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Learning Selective Communication for Multi-Agent Path Finding

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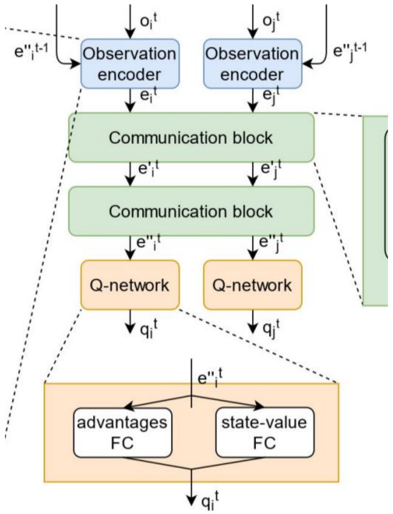
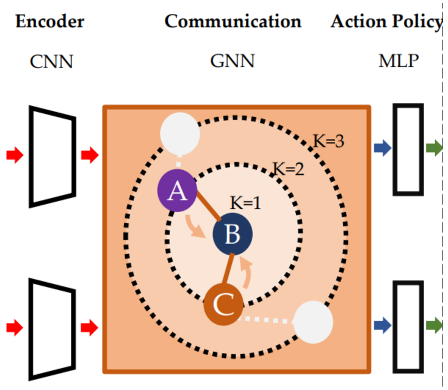
Background

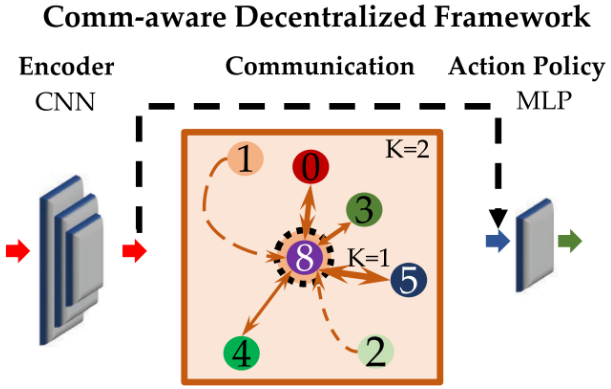
- Learning communication among agents via RL and IL for MAPF
- A graph is formed by treating each agent in the environment as a node and connecting neighboring agents if inside the FOV of each other
- E.g.



DHC [ICRA'21]



GNN [IROS'20]



Message-Aware Graph Attention [RA-L'21]

Broadcast vs. Selective Communication

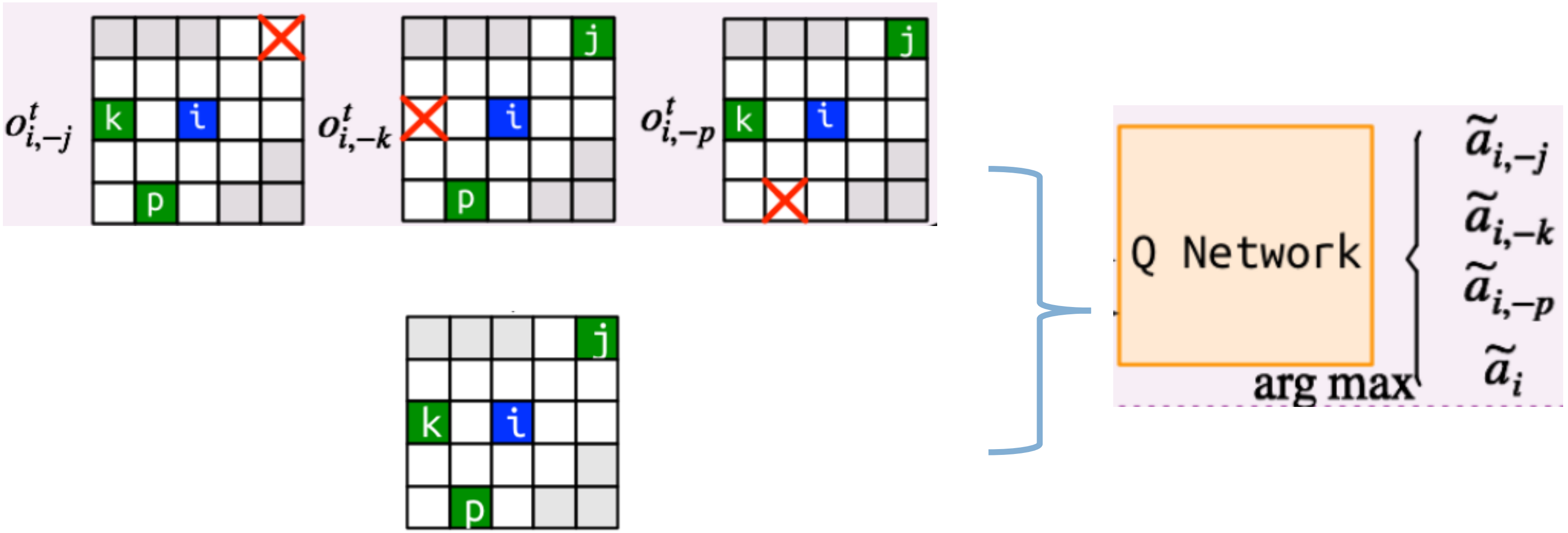
- Most existing communication based MAPF solvers focus on broadcast communication. (An agent's message is broadcasted to all other or predefined agents)
- It is impractical for large scale problem.
  - It causes huge communication overhead
  - It leads to redundant information that could even impair the multi-agent communication.
- Propose to learn a succinct communication protocol which allows agents to actively select relevant and influential neighbors.

Decision Causal Communication (DCC)

- Agent A communicates with its neighbor B, only when the presence of B causes the policy adjustment on A.
- Motivation
  - Most learning based MAPF methods guide RL with global or local optimal path
  - To diminish communication cost, an agent should follow guided policy as often as possible without communication, if neighbors not affect its current policy
  - Otherwise, it communicates with those neighbors who will individually affect its policy

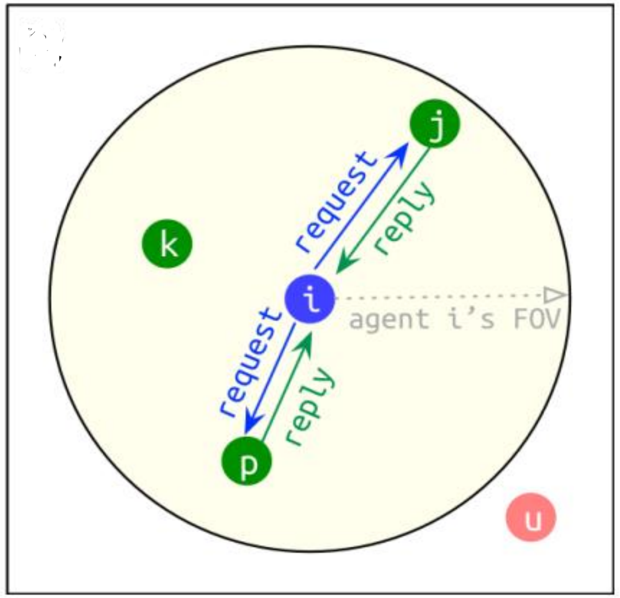
Decision Causal Communication (DCC)

- First stage: determine communication scope
- Use local decision module (Q network) to check if the policy is adjusted due to some neighbor.



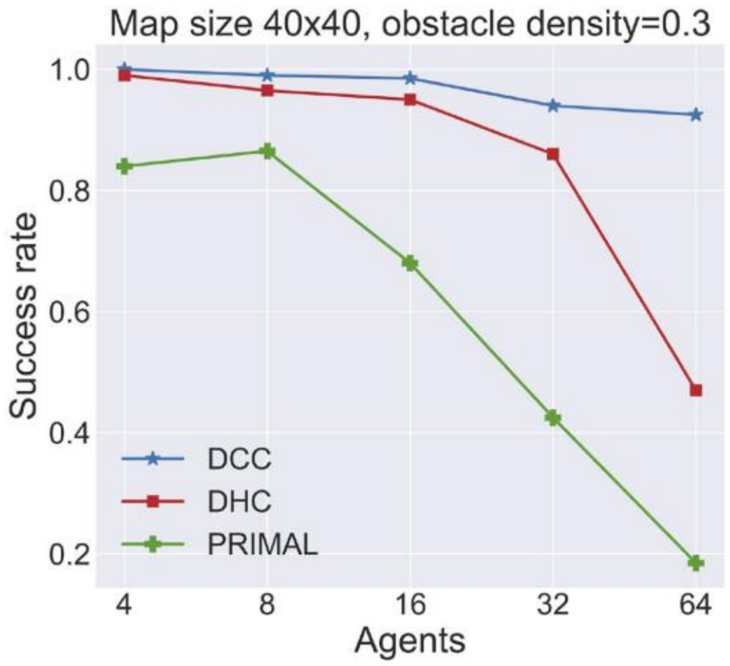
Decision Causal Communication (DCC)

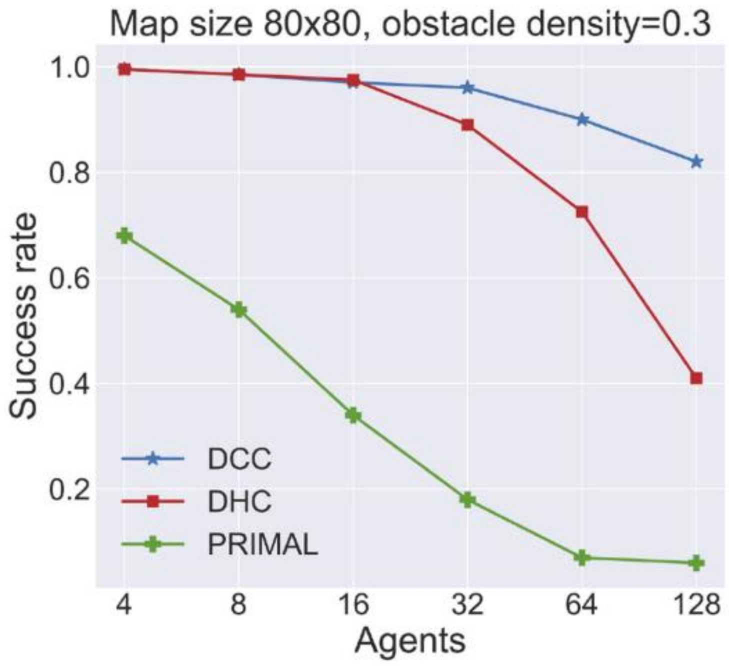
- Second stage: request-reply
- Messages are updated at both request and reply round
  - Request round: agent i sends out rich information to agent j and p. Agent j and p will update their hidden state accordingly
  - Reply round: agent j and p send updated messages to agent i. Agent i will update its hidden state accordingly
- Message update is performed by graph convolution



Can DCC benefit the performance?

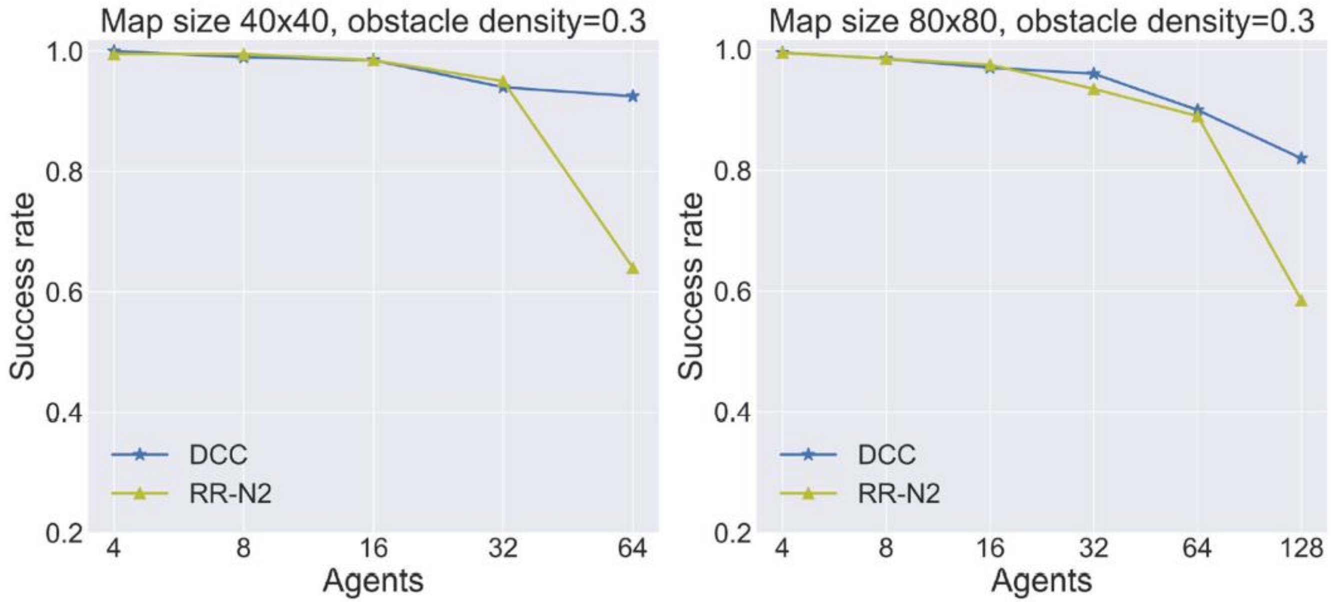
- Test in 40x40, 80x80 maps with obstacle density 0.3
- Compare with RL-based method PRIMAL [RA-L'19] , DHC [ICRA'21]





Can DCC select relevant neighbors?

- One may think the nearest neighbors are most relevant. Not the case.
- Build a baseline model RR-N2: two round update request-reply, but only communicate with the nearest 2 neighbors.



Can DCC reduce communication overhead?

- Baseline model RR-N2: two round update request-reply, but only communicate with the nearest 2 neighbors.
- A request-reply pair is counted as one time communication.

Average Step	Map size 40×40		Map size 80×80	
Agents	DCC	RR-N2	DCC	RR-N2
4	2.42	36.88	1.06	18.36
8	11.56	209.79	5.75	105.86
16	60.47	959.38	24.98	469.58
32	294.69	4111.57	126.685	2125.94
64	1811.33	19490.09	562.11	8780.72
128	-	-	2915.84	36560.30

Thank you

Summary

- Although communication can benefit MAPF, agents should learn to actively select relevant agents for communication, because even the nearest agents are not the relevant ones.
- Communicating with only two agents can already lead to huge communication overhead. Thus, researchers should always devise a succinct communication mechanism in order to reduce the communication overhead for easy deployment to real world problems