Network Motifs with MASS

(Midterm Report)

Matt Kipps
10/30/2014

Project Details

Prof Kim:

- Analyze biological data for statistically significant subgraphs (motifs).

Prof Fukuda:

- Evaluate MASS implementation against MapReduce and sequential implementations

What is MASS?

Multi-**A**gent **S**patial **S**imulation

- designed for simulations
- creates a virtual space over an arbitrary cluster
- abstracts cluster management from programmer

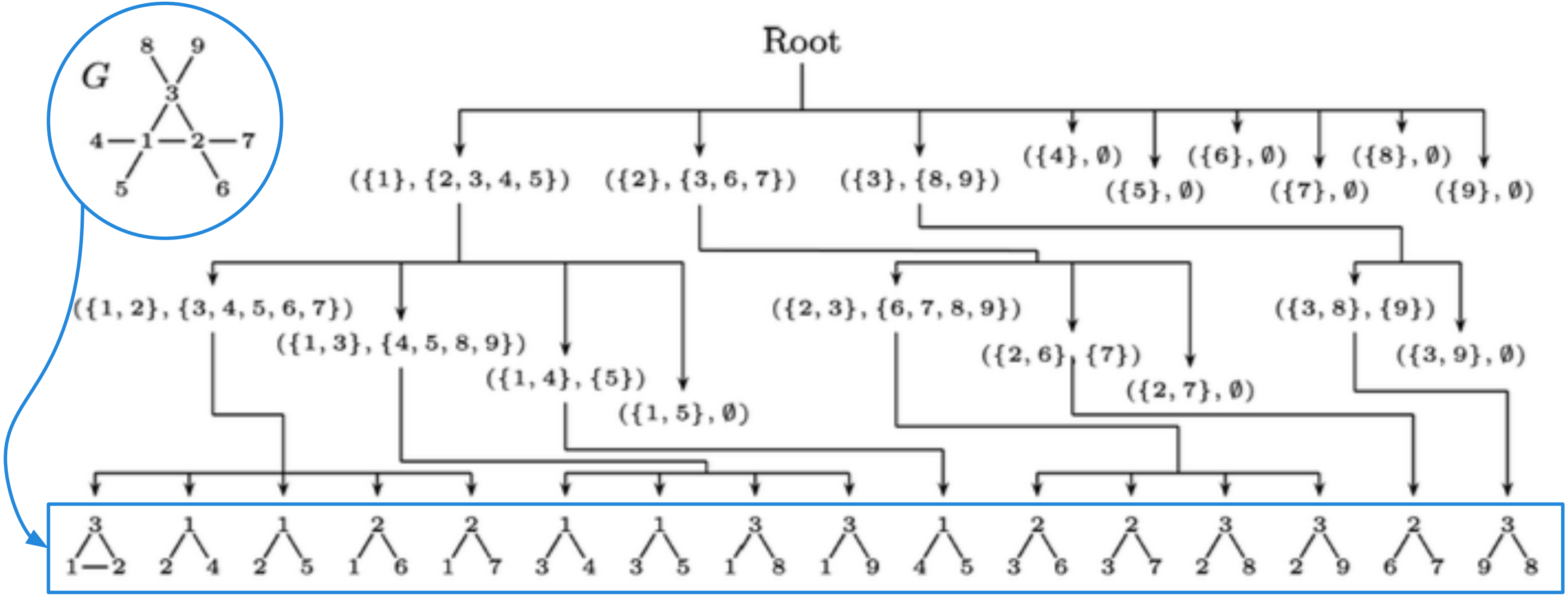
What are Network Motifs?

Statistically significant subgraphs within a network.

Given a motif size **n**,

- Find all subgraphs of order **n** within the network
- Determine subgraph equivalence and count the frequency (and compare to random network)
- Motifs are those subgraphs which occur most often

Finding Subgraphs with ESU



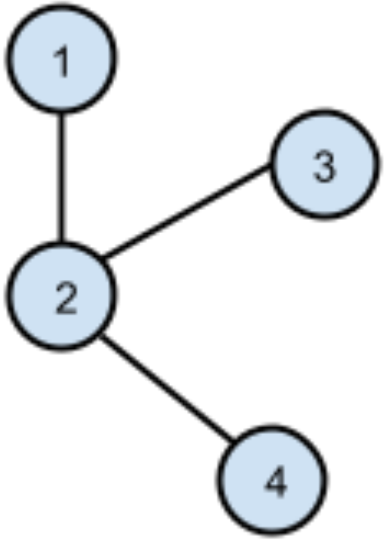
MASS + Network Motifs

This project seeks to simulate “crawlers” that move through a network. Replace recursion with spawning new crawlers.

GraphCrawler extends *Agent*

GraphNode extends *Place*

Algorithm

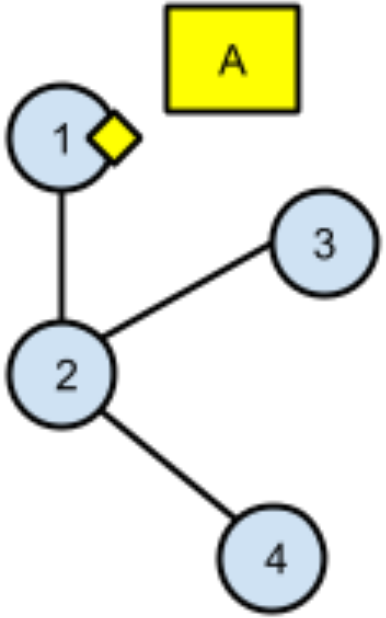


Step 0

Initial network

Agents will be searching for a subgraph motif size of **3** nodes.

(For simplicity, this sketch only shows the behavior of the first agent spawned. Another agent will also be spawned at Node 2 and will recover another subgraph not shown here)

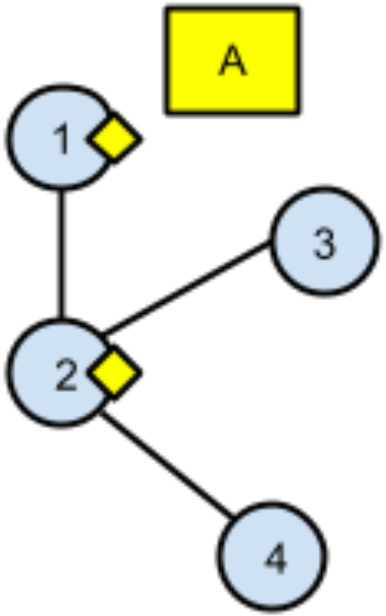


Step 1

Agent A is spawned at node 1

Agent A has a size of 1, so Agent A will keep searching.

Node 1 has only 1 branch so Agent A will not need to spawn any new Agents.

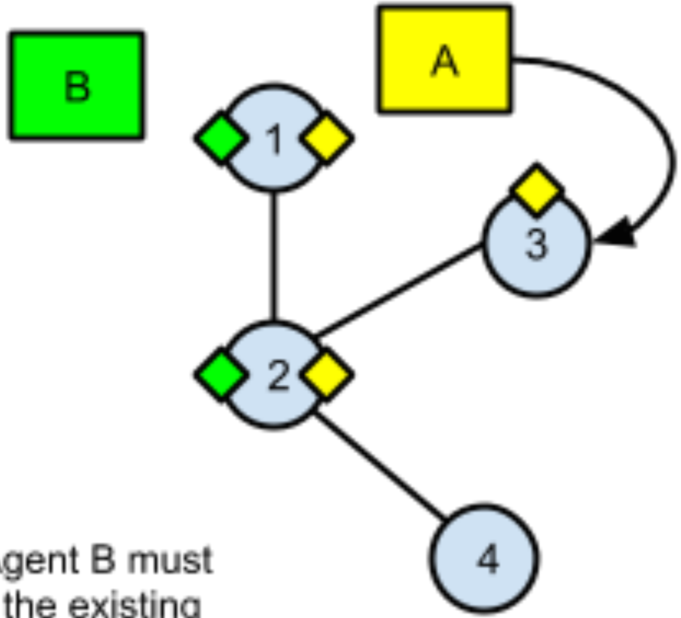


Step 2

Agent A is now at Node 2, and represents the subgraph of “1,2”

Agent A has a size of 2, so Agent A will keep searching.

Node 2 has 2 branches so Agent A will traverse one, and will create a child clone to traverse the other. This can be seen in the next step.



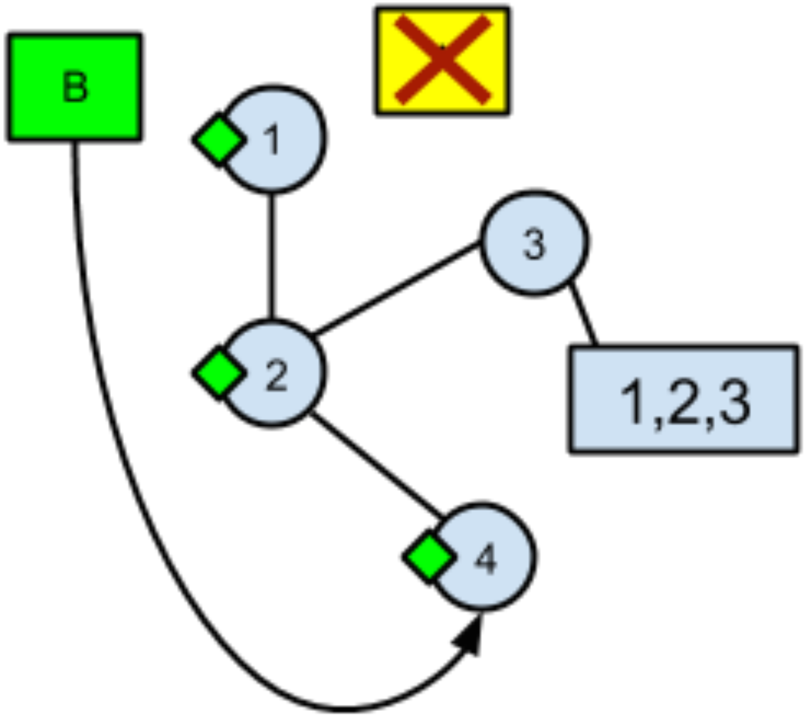
Note - Agent B must "inherit" the existing subgraph path "1,2" from Agent A.

Step 3

Agent A is now at Node 3, with subgraph of "1,2,3"
Agent B is spawned with subgraph of "1,2" and directions to move to Node 4

Agent A has a size of 3, so it will terminate itself and deposit the results Node 3.

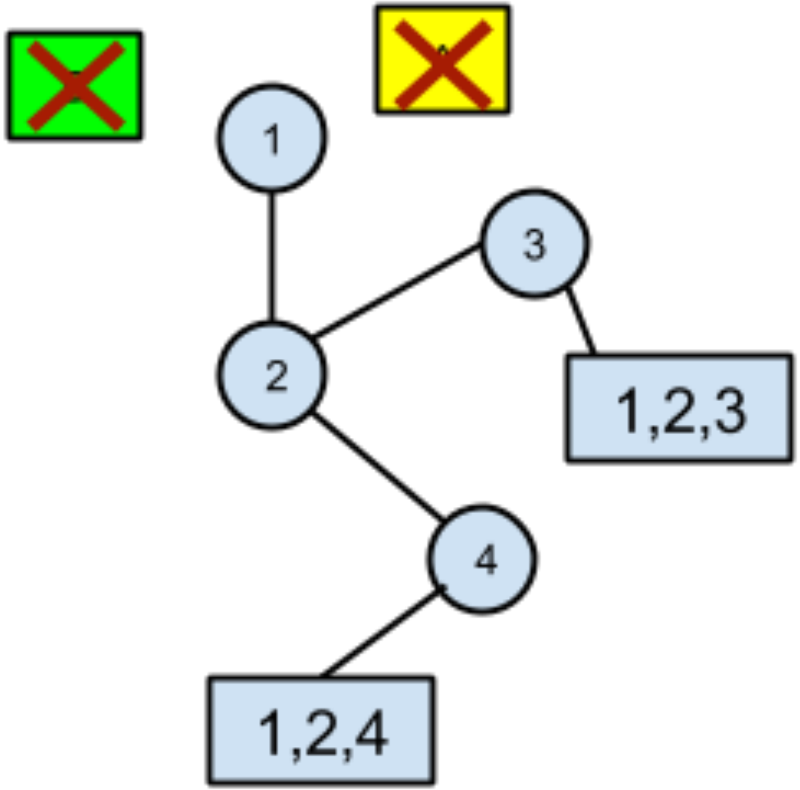
Notice that Agent B is one step behind Agent A because Agent B must be spawned first and then migrate, before proceeding with the algorithm.



Step 4

Agent A is now terminated, and its subgraph of “1,2,3” is stored at Node 3.
Agent B migrated to Node 4, and now has a subgraph of “1,2,4”

Agent B has a size of 3, so now it will also terminate itself and deposit the subgraph results at it's final node, Node 4.



Step 5

Agent B is now terminated, and its subgraph of “1,2,4” is stored at Node 4.

When the entire network traversal is complete, the MASS-based program collects all data from all network nodes, using the return values through the places callAll() method.

Algorithm

After finding all subgraphs, the subgraphs are collected at the master node.

Then, sequentially:

- the subgraphs are sent to **`labelg`** to get canonical labels.
- the canonical labels are counted.

Algorithm Progress

At this point, basic implementation is complete.

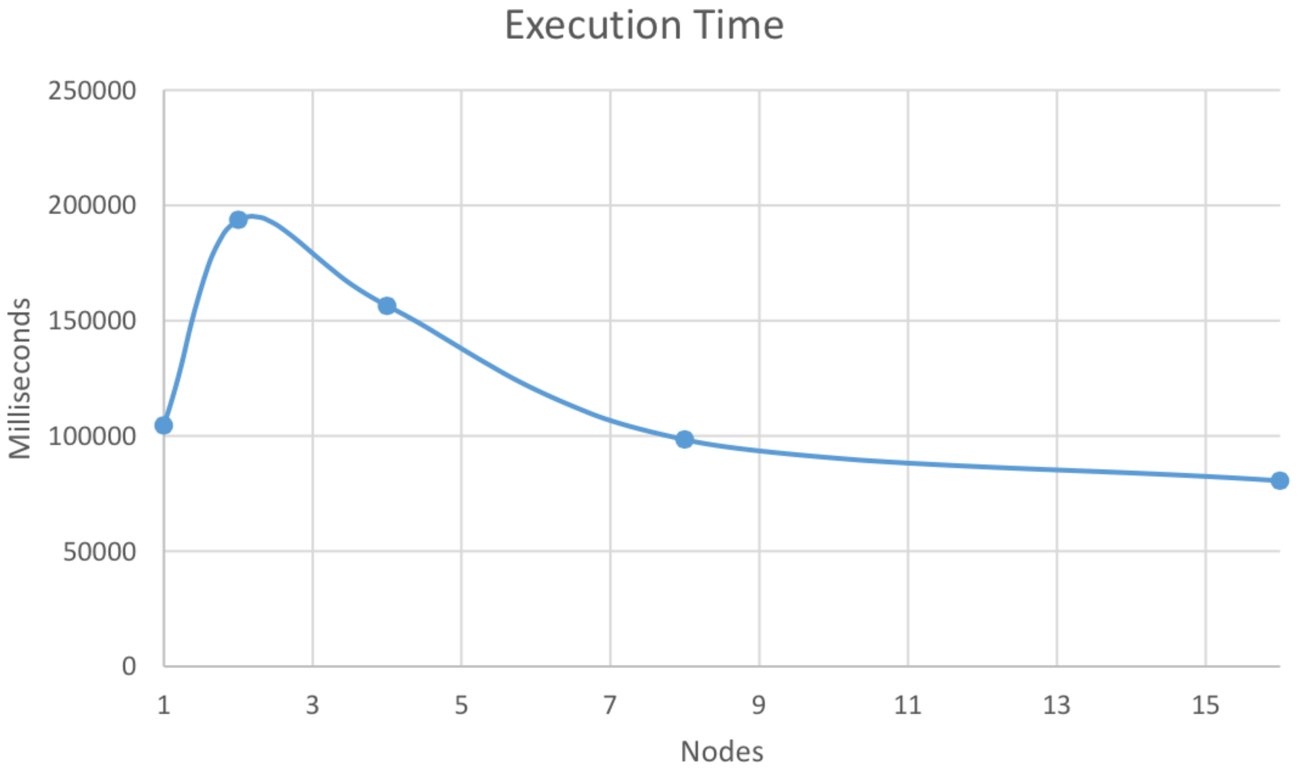
Performance

Input

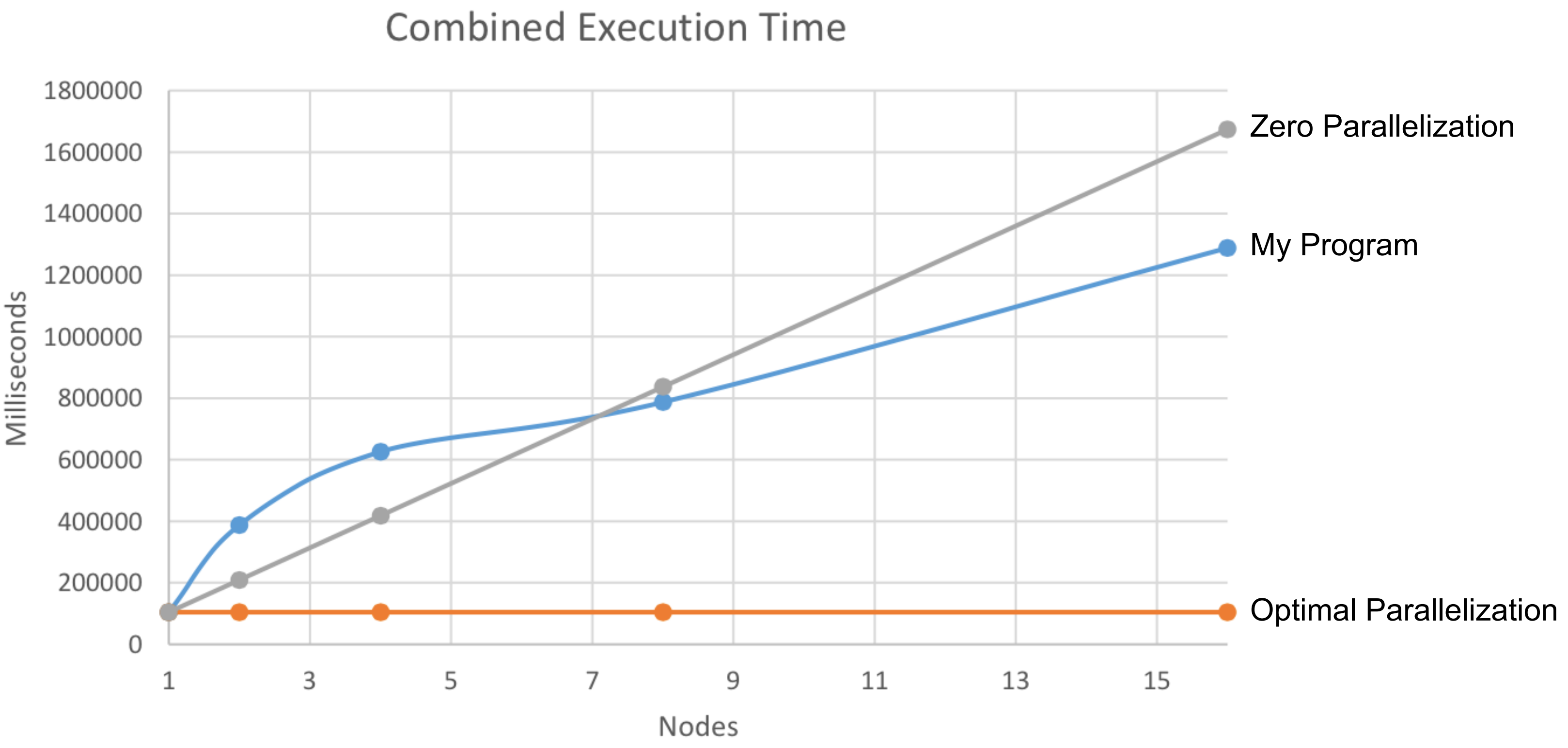
Network size of ~2500 nodes

Analyzing motif of size 5

Performance Analysis



Parallel Performance Analysis



Next Steps

Conduct Evaluation

- Performance vs MapReduce implementation (identical cluster, possibly Google Cloud)

- Programmability of MASS program vs MapReduce program and sequential program

Optimize Program

Prior to conducting evaluation, I will be focusing on optimizing and refining the program.

Primarily:

- Optimizing MASS Agent handling
- Dispersing Agent spawning in algorithm

Agent Population

One more thing...

One more thing...

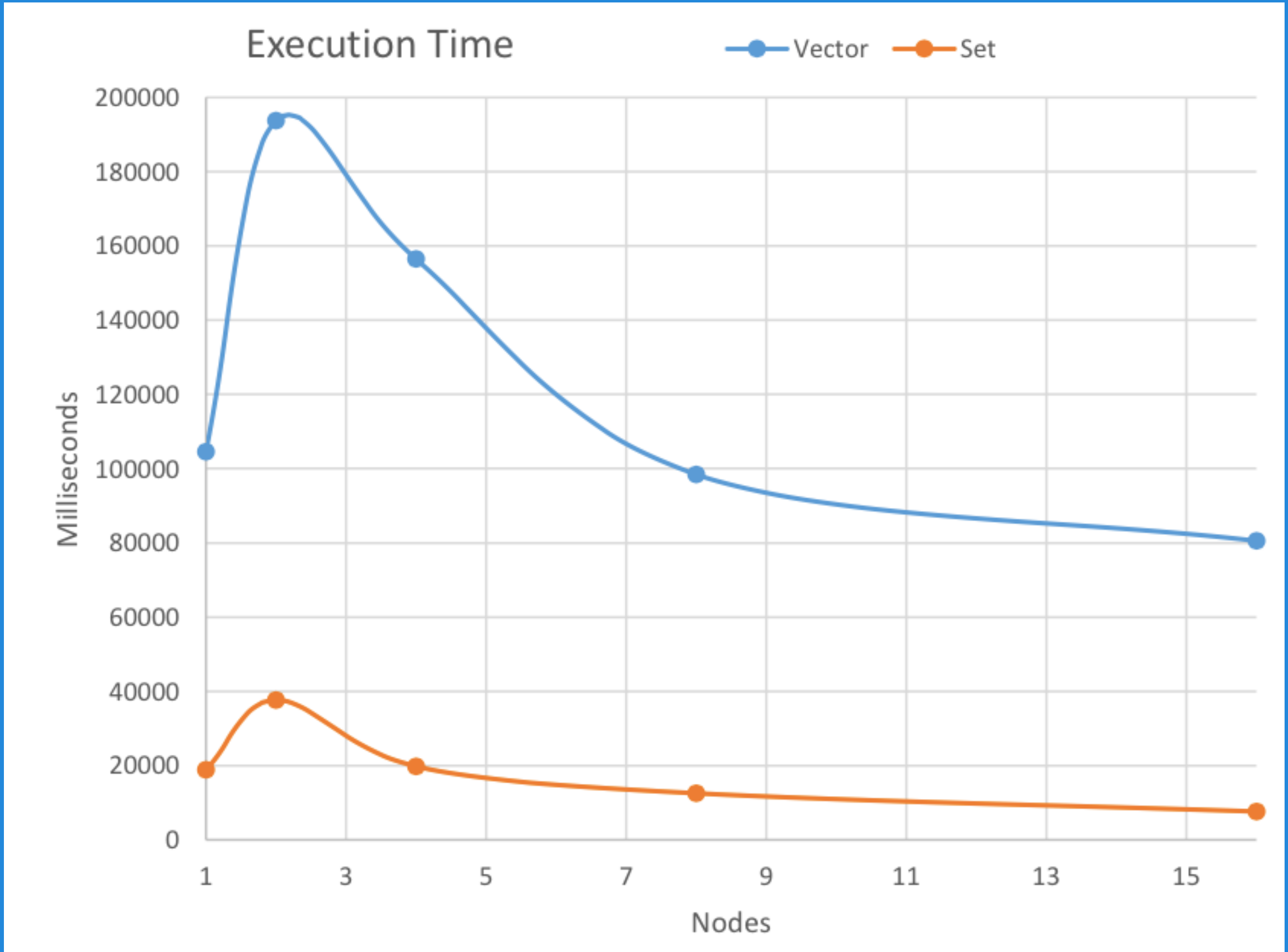
`Place.java`

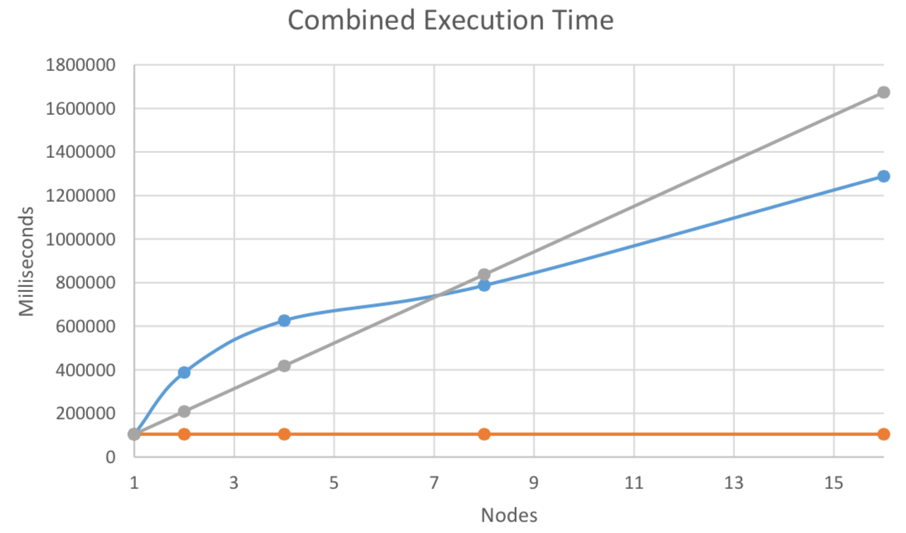
replaced:

```
Vector<Agent> agents = new Vector<Agent>( );
```

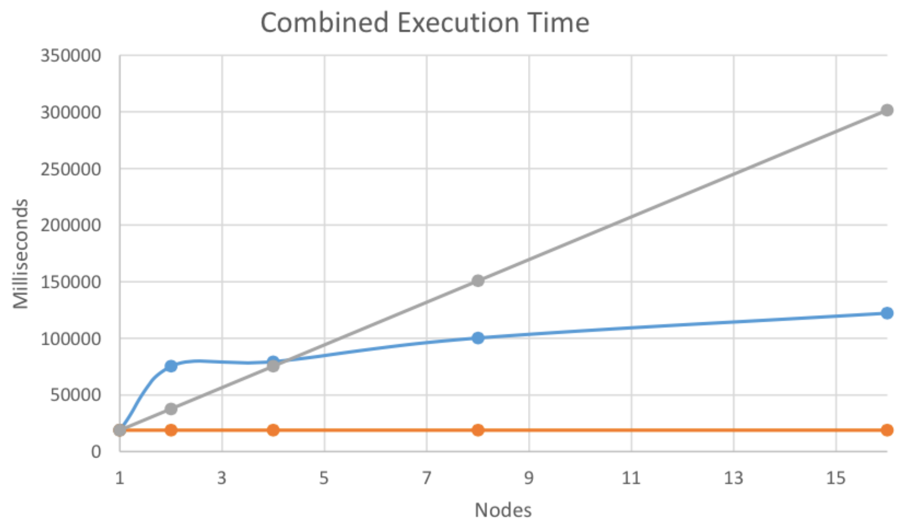
with:

```
Set<Agent> agents = Collections.synchronizedSet(
    new HashSet<Agent>( ) );
```


Execution Time
Vector
Set
Milliseconds
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1
3
5
7
9
11
13
15
Nodes


Combined Execution Time
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
Milliseconds
1
3
5
7
9
11
13
15
Nodes

Vector


Combined Execution Time
350000
300000
250000
200000
150000
100000
50000
0
Milliseconds
1
3
5
7
9
11
13
15
Nodes

Set