Creating a Diplomat

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Abstract

Many programs have been written to play two-player games, but few for multiplayer games in which negotiation becomes important. Diplomacy is a popular board game in which players assume the roles of the major protagonists of world war one. It is a game of negotiations; alliances, promises kept and promises broken. In order to survive a player needs help from others. Knowing whom to trust, when to trust them, what to promise, and when to promise it is at the heart of the game. In this, it provides an exciting and unique environment for negotiation, and one which can generalise to an enormous number of applications.

This report describes a novel approach to creating an automated Diplomacy player, using auctions as a means of negotiation, and simple algorithms to help a Diplomacy player determine if and when to lie.
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# Contents

1 Introduction .......................... 4
   1.1 Motivation .......................... 4
   1.2 Objectives .......................... 5
   1.3 This Report .......................... 5

2 Background .......................... 7
   2.1 Diplomacy: Analysis ............... 7
      2.1.1 Diplomacy: Rules ............... 7
      2.1.2 Diplomacy: Strategies .......... 9
      2.1.3 Diplomacy: Tactics ............. 11
      2.1.4 Diplomacy: Calhamer’s Intentions . 12
      2.1.5 Diplomacy: Properties .......... 13
      2.1.6 Diplomacy: Challenges .......... 14
   2.2 Diplomacy: Existing AI’s .......... 15
      2.2.1 The Israeli Diplomat .......... 15
      2.2.2 The Bordeaux Diplomat .......... 16
      2.2.3 LA Diplomat .................. 19
   2.3 Modelling Negotiation .............. 20
      2.3.1 Argumentation Based Agent Communication Languages 20
      2.3.2 Market Based Control Mechanisms .... 21
   2.4 Existing Resources ................. 22
      2.4.1 Programming Languages .......... 22
      2.4.2 DipAI Organistion .............. 24

3 The Diplomat ........................ 28
   3.1 Aims ................................ 28
   3.2 Assumptions ........................ 28
   3.3 Components and Responsibilities ... 29
   3.4 The Diplomat System ................ 30
   3.5 Diplomat Pseudocode ............... 32

4 Strategy and Tactics .................. 33
   4.1 Order Generation ................... 33
      4.1.1 Target Province Refinement ...... 34
      4.1.2 Builds/Disbands/Retreats ....... 34
   4.2 Plan Generation .................... 34
      4.2.1 Clustering ..................... 36
      4.2.2 Number of Plans ............... 36
Chapter 1

Introduction

Diplomacy is a zero-sum\textsuperscript{1}, completely strategic and deterministic\textsuperscript{2} game, in which the focus is negotiation.

Developing a Diplomat\textsuperscript{3} necessitates integrating the strategic and tactical with an understanding of very human qualities. A Diplomat needs to be able to negotiate, to explain and reason, to know if and when to lie, as well as if it is being lied to. As such, it provides a perfect testbed for artificial intelligence and cognitive science research.

Note that the rules [3], and a much more thorough analysis of Diplomacy is provided in section 2.1, on page 7.

1.1 Motivation

With Deep Blue’s victory over Gary Kasparov in 1997, the AI community achieved a Grand Challenge\textsuperscript{[17]}, and with this, as well as the study of other games, the confidence to say that the theory of deterministic two-player games is now well understood. The intervening years have seen the emergence of a new Grand Challenge, RoboCup\textsuperscript{4}, which aims to develop a team of robot soccer players capable of winning the World Cup. RoboCup moves beyond an abstract domain, to the real world.

For all of its differences, RoboCup is still similar to Chess in that there are only two opposing sides. Diplomacy involves seven, and as such calls for the development and integration of AI techniques important for understanding cognition and human interaction. It is a useful testbed that provides great scope for investigating the complexities of negotiation amongst multiple independent agents, while abstracting away from many of the problems that Robocup faces. Table 1.1 illustrates the relationship between the two approaches.

The only full treatment of Diplomacy so far has come in the form of the Israeli Diplomat [10]. It employed a sophisticated multi-agent architecture to distribute control and processing, and was aimed at answering the question of

\textsuperscript{1}The sum of gained (positive) and lost (negative) is zero, pure competition.

\textsuperscript{2}No element of chance.

\textsuperscript{3}An automated Diplomacy player.

\textsuperscript{4}www.robocup.org
who[^5] would make decisions. However, the more interesting questions regarding Diplomacy have been ignored by it. This project focuses on how and what decisions are made. In so doing, it is hoped that a flexible and general treatment of the challenges posed by Diplomacy will be developed.

### 1.2 Objectives

The objective of this project is to provide a treatment of the major aspects of Diplomacy. In particular:

- The Diplomat should be able to create good orders, from a strategic and tactical point of view.
- The Diplomat should be able to negotiate with other players. A strategy should be employed, such that Diplomats benefit by negotiation.
- The Diplomat should be able to make a reasoned choice as to whether to stick to agreements or not.

### 1.3 This Report

**Background** presents preliminaries regarding Diplomacy and Diplomats. The state of the art, useful tools in the development of Diplomats, and applicable areas of research are examined.

**The Diplomat** presents an overview of the Diplomat, assumptions made throughout the project, and a splitting of the work.

**Strategy and Tactics** describes the problems with managing strategy and tactics in Diplomacy. This is followed by a presentation of the Diplomat’s approach, and it’s limitations.

**Negotiation** takes a look at the exchanges that occur in Diplomacy, and suggests possible representations. The Diplomat’s approach is presented, and the extensibility of it considered. Finally, the limitations of the approach are examined.

**Deceit** considers the questions that must be answered for a treatment of deceit to be provided. The Diplomat’s chosen approach is presented, and the limitations of it are considered.

[^5]: Which agent within a multi-agent architecture.
Findings presents the results from trials of the Diplomat, and an analysis of them.

Conclusion details the contributions of the project, ideas for further work, and concluding remarks.
Chapter 2

Background

This chapter aims to provide an understanding of what a Diplomat will need to do. It presents: 1. A description and analysis of Diplomacy. 2. Previous attempts at creating Diplomats. 3. Negotiation mechanisms. 4. Existing Resources i.e. Diplomacy related applications.

2.1 Diplomacy: Analysis

This description and analysis of Diplomacy is composed of:

- The rules to Diplomacy.
- Strategies employed by Diplomacy players.
- Tactics employed by Diplomacy players.
- An analysis of Calhamer’s intentions when creating the game.
- The challenges of Diplomacy.

2.1.1 Diplomacy: Rules

Players are randomly assigned the role of one of the seven ‘Great Powers’ of Europe prior to World War I. Diplomacy is played on a game map, figure 2.1, that splits Europe into a number of provinces, some of which are also supply centres. At the start of the game, some of these supply centres are occupied by players (deemed Home Supply Centres), and some are unoccupied. For a province to be occupied, a unit (army or fleet) is resident in it. The aim of each of the players is to control more than half of Europe’s supply centres. Diplomacy is turn based, and each turn consists of a number of phases:

Negotiation Phase: Players meet together to make plans and discuss strategies. Bounded only by a time limit (fifteen minutes), agreements between players are openly or secretly made, and orders may be coordinated.

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1Control is established by the last player to occupy a province at the end of a year. Control is maintained so long as no other player gains control of a province.
Figure 2.1: Game Map

Order Writing Phase: Each player writes an order for each of their units, these orders do not have to correspond in any way to agreements that the player previously made. Types of orders are:

Hold: Order a unit to maintain its position.

Move: Move to an adjacent\(^2\) province. It may be either occupied, or unoccupied. Note that moving and attacking are not distinct notions in Diplomacy, to move to a province occupied by another player’s unit is implicitly to attack it.

Support: Add extra strength to another unit’s move. For unit A to support unit B’s move, it must itself be able to move to the province which B wishes to move to. For unit A to support unit B’s hold, it must be able to move to the province B is in.

Convoy: Move an army in a coastal province, via a chain of fleets, to another coastal province.

Order Resolution Phase: When all players have written down their orders they are simultaneously revealed, and, using a set of deterministic rules, resolved. In particular:

Hold: In Diplomacy, all units have equal strength, a unit holding in a province has strength one. A hold move is successful so long as it is not attacked by forces with greater strength than defend it.

\(^2\)The province must also be reachable by that unit. For instance, an army in London is adjacent to, but cannot move to, the English Channel.
**Move**: A move has strength one. When forces of equal strengths contest a province, no move is successful, and the status quo is maintained. A move is successful if it has more strength than other forces contesting the province. The only way that additional strength can be gained is through support moves, these each add a strength of one to the attack or defense, depending upon which unit is being supported. If a move is successful, and the province is occupied, then the occupying unit is displaced (forced to retreat to a reachable province, or to disband if none is available).

**Support**: Unless displaced by another attack, a supporting unit stays where it is. A supporting unit has strength one, however, if another unit attacks a supporting unit, the support is cut, and no strength is added.

**Convoying**: A convoy order will succeed so long as enough strength is present for the army to displace whichever forces guard the destination province, and no fleet in the chain is displaced.

**Build/Disband Phase**: At the end of every year players must reconcile the number of units controlled with number of supply centres controlled; disbanding or building additional units (new units must be built in Home Supply Centres), as required.

### 2.1.2 Diplomacy: Strategies

There are many equally valid approaches to strategy in Diplomacy. This section outlines a few currently popular ideas, many taken from [6]. The aim of this section is not to present a good strategy, but to provide an appreciation of some of the elements involved. Online resources are available which present this topic in much more depth, in particular [1].

A game of Diplomacy can be seen, much like Chess, as consisting of a number of phases. In different phases, players focus on achieving certain goals:

**Early Opening**: This describes the game before players engage in serious conflict with one another:

- Negotiate to establish occupation of neutral supply centres. This is the benefit to all those players who participate, since, it alleviates conflicts, and those who participate may thus ‘gain a tempo’ in comparison to those who don’t.
- Players may attempt to occupy, or threaten to occupy supply centres which more ‘naturally’ belong to other players in the hope of wringing concessions from them.
- The decisions of which neutral supply centres are occupied partly determines the course of the game. For instance, an English presence Belgium, Holland or Denmark may portend future conflict with France or Germany, whilst a presence in Norway suggests conflict with Russia. During this stage, players should also attempt to ‘feel’ each other out, in order to analyse each other’s skills and intentions.

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3 There are two turns per year.
Late Opening: This represents the situation after the early opening, but, before a clear leader has emerged. A number of general principles have been suggested:

- Fight against one opponent at most at a time, preferably with help from other players. In starting a campaign, a player has three objectives; to, remove another player from the game, and thus, increase their chances of winning (one out of six as opposed to one out seven), to capture more supply centres so a larger force can be built, and to temporarily secure a front so that units can be sent elsewhere.
- Fight against immediate neighbours.
- Seek alliances which maintain peace along other fronts. In particular, alliances involving demilitarized zones are very effective. This also reduces the chances of alliances being made against the player.
- Negotiate rapidly, as more offers lead to more gains.
- Potentially, make agreements with every player, and delay the decision of which should be kept or not until later. This can be seen as a way to avoid diplomatic isolation, which inevitably leads to problems.
- Break agreements when necessary, but not frivolously. Ideally break agreements with parties who will not be in a position to retaliate.
- Attempt to end conflicts as quickly as possible, before other players can intervene.
- If forces become locked together, it may be beneficial to cede defeat, and negotiate a withdrawal rather than wait to be attacked by another player.
- Maintain a reserve of units at home supply centres to guard against surprise enemy attacks.
- There is no disadvantage to being specific in negotiations, i.e. specifying precisely the moves that both parties should play. Item Plan builds of new units with regards to the situation in several moves time, as it will undoubtedly take a few turns for units to move to the 'front line'.

Middle Game: By this time, some players have become eliminated. Power waxes and wanes as the 'most powerful' switches between players.

- Perhaps attempt to maintain a position as the second most powerful player. This reduces a players perceived threat, and lessens the chances of being attacked.
- As the most powerful player, attempt to divide and conquer opponents.
- As a less powerful player, ensure that the leader does not assert control of the game.
- Attempt to maintain power balances across the board, so, no particularly strong power arises anywhere. This can be achieved by direct negotiation (e.g. arranging an attack), or more subtly (e.g. by giving advice to other players).

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4Provinces which players agree will remain unoccupied.
• Ally with weak players against strong players, when the campaign can be completed quickly enough so that other players cannot interfere. Ally with strong players against weak players so long as the strong players will not become too strong afterwards.

End Game: Power has consolidated into a few blocks, alliances are largely set, and players have learnt much about each other.

• Large powers may attempt to eliminate other opposition, and advance in concert.
• When facing large powers, smaller powers may attempt to block only one, so as to turn the lesser against the greater (by convincing it that the greater will surely win otherwise).

2.1.3 Diplomacy: Tactics

The tactics of Diplomacy are simpler than its strategies, but still contain much room for debate. This section outlines a few ideas taken from [18]. The aim of this section is to detail some approaches to tactical analyses that a Diplomat may take on board. Once again, online resources are available which present tactics for Diplomacy in much more depth, in particular [1].

The fundamentals of tactics in Diplomacy are to:

• Attempt to maintain fronts, or ‘walls’ of units, so as to separate home supply centres from enemy units.
• Avoid situations which allow an enemy can breach a front.
• Where possible, push against, or break down enemy fronts, so as to move towards enemy supply centres.
• Provide orders for individual units, perhaps as raiders to get behind enemy lines. The usefulness of these is based on the observation that a single unit can move to, on average, one of six provinces. To effectively ‘contain’ this raider the enemy may have to employ several units.
• Obtain positions which will be strategically important in the future.

In addition to these tactical notions, the rules of Diplomacy permit several ‘tricks’ to be employed. These can aid in offense against, or defense from, an opponent, usually involving elements of chance. An example of this is presented below.

Two units can attempt to defend three provinces. In figure 2.2 the light units aim to hold their respective provinces, and also, the province labelled P. However, all three of these provinces are in position to be captured by dark units, so it would seem this is not possible. Any movement of the light units will expose a gap. However, the light units can both attempt to move to P. In this circumstance, neither move will succeed, and they will remain in their original positions, blocking the bottom dark units from occupying their positions. Additionally, the dark unit adjacent to P will not be able to move to it, since, it’s move does not have more strength than either of the light units’ moves.
However, if dark suspects this tactic, it could order its top unit to support the move of one of the light units, thus, forcing the move to succeed (support cannot be refused), and leaving one of light’s bottom provinces unoccupied, and available for capture. However, this tactic could be refuted if light simply holds its position. Ultimately, the situation is a ‘guessing game’, and repeated success in the situation only occurs when one player knows the other.

2.1.4 Diplomacy: Calhamer’s Intentions

Diplomacy was created by Calhamer [5] as a game which brought together several ideas. This section highlights them as a means to demonstrate the breadth of understanding that a Diplomat would need, and the kind of applications that a Diplomat could be put to.

- The game is an abstract model, or simulation of the real world. It is a test, as to whether a world containing several powers roughly equal in strength implicitly contains multiple and flexible checks and balances to the domination of any one. This idea gains credence when the negotiations that actually occurred between parties in World War One are examined. The brevity and sharpness of these led Calhamer to see that negotiation in Diplomacy, the game, really could capture the kind of negotiation that occurred. Additionally, it led Calhamer to allow the ability to lie and deceive as he understood it as ‘realistic in international affairs’.

- The study of Geopolitics, which Calhamer believes to be:

![Diagram](image)

Figure 2.2: Two Units Defend Three Provinces
’the consideration of the effect upon the international power struggle of the particular geometric nature of the divisions of Earth into land and sea’.

- Supply centres necessitate a dispersion of forces, and provide an economic slant to the objective of the game. Additionally, they focus the game on manoeuvre rather than annihilation.

- Whilst playing hearts⁵, Calhamer observed that the game was most interesting when players co-operated against the current leader. This behaviour was encouraged by adding a ruling that if the lead was shared, all players would share equally in the tie. It was noted that experienced players often played ‘optimal strategies’, but beginners did not. This further motivated negotiation in the game.

- Strategy emerged, in the abstract, from chess; 75 spaces as opposed to 64 squares, 34 units as opposed to 32 pieces. The movement of the units is analogous to that of the King in chess.

- Tactics followed a Napoleonic principle: Unite to fight - separate to live. Units can combine their strength through use of supports, but, a province can only be occupied by a single unit.

2.1.5 Diplomacy: Properties

In this section, some of the main findings from the play of Diplomacy are presented. These were researched in order to help analyse the play of the Diplomat.

The powers in Diplomacy, whilst all starting with three units (with the exception of Russia, which starts with four), enjoy varying degrees of success. Clearly then, strategic position has an impact on effectiveness.

One of the simplest explanations for the varying effectiveness of the powers comes from consideration of Diplomacy’s adjacency graph (figure 2.3). This presents an abstract view of which pairs of powers are adjacent in the initial game position. Calhamer [4] describes that experience showed the relative strengths of powers, from strongest to weakest to be: Turkey, England, France, Italy, Russia, Austria-Hungary, and lastly, Germany. This corresponds closely to the list of countries in reverse order by number of neighbours: Turkey, 2; England, France and Italy, 3; Russia and Austria-Hungary, 4; Germany 5. This correspondence shows that the fewer the fronts with other players, the better the strategic position.

Their strategic positions make England and Turkey the greatest ‘threats’ in their respective parts of the board. However, their ‘threat’ can be neutralized by negotiation amongst the other players. In fact, amongst experienced players, Turkey and England do not win more games, negotiation amongst other players implicitly accounts for the strength of their positions. It is only when negotiation is not conducted, or is conducted ineffectively that Turkey and England can employ their strategic advantage. Negotiation then, is needed to differing extents by different powers. Calhamer considered negotiation very important for Germany, Russia, and Austria-Hungary, and of these, for Germany in particular

⁵A card game in which several players participate.
2.1.6 Diplomacy: Challenges

The aim of this section is to summarise some of the challenges that will need to be overcome before a Diplomat is created.

Size of search space: Perhaps the most immediate problem since it relates to strategy and tactics, it arises due to nature of movement in Diplomacy. Units do not move sequentially, but simultaneously, thus the game is seven-dimensional matricial\(^6\). In [8] it was stated that the number of possible non-equivalent openings is over four quadrillion, as compared to just twenty in Chess. Additionally, the nature of movement in Diplomacy is such that a player making a move on one side of the board can block a chain of moves stretching to the other side, so this number cannot be trivially reduced. Kraus [10] observed that the figure of four quadrillion non-equivalent openings does not take into account the various negotiations that players could undertake, she adds; ‘since every basic step in negotiation should be considered a basic move, the number of such possible moves is overwhelming’.

Richness of negotiation: The semantics of negotiation in Diplomacy are very complex. Diplomacy players can, and do, use negotiation in many subtle and varied ways. Threats, rewards, persuasion and complex agreements are all present. Meanwhile, Calhamer suggested as a ploy [6] the proposal of deliberately ambiguous, but only subtly so, agreements, in order to test the extent to which the other player is ‘on the ball’. In order to allow such ploys, a representation very close to, if not, natural

\(^6\)Every permutation of moves by another player creating a new dimension

Figure 2.3: Diplomacy’s Adjacency Graph
language is necessary. In [9] a number of Agent Communication Languages (ACL) types are outlined and only the most sophisticated of these (Argumentation-based approaches) are sufficiently rich enough to contemplate capturing the kind of negotiation that occurs in Diplomacy (described in more detail in section 2.3).

**Treatment of deceit**: A Diplomat will have to both deceive, and react to being deceived by other players. Possible reactions a Diplomat might contemplate are; attack the offending player, ignore the betrayal, refuse to make agreements with the other player in future, or impose ‘tariffs’ on future agreements. All of these approaches have their draw backs, and the ‘correct’ reaction is something that human Diplomacy players are often adept at finding, but it is not at all clear how.

**Psychology of Diplomacy**: Another problem that Hall and Loeb[12] identified is that multi-player games often present ‘paradoxes’. The ‘best’ moves do not always lead to the strongest positions. In general, Diplomacy players often employ strategies such as ‘attack the strongest’. In this environment, winning requires ‘clever psychological’ play. Again, this is something that human Diplomacy players are often adept at, but it is not clear how.

**Incomplete information**: The value for a Diplomat in capturing a supply centre for itself is evident, but the value in giving support to another player entirely depends upon how that support is perceived by that other player. This is information that a Diplomat does not possess.

### 2.2 Diplomacy: Existing AI’s

A number of attempts at creating an automated Diplomacy player have been released to date. The most widely known of these is probably the AI of Hasbro’s Diplomacy game. Unfortunately, the AI is generally accepted to be poor. Other AI’s have been more successful. DiploBot and Dumbbot which are associated with the DAIDE project are quite capable in a limited version of Diplomacy where negotiation is not permitted (called no-press Diplomacy). Unfortunately complete documentation regarding these is absent (more information about these in the Existing Resources section). The three diplomats described below have taken different approaches, and are the state of the art.

**2.2.1 The Israeli Diplomat**

The first serious attempt at a Diplomacy player, and the most sophisticated Diplomat thus far created is the Israeli Diplomat [10]. It employed a rich logic based language which attempted to mimic the negotiation present in Diplomacy. The language itself emerged through observation of the messages human players exchange in the game. Of these messages, the Israeli Diplomat

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7The best.

8For example, Germany is in a position to capture two supply centres early in the game, but this would put it into conflict with a number of other players. As a result, human players very rarely tend to make this combination of moves.
was primarily targeted at being able to suggest and consider exchanges of offers, ranging from abstract notions, such as cooperation or non-aggression to concrete and detailed plans. In order to propose and analyse these offers, a multi-agent architecture was devised, based on that of a war-time government. This multi-agent architecture also served to separate the Diplomat’s tasks, as agents within the architecture would typically be responsible for one of the Diplomat’s ‘fronts’. At the head of this architecture was a prime minister, which had ‘personality traits’, such as the likelihood to break agreements, and willingness to take chances, etc.

Figure 2.4: Israeli Diplomat Architecture

A detailed description of every component in the architecture is provided in appendix A.1.

Summary
In trials with other players, the Diplomat performed very well; winning a good proportion of games, and predicting other player’s intentions better than they could predict it’s. However, no detailed information regarding the design decisions is given. In addition, the evaluation of the Israeli Diplomat does not tell us how effective the individual components are. The focus of the presentation is on distributing the control and processing, so the Israeli Diplomat tells us who makes the decisions, but not how the decisions are made. Nonetheless, the Israeli Diplomat shows the creation of a Diplomat which tackles many of the challenges of Diplomacy is not beyond the realms of possibility.

2.2.2 The Bordeaux Diplomat
The Bordeaux Diplomat [8] was created a few years after the Israeli Diplomat, but focused on different aspects of Diplomacy. It was not built to negotiate, but to formulate good plans. Hall and Loeb outline a number of algorithms
and heuristics whose usefulness in computing good plans they evaluate. The algorithm that the Bordeaux Diplomat used employed the notion of a best first search, determining the best move for one unit initially, and then adding best moves for additional units until a complete plan was formed. The 'best move' was determined with respect to the best moves of adjacent players. Note, that in this, the Bordeaux Diplomat makes the assumption that other player's strategies are known.

The heart of what the Bordeaux Diplomat considered good moves was relatively simple; it would seek to expand its influence over valuable provinces. The Diplomat considered itself to have influence over a province if it had a unit in a position that could occupy it as quickly, or quicker than any other player. Meanwhile, it considered home supply centers as the most valuable provinces, and became increasingly disinterested with provinces further from home. This view encouraged creating a 'sphere of influence', centred on, and expanding from home supply centers. The Bordeaux Diplomat built some quite sophisticated behaviours on top of this. For instance, human players choose a direction for expansion as this allows them to concentrate their forces. In order to model this behaviour, the Bordeaux Diplomat would also evaluate moves with regards to a meta map, which grouped provinces into regions, hence enabling the Diplomat to see the "big picture".

**Move Composition**

The move composition of the Bordeaux diplomat is based on Best First or Beam search; a response to the vast number of ways to compose moves together. Beam search avoids the combinatorial explosion resulting from a breadth first search over combinations of orders by expanding only on the most promising order at each level. In other words, the partial position generated by adding each possible order for a unit to the current best plan was considered one at a time, and the best chosen. The best order is evaluated with regards to the best orders of other players. This was implemented by maintaining a number of processes representing other players, which periodically updated each other as to their best orders. When orders ceased changing, an equilibrium had been reached, a resulting game situation could be predicted, and the value of the move could be analysed.

Hall and Loeb additionally suggested that a set of "Book" openings be provided for all players, in a similar fashion to many Chess computers. These were added to overcome the intricacies inherent in the opening phases of the game.

**Static Evaluation**

Hall and Loeb proposed a simple but effective static evaluation function. It relies upon the notion of influence. If a player has a unit in a territory, it has influence over that territory. Otherwise, if a territory is vacant, the players who own the nearest units share influence over it. If there were suddenly a race for territory, then influence would be predictor of the ownership of it, a concept roughly analogous to control.

When playing the game, it is imperative for a player to control their home supply centers. These are the only places at which a player can build new units,
hence, any static evaluation function should value maintaining control over these highly. One way to view this is as a mountain, with home supply centers at the peak. Diplomats become increasingly disinterested with provinces further from the peak, but continue to acquire them, so long as the acquisition does not lead to losing influence over more valuable provinces (i.e. no other Diplomat can reach the summit earlier). In practical terms, a score map is developed, with home supply centres having the highest values, and values decreasing further from home. Every player has their own score map, depending upon where their home supply centers are located.

This view of the board results in high values being given to moves which expand influence, but not at the cost of exposing home supply centers. Moves which create holes in fronts are discouraged, as Hall and Loeb felt said:

Battle without organised fronts can quickly deteriorate into chaos and mutual destruction for both participants.

The static evaluation function needed some refinements to make it complete. A new unit built in a home supply center, far from the front line currently has no incentive to move, since, no move expands influence over provinces. Additional heuristics are added to ‘punish’ units far from the front line, and encourage them to move.

More Complex Behaviours

So far, the plans that the Diplomat makes are relatively uncoordinated. All acquisitions are on a province by province basis, and the Diplomat attempts to carve out a “sphere” of influence. There is no greater strategy such as concentration of forces, or, the choice of a direction for expansion. Human players much prefer to characterise the map as consisting of regions by grouping provinces into meta-provinces according to the physical, and sometimes political properties of the map. There are some advantages to this approach, it lends itself to concentration of forces (a “front” based approach). Also, regions tend to be grouped in such a way that they are more easily defensible. Hall and Loeb use a conversion process to turn the unit positions on the game board to one on the meta-map, and, through a variety of heuristics identify which region is of most importance at the moment. It can then raise the altitude of these provinces in its static evaluation function to encourage units to gather, and be effective there.

Summary

The aim of the Bordeaux Diplomat was to explore tactical and strategic elements of Diplomacy, the rationale being that a sound strategic and tactical understanding is a prerequisite for creating for an effective Diplomat. To this end, the Bordeaux Diplomat presented a variety of useful heuristics which led it perform well in trials against human players; however, it is not immediately apparent how this could lead to a fully fledged Diplomat being developed. In addition, the Best First search approach may miss optimal sets of orders, given the complex interaction that can occur between them. No measurement of this loss is given. Finally, it is not clear to what extent the ‘game theoretic’ view of
tactics and strategy is justified. When negotiation precedes order generation, is does not seem natural that Diplomat's know each others strategies.

2.2.3 LA Diplomat

Like the Bordeaux Diplomat, the LA Diplomat [19] was aimed at tactical and strategic Diplomacy, not negotiation. Faced with the same problem as the Hall and Loeb; i.e. the combinatorial explosion of sets of orders possible, Shapiro opted for a different approach; pattern weights. The Diplomat starts without any strategic or tactical knowledge and learns important aspects of the game through storing patterns weights and temporal difference learning. The hope was that a thorough computational analysis of the situation could be avoided, and that the patterns might capture some of the more subtle aspects of human tactical play.

Patterns

The LA Diplomat initially utilized featureless patterns. These are representations of the whole state of the game (unit positions, supply centre ownership, turn number) coupled with moves. On any given turn, the LA Diplomat would:

1. Generate all legal orders for individual units.
2. Generate all order combinations.
3. Match the orders against a pattern-weight database.
4. Weigh the orders according to the pattern-weights.
5. Choose amongst top rated moves.

The LA Diplomat non-deterministically chose an applicable weighted move, with the weight affecting the probability of a given move being picked. Later, if it determined that this was a good9 move, it would reinforce this weight.

Featureless patterns, were found to be of only limited usefulness; strategies were only developed slowly, and the size of the database for each player soon became very large. This led to experiments with feature based patterns. A feature of a move might include elements such as “Moving to an unoccupied province”, or, equally “Moving to an occupied province”. Additionally, it is possible to have multiple element features, such as “Unit has no neighbours AND Unit being is supported is a fleet”. The very large number of featureless patterns are thus abstracted into much smaller data sets.

Temporal Difference Learning

Temporal difference (TD) learning provides a mechanism for updating the weights to patterns the Diplomat has chosen in a situation. Before and after every turn, the Diplomat will measure its utility. The difference in utility between the

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9How the Diplomat determines whether a move is good or not was not specified, but, matching against ‘Opening Books’ or, the capture of supply centres are both valid criteria.
two measurements will, on average, be a result of good and bad sets of orders. The weight associated with a pattern will then be changed with respect to this difference.

TD methods are useful because they learn from every turn, regardless of subsequent actions taken. Additionally, TD methods are sound [20], in that convergence to good answers is guaranteed.

Summary

Feature based patterns enabled the LA Diplomat to ‘learn’ some important tactics in Diplomacy, such as moving units towards enemies and then ordering them to maintain their positions. However, it also rated moves which are not so good highly, such ‘Convoying a unit from an enemy supply centre’. Overall, the LA Diplomat shows promise in the use of patterns to aid in tactical decisions, but, it is not clear to what extent it could manage strategic considerations, or indeed how the LA Diplomat could be extended to negotiate.

2.3 Modelling Negotiation

Given Diplomacy’s very strong negotiation component, an analysis of various mechanisms for negotiation was conducted. The two mechanisms seriously considered were argumentation based agent communication languages and market based models respectively, detailed below:

2.3.1 Argumentation Based Agent Communication Languages

One (simple) model of the negotiation that goes on in a game of diplomacy would be as an exchange of offers, such as:

Agent A: I propose that your unit in English Channel support my unit’s move from London to the North Sea, in exchange for which I offer you the support of my unit in Wales.

Agent B: I dont want the support of your unit in Wales, but I do want the support of your unit in Gascony.

Agent A: I accept.

In order for us to use this kind of negotiation, we need three things [9].

Negotiation protocols: Negotiation states (negotiating or not negotiating), events that cause negotiation states to change (entering the negotiation phase), valid actions of the agents in particular states (which messages by whom, at what stage).

Negotiation objects: The range of issues over which agreement must be reached; such as supports, or dont move into this province type agreements.

Agents’ strategies: The decision making apparatus the participants employ in line with the negotiation protocol to achieve their objectives.
In general, this kind of model is powerful enough to describe some of the interactions going on in Diplomacy, but, in [9], a number of critiques of this kind of approach are made:

- The proposals made only denote single points in the space of possible agreements, this can make progress quite tedious, and it difficult to tell when possibilities have been exhausted.
- The only feedback that can be made to a proposal is a counter-proposal, which itself is another point in the space, or an acceptance or withdrawal.
- It is hard to change the set of issues under negotiation.

These criticisms suggest a more general form of negotiation, namely, an argumentation based approach. This allows the exchange of more information, above and beyond proposals. This information can be of a number of different forms, all of which are arguments which explain explicitly the opinion of the agent making the argument. This allows an agent to say a huge number of different things:

- In addition to rejecting a proposal, an agent can offer a critique, explaining why it is unacceptable.
- An agent can accompany a proposal with an argument which says why the other agent should accept it.
- Accompanying arguments do not necessarily have to tie in with the proposal, for instance, threats and rewards can be exchanged.
- Agents need not be truthful in the arguments that they generate.

### 2.3.2 Market Based Control Mechanisms

Market Based Control (MBC) describes the ability of a market to facilitate resource allocations. MBC was inspired by free-market economies, and took off with the rising need for distributed dynamic resource allocation and control. Employing MBC typically offers adaptability, the benefits of decentralized decision making, and efficiency.

The starting point for viewing MBC as a mechanism that could be applied to Diplomacy is looking at the agreements that players in Diplomacy make. If a unit is viewed as a resource, many agreements that a Diplomacy player makes could be seen as allocations of resources.

Markets provides a way to handle this resource allocation. In this instance, Diplomacy can be seen as exploiting the decentralised decision making, and efficiency of markets, although, the ‘distributed’ and ‘dynamic’ aspects are not relevant. Typically, auctions are used, of which there are three popular types, each suitable for a different kind of resource of allocation. The question of which of these, if any, is most suited to Diplomacy is considered further in Chapter 5:

**Vickrey:** A sealed-bid second price auction in which participants simultaneously submit bids. The auctioneer discloses the identity of the highest
bidder, who is declared the winner. The price paid, however, is equal to the second-highest bid placed. This format is named after William Vickrey who first described it and pointed out that the dominant strategy\textsuperscript{10} for bidders is to bid their true valuations.

**English:** A type of sequential second price auction in which an auctioneer directs participants to beat the current, standing bid. New bids must increase the bid by a predefined increment. The auction ends when no participant is willing to outbid the current bid. While the highest bidder pays the highest amount bid, an English auction is termed second-price as the winning bidder need only outbid the next highest bidder by the minimum increment. Thus the winner, effectively, pays an amount equal to (although slightly higher than) the second highest bid.

**Dutch:** A type of first price auction in which a clock initially indicates a price for the object on sale substantially higher than any bidder is likely to pay. The clock gradually lowers the price until a bidder buzzes in or indicates their willingness to pay. The auction is then concluded and the winning bidder pays the amount reflected on the clock at the time he or she stopped buzzed in. This auction is named after a common market mechanism for selling flowers in Holland, but also reflects stores successively reducing prices on sale items.

## 2.4 Existing Resources

This section describes some of the resources used throughout the project, in particular; programming languages/development tools and Diplomacy related resources.

### 2.4.1 Programming Languages

Diplomats are agents, so, a language suitable for developing agents was required. Many such exist; of which Jade is possibly the most well known. Ultimately however, April [13] was chosen.

April is intended to be used to build distributed applications, in particular, multi-agent systems. Many of it’s features are taken from other languages such as; Parlog, Erlang, FCN, CSP, Dijkstra’s guarded commands, LISP, Prolog and APL. April’s appeal is due to the ease with which certain things can be done:

- April agents, by means of the ICM[15]\textsuperscript{11}, have:
  - Agent naming facilities; globally unique naming, aliasing and registration.
  - Messaging facilities; message encoding, transportation, queuing and forwarding.
- Ease of agent creation;

\textsuperscript{10}The best strategy!
\textsuperscript{11}Inter-Agent Communications Model
spawn { function } as agentName;

The new agent will have registered automatically with the ICM, and be globally reachable through:

agentName@host

- Sending messages;

"hello" >> agentName;

- Receiving messages:

repeat {
  "hello" ->> { "hello msg rcvd" >> stdout;
    "hello to you too" >> sender;
  }
  | "bye" ->> { "bye msg rcvd" >> stdout;
    "bye to you too" >> sender;
    "quitTokenRcvd >> self();
  }
  | "I am " ++ aName ->> {
    "msg rcvd from " ++ aName >> stdout;
    "hi there " ++ aName >> sender;
  }
}
until 'quitTokenRcvd;

In the above code sample, the agent waits for incoming messages, of which it can receive three types. Inside the statement block associated with an incoming message, the keyword 'sender' is the handle of the agent that sent the message. Additionally; 'self()' is a function which will return an agent's own handle. The above agent will reply to all three messages, but, in the case of the "bye" message will also send a message to itself which will eventually lead to the agent's termination. Additionally, any message of the pattern "I am X" will elicit a personalised response. This demonstrates the ease of pattern matching within April.

Additional reasons for choosing April, particular to this project were:

- A personal familiarity with April was acquired in previous projects.

- April was developed with the aid of the Department of Computing at Imperial College London\textsuperscript{12}, and so a number of individuals in the department are familiar with it also.

- April supports TCP/IP connections, which were needed for communication with the DAIDE server.

\textsuperscript{12}Particularly Professor Keith Clark.
Meanwhile, the development of visualisations describing the Diplomat were also required. DialoX [14] was chosen.

DialoX, which uses many of the facilities of java.swing, features a rich combination of window primitives, graphics capabilities, and a high-level approach to constructing GUIs to agent applications. This high-level approach is achieved as DialoX requires few parameters to be specified regarding the layout of on-screen items, but makes 'intelligent guesses' as to the optimal. DialoX is especially tailored for use with April. DialoX was chosen as:

- DialoX integrates well with April. In fact, the DialoX server is viewed by agents in April as simply another process, to which messages are sent (detailing on-screen updates), and from which messages are received (upon events such as a button press).

- The user interface is not the focus of the project, merely a tool to help explain it. DialoX’s high-level approach suits this rapid proto-typing, especially when a relatively casual layout will suffice.

2.4.2 DipAI Organisation

DipAI is an organisation which attempts to facilitate and encourage the development of Diplomats. To this end, it has created the DAIDE (Diplomacy AI Development Environment); which consists of, amongst other documents, a syntax document describing the language of negotiation between Diplomats. Several useful applications compatible with the DAIDE syntax have been created. Additionally, dipAI maintains a mailing list where issues relating to creating Diplomats are discussed.

The DAIDE Server

The DAIDE server is an application which adjudicates orders, and thus, removes the need to create an adjudicator amongst the Diplomats. The language of communication with the server is the DAIDE syntax. The DAIDE server is a versatile application that allows multiple game types to be created, with a variety of settings.

The DAIDE Mapper

The DAIDE mapper is an application that visualises a game of Diplomacy. It achieves this by maintaining a connection with the DAIDE server as an observer, and thus receives updates on the game state from it. Additionally, it allows orders for units to be entered using a simple point and click interface, thus allowing human players to play against DAIDE compatible Diplomats.

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13The manual for DialoX is somewhat out of date as the implementation has been considerably revamped. Many of the ideas however are the same.
14Graphical User Interfaces.
Figure 2.5: The DAIDE Server Interface

Figure 2.6: The DAIDE Mapper
The DAIDE Syntax

The DAIDE syntax [16] defines the syntax of negotiation between Diplomats. This is a result of the analysis of the kind of exchanges made in Diplomacy. Kinds of exchanges are associated with tokens so that Diplomat’s may ‘talk’ about a particular subject, without having to understand natural language. These sets of tokens were then ranked, according to the anticipated difficulty in creating a Diplomat that understood them. Table 2.1 outlines a few of these levels. Note that level 0 in itself is not intended for inter-Diplomat negotiation, but describes preliminaries, such as the syntax in which orders are described. Level 0 thus describes no-press Diplomacy.

<table>
<thead>
<tr>
<th>Level</th>
<th>Defines</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Common terms; power names, and province names. Joining games. Describing and submitting orders. General control operations.</td>
</tr>
<tr>
<td>10</td>
<td>Peace and alliances; allowing proposals to be made such as peace treaties and alliances. Semantics for these are not provided, and it is for Diplomats to negotiate what they mean (or to assume they have the same understanding).</td>
</tr>
<tr>
<td>20</td>
<td>Order proposals; suggesting to another Diplomat that they make certain orders, or de-militarize certain provinces.</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>80</td>
<td>Accusations; allow players to accuse others of going back on their words, provide apologies and explanations.</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>110</td>
<td>Puppets and favours; allow players to trade “IOUs”, as well as the facility to cede control of units to other powers.</td>
</tr>
</tbody>
</table>

Table 2.1: DAIDE Syntax Level Structure

---

15The negotiation between Diplomats is forwarded by the server.
DAIDE AI's

There are many AI's (or bots) which are compatible with the DAIDE syntax. These have been created by various members of the Diplomacy AI community. The simplest are designed primarily for testing others\(^{17}\), in particular, Andrew Rose's Bot Package contains the following:

**Holdbot:** All units issues 'hold' orders every turn, and are disbanded when dislodged. All possibilities to built new units are waived.

**Randbot:** Assigns a random, but valid order to each unit.

**Selfbot:** As Randbot except that all orders involving enemy units are excluded (e.g. a unit will not write orders which support enemy units).

**Consbot:** As Selfbot except that orders are self-consistent (e.g. no unused support or convoys).

In addition to these 'testing' bots, there are bots designed for more serious play. None so far has surpassed level 0 however, as none of them are capable of negotiation. The best of these at the time of writing (06/04) are: David Norman's Dumbbot, Brian Roberts’s AngryBot and, Francois McNeil’s Diplobot. Of these, Dumbbot has been known to win a game against a group composed entirely of human players\(^{18}\). A comparison of the three bots based on a trial\(^{2}\) involving 145 games, and detailing the proportion of wins obtained as the various powers is presented in table 2.2.

AngryBot was the most successful bot, winning 63% (85 out of 135), followed by Diplobot (19%) and Dumbbot (18%). None of the bots liked playing as Germany or Austria but both AngryBot and DiploBot managed to win at least once as each power. AngryBot was particularly adept at playing England,

<table>
<thead>
<tr>
<th>Power</th>
<th>AngryBot</th>
<th>DiploBot</th>
<th>Dumbbot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>14%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>England</td>
<td>49%</td>
<td>13%</td>
<td>14%</td>
</tr>
<tr>
<td>France</td>
<td>40%</td>
<td>7%</td>
<td>22%</td>
</tr>
<tr>
<td>Germany</td>
<td>8%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Italy</td>
<td>32%</td>
<td>9%</td>
<td>4%</td>
</tr>
<tr>
<td>Russia</td>
<td>22%</td>
<td>11%</td>
<td>4%</td>
</tr>
<tr>
<td>Turkey</td>
<td>28%</td>
<td>11%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Table 2.2: A comparison of DAIDE bots

DipAI Mailing List

Much of the communication regarding DAIDE occurs through a mailing list\(^{19}\). Through these, issues regarding syntax, bots, and more generally, on creating Diplomats are exchanged.

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\(^{17}\)In addition, they can be viewed as templates for others to use, which handle the low level communications.

\(^{18}\)The win emerged as a result of the human players under-estimating Dumbbot, and spending too much time attacking each other.

\(^{19}\)http://groups.yahoo.com/group/dipai
Chapter 3

The Diplomat

This chapter outlines the aims of, and assumptions underpinning the Diplomat. Following this, a breakdown of the components of the Diplomat, and the responsibilities of each is then provided.

3.1 Aims

The Diplomat’s aim is to play Diplomacy. To this end, it needs an appreciation of the game on all of its levels. This task can be split into providing a treatment of:

**Strategy and Tactics:** The Diplomat should appreciate, or simulate, both the strategy\(^1\), and tactics\(^2\) required for Diplomacy. Ultimately, it should recognise good sets of orders, and bad sets of orders.

**Negotiation:** The Diplomat should be able to determine which potential exchanges are desirable, and, exploit some mechanism to attain them. The potential exchanges should be agreements similar to those made by Diplomacy players.

**Deceit:** The Diplomat should be able to lie when it believes it is beneficial to do so. Additionally, it should be able to react to other Diplomats lying, using a rationale similar to that of Diplomacy players. The Diplomat should, to a certain extent, ‘learn’ as to which Diplomat’s lie frequently or not.

Note, that modelling some aspects of Diplomacy were not attempted, for instance, natural language processing, even to the extent used in Diplomacy is beyond the scope of this project.

3.2 Assumptions

This section describes some assumptions that were made in order to simply implementation and restrict the development of the Diplomat to areas of inter-

\(^1\)Military planning at a macro level.
\(^2\)The military science that deals with securing objectives set by strategy.
- Diplomats are rational. By this, it is meant that Diplomats seek to win the game, and are neither altruistic nor malicious.

- Diplomats only view winning the game outright as a goal. This contrasts with other ways of scoring Diplomacy. Some mechanisms allow for alliances to be formed such that the points for a win are split amongst members of the winning alliance (i.e. half a win each for a winning alliance of two members). Other mechanisms rank players according to the number of provinces controlled at the end of the game, with eliminated players ranked according to date of elimination (being eliminated later results in a better ranking). Points are then allocated according to ranking. The assumption that agents only aim for an outright win simplifies the design and implementation of the Diplomat.

- Diplomats do not know other Diplomat’s strategies, and cannot guess them. This is a very important distinction, which very much changes the complexion of the project. It is made because of the nature of Diplomacy. There should not be a set of finite strategies from which a Diplomat can choose at any point. Any negotiation could have occurred at any point in the game. To know probabilities for another Diplomat’s actions would imply that some bound as the complexity of the negotiation exists. Were the opposite assumption to be made, as in the Bordeaux Diplomat, the project would have followed a much more game theoretic approach, as outlined in /refsec:DipGT.

### 3.3 Components and Responsibilities

A clear division of Diplomacy exists in the Design Aims; the strategic/tactical component, the negotiation component, and the deceit component. The question of the interfaces between these components remains.

The creators of the Bordeaux Diplomat [8] (summarised in subsection /refsubsec:DipIsraeli), suggested that a platform for negotiation could be built upon it. The ‘output’ of the Bordeaux Diplomat’s search is a plan\(^3\). Presumably this could be extended to support agreements with other players by trying to get other players to help support some of the moves in the plan. The plan would need to be dynamically altered and extended depending upon negotiations with other players. However, this idea falls short, as there no way for a Diplomat to know that the best possible plan has been reached.

The intuition for a better solution comes from considering the way that human players might view the game:

- Scan the board, looking for potential partners and plans, create a set of possible plans.
- Negotiate with other players, removing and adding to the set of possible plans depending upon agreements made.

\(^3\)A set of orders. One for each of the Diplomat’s units.
Finally, choose the best plan.

The interface between the tactical/strategic component and the negotiation component then is a set of plans. The interface between the negotiation and deceit component is less clear, and will be considered later.

Given this composition, a much more functional description of the components is possible:

<table>
<thead>
<tr>
<th>Component</th>
<th>Function Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic/Tactical</td>
<td>Given a game situation(^4) and any other relevant information, determine the best possible plans. Note that the best plans at this stage do not include support from other players, but only provide orders for a Diplomat’s own units.</td>
</tr>
<tr>
<td>Negotiation</td>
<td>Given a set of plans, recognise exchanges that can be made with other Diplomats, and are beneficial. Evaluate them, and over the course of negotiation, extend/reduce/prune set of plans as appropriate.</td>
</tr>
<tr>
<td>Deceit</td>
<td>Extend the negotiation component, so that, given a set of plans and some extra information about Diplomats, we can additionally tell which exchanges will be beneficial if we lie. Additionally, account for the fact that other Diplomats may be lying. Over the course of negotiation, extend/reduce/prune set of plans as appropriate.</td>
</tr>
</tbody>
</table>

3.4 The Diplomat System

The architecture in which Diplomats are embedded is presented in figure 3.1:

The DAIDE server: The DAIDE server, described in more detail in section 2.4, is an application which acts as an adjudicator for Diplomacy, additionally synchronising Diplomats, and updating them as to the game state. Communication with the DAIDE server is conducted through an associated syntax [16].

The Diplomats: Consist of three processes:

The Main process: Performs all processing, and represents the Diplomat proper.

The DAIDE process: Collects fragments of, and forwards to the Diplomat, messages from the DAIDE server.
Figure 3.1: Diplomat Architecture
3.5 Diplomat Pseudocode

The Diplomat itself can be seen as a function, which receives a game situation from the DAIDE server, updates its memory, and returns a set of orders for its units every turn. The Diplomat's algorithm follows from this functional description provided. Note, that the syntax here, and throughout the rest of the report informally corresponds to April [13](section sec:DipResources), but, for readability the fact that '=' means 'read only' is ignored.

```plaintext
diplomatsMemory = InitialiseMemory();
repeat {
   ('newTurn,game_situation) ->> {
      /* A message has been received, it is a new turn */
      setOfPlans = FindPlans(game_situation);
      (reducedPlans,diplomatsMemory) = NegotiationOver(setOfPlans,diplomatsMemory);
      SubmitPlan(BestOf(reducedPlans));
   }
} until 'gameOver;
```

*FindPlans* is the strategic/tactical component, and *NegotiationOver* combines the work of the negotiation and deceit components.
Chapter 4

Strategy and Tactics

This chapter details the issues involved, and approach taken to strategy and tactics by the Diplomat.

Unlike in Chess, strategy and tactics do not dominate Diplomacy, but they cannot be ignored. The aim of the strategic/tactical component of the Diplomat is, given a game situation, to create a set of the best possible plans for the Diplomat. The task of computing the best plans can be split into three smaller tasks:

Order Generation: Determining order(s) for each unit (section 4.1).

Plan Generation: Composition of orders into plans (section 4.2).

Static Evaluation: Evaluation of plans so that the best are selected (section 4.3).

A summary of this chapter is provided in section 4.5 on page 39.

4.1 Order Generation

Clearly, the simplest approach for the generation phase would be to create a plan for every possible combination of orders involving every unit, however, this is intractable. The number of plans generated can be reduced by cutting down on the number of provinces that a unit can be ordered to move to, hopefully without losing any useful plans. The reduced set of provinces are called target provinces.

The Bordeaux Diplomat (subsection 2.2.2) presented an influence map as a mechanism for helping in the static evaluation of a position. However, it can also be seen as a useful mechanism for defining the frontiers of powers¹. Two approaches to selecting target provinces were considered:

1. Order units not at the frontier, towards the nearest frontier. For units at the frontier already, consider all orders which either lead to units remaining at a (not necessarily this) frontier or which order the unit to move into enemy territory.

¹Players.
2. As above, but rather than considering every possible order, maintain an n-bit binary word, where n is the number of foreign powers with which this Diplomat shares a frontier. If, in this permutation, the bit representing a foreign power is 1, then, if possible, order this unit to move into its territory (consider it a foe), otherwise, maintain the unit at the frontier (consider it a friend). Create a set of plans for every possible permutation.

The second idea produces plans categorized in a way designed to aid the negotiation component. Its working is also consistent with a concept referred to by members of dipAI as the alliance matrix. However, this idea assumes that a Diplomat will be either a friend or foe to other power at any given time. Diplomacy itself contains no such assumption. Although somewhat unusual, a Diplomacy player might well want to both support and attack another Diplomacy player on different parts of the game board on the same turn. For this reason, the first scheme was chosen.

4.1.1 Target Province Refinement

The number of target provinces can be reduced further by exploiting a better understanding of the game. In particular, static evaluation introduces a notion of value for a province. Low valued target provinces can be ignored given high valued provinces which are equally accessible. This might lead to behaviour such as not considering an order to move to a particular province if the capture of a supply centre is possible with a different order. This behaviour is desirable. More target province refinements are considered later.

4.1.2 Builds/Disbands/Retreats

Quite frequently a Diplomat will be in a position to build new units, disband existing units, or to retreat.

When considering ‘Disbands’, a Diplomat simply imagines the situation without each of its units in turn (using static evaluation). The best situation is chosen. A similar approach is taken towards ‘Retreats’; every province to which the Diplomat’s unit can move to is considered, and evaluated. ‘Builds’ are slightly more complex. The Diplomat must first decide what to build; an army, or a fleet. Such a decision usually requires a rigorous strategic analysis, and prediction of what the game situation will be in a few turns time, however, this lies beyond the scope of the Diplomat. The Diplomat’s decision instead is based upon the initial unit allocations a power is given. These define an army to fleet ratio which the Diplomat attempts to maintain through its choice of Builds. Deciding where to build the new unit involves simply evaluating every potential location.

4.2 Plan Generation

The question of how to compose orders remains. The Bordeaux diplomat approached this problem by choosing a direction. It did this by deciding upon an order for a unit, one at a time, and building up it’s plan incrementally.

---

2The alliance matrix catalogues, for every player, their attitude towards other players.
This 'best first search' undoubtedly led to many potentially good plans being missed. An alternative is to use the cross product of every order for every unit (Note, that support orders will have to be added where applicable), i.e. considering every permutation of every individual unit’s orders. Clearly, the number of plans grows exponentially in the number of units:

\[ p = b^n \]

Where \( p \) is number of plans, \( b \) the branching factor (number of orders for each unit), and \( n \) is the number of units. In fact, when support orders are considered in addition, the number of plans is much greater.

Figure 4.1: An example of clustering units

This complexity would be acceptable, if it could be guaranteed that the number of units, and number of provinces remain small. One way to guarantee this is to cluster units and generate sub-plans for each cluster. These will typically be small in number, and size. Once all sub-plans have been generated for a cluster, static evaluation is used to select the best amongst them, and the rest are discarded. This is repeated for every cluster. Finally the cross product of the best sub-plans is taken, and this results in the best plans.

In summary, the algorithm is:

1. Cluster the \( n \) units into \( c \) clusters.
2. For each cluster, produce a set of sub-plans, \( sp \).
3. For each set \( sp \) use static evaluation to select the best; \( bsp \).
4. Produce the cross product of the all the sets \( bsp, p \), the set of plans.
5. Rank the plans using static evaluation.

Questions remain; how are clusters produced? and how is it ensured that a reasonable number of plans are generated by this process?
4.2.1 Clustering

Clustering is not just an aid to efficiency, maintaining a clustering helps to avoid situations where units become isolated, in short, clustering helps to maintain *cohesion* amongst units. In order to obtain these benefits target provinces for a cluster are generated rather than for individual units, the *cluster* will then try to generate orders to move to these provinces, ensuring it sticks together. This additionally has the benefit of helping to ensure that clusters do not *interfere* with other clusters moves.

We assume that a pre-defined *cluster size* is provided. In order to find a clustering we:

1. Convert the representation of the map and unit locations into an undirected graph; nodes represent units, weighted edges describe the shortest path between units.
2. Construct a minimal spanning tree (MST) for the graph using Prim’s\(^4\) algorithm.
3. Break the MST into useful clusters:
   
   (a) Remove all weighted edges with weight two or more, since a weight of two represents units which are unable to help each other (since, if two provinces minimally separate a pair of units, then, they cannot converge on a province).
   
   (b) If a sub-tree contains less than *cluster size* elements, flatten it, and return it as a cluster, otherwise, recursively break the tree (by removing links), until all sub-trees can be made into clusters.

Note that, supports between clusters are not considered, as clusters are intended to operate independently.

4.2.2 Number of Plans

In order to ensure that a reasonable number of plans are generated a figure for the number of desired plans is first provided. The number of sub-plans generated for each cluster (\(p\)) is then capped, such that, where \(n\) is the number of clusters and \(r\) is the number of plans we wish to generate:

\[
    r = p^n
\]

4.3 Static Evaluation

Orders in Diplomacy are revealed and resolved simultaneously, hence, the outcome of a plan is not clear. This means that prior to position evaluation, *position prediction* must be conducted, the process of determining the resulting position from a plan, and the current position.

\(^3\)Interference occurs when sub-plans for different clusters issue contradictory moves, i.e. two units attempting to move to the same province will standoff each other

\(^4\)http://www.comp.lancs.ac.uk/kristof/research/notes/clustr/
4.3.1 Position Prediction

One of the assumptions made earlier was that other players strategies are not known to the Diplomat. For this reason, we do not know what orders other players will, or are likely to make. Thus position prediction makes several assumptions in order to estimate the expected position:

1. By default, all units, both belonging to other players (hereafter referred to as ‘enemy’ units), and belonging to the Diplomat, hold position.

2. Any move to an unoccupied province will succeed.

3. If an enemy unit is being attacked by a move from a lone (unsupported) unit it will not be dislodged, and the attacking unit will not move.

4. If an enemy unit is attacked by a supported order (involving two or more units) it will be dislodged and forced to retreat. The unit with an order to move to the province will move to it.

5. If a unit belonging to the Diplomat, moves, and the province which it occupied can be moved to by an enemy unit, and is not occupied by another of the Diplomat’s units, then, the enemy unit will move to that province. As exception to this occurs when the province that the enemy unit was in was attacked by the the Diplomat’s unit (i.e. units do not ‘trade’ positions). The assumption that enemy units will always exploit ‘gaps’ in fronts could be described as cautious position prediction.

Conditions 1 to 3 can be justified straightforwardly. Condition 4 is somewhat more subtle. It emerges from the desire, as described in [8], to maintain an organised front, as, a conflict without organised fronts can ‘quickly descend into chaos’. The cautious position prediction ensures that Diplomat’s do not attempt to gain territorial advantages at the cost of creating gaps in their defenses.

Note that when determining the effect of plans involving supports from enemy units, they are considered one of the Diplomat’s units for the position prediction phase, but not for the position evaluation phase.

4.3.2 Position Evaluation

Position evaluation is conducted in a very similar manner to that of the Bordeaux Diplomat:

1. Produce an influence map, describing the provinces under the Diplomat’s ‘influence’.

2. Using the score map (an assignment of values to provinces), and the influence map, compute a score for this position.

3. Augment this score with other heuristics, in particular:
   - A large bonus for occupying supply centres which belong to the enemy. Whilst supply centres are given an extra weight in the score map, this tells a Diplomat that moving, and capturing, an enemy supply centre is more useful than simply moving to a supply centre already owned by it.
• A medium sized bonus for maintaining larger clusters. This is calculated by awarding a bonus for every unit in a cluster above a minimum size. Supposing the minimum size was 3, this would favour clusters of size 3,3 over 4,2, and 4,2 over 3,2,1.

• A small bonus for each home supply centre not occupied. This helps the Diplomat ‘clear’ its home supply centres so that new units may be built there. The reason that a small bonus is given is that this behaviour should only come into effect when this does not expose the home supply centres to enemy capture.

Position evaluation and position prediction are closely knit. In particular it should be noted that the cautious position prediction described above will recognise bad plans. In the instance that an enemy unit can move to a position to gain influence over the territories behind\(^5\) a Diplomat, moves which permit this will be punished severely.

4.4 Limitations

The strategic and tactical component presented in this chapter suffers from many limitations. In particular:

• The Diplomat only looks one move ahead, which imposes a clear limit on its play. Although, this is the same as all other Diplomat’s, and one move in Diplomacy is enough for the game to change a great deal.

• Convoy orders were ignored (see section 2.1.1 for more information on convoying).

• In Order Generation
  
  - Orders ‘deeper’ into a Diplomat’s territory may be useful, but are not considered.
  
  - The target province refinements can result in strategically useful provinces being ignored.

• in Plan Composition
  
  - The Diplomat has no real strategy/overall direction. A possible mechanism for overcoming this was described in [8].
  
  - The achieved clustering might not be optimal. The clustering algorithm non-deterministically chose a splitting if it could not create small enough clusters. Perhaps several clusters should have been produced and evaluated by some metric.
  
  - Plan Generation assumes every cluster is equally ‘important’. Some clusters might only have a single ‘obviously’ good sub-plan (one sub-plan which is a great deal better than all the others) yet, it, along with several bad sub-plans are promoted, whilst, another cluster may have to arbitrarily choose amongst many equally good plans.

\(^5\)Between a Diplomat’s front and the Diplomat’s home supply centres.
- Potentially, interference can occur between clusters.
- No treatment of more subtle Diplomacy tactics. For instance; figure 2.2 presents a situation in which a contradictory plan is desirable. It enables a Diplomat to maintain control over three provinces with two units (in such a way that no single enemy unit can gain control over any of the three provinces). A tactical and strategic component as described in [19] might be much more able in these circumstances.

- in Static Evaluation
  - The Diplomat’s position prediction is very naive. In particular, it doesn’t account for any enemy initiative (apart from the ‘cautious’ heuristic).
  - The value of the cautious heuristic is not clear. It might exaggerate the scores of some plans, in the instance where it is preferable to the Diplomat that an enemy unit occupy the position where one of it’s unit previously was.
  - The Diplomat’s position evaluation is very naive. It does not take into account several potentially useful factors, i.e. number of opponents with which the Diplomat shares borders, etc.

4.5 Summary

In this chapter, the Diplomat’s strategic/tactical component was described. This consists of three parts; determining what order to give to each individual unit, i.e. where it should move (section 4.1). Determining how these orders for individual units can be composed to create a coherent plan (section 4.2). Finally, how a value for plans can be computed so as to find the best one (section 4.3).

In section 4.1, it was explained a Diplomat’s creates its orders by considering which provinces it would like to occupy (target provinces), and then moving into, or towards these. These provinces lie on the frontiers of a Diplomat’s territory with respect to other Diplomats. Attempting to determine the best target provinces remains the biggest problem of Order Generation.

In section 4.1, the problems associated with composing moves were described. In particular, on any turn, there are exponentially many possible permutations of sets of orders (plans) for a Diplomat. The approach the Diplomat takes to tackling this problem is to cluster units into small groups, and only select the best sub-plans for each group, then, attempt to combine them, greatly reducing the amount of computation required. The problem of attempting to find the best trade-off between losing good plans, and computing too many plans remains.

In section 4.3, an approach to static evaluation is presented. The main problem associated with static evaluation is not the evaluation of the position itself, but, determining which position will arise as a result of a plan, particularly considering that Diplomats do not know each other’s strategies. A simple Position Prediction algorithm, designed to encourage ‘good’ behaviour from the
Diplomat is presented in subsection 4.3.1, but, it leaves much scope for improvement. Position evaluation itself is conducted in a very similar way to that of the Bordeaux Diplomat.
Chapter 5

Negotiation

This chapter details the negotiation mechanism employed by the Diplomat.

Once every turn, Diplomacy players enter a negotiation phase, during which they meet together to make plans and discuss strategies. Bounded only by a time limit, agreements between players are openly or secretly made, and orders may be coordinated. The aim of the negotiation component was to enable a Diplomat to use this phase to determine desirable potential exchanges, and, exploit some mechanism to attain them. It is given a set of the current ‘best’ plans by the strategic/tactical component (Chapter chap:Strategy), and, over the course of the negotiation, updates them to reflect agreements made.

A summary of this chapter is provided in section 5.6 on page 54.

Two possible approaches to modelling negotiation, presented in more detail in section 2.3 are:

**Argumentation Based ACLs**\(^1\)[9]: A negotiation mechanism which allows Diplomats to exchange almost any kind of information, not just proposals. A ‘language’ can be defined, so that Diplomats can literally ‘argue’ in order to reach agreements. One way to apply ACLs is to develop a Diplomacy ontology\(^2\). Such an ontology might define the attributes of a Diplomacy player (‘personality traits’ in the Israeli Diplomat [10]). Argumentation based ACL’s would also allow threats, rewards, and lies to be exchanged. As such, they are, next to natural language, possibly the closest representation possible to how the real game of Diplomacy is played.

**Market Based (MB)**: A negotiation mechanism based on the exchange of resources. When a Diplomat submits a set of orders for a set of units, it is essentially assigning resources to a task. In the same way, when one Diplomat exchanges one support for another with a different Diplomat, they are exchanging use of resources. MB methods assume an economic/resource-based view of Diplomacy. As described in subsection 2.1.4, this is one possible view of Diplomacy, but, whilst it might emerge from an Argumentation Based ACL, it is part of a MB approach.

The primary difference between the two approaches can be seen as one of focus. Use of an Argumentation Based ACL, with an interesting and rich

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\(^1\)A hierarchical structuring of the properties of Diplomacy.
communication between Diplomats will focus on, and highlight the process of making an exchange. Meanwhile, MB methods often involve minimal, and not very descriptive communication between Diplomats, and thus focus on the results of the exchanges themselves.

Ultimately, a Market Based approach was decided upon since:

- MB approaches present a much simpler implementation than Argumentation Based ACL’s, whilst not necessarily restricting the effects that negotiation might have.

- Efficiency. It is likely there would be much more processing associated with an Argumentation Based ACL’s approach, as compared to an MB one.

- An Argumentation Based ACL - type approach has already been experimented with in the Israeli Diplomat [10], whilst no MB based approaches have been attempted so far.

Having broadly decided upon Market Based methods as the Diplomat’s mechanism for negotiation, several questions needed to be considered:

Negotiation space: What kind of exchanges are conducted by Diplomacy players, and how can they be modelled? (section 5.1)

Protocol: How do Diplomats come to make these exchanges? (section 5.2)

Strategy: How do Diplomats use the protocol to get the best possible payoff? (section 5.3)

5.1 Negotiation Space

As outlined in [10], exchanges in Diplomacy can be categorized into a number of different types:

Declarations: Which may or may not be true.

Questions: Used to clarify previous suggestions.

Suggestions: Steps towards agreements.

Answers: Used to finalize agreements or answer questions.

Typically, the exchanges are initiated, and have a view to achieving one of two things:

- The formation of an agreement (whether it be to prevent a player from entering into an agreement with another player, or upon its own merits).

- Getting the opposing agent to believe some fact.³

³Need not be a “unit” fact as in the AR sense, more generally, its any representation of knowledge.
Figure 5.1: An example game situation
For the Diplomat, only agreements were considered, and in particular, only agreements in which a Diplomat agrees to support another Diplomat’s move next turn in exchange for an *IOU*.

An ‘ideal’ agreement between A and B can occur when A is in a position to receive support from B, and, at some other point on the game board, to support B. This corresponds to, in figure 5.1, on both pattern 1 and pattern 2 occurring in different parts of the same position. This happens relatively infrequently, especially given the nature of game (organised along fronts), which means few agreements would be possible. The number of occasions on which either pattern 1 or pattern 2 occurs is much greater.

An IOU is ‘the other half’ of an agreement when either pattern 1 or pattern 2 occur. For example, if pattern 1 occurs (B can support A), then, if A wishes support from B, it gives B an IOU, which represents a commitment to support B at some future point. If, in some future position, pattern 2 occurs, B can choose to ‘cash in’ its IOU and A is *obliged*\(^4\) to honour its commitment, and support B. The only instance in which A can not fulfil this commitment is when A has already promised the unit to another Diplomat, or, if several Diplomats attempt to cash in their IOUs at the same point (A can choose which IOU to honor). Unsuccessful attempts at cashing in IOUs lead to retention of IOUs, until they are accepted.

This type of agreement was chosen because:

- With the addition of IOUs, this kind of agreement plays an important role in the game, and the extent to which Diplomats negotiate, or don’t negotiate will have repercussions for their effectiveness in the game.
- Relatively easy for Diplomats to calculate the value of the agreement.
- Trivial to verify that an agreement has, or has not been kept, hence can model ‘Deceit’ (discussed more in chapter 6).
- Fits protocol well (see section 5.2).

Types of agreements ignored in this presentation are:

- Agreements with more than two participants.
- Other specific agreements (Demilitarized Zones, etc).
- More multi-faceted agreements, such as Peace/Alliance, or abstract agreements, such as ‘Co-operation’.

In general, an approach which enables negotiation over the chosen subset of possible agreements can be extended to cover all agreements by simply adding the ability to value those additional agreements. Additionally, getting an opponent to believe something (information exchange) can also be considered a kind of agreement. One party initiates the exchange (states the fact), and the other has the choice of whether or not to believe it. Two differences remain:

1. No confirmation of belief/disbelief needs to be given.

\(^4\)The consequences of breaking this obligation are considered in chapter 6.
2. Whether or not the fact is believed by the other Diplomat cannot be verified, by, for example, watching the play of the Diplomat (in contrast to an agreement).

In answer to 1, information exchange could be viewed as an agreement that is implicitly accepted. To 2, there are many kinds of agreements for which whether or not they have been kept cannot be verified, for example, an agreement with a party not to make agreements with another. An ability to deal with this lack of knowledge will have to be provided.

5.2 Protocol

Negotiation in Diplomacy can involve a number of meetings between two and seven players. There is a bound on the duration of the negotiation (in the board game, fifteen minutes), i.e. there is a finite number of meetings that can occur. During these meetings, any agreements can be made. Note, there are certain aspects of physical locality, such as eavesdropping, which are not considered in this presentation.

The chosen setting for negotiation is a one-time negotiation (encounter) involving all remaining Diplomat’s in the game. Only one such encounter occurs every negotiation phase. This setting was chosen because:

- Will allow simple (uncontradictory\(^5\)) agreements that can be made to be made.
- Easily implementable, and efficient.
- Extendable to the more general setting.

For extensibility, consider, negotiation in the game as a multiple, sequential\(^6\) set of encounters involving subsets of the Diplomat’s still in the game. This setting captures Diplomacy’s negotiation quite well. The presented negotiation setting could be extended to become analagous to the negotiation in the game with the addition of:

- Some way for Diplomat’s to decide which players they next wish to encounter (including an appreciation of how a possible encounter will appear to other Diplomat’s).
- Some mechanism for analysing the significance of which encounters were undertaken between other players.
- Some way for the Diplomats’, possibly contradictory desires regarding who they next want to encounter to result in a set of encounters. Difficult might be situations in which A wishes to encounter B and C, B wants to encounter A and C, but C only wants to encounter A (perhaps to organise an attack on B).

\(^5\)This setting may disallow contradictory agreements, as if something is promised to A, and then, to B (in front of A), then A and B will both know something is amiss!

\(^6\)Only so far as a Diplomat can only undertake one encounter at a time.
An encounter is modelled as a sealed, first-price, secret auction. Auctions were chosen as:

- They are well understood
- They are easily implementable.

The protocol in more detail is:

1. Diplomat’s enter the auction, and are randomly assigned a sequence no., indicating at which point it will be their turn to present possible agreements in the auction.

2. A Diplomat (the auctioneer) is informed (by the auction house) that it is its turn to present its agreements/partial agreements (hereafter referred to as just agreements).

3. While the auctioneer still wishes to make agreements, it presents an agreement to the next Diplomat in the sequence (the receiving Diplomat). The auctioneer will cycle the sequence, i.e. if there are three Diplomats (1,2,3) and Diplomat 2 is the auctioneer, it will approach 1, then 3, then 1 again. We stop proposing a particular agreement, and move to the next one when:
   - No Diplomat is interested, there is no current leader, and there were no toppling bids in a complete pass of the sequence.
   - The auction has been won by a Diplomat. If we are about to approach a Diplomat, and that Diplomat is the current leader, then we have made a complete pass through the sequence without this bid being toppled.

4. The receiving Diplomat has three choices:
   - Make a bid for the item (one of its own IOUs). In the instance that the bid topples the leading bid, the receiving Diplomat is informed that it is the current leader, and the auctioneer will approach the next Diplomat in the sequence. If the bid does not topple the leading bid, the auctioneer informs the receiving Diplomat of this, and it has the choice to try again, or to indicate disinterest.
   - Cash in an IOU, so long as it possesses one. The auctioneer is obliged to accept this, and it always topples the leading bid. The auctioneer will continue to the next Diplomat in the sequence, but, from then on, only other Diplomat’s attempts to cash in an IOU will be considered, and the auctioneer will maintain a list of Diplomats which have. Eventually, when all Diplomats have had an opportunity to cash in IOUs, the auctioneer must choose an IOU to honour.
   - Indicate disinterest in pursuing this agreement further, in which case the auctioneer will consider the next Diplomat in the sequence.

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7Bid is only visible to auctioneer.
8The Diplomat that bids highest wins.
9Bids that dislodged the current leader.
By way of example, an auction with three participants (A,B,C), and a game situation as described by figure 5.1, position 1, might proceed as follows:

**Arrival:** A,B,C enter the auction hall, and are re-ordered C,A,B (i.e. A is given sequence no. 2, etc).

C: Assumes the role of auctioneer.

- C is the auctioneer, but is unable to aid any other Diplomat- so, has nothing to put for auction. C steps down, and A becomes the auctioneer.

A: Assumes the role of auctioneer.

- A has a unit capable of offering support to another Diplomat, so, it puts it up for auction.
- A approaches C with the offer of the unit, but C is not able to utilize it in a plan, so, indicates it is not interested.
- A approaches B with the offer of the unit, B can utilize the unit (in an attack on C), so, it tends a bid (B offers A an IOU).
- A evaluates the bid, but finds that the the bid does not meet it’s ‘reserve’, and informs B of this, B decides it does not want to bid higher (B had the option of playing a previously acquired IOU of A’s, which would compel A to support its attack on C, but it valued that more than the support).
- A has made a complete pass through the sequence without any topping of the leading bid (its own reserve). It has no more units to offer, so, B becomes the auctioneer.

B: Assumes the role of auctioneer.

- B has a unit capable of offering support to another Diplomat, so, it puts it up for auction.
- B approaches C with the offer of the unit, but C is not able to utilize it in a plan, so indicates it is not interested.
- B approaches A with the offer of the unit, A can utilize the unit (in an attack on C), so, it tends a bid (A offers B an IOU).
- B evaluates the bid, but finds that the bid does not meet its’s reserve, and informs A of this. A decides it wants to bid higher, and has a previously acquired IOU of B’s which compels B to support its attack on C.
- B receives the IOU. Since a bid toppled the leader, it cycles through the sequence again (asks C again if it is interested, but C is still not), so B informs A it has won the auction for B’s unit.
- A tells B that it wishes B’s unit to support an attack on C.

**Departure:** All Diplomats have finished assuming the role of auctioneer, so, the Diplomats leave the auction house.
5.2.1 IOUs as Bids

Note that cashing in IOUs is part of the auction process. This is for a number of reasons:

- A Diplomat may not necessarily want to ‘call in a favour’, if it can offer something it values less in exchange instead.
- A Diplomat may not know which favour it wishes to ‘call in’, until during negotiation, when it can clarify which other agreements it wishes to make.
- A Diplomat may owe several other players, so they should all be given a chance to cash in their IOUs.

5.2.2 Protocol Features

The description and example highlight the features of the protocol. In particular:

Local Evaluation: B presents a bid to A, not knowing whether or not it will beat the leading bid. If B is asked to submit another bid, it does not even know whether its next proposal will be valued higher or lower by A. This is because Diplomats don’t know other Diplomat’s valuation of offers, a direct consequence of not knowing each others strategies. The exception is playing an IOU, since, a Diplomat knows this bid will have to be taken very seriously.

Secrecy: The direct communication means no Diplomats except the winning Diplomat, and the auctioneer know what agreements have been made. This is designed to be analagous to negotiation in Diplomacy, the game.

Randomness: Going first in an auction may be a big advantage or disadvantage, depending upon the strategy employed by Diplomats. The analogue to auction position in Diplomacy, the game, would be ‘who talks first’. Randomness is as an approach to modelling this variable.

Partial Agreements: When A proposes an agreement to B, it only proposes part of the agreement. Only that is has a unit, which could support one of B’s units. If it were proposing the ‘full’ agreement it would also specify which of B’s units it were to support. This omission is made for three reasons:

- This better represents the intention of ‘auctioning’ the unit. Once A has auctioned the unit, it could be considered temporarily as B’s unit, for it to do with as it wishes.
- B would be forced to supply more information about itself than it would want to supply. In a situation with many units, A could learn much about B’s valuations.
- It is more efficient.
However. It suffers from the limitation that A cannot set its ‘price’ dependent upon what B wants to do with the unit. This may mean agreements which could be made are not made.

**Reserve Price:** B may have a unit which can be offered to other Diplomats, but which also forms a central part of its own plans. The reserve price in the auctioning of any unit can be set to any value by the auctioneer. Hence B need not part with the unit cheaply.

**Contradiction:** In some situations, the secrecy property makes it possible for A to get away with auctioning a unit to B, and then bidding for another Diplomat’s unit, with the intention of using it to support the unit it auctioned to B. In fact however, other Diplomats might well be able to infer that a contradiction has occurred. In general however, the idea of issuing contradictory information is inconsistent with the semantics of the auction. The auction represents one meeting, perhaps of many. A Diplomat, if it wishes to make different promises to different Diplomats should meet them on separate occasions!

### 5.3 Strategy

A strategy specifies how Diplomats use the protocol to get the best possible agreements for themselves. A number of features of the Diplomat’s strategy emerge directly from the protocol. In particular, a naive strategy might be:

1. All parties produce an *egotistical* valuation for potential agreements directly from the valuations provided by a strategic and tactical analysis (including Deceit, presented in Chapter 6) of the game.

2. As the auctioneer, the reserve price for a unit in auction is set equal to the value placed on that unit by the auctioneer. This means an auctioning Diplomat never makes an agreement it is unhappy with.

3. As the auctioneer, the Diplomat should present every unit which can possibly be of use to anyone, since, any agreement it makes can only be good for it.

4. As a bidder, bid for anything that you value so far as your true valuation of it.

5. As a bidder, whilst bidding Diplomats don’t know how their bids are valued by the auctioneer, they know how they themselves value them. The best strategy is for Diplomats to order bids lowest to highest by their own valuations, so, they acquire the units as ‘cheaply’ as possible.

6. IOUs are valued according to the *size* of the bidding Diplomat. A logarithmic scale is used, so an IOU of a Diplomat which is ten times the size of another is worth twice as much, on the basis that a larger Diplomat is likely to have more opportunities to help than a smaller Diplomat (hence,
more opportunities to ‘play’ the IOU), but, a linear scale would over-
exaggerate this effect. Additionally, after obtaining a number of IOUs
from a particular Diplomat, the incentive to acquire new ones diminishes.
The continual acquisition, without opportunity for play, of IOUs would
indicate a very one-way relationship. A situation the Diplomat wishes
to avoid. The value of an IOU shifts dynamically (is re-calculated every
turn).

Figure 5.2: An example game situation presenting six possible agreements

There seem to be several ways that the above strategy could be improved.
Two of them, presented below are related to the bidding, and valuation (points
4 and 1 in the strategy above respectively).

5.3.1 Bid Strategy

Many potential agreements are mutually exclusive. For example, in figure 5.2,
six agreements are possible. Two of these are; B supports A which attacks C,
and C supports A which attacks B, i.e A could be supported by either B or C in
an attack against the other, obviously, A cannot enter into both of these agree-
ments. Suppose A considers the province which C occupies as very valuable,
and B’s province as only slightly valuable, then the better agreement would be
to attack C with support from B. However, C may assume the role of the auc-
tioneer before B does, and, according to the naive strategy outlined above, A
will bid for, and may obtain this agreement.

A solution to this might be for a Diplomat, as a bidder, upon being pre-
sented with an agreement, to consider which agreements this precludes it from
entering into. It can then compare these agreements with the present agree-
ment, and determine which agreements are preferable. However, other factors
need to be taken into consideration, notably, whether the Diplomat believes it
can obtain the agreement. In the instance above, B could also choose to make
an agreement with C (which is not compatible with making an agreement with
A). In general, there are two reasons that A may fail to make the agreement
with B:
1. B ‘purchases’ another unit, which it intends to use to support its unit. This will mean it will not offer its unit for auction, so, A will not get a chance to bid for it.

2. A is out-bid for the unit by another Diplomat, (including B itself, represented by the reserve).

This means there is no instance in which A knows that it will be able to make the alternative agreement. However, A does know certain facts:

In regards to point 1, A can determine, from the game position, how many agreements B can make. In addition, A might know, in general, what proportion of possible agreements are made. These two facts together would enable A to determine the probability of point 1 occurring.

In regards to point 2, A may be able to determine how much competition there is for B’s unit, knowing in what proportion of instances a Diplomat’s finds it favourable to make a bid, and, assuming that every bid has an equal chance of being the best valuation in B’s eyes, A could guess what the probability of point 2 occurring is.

In general, this strategy suffers from a lot of variables, and, in addition, does not fully appreciate the ramifications of making, or not making an agreement (next subsection). The naive bid strategy was thus chosen in preference to it.

### 5.3.2 Valuation Strategy

Consider point 1 in regards to figure 5.2. From A’s point of view, if it does not negotiate a role as a supporter or as the attacker against either B or C, then, only two of the six possible agreements remain. In both of these agreements, A is subject to a supported attack, with which A may be dislodged (unless it is supported). Clearly then, in this situation, there should be some bias towards making agreements.

However, simply because A does not make an agreement with B or C, it does not mean that an attack will definitely occur. B or C may both be disinterested in attacking A. In order to determine the magnitude of the bias, a number of facts are required:

- The extent of the loss in the case either attack occurs (relatively easily calculable).
- The probability that the agreement to attack will be made.

As we have seen in considering the Bid Strategy, attempting to determine the probability that an agreement will, or will not be made is very difficult, and involves many variables. For this reason, the naive valuation strategy was chosen in preference to it.

### 5.4 Mechanism Properties

As presented in [7], there are several desirable properties to negotiation mechanisms. In table 5.1 a consideration of the Diplomat’s negotiation mechanism against them is provided:
<table>
<thead>
<tr>
<th>Property</th>
<th>Explanation</th>
<th>Presence in Diplomat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rationality</td>
<td>Individual Diplomats should want to participate. No negative payoffs.</td>
<td>Yes. Since, Diplomats as auctioneers only accept bids which beat their reserve, and as bidders always do not bid beyond their true valuations.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Outcomes should be <em>Pareto optimal</em></td>
<td>Yes. Since, the bidding Diplomat always bids lowest to highest we consider all agreements that are better for it, which is enough to show Pareto optimality.</td>
</tr>
<tr>
<td>Stability</td>
<td>Diplomats have no incentive to deviate from a particular desired strategy</td>
<td>Yes and No. As presented in section 5.3, and as will be presented in section 5.5, strategies can soon become very difficult to navigate. However, it is difficult to see for what reason a Diplomat would want to deviate from a number of aspects of the naive/desired strategy (such as offering for auction every unit that is not already involved in an agreement).</td>
</tr>
<tr>
<td>Fairness</td>
<td>The negotiation mechanism should not intrinsically favour any Diplomats.</td>
<td>Yes and No. The order of the Diplomats in the auction will favour some Diplomats over others. However, over a long period of time, and many auctions, the randomness should average advantages and disadvantages to all Diplomats.</td>
</tr>
<tr>
<td>Simplicity</td>
<td>The computational burden and communication required by Diplomats should be minimal.</td>
<td>Yes. The negotiation mechanism itself does not require too much communication. Additionally, it is clear that Diplomats following the naive strategy will not endure too great a computational burden, and it is not at all obvious how this burden could be minimised by any other mechanism.</td>
</tr>
<tr>
<td>Verifiability</td>
<td>That Diplomat’s follow the rules should be verifiable.</td>
<td>No. That Diplomats do not make contradictory agreements cannot be verified by other Diplomats. Additionally, Diplomats as auctioneers can lie in the hope of obtaining greater bids from other Diplomats. The private communication makes this impossible to detect.</td>
</tr>
</tbody>
</table>

Table 5.1: An evaluation of the properties of the negotiation mechanism
5.5 Limitations

The treatment of negotiation provided above has many limitations. In more detail:

- The negotiation mechanism does not at all model the ‘cut and thrust’ of negotiation in Diplomacy. There is no argumentation or slander, or, involvement of many other interesting aspects of negotiation. An argumentation-based ACL approach would model this much better.

- The negotiation mechanism lacks some desirable properties. This can be attributed to attempting a compromise between making as mechanism with ‘nice’ properties, and capturing the way in which real Diplomacy players negotiate.

- In the negotiation space
  - A reduced negotiation space will not correctly identify the importance of negotiation, and will favour powers within the game that have a stronger strategic and tactical position initially.
  - No treatment of more abstract agreement types such as ‘peace’ and ‘alliance’ is provided.

- In the negotiation protocol
  - A detailed presentation of how the negotiation setting could be extended to become analagous to Diplomacy is not given.
  - The Diplomat’s lack of contradiction is not enforced by the protocol.
  - Much more communication than is strictly necessary may be conducted (i.e, in the instance that no Diplomat wants to make any agreement).
  - The auction mechanism, with an arbitrary ordering of Diplomat’s is not tackling the ‘real’ problem. That of finding the best solution for a group of Diplomat’s with differing desires (agreements they wish to make).
  - Following from the previous point, whilst individual agreements made are Pareto optimal, in real Diplomacy, a set of agreements which, overall, is ‘much more’ optimal is likely to be made.

- In the negotiation strategy
  - The strategy is naive, for reasons already presented. Human Diplomacy players can resolve many of issues presented.
  - The strategy assumes no value for information. The bids a Diplomat receives might tell it much about the bidding Diplomat. Similarly, from which bids are accepted and rejected, a Diplomat might be able to infer some facts about the auctioneer. No analysis of this is given.
  - The scheme for valuation of IOUs could take into account many more variables; such as how distant the opponent is (a more distant Diplomat will have few opportunities to help), and consideration
of the ‘traffic’ of IOUs between Diplomats (to what extent has this Diplomat been helpful in the past? Presumably, a Diplomat often helpful in the past may be helpful again in the future).

5.6 Summary

A Market Based approach to modelling negotiation was chosen over an Argumentation Based ACL approach. This represents the Diplomat’s focus on ‘What’ is being agreed upon, rather than ‘How’ it is agreed.

The Diplomat implements the negotiation mechanism in following manner:

**Negotiation Space:** A small subset of the possible agreements; those involving the exchange of a ‘support’ next turn for an *IOU*, representing a commitment to return the support at some future point. In 5.1 an argument is presented to show that a treatment of these kind of agreements could be generalised to a much wider range of agreements, including, possibly, information exchange.

**Negotiation Protocol:** Describes the setting for negotiation as one *meeting*, involving all active Diplomats, and also the structure of the meeting, namely, as an auction. The details of the auction protocol are provided in subsection 5.2. Additionally, in subsection 5.2.2 the main features of the protocol are described, such as *secrecy*, which means that the only Diplomats that know that an agreement has been reached are those directly involved.

**Negotiation Strategy:** A naive strategy, which makes mostly common-sense decisions as to how Diplomats should make use of the protocol is presented in section 5.3. Throughout the rest of the section, possible extensions to this naive strategy are considered, and refuted, on the basis of complexity, or absence of necessary information.

Following the presentation of the negotiation mechanism, a consideration of its properties (section 5.4) and limitations of it (section 5.5) is provided.
Chapter 6

Deceit

This chapter details the Diplomat’s treatment of deceit.

So far, a Diplomat that has a strategic/tactical understanding of Diplomacy, and can reach agreements has been described. However, an important element of Diplomacy is that agreements do not have to be kept. The aim of the deceit component is to augment the negotiation component with the ability to lie, and to be lied to.

This leads to two questions:

1. How does a Diplomat decide which agreements to keep, and which agreements to break? (section 6.1)
2. How does a Diplomat react to agreements broken by other players? (section 6.2)

6.1 Keeping/Breaking Agreements

A Diplomat must consider two factors when deciding whether or not to keep an agreement:

1. The utilities resulting from the four possible agreement outcomes (Diplomats D1 and D2 both keep the agreement, D1 keeps and D2 breaks, ... etc); U1 to U4.
2. Whether the other agent will break the agreement or not.

Note that the utilities U1 to U4, described in point 1 could include an appreciation of how keeping or breaking agreements will be perceived by other Diplomats. An appreciation of this fact however, would necessitate an understanding of how other Diplomats interpret events. For this reason, Diplomats do not do this, but calculate the utilities using static evaluation, as described in section 4.3.

In order to answer point 2 the notion of reliability is introduced. If a Diplomat has kept every agreement thus far, they are reliable, and there is a good chance that this next agreement will also be kept. If a Diplomat regularly
breaks agreements, they are *unreliable*, and there is not a good chance that this agreement will be kept.

One well-known formula associated with Laplace is the Rule of Succession. Suppose that some trial has only two possible outcomes, labelled "success" and "failure". Under the assumption that little or nothing is known a priori about the relative plausibilities of the outcomes, Laplace derived a formula for the probability that the next trial will be a success.

To calculate an opponents reliability, a Diplomat employs Laplace’s *Rule of Succession*. This was chosen as a model, as it fits with the notion that Diplomats have little or no information about each other, and, potentially, few exchanges take place:

\[ r = k + 1/n + 2 \]

So the reliability \( r \) of an agent is the number of agreements kept; \( k \) plus one, over the total number of agreements, \( n \), plus two. This means that a Diplomat has no bias to whether it expects agreements to be kept or not (the ‘default’ reliability of a Diplomat is 0.5).

![Figure 6.1: Possible permutations of keeping and breaking agreements](image)

Figure 6.1 illustrates the four possible outcomes when Diplomats D1, and D2 make an agreement from the perspective of D1. \( U_1 \) to \( U_4 \) represent the utilities of each of these outcomes for D1, \( p_1 \) and \( p_2 \) represent the reliability and ‘unreliability’ of D2 respectively (\( p_2 = (1 - p_1) \)). The figure can be viewed
from this perspective; D1 has the option to keep or break the agreement, and D2 has the same option. D1 is seeking to determine the utility at $X$ and $Y$, as a precursor to deciding what action to take.

Figure 6.2: D2’s options given that D1 has kept the agreement

Figure 6.2 presents two alternatives; A is a ‘close-up’ of part of figure 6.1, whilst B is a guarantee to obtain utility $U_5$. A contains no decision points for D1, so, it is a lottery with probability $p_1$ of obtaining utility $U_1$ and $p_2$ of obtaining utility $U_2$. Note that $p_2$ is the same as $(1 - p_1)$. Suppose that:

$$U_5 = p_1 \times U_1 + (1 - p_1) \times U_2$$

According to [11], a risk neutral Diplomat, would be completely neutral to the choice of these, so, they can be substituted. Thus, the utilities $X$ and $Y$ can be determined, and D1 can know the utility obtained, for it, of keeping or breaking the agreement.

In order to use these utilities to make a decision, the notion of honesty for a Diplomat is introduced. The honesty of a Diplomat describes whether it is weighted towards keeping, or breaking agreements. The honesty of a Diplomat, and its perceived reliability are related. In particular, if, over all agreements, $X$ and $Y$ are both uniformly distributed, and share the same mean, then over the course of many agreements, the perceived honesty and reliability will tend towards the same value.

However, honesty and reliability also differ. The honesty of a Diplomat is fixed, internal to that Diplomat, and a means to help it decide what to do. Reliability meanwhile, is a variable/footnoteThe value varies as agreements are made and kept/broken. estimate of whether or not other Diplomats will lie, based upon observations of them, and a means to help a Diplomat predict what other Diplomats will do.

The algorithm that Diplomats use for determining whether or not to keep an agreement based on honesty is:

```python
if keepUtility * honesty > breakUtility * (1 - honesty)
    keep the agreement
else
    break the agreement
```

Note that $\text{keepUtility} = X$ and $\text{breakUtility} = Y$.

1The probabilities of any particular value occurring is the same.
6.2 Reacting to Broken Agreements

Reacting to broken agreements, or stabs, is an important part of Diplomacy. The Diplomat currently reacts in two different ways:

1. As described in section 6.1, a Diplomat maintains a reliability for other Diplomats. If a Diplomat believes the other Diplomat is unreliable, and will break its agreement, it is less likely to make to an agreement, and, when it does, is more like to break the agreement itself.

2. The IOU valuation strategy presented in section 5.3 is extended to take into account the reliability of the other Diplomat. The IOU valuation is now the product of the reliability and the previous valuation, so, an IOU which it is believed will not be kept is considered worthless.

The reactions below were considered, but are not implemented by the Diplomat. In general, this is because the measures above can be seen as ‘sanctions’, or perhaps a lowered ‘credit rating’ for the Diplomat, broadly, economic measures. Meanwhile, the measures below could be seen as equivalent to ‘kneecapping’, a much more direct, primitive, and immediate response to being stabbed. Whilst both recourses have their place within Diplomacy, the market based model of negotiation described in chapter 5 is much more consistent with the former.

- Arbitrarily favouring breaking agreements with this Diplomat. This could be achieved by reducing honesty (perhaps temporarily) with regards to this Diplomat.

- Favouring plans which involve attacking this power, perhaps by some constant (a magnitude of revenge), or related in some way to the loss incurred as a result of the stab.

6.3 Limitations

The above treatment of reliability suffers from many limitations:

- Is the figure of 0.5 a good default reliability?

- The reliability estimate works over the complete history of agreements. This does not work well when a Diplomat’s honesty changes throughout the game. Several recent agreements may be broken in succession, and yet the reliability estimates may still be high.

- The Diplomats have been given the ability to react to being stabbed, but no understanding, as the stabber, that negative consequences will ensue. They also do not have the ability to change their honesty values. A high degree of honesty, as a positive attribute, may thus come from survey of a large number of Diplomats with differing honesty values, but a sole Diplomat does not have the ability to learn this feature of the game.
Chapter 7

Findings

This chapter details and analyses the results of trials covering every aspect of the Diplomat.

Throughout the last few chapters, a Diplomat has been described. The aim of this chapter is to:

- Provide an analysis of the Diplomat, through experiments, and observations of its behaviour.
- Highlight any interesting behaviours that the Diplomat exhibits.
- Highlight deficiencies in the Diplomat’s play.

For clarity, analysis focussed on individual components of the Diplomat in turn; strategy and tactics (section 7.1), negotiation (section 7.2) and deceit (section 7.3). Finally this chapter is summarised in section 7.5.

7.1 Strategy and Tactics

Preliminary tests of the Diplomat involved ensuring that it could beat the following opponents:

- A Diplomat which only issues ‘hold’ orders \((\text{holdbots})\)^1.
- A Diplomat which only issues random orders \((\text{randbots})\)^2.

In order to test the ability to beat holdbots, trials involving 1 Diplomat, and 6 holdbots was conducted. The rationale behind this; that the trials aim was to determine whether the Diplomat could avoid deadlock, and the addition of more Diplomats only makes this task easier. The Diplomat managed to succeed (win the game) in every instance. 11 trials were conducted (as many as were needed so that the Diplomat played the game at least once as every power).

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1\(^{1}\)holdbot from Andrew Rose’s Diplomacy package (section 2.4.2)
2\(^{2}\)consbot from Andrew Rose’s Diplomacy package (section 2.4.2, which creates random, but self-consistent orders)
The quickest Diplomat to win the game was Russia, which accomplished this in 1905. The slowest Diplomat to win was Turkey, which took until 1942. This disparity occurs for two reasons:

- The starting position of Turkey is very constricted. Armies can only leave Turkey in single file. Meanwhile, Russia’s position is very open, and presents multiple possible avenues of attack.

- The Diplomat does not look more than one move ahead, hence it has to ‘chance upon’ a position where it can force an opposing unit to retreat. This can be a lengthy process.

Similar trials were conducted to test the ability to beat randbots. In 21 trials (again, the number of trials needed so that the Diplomat played once as every power), the Diplomat won every time. The quickest win was shared amongst several Diplomats; in 1905. The slowest in 1912 by England. The greatly reduced disparity is due to the fact that the continual movement of enemy units meant that Diplomat’s did not need to ‘wait’ until the proper tactical formations were chanced upon, but could advance relentlessly across the board.

Having conducted these preliminary trials, a much truer analysis of the strategic and tactical play of the Diplomat was needed. Ultimately Dumbbot, so named because of its ability to only play no-press Diplomacy, was chosen as a reference AI to play against. Dumbbot is a competent Diplomacy AI, which has even been observed to play well in no-press games against human opposition.

### 7.1.1 Observations

In the first trial, 6 Diplomats and 1 Dumbbot played ten games. In subsequent trials, various different permutations of Diplomats and Dumbbots played games, the results of which are recorded in table 7.1. The associated metric recorded is victory in the game. Note that in these trials; negotiation between Diplomats was prohibited, since, this was solely intended to be a test of the Diplomat’s strategic and tactical understanding.

The Diplomat won 26 out of 60 games, which indicate that the Diplomat is slightly less successful than Dumbbot. In no trial did the Diplomat achieve 10/10, or 0/10 indicating that neither the Diplomat nor Dumbbot is able to enforce an environment in which the other can’t win. The structure of the results, particularly the trial involving 4 Diplomats and 3 Dumbbots in the context of the surrounding, indicate that the results are somewhat random.

Whilst, Dumbbot achieved more victories, the Diplomat suffered less eliminations in games. The results are summarized in table 7.2. These results can be explained by the ‘attitude’ of the two AIs. The Diplomat’s attempts to maintain a closed sphere of influence around its home supply centres sometimes lead to quite conservative play. In trials, it was observed that Dumbbot is tied to its home supply centres much more loosely than the Diplomat, representing more aggressive, but risky, play.

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3The Diplomat chooses randomly from amongst the highest rated plans
4more information about which is available in 2.4.2
Both the Diplomat and Dumbbot clearly found some powers in the game easier to play than others. Table 7.3 presents the proportion of wins obtained for each AI for each power.

A correlation can be seen between the Diplomat’s favoured provinces and Diplomacy’s adjacency graph, presented in subsection 2.1.5. Generally in Diplomacy, the players on the outskirts have a clearer strategy, and less to worry than the players in the centre. Meanwhile, the strategic deficiencies of the players in the centre can be offset by their increased potential for negotiation. The central powers can usefully engage in more agreements earlier than the outer powers.

The Diplomat’s played particularly well as Turkey. In many ways, Turkey’s constricted position is an advantage. It forces the Diplomat to adopt a good strategy, restricts the number of enemies that it can engage at one time to a ‘manageable’ number, and makes it difficult for enemy units to get at its home supply centres.

Meanwhile, for similar reasons, the Diplomat also played well as France. France has, in common with Turkey, home supply centres which are relatively

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### Table 7.1: The Diplomat vs Dumbbot: victories

<table>
<thead>
<tr>
<th>Power</th>
<th>The Diplomat</th>
<th>Dumbbot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>7.7%</td>
<td>0%</td>
</tr>
<tr>
<td>England</td>
<td>0%</td>
<td>23.5%</td>
</tr>
<tr>
<td>France</td>
<td>23.1%</td>
<td>17.6%</td>
</tr>
<tr>
<td>Germany</td>
<td>3.8%</td>
<td>0%</td>
</tr>
<tr>
<td>Italy</td>
<td>7.7%</td>
<td>20.6%</td>
</tr>
<tr>
<td>Russia</td>
<td>7.7%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Turkey</td>
<td>50%</td>
<td>29.4%</td>
</tr>
</tbody>
</table>

Table 7.3: The Diplomat vs Dumbbot: percentage win by power
inaccessible by opposing players\(^6\), and a clear direction in which to expand. However, it has both of these to a lesser extent than Turkey, perhaps explaining the Diplomat’s lesser success with it.

The Diplomat demonstrated the ability to win, albeit rarely, with every other power apart from England. The Diplomat’s failings with England cannot wholly be explained by the absence of convoying, as Dumbbot suffers from the same restriction. In the trials, it was apparent that the Diplomat often \textit{started} the game well with England, capturing 12 or 13 of the required 18 supply centres, however, in order to win the game (without convoying), the Diplomat needs to move fleets into the Mediterranean. The Diplomat’s desire to cluster it’s units meant that it failed to do so.

### 7.1.2 Problems Identified

Through observation of the Diplomat’s games with Dumbbot, a number of problem areas in the Diplomat’s play were identified:

**Recognition of leaders**

A Diplomat calculates a utility for plans based on a \textit{self-absorbed} metric. This does not take into account the ‘relative’ effect of its plan on other Diplomats. In particular, one Diplomat may be in a very strong position, and about to win the game. In this situation, human players of Diplomacy would almost certainly unite against this Diplomat, however, a Diplomat’s self-absorbedness means it does not. Consequently, a Diplomat’s success or failure is not necessarily due to \textit{sound} strategic and tactical play, but biased towards ‘speedy’ Diplomats.

![Figure 7.1: A breached sphere of influence](image)

**Influence Map Issues**

As a strategy, a Diplomat’s desire to expand its influence works well. However, it fails in the instance that it’s sphere of influence is \textit{breached} by a unit

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\(^6\)This is even more so the case given the absence of convoying, meaning that England can only ever capture one of its home supply centres

\(^7\)Reasoned, and good, regardless of the actions of other Diplomats.

62
belonging to an opposing Diplomat. As shown in fig 7.1, in this situation, the Diplomat’s sphere of influence becomes donut shaped, with units facing the choice of moving outwards, or inwards. Typically, since provinces in the centre are more valuable, the Diplomat will choose to retreat inwards. This may not be the best strategy, since, there is a limit to the damage\(^8\) that a single unit can accomplish. Furthermore, attempting to move clusters towards a single point often means interference\(^9\) between them occurs, which is clearly undesirable. Additionally, in capturing more supply centres, a Diplomat will often have the ability to build more units in its home supply centres, providing it the means to deal with the threat of the enemy unit. In general, two ways to improve this situation can be seen:

- A much more robust treatment of strategy, using the aid of heuristics to ignore features not deemed to be relevant, i.e. isolated units whose potential to cause damage is limited.
- Allowing the Diplomat to include the effect of projected builds in evaluating a position, more generally, looking further ahead in the game.

This issue was particularly prevalent in the Diplomat’s games against Dumb-bot. Whilst the Diplomat strives to, quite rigidly, maintain cohesion amongst its unit, Dumbbot much more frequently allows units to become isolated from others, often breaching an opponents position.

**Tactical Issues**

In a number of instances, the Diplomat demonstrated limited tactical understanding. This was particularly noticeable when a Diplomat’s position was breached by an isolated enemy unit. Once a Diplomat’s units had reached an opposing Diplomat’s unit, they would attack it, forcing it to retreat to another province, but leading to a position only marginally better than the previous. In general, a human player would attempt to keep further restricting the choice of move for an opposing unit, until it is trapped and destroyed. Unfortunately, the Diplomat did not have the same appreciation.

**Maintaining Positions**

There are several provinces which, in certain positions, achieve strategic importance. For instance; Bulgaria is important for Turkey, since, it is its ‘gateway’ to the Balkans, and, ultimately mainland Europe. Having attained this province however, the Diplomat will often lose it, through moving the occupying unit elsewhere, or allowing it to be dislodged. In general, this occurs as a result of not accrediting other Diplomats with enough initiative, and not truly recognising important provinces.

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\(^8\)Number of supply centres capturable.
\(^9\)Attempts by two or more units to move to the same province, with the result that neither succeeds.
Strategy

A side-effect of not appreciating important, and not so important, provinces, is engaging units in pursuits which are not worth the trouble. For instance, France should control Spain and Portugal, but, if it becomes ‘obsessed’ with these it risks losing out to the much more obvious and potent threat of England, Germany, or Italy capturing its home supply centres. Once units are in Spain and Portugal, it is not easy to bring these back to France. In general, the Diplomat needs a much more holistic view of strategy.

![Figure 7.2: An example of units getting stuck](image)

Units Get Stuck

Sometimes, the Diplomat’s units get ‘stuck’. This is illustrated in figure 7.2. The hollow circle represents a fleet, whilst the solid circle represents an army. The fleet cannot move north, since, the province north of it is neither a body of water, nor a coastal province. A good plan, as indicated by the arrows, is to withdraw the fleet and replace it with an army that can move further north. However, in order to do this, the fleet has to move to a position ‘deeper’ within the Diplomat’s sphere of influence. This set of moves, essentially a ‘reordering’ of units, rather than an acquisition of new provinces is not considered by the Diplomat.

In general, this is a case of tactics being overwhelmed by strategy. The ‘desire’ to form good tactical patterns, when appropriate, should be able to overcome the pull generated by a direction provided by strategy.
Negotiation is a critical part of Diplomacy, and the facility to negotiate adds much to the Diplomat. The key question that emerges regards its usefulness, are negotiating Diplomats more effective at Diplomacy than non-negotiating Diplomats? (subsection 7.2.1). Meanwhile, further observations and patterns of play were analysed in subsection 7.2.2.

### 7.2 Effectiveness

The trials chosen to test effectiveness of negotiation involved allowing only 6 of the 7 Diplomats to negotiate (only honest negotiation, since consideration of deceit is covered in the next section). The success or failure of the non-negotiating Diplomat is an indicator of whether negotiating, or not negotiating is beneficial to the Diplomat. The scenario; 6 negotiating Diplomats versus 1 non-negotiating was chosen as:

- This maximises the number of agreements possible, meaning that impediments to negotiation will be minimised. This was important, as, given the very restricted negotiation space, it was felt that the effect of negotiation on the game would be quite subtle.

- With a number of non-negotiating Diplomats, there is the possibility of one of them achieving a quick victory by beating the others, whilst not really combating the negotiating Diplomats.

In all, 157 trials were conducted, the results are summarised in table 7.4. The ‘Units at End’ result is the sum of the remaining units of that Diplomat at the end of each game, divided by 157 (no. of games). The results for the ‘negotiating Diplomat’ were calculated by averaging the results of the negotiating Diplomats.

The results of the trials show that negotiating Diplomats are more effective than non-negotiating Diplomats. They win more often, are eliminated less often, and generally have more units at the end of the game than their non-negotiating counterparts.

Further evidence of the disparity between negotiating and non-negotiating Diplomats comes from consideration of the powers with which the Diplomats achieved wins. These are presented in table 7.5.

Almost all of the non-negotiating Diplomat’s wins came as a result of playing Turkey. In fact, the non-negotiating Diplomat assumed the role of Turkey.
Table 7.5: The Diplomat vs Negotiating Diplomat: percentage win by power

<table>
<thead>
<tr>
<th>Power</th>
<th>Non-Negotiating Diplomat</th>
<th>Negotiating Diplomat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>0%</td>
<td>3.6%</td>
</tr>
<tr>
<td>England</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>France</td>
<td>0%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Germany</td>
<td>5.9%</td>
<td>5%</td>
</tr>
<tr>
<td>Italy</td>
<td>5.9%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Russia</td>
<td>0%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Turkey</td>
<td>88.2%</td>
<td>76.4%</td>
</tr>
</tbody>
</table>

24 times across the 157 games, and converted 15, or 63% of these to wins. Meanwhile, when a negotiating Diplomat assumed the role of Turkey, (133 occasions), it managed to convert 104, or 80% of these to wins. This shows:

- Negotiation, as implemented by the Diplomat, is not enough of an extra faculty to offset Turkey’s strategic strength. This could be seen as a reflection of Turkey's strength, the Diplomat's weakness in terms of negotiation, or both.

- Negotiating Diplomats play as Turkey better than non-negotiating Diplomats. Negotiation complements, and doesn’t detract from Turkey’s good strategic position.

Meanwhile, the non-negotiating Diplomat managed to win just 2 of the 133 (1.5%) games in which it assumed a power other than Turkey. The negotiating Diplomats collectively won 9 out of 24, or an average of 1.5 games each (6.3%) in the instances in which they did not play Turkey. This shows that, relatively, it is very difficult for a non-negotiating Diplomat to win with any power other than Turkey. In other words, if the Diplomat was equally strategically and tactically adept with every power, then, it is likely that the consequences of negotiating or not negotiating would be felt much more.

### 7.2.2 Further Observations

Negotiation was examined in two ways; a qualitative assessment, based on the statistics obtained in trials above, and a quantitative assessment based on an observation of the way the Diplomats used negotiation. These analyses were aimed at the following questions:

- How many agreements do the Diplomats have the potential to make? (success of the negotiation space)
- How many agreements are made, when, and by whom? (success of the mechanism and strategy)
- How can the agreements the Diplomat makes be characterised (success of the Diplomat’s agreement evaluation functions)
<table>
<thead>
<tr>
<th>Power</th>
<th>Average Potential Agreements / Game</th>
<th>Average Potential Agreements / Turn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>308</td>
<td>12.3</td>
</tr>
<tr>
<td>England</td>
<td>271</td>
<td>7.2</td>
</tr>
<tr>
<td>France</td>
<td>410</td>
<td>11.3</td>
</tr>
<tr>
<td>Germany</td>
<td>438</td>
<td>13.4</td>
</tr>
<tr>
<td>Italy</td>
<td>234</td>
<td>8.6</td>
</tr>
<tr>
<td>Russia</td>
<td>302</td>
<td>10.9</td>
</tr>
<tr>
<td>Turkey</td>
<td>464</td>
<td>12.7</td>
</tr>
</tbody>
</table>

Table 7.6: Negotiation Space by power

<table>
<thead>
<tr>
<th>Potential Agreements</th>
<th>1214</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bids</td>
<td>79</td>
</tr>
<tr>
<td>Leading Bids</td>
<td>48</td>
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<tr>
<td>Rejected Bids</td>
<td>31</td>
</tr>
<tr>
<td>Agreements</td>
<td>46</td>
</tr>
</tbody>
</table>

Table 7.7: The Auction: statistics

Table 7.6 describes the Diplomat’s negotiation space whilst playing various powers, including the average number of potential agreements per game. That the numbers are ‘quite’\(^{10}\) large reflects positively upon the negotiation space, demonstrating that, so long as within this space lie both good and bad agreements, it is broad enough for Diplomats to usefully employ a strategy, and for the manner of negotiation to make a difference.

Turkey has more potential agreements than any other power. It should be borne in mind, however, that Turkey is by far the most successful power in so far as it is more often ‘alive’ for longer during games, and has many more units than other powers. When the longevity of powers is taken into account, Turkey no longer fairs best. Additionally, if the effect of the number of units was somehow taken into account it is likely Turkey would fair much worse. Meanwhile, the average potential agreements for the rest of the powers favor those more centrally located; England and Italy fair badly, partly a result of fewer negotiation opportunities, and partly a result of their longevity; their positions make them difficult to eliminate from the game.

Table 7.7 presents statistics regarding auctioning. It shows that whilst, on average, there are approximately 1200\(^{11}\) potential agreements during a game, Diplomat’s are very selective, and only about 45, or 3.5% of potential agreements become agreements. The reasons for this are:

- Mutual exclusion between agreements. Often, the same unit is involved in many different potential agreements. Making one agreement means

\(^{10}\)A situation in which there were only 0 or 1 possible agreements per turn would be much less interesting.

\(^{11}\)Determined by summing the potential agreements for individual powers, and dividing by two to remove repetitions.
• Others cannot be made.

• Whilst a unit may be able to participate in agreements, and be offered at auction, it may not add value to any other Diplomat’s plans.

• The unit (of Diplomat A) may be desired by another Diplomat (Diplomat B), but not enough to justify playing an earlier acquired IOU (from a previous instance in which Diplomat B helped Diplomat A), or offering its own IOU (a commitment by Diplomat B to help Diplomat A in the future).

• The unit may be desired by Diplomat B enough to make a bid, but, it could be rejected (about 40% of bids are rejected). A bid might be rejected because another Diplomat has made a higher bid, or the bid has not met the reserve; the offering Diplomat’s valuation of the unit.

• Alternatively, the Diplomat may be leading the auction, but later be outbid. This is quite rare, and appears in the results as the difference between leading bids, and agreements, i.e. 2/48 bids. This rarity is explained by the fact that very few potential agreements get as far as bids being made; indicating, amongst other things, a large degree of selectiveness on the part of Diplomats, that two different Diplomats’ valuations both lead it to want a unit is unusual.

Another feature of table 7.7 is the large proportion of bids that become leading bids, and ultimately agreements, (approximately 60%). This is largely due to Diplomat’s ‘indifference’ towards offering support to another Diplomat. For instance, suppose that figure 7.3 presents a situation in which A is occupying a province which it values much more than any of the surrounding provinces. If it were to move anywhere, it would lose this province. This means that, in the absence of negotiation, A would probably choose to conduct a hold move. However, the effect of supporting another unit is the same as a hold. A is thus likely to accept any offer which it values positively.

In any agreement that the Diplomat’s make, there are three parties, or roles; the attacker, the supporter, and the defender, although, the defending Diplomat does not know about the agreement in advance. With an average of 45 agreements being made each game, there are 135 roles. Table 7.8 presents the extent to which powers are involved in agreements, and the distribution of roles in these agreements.

Germany and Turkey are involved in many agreements, whilst Italy and Austria are involved in few. That Turkey is involved in many is not surprising, considering its size and longevity, whilst Germany’s central position, the fact that it has more potential agreements than any other power, and its relative longevity provide it’s reasons for featuring strongly. Italy plays a smaller role due to its somewhat more isolated position, as indicated by its few potential agreements. Finally, Austria, which is often in direct competition with Turkey early in the game is often eliminated quickly. That it does not fare worse is a

---

12 The current best bid for a unit in the auction
13 Purchaser of the unit
14 The auctioneer of the unit
15 Diplomat being attacked
reflection of its central position, and the many agreements it does make whilst alive.

Whilst the extent to which Diplomat’s feature in agreements varies, the roles which they assume are much more uniform. No Diplomat is cast entirely as attacker, defender or supporter, there are only relatively slight leanings towards certain roles, in particular:

- Turkey gets more opportunities to attack. This is a result of the IOU valuation scheme. Since Turkey is in a good strategic position, it often becomes powerful early in the game. When bidding for units from other Diplomat’s, the Diplomat representing Turkey will have its IOUs valued higher than other Diplomats, meaning that when competition for a unit occurs, Turkey will most likely win. Even when competition does not occur, the higher value of a Turkish IOU is more likely to overcome the auctioneer’s reserve price, meaning that Turkey obtains a higher proportion of the units it desires than other powers.

- Austria gets fewer opportunities to attack. This is a result of the same effect as demonstrated by Turkey, except in reverse. If Austria is weak, other Diplomat’s are less likely to accept its IOUs, since, they have low valuations for it. Turkey as a neighbour may exacerbate this effect, for example, in a situation in which a third Diplomat can help either Turkey or Austria attack the other, Turkey will almost certainly win the auction, which, will mean that, following the fruition of the agreement and the attack on Austria, Turkey is in an ever more dominant position in future auctions - whilst Austria is more subservient.

- England is biased towards supporting other Diplomats. This is a reflection of the fleet-orientation of it’s forces. A fleet which is an ocean

\[ \text{Figure 7.3: An example of neutrality towards support} \]
province can support units on adjacent coastal provinces, but, unless both of the other units under consideration are fleets, cannot be attacked by them. In general then, fleets in ocean provinces lead to asymmetrical situations, which bias England towards supporting other Diplomats.

The following types of agreements were observed through observing games of Diplomacy amongst seven honestly negotiating Diplomats.

- Often, two units belong to different Diplomats will want to occupy the others territory. In this situation, as demonstrated by figure 7.4, the support will act as a tie-breaker.

- Supporting another unit can sometimes be surprisingly beneficial. In figure 7.5, supporting another unit helps one of the units to avoid being dislodged. It is very difficult to account for these kinds of results. The Diplomat does not, but sometimes, it is lucky.

- In a situation where there are several different powers, quite complicated sets of agreements can be made, which interact in non-obvious ways. In figure 7.6, Turkey loses out through a surprise support from Italy from a unit it expected would be dislodged. The ensuing situation is not good for Turkey, the agreement enabled a fissure to be made in it's line where none existed before. Put another way, no Diplomat, individually, had more than one unit to bring to bear against Turkey on that turn, but, through negotiation, an attack was formed.

- Negotiation seem to lead to less stable situations. Considering figure 7.6, it can be observed that a Russian unit has got ‘behind’ Turkish lines. Before negotiation, the only way to ‘breach’ a defense to this effect was to bring several units to bear on it. With negotiation, two units of any power can make such advances, meaning situations become much more fluid, and choosing the right partners can overcome numerical deficiencies.

- Offering a support can sometimes leave a power in a difficult situation. An ’Idealized’ support, is presented in figure 7.7. In it, England is very detached from the consequences of its actions. Whether or not the support succeeds, England is at no additional threat, representing a ‘safe’ support.

---

<table>
<thead>
<tr>
<th>Power</th>
<th>Agreements / Game</th>
<th>Attacker</th>
<th>Defender</th>
<th>Supporter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>12.7</td>
<td>31%</td>
<td>36%</td>
<td>33%</td>
</tr>
<tr>
<td>England</td>
<td>19.2</td>
<td>32%</td>
<td>32%</td>
<td>36%</td>
</tr>
<tr>
<td>France</td>
<td>22.7</td>
<td>34%</td>
<td>33%</td>
<td>33%</td>
</tr>
<tr>
<td>Germany</td>
<td>25.5</td>
<td>33%</td>
<td>34%</td>
<td>33%</td>
</tr>
<tr>
<td>Italy</td>
<td>11.3</td>
<td>34%</td>
<td>33%</td>
<td>33%</td>
</tr>
<tr>
<td>Russia</td>
<td>18.2</td>
<td>31%</td>
<td>35%</td>
<td>34%</td>
</tr>
<tr>
<td>Turkey</td>
<td>25.1</td>
<td>36%</td>
<td>32%</td>
<td>32%</td>
</tr>
</tbody>
</table>

Table 7.8: Roles assumed by powers
Figure 7.4: Agreements as tie-breakers

Figure 7.5: Agreements, surprisingly beneficial
Figure 7.6: A web of supports

Figure 7.7: Ideal supports
7.3 Deceit

An analysis of various aspects of Deceit was conducted. The analysis hoped to answer two questions:

1. Are deceitful Diplomats more effective than honest Diplomats? (subsection 7.3.1)

2. How deceitful should Diplomats be? (subsection 7.3.2)

### 7.3.1 Effectiveness

In order to determine the effectiveness of deceit, a similar set of trials to those that determined the effectiveness of negotiation were used. The scenario used allowed 6 of 7 Diplomats to negotiate honestly\(^{16}\), whilst the last Diplomat has the capacity to be deceitful. The honesty parameter for this Diplomat was set to 0.5, a value at which it is neither biased towards making, or breaking agreements, but seeks to maximize its utility. The success or failure of the deceitful Diplomat is an indicator of whether lying, or not lying is beneficial to the Diplomat. The scenario; 6 honest Diplomats versus 1 deceitful one, was chosen as it maximises the number of agreements possible for the deceitful Diplomat, meaning that impediments to negotiation will be minimised. This was important, as, given the very restricted negotiation space, it was felt that the effect of deceit on the game would be quite subtle.

In all, 182 trials were conducted, the results are summarised in table 7.9. The ‘Units at End’ result is the sum of the remaining units of that Diplomat at the end of each game, divided by 182 (no. of games). The results for the ‘honest Diplomat’ were calculated by averaging the results of the honest Diplomats.

The results of the trials show that deceitful Diplomats are more effective than honest Diplomats, in that they win much more often, and will have many more units at the end of the game. Their increased capacity to win does not affect their ability to avoid elimination, this may be due to several reasons:

- Sometimes, Diplomat’s can be eliminated very early in the game, before they really have a chance to negotiate.

- There may be certain powers for which the ability to be deceitful, or even negotiate is no help at all, perhaps even counter-productive.

Table 7.10 presents a breakdown of with which power the victories for the deceitful and honest Diplomats were achieved respectively.

\(^{16}\)By honest Diplomats, it is meant that the Diplomat’s do not have the ‘deceit component’, so, they do not react in any way, even internally, to broken agreements.
Table 7.10: The Deceitful vs Honest Diplomat: percentage win by power

<table>
<thead>
<tr>
<th>Power</th>
<th>Deceitful Diplomat</th>
<th>Honest Diplomat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>2.6%</td>
<td>7.6%</td>
</tr>
<tr>
<td>England</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>France</td>
<td>10.5%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Germany</td>
<td>15.8%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Italy</td>
<td>2.6%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Russia</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Turkey</td>
<td>68.4%</td>
<td>72.2%</td>
</tr>
</tbody>
</table>

Both Diplomat’s played well as Turkey, with the deceitful Diplomat winning 76% (26 out of 34), and the honest Diplomat winning 70% (104 out of 148) of games when cast as Turkey. The main difference between the Diplomats come whilst playing Germany. An honest Diplomat won on only 10 occasions as Germany, making about 2 wins per Diplomat, whilst the deceitful Diplomat, individually, won on 6 occasions.

That Germany should benefit most by lying is not surprising. An analysis of honest negotiation, (table 7.8) showed that, on average, 25.5 agreements involve Germany each game, more than any other power. The effects of an improved negotiation strategy are aggregate, so relatively minor gains from individual agreements, when summed over many, can change the shape of a game.

7.3.2 Optimal Levels of Honesty

Trials were conducted in order to test what the best value of honesty for a Diplomat’s is. In the first trial, the honesty for 6 of the 7 Diplomat’s was set to 0.5, and the honesty for the final Diplomat allowed to vary between 0.5 and 1. An honesty of 0.5 means that the Diplomat’s are neither biased towards keeping, or breaking agreements. In practice, since, there is very often a pay-off in breaking agreements, such Diplomats will rarely keep agreements. The last Diplomat’s honesty varies between 0.5 and 1, as these can be seen as sensible values. An honesty of below 0.5 represents a Diplomat that is biased towards breaking agreements, even when keeping them would offer a greater pay-off.

In all, 77 games with 6 Diplomats of fixed honesty, 0.5 (dishonest Diplomats), and one Diplomat of varying honesty (deemed the ‘more honest’ Diplomat) were played. The results are summarised in table 7.11. Note, that the number of games played to completion for each value of honesty varies due to the method of running the trials, not because of any property of the Diplomat. The results show that, when others are dishonest, a Diplomat should itself be dishonest. When the more honest Diplomat had a value for honesty of between 0.5 and 0.7, it won 7/46, or approximately 1/7 games. When it had a value for honesty between 0.8 and 1, it won only 2/31.

There could be several reasons for this:

- When the Diplomat is honest, as an auctioneer, it will refuse bids, rather than accepting them and intending to break the resulting agreement. Thus,
Table 7.11: Varyingly Honest Diplomat; Environment of Dishonest Diplomats

<table>
<thead>
<tr>
<th>Honesty</th>
<th>Wins/Games</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>3/18</td>
</tr>
<tr>
<td>0.6</td>
<td>2/15</td>
</tr>
<tr>
<td>0.7</td>
<td>2/13</td>
</tr>
<tr>
<td>0.8</td>
<td>1/12</td>
</tr>
<tr>
<td>0.9</td>
<td>0/11</td>
</tr>
<tr>
<td>1.0</td>
<td>1/8</td>
</tr>
</tbody>
</table>

whilst being misled by other Diplomats it will not itself mislead others, making it, comparatively, less effective. Note that, following the stab, the deceitful Diplomat will regard the honest Diplomat as honest (it’s reliability estimate for the other will increase), and the honest Diplomat will regard the deceitful Diplomat as deceitful (it’s reliability estimate for the other will decrease). This allows both Diplomat’s to better predict the other Diplomat’s intentions, however, some issues arise:

- By this time, the damage has already occurred. No matter how well the honest Diplomat learns, it would have to be proactive to regain what it has lost. It is likely that the small negotiation space, and the relative paucity of agreements means that the Diplomat may not even have an opportunity to do this.

- Knowing better the dishonest Diplomat, the honest Diplomat will view the utility of keeping agreements in future as lower, and the utility of breaking agreements as higher. The fact that the honest Diplomat fares worse may be because these utilities do not change enough for the Diplomat to become dishonest. The fundamental nature of the Diplomat does not change to a big enough extent.

• Similarly as an honest bidder, the Diplomat will be misled by the auctioneer.

• The likelihood of these results being due to chance cannot be discounted. More games are needed before conclusions can be stated firmly.

Additionally, of the 9 games that the more honest Diplomat won, 8 of these came as Turkey, whilst the dishonest Diplomats collectively won 49 of 68 games with Turkey. This is consistent with findings so far, that the strategic advantage of Turkey is enough to overcome poor performance in negotiation.

Overall, the more honest Diplomat won 9 of 77 games, indicating similar performance to the dishonest Diplomats. Meanwhile, it was eliminated in 28.7% (22 of 77) games, as opposed to 34.9% of games, and had 344 units left at the end of the games against an average of 349.

In the second trial, the honesty for 6 of the 7 Diplomats was set to 1, and the honesty for the final Diplomat (the less honest Diplomat) allowed to vary between 0.5 and 1. The results are shown in table 7.12. In all, 71 games were played. At first glance, there appears to a be a spike at honesty 0.6. The less

17157 eliminations, but, spread over 6 Diplomats
Table 7.12: Varyingly Honest Diplomat; Environment of Honest Diplomats

honest Diplomat appeared to enjoy much more success with this degree of honesty than any other. A deeper analysis reveals this is mostly due to chance. Of the 15 games in which the less honest Diplomat had honesty 0.6, 6 of these were played as Turkey. It managed to convert all of these to wins.

Overall, the less honest Diplomat won 11 of 71 games. It was eliminated in 32.3% of games (23 of 71), compared to an average of 36.8% (157 eliminations over 71 games, summed over 6 Diplomats). Additionally, the less honest Diplomat had a sum of 348 units at the end of games, compared to an average of 317 for the honest Diplomats. The last result seems to indicate that whilst the less honest Diplomat may not have managed to win more games than expected, or indeed, avoid elimination more often, it did, have larger forces at the end of games; 4.90 units per game (348 over 71) against 4.47 units per game.

In general, across all of the varied honesty results, we see an indifference towards which honesty value a sole Diplomat uses. This contrasts with the experience of deceptive against naively honest Diplomats in the previous section. There, it appeared that the deceptive Diplomats did considerably better (table 7.10). The indifference found here shows the effectiveness of maintaining a reliability for other Diplomats. It is a mechanism that will stop a Diplomat from being continually taken advantage of.

Table 7.13 details how many wins each power managed to achieve. These are summed over both the more honest, and less honest results, making 148 games in total. The addition of reliability leads to a reversal in Germany’s fortunes. When the deceptive Diplomat was playing against naively honest Diplomats (7.10), it enjoyed the ability, as Germany, to make and break a number of agreements without any ensuing consequences. This time, France, which enjoys a better strategic position, enjoys better prospects. The rest of the results are largely unchanged.

7.4 Balancing Negotiation

Negotiation within Diplomacy is, as described in subsection 2.1.5, a balance to the better strategic positions of particular powers within the game. An analysis of the Diplomat’s play indicates that this is not the case.

The polarisation of wins obtained by powers increases with the addition of negotiation, and further still with the addition of with lying. This runs contrary to expectations; which viewed negotiation as a balancer, introducing random effects and subtle minutiae that enable more powers to win. Figure 7.4,
<table>
<thead>
<tr>
<th>Power</th>
<th>Wins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>4.7%</td>
</tr>
<tr>
<td>England</td>
<td>0%</td>
</tr>
<tr>
<td>France</td>
<td>8.8%</td>
</tr>
<tr>
<td>Germany</td>
<td>7.4%</td>
</tr>
<tr>
<td>Italy</td>
<td>1.4%</td>
</tr>
<tr>
<td>Russia</td>
<td>0.7%</td>
</tr>
<tr>
<td>Turkey</td>
<td>79.1%</td>
</tr>
</tbody>
</table>

Table 7.13: Deceitful Diplomats: percentage win by power

presents a graph, showing this effect. Note that the results used for it were obtained from tables 7.3, 7.10, and 7.13.

It is likely that this polarisation of effectiveness is a result of the ‘power begets power’ philosophy of the Diplomats resulting from self-absorbedness (Diplomat A doesn’t care if Diplomat B is about to win, so long as it (A), gets more powerful), and preference for powerful debtors (IOU Valuation, which includes the ‘power’ of the other Diplomat as a multiplier).

A trial was conducted to see whether this trend could be reversed. In the trial, the IOU valuation scheme was altered, so whereas before it was multiplied by the Diplomat’s ‘power’, now it is divided. In other words, the value of an IOU was made inversely proportional to the ‘power’ of the Diplomat, so, Diplomats would prefer to make agreements with weak, rather than strong Diplomats. Size. The trial is in every other way, exactly the same as that used when determining an optimal level of deceitfulness for Diplomats. Results are shown in table 7.14.

The results from the trials, involving 87 games, show that, Turkey’s dominance is somewhat lessened, winning 73.6% as opposed to 79.1% of games. This is a step in the direction of achieving a balancing, but is not as significant a change as might have been expected. There are several reasons for this:

- The Diplomat’s power is scaled logarithmically by Diplomats, so, the new way that IOU valuation is factored in makes little difference for many agreements.

- Turkey, even when played by the non-negotiating Diplomat, in a field of six negotiating Diplomats managed to win 63% of games, to push Turkey below this limit, other powers would have to actively mislead Turkey, or conspire against it. This can be seen as a limitation of the implementation of Diplomats described.

7.5 Summary

The findings produce a number of key results, which show that the Diplomat has captured many important properties of Diplomacy. In particular:

- Strategically and tactically the Diplomat is slightly less effective than Dumbbot. The powers with which it prefers to play are related to Diplo-
Figure 7.8: Polarisation of Effectiveness

<table>
<thead>
<tr>
<th>Power</th>
<th>Wins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>0%</td>
</tr>
<tr>
<td>England</td>
<td>0%</td>
</tr>
<tr>
<td>France</td>
<td>12.6%</td>
</tr>
<tr>
<td>Germany</td>
<td>10.3%</td>
</tr>
<tr>
<td>Italy</td>
<td>3.4%</td>
</tr>
<tr>
<td>Russia</td>
<td>0.7%</td>
</tr>
<tr>
<td>Turkey</td>
<td>79.1%</td>
</tr>
</tbody>
</table>

Table 7.14: Reversed IOU Valuation Diplomats: percentage win by power
macy’s adjacency graph, in exactly the way that Calhamer suggested (figure 2.3).

- Negotiation makes the Diplomat more effective. Negotiating Diplomats outperform non-negotiating Diplomats in key areas, such as, winning the game, having more units, and being eliminated less often. On average, powers will make about 10-30 agreements per game. The number of agreements made varies greatly due to strategic position and longevity in the game, so negotiation effects different powers to different extents.

- Lying makes the Diplomat even more effective. In particular, Germany is surrounded by other Diplomats. Lying enables it to buy time, and so, given this faculty, it performs much better.

Another facet of Diplomacy, is that it is balanced. Any power can win, since strategic advantages are often eliminated by the increased negotiation potential of powers in the centre of the game. However, the negotiation the Diplomat’s exhibit only served to widen the gap between the powerful and less powerful players. An attempt to rectify this showed that the Diplomats can be modified to enact slightly more normal behaviour, but, the fundamental strategic position of power remains the dominant factor in success as far as this Diplomat is concerned.
Chapter 8

Conclusions

In this chapter, the contributions that this report has made, ideas for further work, and some concluding remarks are presented.

8.1 Contributions

The objective of this project was to provide a treatment of the major aspects of Diplomacy. In particular:

- The Diplomat should be able to create good orders, from a strategic and tactical point of view.
- The Diplomat should be able to negotiate with other players. A strategy should be employed, such that Diplomats benefit by negotiation.
- The Diplomat should be able to make a reasoned choice as to whether to stick to agreements or not.

In the process of fulfilling these objectives, many of the major problems in creating a Diplomat, have been identified. While there are undoubtedly many other approaches; the behaviour of the Diplomat is validated by the behaviour of Diplomacy players, demonstrating that the Diplomat is a useful tool for understanding and analysing the game.

Strategy and tactics are examined in chapter 4. An approach, employing several ideas from previous work [8], but also many novel ones, is presented. The effectiveness of the Diplomat against other AIs indicate that there are merits to the approach.

A novel mechanism for Diplomatic negotiation, through auctions, is presented (chapter 5). In trials, it was conclusively shown that negotiating Diplomats were more effective than non-negotiating Diplomats. Additionally, several interesting patterns of negotiation were identified, and related to the game.

The Diplomat implements a novel treatment of deceit (chapter 6), which tackles fundamental questions; 1. What prompts a Diplomat to keep or break agreements? 2. How does the Diplomat react to agreements being broken by
other players? In trials, deceitful Diplomats are shown to play Diplomacy more effectively. Additionally, patterns in deceit were identified, and related to the game.

### 8.2 Further Work

The potential for further work on this project is immense. Some ideas are outlined below:

**Further Trials**

- Examination on the effect, or correlation, of negotiation with the length of the game. Do agreements fly back and forth, extending the game?
- Investigation of the behaviour of groups of Diplomat’s with differing reliabilities. In particular, do honest Diplomats ‘stick with’ other honest Diplomats? Essentially, this is a trial to see whether the individual strategies of Diplomat’s could demonstrate an overall emergent group behaviour.
- Evaluation of the Diplomat’s choice of moves against standard opening moves. How do the Diplomat’s strategic and tactical choices measure to the optimal?

**Strategy and Tactics**

- Attempt further to refine target provinces. This would involve trying to understand the processes that human Diplomacy players use to determine valuable acquisitions.
- Further work on position prediction to help the Diplomat better predict the position resulting from a plan. This may involve using a history of their moves to attempt to develop a model of the other player, and thus predict their moves in future.
- More sensitive static evaluation, so that more plans can be differentiated. This could be achieved by identifying more factors in a Diplomacy players valuation of a position.
- Strategic evaluation functions to help a Diplomat decide who, not just where to attack. In order to achieve this, a Diplomat needs some way to appreciate the game board in a holistic way.

**Negotiation**

- Experiment with increasing the size of the negotiation space by allowing the Diplomats to auction other agreements. An interesting aspect would be to try and auction much more abstract agreements, such as peace or alliance.

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1Diplomats with the ability to lie.
• Improve the ‘IOU’ valuation scheme; so, elements such as, how many agreements have been made between these parties before, have an impact. This may lead to behaviour analagous to that of alliances. Again, this is a test to see whether the Diplomats might demonstrate emergent group behaviour.

• Extend the negotiation mechanism to an argumentation based ACL approach. The market based approach was primarily chosen as it is easily implementable. Many problems were identified which would need to be overcome in order to achieve a Diplomacy like negotiation. Several of these problems are very interesting.

Deceit

• Allow Diplomats to maintain different levels of honesty towards different Diplomats (perhaps drawing upon strategic evaluation functions to help determine these). This may lead to informal groupings of co-operative Diplomats being established.

• Allow a Diplomat to become more or less honest, depending upon the game situation, for instance, being honest towards a more powerful Diplomat, and less honest to a less powerful Diplomat.

8.3 Concluding Remarks

Creating a Diplomat requires a number of decisions to be made, each of which present an immense number of ways of doing things, which inevitably themselves lead to more decisions. There are very few right or wrong answers, making this project very much like working on a blank canvas. It is hoped that this work has provided an insight into Diplomacy and Diplomats, and will make the challenge of creating Diplomats in future, somewhat less daunting.
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Appendix A

Miscellaneous

A.1 Israeli Agent Architecture Components

The agent architecture is presented in figure 2.4. A description of the various components follows:

Prime Minister: Directs the Diplomat’s activities. It is the only module that has personality traits such as aggressiveness and willingness to take chances. The personality traits allow the Diplomat to change personality from one game to another, making it difficult for other players to estimate its intentions.

Secretary: Keeps and maintains the Diplomats knowledge base, consistent with the information the Diplomat receives. It contains:

- The rules of Diplomacy, and information about the game board.
- The game state.
- A history of the messages exchanged between the Diplomat and other players.
- A history of agreements made, and information such as the Diplomat’s intention (keep or break) when it made the agreement.
- Information regarding other players, and their relations.

Ministry of Defense: Responsible for planning and analysis, it is influenced by the Prime Ministers personality traits. The Ministry of Defense directs the behaviour of other agents in the system, in particular; The Foreign Office, HQ and Intelligence. When analysing the game state, the Ministry of Defense considers each possible front in turn, searching for potential partners in negotiation, and possible strategies to employ. The evaluation of strategies leads to preferences in terms of partners for negotiation. A Desk at the Foreign Office is established, and is responsible for each negotiation with each partner. The Ministry of Defense provides the Desk with a strategy that forms the basis for negotiation. It also helps the Foreign Office evaluate different suggestions received from the other players.
**Foreign Office:** This module directs the communications of Diplomat with the other players. During negotiation, Desks within the foreign office analyse messages and evaluate suggestions received from other players, as well as themselves making suggestions. Desks also decide whether or not to sign agreements.

**Military HQ:** This module decides upon the Diplomats orders at the end of each turn. It queries the Diplomats KB regarding current agreements, to determine its allies and enemies. It also collects the promises that it made and intended to keep as well the promises other players made to the Diplomat that it estimates will be kept. Military HQ then asks the Strategies Finder to provide it with strategies that fit the set of allies and enemies, bearing in mind promised activities. Military HQ chooses the 'best' strategy from amongst these with regards to the Diplomats personality.

**Intelligence:** Estimates both the relationship between players and their individual characters. The estimation is primarily based on an analysis of the players orders at the end of every season. The Diplomat may also receive messages concerning other players characters and behaviour, or the relationships between players. Intelligence decides whether or not the messages are to be believed. It’s conclusions are reported to the Prime Minister.

**Strategies Finder:** Takes a set of allies, a set of enemies and a configuration of the board as an input. Based on this input it finds plausible strategies and evaluates them. The Ministry of Defense, HQ and Intelligence use this module. They can restrict the generation of strategies by providing the SF with portions of strategies already agreed upon, areas of special interest, and various parameters such as ‘willingness to take chances’.

In addition to these modules, the Israeli diplomat contains a number of local agents. A type of local agent was developed for any task the Diplomat performed. The types are as follows:

**Head of Defense:** Creates fronts in the Ministry of Defense at the start of each turn, and allocates the Diplomats units amongst them.

**Front:** Takes friends and enemies as parameters. It maintains move sequences, for its own, and allied units, and their minimum, maximum, and expected utilities.

**Desk:** A desk receives the best strategy from the corresponding front. It represents relationships, and is responsible for negotiating.

**Write-Orders:** Plans and announces the Diplomats moves at the end of each turn.

**Analyse-Moves:** Part of intelligence. Analyses the moves that were made by other powers at the end of each season and reports its conclusions to the Prime Minister.
**Analyse-Messages:** Part of intelligence. Analyzes declarative messages received from other players, and reports its conclusions to the Prime Minister.

**Retreats-Builds:** Writes the Diplomats retreats, builds, or disbands wherever appropriate.

**Analyse-Builds-Retreats:** Analyses the builds, retreats and disbands of other powers.
Appendix B

Example Game

In order to demonstrate the capabilities and limitations of the Diplomat, a few opening moves and commentary are provided. For brevity, in the game below, the agreements and moves of only France are considered. Note that the initial board position is presented in figure B.1, and subsequent figures illustrate France’s progress on alternate turns.

The following notation is used:

- A(X) denotes the army that started the turn in the province X. Similarly, F(X) denotes the fleet that started the turn in the province X.
- A(X) - Y is the order that moves A(X) to province Y (similarly F(X) - Y).
- A(X) s A(Y) - Z is the order that tells A(X) to support\(^1\) A(Y)’s move to province Z.
- (Bounce) is a suffix describing that a move failed as another unit, possibly belonging to another Diplomat, attempted to move to the same province, or currently occupies it.
- (Cut) is a suffix referring to a support order, and indicates that the support was not provided, as, the supporting unit was attacked.
- B(A(X)) is the order to build a new army at the province X (similarly B(F(X)) to build a new fleet at X).
- H(A(X)) is the order to hold the army at province X (similarly H(F(X)).
- (NC)/(EC)/(SC)/(WC) are suffixes denoting the north, east, south and west coasts of the preceding provinces respectively (so SPA(SC) refers to the south coast of Spain).

**Turn 1**

**Moves**

\[
A(\text{PAR}) \rightarrow \text{BUR (Bounce)}
\]

\(^1\)The strategies and rules to Diplomacy are summarised in section 2.1
A (MAR) - SPA
F (BRE) - ECH (Bounce)

Analysis
All moves are sensible. France has moved to an additional supply centre. No agreements are yet possible, as the units of various powers are too far apart.

Turn 2

Moves
H (A (SPA))
A (PAR) - BUR (Bounce)
F (BRE) - ECH (Bounce)
B (F (MAR))

Analysis
The Diplomat has played sensibly, capturing a new supply centre, and maintaining its attempt to move to the English Channel. Additionally, the choice
and location of the build was wise. Again, no agreements are yet possible.

**Turn 3**

**Moves**

- A (PAR) → BUR
- F’ (BRE) → ECH (Bounce)
- F’ (MAR) → SPA (SC)
- A (SPA) → POR
Analysis

The Diplomat’s moves are sensible, except, the value of the move to Spain’s south coast is not clear (a move to the Gulf of Lyon would probably be preferable). Again, no agreements were possible.

Turn 4

Negotiations

Bid for Austrian unit at Tyrolia rejected.

Moves

A (BUR) - MUN
H (A (POR))
F (SPA) (SC) - GOL
F (BRE) - ECH (Bounce)
B (A (PAR))
B (A (MAR))

Analysis

The Diplomat’s moves and choice of builds are generally sensible, with the exception of the army in Portugal, which should be employed more usefully. Attempting to get help from the Austrian unit in Tyrolia was also a good idea, since, it would have helped the Diplomat to gain control of Munich.

Turn 5

Negotiations

Austria-Hungary made for the unit at Munich, rejected.
Analysis

The offer from Austria-Hungary was rejected, as France can see a ‘good’ use for this unit, which it values more than Austria’s IOU. It intended to capture Kiel, which, in fact was not such a good move as it would make France’s forces fragmented, and whilst gaining a supply centre, might also lead to one being lost. The Diplomat’s move from Marseille to Burgandy was sensible, since, it’s units have now formed a ‘wall’ to the North, a good formation, and one
that threatens Germany’s supply centres. In general, the rest of the Diplomat’s move were sensible, particularly the move of the French fleet to the Tyrrhenian Sea- where it threatens three unoccupied supply centres. This is an example of where ‘maximising’ influence identifies good moves.

**Turn 6**

**Moves**

A(BUR) s A(PIC) – BEL (Bounce)
A(MUN) – BER
F(TYS) – NAP
A(PIC) – BEL
F(BRE) – MAO (Bounce)
A(SPA) – MAR

![Figure B.7: Turn 6](image)

**Analysis**

The Diplomat’s has chosen a, generally, sensible set of moves, particularly with the capture of Belgium. The support occurred because the Diplomat will value plans which include supported moves above those which do not. Question marks over the move to Berlin however, since, the French unit there has become isolated. Meanwhile, the French fleet in Brest’s attempt to move to the Mid-Atlantic Ocean stopped, for a turn, England being able to move there. This was a good move, since, if England were to move there, it would be able to capture Spain or Portugal. It was motivated by the Diplomat’s urge to retain provinces it deems as valuable.

**Turn 7**

**Negotiation**

Bid for English fleet in the North Sea. Rejected.
Bid for English fleet in Kiel. Rejected.
Bid for German unit at Holland. Rejected.
Bid for German fleet at Denmark. Accepted.

Moves
A(BUR) s A(PAR) - PIC
A(PAR) - PIC
A(BEL) - HOL (Bounce)
A(BER) - KIE
F(BRE) - MAO (Bounce)
A(MAR) - GAS
F(NAP) - ROM (Bounce)

Figure B.8: Turn 7

Analysis
The Diplomat’s negotiated in order to gain support in the North. It persevered, and finally obtained support from the German unit in Holland. This was a good choice of agreement to make, since, it enables France to dislodge the English unit there, in so doing, regaining cohesion amongst its units, and capturing another supply centre. However, a move made by another French unit also attacked Holland, nullifying the effect of the support of the unit. This demonstrates a lack of appreciation for the consequences of supporting. Additionally, there are question marks over the armies in Paris and Burgandy, which could be move usefully employed moving eastwards. As a strategic direction, Northwards offers few possibilities, but the Diplomat is unable to see that. The rest of the moves of the Diplomat are sensible.