A Penny for Your Thoughts: The Value of Communication in Ad Hoc Teamwork

Reuth Mirsky, **William Macke**, Andy Wang, Harel Yedidsion, Peter Stone

@ IJCAI-PRICAI

January 2021

1

Ad Hoc Teamwork

"To create an autonomous agent that is able to efficiently and robustly **collaborate** with **previously unknown** teammates on tasks to which they are all individually capable of contributing as team members".

Stone, P., Kaminka, G. A., Kraus, S., & Rosenschein, J. S. (2010, July).
Ad Hoc Autonomous Agent Teams: Collaboration without Pre-Coordination. In AAAI Conference on Artificial Intelligence (p. 6).

Communication in Ad Hoc Teamwork (CAT)

Previously unknown teammates ≠ solo player

Use existing communication channels

Learn new communication channels

Teach other teachable agents

Ackerman, E. "**Moxi Prototype from Diligent Robotics Starts Helping Out in Hospitals**." *IEEE Spectrum.*
https://spectrum.ieee.org/automaton/robotics/industrial-robots/moxi-prototype-from-diligent-robotics-starts-helping-out-in-hospitals (2018).

3

SOMALI CAT

Sequential

One-shot

Multi-

Agent

Limited
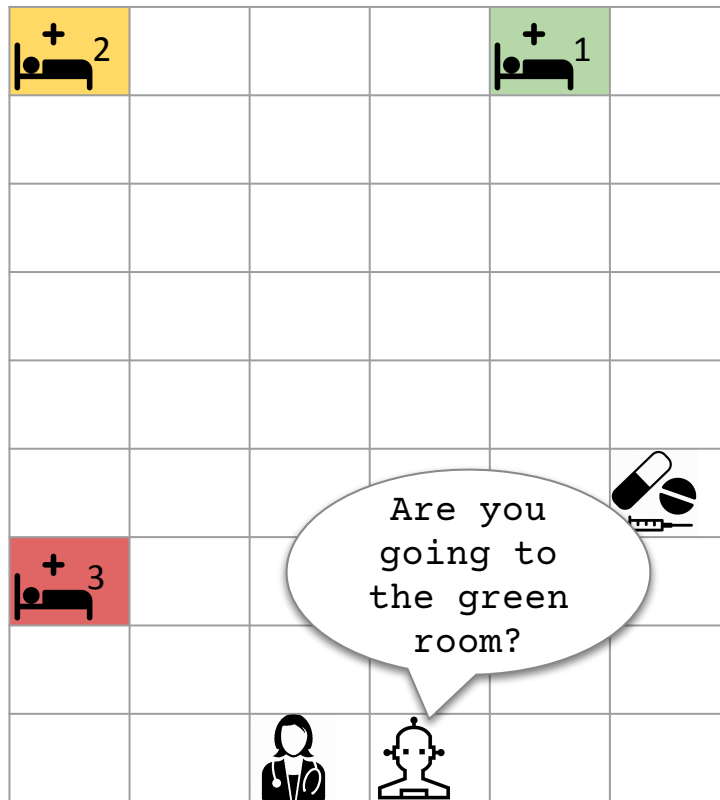
Inquiry

Communication

in

Ad hoc

Teamwork

When to Communicate
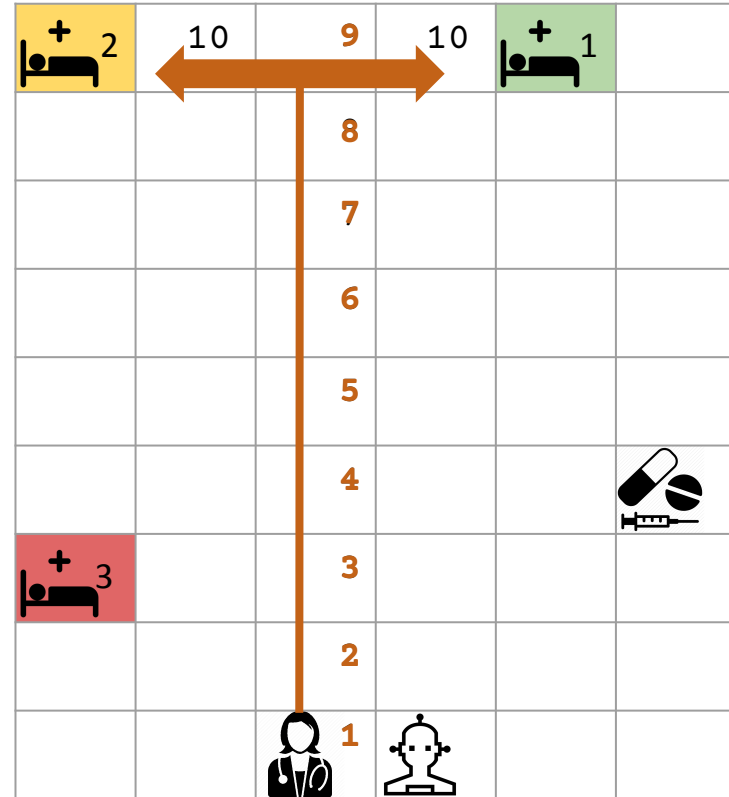
Zone of Information (Z_I)

Ad hoc agent may have

Uncertainty about the physician's goal

worst cases distinctiveness (wcd)[1]

$Z_I = \{t \mid t \leq wcd_T(i,j)\}$

$Z_I(1,2) = 1\text{-}9$

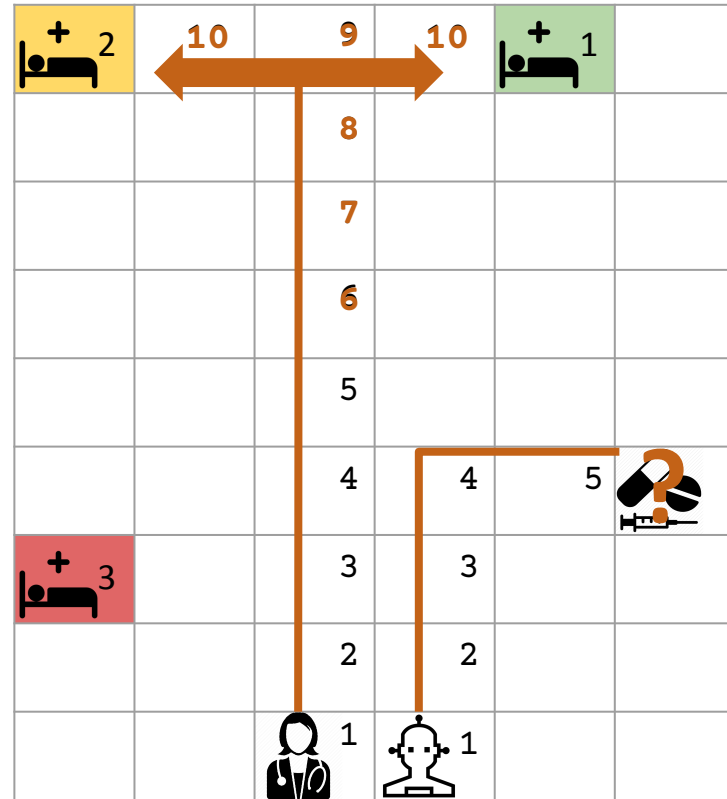1. Keren, S., Gal, A., and Karpas, E. (2014). **Goal recognition design**. In ICAPS.

When to Communicate

Zone of Plan Branching (Z_B)

Ad hoc agent must

commit to goal

$$Z_B = \{t \mid t \geq wcd_A(i,j)\}$$

$$Z_B(1,2) = 6\text{-}10$$
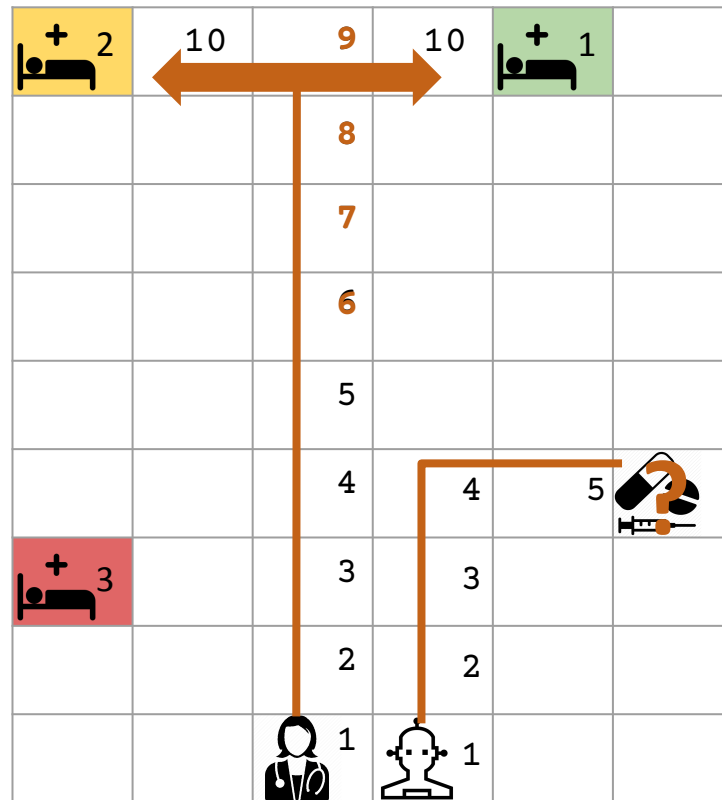
When to Communicate

Query when:

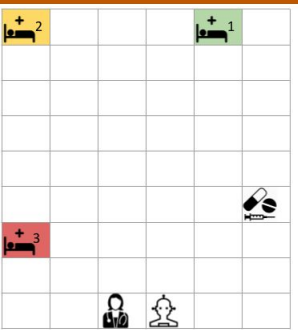Ad hoc agent both is

uncertain and must

commit

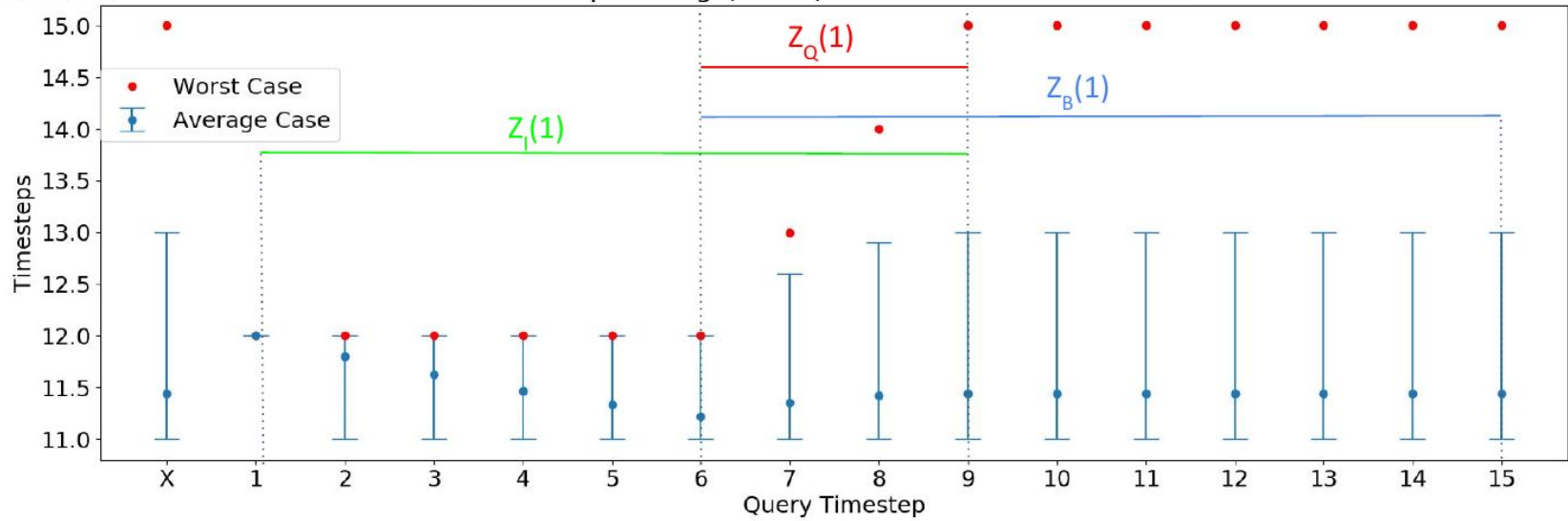Zone of Querying

$$Z_Q = Z_I \cap Z_B$$
$$Z_Q = \{6, 7, 8, 9\}$$
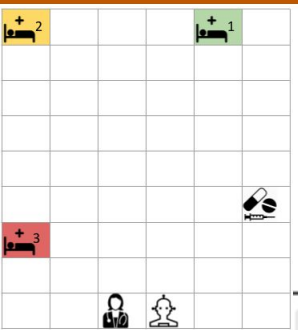
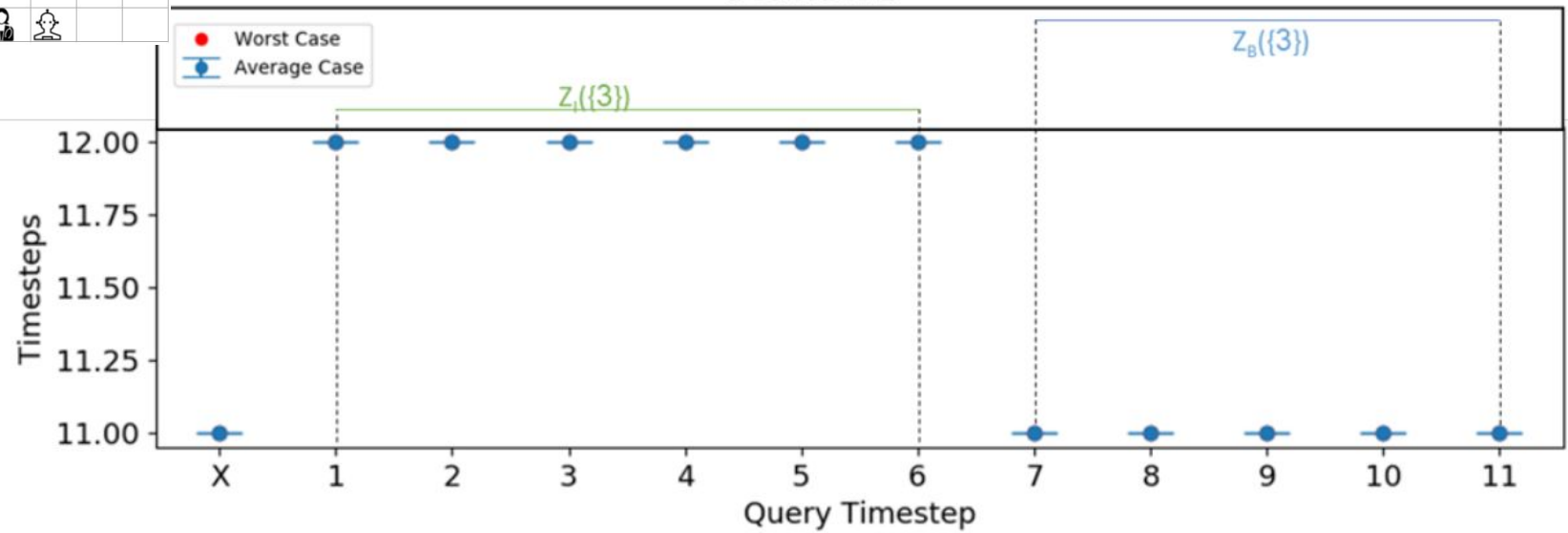Critical Querying Point(CQP) = 6
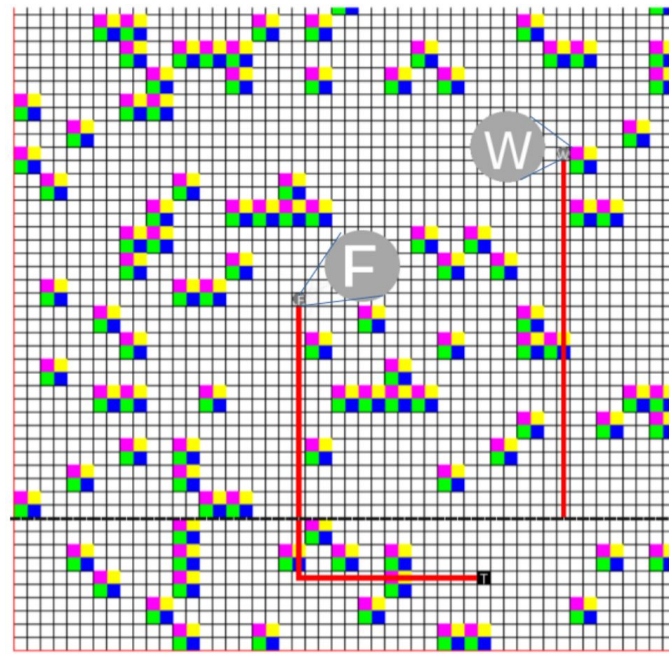
Methodical evaluation

Methodical Evaluation

Experimental Setup

- Never
  - Only use Bayesian inference
- First
  - Query at beginning of simulation
- Z_Q
  - **Query at beginning of Zone of Querying**
- Random
  - Query randomly during simulation
- All vs One
  - Query until certain vs once

50x50 grid with 100 domain instances

10

Results

- ## Never
  - Only use Bayesian inference
- ## First
  - Query at beginning of simulation
- ## Z_Q
  - **Query at beginning of Z_Q**
- ## Random
  - Query randomly during simulation
- ## All vs One
  - Query until certain vs once

Average Marginal Cost for Various Algorithms

11
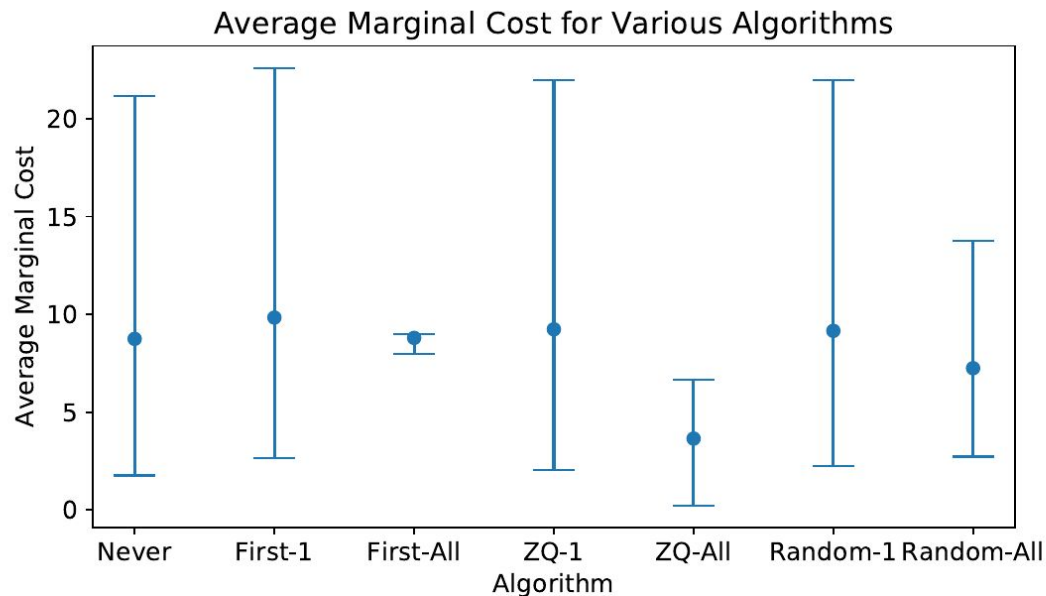
Summary

- We present **Communication in ad hoc teamwork (CAT)** as a novel paradigm for representing various real world tasks
- We introduce **The Tool Fetching Domain** as a new problem setting for representing CAT tasks
- We demonstrate that **Value of communication** is significantly dependent on timing

Would you like to hear more?

https://www.cs.utexas.edu/~pstone/Papers/bib2html/b2hd-IJCAI2020-Mirsky.html

Expected Value of Communication for Planning in Ad Hoc Teamwork in AAAI'21

Reuth Mirsky, reuth@cs.utexas.edu

William Macke, wmacke@cs.utexas.edu

Andy Wang, andywang6666@yahoo.com

Harel Yedidsion, harel@cs.utexas.edu

Peter Stone, pstone@cs.utexas.edu

13