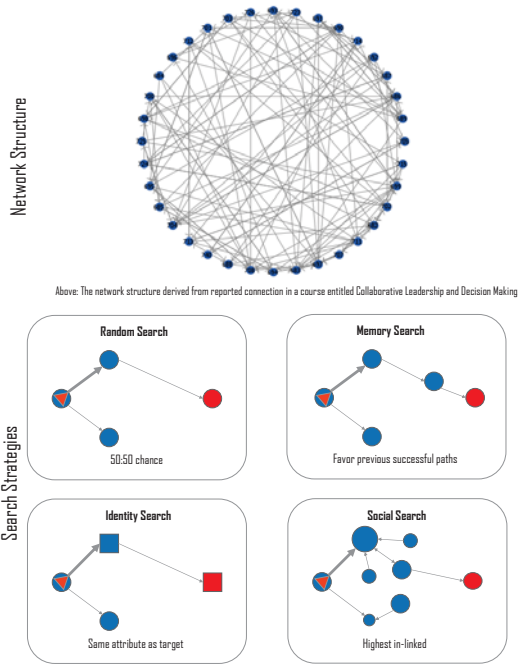


# Creating a Framework for Evaluating the Effectiveness of Various Search Strategies in the Small-World Phenomenon

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How do agents' search strategies influence observed **completion rate** and observed **median path length**?

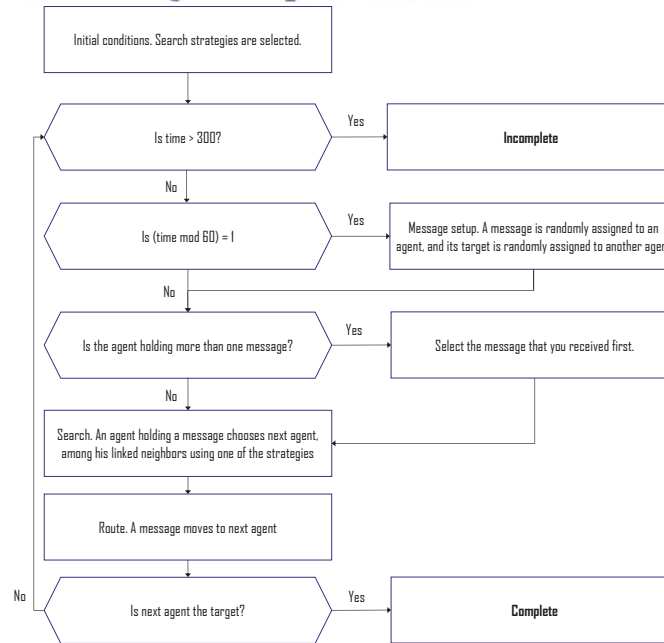
- Milgram's small-world experiments provided evidence for six degrees of separation, only a chain of five contacts separates any two random people. In theory, this small-world phenomenon is prevalent from a network structure perspective. However, empirical evidence shows that successful message chains are occasional, and the length of message chains are longer than the expected shortest path length.
- We aim to create a "null model" that we will use to examine how participants' search strategies impact both the rate at which messages are successful routed and the length of these resulting paths. Using an agent-based modeling approach, we simulate different message routing situations based on the implementation of four different search strategies (i.e., random, memory, identity, and social search) on a network derived from students in a course entitled Collaborative Leadership and Decision Making.



## Key Takeaways

- Simple strategies may not suffice:** Simulated completion rate lags significantly behind the empirical result, so there may be a more complex strategy used by individuals in practice.
- Disconnect between completion and path length:** Completion rate goes up as median path length is shorten since long paths tend to fail to reach due to message congestion.

## Modeling Setup & Rules

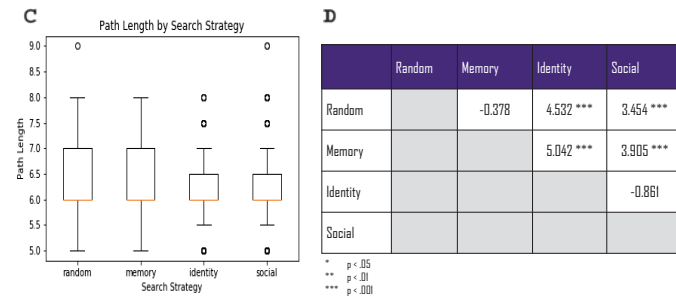
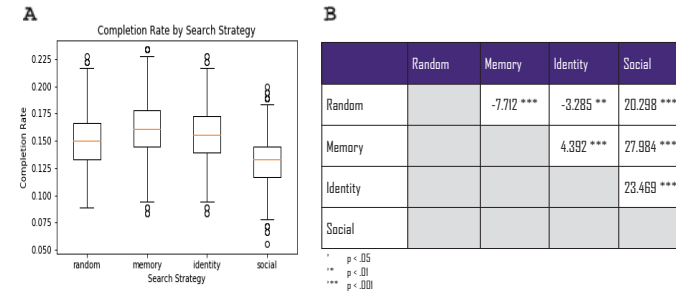


## Results & Analysis

- Primary Metrics**
- Completion rate: the number of messages that have reached their intended targets divided by the number of messages that have been introduced into the network in total
  - Observed path length: the median path length of completed messages for a selected run of the simulation

### Summary Results

- Completion rate: the mean completion rate for any of the tested search strategies differs in a statistically significant way from every other search strategy. The social search actually performs worse than if the message had traversed the network in a random walk. A possible explanation for this behavior is that the central nodes that tend to receive many messages get overloaded, causing a bottleneck.
- Observed path length: while each search strategy had the same median, the spreads varied dramatically. Identity and social searches seemed the most effective for finding short paths, though it is possible that this an artifact of the relative lack of messages completed overall.



## Conclusion

- This work is a critical first step in the creation of a repeatable framework for evaluating the effectiveness of various search strategies as they compare to empirical results.
- For future work, we intend to explore variations on the current search strategies examined. For example, it may be the case that in reality, participants have some knowledge that goes beyond their own local connections.
- Additionally, we hope to examine emergent behavior in the small-world network structure in cases where different agents employ different search strategies.
- Likewise, we plan to run this model on a number of other small-world networks to further demonstrate the validity of our framework.

## Acknowledgments

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## Experimental Setup

| Parameter                      | Experiment 1  | Experiment 2  | Experiment 3    | Experiment 4  |
|--------------------------------|---|---------------|-----------------|---------------|
| Number of Runs                 |   | 1000 Runs     |                 |               |
| Time                           |   | 300 ticks     |                 |               |
| Number of Nodes                |   | 36            |                 |               |
| Number of Links from each Node |   | 4             |                 |               |
| Network Structure              | Fixed based on the reported structure   |               |                 |               |
| Message Constraints            | Each message begins a path length of three away from its intended target<br>The order in which messages are introduced is fixed from run to run |               |                 |               |
| Search Strategy                | random search   | memory search | identity search | social search |