

A Ghost of Chance: Polyagent Simulation of Incremental Attack Planning

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Outline

Issues in Agent-based Modeling for C2

The Polyagent Construct

The Polyagent Model

Simulation and Experiment Results

Conclusions

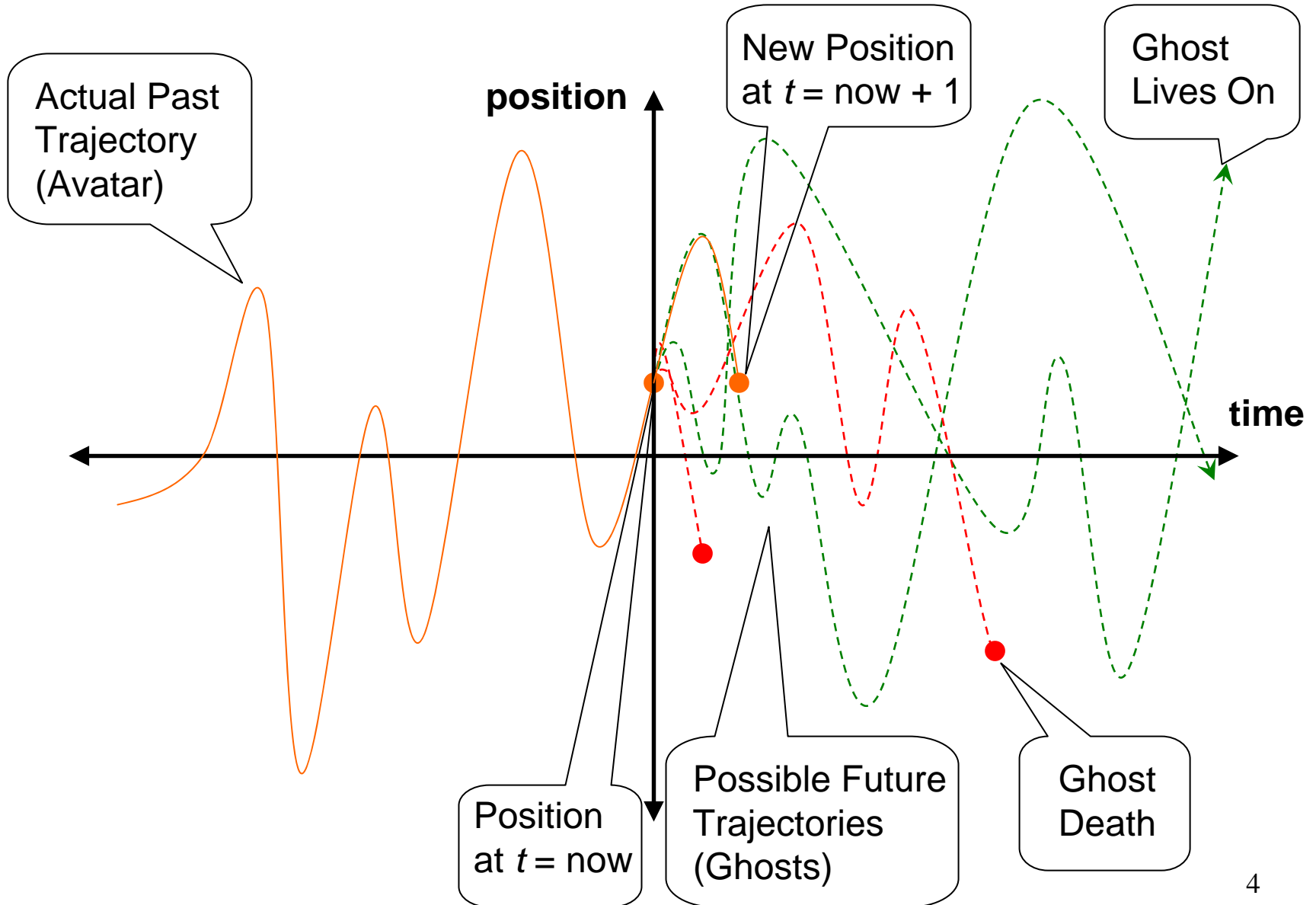
Agent-based modeling has been used to explore a variety of C2 problems

Traditional models execute a single trajectory through a vast space of “possible futures”

Exploration of multiple possible futures requires repeated execution of model using different initial conditions

Analysis of emergent dynamics of agents must be done offline

Polyagents



Polyagents – Key Points

Two key components

- Avatar: persistent agent taking action in virtual world
uses results from ghosts to decide next action
- Ghost: transient actor in virtual world
plays out alternative probabilistic scenarios
utilizes pheromone fields

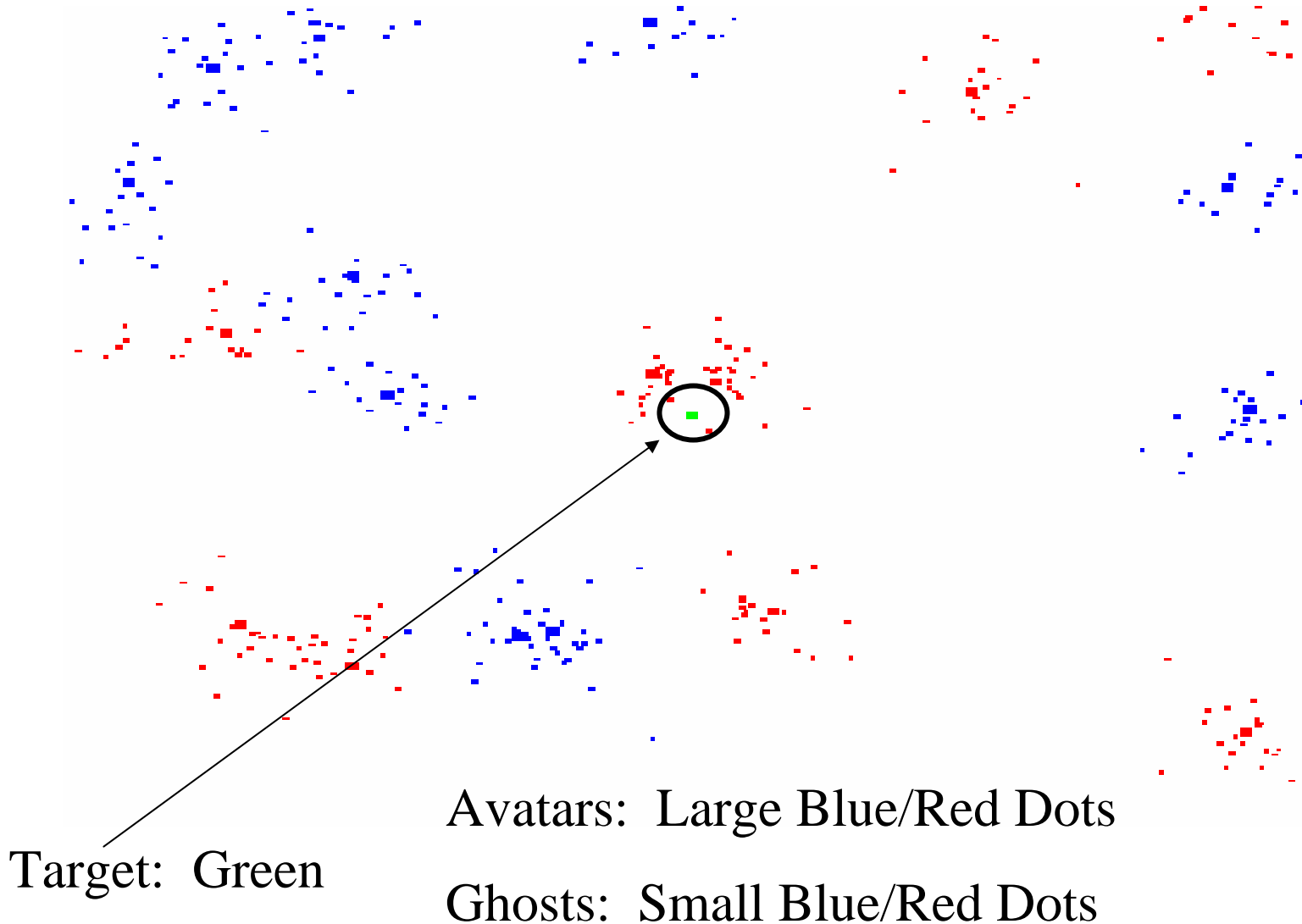
Key features

- Utilize complex reasoning techniques and swarm intelligence
- Explore many more possible futures per decision cycle

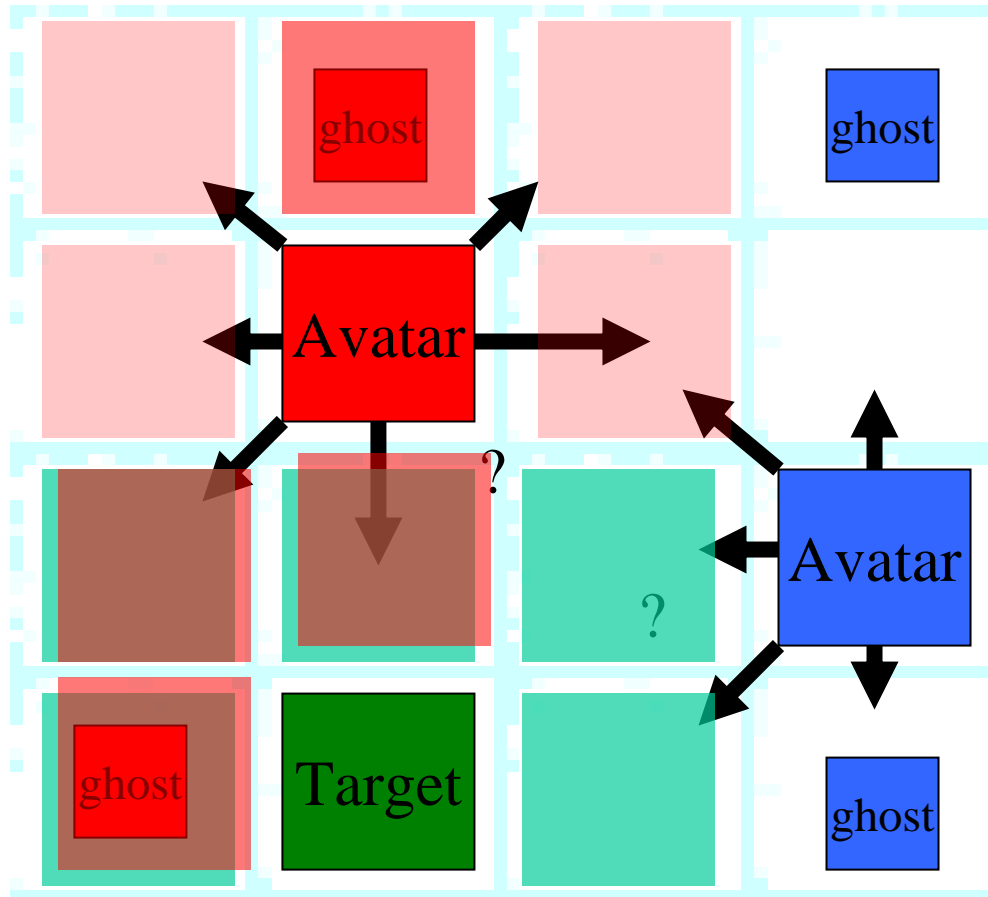
Previous applications of polyagents

- Robotic vehicle path planning
- Characterizing behavior of other agents
- Factory scheduling

Snapshot of Polyagent Model



Primary decision: where to move next?



Note: can only move one square at a time (like a King in chess)

Note: Blue pheromones not shown

Description of Polyagent Model (1)

Initial Conditions

- Random placement of target(s) and Red/Blue forces on grid

- Specified numbers of Red/Blue polyagents

Agent goals (avatars and ghosts)

- Red – avoid Blue, seek target

- Blue – seek out Red

Pheromone “flavors” (emitted by the ghosts and the target)

- Green – Emitted by target at a consistent rate

- Blue and Red – Lay down “Threat” indicators for other side

- (Pheromones propagate and evaporate over time)

- Encounter between Red and Blue could result in “death” for one or both

Description of Polyagent Model (2)

“Next move vector” for ghosts:

Red: Highest concentration of green – highest blue + weighted random factor

Blue: Highest red + weighted random factor

“Next move vector” for avatars:

Red:

Highest green square reported by any of its ghosts
– Sum of components of its ghosts’ death locations
+ Weighted random factor

Blue:

Sum of components of its ghosts’ death locations
+ Weighted Random factor

Description of Polyagent Model (3)

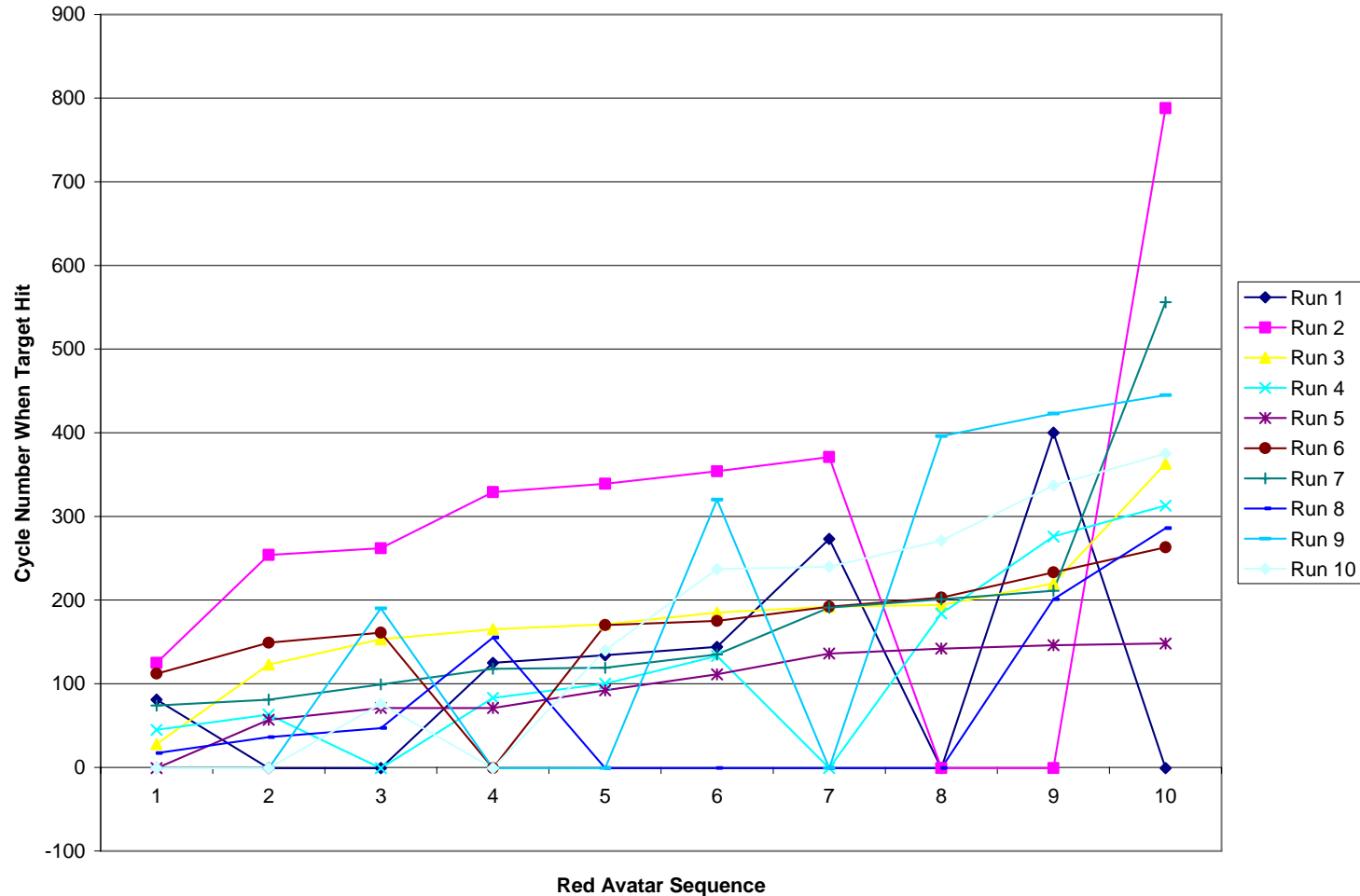
Parameters (range) [default]

- ❑ NG -- # of ghosts per avatar (0..) [5]
- ❑ KP -- Kill probability when encountering opposition (0..1) [0.9]
- ❑ FH -- Forecast horizon (how far ahead ghosts “play act”) (0..15) [5]
- ❑ WR -- Weight of random factor (0.1) [0.1]
- ❑ DG -- Dimensions of grid (0.. x 0..) [25 x 25]

Measures of success

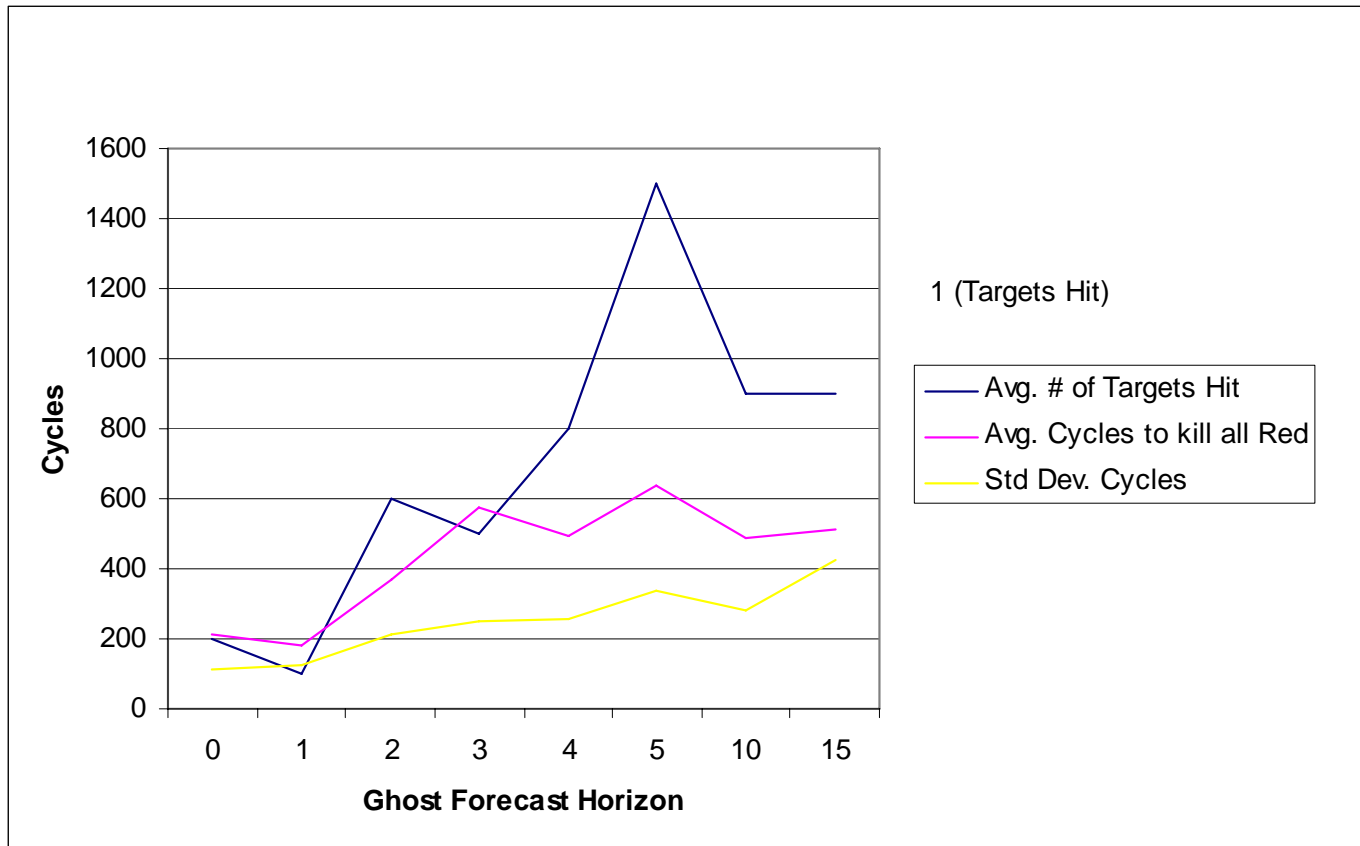
- ❑ Red – max # of targets found, max # of surviving avatars
- ❑ Blue – min # of targets destroyed

Sample Data (Equal Forces)



10 Red Avatars on 10 Blue Avatars,
Ghost Forecast horizon $FH = 5$, ghosts per avatar $NG = 5$

Aggregated Data (Unequal Forces)



5 Red Avatars on 25 Blue Avatars,
Ghost Forecast horizon varies, ghosts per avatar $NG = 5$

Experiment results overview

- 1) **Equal strength Red and Blue forces (e.g., 10 and 10)**
 - ❑ Red “easily” hits targets multiple times (within 100 cycles)
 - ❑ Robust across number of forces, ghosts per avatar, etc.
 - ❑ Intuition: Information Asymmetry: Blue does not know where the target is!
- 2) **Blue force much larger than Red force (e.g., 25 to 5)**
 - ❑ Red still can hit at least one target if it can plan ahead sufficiently
 - ❑ Increasing Red success by planning ahead up to FH=5, drops off after that

Conclusions

Demonstrated utility of polyagent model in incremental attack planning scenarios

Planning ahead is good, but don't overdo it!

More work needed to explore

Other parameter variations

Other varieties of information available

Backups
