Solution Summary

Approach and Key Insights

In Assignment1.2, the approach to solving the FAUhalma game was based on a minimax algorithm with alpha-beta pruning, suitably generalized for two players as well as three players. This need has been driven by the fact that this game belongs to a category of perfect information games with a need to take into account the opponent's moves also.

Key Design Decisions:

- **Representing the board:** A hexagonal co-ordinate system (x, y, z) so that z = –x–y. This made distance calculations easier to carry out, and neighbor identification was key for generation and evaluation of moves.
- **Generation of moves:** We applied a two-step move generation process—simple moves to adjacent spaces and hop chains. This will be a complete methodology, ensuring all possible valid moves are generated even in the most complex forms of hop sequences.
- **Evaluation Function:** The evaluation function will consider the following factors: the number of pieces in the goal area, distance of pieces from the goal area, the formation of the pieces, and penalties for isolated pieces. All of these combined should have the immediate gains balanced against strategic positioning.
- **Search Algorithm:** We have used minimax with alpha-beta pruning because it works well with adversarial games. With the help of pruning, this algorithm has visibly improved in search efficiency, reaching greater depths within the stipulated time.
- **Time Management:** A basic time management system has been developed that enforces different depth and time constraints for rhombus and star boards to make sure the agent responds to the server's time limits while ensuring a maximum depth of search.
- **Dynamic Board Type Handling**: We determine the type of board based on the configuration file dynamically. It makes our agent work for both Rhombus and Star boards without changing any code.

Challenges and Insights:

- **Determination of a Valid Position:** At the beginning move validation was the toughest portion due to a rhombus board. But we solved this by defining the set of valid positions at the start for each type of board, which rigorously follows the rules of the game.
- **Adaptation to Three Players:** The minimax algorithm was quite tricky to adapt for three players. In this case, we considered the next player in the rotation as the opponent, which is probably not the best solution but works.
- **Balancing the Evaluation Function:** All the different factors in the evaluation function had to be balanced, which proved tricky. Heavily weighting goal occupation but still considering the formation of pieces seems to work better.

Potential Improvements:

- Opening book of common starting positions
- Improved the valuation function based on knowledge from game analysis
- Implemented iterative deepening for much better exploitation of the whole time end
- Innovative Endgame strategies

Conclusion:

Our agent is able to play most of the FAUhalma scenarios rather well, allowing for further optimizations in special game stages or multi-player dynamics.