

Executive Summary

StarCraft: Brood War (1998), developed by Blizzard Entertainment, has become a well-established benchmark for AI research, with StarCraft AI competitions being held since 2011. Its real-time gameplay, fog-of-war, and pathfinding present significant challenges for artificial intelligence, making StarCraft: Brood War valuable for research in real-time decision making and long-term planning.

Our agent, ProtoBot, was developed to compete against other agents using the Brood War API (BWAPI) and integrates six rule-based modules to allow for intelligent decision-making and human-like gameplay.

To evaluate the performance of our agent, ProtoBot was uploaded to BASIL, a 24/7 online competitive ladder with over 100 bots already submitted. Through this project, the team has experienced the complexities of developing an intelligent RTS AI and achieving competitive results. Despite these challenges the project has proved value for exploring rule-based solutions to real-time strategy problems and developing technical programming skills.

Background

What is StarCraft: Brood War?

StarCraft: Brood War is a real-time strategy game released in the late 1990s. Players gather resources, expand their influence across the map, and control units to defeat an opponent. Unlike turn-based games, everything happens simultaneously in real time, requiring players to make fast decisions, manage multiple tasks at once, and adapt to incomplete information due to limited visibility of the opponent.

Why does AI in StarCraft matter?

StarCraft presents a challenging environment for AI because it combines real-time decision making, resource optimization, and strategic planning under uncertainty. Developing AI for games like StarCraft helps advance techniques in areas such as automation, multi-agent coordination, and adaptive decision systems. The same challenges that appear in real-world problems like robotics, logistics, and cybersecurity. AI research in games also provides ways to be able to train agents without having to make complex machinery and only requires hardware to run online games to train. Artificial intelligence has already transformed how people approach games like chess, and StarCraft represents the next level of complexity, where AI can both compete with and teach human players new strategies.

Experimental Set up and Constraints

To make the development process of our agent be as smooth as possible, the team utilized STARTcraft as a skeleton to structure ProtoBot. STARTcraft is an open-source repository created by Dr. Churchill at Memorial University in Newfoundland and serves as an accessible blank project for those interested in developing AI for StarCraft: Brood War. STARTcraft provides all the necessary BWAPI and StarCraft files needed to start developing an agent, allowing us to test early iterations of our bot against StarCraft's native AI to develop basic behavior.

We then constrained our bot to adhere to the COG, SSCAIT, and BASIL rule set, providing us defined guidelines and rules we need to follow to create a competition ready bot.

The following items are a few of the rules defined for BASIL we used as our constraints:

- Games will be a full 1v1 game of StarCraft 1.16.1 Brood War, fog of war enabled.
- Bot must be compiled with BWAPI and be able to run on Windows 10.
- 1 frame exceeding 10 seconds, 10 frames exceeding 1 second, or 320 frames exceeding 55ms will result in a loss for the bot.
- Games will have a frame limit of 86400 frames, approximately one hour of gameplay, for the competition and BASIL ladder
- A bot crashing or pausing the game will result in a loss for it.
- Bots will be disqualified if they use Perfect Information or exploit any bugs.

Architectural Design and Experimental Test Plan

Centralized System Architecture

ProtoBot's architecture has a central system with subsystems that ensures transparent and logical data flow. The central system, **ProtoBot Commander**, handles multiple subsystems, a.k.a. managers, that are each responsible for a particular task in the game.

Combat Manager: Manipulates large groups of units to attack enemies and defend key positions.

Scouting Manager: Controls individual combat units for scouting possible enemy locations and harassing/killing important targets

Economy Manager: Assigns worker units to resources and optimizes their farming routes to maximize resource gains.

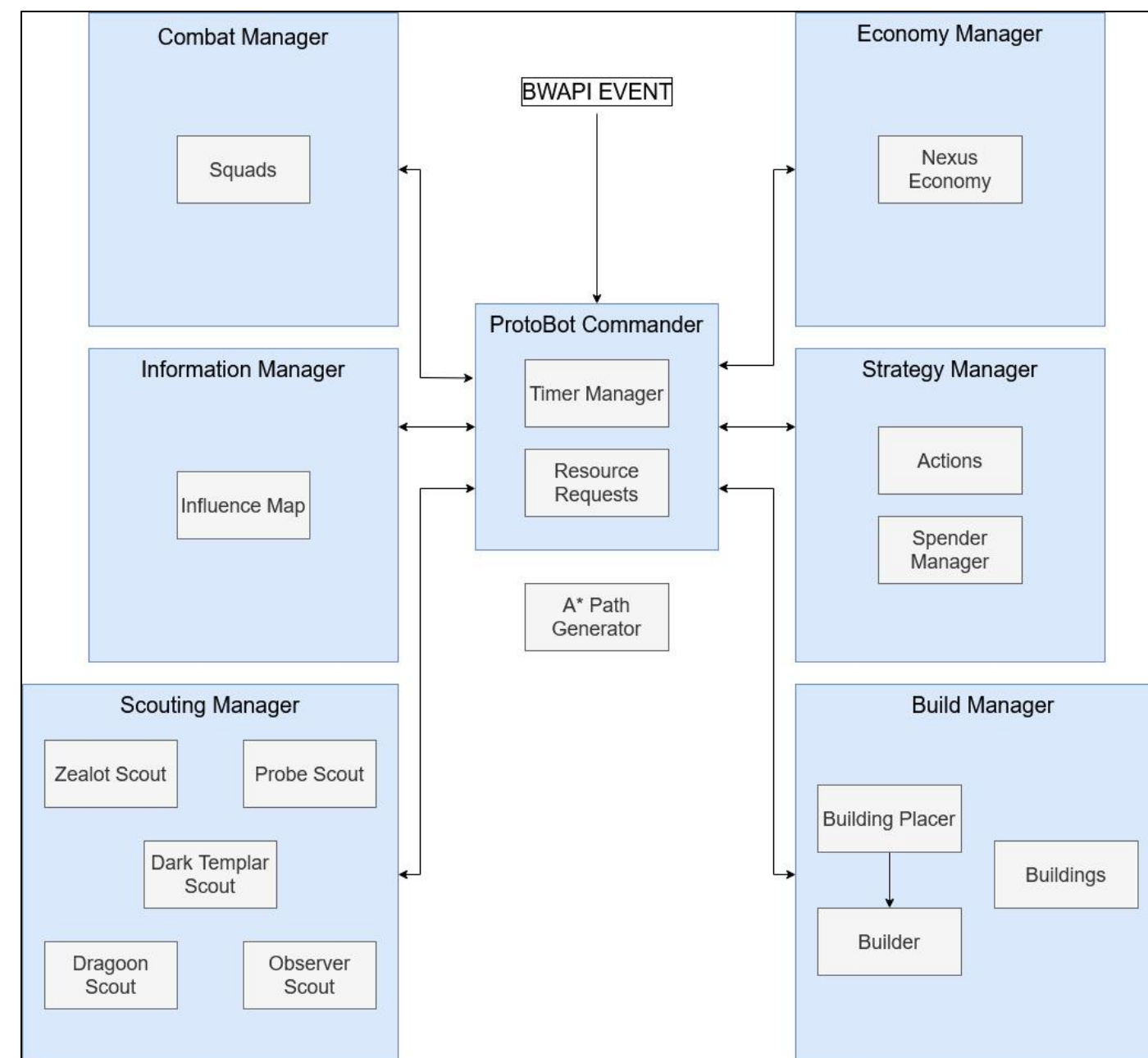
Information Manager: Scans for enemy units, buildings, and bases to store their positions, counts, and current states for use in other managers

Build Manager : Queues building placements and verifies unit production to strengthen ProtoBot's army.

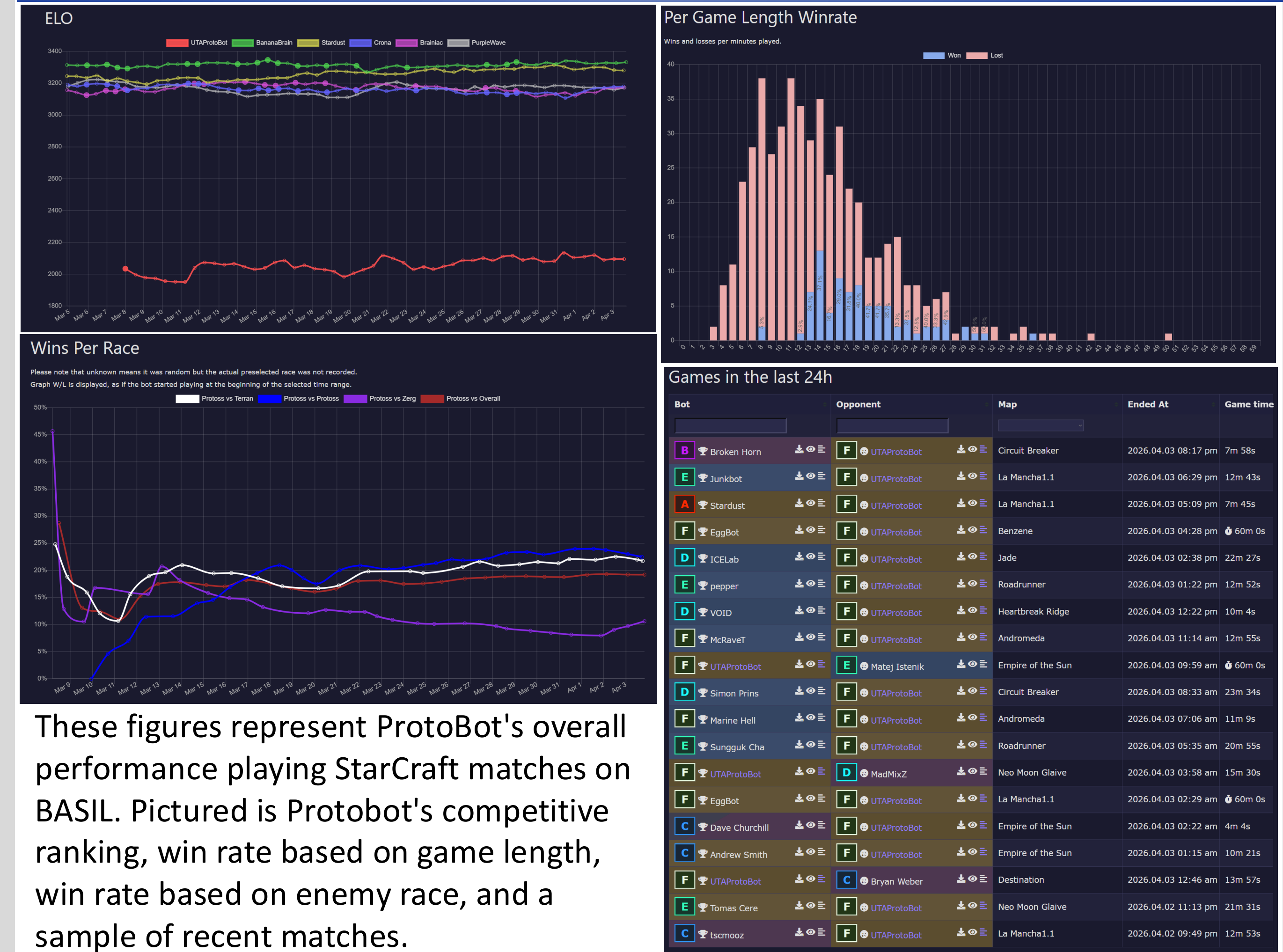
Strategy Manager : Analyzes current game state to issue strategic commands to other managers.

BASIL AI Ladder

To measure the overall level of gameplay of ProtoBot, we uploaded our bot to a public Starcraft: Brood war AI league called BASIL, which orchestrates 24/7 matches between over 100 other StarCraft: Brood War agents. BASIL hosts an online leaderboard, replay system, and statistics to analyze many different metrics of each agent's performance. Through these features, we have been able to test ProtoBot within a competitive environment and watch match replays to analyze our bot's strengths and weaknesses.



Experimental Results



After uploading ProtoBot to BASIL, we have gathered useful data and feedback from other bot authors to allow us to make improvements to ProtoBot's overall performance. With many of the core issues needing to be addressed around the 7-to-11-minute mark.

Conclusions and Future Work

ProtoBot demonstrates a working, student-made StarCraft: Brood War bot that can win matches against opponents without crashes or interrupts and serves to help future senior design teams understand the scale of projects involving game-playing agents in real-time strategy games. As well as highlighting the applications of games as environments for AI research. Future improvements involve fine-tuning small-scale combat (target prioritization, formation variety, etc.), tailoring unit production to the weaknesses of the enemy's current units, more adaptable placement of buildings, and optimization of ProtoBot's long computation times of specific algorithms.

Special thanks to the StarCraft: Broodwar bot authors that guided us: Dave Churchill, **Purplewave** (Dan Gant), **Microwave** (Micky Holdorf), **Infested Artosis** (Brad Ewing), **McRave** (Christian McCrave), **Stardust** (Bruce Nielsen), **NiteKat** (Daniel Maize)

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