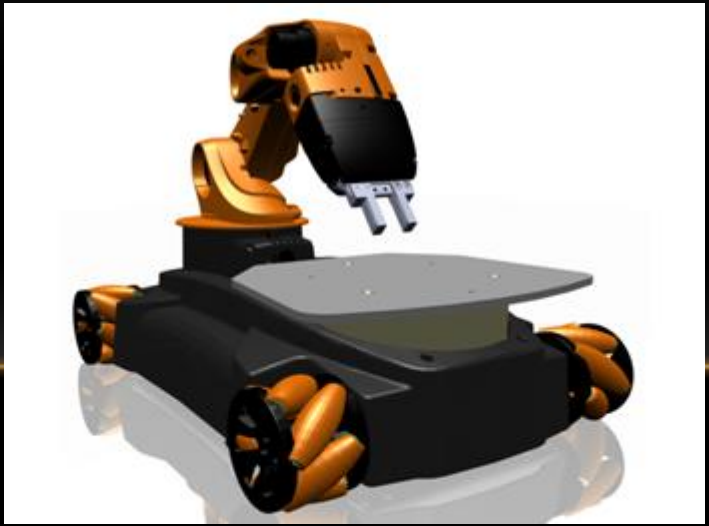
A CONTRIBUTION TO THE INFRASTRUCTURE OF THE RESCUE SIMULATION COMPETITION



Amsterdam Oxford Joint Rescue Forces

Victor Spirin and Arnoud Visser

RoboCup Rescue Simulation Infrastructure Competition,
João Pessoa, June 22, 2012

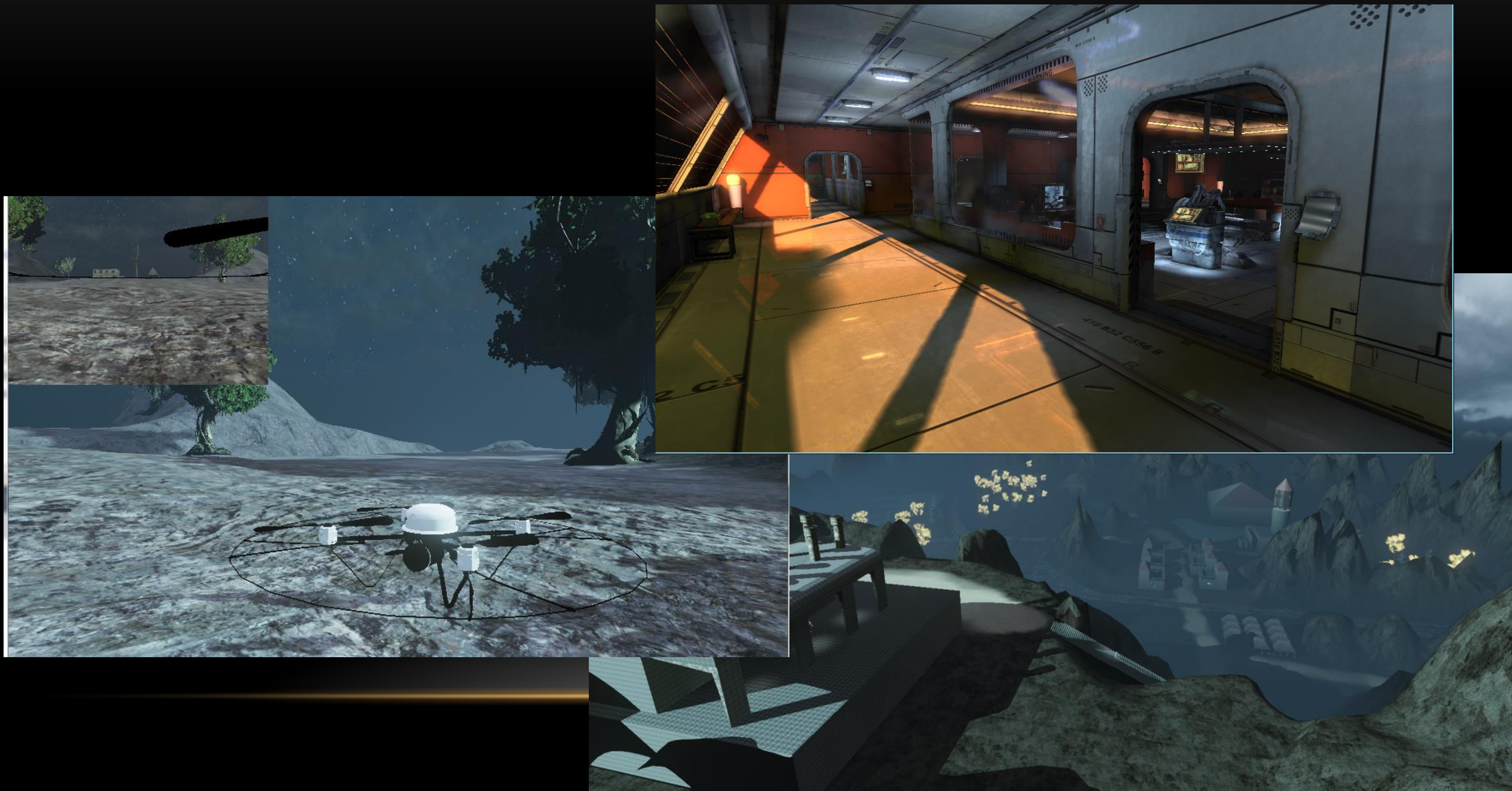
Oxford University
Computer Science Department

Universiteit van Amsterdam
Intelligent Systems Laboratory

HISTORY OF UVA-RESCUE AND AOJRF

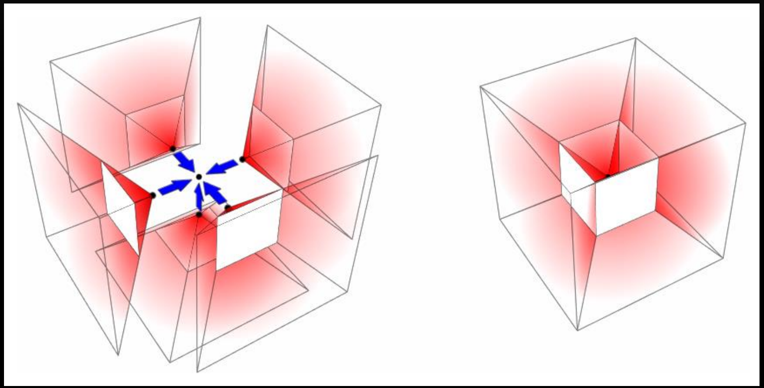
- UvA-Rescue is active in the Rescue Simulation League since 2003.
- Joint Rescue Forces with Oxford since 2008.
- Several infrastructure contributions over the years:
  - Smoke visible to the laser scanners
  - Omnidirectional camera
  - Validated walking robot
  - Validated flying robot
  - Upgrade from UT2004 to UDK

THE DETAILED MAPS BY THE TEAM

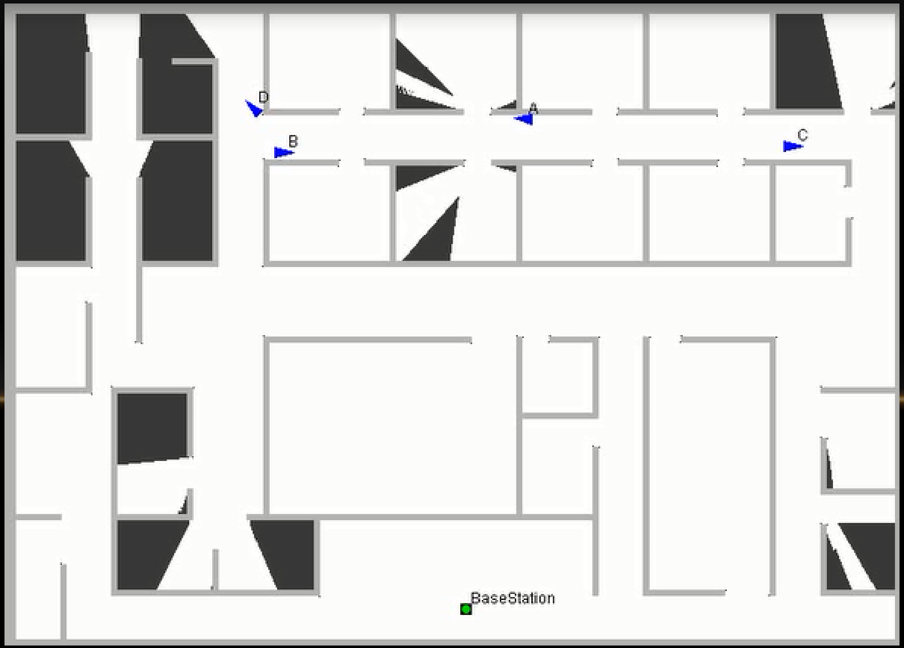


IDEAS OF UVA RESCUE FOR THE INFRASTRUCTURE COMPETITION

- Uniform Robot Description Format
- Ricoh Theta
- RoboCup@Home Simulation
- KUKA youBot
- Observations while moving



A SIMULATOR WITH A DETAIL LEVEL BETWEEN THE AGENT AND VIRTUAL COMPETITION



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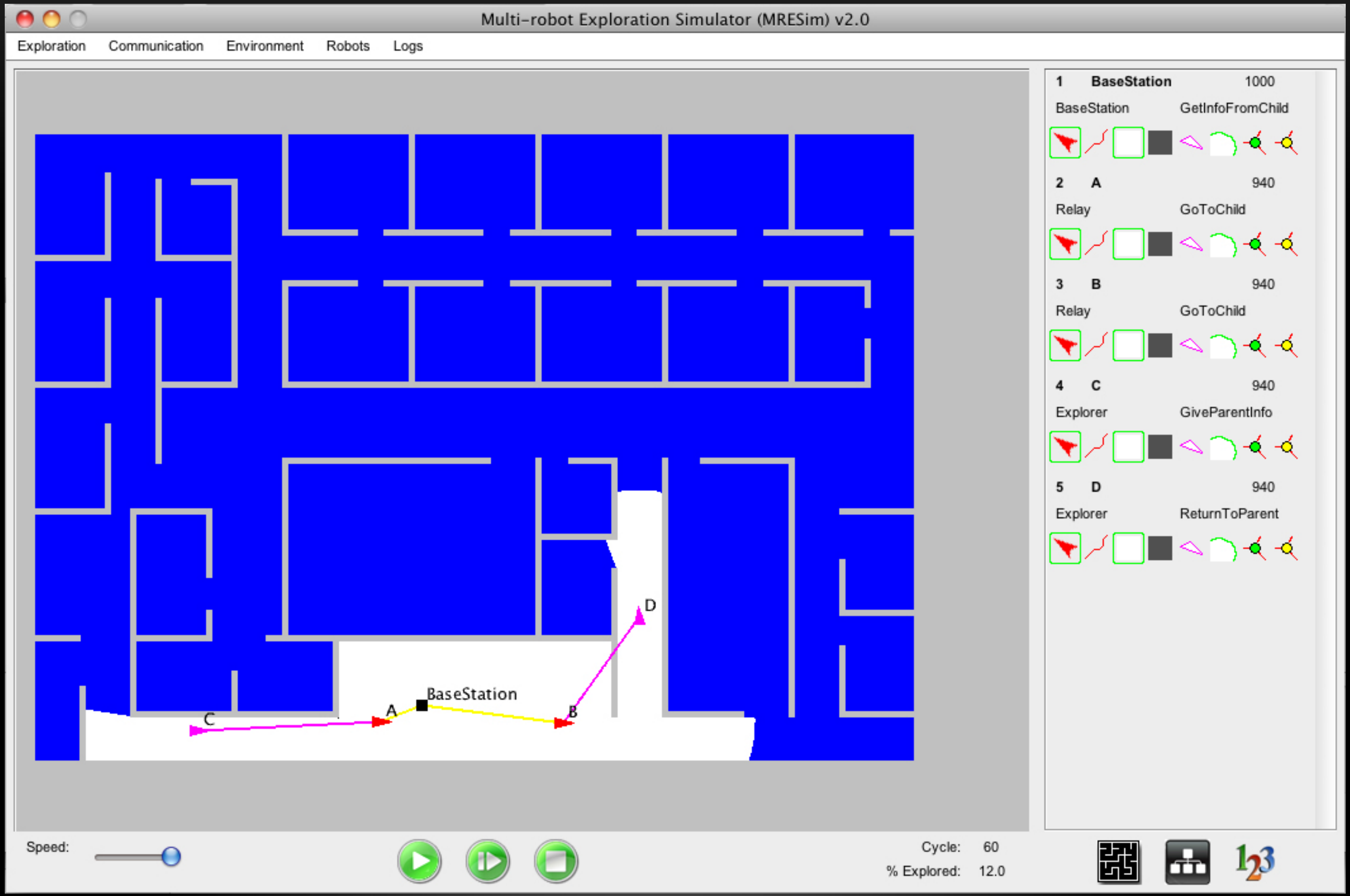
Role-Based
Multi-Robot Exploration

Julian de Hoog

University of Oxford

RESULT: A 2D ROBOT SIMULATOR (VERSION 2.0)

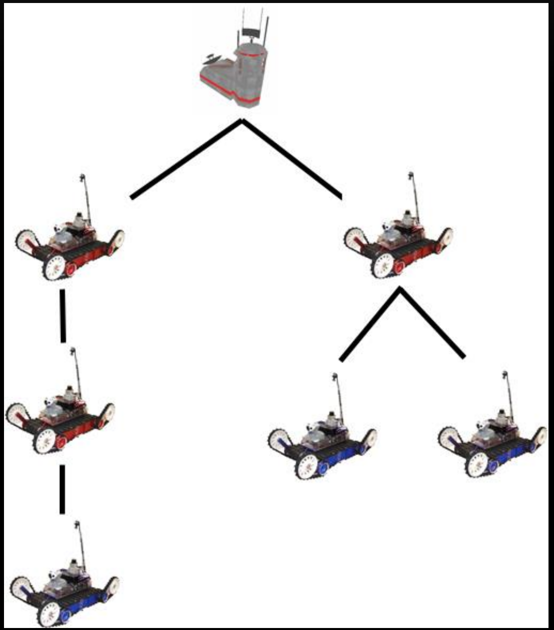


CONTEXT

- High-bandwidth communication is limited
- Emphasis on cooperation strategies under the constraints of limited communication

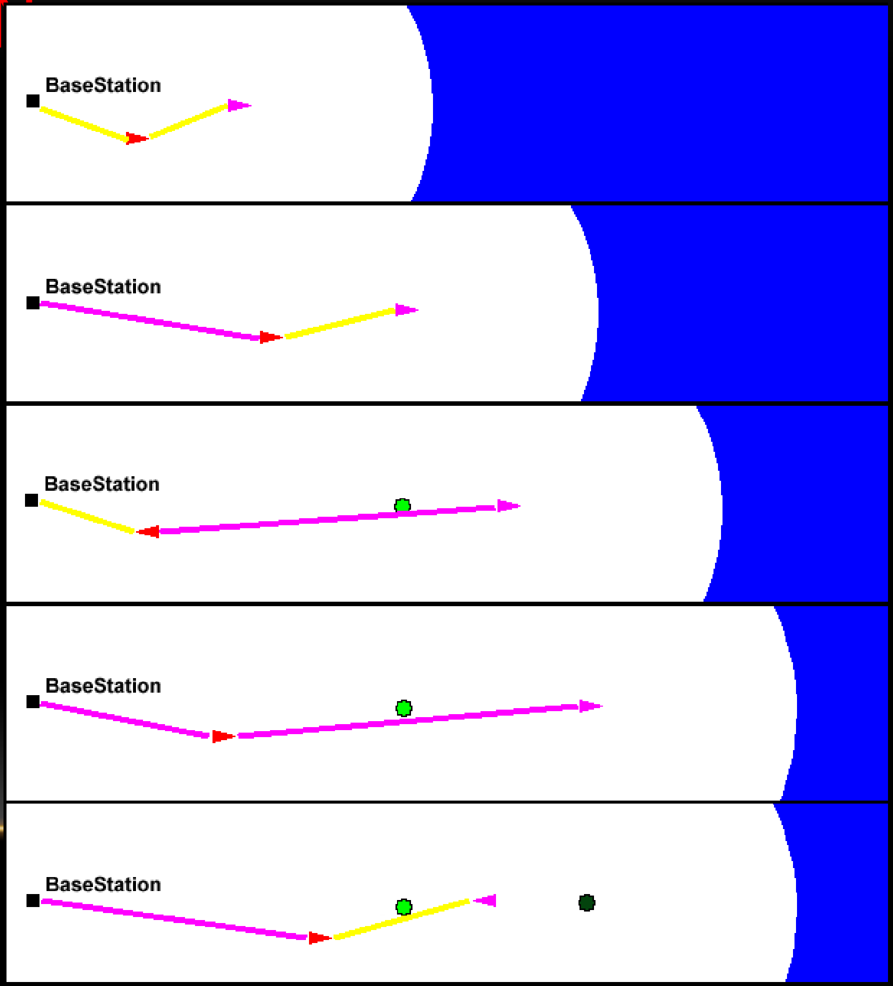
ROLE-BASED EXPLORATION

- Agents assigned one of two roles:
    - Explorer
    - Relay
- Explorers explore new frontiers, bring information back to rendezvous points
- Relays move information between base station and explorers
- Agents can swap roles in the tree, but the tree structure doesn't change



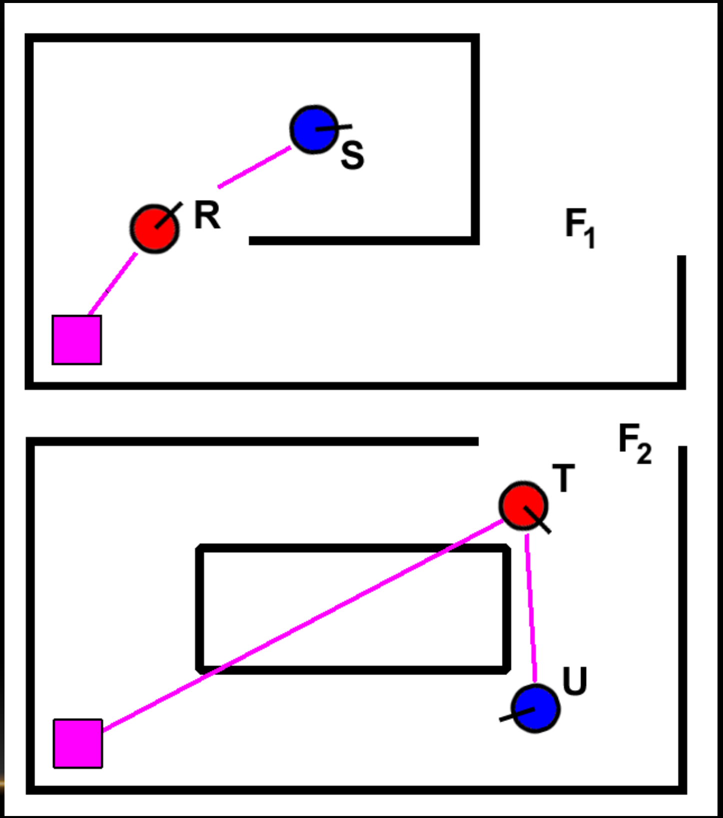
ROLE-BASED EXPLORATION

- Explorer starts exploring, relay follows
- Once they are outside communication range, they pick the next rendezvous point (nearest to next frontier, within safe space), relay goes back to base
- Explorer estimates how long it would take the relay to return to the rendezvous point; stops exploring and returns to RV at the right time



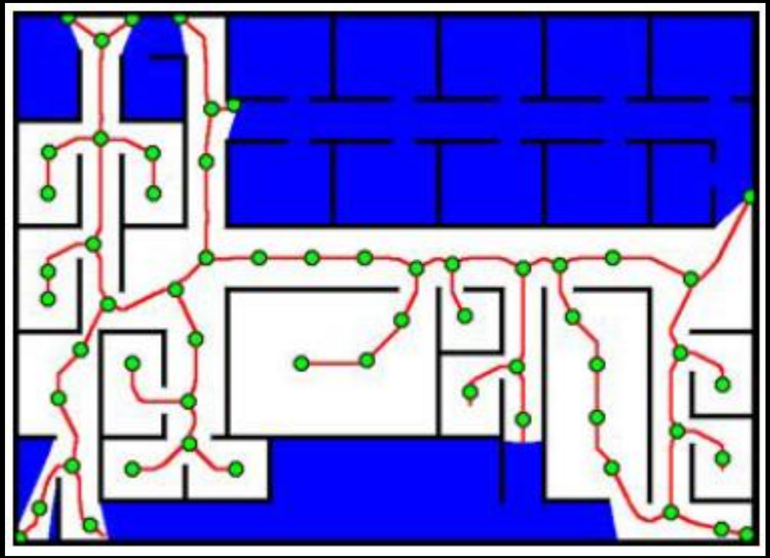
SWAP ROLES

- Agents can swap roles if it would reduce travel time
- Swapping roles leads to emergent behaviour, where relays can form longer chains not explicitly defined in the relationship tree

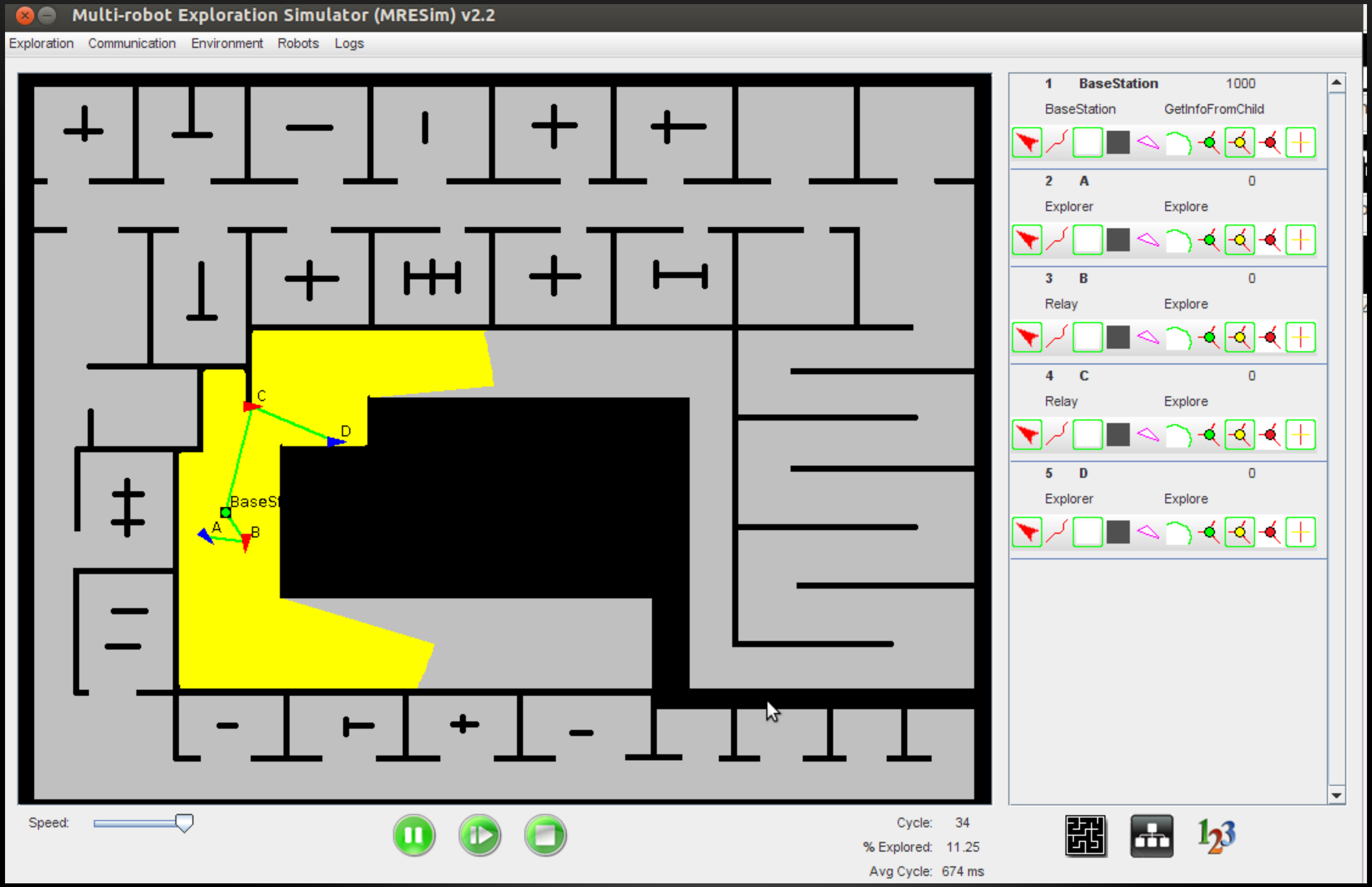


RENDEZVOUS POINT SELECTION

- Rendezvous point selection has a crucial effect on team behaviour
- RV points closer to base station lead to more frequent updates; closer to frontiers leads to faster exploration
- Good to pick points near frontiers but in open space (corridors, junctions)
- Get a skeleton of the environment, select points at junctions, remove points too close to others, fill in gaps, select best point



NOW: OPEN SOURCE & VERSION 2.2



Multi-Agent Exploration in Indoor Environments with Limited Communication

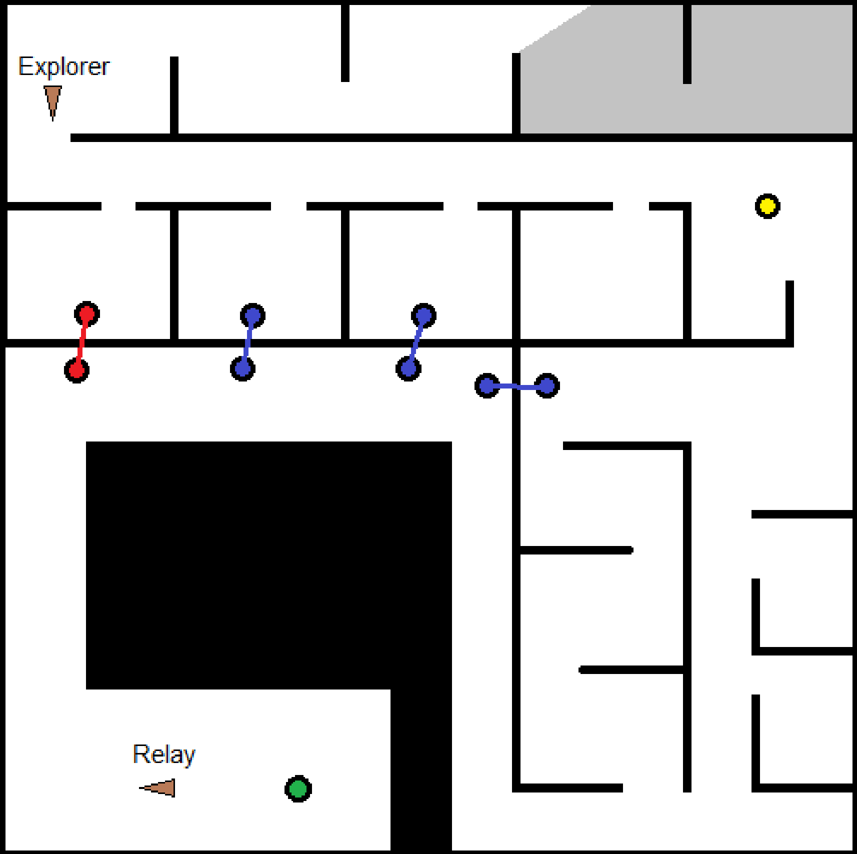
Victor Spirin

University of Oxford

PAPER I

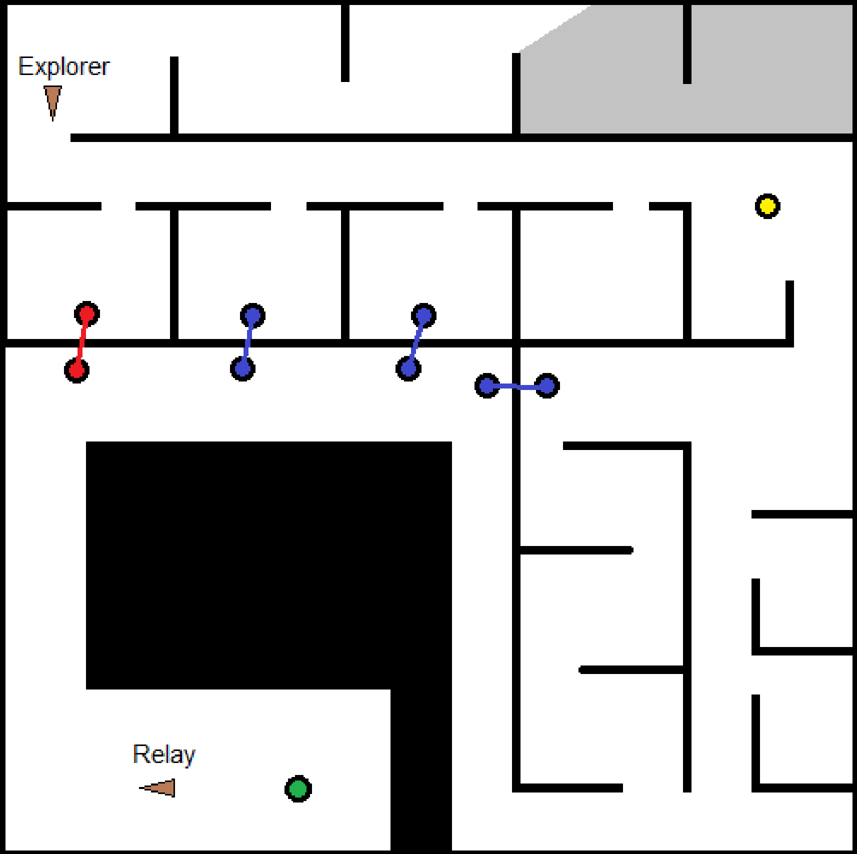
RENDEZVOUS THROUGH OBSTACLES

- Doesn't take into account communication range
  - Robust to communication problems
  - But can be very inefficient
- What if the robots planned to communicate through obstacles?
  - Need to select rendezvous point pairs – how?
  - What to do if communication does not happen?



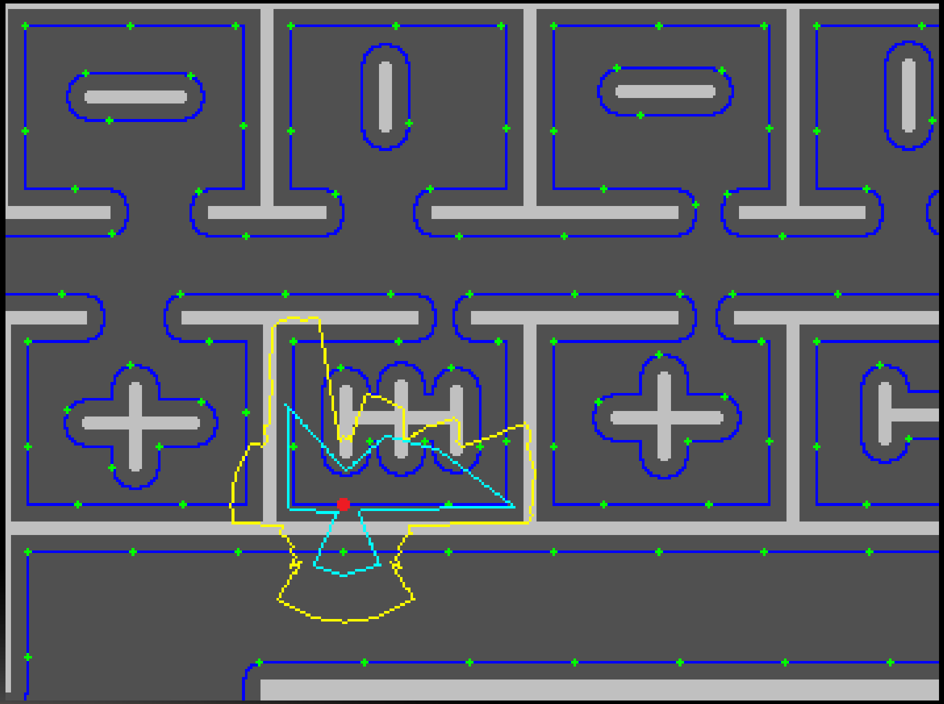
WHAT ARE THE CANDIDATE RV POINT PAIRS?

- We want point pairs that have an obstacle between them (no line of sight comms)
- Using the point pair has significant advantage over using a single rendezvous point
  - We want the benefit to outweigh the additional risks introduced with lack of line-of-sight



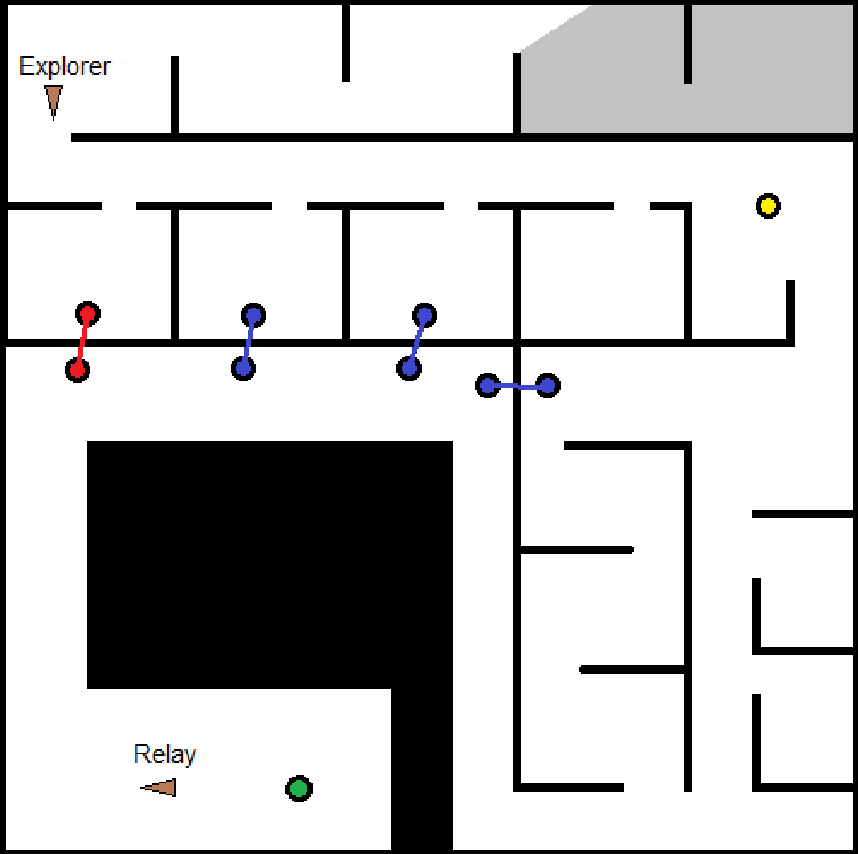
GENERATING CANDIDATE RV POINT PAIRS

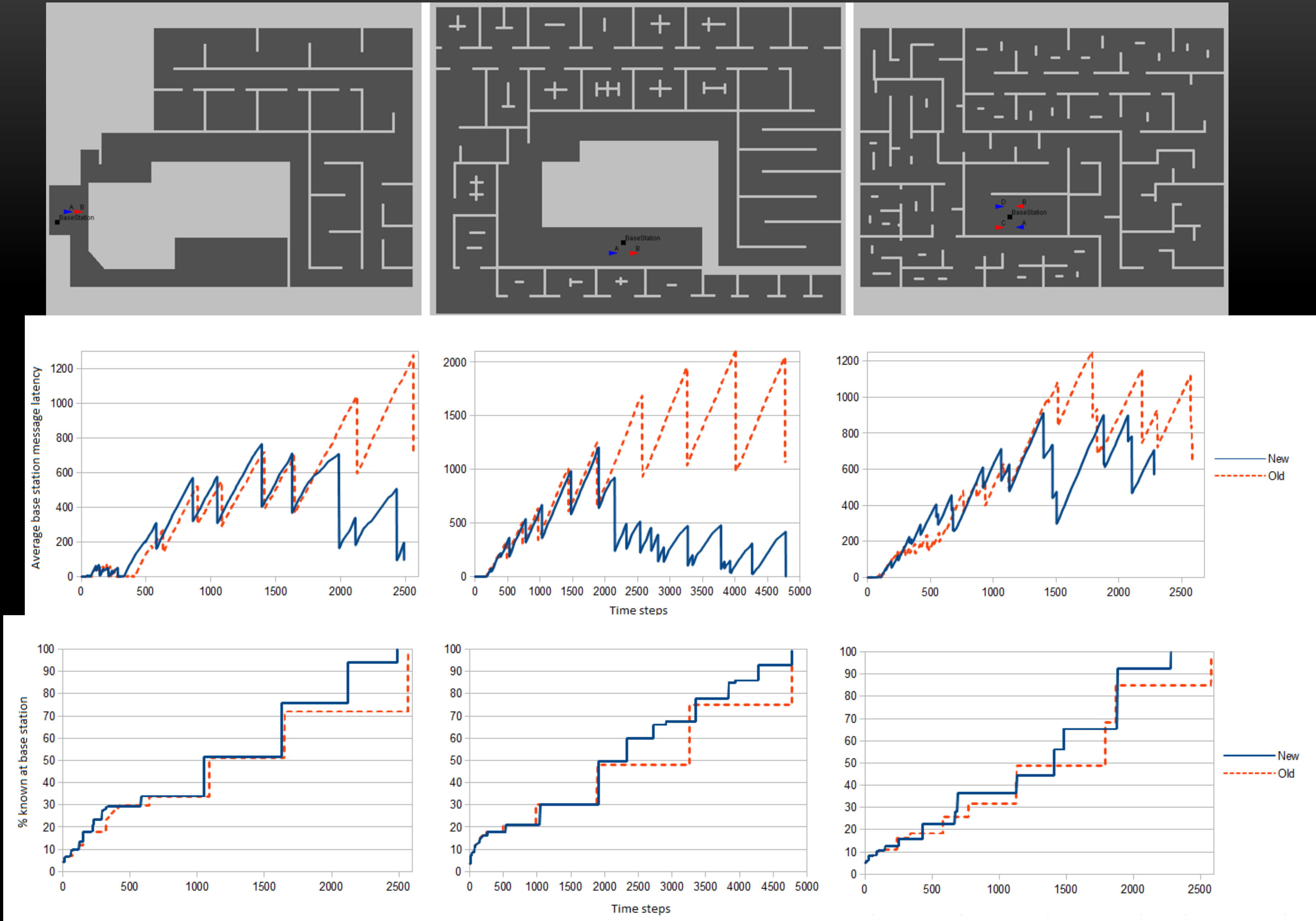
- Sample points close (but not too close) to obstacles.
  - Use several iterations of “thinning” to obtain a set of such points
  - Sample points from the set uniformly
- Evaluate communication range at each point (using a communication model with attenuation factor for walls); reduce the resulting range by a factor for additional safety
- Sample points from the communication polygon as candidates for the 2nd RV point in the pair
  - Evaluate distance to base



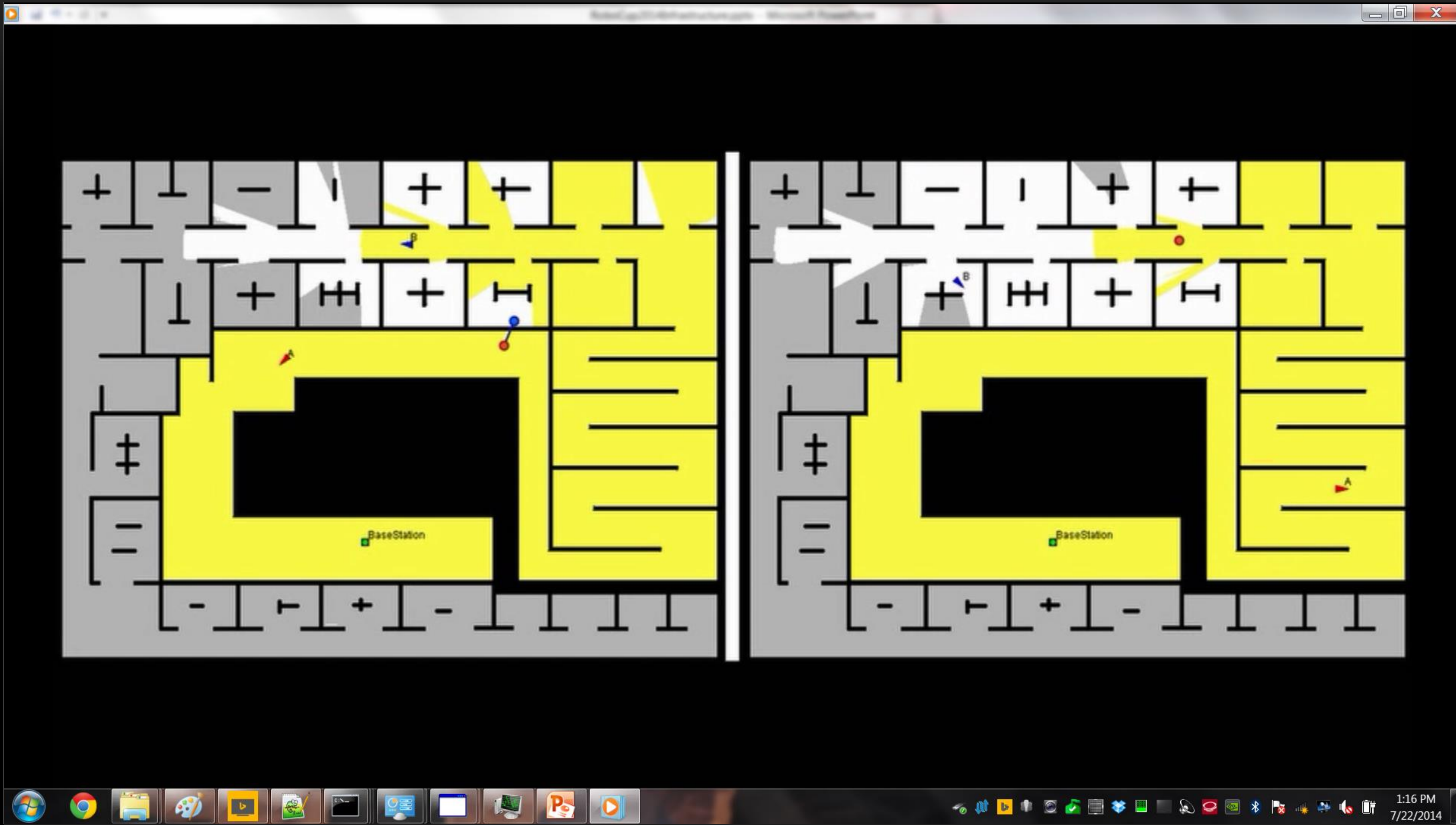
FALLBACK

- Agents can estimate meeting time, and agree on a timeout
- After the timeout, they can proceed to the single rendezvous point as a fallback
- Use low-frequency (low-bandwidth) high-range communication channel for control messages




BaseStation
A
B
C
D
Average base station message latency
Time steps
% known at base station
New
Old

Video



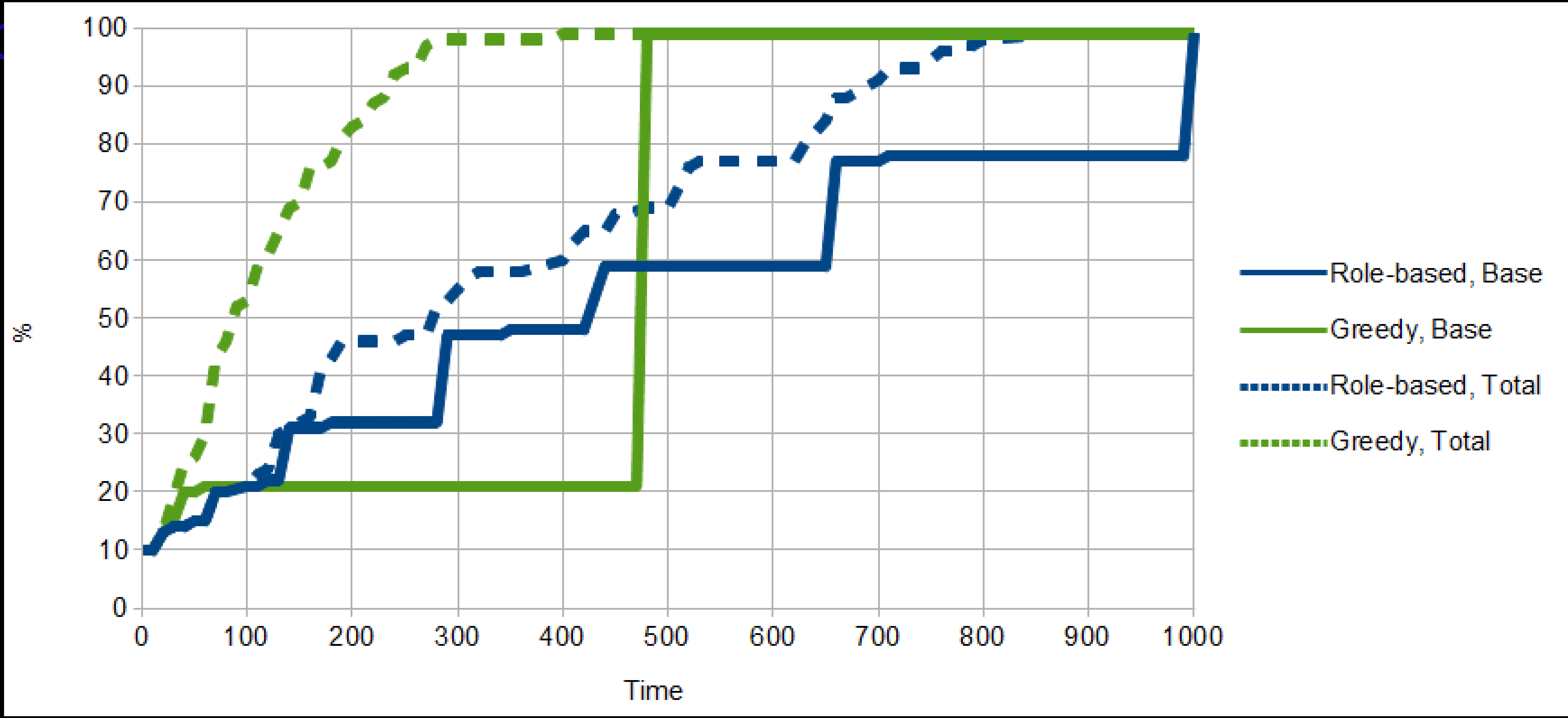
RESULTS

- Improved team connectivity
- Base station gets more frequent updates
- But, overall exploration speed not affected – as additional resources are not allocated to exploration
- Relays kept close to base station – safer, avoid going into risky areas, spend less time travelling
- Relays spend more time idle – may allow us to convert some relays into explorers, as fewer relays may be required

PAPER II

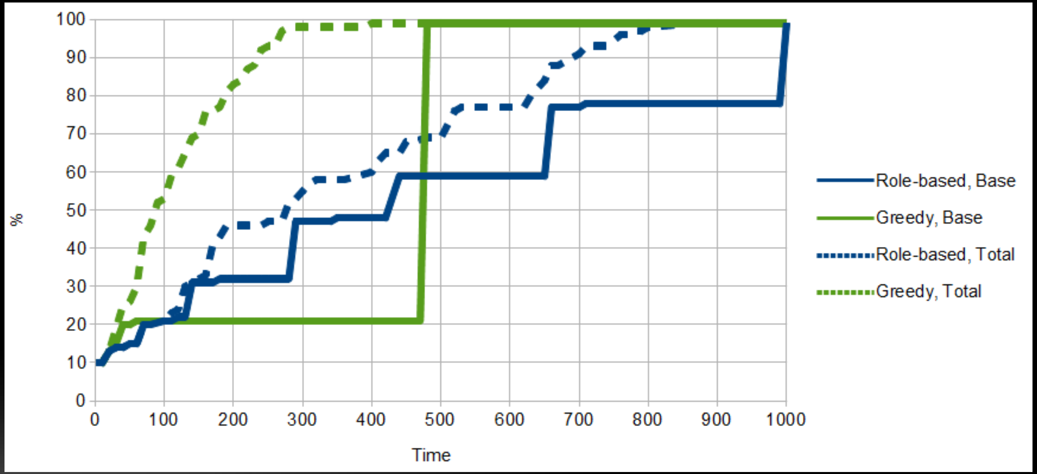
DYNAMIC ROLE SELECTION

- Favour different metrics: overall time VS



PROPOSED METHOD

- Set the desired minimum ratio of total agent knowledge known at base station
- Control team behaviour with a single parameter, a real number between 0 and 1



IMPLEMENTATION

- User sets $targetInfoRatio \in [0; 1]$
- For each agent i,
  - $infBase_i$ is the information i believes the base station to have
  - $infNew_i$ is 'new' information i knows
- Each agent either exploring, or returning to base
- An agent i only decides to return if

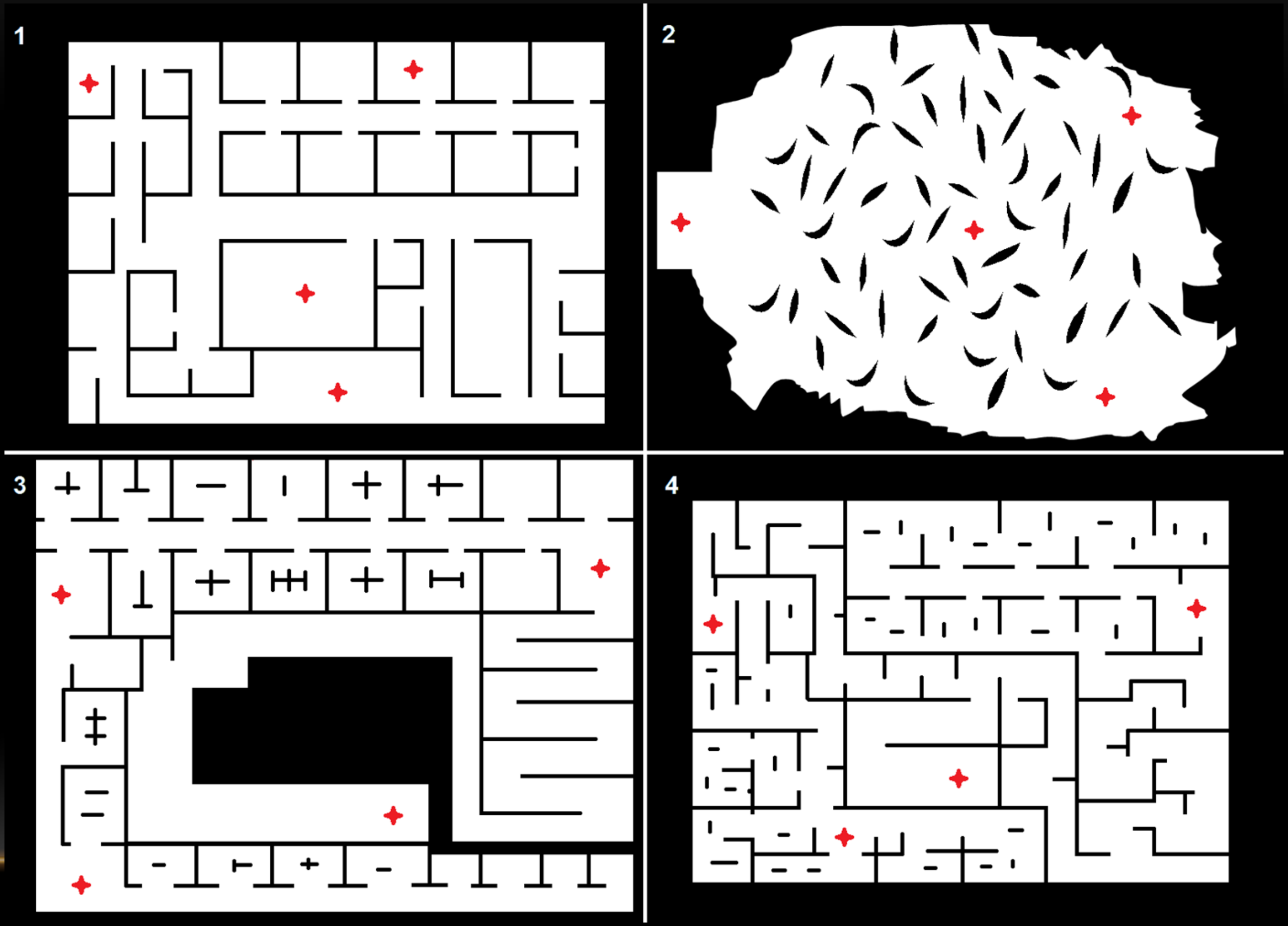
$$\frac{|\,infBase_i\,|}{(|\,infBase_i\,|+|\,infNew_i\,|)} < targetInfoRatio$$

IMPLEMENTATION - RELAYS

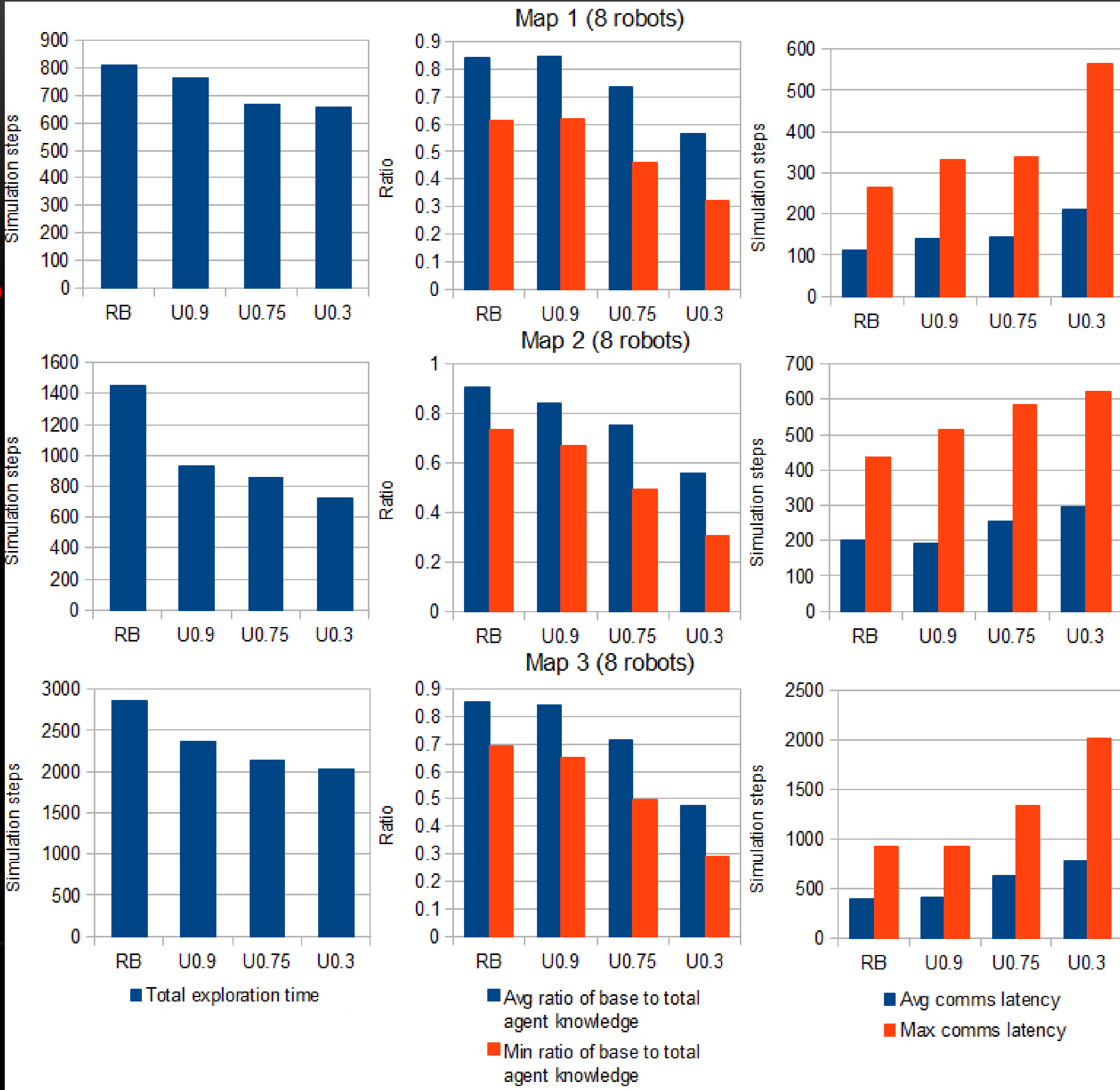
- Agents delivering same information to base = wasted resources
- When two agents, i and j meet, and j closer to base
  - $infNew_i$ added to $infNew_j$, $infNew_i$ set to 0
  - $infNew_i$ is marked as “being relayed”
- Reduce the risk of several agents trying to deliver the same information to base

EVALUATION

- Evaluated in a 2D simulator
  - Assumed perfect localization and mapping
- Used target ratios of 0.95,
- 0.90, 0.75, 0.5 and 0.3,
- compared with Role-based
- exploration; tried with 4 and 8 robots
- 4 maps, 4 runs on each map for each configuration



RESULTS

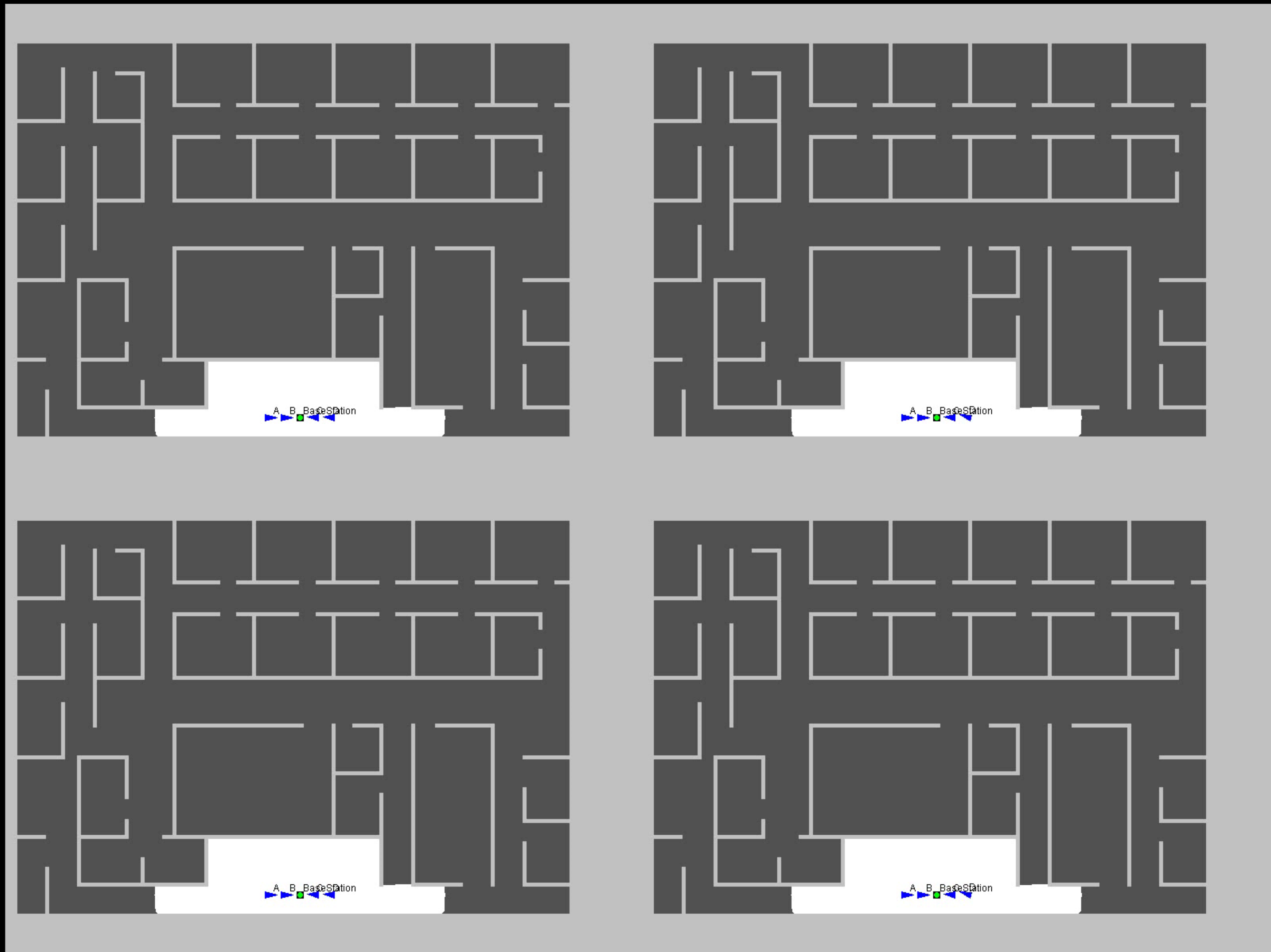


Map 1 (8 robots)
Map 2 (8 robots)
Map 3 (8 robots)
Simulation steps
Ratio
RB
U0.9
U0.75
U0.3
Total exploration time
Avg ratio of base to total agent knowledge
Min ratio of base to total agent knowledge
Avg comms latency
Max comms latency

EMERGENT BEHAVIOUR

- All agents start off as explorers
- As exploration moves deeper into the environment, dedicated relays emerge
- Relays create relay chains, as they navigate towards "popular" frontiers, plan similar paths and meet other relays on the way

Video



RESULTS

- A simple, effective way of specifying desired team behaviour and having the team adapt, by changing a single numerical parameter
  - Need to test in a realistic simulator and on a team of real robots
  - Which target ratios should be used for any particular situation
  - Bigger environments, more robots

CONCLUSIONS

- The MRESim Simulator is a Java based Open Source Simulator.
- Robots / Agent have a limited field of view, resembling a laser scanner (without noise)
- Robots / Agent have a limited communication range, attenuated by walls (like the WSS)
- Robots have to be distributed over the map
- Cooperation can be modelled by combining robots in explorer / relay pairs

https://github.com/v-spirin/MRESim

Julian de Hoog, Stephen Cameron and Arnoud Visser, "Role-Based Autonomous Multi-Robot Exploration", International Conference on Advanced Cognitive Technologies and Applications, 2009.