Where Do You Want To Go On Holiday?

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Abstract

This paper is about the problem of planning a holiday. We argue that the problem requires different kinds of knowledge for successful solution, and that it often requires previous experience to be taken into account. The domain, we suggest, has the property of sparseness: that is, any realistic agent will have significant gaps in background knowledge and experience, a property that is of considerable interest within Case-Based Reasoning. We then briefly discuss a Case-Based Reasoning program called HOLS that will plan holidays on request. We then argue that holiday planning is often a group activity and discuss concepts from social psychology that are relevant to group problem solving. Following this discussion, we outline a variety of experimental arrangements in which a number of independent Case-Based holiday planning agents cooperate to plan a holiday which is acceptable to all.

1 Introduction

"Where do you want to go on holiday?" may seem a trivial question. Where they are going on holiday, what they will do, and how much it will cost are very important problems to many millions of people. A travel and tourism industry has grown up to cater for their needs, and there are peak-time television programmes devoted to the subject. Planning a holiday is something that most of us have done, but have probably given little thought to it as a whole, nor to what we do when planning one. Indeed, the idea of thinking about planning a holiday seems in some ways absurdly simple: one decides where to go, decides how much to pay, and does it. As will become clear, the process is not quite as simple as it seems at first: the domain is rich and the problem complex, particularly if the planning task is undertaken by a group of people.

In this paper, we will examine some aspects of the holiday planning domain as a preliminary exercise before building a computational model of the process (we have named the program HOLS). The approach we will adopt for the computational models is *Case-Based Reasoning* (CBR) [19, 17, 8, 10, 12]. As will be seen, experience enters the planning process in a variety of ways: CBR is based upon the idea of making use of previous experience in order to solve a problem. We will try to show that holiday planning is an interesting and open-ended problem, and that a number of factors are used in determining what sort of holiday to have. This will lead to an outline description of a CBR system that will plan holidays.

Next, we will consider the fact that holidays are often planned as a group activity. Family holidays are often jointly planned by spouses, perhaps with input from children. Groups of friends can also plan collective holidays. By introducing the concept of a group planning exercise, we will be able to expand upon the approach outlined earlier and introduce new aspects as well as seeing how the concept of group planning raises important issues in multi-agent systems. We hope to use the HOLS program as a basis for new experiments in multi-agent systems and Distributed Artificial Intelligence: the aim of this work is to replace the CASSANDRA architecture [4, 5] with something more flexible and richer in behaviour (see [6] for a discussion of some possible extensions).

Aknowledgements

The idea that holiday planning might be an interesting domain was originally suggested by my wife Margaret. She helped me determine the factors involved in planning a holiday, as well as helping to determine the various categories of holiday (adventure, cruise, etc.) and collecting a list of places where people actually go on holiday. The name 'HOLS' is also due to her. For her idea and her help and encouragement, I thank her. The rest, as they say, is my fault.

2 The Holiday Domain

In this section, we examine the problem of planning a holiday. In the next subsection, we consider some of the factors involved. Then, we consider the domain as a whole and suggest the basic kinds of knowledge needed before one can begin planning a holiday. The necessary knowledge is neither technical nor esoteric: it is of a kind we all possess and which is easily obtained from a variety of sources. Next, we argue that previous experience is important in choosing where to go, what to spend and what to do.

2.1 Factors involved in choosing a holiday

The holiday planning domain is surprisingly rich. Not only are there many locations on offer these days, but the range of activities is also broad. Different kinds of holiday appeal to different people: some people like to lie on a beach all day, others like to visit museums and places of historical interest, others like active holidays like walking or sailing. Different geographical locations can offer similar holidays; different locations may offer different standard of comfort—a single location may offer a broad range of holiday types, standards of comfort, and so on. Of course, some holidays are more expensive than others: in part this is determined by location, in part by facilities. Some holidays are intrinsically more expensive than others.

Out of curiosity, we recently looked at the advertisements in a travel agent's window. Most of the holidays being advertised looked very similar: beach resorts in Spain, Italy, Greece and Cyprus. These holidays also cost about the same (about £150), but length of holiday varied between five and ten nights for about the same cost. Next to these offerings were two posters advertising cruises. One was around the African coast, and the other was a Mediterranean cruise. Both cruises had the same duration (two weeks), and roughly the same cost (about £600). The cost of cruises is higher than beach resort holidays because capital and running costs are intrinsically higher for cruise liners.

Different people want different things from a holiday. Some people have definite preferences; others don't much care as long as the location satisfies some demand (typically that it be hot and sunny). Different groups of people impose different constraints on their holiday plans. The elderly are less likely to opt for an adventure holiday than the young. The young are probably more likely to choose a holiday in a place with good night-life than other groups. Sailing enthusiasts may choose to go sailing; golfers might want to tour golf courses in a country or region (and such holidays are on offer as packages); fishermen often take fishing holidays. Touring by car may appeal to some, but, for others, touring by bus is preferable. Comfort is another factor. Some people like to live rough on holiday, so might prefer a camping holiday with only the bare necessities; other people like to stay in the most comfortable hotels possible and have all their needs attended to by others.

Climate and holiday type also interact. It is not, in general, possible to take a skiing holiday in the Northern Hemisphere's summer unless one is prepared to travel to the South. France, Italy and Switzerland are the immediate choices for skiing holidays in winter, not Greece or Tunisia. Equally, if one wants a holiday lounging on a beach, northern regions (e.g., Iceland) may not be suitable—the best bet is to head south.

Travel time is a further factor. Holidays that involve long air flights may be unacceptable. Locations that are distant may be impossible for people with only limited free time (two weeks on the Queensland coast might seem ideal, but the time taken to get there severely reduces the time actually spent on the coast). There are people who are unable to fly in an aircraft for one reason or another: this imposes restrictions on where they can go on holiday—particularly if there is no alternative form of transport that will get them to their chosen destination in a reasonable time.

The cost of a desired holiday may be prohibitive: what one can afford determines range of holidays that one can take[1]. Some people will save for a number of years

[1] My wife firmly believes that cost is a fundamentally determining factor: this belief appears

• Cost	How much will the holiday cost?
• Duration	How long will the holiday be?
• Travel time	How long will it take to get there?
• Location	Where shall we go?
• Activities	What do we want to do on holiday?
• Facilities	What is there at the destination?
• Accommodation	What sort of accomondation do we want? (E.g., self-catering, half-board, full-board)
• Standard of comfort	
• Climate	What sort of weather do we want?
• Time of year	When are we going?
• Holiday type	What sort of holiday? (E.g., adventure holiday, package holiday, cruise)
• Political situation	E.g., is there a civil war?
• Medical care	Do we need insurance?
• Special precautions	E.g., do we need vacinations?
• Previous experience	

Table 1: Factors in planning a holiday (unordered).

in order to take a dream holiday; others will take at least one holiday every year. In the latter case, what they can afford at any one time will determine the range of possible holidays.

A number of the factors that determine the kind of holiday that one might choose are shown in Table 1. The table is necessarily incomplete: there are probably as many factors as there are people, but it contains most of the common ones. Table 1 mentions the *previous experience* factor: we will discuss this in some detail below. In Table 2, we list a number of holiday types: again, these are the relatively common ones.

2.2 Domain knowledge

Planning a holiday depends upon a variety of different kinds of knowledge. One has to know what sort of holiday to plan for. One also needs to know a little about geography (or at least relate names of places to climate, etc., so that expectations can be formed). For some holidays, it is useful to know about the political situation (it would not be wise to plan a holiday on the Dalmatian coast at the moment, nor would it be advisable for a westerner to go to Iran), the culture (museum tours presuppose museums), the situation with respect to medical care (it might turn out to be expensive to take a climbing holiday in the USA without extensive medical

broadly to be supported by evidence.

- Touring

    own transporation

    not own transportation (organized tour)

- Camping
- Hiking
- Caravanning
- Adventure

    mixed activity

    sailing

    water skiing

    climbing

    caving

- Package holiday
- Holiday camp
- Cruise
- Safari

Table 2: Some common holiday types

insurance), the prevailing conditions at various times of year, and how to get to the destination. If the type of holiday being planned is a tour, it is necessary to know something about the various places that will be visited. Economic conditions may also play a part: if the destination suffers from hyperinflation, there won't be much money to spend during the holiday; if services are expensive, the cost of the holiday will be higher.

Most of the information needed to plan a holiday is readily available. Not everyone will investigate all aspects of a proposed holiday, of course, and may even rely upon the reports of others. The information that is required can be obtained from a travel agent, from newspaper and television reports, and even from an atlas. The knowledge required to plan a holiday is available to everyone, and its interpretation rests upon commonsense notions.

The domain is open-ended in a number of ways. For people planning real holidays, there are new places becoming available each year, and new specialist holidays are being offered all the time. Furthermore, it is always possible to invent (within reason) the kind of holiday that will suit. For computer modelling, the domain is also open-ended. The range of geographical information that can be employed; the range of holiday types, the factors used to create holiday plans, and the variety of other information used by the model can be varied to a great extent. As will be seen below, the range of experience available to a model can be varied. We will expand on these points in the next section.

2.3 Experience

A factor that we have ignored until now is *experience*. Experience is an important factor in determining how we behave next. In the holiday domain, a successful holiday of a given type in a given location may tend to reinforce a preference for that kind of holiday. The are many people who return to the same place each year; many more take the same kind of holiday each year, perhaps not in the same place, but in similar ones.

Consider the 'horror stories' one hears about, for example, holidays in the Spanish coastal resorts—hotels still under construction, swimming pools filled with mud, unacceptable levels of catering, and so on. One can hear comments like:

> "We went to X this year, but it rained, so we won't go there again"

or:

> " We went to Y three years ago and the weather was wonderful, so we're thinking of going there again this year".

Reports of the experiences of others also play a part in helping one decide what to do and where to go—we will return to this point below.

Previous experience does not wholly determine where to go on holiday. After a mildly disasterous holiday at a particular location, one might decide to try the same place again hoping to do better. Conversely, after a particularly spectacular holiday, one might choose to go elsewhere on the grounds that it would not be as good a second time. Having spent a number of years happily going to the same place and doing similar things, one might decide to go elsewhere for a change or because what had previously been the norm is now boring.

The point we are making is that previous experience is useful in deciding on a holiday. If someone has taken a holiday and found that it was not to their taste, that fact will be remembered and used in deciding what to do in the future. Previous experience of types of holiday, as well as location, and previous outcomes also play a part (e.g., "We went camping in July—never again!"). It is not only the type and location that is important. Aspects of a holiday may be important in the future. Consider the remark:

> "We went to I last year, but the food wasn't very good. We liked the place, so we're going again, but it will be self-catering this year".

This exemplifies the point that there are often good and bad points to any holiday, and they may determine future choices. Consider the case of someone who goes to Rome, develops a liking for antiquities, and decides the following year to visit Crete. Variation is, of course, endless. Previous experience seems to determine which holidays one will choose in the future.

3 Holiday Planning as a CBR Task

3.1 Holiday planning and CBR

We have now explained enought of the holiday planning domain to be able to consider it in relation to CBR. The main assumption of CBR is that problem-solving activities are *memory based*. CBR, in other words, assumes that previous experience is an important factor in explaining and engaging in problem-solving. In the last section, we argued that planning a holiday depends upon a number of factors—some of which are rooted in commonsense and geographical knowledge. One important factor is previous experience, and we argued that previous experience can contribute to the planning process in a variety of ways (including 'changing one's mind'). In this section, we will be concerned with the CBR issues that the holiday planning domain raises.

Unlike a number of previous case-based planners, for example CHEF [9, 8], the holiday domain may not have goals strictly ordered in a fixed priority scheme. At any one time, it is plausible that someone planning a holiday will have relative priorities, but, as we argued in the last section, the relative priorities may change for a variety of reasons. If the holiday planning problem is conceived across time (i.e., as taking place over a number of years, and involving the production of plans for a number of holidays), goals may come and go *as well as* change priority. For example, what is affordable this year might be too expensive next year. In this respect, holiday planning is more like the problems tackled by CASEY [12] or HYPO [1, 18].

It is, of course, possible to view the planning problem in the context of a holiday planning advisor: in this case, the system would have to elicit goal importance from the client in order to create a plan. At present, though, we are more concerned with the *general* problem of planning a holiday, and are, therefore, interested in changes to goals, desires, etc.. Furthermore, in the next section, we will discuss the problem of group holiday planning: group planning involves the reconciliation of goals, so we feel justified in making the assertion at the start of this paragraph.

The holiday planning domain is rich in information and, as we pointed out in the last section, is essentially open-ended. This allows considerable latitude in the way we construct a model of the problem, but it also poses a problem. The holiday planning domain is, in a sense, *sparse*. This fact can be seen when previous experience is taken into account: none of us has ever taken all the holidays that are now possible. This has the consequence that we may not be in a position to decide on a particular holiday from our own experience: instead, we have to consider related holidays or else rely upon reports from others or *a priori* considerations. Because of our lack of enough detailed, direct, experience, we may have to rely upon other information or else try to visualize what such a holiday might be like.

For example, someone might want to go to Guatemala. Unfortunately, in Guatemala, there are many, varied and annoying (sometimes lethal) parasites which attack humans. Upon learning this, the traveller might decide against Central America and choose somewhere else[2].

The sparseness issue can be a problem when the holiday is somewhat out of the ordinary, for reports from other people may be had for many locations (once again, we will return to this issue below).

Because of this limited experience, retrieval failure may be complete in some cases. In other cases, too, because there are so many factors in determining the next holiday to take, retrieval failure may occur. What one wants this year may be different from what one wanted last year. With experience, it becomes easier to retrieve a related holiday—i.e., to be reminded of a previous holiday—and this is the essence of CBR. However, the indices which are used in encoding and retrieval are numerous. The discussion in sections 2.1 and 2.3 is aimed at showing that there are many different ways of indexing a holiday. It might be indexed by place, climate, holiday type, cost, and so on. If one's experience is great enough—if one has had enough holidays—it seems plausible that the desiderata for this year's holiday will remind one of a previous holiday along *some* dimension. But, as we argued in section 2.3, what one might be looking now for may not be obvious at the time it was experienced (i.e., the person who decided to go to Crete as a result of a stay in Rome may not have indexed the Roman holiday as a visit to a place of great antiquity). This is the classic CBR indexing problem.

The indexing problem is complicated by the fact that goals can change in importance (as pointed out above): this problem has been tackled by Koton [12] and by Ashley and Rissland [1, 18]. In both cases, index selection had to be performed in a dynamic fashion (which contrasts with the static indexing used by CHEF or MEDIATOR [11])

There is more to planning a holiday than simply remembering previous ones, of course. It is relatively unlikely that a previous holiday will be exactly what one wants now. Previous holidays have to be used as a basis for new plans. This is a plan modification problem similar to that exemplified by CHEF [9, 8]. The holiday domain cannot rely upon a simple plan modification process: CHEF used a relatively simple plan modification process that added and modified plan steps until its plan critics were satisfied. In the holiday domain, the modification process is constrained by factors such as cost, travel time, and so on. Furthermore, the modification process may be driven by explanations of previous failures or sucesses.

[2] We were informed of these problems with Guatemala by a fried whose son lives there. Before this conversation, we had been unaware of the problems of living in Guatemala.

That is, a previous holiday's usefulness to planning a new holiday is dependent its success or failure. As we noted above, factors other than the immediate ones used in indexing may be important in explaining previous success or failure. This point seems to indicate that planning is guided by both evaluation and explanation of previous experience.

3.2 A CBR program for holiday planning (an outline)

In this subsection, we want to mention a few points about the implementation of a CBR program that plans holidays. As has been hinted above, the problem is more akin to constraint satisfaction than planning as the term is conventionally understood: the parameters that define what one wants effectively constrain the holiday that one actually gets. However, we will ignore this aspect of the problem here, and will, instead, consider some practical issues.

The first issue that needs to be addressed is the amount of information and knowledge required by the domain. As we noted in the last section, the domain is open-ended in a variety of senses. This has a number of advantages because it enables an implementer to choose what is to be included in any version of the program. Initially, one can start with a relatively limited repertoire of holidays in the case-base. The representation for the stored holidays can be simplified: for example, outcomes can be ignored, and geographical information severely restricted. The case-base and representations can be extended gradually, either by coding (i.e., programming) or learning. As new holidays are planned, they can be indexed in memory—this is a kind of rote learning, thus contributing to the repertoire of holidays in memory.

What the program does can also be altered in an incremental fashion. At the very minimum, cases must be retrieved from memory and adjusted to fit current needs. In the minimum configuration, the program (which we might call McHOLS) would behave in a fashion similar to MEDIATOR [11] using previously stored cases, together with user input, to develop new holidays. The McHOLS version could be an interactive holiday adviser in style.

As the repertoire of holidays increases, it becomes possible to increment the program's functionality. It could still retain its advisor character. One important feature that could be added is that of analysing the outcomes of planned holidays. Such an addition would require the development of explanation facilities so that the program can explain failures to itself. The output of the explanation process could then provide a means for indexing new holiday plans and for reindexing old ones (cf. [15, 16]). This version would work as follows. The program creates a holiday plan which is then evaluated by the experimenter[3]. The results of the evaluation are then presented to the program: it must then determine what caused the outcome given the response—this is an explanation process. The results of explanation can be used, as in CHEF, to index the report on the holiday. The indexed report can be used in

[3] An alternative would be to have a panel of people evaluate the holiday and suggest outcomes.

later episodes to generate new holiday plans. The scheme for introducing feedback into the program is important: it would not otherwise be possible to simulate every aspect of every holiday planned by the program[4]. The input to this version could also be subjected to an explanation process: here, the role of explanation is to find reasons for anomalous user requests (this is similar to the motivation for XPs in Schank's theory of explanation [20, 21, 13, 14]). The role of XPs in this case can be augmented to assist in prediction during indexing, as well as in finding meta-MOPs.

Considering HOLS at this stage as an advisor program is important. The version we have just described cannot originate constraints that define the next holiday. That is, it is unable to *decide* what it wants for the next holiday it will create. This ability is a next step: we will discuss it in the next section.

4 HOLS In A Multi-Agent Environment

Most people do not plan their holidays on their own. It is perhaps more common for the final decision to be made as a group decision. Partners discuss joint plans for holidays; children may have to be taken into account; a group of friends may decide to go on holiday together. In this section, we look at this extension of the HOLS program.

4.1 Group decision making

All of the factors we discussed in the last section still are still important when we move to a group context. More, however, is added. In particular, it is no longer possible to consider the holiday planning program as acting merely as an advisor. Instead, the advisor has to be extended to cope with a *social* situation: it must be able to discusss its holiday ideas with other agents in order to reach an agreement. To do this, the planner must have ideas about its[5] own requirements and preferences, and must be able to recognize when another planner's proposal agrees or disagrees with its wants. The planner must also know how to communicate with other planners, how to propose suitable variations on previous proposals, how to make proposals itself.

The proposal and negotiation processes take place in the context of a community of agents, each of which has its own idea of what it wants for a holiday. The aim of the negotiation process is to find a holiday that is suited to all parties. Additional constraints are imposed by the nature of those other parties and by their preferences (for example, one would probably not take a toddler on a sailing holiday if the weather were expected to be bad or the boat too small—one might even have second thoughts about the idea if the holiday were to be on a large boat).

[4] One of the reasons that this domain appeared attractive to us was that we could not hope to simulate it in any real detail.

[5] We use 'its' because we are also thinking about the HOLS *program*.

What this entails is that concepts from social psychology[7] need to be introduced. In particular, the ideas of *self* and *other* need to be introduced. The self is represented by a schema [2]. The self schema represents a planner and its goals, intentions, and its role in various social contexts. In order to originate plans, each planner must be in a position to know what it wants, but it also needs to know what will be acceptable or possible within the group as a whole. This entails that each planner must also have a model of the other members of the group: that is, it must have schemata for the others. When proposing a plan, the planner must examine the schemata it possesses for the other group members and determine possible reactions, perhaps even possible counter-proposals (this idea is reminiscent of 'counter planning' in Carbonnell's POLITICS program [3]). The process of comparing a proposed plan with information derived from the various schemata describing the other agents in the group can lead to a variety of conclusions:

- The plan is cleared as being probably acceptable to the others.
- The plan is modified so as to avoid potentially contentious aspects.
- The plan is rejected (and possibly a new one proposed).

Without knowledge of the others in the group, a planner will blindly propose only plans that it finds suitable. In a social context, such behaviour will only rarely, if ever, lead to a plan that is suitable to all. Furthermore, exploitation of what one knows about another person allows one to form *expectations* about the kinds of things they like, they ways in which they respond to suggestions, and so on. This forms a context within which to plan holidays (as well as doing other things).

The exploitation of such information makes it more likely that a proposed plan will be accepted. However, information about other group members must not be used to the exclusion of the desires (etc.) of the self. It must be *taken into account*, but not used as a strict framework. If the planner is a member of a large group, the constraints imposed by other group members may be so many that the planner's own aims are swamped. The planner's aims should have higher priority than those of the others unless there is some good reason for reducing their importance (for example, in the case of planning a holiday involving small children or elderly relatives).

A second aspect of the social situation can have benefits for the planner. One way of arguing about holidays (indeed, about many issues) is to cite cases and their outcomes. We mentioned the comparative sparseness of the holiday domain above and said that no-one has ever experienced all possible holidays. In a social setting, however, it is possible to extend the range of available holidays. In other words, the social setting provides each planner with an increased collection of cases with which to work. Of course, the cases that are provided by other group members will not be as detailed (or vivid) as those remembered by the planner itself, but it can still make good use of them.

A short while ago, we heard some people discussing a holiday plan. The conversation ran something like this:

> A: We're thinking of going to C. We've not been there before and we thought it sounded good.
>
> B: We went there three years ago in July. The weather was awful and there wasn't anything to do.
>
> A: I thought you'd enjoyed it.
>
> B: We were glad to come home.

The conversation continued with a discussion of the failed holiday in C. A more detailed explanation was provided by B, and, at the end, A said something like "Well, we won't go there then."

During the discussion, A acquired enough information about C to decide that it was not a suitable place for a holiday. Perhaps some of B's comments needed internal explanation by A; others will have been fairly straightforward. There are two important lessons to be learned from this example:

1. The information provided by one person can assist another in making a decision.
2. The information that is imparted by one party to the other will be remembered and can, if recalled, be used in later reasoning.

In addition, it must be pointed out that the reasons B gave A for not wanting to return to C must be such that they are 'good enough' to dissuade A from going there. If B had said:

> "We went there three years ago with Uncle Fred. On the second day, Uncle Fred broke his leg when he was climbing a cliff. We had a miserable time"

it would be quite reasonable for A to dismiss B's dislike of the holiday (A could argue that it was Uncle Fred's fault for climbing up cliffs at an age when he should have known better).

What the example shows is that information provided by someone else can be incorporated into the decision-making process. This extends the range of cases that can be taken into account. It does so, however, at the expense of more work on the part of the planner. The planner has to determine why some factors are more important to the other person than others, and must also provide explanations about unusual or incomplete aspects of the case being discussed. In the context of a group activity, such interaction seems important (this is based on our previous experiences in group problem solving).

There is more to the problem than simply exchanging information and explaining it relative to various schemata and criteria. The roles the various planners take are also important. For example, a while ago, a friend wanted to go to Northern France to look at properties (at that time, he wanted to buy a house in France). We discussed the project, but at all times it was clear that our friend was the leader. We were planning to go by car, and he was going to take his. This fact, together with the goal of looking at properties, made his desires more important than ours. In another setting, if there is a considerable difference in the amount that group members can afford, the final decision may be based upon how much the poorest member can spend. At different times, with different proposals on the table, the dominance hierarchy of the group may change—different proposals may be more in accordance with the wishes or capabilities of some than of others.

We view the group planning exercise as a negotiation process (negociation has formed the basis of a number of CBR systems; for example, [22]), and can also be considered as a species of adversarial reasoning, particularly if debate is heated. Proposals are made, modified and rejected according to various criteria. Modification and rejection are based upon criticism and presentation of counter-cases. When a criticism is made, it must be compared with the current proposal and explained. Sometimes a criticism will be good, sometimes it will not be so good. Counter-cases must be similarly evaluated, as must counter-proposals. Each member of the group may evaluate a criticism, counter-case or counter-proposal in different ways based upon its experience and also upon the facts and properties that it considers most important. During this process, the schemata describing the other group members will be updated, as will memory—new information is being supplied all the time.

4.2 Configurations for HOLS

In the last subsection, we briefly examined the main issues raised by extending the holiday planning problem from a single agent (planner) to a group. In this subsection, we consider a number of experimental arrangements for HOLS in a multi-agent context. Our aim is to show that a variety of configurations is possible and that different aspects of the group problem-solving process can be studied.

The initial configuration (the simplest) is to have two agents. Their task is either to plan a holiday that is mutually acceptable, or else to disagree (and, hence, not go on holiday together). The schemata possessed by the two agents can be configured in a variety of ways. Initially, one might want them to have roughly the same aims and to have relatively complete knowledge of each other (this can be thought of as a situation in which spouses or old friends plan a holiday). Later, greater differences can be introduced in order to study the negotiation process in more detail. In a similar fashion, the background knowledge possessed by each agent can be varied. There may be cases in which both agents remember as direct experience; there may be wide variation in experience, so that discussions about previous holidays can be produced as a result of proposals.

More agents can be introduced into the system. Again, schemata and background knowledge can be varied. The introduction of more agents makes the roles played by individual agents more important. It also brings in the concept of n-way conversations, as well as making the constraint satisfaction problem more acute. In addition, a multi-agent system affords more opportunities for learning and explanation of the kind discussed in the last subsection. A further twist is that knowledge and memory can be partitioned in different ways.

In this setting, it becomes possible to introduce and remove agents. When an agent is removed, the others will still retain memory structures that relate to the former group member. These memory structures can be used in future planning sessions—it is not lost. The schema for the former member may also be retained by each agent: this will allow reasoning by analogy from what was known of the former member. Agents can be introduced in a number of ways. One way (the way that seems the hardest to model) is to provide very little information about the new agent: the other agents have to try to form schemata on the basis of interactions with the new one. The information in this case might amount only to an identifier or a description of an association (for example, "Emily's boyfriend"); it might be a little more detailed (for example, "Emily's boyfriend who's a botanist"). At the other end of the spectrum, highly detailed information might be provided—for example, it is possible to introduce an agent which has a memory that overlaps with one of the others (in the HOLS context, this amounts to the fact that they have either planned or have taken at least one holiday together in the past).

After a holiday has been agreed—and it might only be agreed by a subset of the agents—it can be taken. As we have no intention of simulating holidays, this becomes a matter of supplying each agent with a collection of experiences. These experiences may be widely different for each agent, or they may roughly be similar (identical experiences are, though, unrealistic for the reason that no two people ever experience *exactly* the same thing). This feedback corresponds to the feedback we proposed in the last section for the single agent version of HOLS: it plays exactly the same role in the multi-agent context as it did in the case of the solitary planner. By providing the agents with experiences while on holiday, it becomes possible for them to evaluate the holiday and to use their experiences as a basis for future plans.

5 Conclusions

This paper has been about the use of CBR in the development of a holiday planning program to be called HOLS. Although holiday planning does not seem a particularly spectacular problem in terms of difficulty, it does require the application of different kinds of knowledge and is also memory-based in the sense that previous experience is used in deciding what to do next—there is more to the problem than one would initially believe. Holiday planning can be considered to be based as much on constraint satisfaction as planning proper: this increases the interestingness of the problem from a technical stance. The knowledge employed in planning a holiday is of an everyday, non-technical kind: this has the pleasant consequence that there are no problems in acquiring the right knowledge—we are all potentially expert in the domain. Furthermore, holidays form an important part of many people's lives, and planning a successful holiday is clearly important to them.

We have outlined some of the important factors in planning a holiday and have also outlined some of the background knowledge that is needed to perform the task. We noted that holiday planning can be a domain that is relatively sparse in the sense that previous experience may be lacking. Furthermore, the indexing problem in this domain is acute: this is because there are many different ways to index a holiday in memory. We then gave the broad outline of a program to plan holidays. We suggested that the program could be configured in different ways, and that the problem has the pleasant property that the amount of knowledge and range of experience available to the program could be varied quite considerably.

We next considered holiday planning as a group activity. We noted that holidays are often planned by more than one person, and that the needs or wants of others in a group played an important role in determining which plans are proposed. We argued that the extension to group problem-solving brought benefits in terms of the expanded range of experience that can be drawn upon, but that this expansion comes at the cost of more work on the part of the participating agents. We also argued that concepts from social psychology play an essential role in a multi-agent planning system.

Finally, we sketched ways in which a community of holiday-planning agents could be arranged. We briefly considered various experimental arrangements, each of which depends upon a different distribution or provision of knowledge and experience.

We wanted to consider holiday planning as a group activity for reasons other than realism:

1. Group processes and social interaction are, we believe, important in understanding cognition. The holiday planning task seems ideally suited to this, as should be clear.

2. The multi-agent HOLS program is an initial exercise in the revision of our CASSANDRA architecture [4, 5].

In [6], we argued that the original definition of the CASSANDRA architecture was severely limited, and that additional facilities were necessary to make it as flexible as we orginally intended. In that paper, we cited extensions such as introspection, knowledge of organization and the inclusion of a declarative database in the system. The proposals were based on concepts in rule-based systems.

More recently, we have come to see that the needs for communication between agents are more extensive than the simple inclusion of a communications interface. In [4], we proposed using speech acts [23] as a basis for communication: many of the proposals in [6] derived from a more detailed examination of what was needed to support communications based on the speech act theory. At the same time, we have come to believe that effective acts of communication can only be performed when agents have knowledge of the agents with which they communicate. Paradoxically, such a requirement entails that they have knowledge of themselves. As part of this knowledge, previous experience is important. The HOLS programs are an initial attempt to build systems with this knowledge and which uses previous experience as an integral part of their operation.

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