

Decentralized architecture for robust
semi-autonomous logistics and
construction robots

Motivation

- Logistics robots are increasingly adopted in warehouse settings to improve efficiency, decrease downtime of various industry supply lines
- Robotics for construction are presently being evaluated in many forms, especially to aid in lifting heavy equipment/supplies
- Safe and collaborative robot control architectures can be used to increase productivity in both of these settings
- Decentralizing the control architecture can increase safety and robustness to signal drops, robot equipment malfunction, and other unforeseen failures

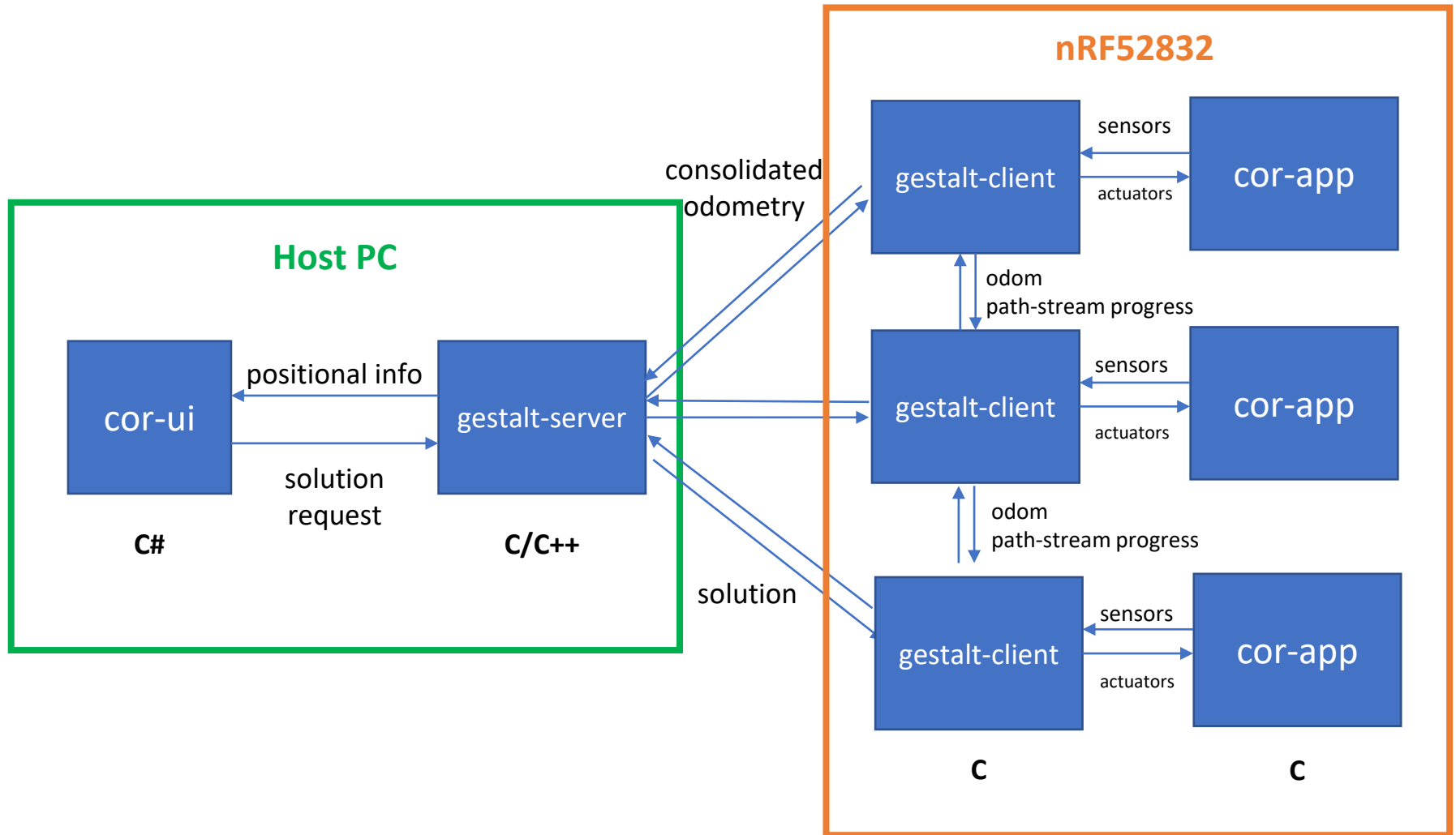
Goal

- This project will demonstrate a decentralized robot control architecture by which a user-controlled interface prescribes an objective to a semi-autonomous robotics network. This network is then able to arrange props collaboratively in arbitrary patterns safely without further guidance from the operator and is robust to losses within the network.

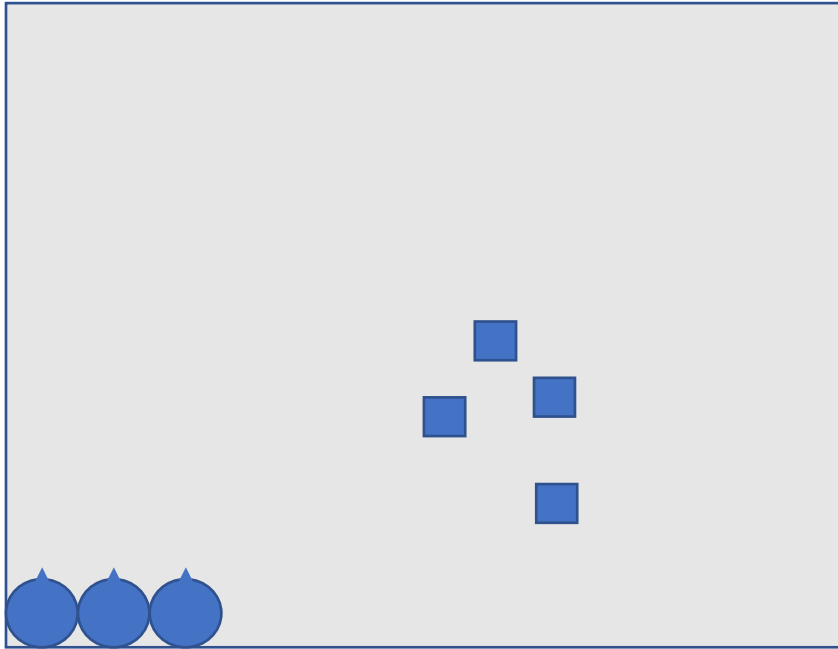
Project Approach

- The project involves a demonstration of 2+ robots operating in collaboration within an isolated environment to arrange props in arbitrary patterns as assigned by an operator.
- At tasking-time, a solver will calculate a stream of paths for the robots to follow, and this path is then downloaded to all robots in the network.
- During execution-time, the operator is disconnected from the network, and the path-stream will be correlated with live sensor data on each robot to move toward the solution state. Furthermore, during this phase, state space measurements and path-stream progress will be communicated between all operating robots, enabling higher spatial certainty and decreasing chances of collision.
- To demonstrate loss-tolerance, all robots will receive redundant path-streams such that network members may be removed at any time and the same outcome will be achieved.

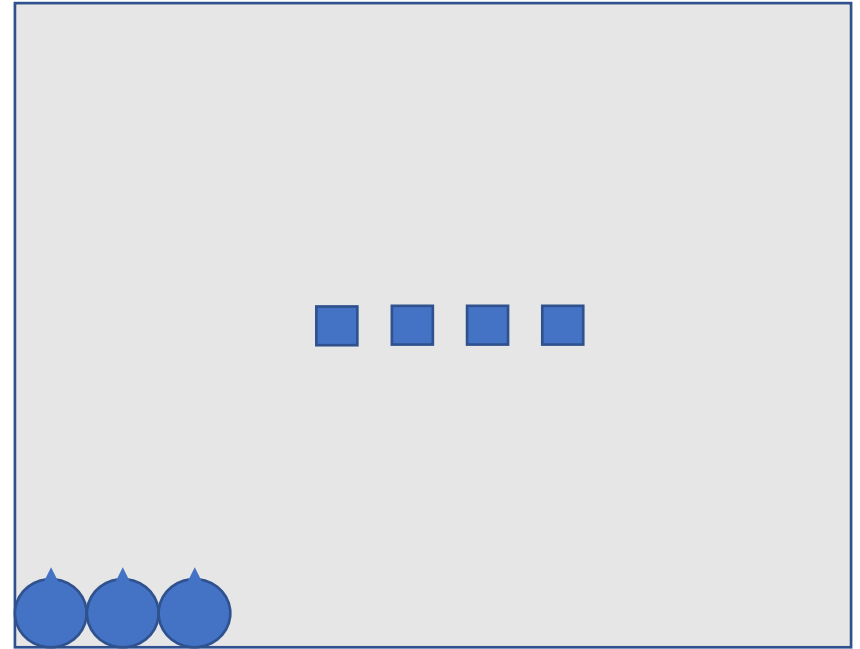
Coarse-Grain Hierarchy



Proof of Concept

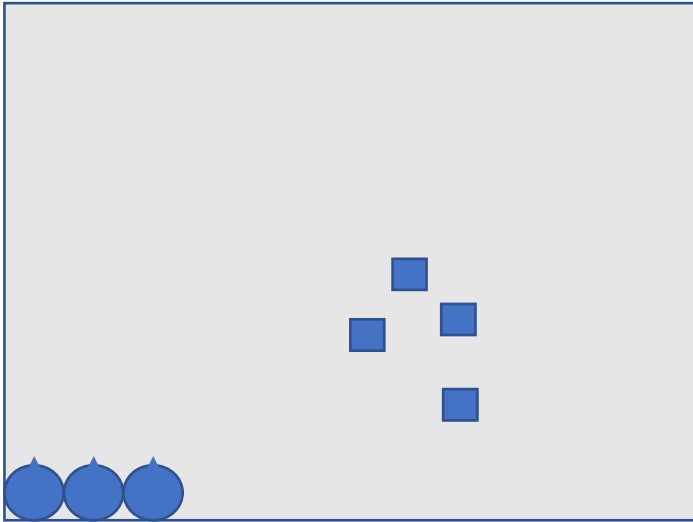


Starting condition

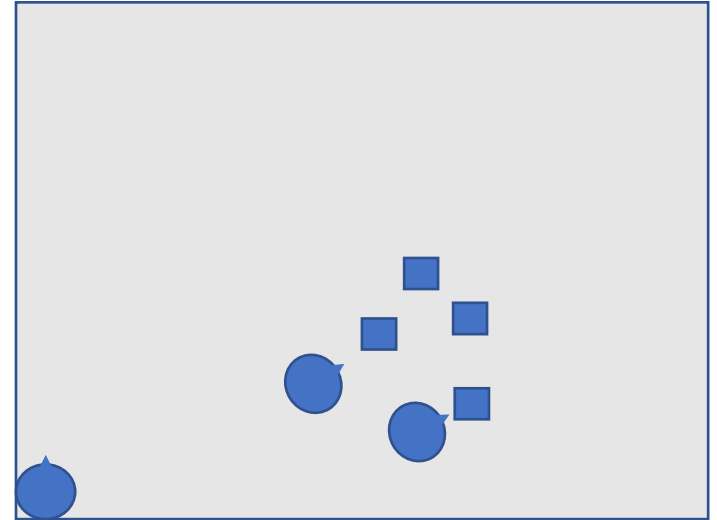


User-prescribed target

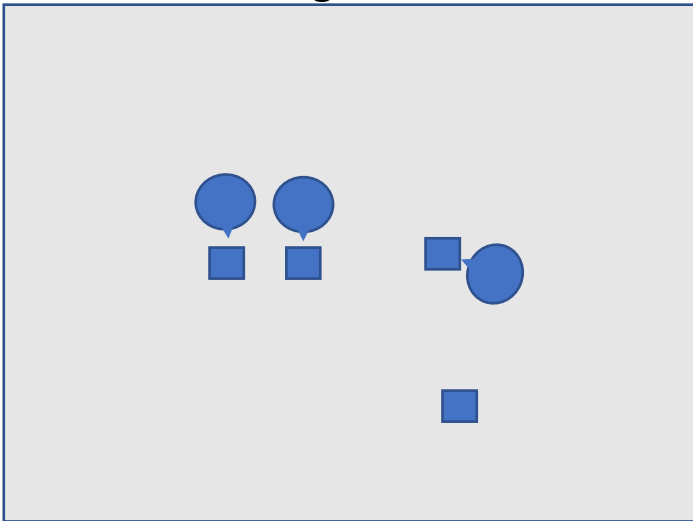
Proof of Concept - Solver



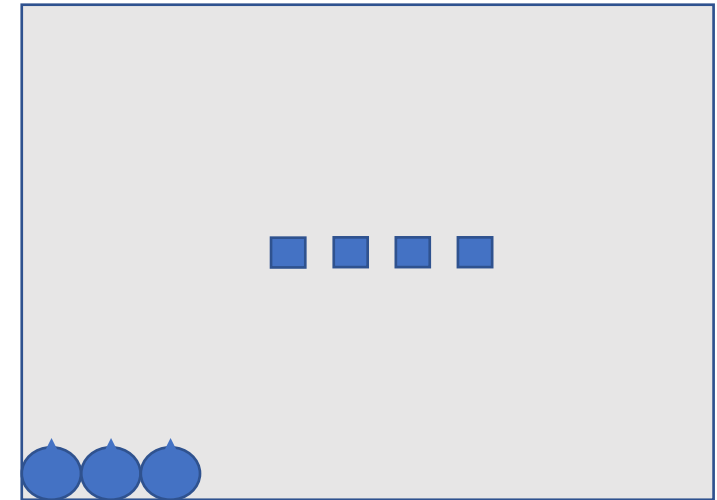
Starting condition



Step 1

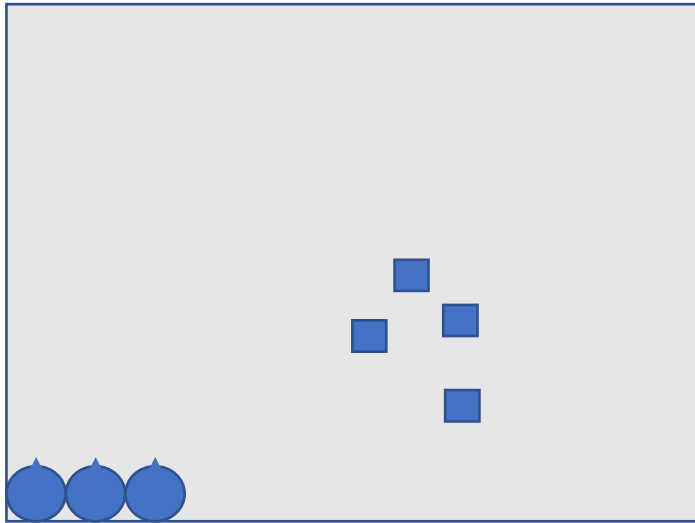


Step i

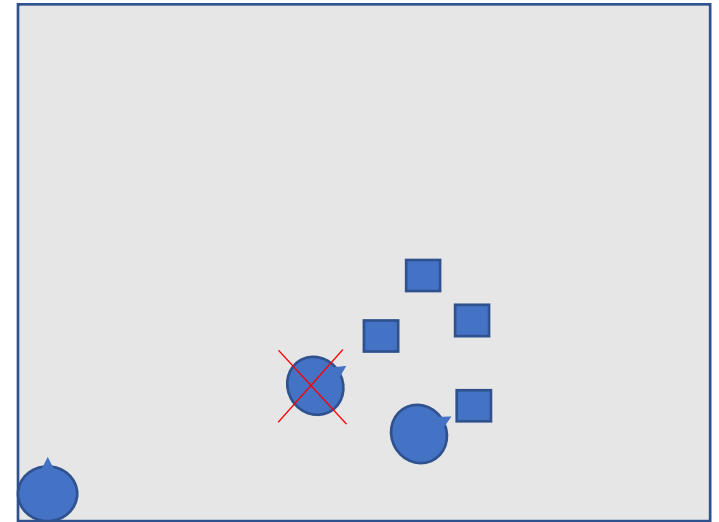


Step N

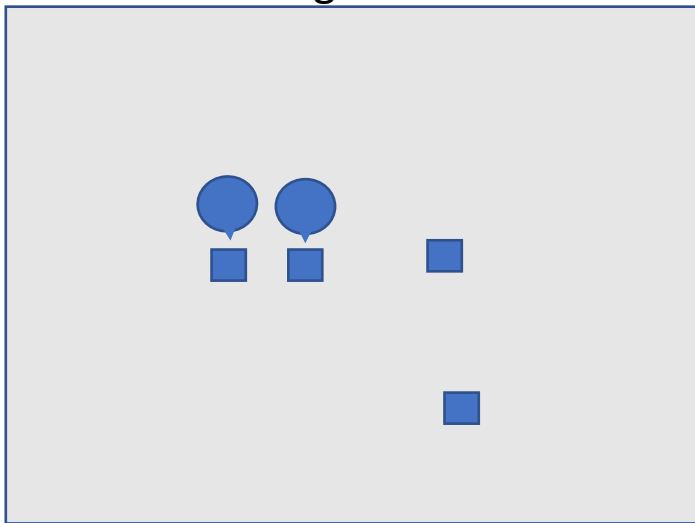
Proof of Concept – Loss-Tolerant Solver



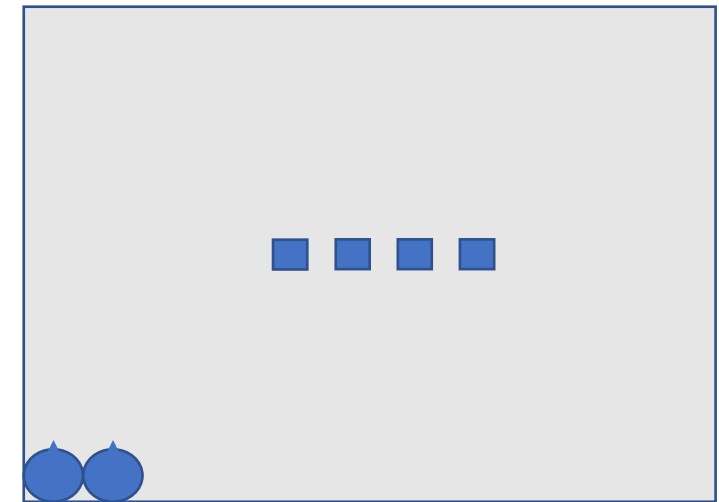
Starting condition



Step 1



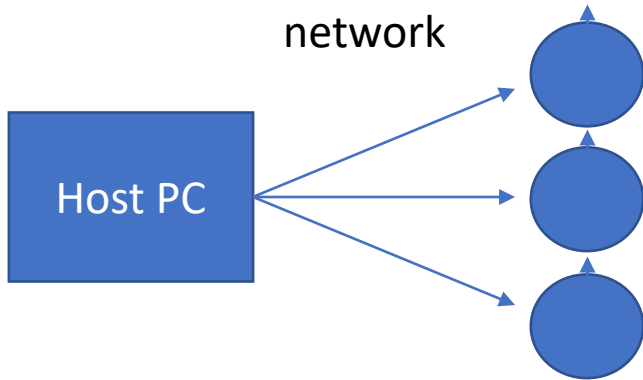
Step i



Step N

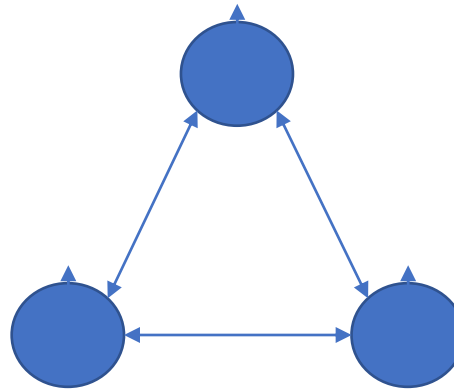
Architecture

Solution path-streams
are uploaded to robot
network



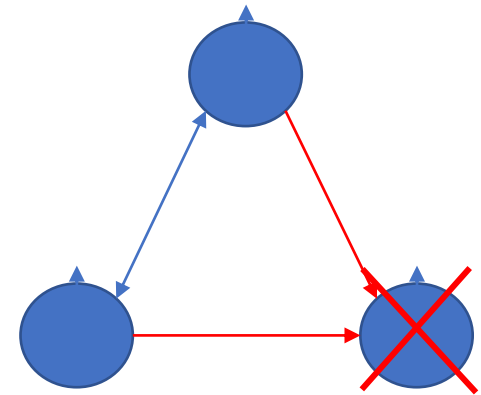
Architecture at tasking

Path-stream progress
and odometry are
exchanged



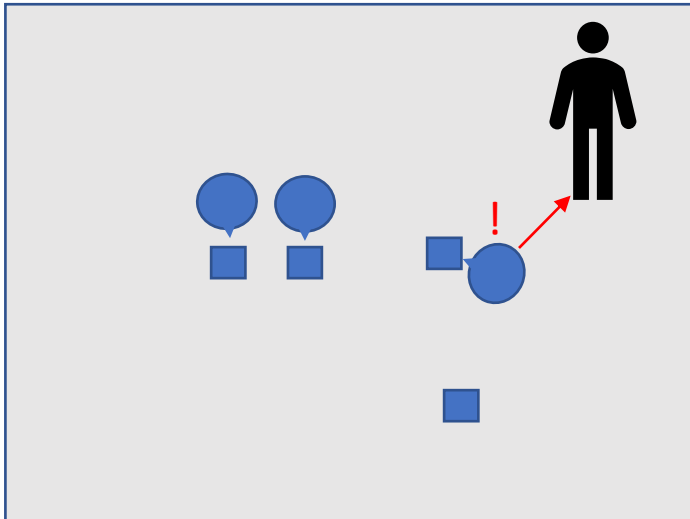
Architecture at execution

Remaining path-streams
are consolidated and
distributed between
robots



Architecture at loss-time

Safety



STOP

If any single member of the network senses an unrecognized object within the operational space, all members will be stopped

RESUME

All members of the network must confirm that the unrecognized object has exited the space before the entire network may resume

Equipment

- 3x Robot platform – Kobuki
- SoC
 - nRF52832
- Sensors
 - Accelerometer from Buckler
 - Gyro from Buckler
 - [2D top-mounted LiDAR](#) \$100
 - Bluetooth from nRF
- Actuators
 - One-dimensional linear actuator to grip cubes
- Host PC
 - Any OS running Unity