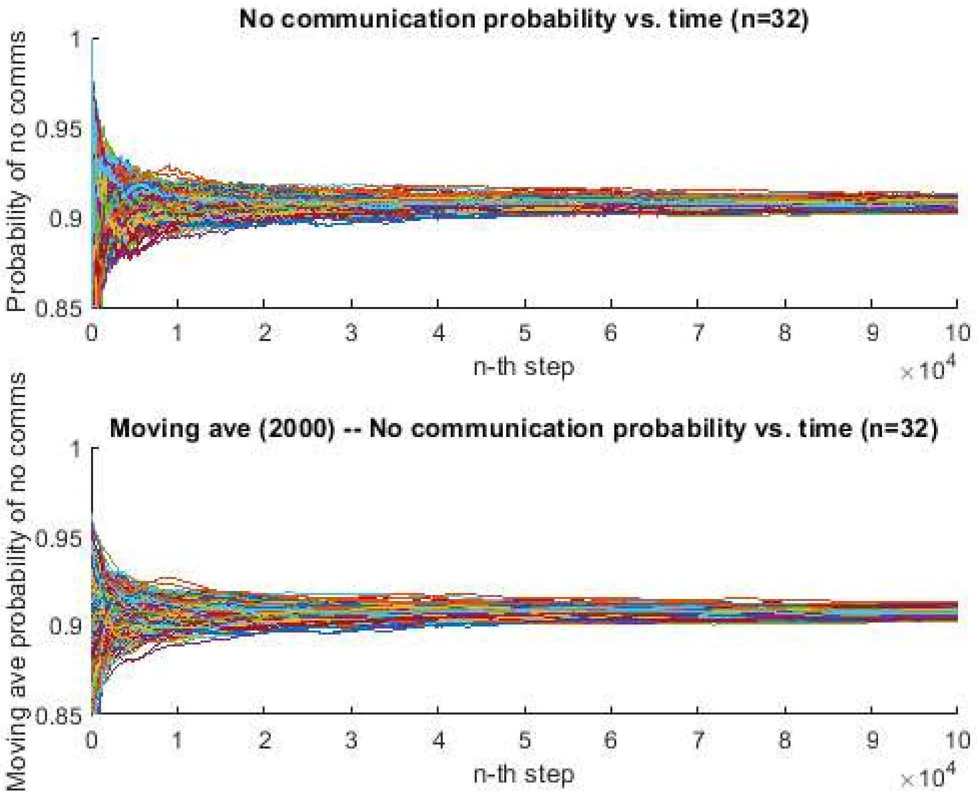
```
Done: 10x10 inf horizon
```


Trend of no communication vs Boundary area
Probability of no communication
1
0.95
0.9
0.85
0
1000
2000
3000
4000
5000
6000
7000
Boundary area


No communication probability vs. time (n=4)
Probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
$\times 10^4$
Moving ave (2000) -- No communication probability vs. time (n=4)
Moving ave probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
$\times 10^4$


No communication probability vs. time (n=8)
Probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4
Moving ave (2000) -- No communication probability vs. time (n=8)
Moving ave probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4


No communication probability vs. time (n=16)
Probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4
Moving ave (2000) -- No communication probability vs. time (n=16)
Moving ave probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4

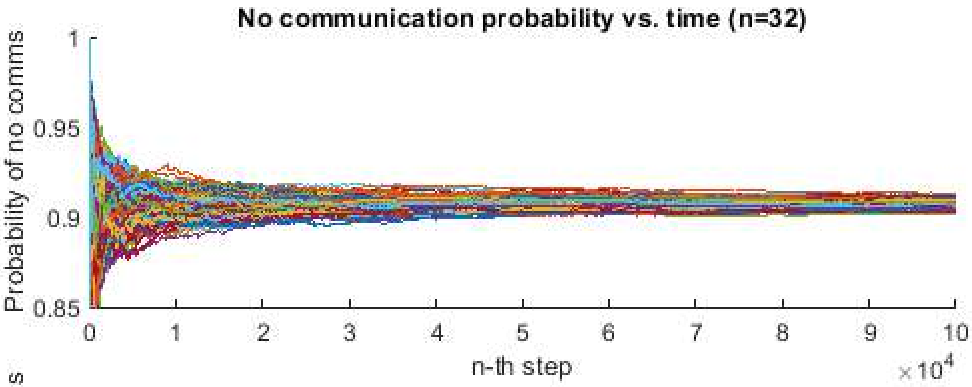


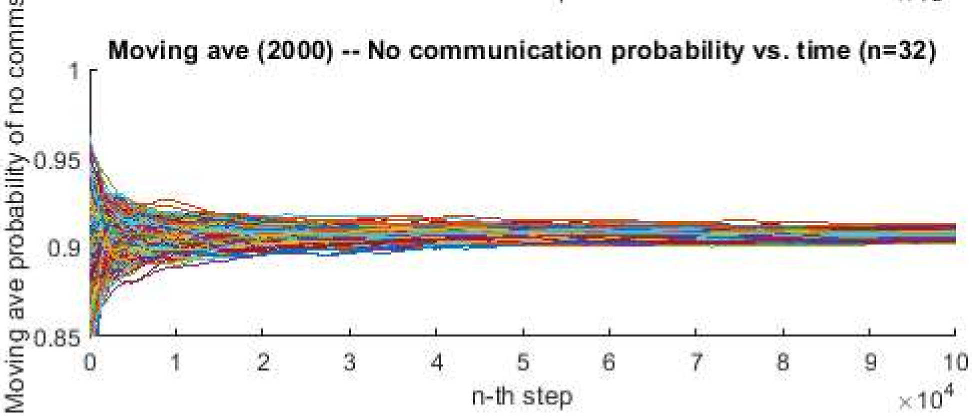
4, 8, 16, 32 Agent Inf Horizon Test in 20x20 Box

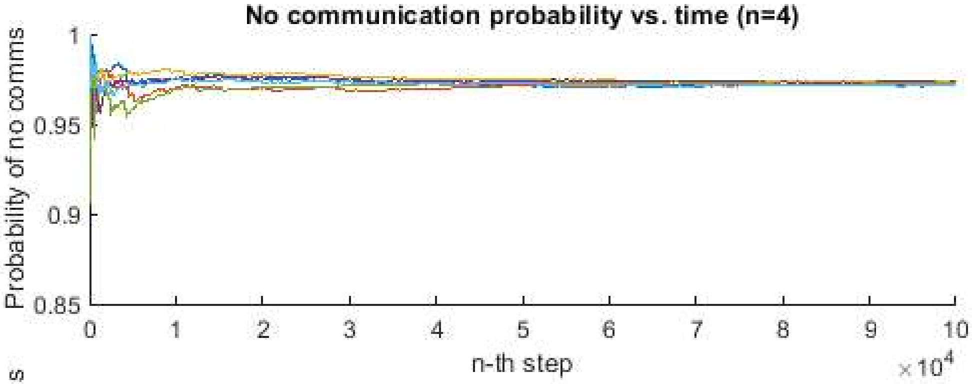
Results: 4-Agent case: converges to [0.970, 0.974] 8-Agent case: converges to [0.969, 0.975] 16-Agent case: converges to [0.969, 0.976] 32-Agent case: converges to [0.969, 0.976]

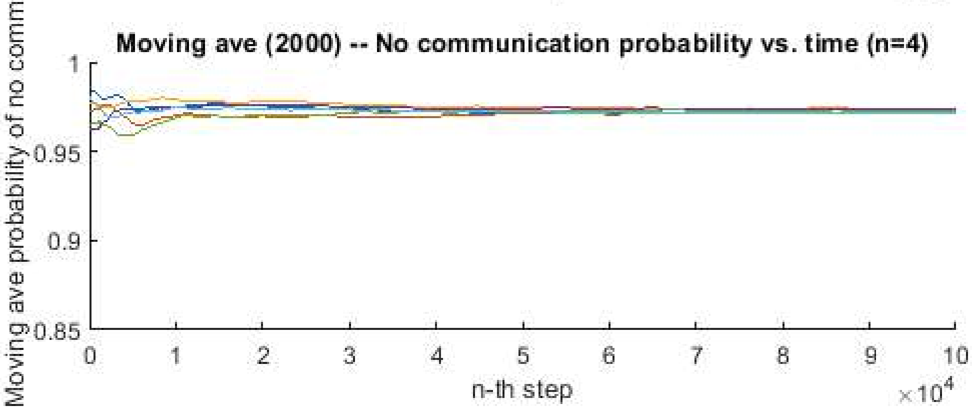
```
bounds = [0 20 20 0; 0 0 20 20];

a.steadyStateCommProb(bounds, 4, 100000, 1);             % bounds, numAgents, N, sim_itrs
a.steadyStateCommProb(bounds, 8, 100000, 1);
a.steadyStateCommProb(bounds, 16, 100000, 1);
a.steadyStateCommProb(bounds, 32, 100000, 1);

SimAnalysis.clearEmptyFigs();                            % closes figures without titles (for empty ones!)
disp("Done: 20x20 inf horizon")
```

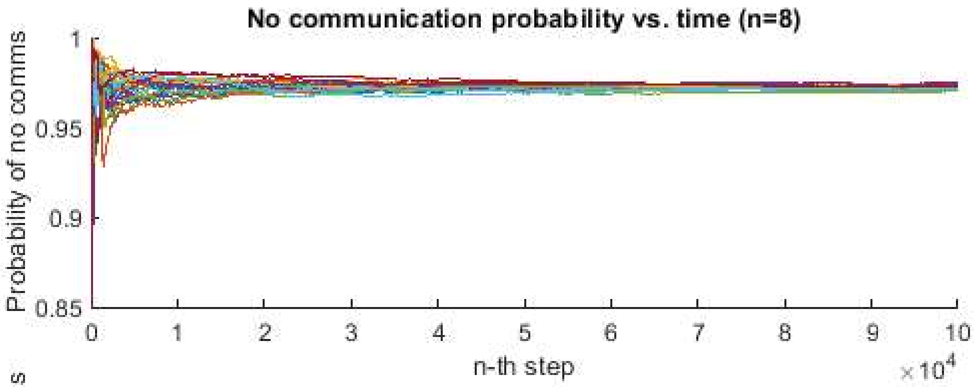
```
Done: 20x20 inf horizon
```


No communication probability vs. time (n=32)
Probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4

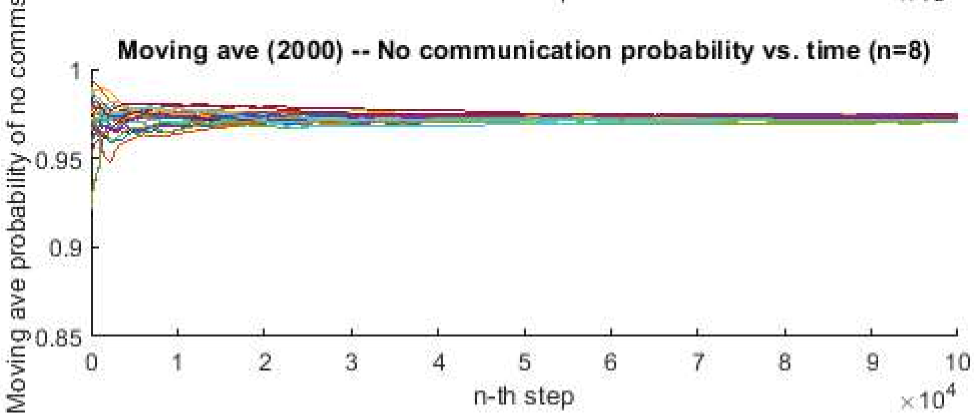

Moving ave (2000) -- No communication probability vs. time (n=32)
Moving ave probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4


No communication probability vs. time (n=4)
Probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4

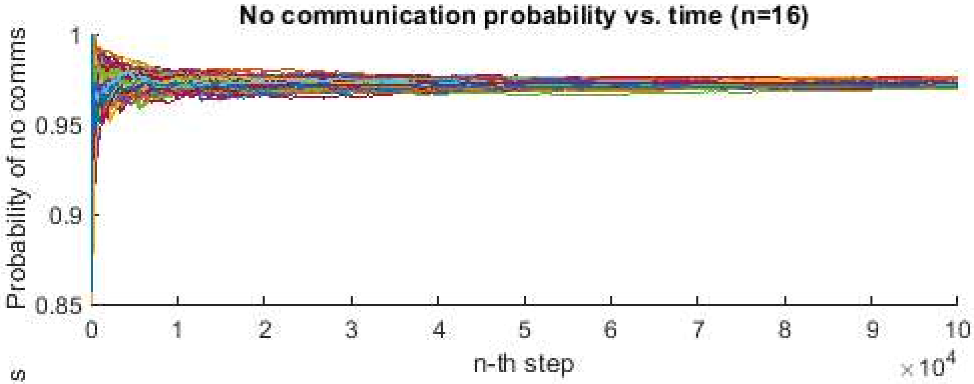

Moving ave (2000) -- No communication probability vs. time (n=4)
Moving ave probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4



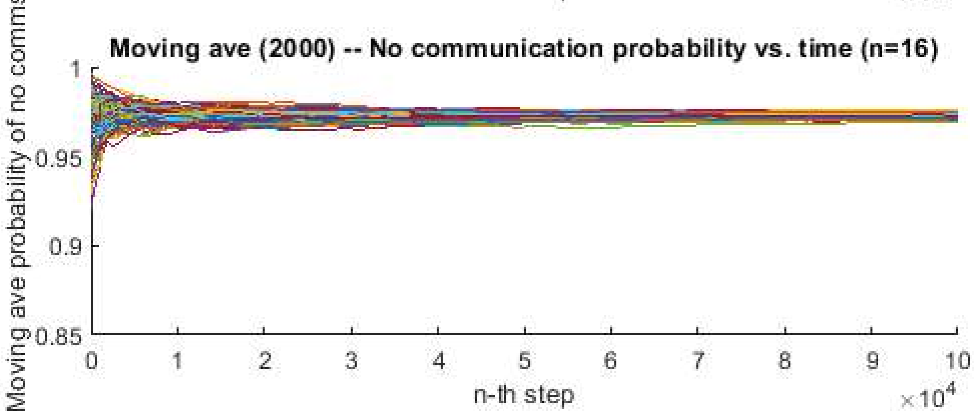
No communication probability vs. time (n=8)



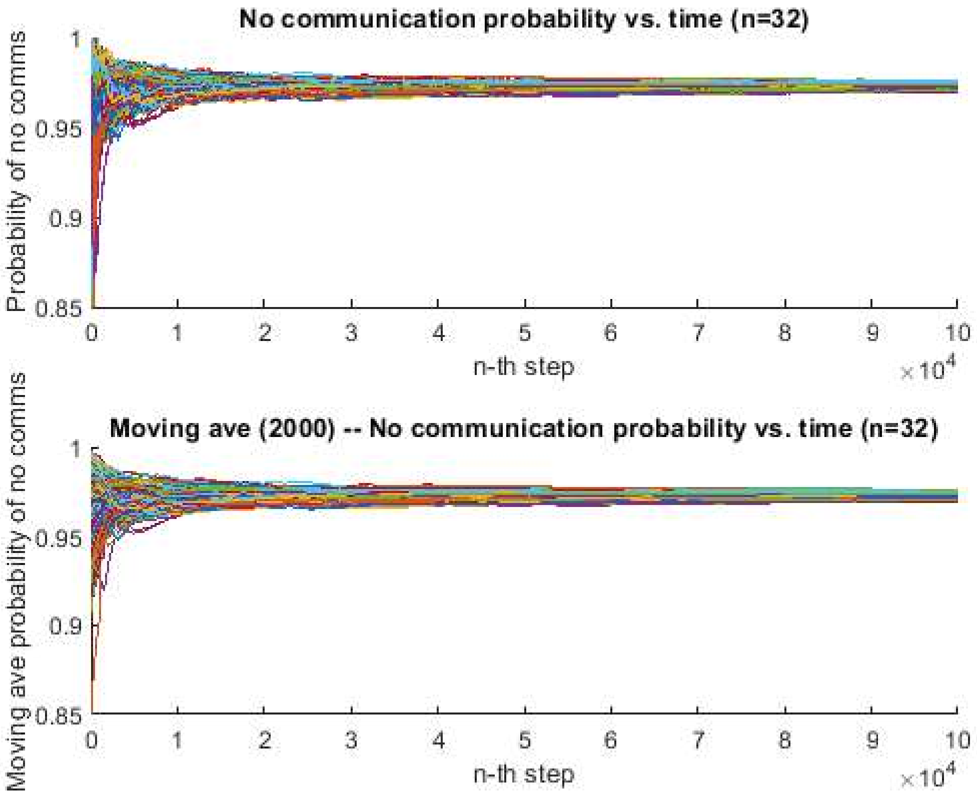
Moving ave (2000) -- No communication probability vs. time (n=8)



No communication probability vs. time (n=16)



Moving ave (2000) -- No communication probability vs. time (n=16)

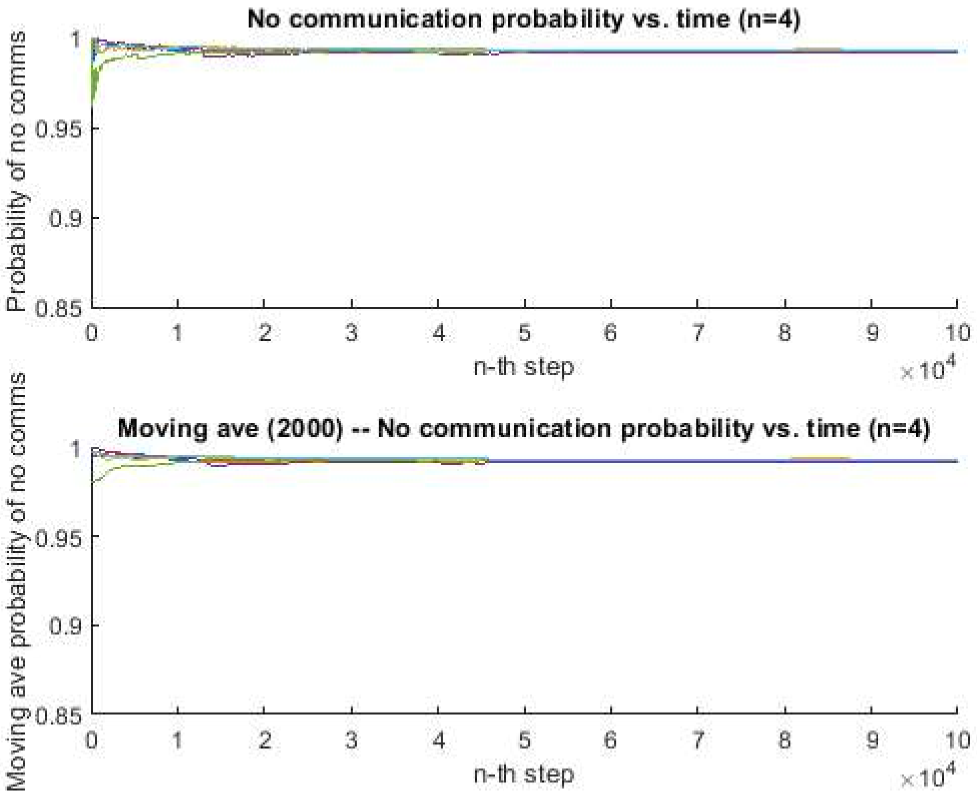


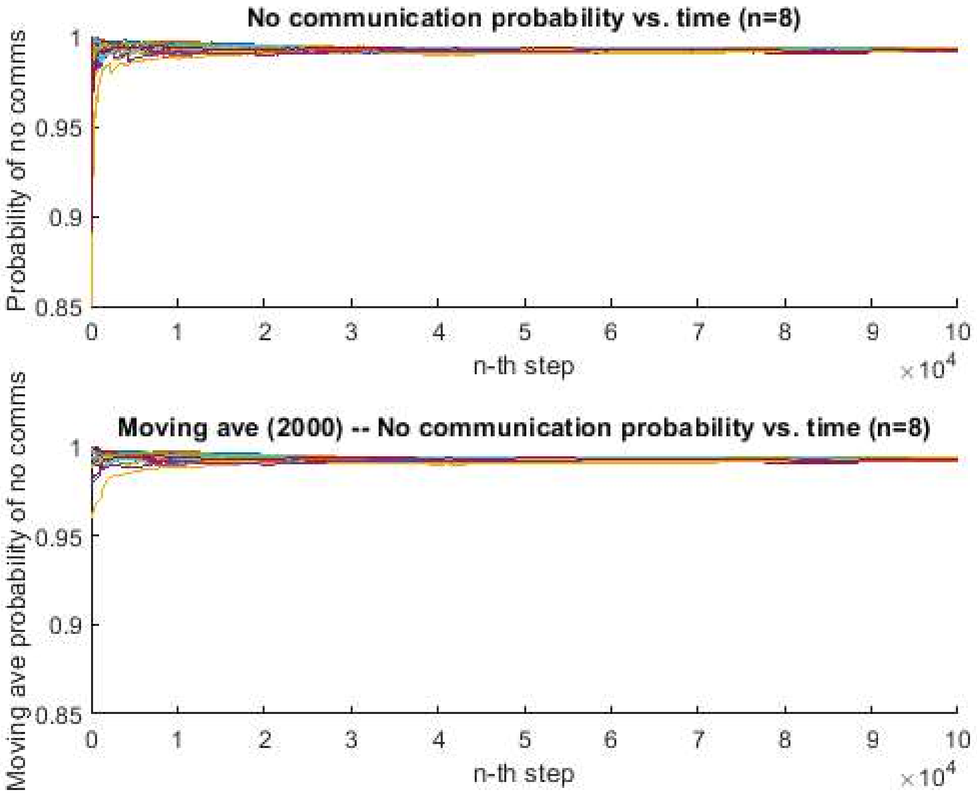
4, 8, 16, 32 Agent Inf Horizon Test in 40x40 Box

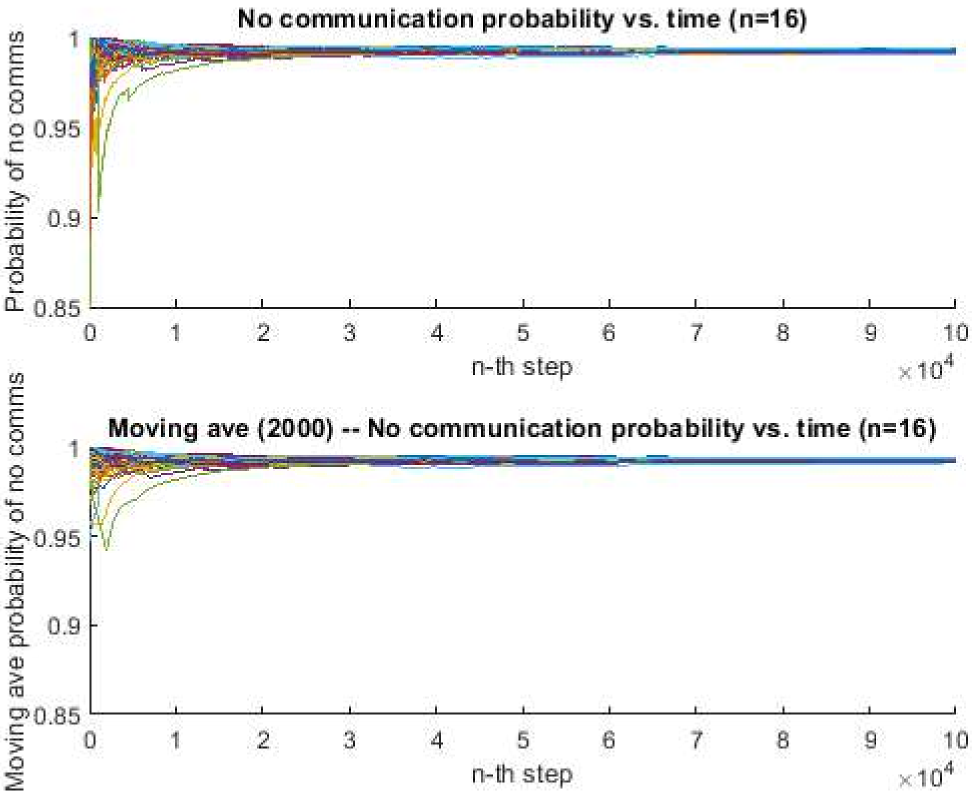
Results: 4-Agent case: converges to [0.991, 0.994] 8-Agent case: converges to [0.990, 0.993] 16-Agent case: converges to [0.991, 0.994] 32-Agent case: converges to [0.990, 0.994]

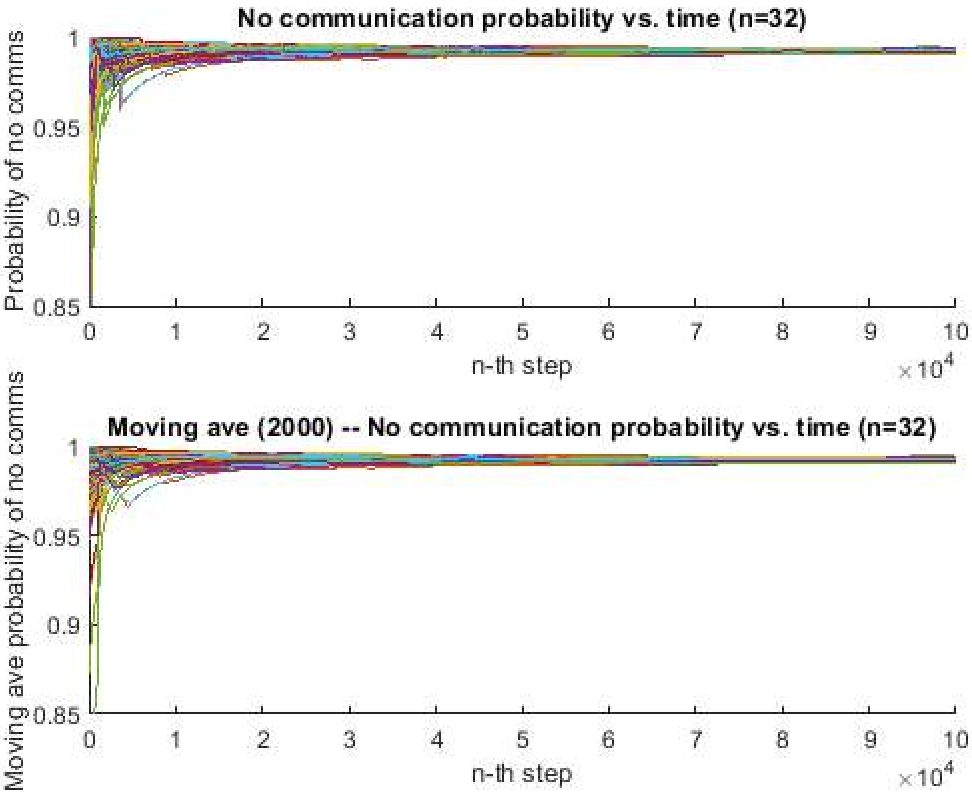
```
bounds = [0 40 40 0; 0 0 40 40];

a.steadyStateCommProb(bounds, 4, 100000, 1);             % bounds, numAgents, N, sim_itrs
a.steadyStateCommProb(bounds, 8, 100000, 1);
a.steadyStateCommProb(bounds, 16, 100000, 1);
a.steadyStateCommProb(bounds, 32, 100000, 1);

SimAnalysis.clearEmptyFigs();
disp("Done: 40x40 inf horizon")
```

```
Done: 40x40 inf horizon
```


No communication probability vs. time (n=4)
Probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4
Moving ave (2000) -- No communication probability vs. time (n=4)
Moving ave probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4


No communication probability vs. time (n=8)
Probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4
Moving ave (2000) -- No communication probability vs. time (n=8)
Moving ave probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
×10^4



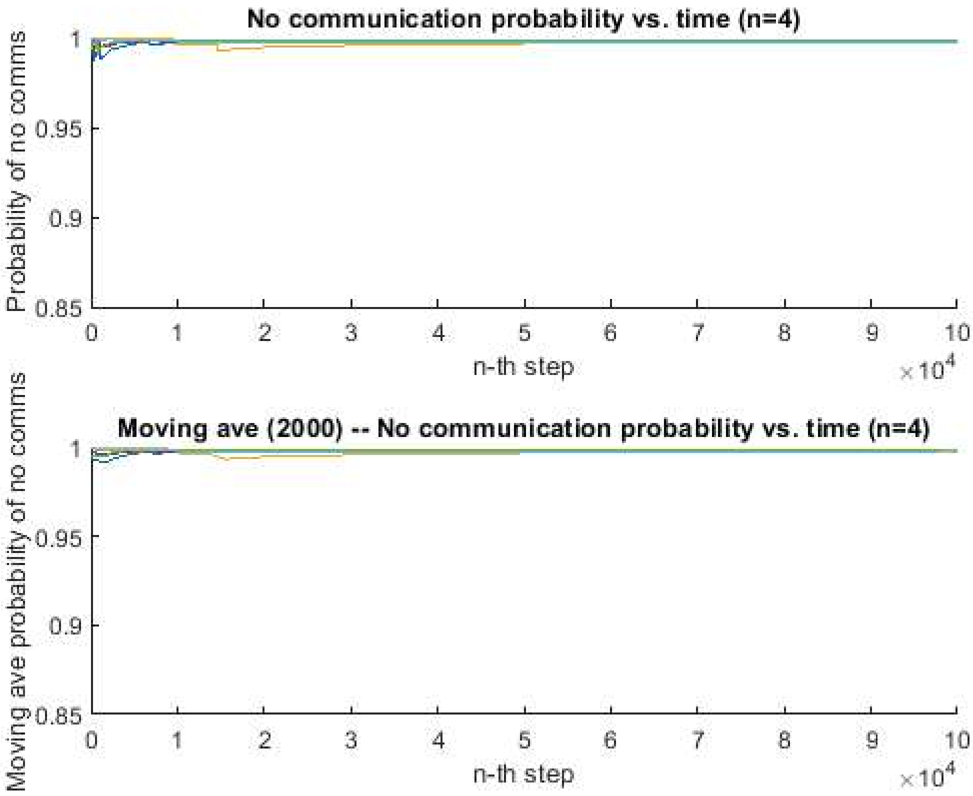


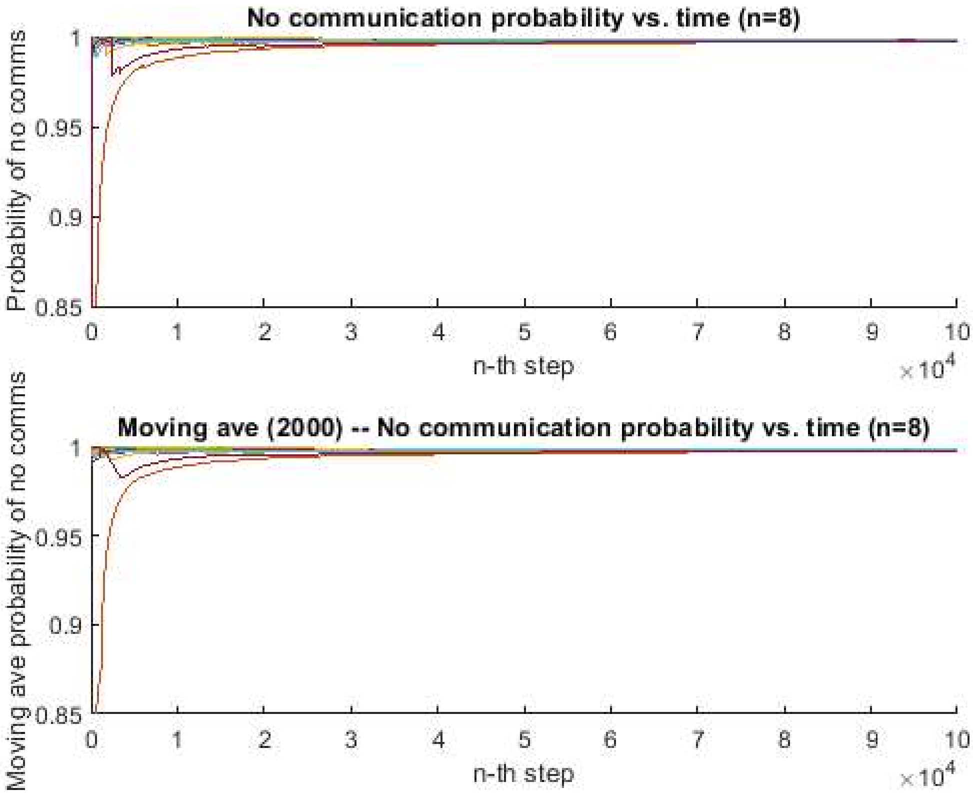
4, 8, 16, 32 Agent Inf Horizon Test in 80x80 Box

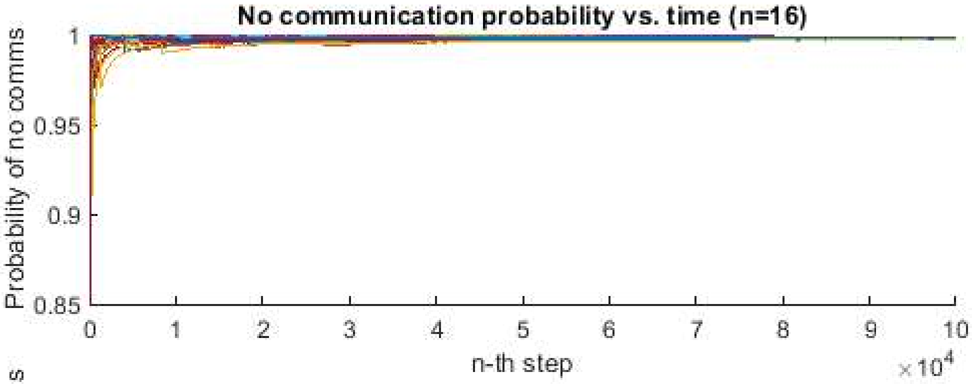
Results: 4-Agent case: converges to [0.997, 0.998] 8-Agent case: converges to [0.997, 0.998] 16-Agent case: converges to [0.996, 0.998] 32-Agent case: converges to [0.996, 0.998]

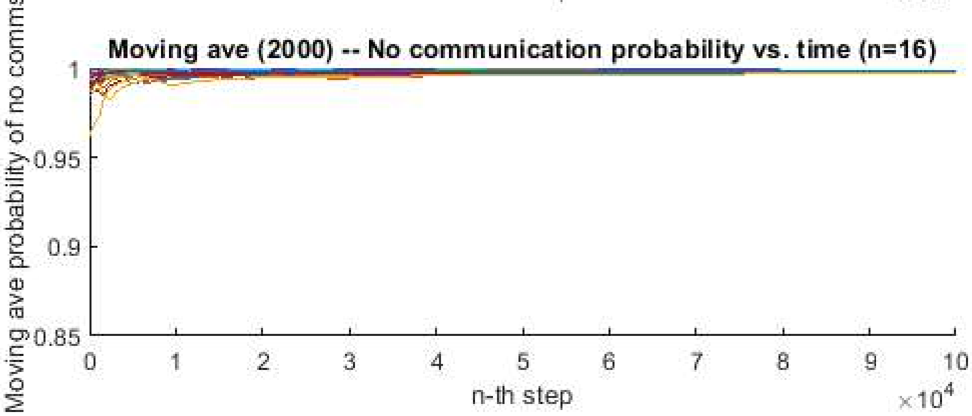
```
bounds = [0 80 80 0; 0 0 80 80];

a.steadyStateCommProb(bounds, 4, 100000, 1);             % bounds, numAgents, N, sim_itrs
a.steadyStateCommProb(bounds, 8, 100000, 1);
a.steadyStateCommProb(bounds, 16, 100000, 1);
a.steadyStateCommProb(bounds, 32, 100000, 1);

SimAnalysis.clearEmptyFigs();
disp("Done: 80x80 inf horizon")
```

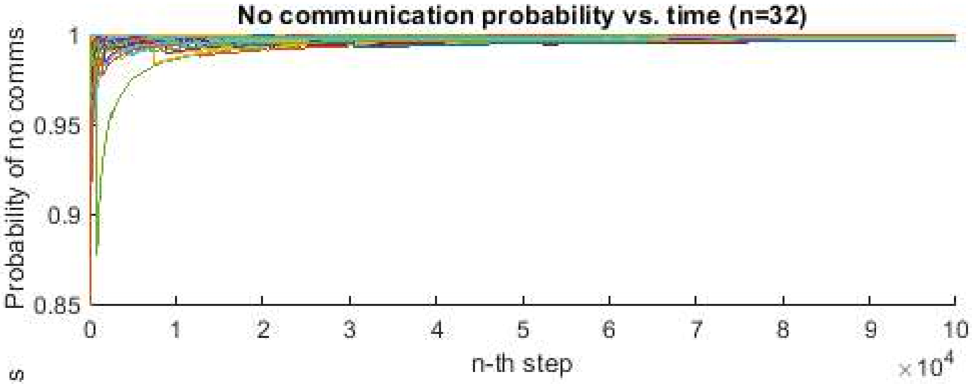
```
Done: 80x80 inf horizon
```

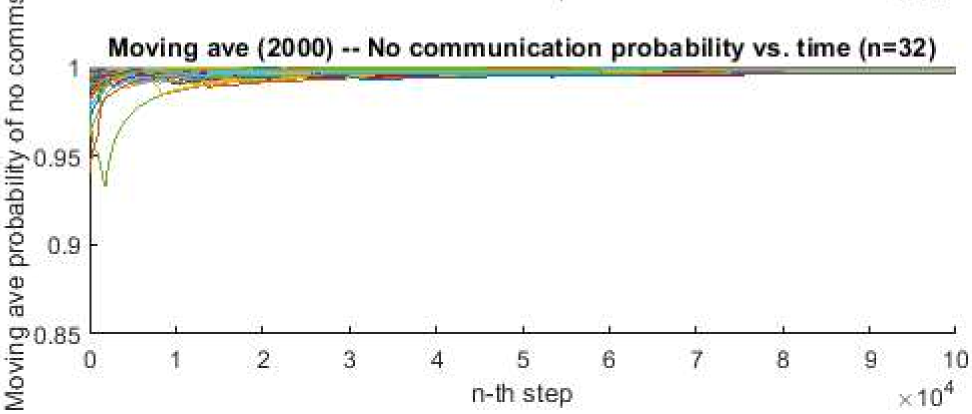

No communication probability vs. time (n=4)
Probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
$\times 10^4$
Moving ave (2000) -- No communication probability vs. time (n=4)
Moving ave probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
$\times 10^4$


No communication probability vs. time (n=8)
Probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
$\times 10^4$
Moving ave (2000) -- No communication probability vs. time (n=8)
Moving ave probability of no comms
1
0.95
0.9
0.85
0
1
2
3
4
5
6
7
8
9
10
n-th step
$\times 10^4$







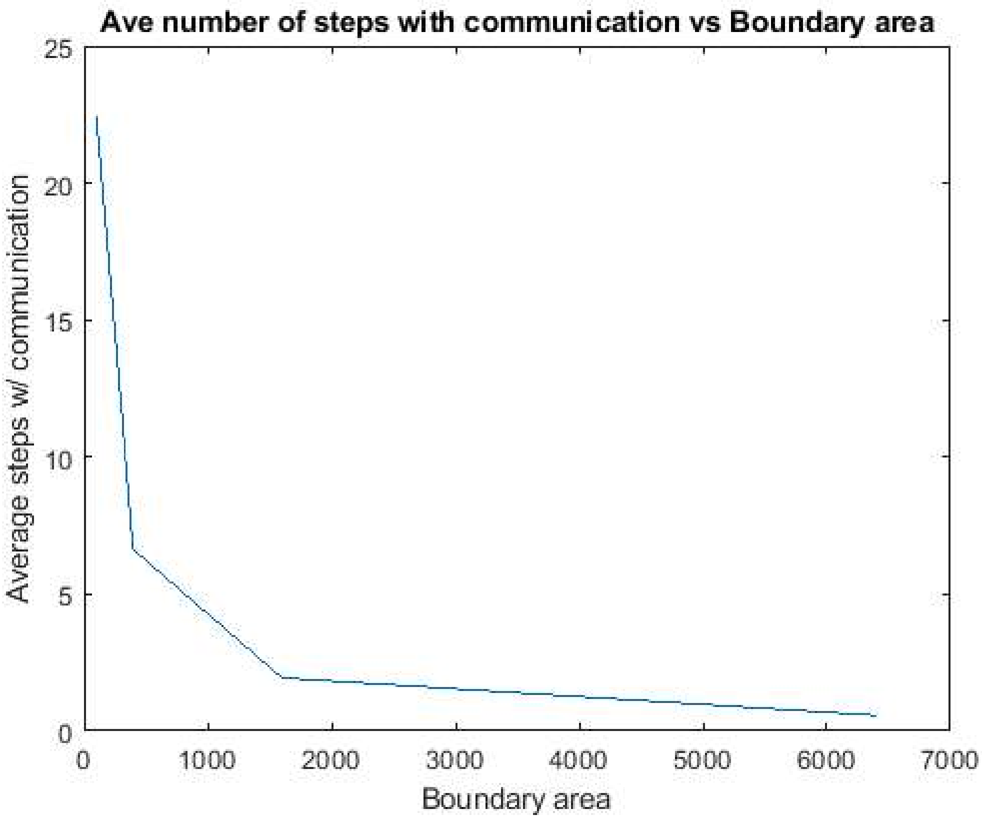


General Analysis -- 240 path length, multi-start simulations

Analysis: For axis-align square boundaries the average number of steps with communication drops off sharply as the boudary area increases, but seems stationary (wrt the mean) to the number of agents. It should be noted that the std. deviation of the average number of steps in communication appears to increase as the number of agents increases. We can also note that the number of multi-start iterations with at least one agent pairing experiencing no communications increases sharply from the 20x20 bounds to

40x40 and beyond. We know that any iteration with two agents experiencing no communication results in an un-connected graph, which needs to be avoided. This is a target for future work.

```
xgen = [100, 400, 1600, 6400];
ygen = [22.42, 6.64, 1.935, 0.57];

figure()
plot(xgen, ygen)
xlabel("Boundary area")
ylabel("Average steps w/ communication")
title("Ave number of steps with communication vs Boundary area")

ylim([0 25.0])
```

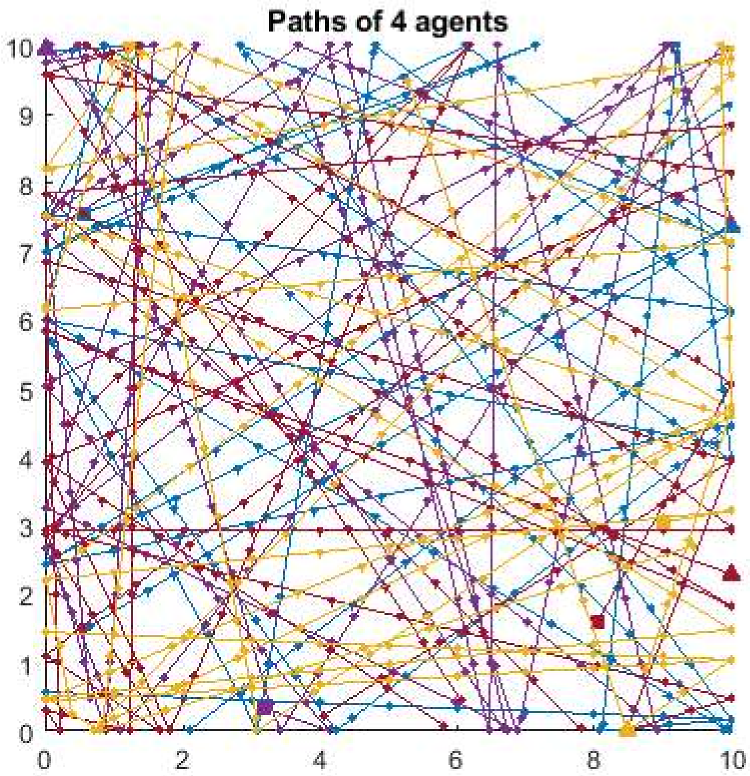


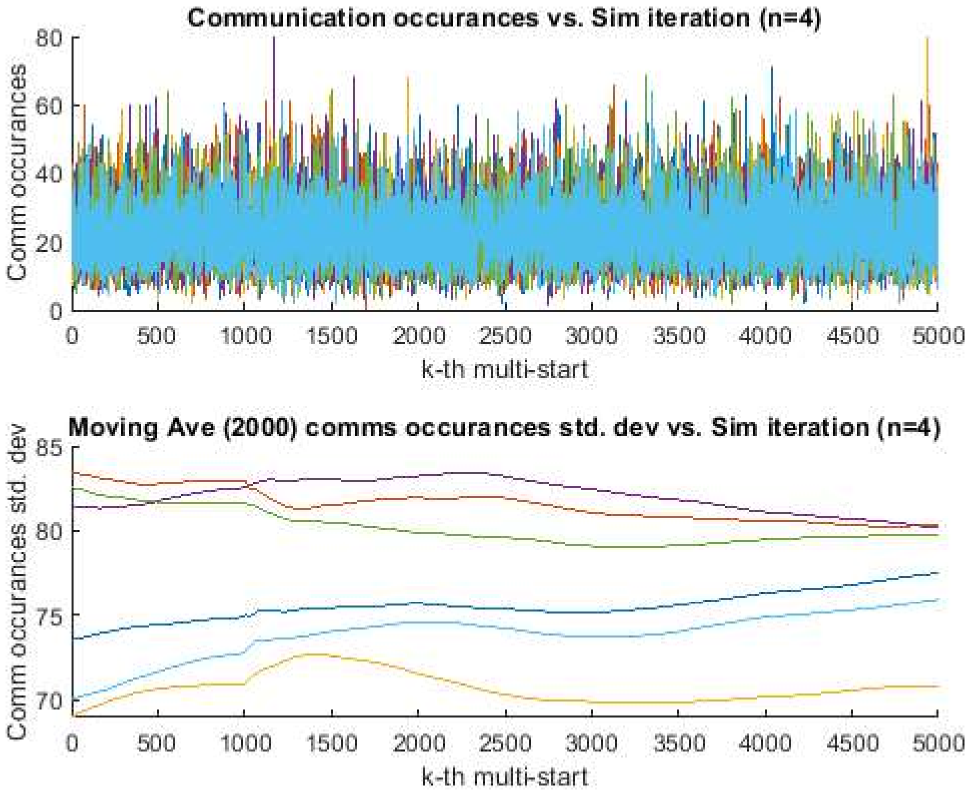
4, 8, 16, 32 Agent Multi-Start Test in 10x10 Box

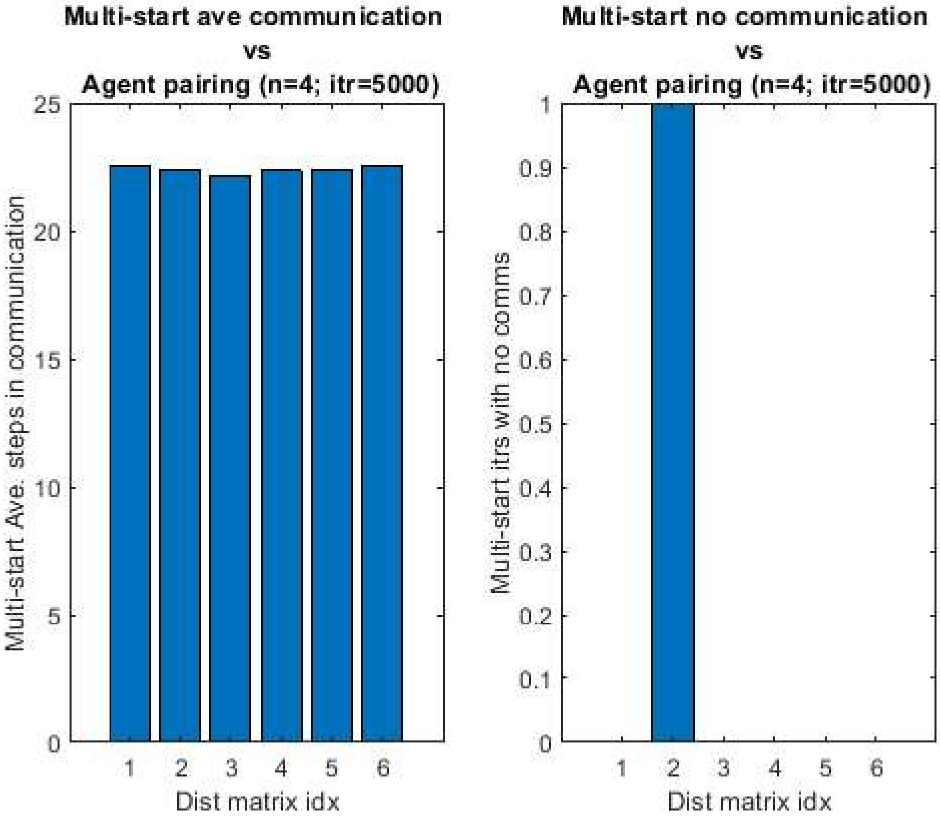
Results: 4-Agent case: ave comms [22.36, 22.47]; no comms itrs [0, 1] (0.33 ave) 8-Agent case: ave comms [22.33, 22.61]; no comms itrs [0, 1] (1/28 ave) 16-Agent case: ave comms [22.10, 22.70]; no comms itrs [0, 1] (? ave) 32-Agent case: ave comms [22.27, 22.78]; no comms itrs [0, 1] (? ave)

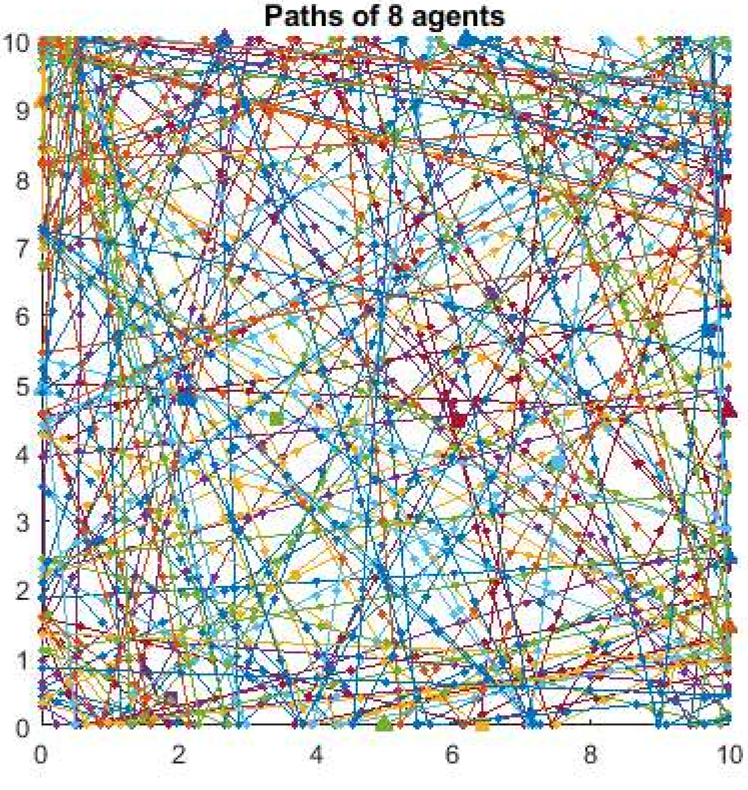
```
bounds = [0 10 10 0; 0 0 10 10];

a.multiStartData(bounds, 4, 240, 5000);              % bounds, numAgents, N, sim_itrs
a.multiStartData(bounds, 8, 240, 5000);
a.multiStartData(bounds, 16, 240, 5000);
a.multiStartData(bounds, 32, 240, 5000);

SimAnalysis.clearEmptyFigs();
disp("Done: 10x10 multi-start")
```

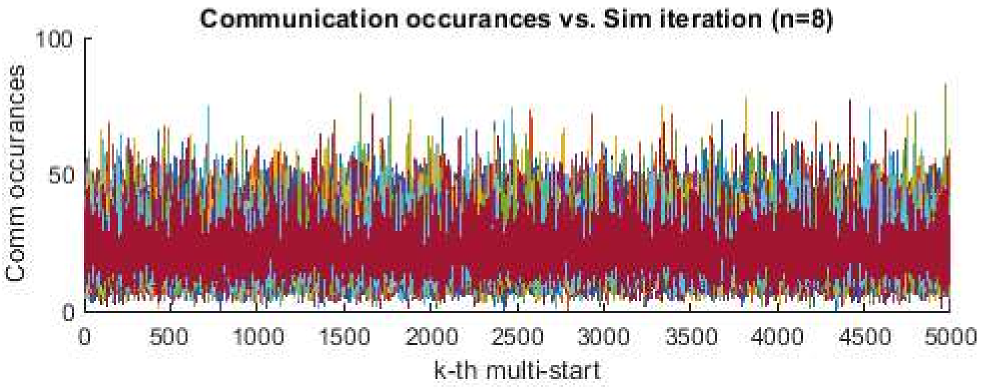
```
Done: 10x10 multi-start
```

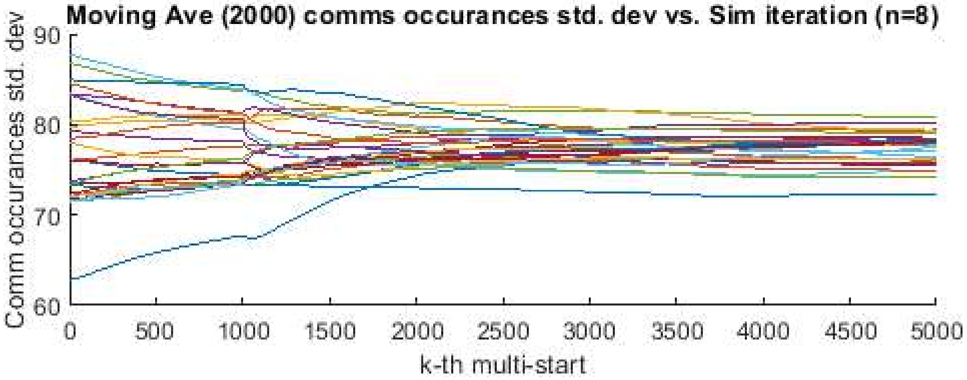


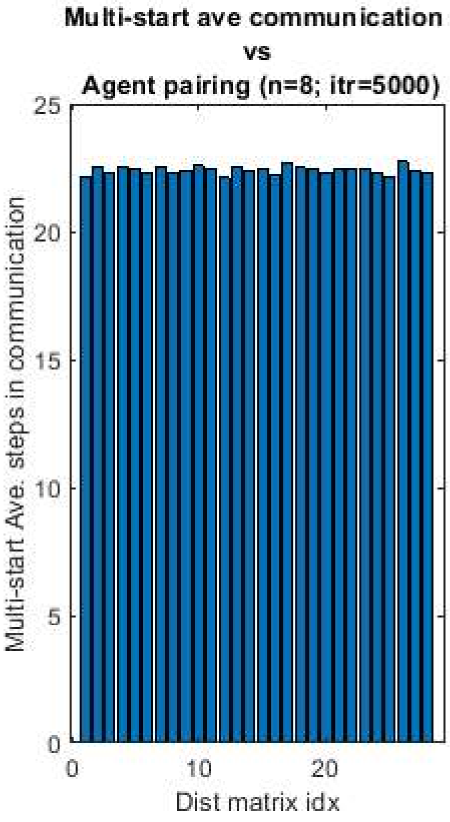


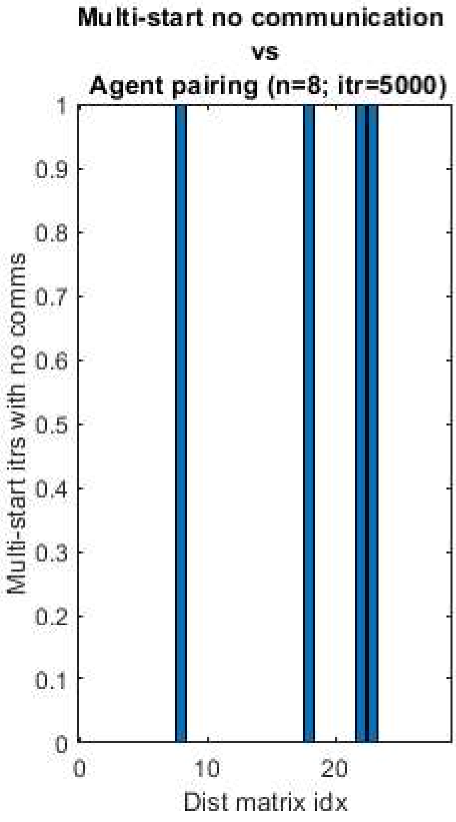

Multi-start ave communication
vs
Agent pairing (n=4; itr=5000)
Multi-start Ave. steps in communication
25
20
15
10
5
0
1
2
3
4
5
6
Dist matrix idx
Multi-start no communication
vs
Agent pairing (n=4; itr=5000)
Multi-start itrs with no comms
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
6
Dist matrix idx

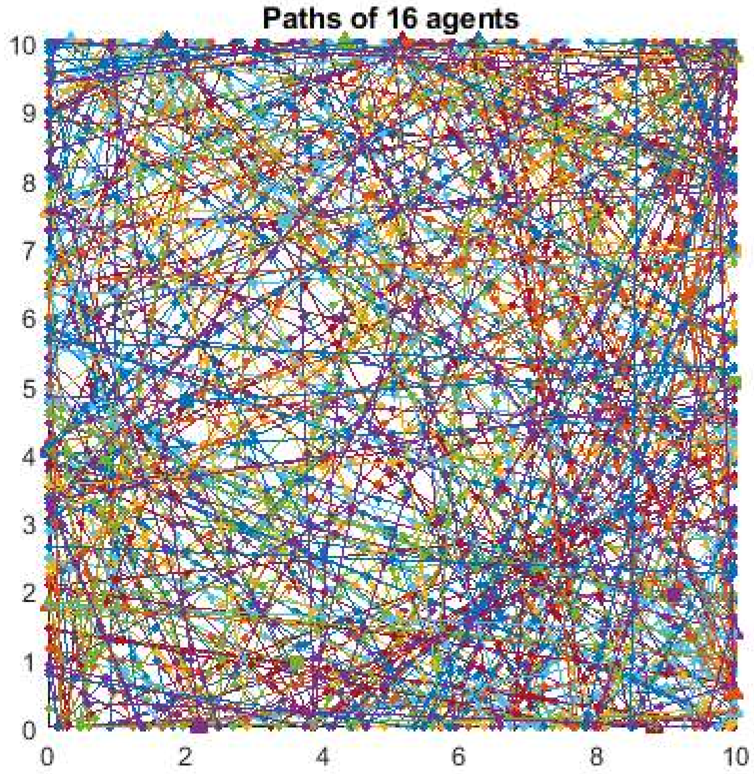

Paths of 8 agents
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10

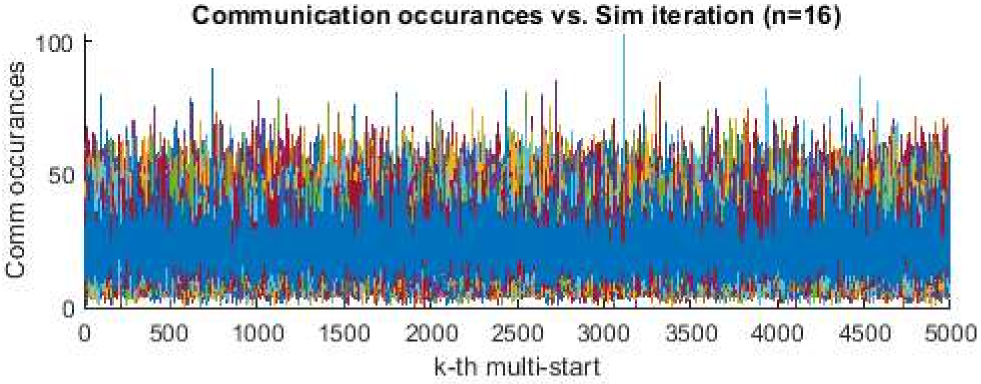

Communication occurances vs. Sim iteration (n=8)
Comm occurances
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start

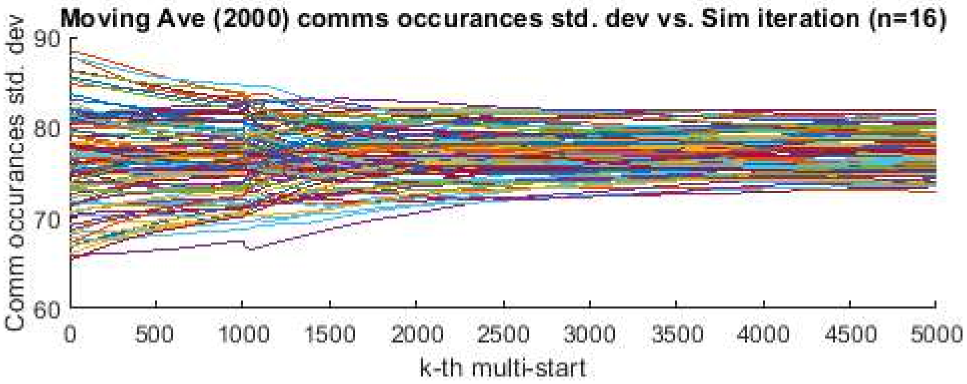

Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=8)
Comm occurances std. dev
90
80
70
60
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start

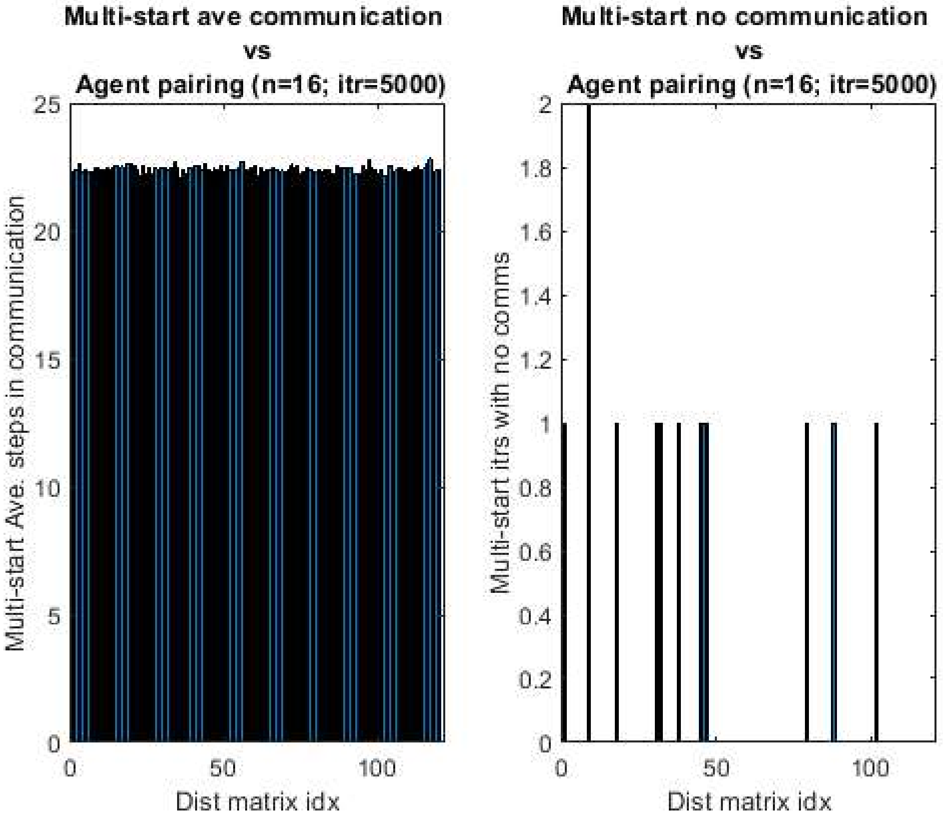

Multi-start ave communication
vs
Agent pairing (n=8; itr=5000)
Multi-start Ave. steps in communication
25
20
15
10
5
0
0
10
20
Dist matrix idx

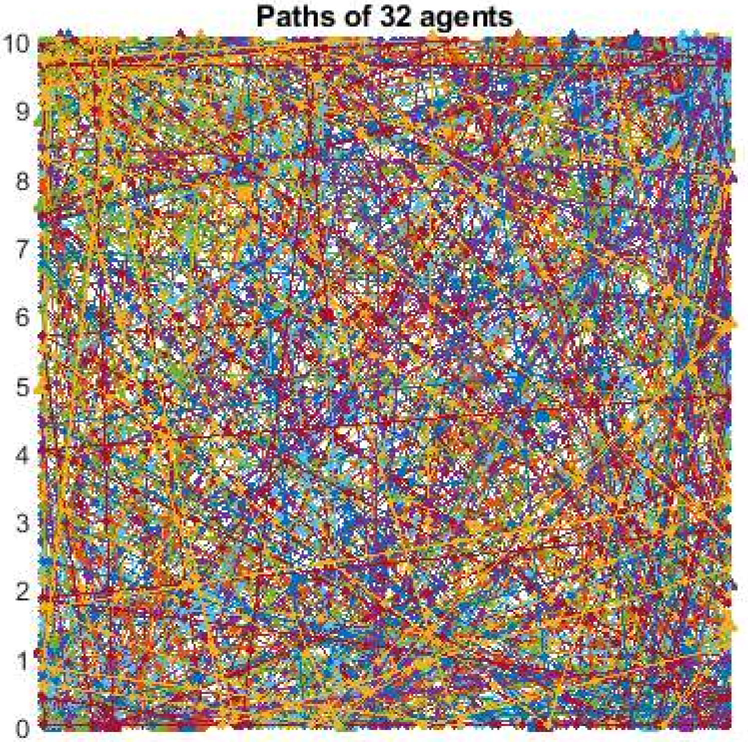

Multi-start no communication
vs
Agent pairing (n=8; itr=5000)
Multi-start itrs with no comms
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
Dist matrix idx

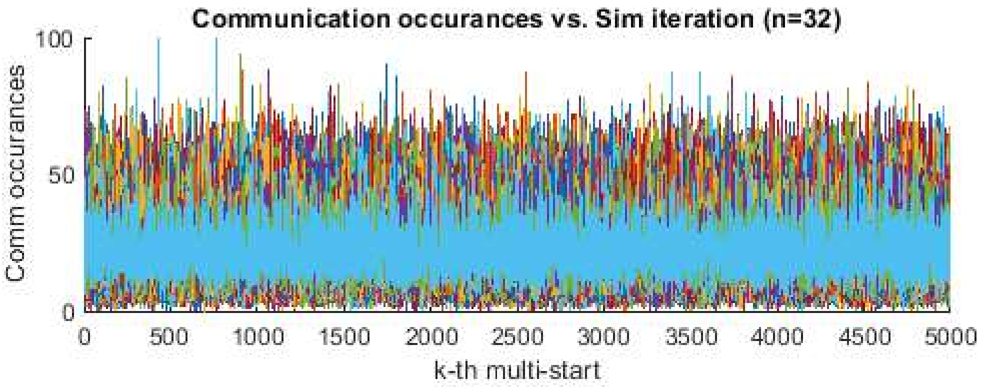

Paths of 16 agents
0
1
2
3
4
5
6
7
8
9
10
0
2
4
6
8
10

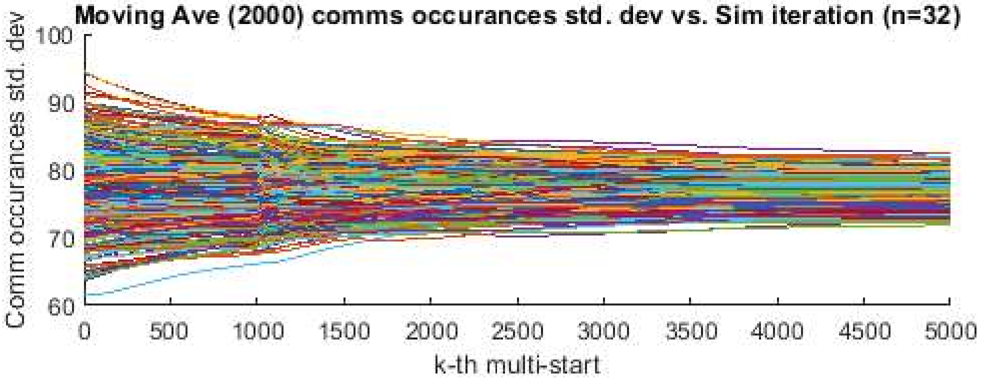

Communication occurances vs. Sim iteration (n=16)
Comm occurances
0
50
100
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start

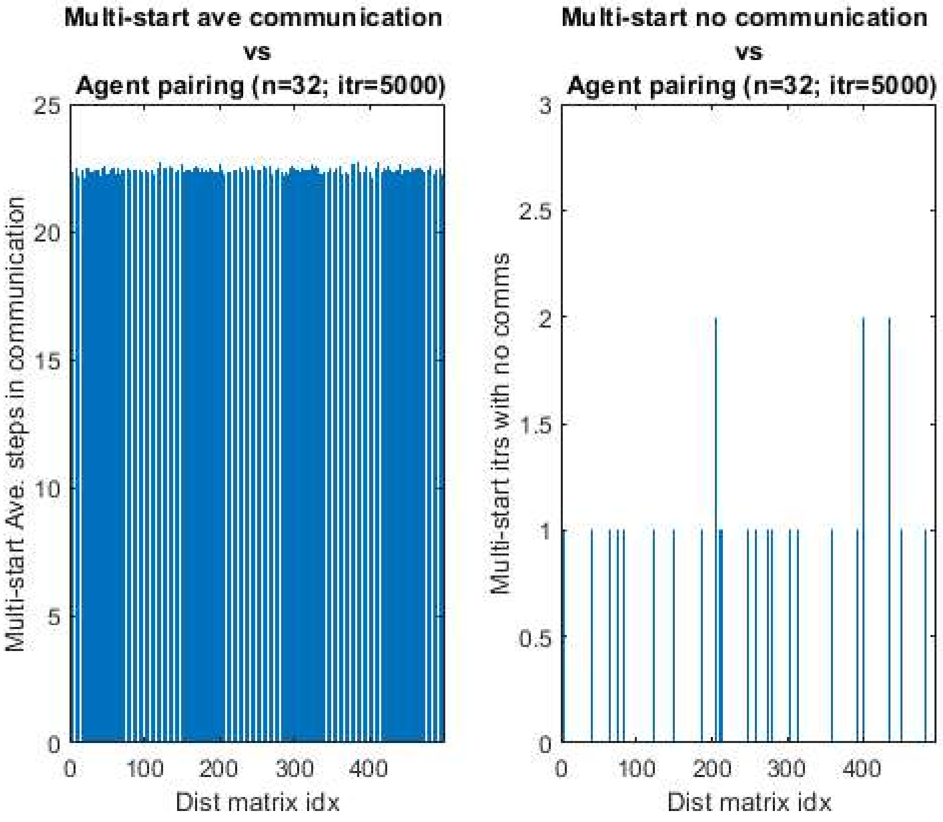

Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=16)
Comm occurances std. dev
60
70
80
90
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start


Multi-start ave communication
vs
Agent pairing (n=16; itr=5000)
Multi-start Ave. steps in communication
25
20
15
10
5
0
0
50
100
Dist matrix idx
Multi-start no communication
vs
Agent pairing (n=16; itr=5000)
Multi-start itrs with no comms
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
Dist matrix idx


Paths of 32 agents
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10





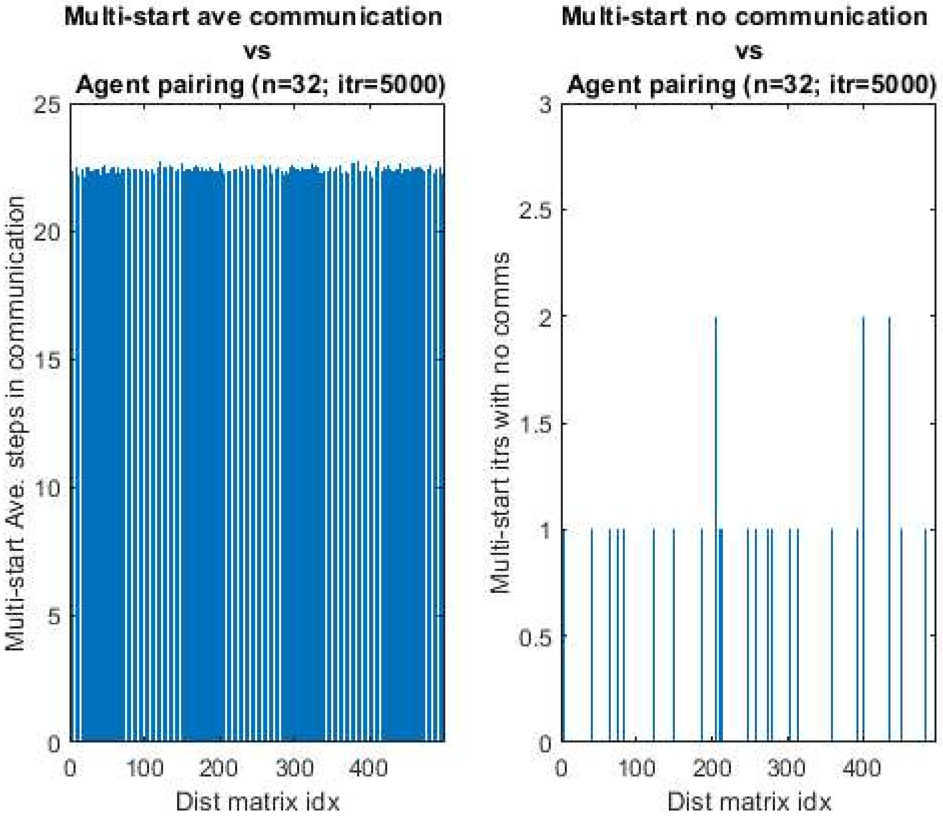


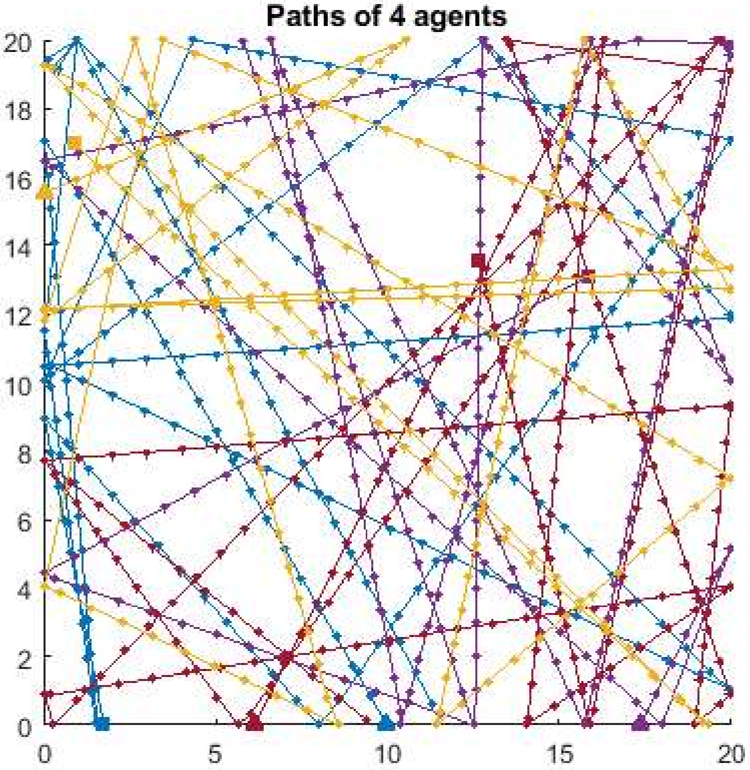
4, 8, 16, 32 Agent Multi-Start Test in 20x20 Box

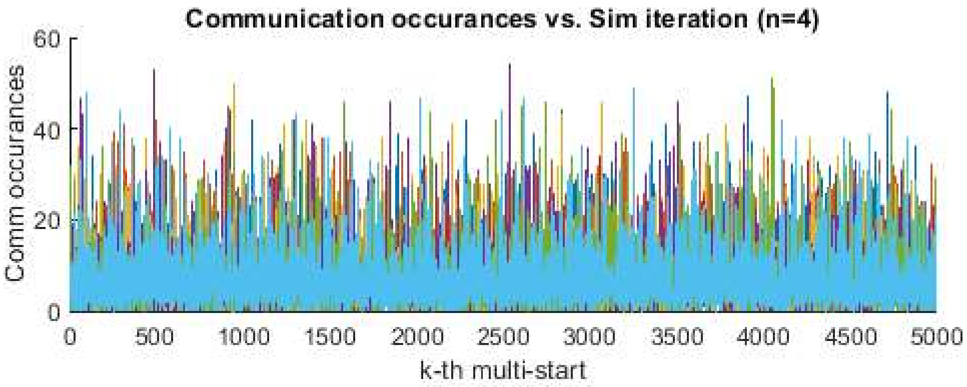
Results: 4-Agent case: ave comms [6.52, 6.75]; no comms itrs [318, 372] 8-Agent case: ave comms [6.51, 6.88]; no comms itrs [297, 388] 16-Agent case: ave comms [6.44, 6.85]; no comms itrs [299, 380] 32-Agent case: ave comms [6.41, 6.92]; no comms itrs [292, 397]

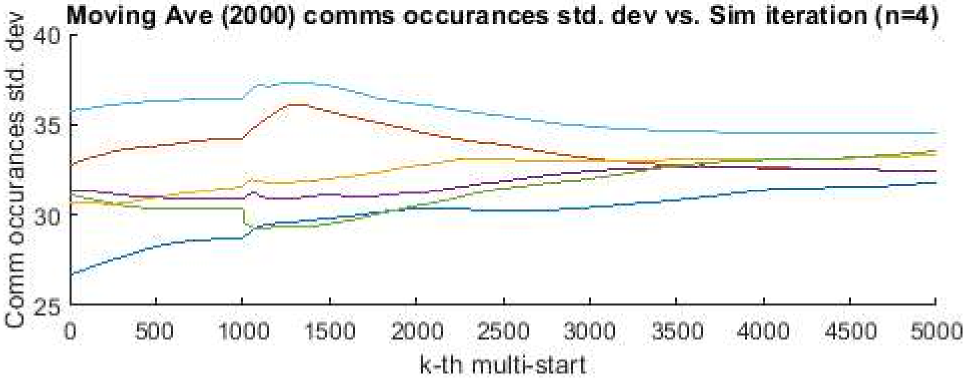
```matlab
bounds = [0 20 20 0; 0 0 20 20];

a.multiStartData(bounds, 4, 240, 5000);                 % bounds, numAgents, N, sim_itrs
a.multiStartData(bounds, 8, 240, 5000);
a.multiStartData(bounds, 16, 240, 5000);
a.multiStartData(bounds, 32, 240, 5000);

SimAnalysis.clearEmptyFigs();
disp("Done: 20x20 multi-start")
```

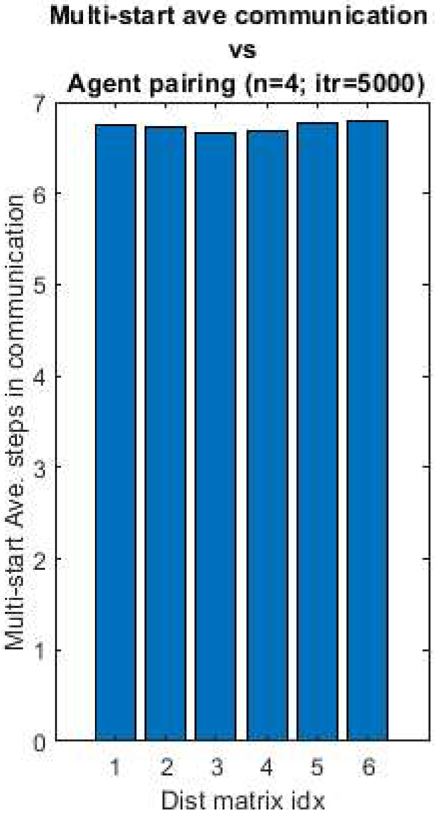
```
Done: 20x20 multi-start
```

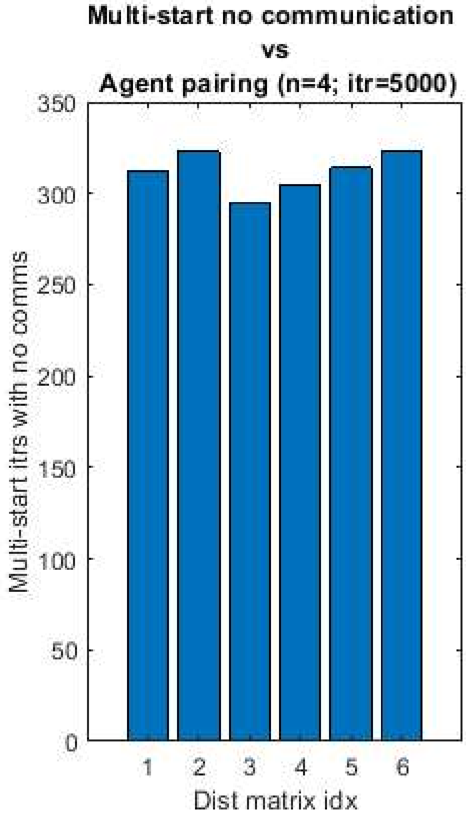

Multi-start ave communication
vs
Agent pairing (n=32; itr=5000)
Multi-start Ave. steps in communication
0
5
10
15
20
25
0
100
200
300
400
Dist matrix idx
Multi-start no communication
vs
Agent pairing (n=32; itr=5000)
Multi-start itrs with no comms
0
0.5
1
1.5
2
2.5
3
0
100
200
300
400
Dist matrix idx

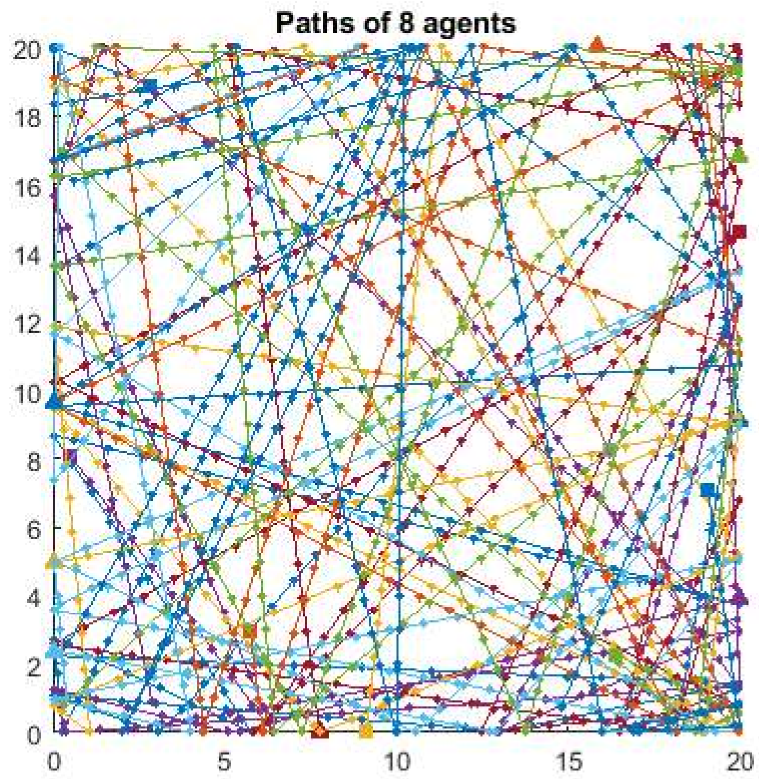

Paths of 4 agents
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20

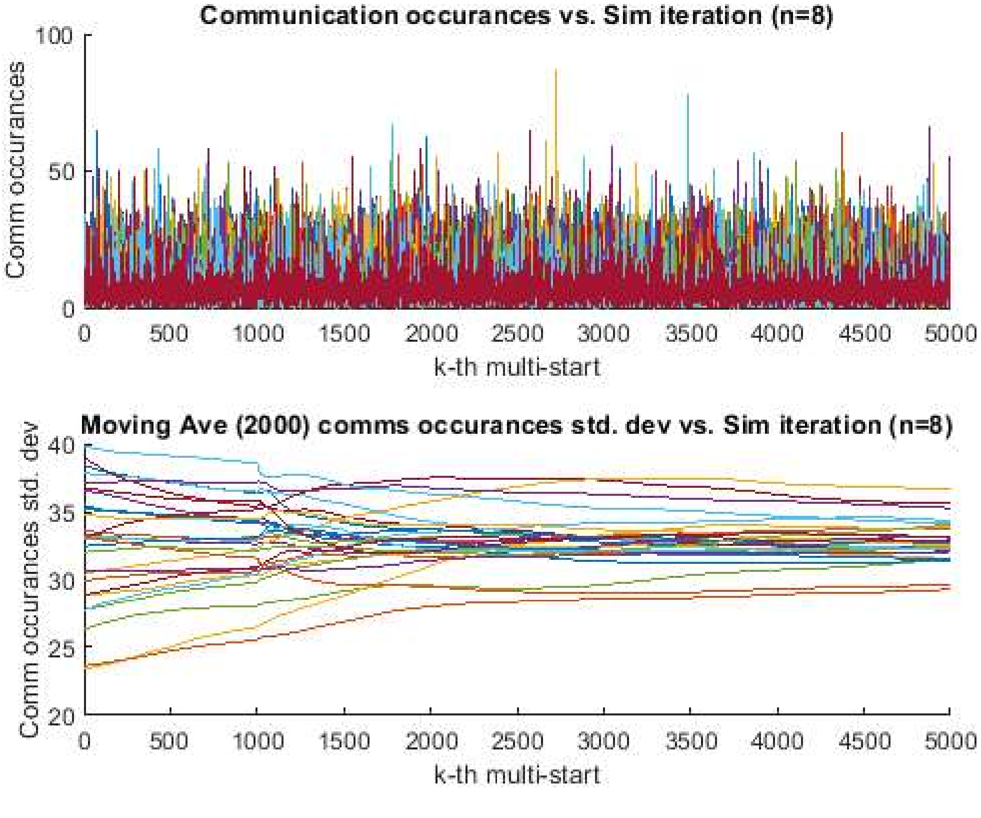

Communication occurances vs. Sim iteration (n=4)

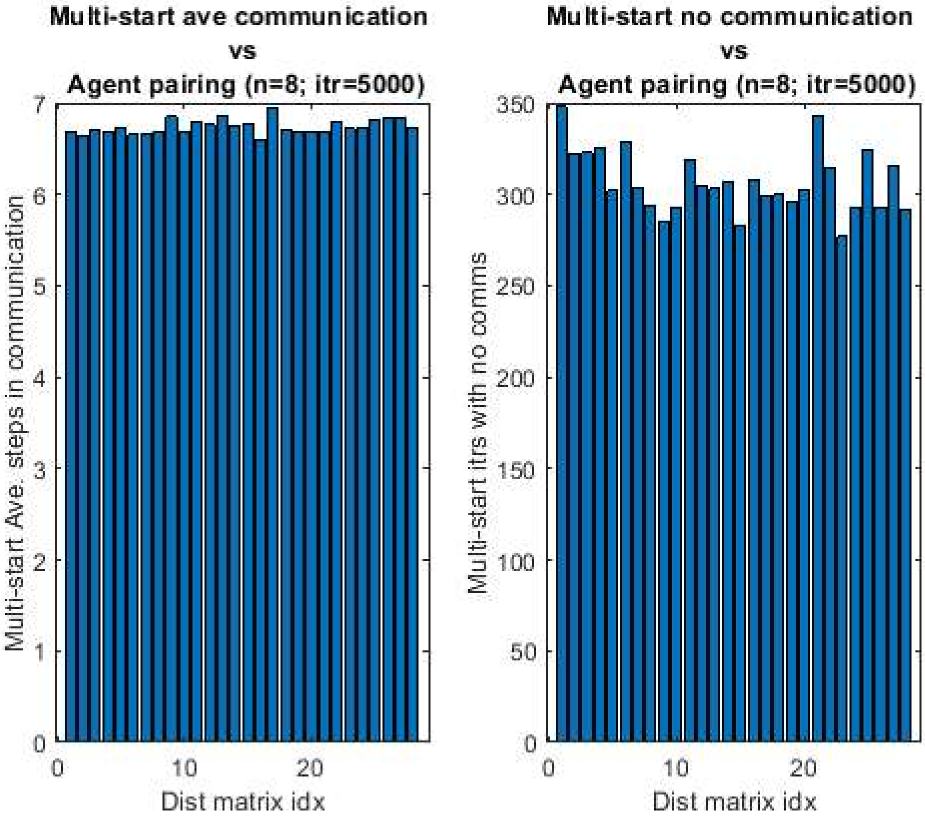

Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=4)

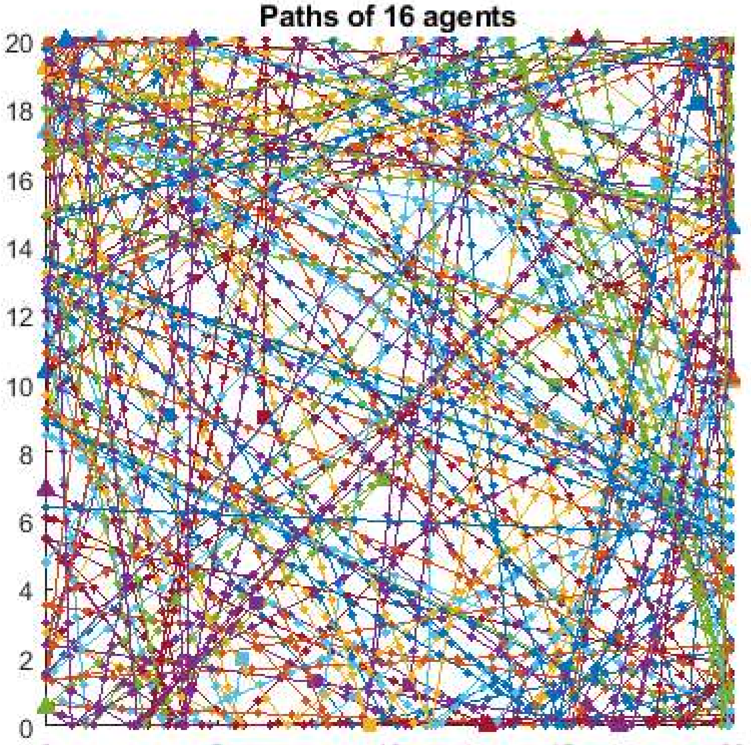

Multi-start ave communication
vs
Agent pairing (n=4; itr=5000)

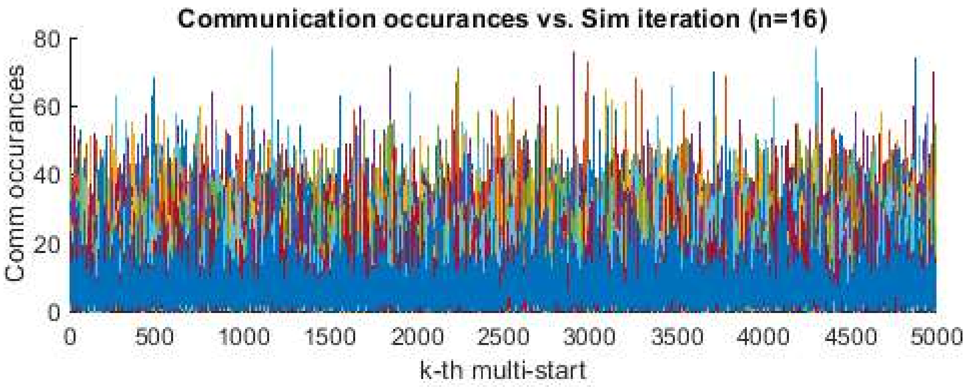

Multi-start no communication
vs
Agent pairing (n=4; itr=5000)

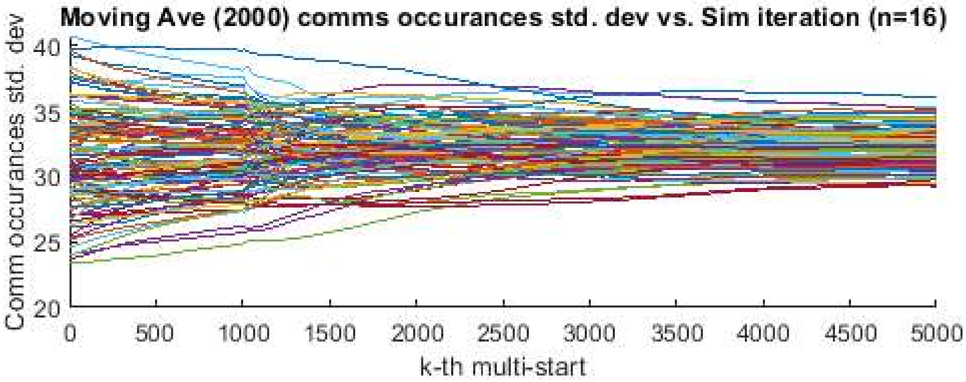

Paths of 8 agents
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20

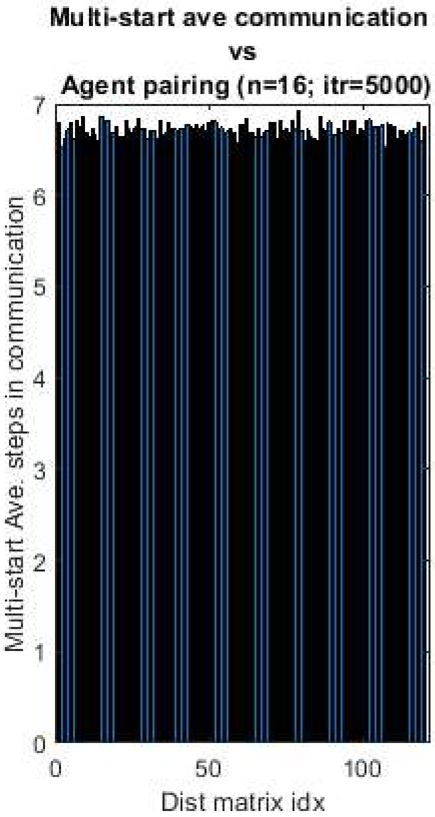

Communication occurances vs. Sim iteration (n=8)
Comm occurances
0
50
100
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start
Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=8)
Comm occurances std. dev
20
25
30
35
40
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start

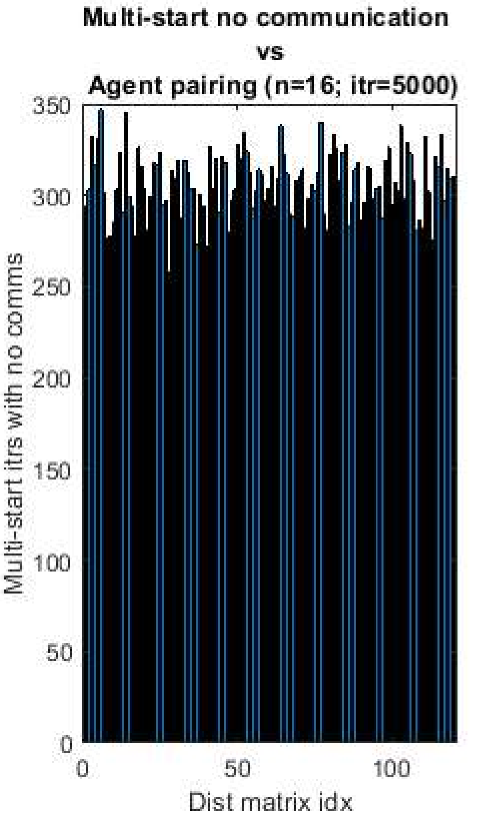

Multi-start ave communication
vs
Agent pairing (n=8; itr=5000)
Multi-start Ave. steps in communication
Dist matrix idx
0
1
2
3
4
5
6
7
0
10
20
Multi-start no communication
vs
Agent pairing (n=8; itr=5000)
Multi-start itrs with no comms
Dist matrix idx
0
50
100
150
200
250
300
350
0
10
20

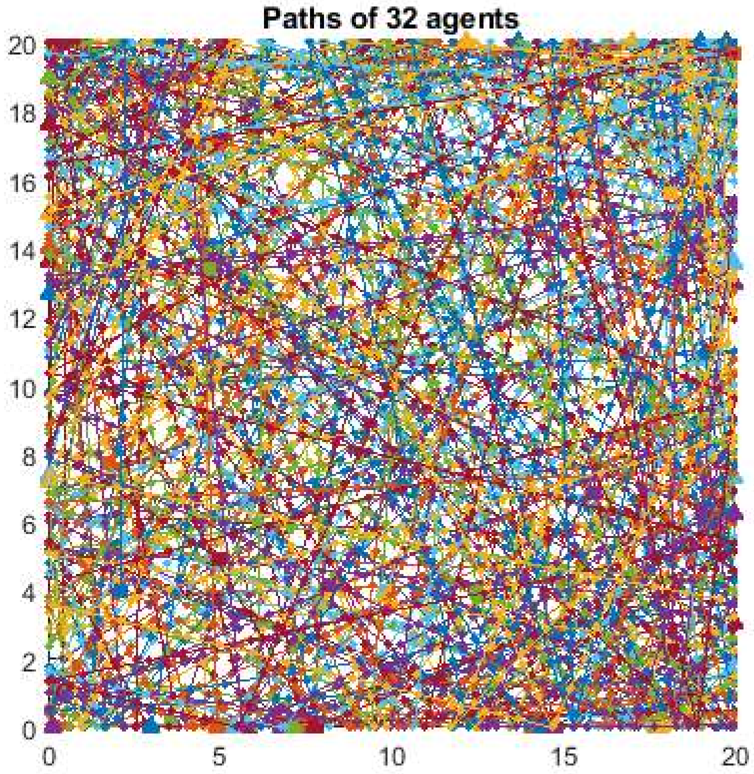

Paths of 16 agents
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20


Communication occurances vs. Sim iteration (n=16)

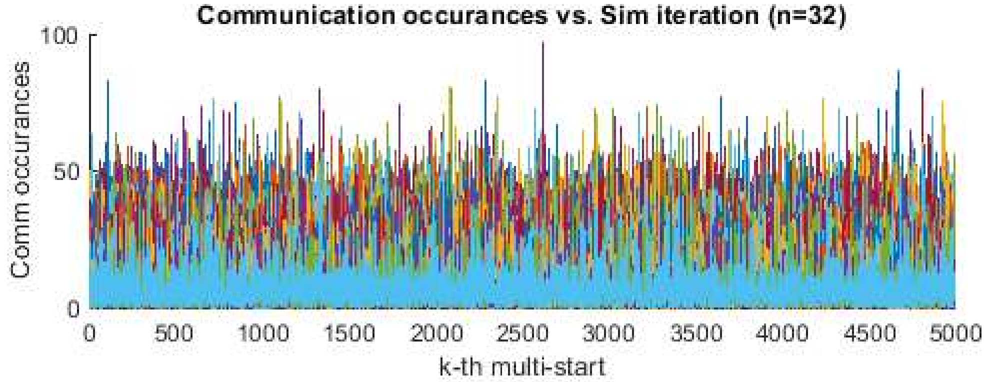

Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=16)


Multi-start ave communication
vs
Agent pairing (n=16; itr=5000)

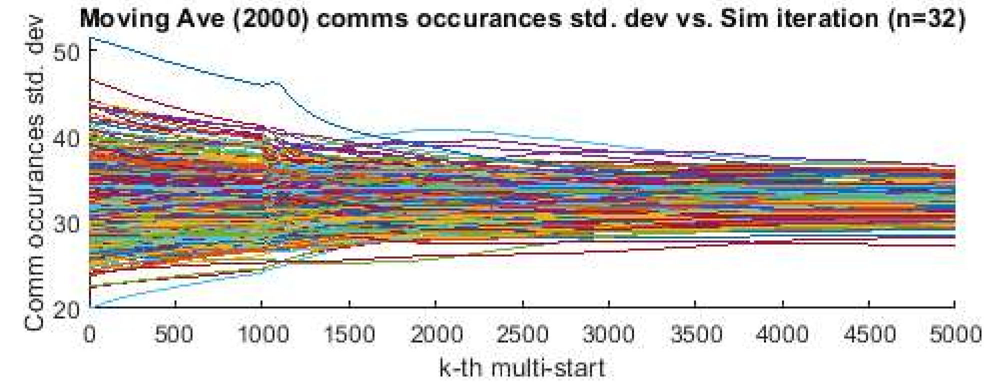

Multi-start no communication
vs
Agent pairing (n=16; itr=5000)



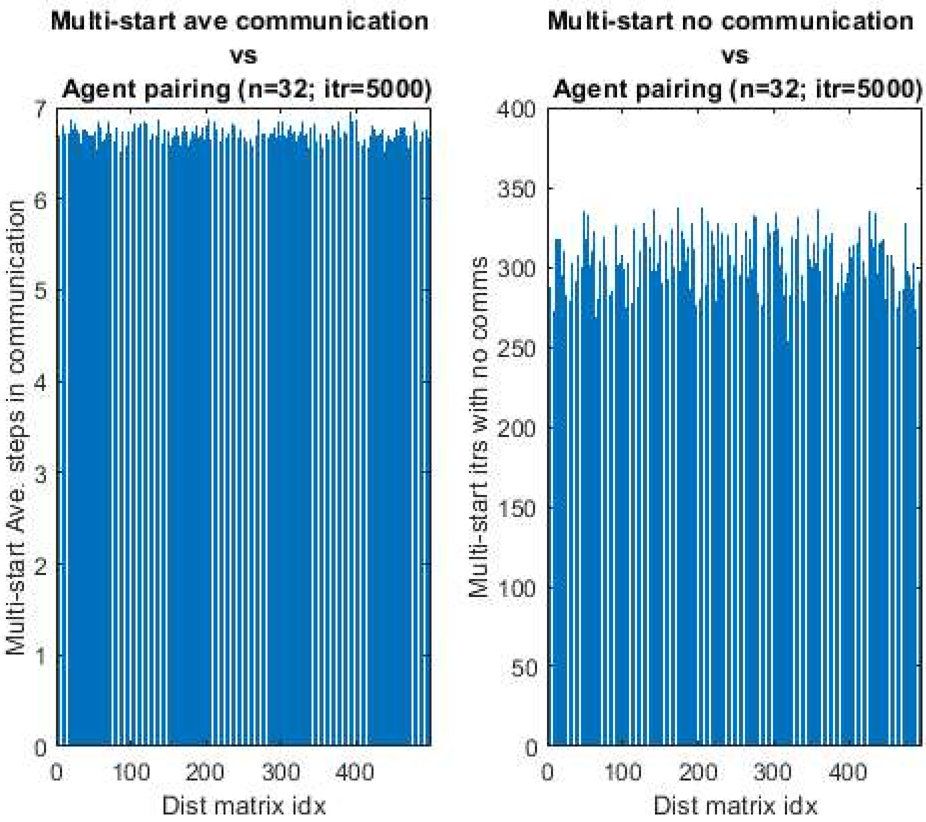
Paths of 32 agents



Communication occurances vs. Sim iteration (n=32)



Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=32)

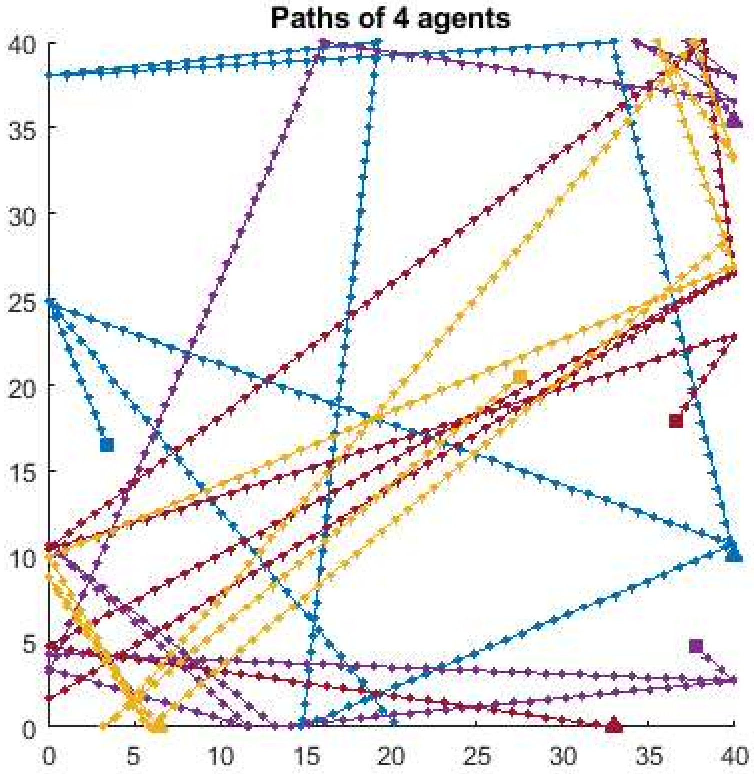


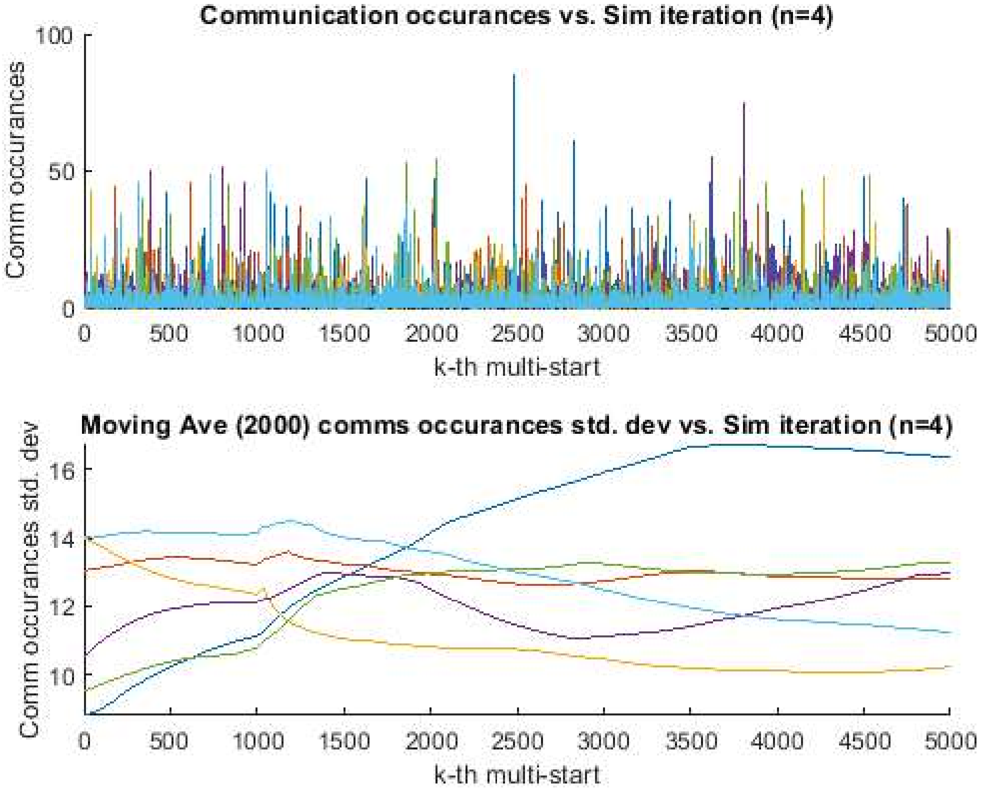
4, 8, 16, 32 Agent Multi-Start Test in 40x40 Box

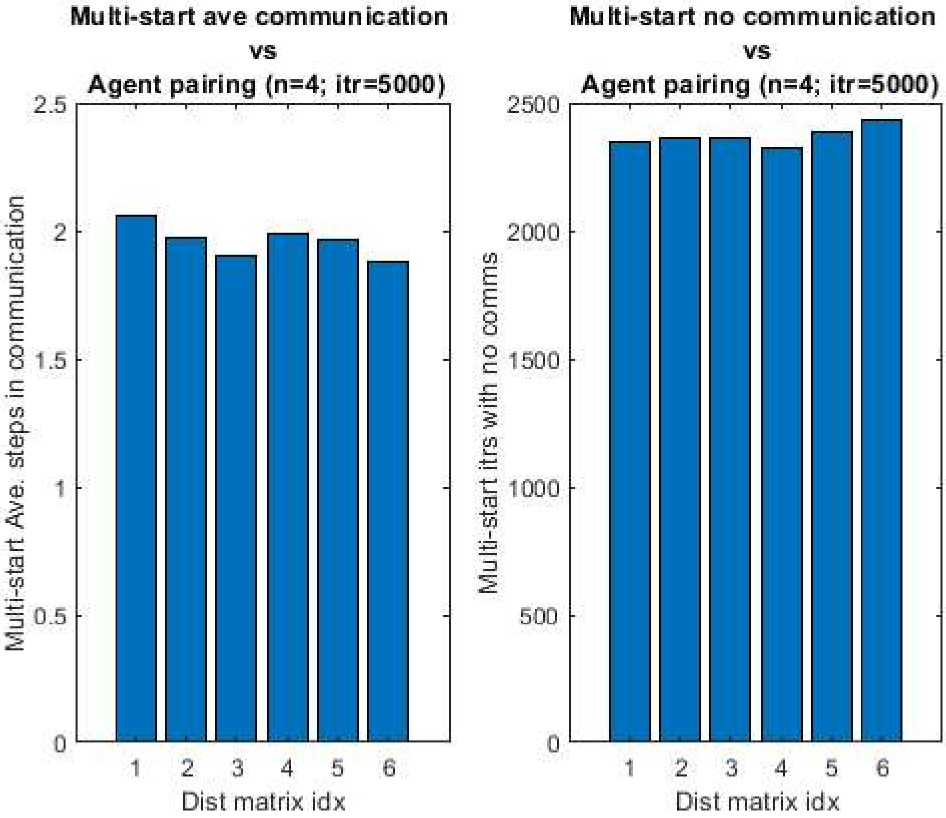
Results: 4-Agent case: ave comms [1.86, 2.01]; no comms itrs [2389, 2474] 8-Agent case: ave comms [1.82, 2.03]; no comms itrs [2342, 2491] 16-Agent case: ave comms [1.82, 2.09]; no comms itrs [2322, 2507] 32-Agent case: ave comms [1.76, 2.06]; no comms itrs [2334, 2515]

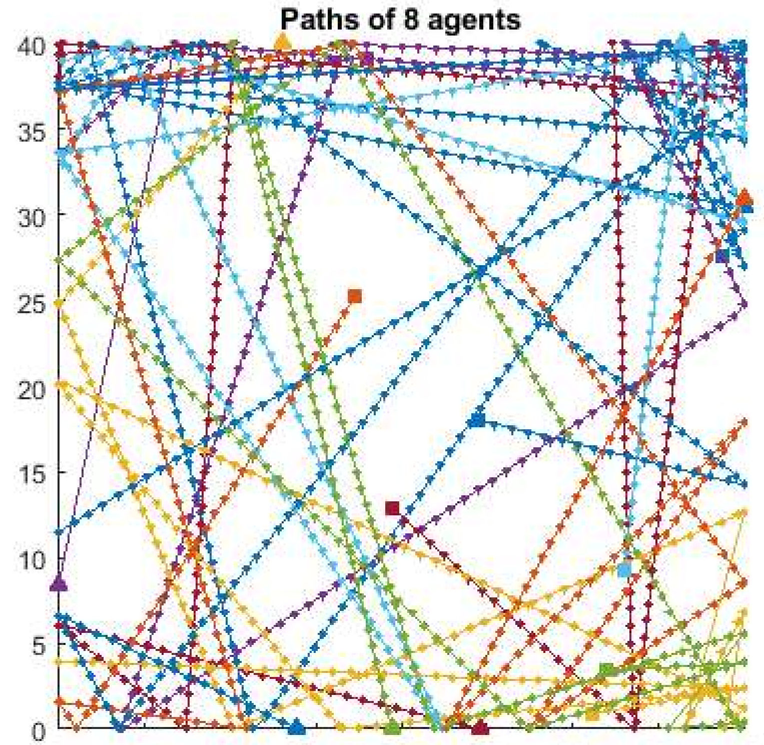
```
bounds = [0 40 40 0; 0 0 40 40];

a.multiStartData(bounds, 4, 240, 5000);                 % bounds, numAgents, N, sim_itrs
a.multiStartData(bounds, 8, 240, 5000);
a.multiStartData(bounds, 16, 240, 5000);
a.multiStartData(bounds, 32, 240, 5000);

SimAnalysis.clearEmptyFigs();
disp("Done: 40x40 multi-start")
```

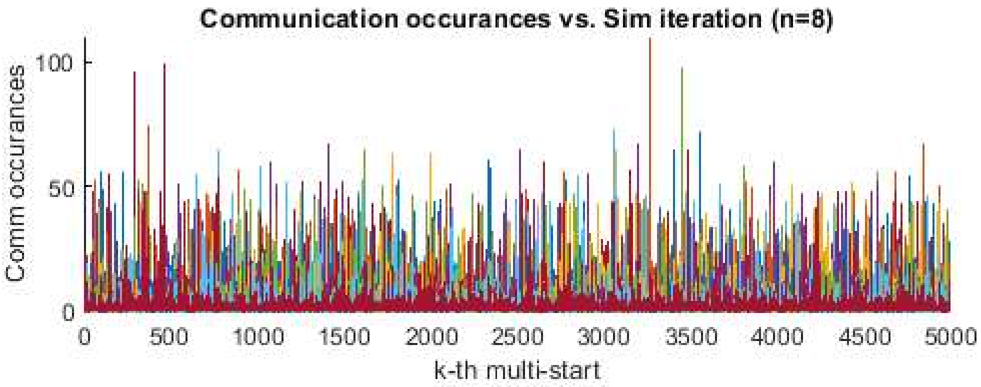
```
Done: 40x40 multi-start
```

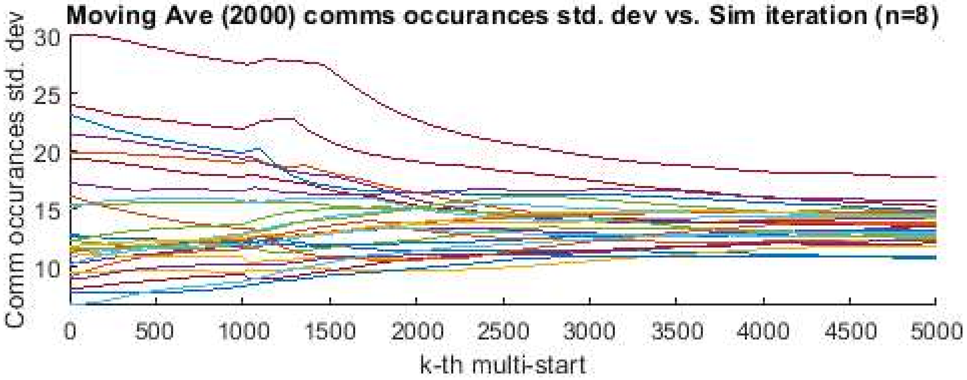

Paths of 4 agents
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40

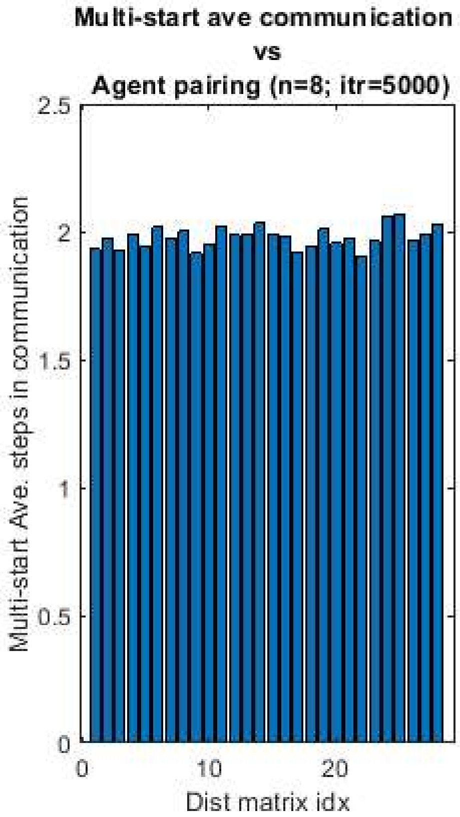

Communication occurances vs. Sim iteration (n=4)
Comm occurances
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start
Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=4)
Comm occurances std. dev
16
14
12
10
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start

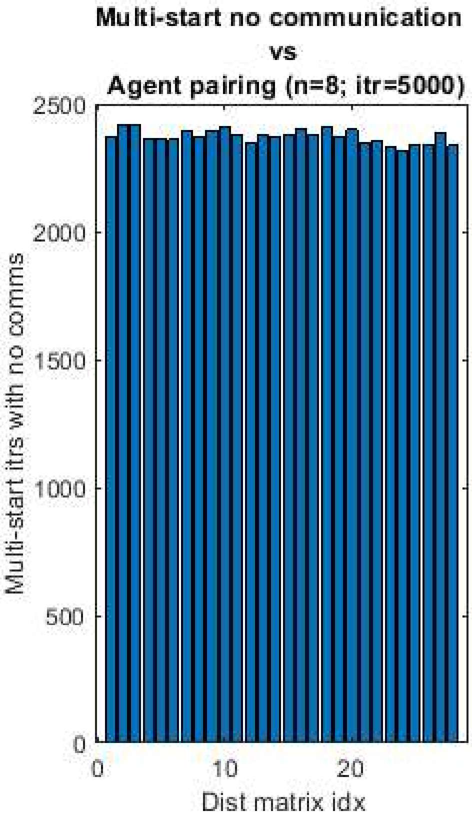

Multi-start ave communication
vs
Agent pairing (n=4; itr=5000)
Multi-start Ave. steps in communication
Dist matrix idx
0
0.5
1
1.5
2
2.5
1
2
3
4
5
6
Multi-start no communication
vs
Agent pairing (n=4; itr=5000)
Multi-start itrs with no comms
Dist matrix idx
0
500
1000
1500
2000
2500
1
2
3
4
5
6

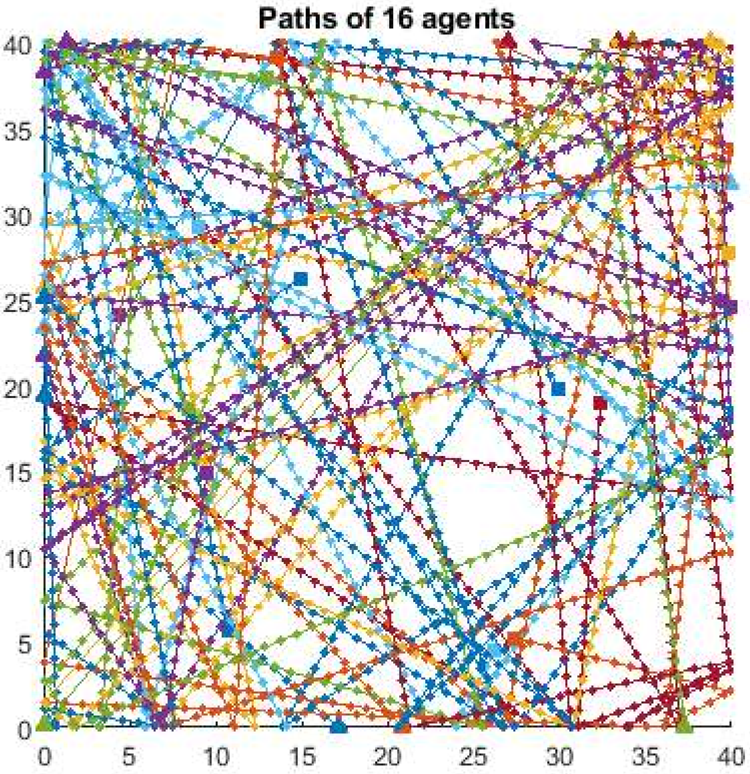

Paths of 8 agents
0
5
10
15
20
25
30
35
40
0
5
10
15
20
25
30
35
40


Communication occurances vs. Sim iteration (n=8)
Comm occurances
0
50
100
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start

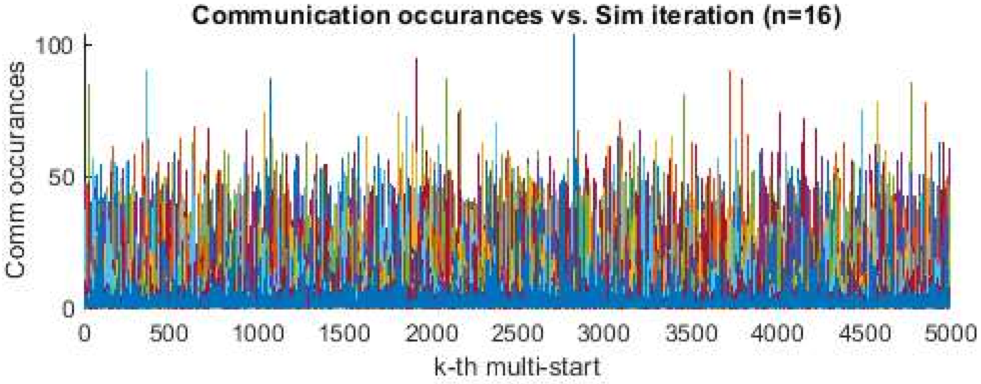

Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=8)
Comm occurances std. dev
10
15
20
25
30
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start


Multi-start ave communication
vs
Agent pairing (n=8; itr=5000)
Multi-start Ave. steps in communication
0
0.5
1
1.5
2
2.5
0
10
20
Dist matrix idx

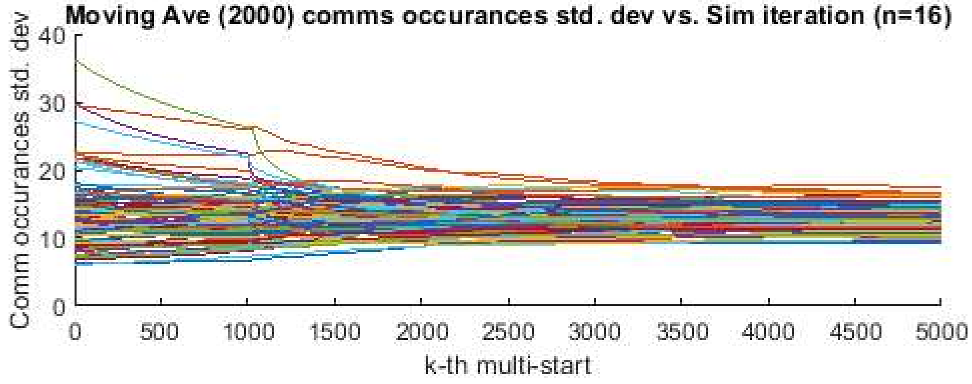

Multi-start no communication
vs
Agent pairing (n=8; itr=5000)
Multi-start itrs with no comms
0
500
1000
1500
2000
2500
0
10
20
Dist matrix idx



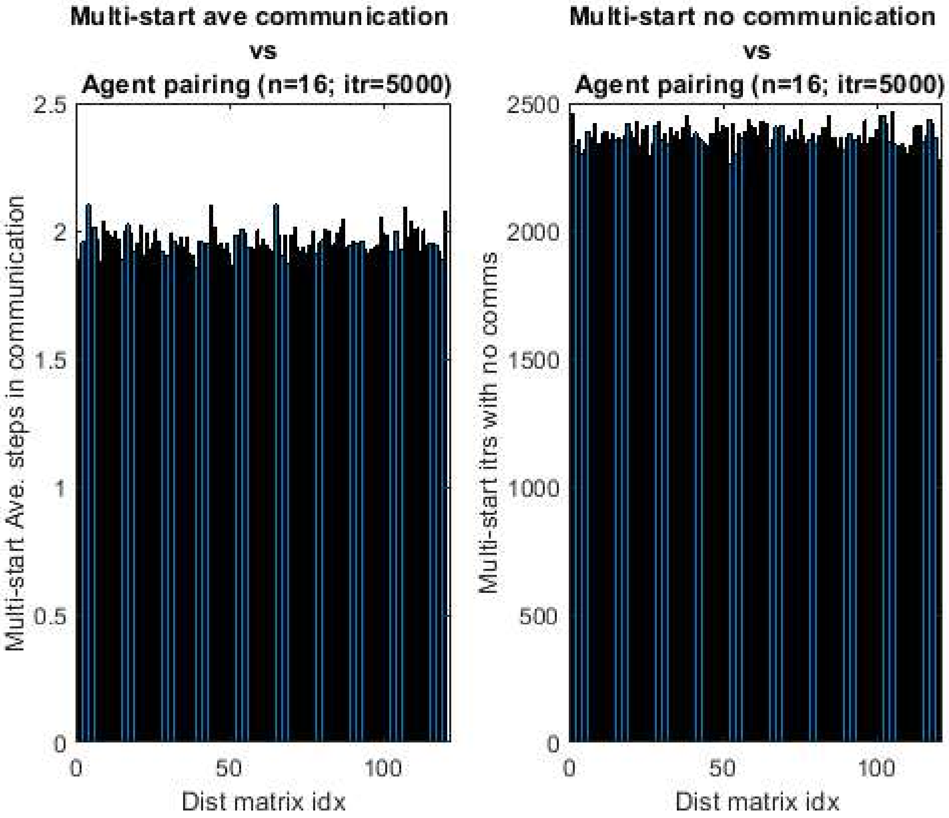
Paths of 16 agents

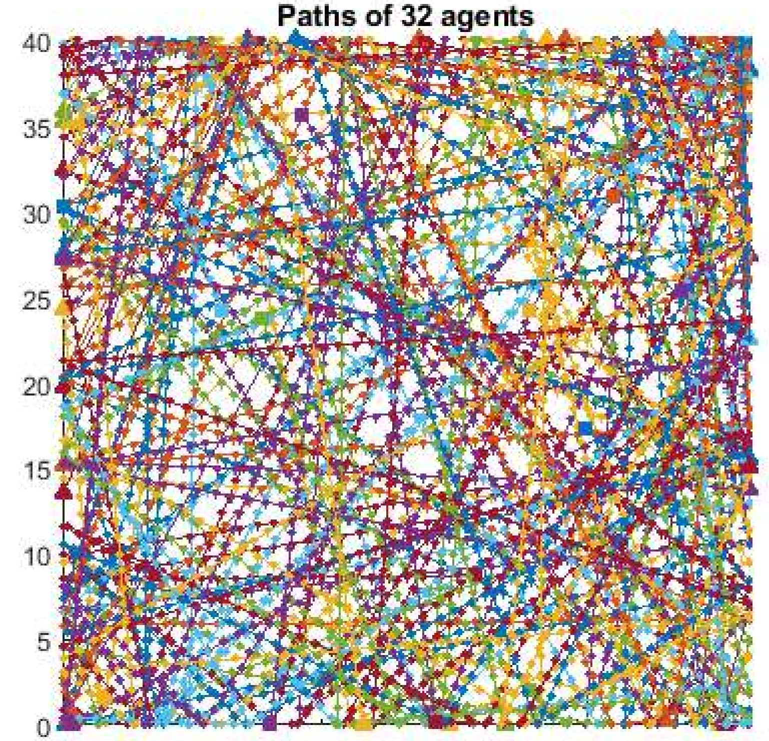


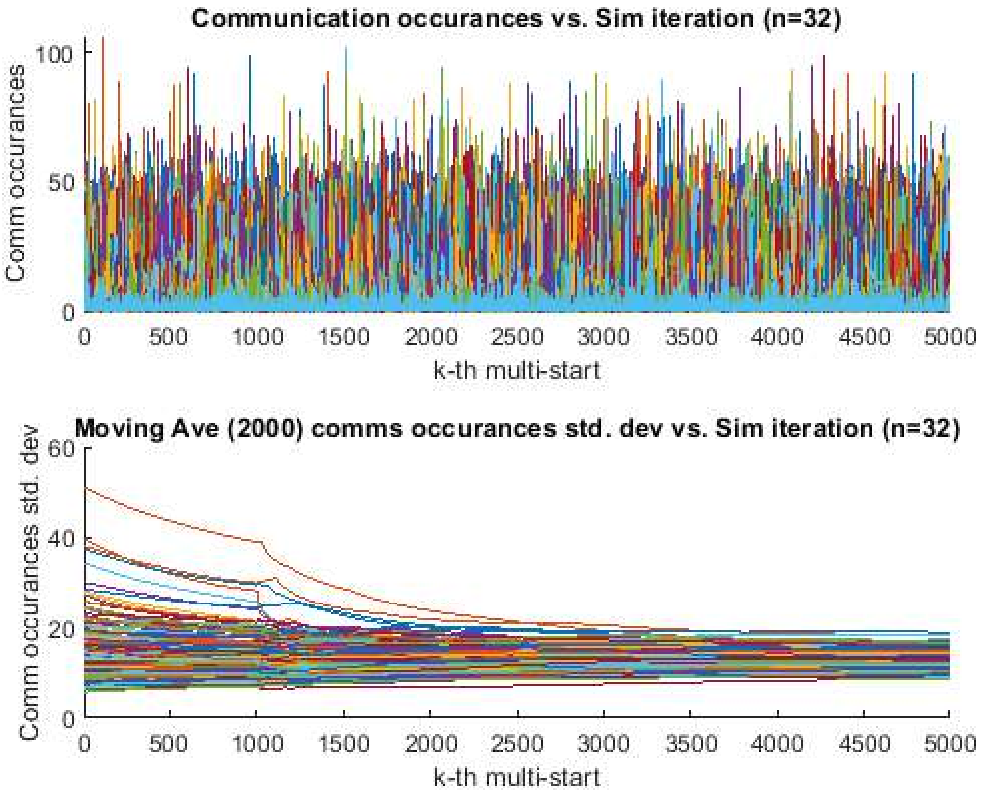
Communication occurances vs. Sim iteration (n=16)

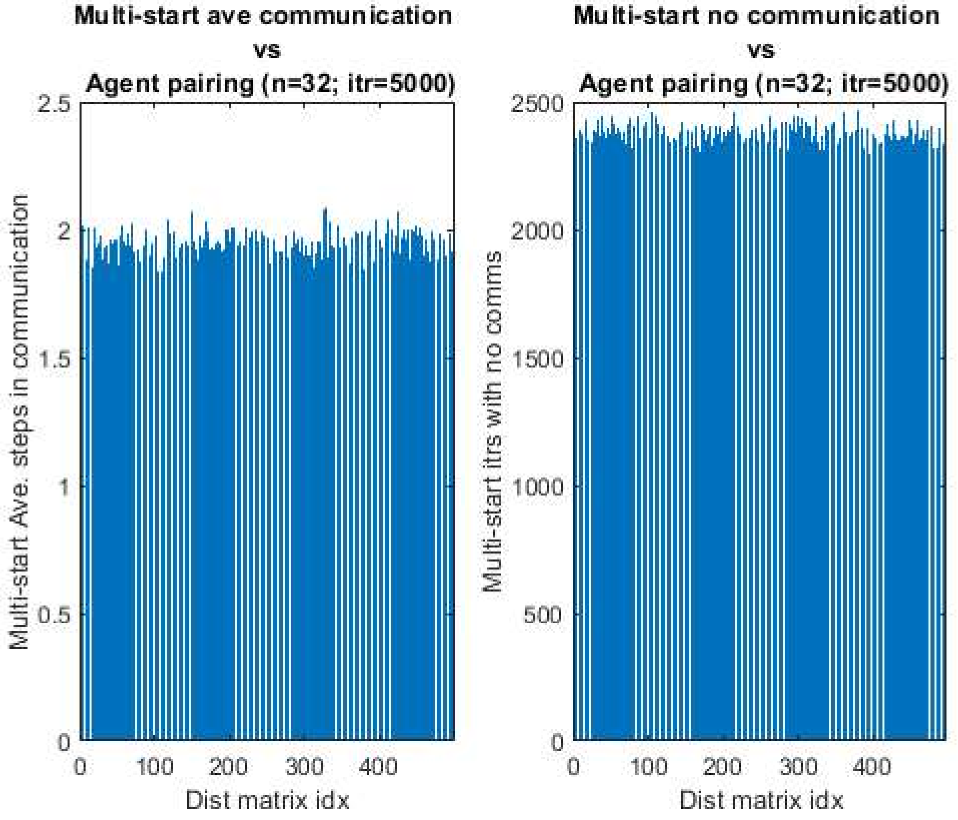


Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=16)


Multi-start ave communication
vs
Agent pairing (n=16; itr=5000)
Multi-start Ave. steps in communication
Dist matrix idx
0
0.5
1
1.5
2
2.5
0
50
100
Multi-start no communication
vs
Agent pairing (n=16; itr=5000)
Multi-start itrs with no comms
Dist matrix idx
0
500
1000
1500
2000
2500
0
50
100


Paths of 32 agents
0
5
10
15
20
25
30
35
40
0
5
10
15
20
25
30
35
40



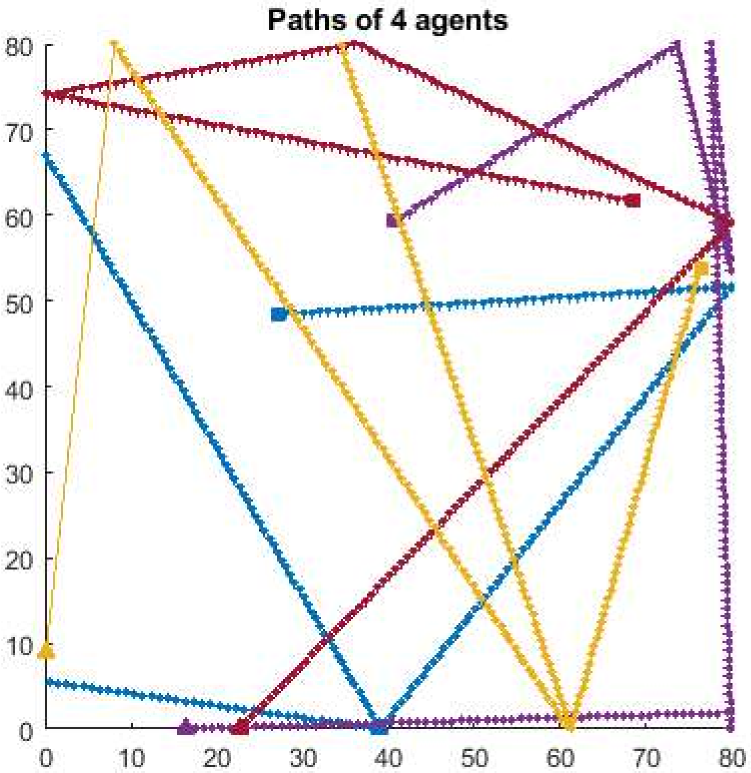


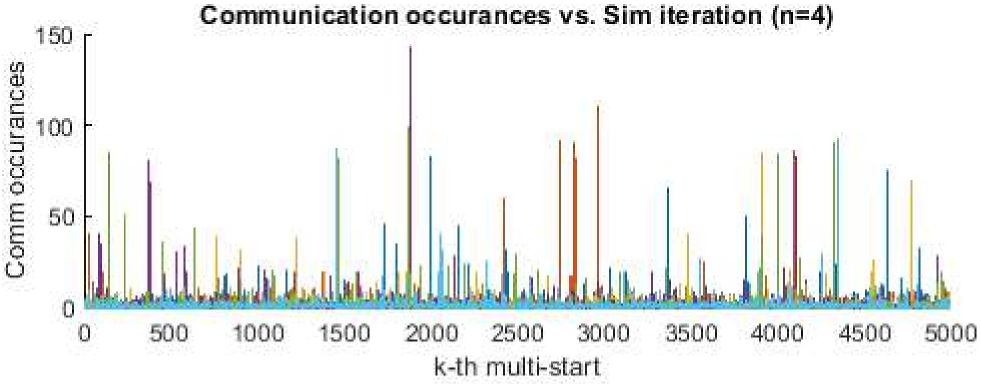
4, 8, 16, 32 Agent Multi-Start Test in 80x80 Box

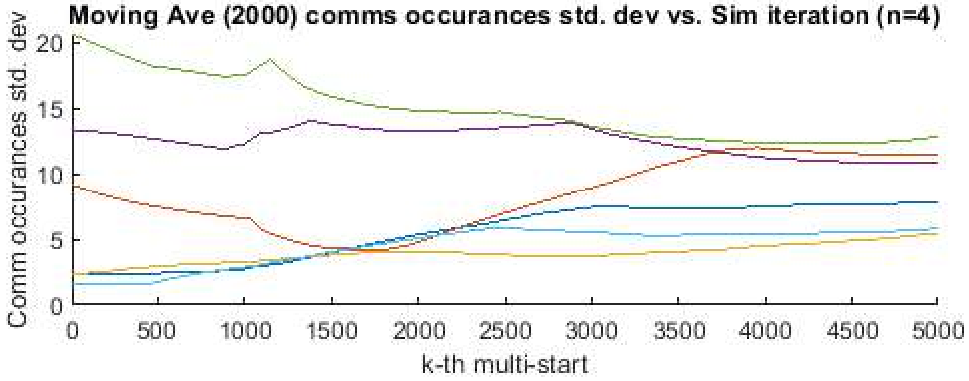
Results: 4-Agent case: ave comms [0.53, 0.61]; no comms itrs [4064, 4119] 8-Agent case: ave comms [0.49, 0.62]; no comms itrs [4031, 4140] 16-Agent case: ave comms [0.49, 0.69]; no comms itrs [4034, 4145] 32-Agent case: ave comms [0.49, 0.72]; no comms itrs [4026, 4166]

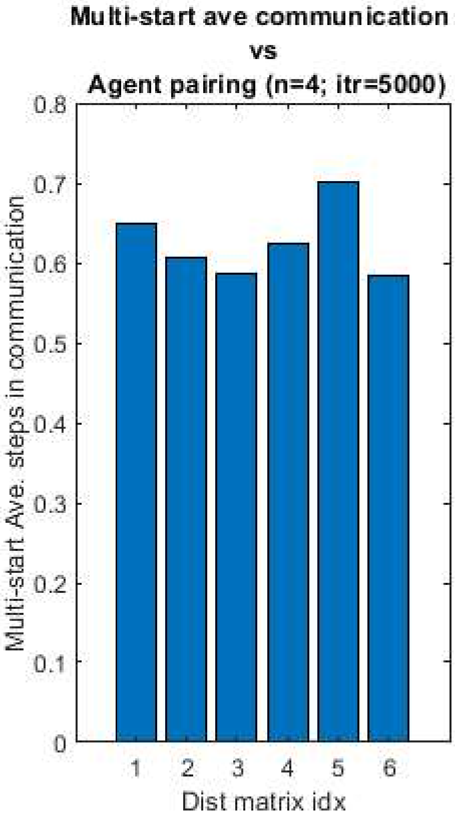
```
bounds = [0 80 80 0; 0 0 80 80];

a.multiStartData(bounds, 4, 240, 5000);                 % bounds, numAgents, N, sim_itrs
a.multiStartData(bounds, 8, 240, 5000);
a.multiStartData(bounds, 16, 240, 5000);
a.multiStartData(bounds, 32, 240, 5000);

SimAnalysis.clearEmptyFigs();
disp("Done: 80x80 multi-start")


disp('Done')
```

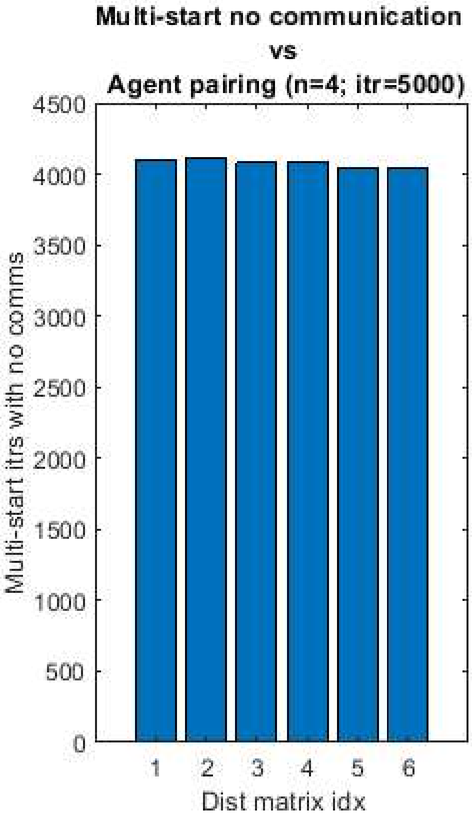
```
Done: 80x80 multi-start
Done
```

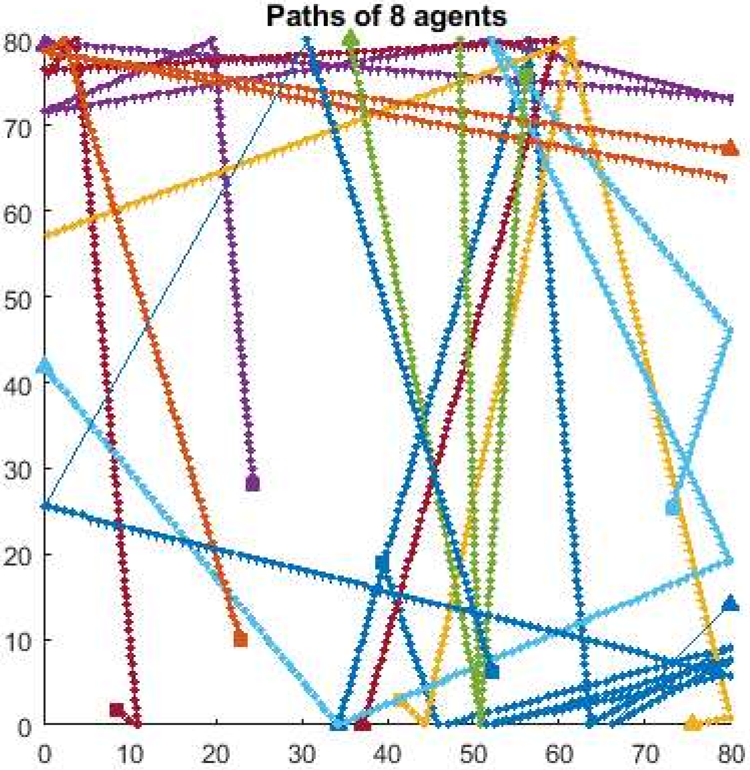

Paths of 4 agents

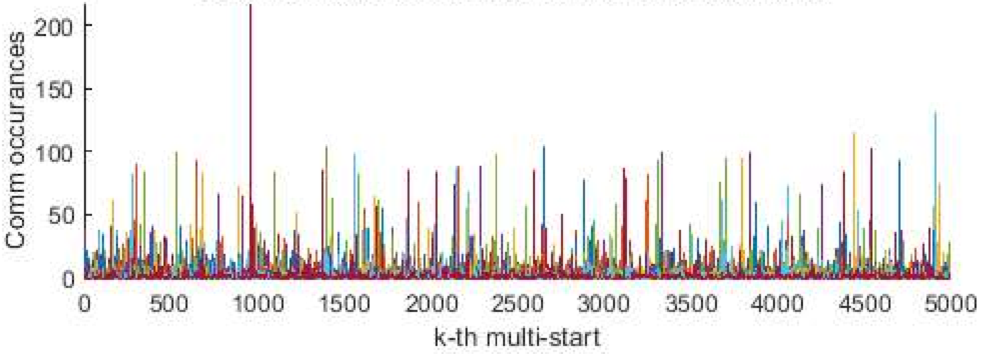

Communication occurances vs. Sim iteration (n=4)


Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=4)

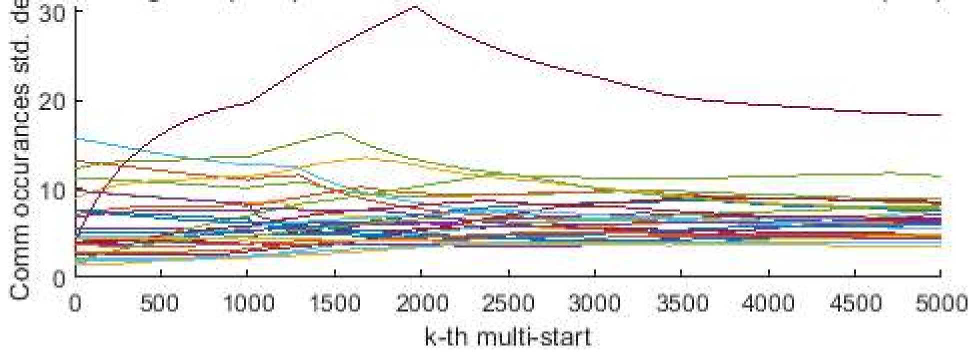

Multi-start ave communication
vs
Agent pairing (n=4; itr=5000)
Multi-start Ave. steps in communication
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1
2
3
4
5
6
Dist matrix idx


Multi-start no communication
vs
Agent pairing (n=4; itr=5000)
Multi-start itrs with no comms
0
500
1000
1500
2000
2500
3000
3500
4000
4500
1
2
3
4
5
6
Dist matrix idx


Paths of 8 agents
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
80

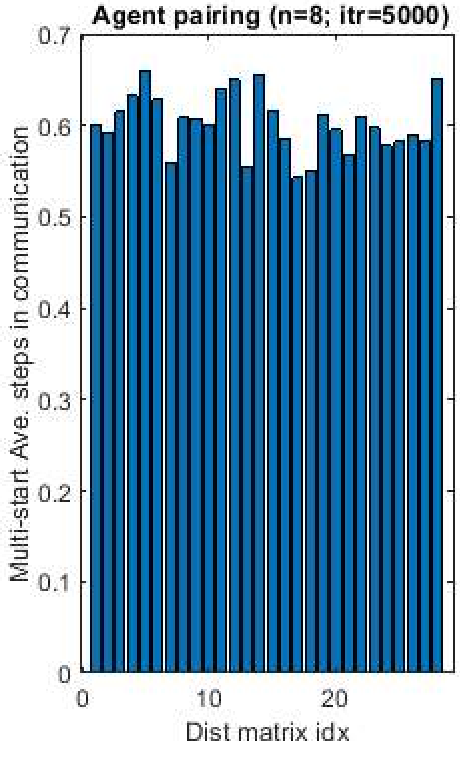


Communication occurances vs. Sim iteration (n=8)

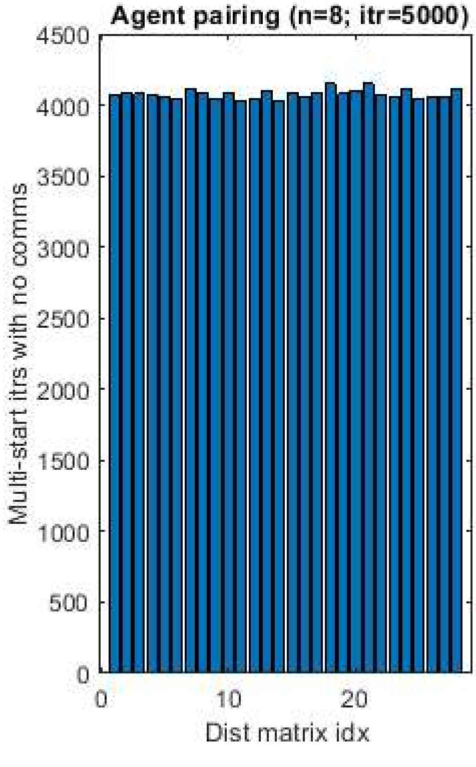


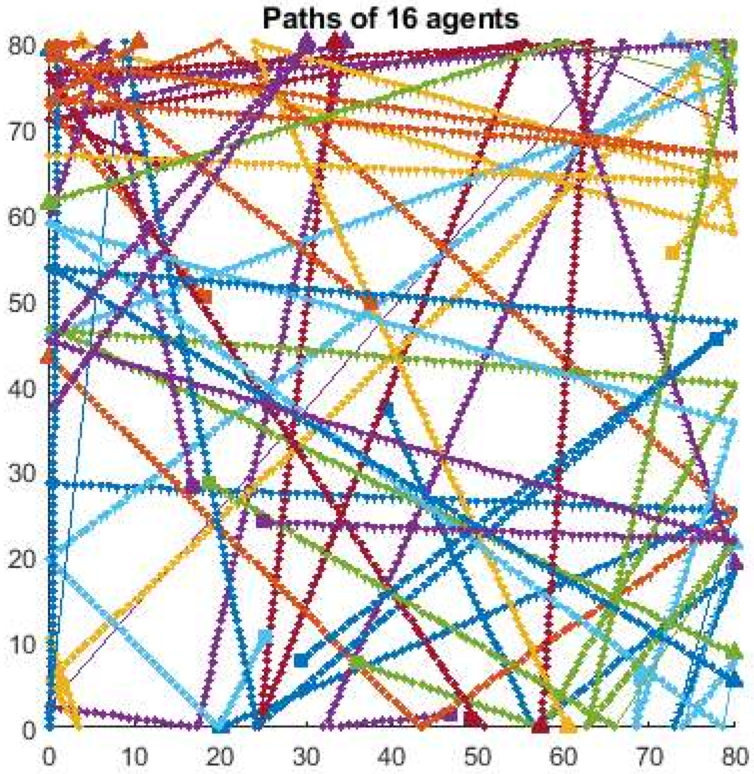
Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=8)

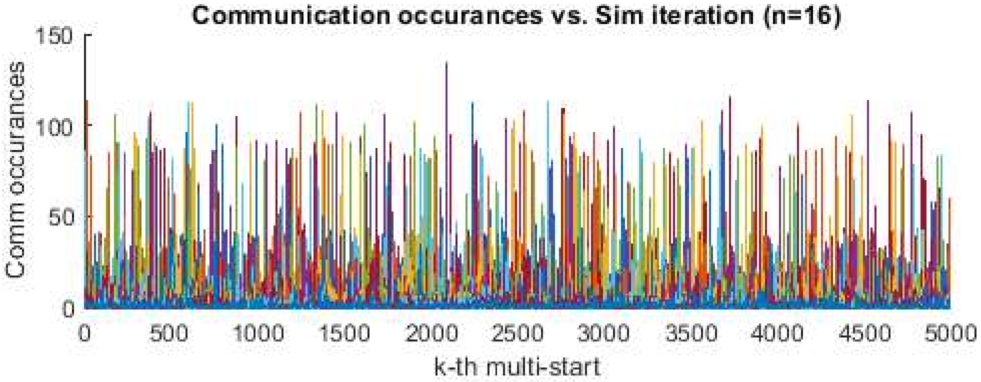
Multi-start ave communication
vs
Agent pairing (n=8; itr=5000)

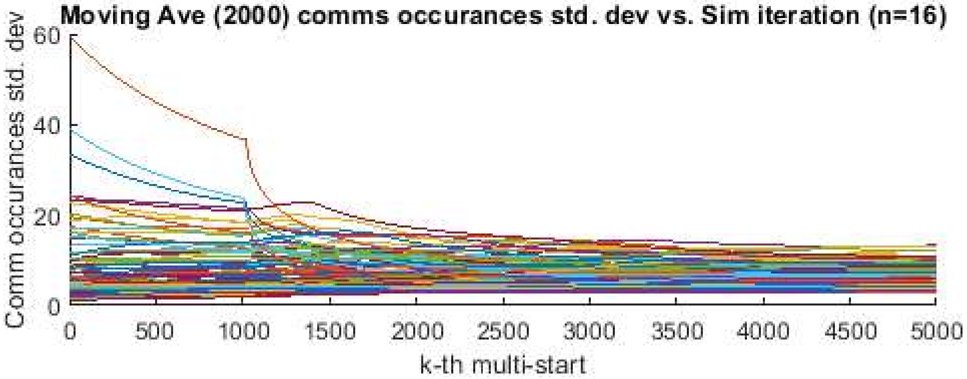


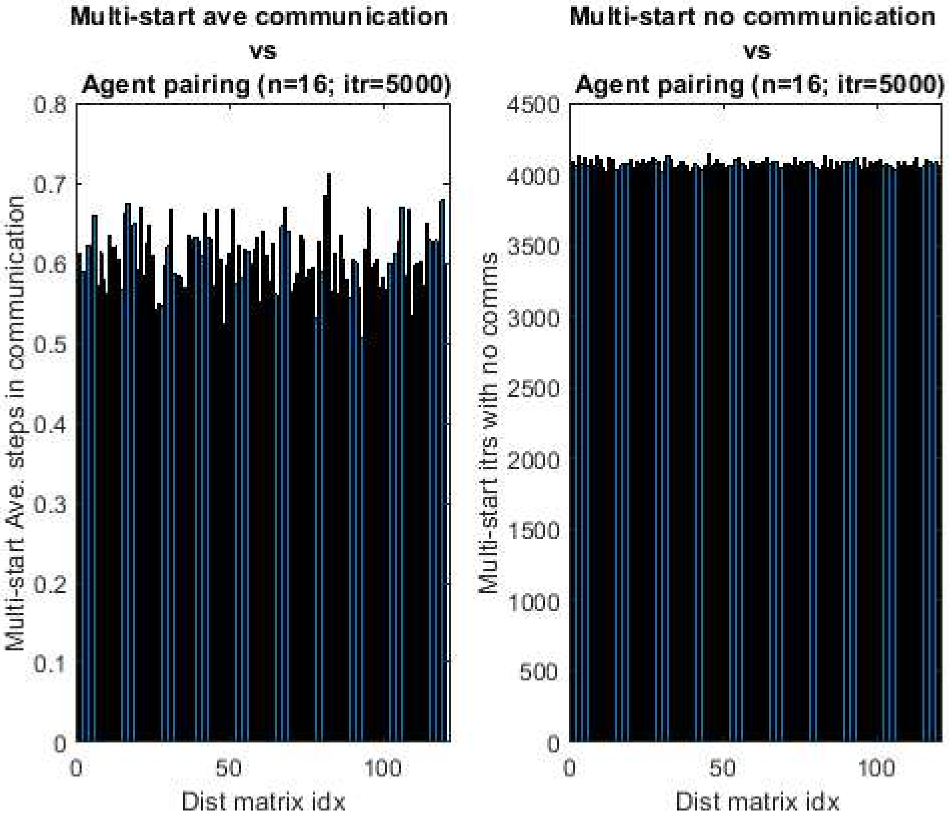
Multi-start no communication
vs
Agent pairing (n=8; itr=5000)

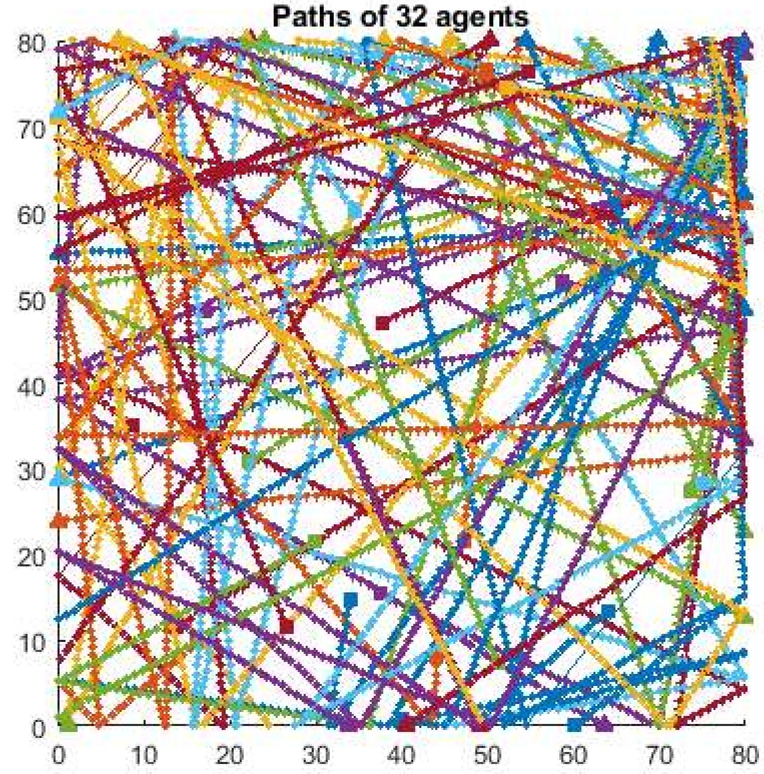


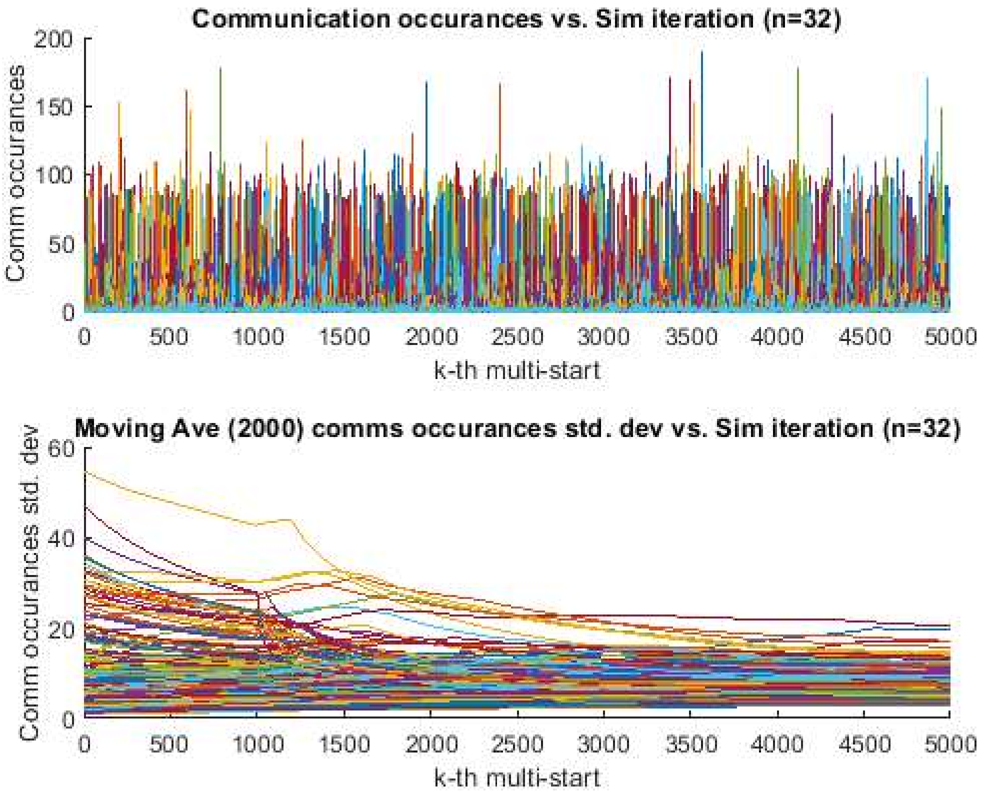

Paths of 16 agents
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
80


Communication occurances vs. Sim iteration (n=16)
Comm occurances
0
50
100
150
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start


Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=16)
Comm occurances std. dev
0
20
40
60
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
k-th multi-start

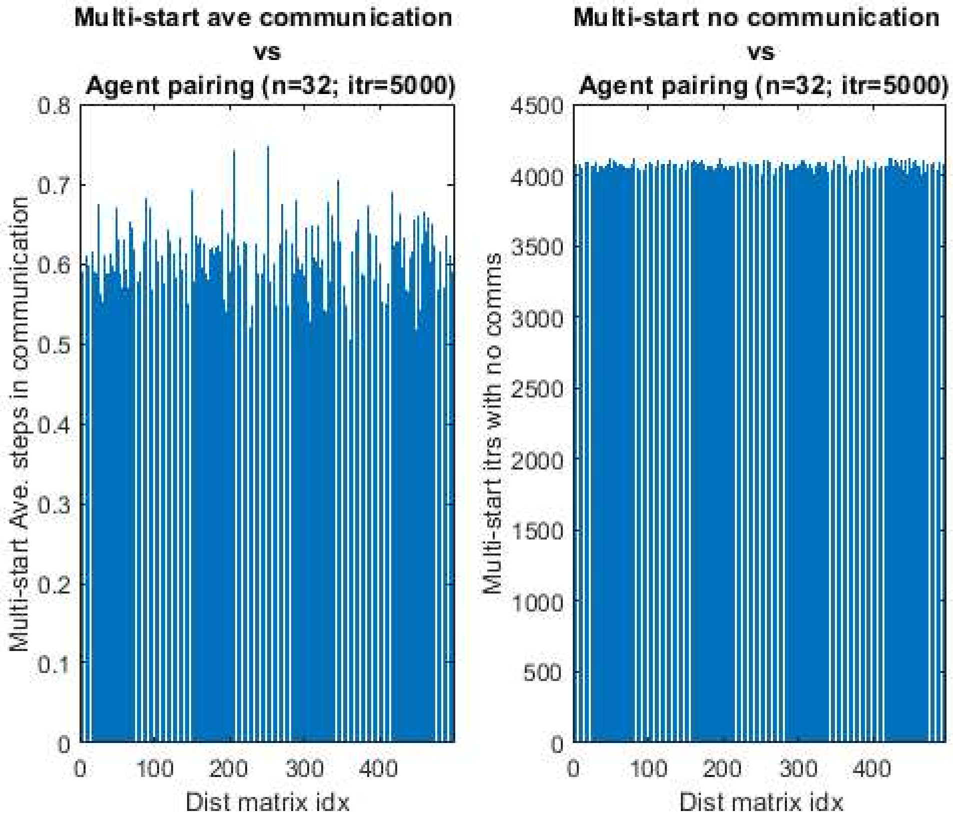

Multi-start ave communication
vs
Agent pairing (n=16; itr=5000)
Multi-start Ave. steps in communication
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
50
100
Dist matrix idx
Multi-start no communication
vs
Agent pairing (n=16; itr=5000)
Multi-start itrs with no comms
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
50
100
Dist matrix idx


Paths of 32 agents
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
80



Communication occurances vs. Sim iteration (n=32)

Moving Ave (2000) comms occurances std. dev vs. Sim iteration (n=32)



Multi-start ave communication vs Agent pairing (n=32; itr=5000)

Multi-start no communication vs Agent pairing (n=32; itr=5000)

Published with MATLAB® R2021b