Performance of a Distributed Task Allocation Algorithm in a Realistic Network Environment

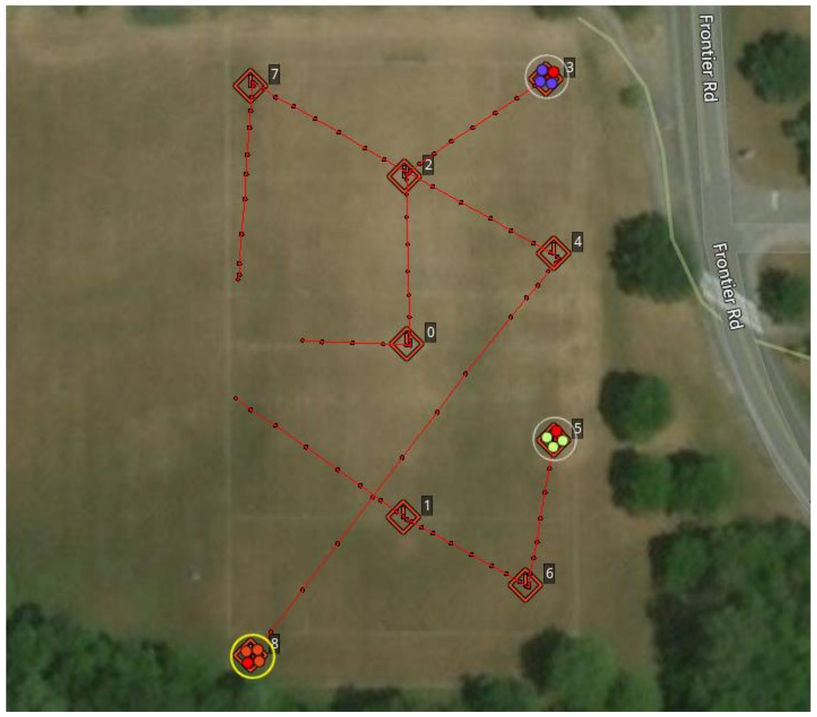
Matthew Rantanen[1], Dr. Nicholas Mastronarde[1], Dr. Karthik Dantu[2]
Departments: [1]Electrical Engineering , [2]Computer Science and Engineering

Objective

- Allocate a set of tasks to a set of agents where no two agents are assigned the same task
- Attempt to optimize the overall reward obtained from agents being assigned a specific assignment of tasks
- Evaluate the performance of the Asynchronous Consensus Based Bundle Algorithm (ACBBA) [1] in a lossy network environment

Testing

- Evaluated the performance of the ACBBA in a perfect communication scenario to determine optimal performance
- Evaluated the ACBBA performance using the 802.11b broadcast mechanism for communication in the UB Airborne Networking Communications Testbed[2]
- Static routing used for each node in the network



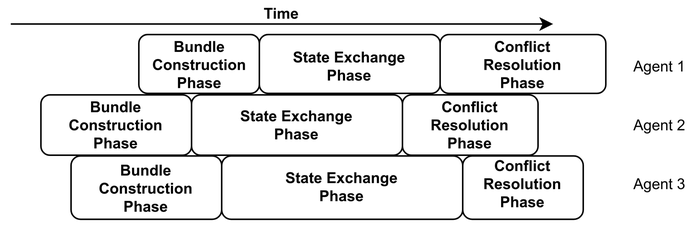
Visualization of a simulated scenario in the emulator software. Numbered squares denote tasks while multi-colored circles denote agents. Dotted trails show the list of assigned tasks and paths taken by agents.

Algorithm Description

- Agents continuously loop through three main phases:
- Bundle Construction Phase: Agents bid on tasks in order to place tasks in their set of assigned tasks (bundle)

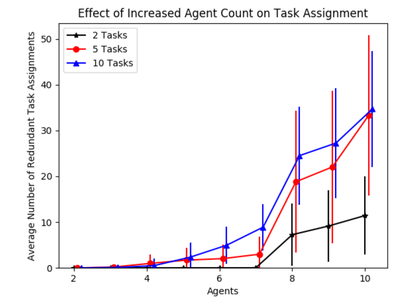
Algorithm Description (cont'd)

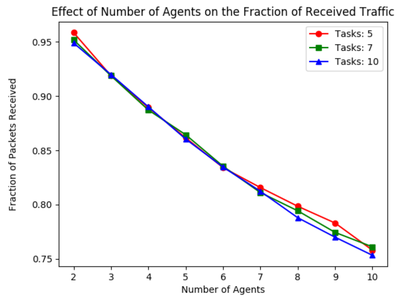
- State Exchange Phase: Agents exchange messages regarding task bids and bid winners
- Conflict Resolution Phase: Agents determine which agent had the highest bid and adjust their bundles based on received information and their current internal state
- The highest bidder for a task is assigned that specific task
- Each message only contains info about a single task
- Silence on the network is interpreted as convergence

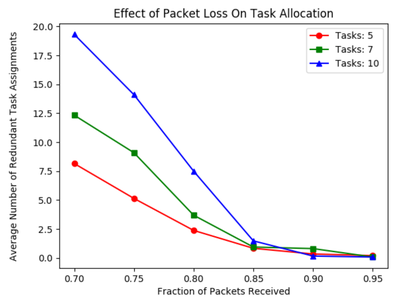


Execution flow graph of the ACBBA for one iteration of each agents main logic loop. Note the lack of phase synchronization between agents

Results

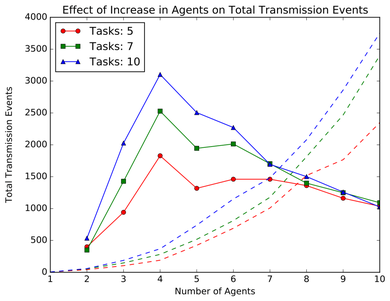






- An increase in agents resulted in an increased occurrence of the same task being assigned to multiple agents
- An increase in repeated tasks is interpreted as a decrease in performance
- An increase in agents lead to more packet loss in the network
- Packet loss was mostly independent of the total number of tasks available for assignment
- Increased packet loss resulted in decreased performance
- Packet loss resulted in lost messages needed for consensus and accurate conflict resolution

Results (cont'd)



Dotted lines denote data from the perfect network environment while solid lines denote data from the realistic network.

- Loss of information due to packet loss lead to premature convergence resulting in less messages being sent between agents to resolve bid conflicts
- Total transmission events uniformly increased with an increased amount of agents in the perfect network environment
- The ACBBA produced no redundant task assignments in the perfect communication network
- The ACBBA was able to tolerate some packet loss due to the redundant broadcast nature of transmissions
- Performance only degraded after a certain threshold number of agents (4 agents) participated in the network

Conclusion

- An increased amount of transmitting nodes in the network resulted in wireless interference that prevented the algorithm from properly communicating and resulted in degraded performance
- A lack of methods for ensuring message delivery resulted in a loss of critical information necessary for proper performance that lead to a decrease in performance

Future Work

- Characterize the ACBBA when reliable communication methods are used for packet delivery
- Test the algorithm's performance when deployed on physical drones in a mobile ad-hoc network
- Test the performance of the algorithm when different dynamic routing protocols are used, such as the OLSR and AODV protocols

References

1. L. B. Johnson, S. Ponda, H.-L. Choi, and J. P. How, "Improving the efficiency of a decentralized tasking algorithm for uav teams with asynchronous communications," in AIAA Guidance, Navigation, and Control Conference (GNC), vol. 5, pp. 5406–5411, 2010.
2. S. M. Najafabadi, N. Mastronarde, M. J. Medley, and J. D. Matyjas, "Ub- anc: An open platform testbed for software-defined airborne networking and communications," arXiv preprint arXiv:1509.08346, 2015.

This material is based upon work funded by the US Air Force Research Laboratory in Rome, NY,USA