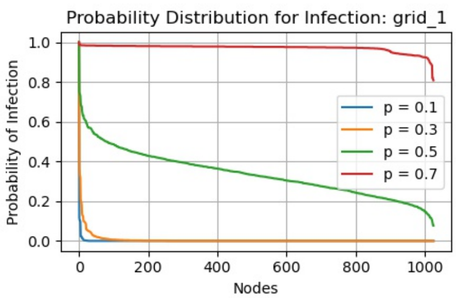
# 1 Grid Graph Analysis

1. **$G^1_{gr}$ and $G^4_{gr}$ Infected Nodes and Probability Distribution**

   For the two grid graphs, the infected node count is shown below for each probability level.



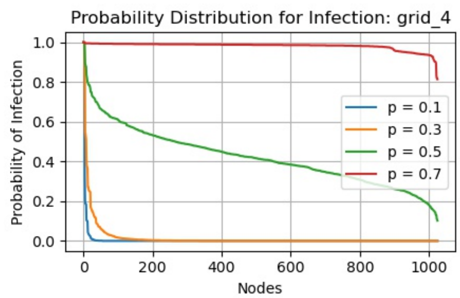




Table 1: Count of Infected Nodes

| p | $G^1_{gr}$ | $G^4_{gr}$ |
|---|---|---|
| 0.1 | 28 | 56 |
| 0.3 | 310 | 417 |
| 0.5 | 1024 | 1024 |
| 0.7 | 1024 | 1024 |

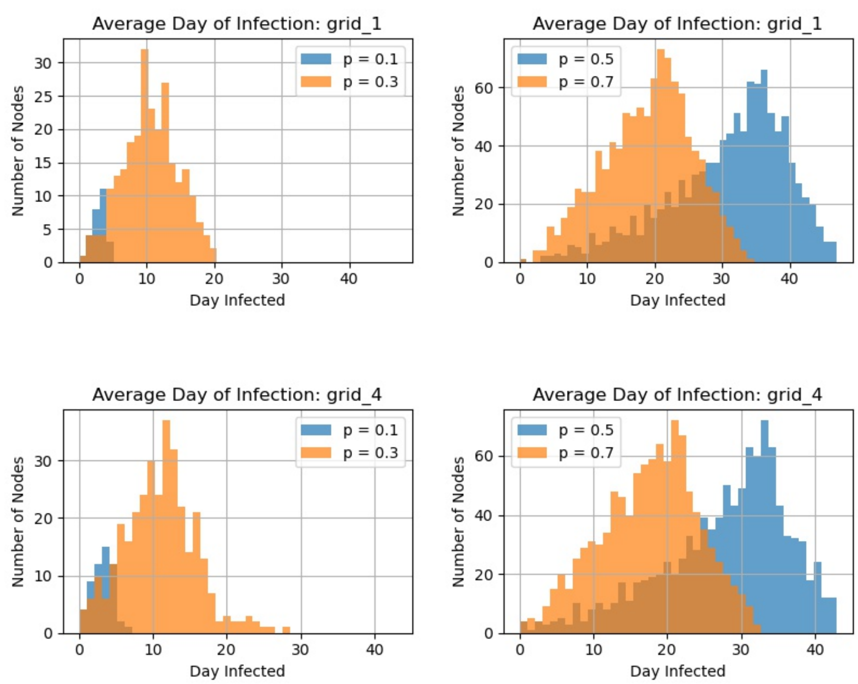
   $G^4_{gr}$, the grid graph with four infected source nodes, has clearly higher infection rates in the 0.1 and 0.3 probability levels. At 0.5 and above, however, both graphs have a significant probability of infection for all 1024 nodes. The following figures show the probability distributions for both graphs.

   The probability distributions for $G^1_{gr}$ and $G^4_{gr}$ seem to follow the same pattern, but $G^4_{gr}$ has a slightly higher absolute probability of infection for the same number of nodes. This makes sense as the graphs are of the same general structure, so they scale similarly.

2. **$G^1_{gr}$ and $G^4_{gr}$ Days to Infection Distribution**

   The days to infection are provided here for $G^1_{gr}$ and $G^4_{gr}$ respectively at each probability level. 0.1: 3.43 and 3.62, 0.3: 10.89 and 11.17, 0.5: 30.74 and 27.72, 0.7: 19.19 and 17.70.

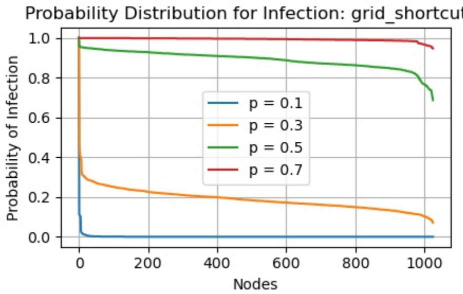
   The average infection time is pretty close between $G^1_{gr}$ and $G^4_{gr}$ until we reach the p levels of 0.5 and 0.7. These are also the cases where the graph gets more saturated as seen in the previous section. The histograms below show the distribution for each p level.




   The most interesting change is from 0.5 to 0.7 where in both graphs the time drops significantly. This is most likely because the graph gets fully saturated in 0.7. In other probability levels the graph is still spreading until the disease dies out at longer time scales.

3. **$G^1_{gs}$ and $G^4_{gs}$ Infected Nodes and Probability Distribution**

   The outcome for $G_{gs}$ is similar to that of $G_{gr}$. The curves on the graph with 4 sources has the curve moved up slightly in the distribution plot. I think the same pattern is followed as both graphs are the same the extra sources just allow for more nodes to be effected at a similar time.



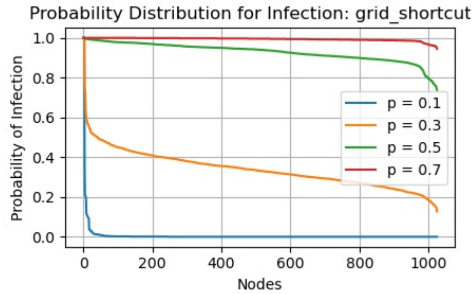
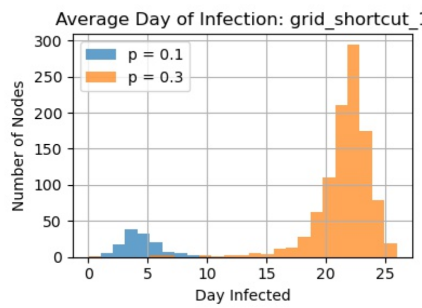
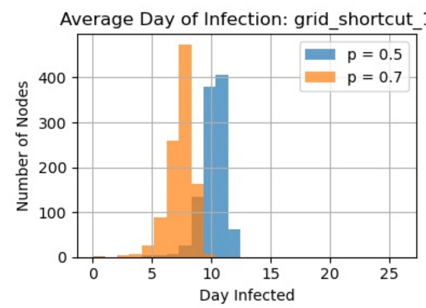



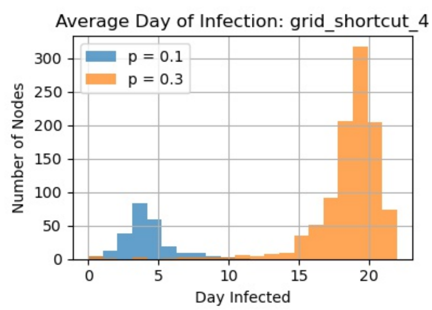

Table 2: Count of Infected Nodes

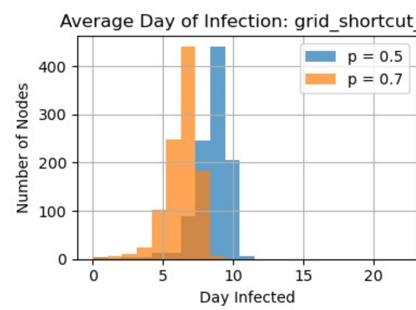
| p | $G^1_{gs}$ | $G^4_{gs}$ |
|---|---|---|
| 0.1 | 131 | 244 |
| 0.3 | 1024 | 1024 |
| 0.5 | 1024 | 1024 |
| 0.7 | 1024 | 1024 |

4. **$G^1_{gs}$ and $G^4_{gs}$ Days to Infection Distribution**




The days to infection are provided here for $G^1_{gs}$ and $G^4_{gs}$ respectively at each probability level. 0.1: 4.81 and 4.55, 0.3: 21.29 and 18.29, 0.5: 10.26 and 8.65, 0.7: 7.63 and 6.61. The pattern here is similar to $G_{gr}$ in that higher probabilities see a drop in average time. This is because the entire graph is saturated quickly. The spread is accelerated with more sources and more shortcuts.

5. **$G_{gr}$ and $G_{gs}$ Comparison**

   For the $G^4$ graphs, the shortcut graph clearly has more infected nodes and higher curves for the probability density functions seen in prior tables and figures. The same trend is seen in the $G^1$ graphs just with slightly lower number of nodes infected and probability curves. This shows that the same structure graph gives the same spreading characteristic, more sources give a higher probability of infection with the same shape and shortcuts greatly accelerate spread.

   The same pattern is also seen in time to infection. The saturation point seems to be reached faster as expected in the shortcut graphs and the time to infect is higher before that because the more connected graph makes the spread harder to die and once saturated the times drop much faster.

6. **Influence of extra shortcut edges**

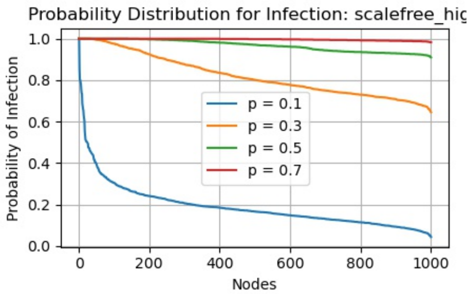
   The extra shortcut edges both accelerate the spread and make it tougher for the spread to die out once it starts. This is evidenced by the upward movement in probability distributions in both $G^1$ and $G^4$ graphs as well as higher spread times before saturation and lower spread times after saturation.

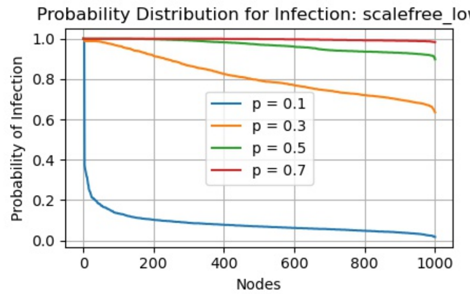
7. **P=0.5 Impact** The difference in infected population when under vs over probability of 0.5 makes sense because when over 0.5 a node is now more likely than not to be infected. Since these graphs are in a grid shape, most of the near-by nodes are also near by to each-others neighbors. If it is more than likely a node will be infected and there are many chances for infection spread becomes almost certain. The spread is exacerbated when shortcuts are added because new clusters of infections can start at a distance.

# 2 Scale Free Graphs

1. **Scale Free Networks Comparison**

   For each probability level, both $G^l_{sf}$ and $G^h_{sf}$ have 1000 nodes with a significant chance of being infected - this is all of the nodes in the graph. However, from the probability distributions we can see that there is a significantly higher probability of a number of nodes being infected as we go up in propagation probability. The low and high degree source graphs show similar shape with the high degree having its probability curves shifted up slightly.

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