Generation of Dilemma-based Interactive Narratives with a Changeable Story Goal

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ABSTRACT
This paper describes the Generator of Adaptive Dilemma-based Interactive Narratives (GADIN) system. This system automatically generates interactive narratives which are focused on dilemmas in order to create dramatic tension. The user interacts with the system by making decisions on relevant dilemmas and by freely choosing their own actions. In this paper we introduce the version of GADIN which is able to create a finite story. The narrative finishes – in a manner which is satisfying to the user – when a dynamically determined story goal is achieved. Satisfaction of this goal may involve the user acting in a way which changes the dispositions of other characters. If the user actions cause the goal to become impossible or unlikely then they cause the story goal to be re-selected, thus meaning that the user is able to fundamentally change the overall narrative while still experiencing a coherent narrative and clear ending. This method has been applied within the children's story domain of a dinosaur adventure but is applicable in any domain which makes use of clichéd storylines. The story designer is required only to provide genre-specific storyworld knowledge and dilemmas.

Categories and Subject Descriptors
I.2.1 Applications and Expert Systems
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General Terms
Performance, Design, Human Factors

Keywords
Interactive narrative; games; story

1. INTRODUCTION
In recent years computer games from most genres have included a progressive story line to increase the immersive experience of the user and their enjoyment of the game. However, such stories are often linear (i.e. non-branching), and in almost all cases pre-defined, which reduces the replay value of these games. Research into interactive narrative generation (or interactive drama) tries to overcome these weaknesses. Most interactive narrative systems (prominent examples include [3], [5], [6], [7], [9], [10], [11], [12], [14], [15], [17], [18], [19]) do not provide a story which is completely original on every play and that also responds to the user's actions both immediately and in the overall structure of the narrative.

At the end of a story, the audience should come away feeling that the story has ended – they will experience a sense of closure. This is not always strictly the case, *The Italian Job* being possibly the most famous example of a film with an 'open ending'. If such stories are well created, the audience will still leave with a sense of closure. Generally, they will impose their own ending which they imagine to be what will happen next. This may change as they consider the film in greater depth. In such cases, the audience may leave with a greater sense of closure, since the ending will be much more satisfying for them personally. A sense of closure can be otherwise described as a 'clear ending' to a story.

There are two extremes in plan-based interactive narrative research thus far. In one the stories are plan-based with a fixed overall story goal ([9], [18], [19]). In another the stories are plan-based with no overall story goal, and thus an infinite story is generated [2]. The system described in [12] involves more than one possible goal, but all are pre-defined. Should the user and other autonomous characters act in a certain manner then the system will choose a new ending to plan for. However in this there are only a very limited number of story goals. In addition the narratives produced are not designed to provide a high level of dramatic interest as they are intended for use in training rather than storytelling.

In this paper, we propose a system that generates interactive narratives which are both finite and original on each play. The story is influenced by the user and to some extent by non-determinism. To add dramatic tension, the story incorporates dilemmas as decision points for the user. These dilemmas are based on the clichés found in many domains, such as the trade-off between personal gain and loyalty to a friend. To ensure a clear ending to the narrative a story goal is selected (and the user is made aware of it) and in its achievement a coherent plotline is dynamically created, based on the user's response and action choices. These can cause the story goal to be re-selected, thus meaning that the user is able to fundamentally change the overall

narrative while still experiencing a coherent narrative and clear ending. Other characters will directly respond to the user's actions in an appropriate manner consistent with their individual disposition, thus ensuring a short-term effect of the user's actions within the experience.

Our goal is to keep the story designer's input to a minimum and the user involvement as high as possible. In the proposed system, the story designer provides the story background in the form of character information and other knowledge that relates to the world in which the story is to be created (for example a prehistoric forest). The system then instantiates all generic knowledge on story actions and dilemmas and thus creates the narrative in collaboration with the user's actions and dilemma decisions.

This paper is structured as follows. First related work is surveyed, then a general overview of the system is given, followed by a description of the story background representation and dilemmas. We proceed with a discussion of the story generation process and how a clear ending and dramatic interest are ensured in the narrative. There is then an introduction to the specific implementation of the system in a prehistoric children's story. The paper finishes with conclusions and future directions.

2. RELATED WORK

There is increasingly a tendency for interactive narrative systems to employ planning techniques. Those systems which do not do so tend to have more limited scalability, transferability and originality of story on subsequent experiences. In this section other interactive narrative systems, in particular those which use planning techniques, are considered and the shortcomings of their techniques are discussed.

Many of the systems which do not use planning have a plot graph structure. This means that only a fixed limited number of narratives will be possible. These include the Oz Project [3], the Virtual Theater Project [14], and in a more generalised sense also IDA [10] and Façade [11]. Other interactive narrative systems (such as [6], [15] and [17]) utilise rule-based systems. These impose a series of rules to determine which actions can take place at a given stage. This results in the potential for repetitions and looping within the story, with the originality being limited by the generality of the rule base.

Mimesis [19] uses planning to achieve the story goals. This is much longer-term planning and is less flexible around the user's interactions - which will either be accommodated in re-planning or intervened with. In the I-Storytelling [4] system, hierarchical task network (HTN) planning is used. Each character is equipped with an HTN to follow in the story, which is defined before the story begins. There is very little allowance for user interactions in this system. In neither system is there any allowance for the story to be dynamically created, but only for it to be dynamically adjusted.

More recent systems use planning techniques to create stories in collaboration with a user. In [18] the planner is used to create each stage of a planning graph. The user is then able to choose from the subsequent options to decide which will appear in the final version of the story. The story presentation will be a mimesis-style experience. Points for re-planning and intervention by the system are specified by the user at the story creation stage, whereever a need is identified by the system. The shortcomings of Mimesis apply here also.

The system described in [9] involves goal events which are planned for. The user is able to specify some of these events and to prompt re-planning for any. They may be ignored. The user must then select the final ordering of events - given any constraints. The resulting story is then graphically produced without any interaction, and at a much lower level than that at which the user aided in the story creation.

Fairclough's system [7] utilises planning techniques to dynamically create an interactive story in the fairy tale genre. There are a finite number of subplots and the user's actions determine which is experienced. A plan is then created for the subplot, which consists of a "sequence of character actions" given to the characters (other than the user) as goals. The user has a high level of freedom but they are not entirely flexible as they must adhere to a limited number of pre-defined subplots.

Interactive narrative systems such as those discussed in [9], [18] and [19] involve planning for a story goal in order to achieve a clear ending of the narrative. However this story goal is pre-defined and fixed. As a result the user's actions are not having an effect on the long-term outcome of the narrative. The system discussed in [12] involves more flexibility in the final outcome of the narrative depending on the user's action choices. However there are still only a limited number of pre-defined possible endings to the narrative.

Previous work has used planning and the GADIN system in the creation of infinite stories. In this planning takes place in order to reach points of dramatic interest within the overall narrative. This means that the overall narrative is entirely dependent on the manner in which the user acts, but there is no ending.

3. THE GADIN SYSTEM

3.1 System Overview

Figure 1 shows an overview of the GADIN architecture. The interactive drama knowledge base consists of: the storyworld (which contains information regarding the characters); story actions; and dilemmas which can occur in the storyworld. This information is partially genre dependent and provided by the story designer, with the remainder being hard coded. The knowledge base components are drawn upon in the generation of a narrative through planning. The user is able to interact with the narrative generator, and their actions affect the story experienced.

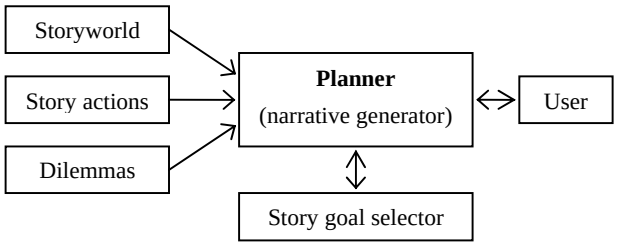

Figure 1: An overview of the GADIN architecture

3.2 Storyworld

The storyworld consists of: characters; locations at which the characters can be; and objects. These characters have various associated traits, as detailed here.

• Each character's associated attributes can include information such as attractiveness and gender. Examples of characteristics are generosity and morality. A range of values is associated with each attribute and characteristic.

• Characters have storyworld relationships with one another, including friendship and love. Relationships are unidirectional and have an associated strength, although feelings of one character for another affect the reciprocity.

• The characters hold storyworld principles, such as not stealing, which make their behaviour more believable. Under specified pressures and circumstances, principles can be broken (or their associated strength of belief reduced).

The characters also have a disposition which is defined along each of a number of dimensions. Each character has an individually associated value for each disposition dimension. These will change throughout the story depending on how the user acts towards that character.

A character's traits and disposition affect which actions and dilemmas they can participate in and also, ideally, the user's opinion of that character. Each character should act in a manner which is consistent with their traits and how they have acted previously, while at the same time avoiding predictability.

A series of genre-specific locations are required by the storyworld. At any given time in the story, each character is at one of these locations. Direct interactions between characters can only take place if they are at the same location.

Where appropriate for the domain there will also be objects within the system. Objects can be obtained by characters, after which they will belong to that character and will always be at the same location as them. Various things can be done with and to each object. Objects also have associated reasons why characters would want possession of it, depending on that character's individual traits and disposition.

3.3 Actions

Those actions which can take place within the storyworld must be specified for each domain. Every possible action should be included and although these vary between domains there remains a significant overlap. These can include characters becoming friends and moving between locations.

Each action has associated conditions which must be satisfied before execution (preconditions) and effects representing changes to the storyworld following execution. For example, the action of a character moving between locations l and k has preconditions of the character being at location l and the existence of a path between locations l and k. The effects of this action are that the character is at location k and is not at location l. This follows the STRIPS representation.

Before an action is made available to the system for use within a storyline an applicability check is carried out. An action can only be utilised if its applicability is high enough. This ensures that the action is of the type that the acting character is likely to make, depending on that character's individual traits and disposition. For example, a very moral character will never encourage another character to steal. This applicability check is supplementary to the preconditions of an action.

3.3.1 User actions

Every action that other characters within the system can take is available to the user who is able to freely specify their own actions within the scope of the current genre. Additional options available to the user include being able to see information on their current location or on other characters. They will also see a description of this, which should make the world seem more real to the user.

Throughout the narrative the user will always be completely free to act however they require.

3.3.2 Dispositions

As discussed in section 3.2, each character has an associated disposition defined along one of a number of dimensions. These dispositions determine how the characters act – both in what actions they can take and in the manner in which they carry these out. This makes characters more interesting, appealing and believable.

Before the story begins, each character is non-deterministically assigned a value for each disposition dimension. It is possible for the user to act in a way which causes changes to the dispositions of characters, and thus how that character will act in the following stages of the narrative.

Throughout the story characters will choose to take actions which are consistent with their disposition. For example, a charming character may consistently tell others they look nice and give them objects, or a grumpy character may moan about the weather and not play with other characters.

To a large extent character dispositions can become clear through the manner in which they act. For example, in order to become friends with the user an artistic character may draw them a picture, whereas a bolder character may ask the user to play.

In order to reflect a character's disposition to as great an extent as possible adverbs are associated with each disposition dimension, such as 'languidly' or 'nervously'. These can then be presented in the output as a descriptor for actions when and where it is appropriate. For example rather than the action description being "Joe comes to the forest", this will become "Joe comes to the forest languidly". This gives the user a clear impression of the character's disposition and a range of possible adverbs reflecting the same disposition add more interest to this. The user's future actions towards a character may well be determined by the manner in which that character has carried out their actions, for example if an angry "Joe incredibly agressively asks you to play" it is unlikely that the user will respond positively, unless they are intimidated.

The adverb selected as an action descriptor will be randomly chosen from those associated with the greatest absolute value disposition dimension. Modifying adverbs can be used if these dispositions are more or less extreme. This gives the user a clearer image of the changes they are causing to character dispositions

than attempting to choose an adverb which reflects the full disposition of that character.

The user can change these dispositions through their actions towards other characters, for example playing with a shy character will make them more outgoing, and these changes will be clear in the changed adverbs describing character actions as well as in the future action choices of the involved character. This will give the user a great sense of their actions having an effect in and on the storyworld and its characters.

3.4 Dilemmas

Field [8] states that "drama is conflict", that the dramatic interest in a story centralises on its conflicts. In genres which make use of clichéd storylines these are usually found to be essentially conflicts (or dilemmas). Writers utilise these dilemmas in the creation of stories. A general form of each such clichéd dilemma can be determined, and a computerised storywriter can create an interactive drama around these. Dilemmas require characters to make fundamentally difficult decisions within the course of the story.

Following a decision on a dilemma there will be consequences, or outcomes, for involved characters. These outcomes may be good or bad and are defined quantitatively. The outcomes are known as the payoffs of the dilemma. The numerical values – which reflect how positive or negative the outcome is – associated with the outcomes are referred to as utilities for the involved characters.

Our experience showed that when more than two characters were involved in a dilemma it was either expandable to multiple two character dilemmas, or the characters receiving payoffs naturally divided into two groups with the same resultant utility. Therefore a decision on a dilemma involves only two recipients of utility payoffs. Five such dilemma categories were identified. These consist of all situations with two payoff recipients where there is a dilemma involved. This may require characters to be friends or enemies. The relevant categories are: Betrayal, Sacrifice, Greater Good, Take Down and Favour. Further details are given on each dilemma type in the following subsections.

3.4.1 Betrayal

When presented with a Betrayal dilemma a character must decide whether or not to take an action which would result in their best possible utility but simultaneously the worst possible outcome for their friend (or someone close to them). The decision would not involve a dilemma were the two characters not friends. A character having the option to be unfaithful to their partner is an example of the Betrayal dilemma.

3.4.2 Sacrifice

A character facing the Sacrifice dilemma is able to choose an action which will result in their worst possible utility but also the best outcome for their friend. These characters must be friends for this to be a dilemma. An example of the Sacrifice dilemma occurs when a character has committed a crime which their friend has been accused of and has the opportunity to admit to their crime and thus accept the punishment rather than allowing their friend to take the blame.

3.4.3 Greater Good

Involvement in a Greater Good dilemma means that a character is able to take an action which will result in their best possible utility but also the best outcome for their enemy. This would not be a dilemma if the characters were not enemies. An instance of the Greater Good dilemma involves a character deciding whether to give something (such as information or a friend) to their enemy in order to save themself.

3.4.4 Take Down

In the Take Down dilemma a character has the option of an action which will result in their worst possible utility but also the worst outcome for their enemy. The characters must be enemies for the dilemma to exist. A character deciding whether to harm their enemy in full awareness that they will be punished for this is involved in the Take Down dilemma.

3.4.5 Favour

The favour dilemma sees a character X able to choose between two actions where there will not be any immediate discernible benefit to X as a result of their decision. The utilities of characters Y and Z will change as a result of this action choice. If X chooses to take the action the outcome will be the best possible for Y and Z will receive their lowest utility – and vice versa if X chooses not to take this action. An instance of this dilemma occurs when a character must choose between potential partners.

As can be seen, the Betrayal and Sacrifice dilemmas are the inverse of one another, as are the Greater Good and Take Down dilemmas. This means that any dilemma which falls into one of these categories can be inverted to become a dilemma of the other category. All five categories are kept to increase ease of dilemma identification within specific genres. From these categories dilemma instances can be found and generalised for each domain. From the generalised form of the dilemma the system will be able to create new dilemmas. In the presentation of these wholly original stories are created.

It will not be possible to create great literature in this way – the use of clichéd storylines prevents this. However, such stories are enjoyed by many people and this method is common in such genres as James Bond films, soap operas (soaps) and "chick flicks". The story is built around the cliché, and it is the cliché as well as the story which the audience appreciate, the very repetitiveness and familiarity of the dilemmas adding to the dramatic interest.

4. PLOT CREATION

4.1 Story ending

At the end of a story, the audience should come away feeling that the story has ended – they will experience a sense of closure, which can be otherwise described as a 'clear ending' to a story. The GADIN system has previously been applied to the creation of interactive soaps [2]. The infinite nature of soaps means that an ending will never be required. However in order to apply GADIN to other domains it is necessary for the narrative to end in a in a manner which is clear, satisfactory and understandable for the user. This section discusses how that ending is chosen and how it is re-selected should its achievement become unlikely.

Before the story begins GADIN selects a story goal. This is a condition which must be true for the narrative to end, and which when it becomes true the narrative will be complete. This is selected randomly from everything which is not true in the initial state of the storyworld, but which could be true within the current domain. For example, if the user is initially in the desert the story goal could require that they be in the cave. It could also be something more complex, such as that they must steal a certain object, or become friends with a particular character.

A character's disposition can affect the achievement of a story goal. By acting in the correct manner the user can change that character's disposition and thus the goal can be achieved. This is not a fixed condition and will not hold every time this goal is selected, as it depends on the non-deterministic character disposition. It is made clear to the user what the problem with the disposition is. For example, if it is necessary that the user become friends with a particular character, that character could be grumpy and thus refuse the user's overtures of friendship in a particularly grumpy manner. If the user changes that character's disposition (for example by giving them a gift) their later overtures of friendship will be accepted and thus the story goal will be achieved. The potential combination of dispositions with the story goal increases the scope of possibility and interest of narratives produced by GADIN.

Should it become unlikely that a story goal will be achieved (the conditions for which are discussed in section 4.2), due to the user's previous actions, then a new story goal will be selected. As with the initial story goal this is selected randomly from every predicate which could be true within the current domain. However it is also necessary to consider the record of every predicate which has been true in the history of this narrative. It is required that the goal has never been true, or the storyline would become illogical to the user as it would appear that it could have ended at an earlier stage. The ability to dynamically select a new story goal gives the user a clear effect of their actions on the long-term path of the story. It also increases the originality of storylines produced and thus the re-playability.

Once a new story goal has been selected the old story goals will still be maintained as possible endings for the story. As soon as any one of the story goals is satisfied the narrative will complete. This is necessary as the user may still discover some way to achieve these goals, it is just unlikely that this will happen. For example, the user may become friends with someone they were previously betrayed by.

For the ending of the story to be clear to the user it is necessary that they know that they have achieved the story goal and that this is why the story is ending. This requires that the user knows the story goal from the outset. This is accordance with Aaron Shephard's [16] requirement that there must be a problem that the main character needs to solve within a story. If another character is at the same location as the user then they will hint at the story goal to the user, for example telling them that "Going to the cave is good" if the story goal is that the user is at the cave. If there is no character at the user's current location then a character moves there in order to communicate the goal. If possible this will be a character who the user is friends with. It should be clear to the user that this goal is a possible way to end the story and not a mission which it is essential that they achieve.

The user knows what the ending of the narrative is, or could be, and can thus either act to achieve that ending or choose not to. This could be deliberate or accidental. For instance if it is required as the story goal that the user steal an object they could choose not to do so when presented with the opportunity. If the user chooses to avoid achievement of any of the story goals then the narrative will still continue ad infinitum, with presentation of dilemmas and character actions. That is the user's choice and this should still be a dramatically interesting experience. The ending(s) will still be possible throughout this should they become true. In order to achieve this techniques used in [2] to ensure the infinite creation of soap-style stories are applied.

The creation of a plot with more than one story goal does not mean that the resultant narrative is poorly structured. This is consistent with the manner in which stories often develop in non-interactive stories, where it appears that one ending will take place before this changes and another ending emerges and either (or a later emerging possibility) may become the final reality. In order to ensure that the narrative remains coherent and believable characters act consistently throughout, with the action applicability check ensuring this.

4.2 Story Generation

4.2.1 Achieving the story goal

It is the task of the story generation component to achieve the story goal. Given actions (including those for the user) and dilemmas (separately for each possible outcome, with corresponding preconditions and effects) within the storyworld the system can plan to satisfy this goal. Such a plan guides the plot of the narrative. The plan to achieve the story goal will take into account the current storyworld state and background knowledge.

The applicability check used in the planner assumes that the user will act in a manner consistent with the way characters with similar traits act in non-interactive stories in the current genre. Once a plan has been found its actions are presented until the preconditions of an action cannot be satisfied without the user's participation. If the user acts in a manner which satisfies the necessary preconditions at this stage then the presentation of the plan continues until a user action is required again. As soon as the story goal is satisfied the ending is presented to the user and the story is complete.

If achievement of a story plan is not possible given the character dispositions then by default the planner will return failure and a new story goal must be selected. In order to ensure that this does not happen, and that story goals which require the dispositions of characters to change will be included, when planning for story goals the action applicability check allows the values of each character disposition to be between ±1 of the actual value. This is because a single user action can cause at most such a change to a character's disposition value along a particular dimension. For example if the selected goal is that a grumpy character likes the user it is a prerequisite of story goal achievement that the user change this grumpiness. However the standard applicability check in the planner would prevent this from being achieved. Flexibility in the applicability check when planning allows for this change where it is appropriate.

4.2.2 Incorporating user interactions

It must be ensured that the user is as free as possible while still experiencing a dramatically interesting narrative with a clear ending. In its current version the system is control-based. This means that the user selects actions until they choose to pass control back to the system, which then acts until a user action is required. When the user has control they can take any number of actions. The user can spend as long as they want considering their options.

The user will not always act in a manner which satisfies the preconditions of the next stage of the plan. In order to make it more likely that the current story goal will be achieved an attempt is made to coerce the user into acting as required. For example, if it is necessary that the user be at location k a friend can move to ask the user to go with them to location k. In this the user is still completely free to refuse.

The system is able to provide direct responses to user actions through a system based on tit for tat reactions and utility scores. This involves a numerical utility value being assigned to each character in all story states. Actions change this value due to an author-defined (and potentially character dependent) corresponding change to the affected character's score. When the user acts in a way which affects the score of another character, that character responds by acting to change the user's score by the same amount.

An example would occur when a character is not friends with the user, and thus has an associated negative score in that state. If the user asks that character to become their friend then the character's score is resultantly increased. In response the character will act in a way which increases the user's score by the same amount. For example, they could play with the user, or perhaps give the user an object.

The use of utility values means that extension to additional actions requires only the association of a value with each. This method also makes system responses less predictable and more versatile. The responses update the state and thus effect the future path of the story - both immediately and in the longer term. These are an immediate effect of the user's actions and result in a story more specific to the particular user. This method is likely to encourage the user to act more, as they see an immediate effect of their actions, and to increase the believability of the characters.

4.2.3 Changing story plan and story goal

The story plan must be checked following each user action to ensure that the current story goal is still achievable. For this a list of required state elements following every level in the plan is maintained. If the user actions cause a predicate in the storyworld to contradict a predicate which is required to be in the state at the current or the next level (where the story plan is followed) then the plan is assumed to have been violated. If this has happened then a new story plan must be found, whether this be for an already existing or a new goal. The system first attempts to find new plans for all existing goals and only if no such plan is possible will a new goal be selected.

The story plan will also be assumed to have failed if the user does not cooperate with the actions required of them therein. This will occur if there is a predicate which the user must act to satisfy at the current or the next level but they do not do so. The re-planning in this case will not be immediate – as the user may later act in the required manner – but instead will take place after 3 other character actions or a dilemma have occurred within the storyworld. An example of this occurs if the user does not move to the location where the next action is required to take place – even though (if appropriate) they will have been coerced into doing so.

In attempting to re-plan for the same story goal actions which the user is required to initiate will be excluded from consideration, so that should a plan be found it is more likely to be adhered to. As a result there will be less wasted production of story plans with which in all likelihood the user will never cooperate. This does not mean that there is no user involvement in the plan, for example a character asking the user to become their friend will still be included. If this limitation results in the planner not being able to find a valid story goal and plan combination then GADIN will once again consider such actions in the planning process.

As the narrative reaches the later stages (i.e. after failure of the first story goal) a search depth limit is imposed on story plans, the effect of which is that only shorter action sequences will be considered and thus that an ending will be more likely to be reached without continual need for newly defined goals. This is because if the story plan is too long then it is likely to become unrealistic in that the user will be unlikely to make all of the action choices which the planner expects of them. In addition it will take too long to plan and re-plan for new story goals if no search depth limit is imposed, resulting in the user experiencing waiting times. If no plan is possible within the search depth limit then a new goal is selected.

As the user may require time to consider their actions, planning takes place while the user thinks. A thread continuously updates a global planning graph. When required, this is used to find a new plan for the current story goal, a previously attempted story goal or a new story goal. This means that the re-planning will be much faster. Although there is some risk of unreliability in the planning graph due to it not being fully up to date this risk is minimised by the reduced planning depth and by the continuous nature of this updating of the planning graph.

4.3 Dramatic Interest

Any narrative requires dramatic interest to maintain the experiencer's involvement. The methods used to ensure dramatic interest in the finite narratives created by GADIN are discussed in this section.

The use of dilemmas and requiring the user to make decisions on these provides dramatic tension within the narrative. Following the plan for the story goal means that every dilemma has a purpose within this and that there is structure to the story.

With certain story goals a dilemma will not be necessary prior to achievement. It is possible to constrain the planner so that only plans with dilemmas are accepted but these dilemmas are unlikely to pose sufficient conflict – and thus dramatic interest – for the user given that they are aware of the goal of the story. Thus in order to ensure that the experience is dramatically interesting it is advantageous to also present dilemmas to the user which are supplementary to this plan. This will have the added advantages of maintaining the user's interest and ensuring that the narrative

does not become predictable. The system will not cause the story goal to be satisfied until the user has experienced a dilemma which is not directly related to that story goal.

When not directed by the story plan, or in response to the user's action or dilemma decision, characters are able to act freely when given the opportunity. Characters act randomly in accordance with their disposition and traits, which is ensured through use of the applicability check in selecting actions. As a result of this characters act more frequently than they would be able to if they only acted when directed by the story plan. This means that there is more opportunity for the user to become aware of the characters' dispositions and traits and thus that they will develop stronger feelings for and greater attachments to these characters. This will result in the story becoming more dramatically interesting and the dilemmas more conflicting. It is important to ensure before selection that the effects of these actions do not negate anything in the story plan state at the current or next level.

Although it would be possible to plan for dilemmas which are supplementary to the story plan this is not done. This increases efficiency and reduces time spent planning. It reduces time spent attempting to follow plans which later fail, and the associated coercions and expectations of the user. Instead these dilemmas are only presented when they become possible through the actions of characters and the system. This is the case when all of the preconditions of the dilemma are satisfied within the current state of the storyworld. If more than one dilemma is possible at a given time then that selected for presentation must depend on what has happened previously to become part of a consistent story, and also on the appropriate frequency of use for each dilemma.

When presented with a dilemma the potential consequences of each decision must be clear to the user before they make their choice. Once they have chosen, these repercussions on the storyworld are implemented. The resultant state is thus entirely dependent on the user's decision.

At the start of the story there will be various character actions and interactions, and at least one dilemma, before the plan begins to be followed. This ensures that there is dramatic interest and enables the user to build up familiarity with the characters and their dispositions before they become part of the story plan (and its dilemmas) so that these will be more conflicting.

The user is free to act however they want, even if this means achievement of the story goal before a dilemma has been presented. In a circumstance involving such a trivial goal – should it be the first story goal selected – a restriction is added to the dispositions of the other characters which ensures that one must be changed (by the user) for achievement. This creates dramatic interest in the overall narrative even with trivial goals.

The user may try to avoid experiencing dilemmas. In this experience, as in life, however much the user tries to avoid dilemmas there will always be another. The adaptive nature of this story creation method means that there will always be dilemmas which can and will be experienced by the user. In some cases no user actions are required to lead to their experiencing a dilemma.

The nature of the dilemmas is such that at least one other character will have either benefited or suffered as a result of the user's decision. It is subsequently appropriate for these characters to respond to the user's decision in some way (providing they are aware of the decision). This will be done in a utility-based fashion. The corresponding changes in utility are defined for each dilemma, and characters will respond to the user in a way related to their disposition and this utility change. This is similar to the characters' response to user actions and ensures that dilemma decisions have an immediate action effect on the storyworld and thus the narrative.

5. DINOSAUR STORY

It is possible to apply the techniques discussed here – for the creation of a finite interactive narrative with a changeable story goal – to a children's story domain. The specific example discussed here involves a prehistoric world, in which the characters other than the user are dinosaurs.

The nature of the dilemmas requires that the system maintain a representation of character's likings for one another, and in particular those to and from the user. However as the target audience of this storyworld is children it was decided that these should not be explicit statements. So rather than a character saying that they no longer like another they will express this in another way, perhaps by chasing the other character. Internally this will be represented as no longer liking and the future dilemmas and actions will reflect this.

As this is a text-based system descriptions are required to make the storyworld more real to the user, particularly in a domain such as a prehistoric world which will be unfamiliar to them. Whenever the user moves to a new location they are presented with a description of that location. When required, the system will also provide the user with a description of the storyworld characters, the dinosaurs.

In the dinosaur adventure the user begins by being transported to a prehistoric world. When they achieve a story goal they are taken back to their original world. Although this is an inevitable and predictable beginning and ending they are not important, nor do they play any part in the story. This is simply a device which takes the user into the storyworld. The sense of inevitability, that they will always get home at the end, is common in children's literature and will be necessary to provide them with a happy ending. This is not an essential requirement for the plot to be created as discussed in section 4.

In order to make the world simpler, the user only sees other characters' actions which take place at the user's current location. They will never see the full state of the storyworld, for example information on characters' locations, object ownership and feelings between other characters. This is assumed to be private as it is modelled as the user's feelings are. The actions of other characters will involve the user as frequently as is possible. This ensures that the focus is continually on the protagonist of the story, the user, which is as required for children's stories.

All background knowledge specific to the considered domain was added to the system, including STRIPS-style actions (such as characters becoming friends) and locations (for example forest and desert). An action from the system is shown here with its pre- and postconditions.

Action: X gives object T to Y
Preconds: likes(X,Y) /\ owns(X,O)
Effects: likes(Y,X) /\ owns(Y,O) /\ ¬owns(X,O)

Any characters can participate in this STRIPS representation action. Here a character decides to give an object to another character who they like. As a result of this, the recipient is internally represented as now liking the giver.

Each dinosaur is assigned a disposition along three dimensions, taking a value between -3 and 3 for each. The dimensions are chosen as being particularly appropriate to this domain, and are happiness, outgoingness and agility. Shown here are some of the adverbs associated with the happiness dimension, and a sample of the ways in which the user can change the associated happiness value for a dinosaur character.

Positive adverbs: delightfully; happily; joyfully

Negative adverbs: grumpily; angrily; resentfully

To make happier: give them something; draw them a picture

To make less happy: throw something at them; steal from them

Agility is only considered to be the dominant dimension if the others are equal, or (with every third action by that character) to complement the adverb of another dimension. If the action is chosen to be complemented, a character could act "brightly and agilely".

If a character's disposition is at the greatest value extreme for the dominant dimension, a strongly modifying adverb (selected randomly from a range of possibilities) is associated with the adverb, so a character with an happiness value of 3 may act "incredibly joyfully". If the value is at the lowest extreme, a slightly modifying adverb is randomly selected. This means that a character with an happiness value of -1 can act "almost angrily". Modifying adverbs will not be used for every third action of a character, this reflects the range of behaviour intensity within their overall disposition.

An example of a dilemma being presented to the user is shown here.

You like trex and diplo. They both want your marble

Who will you give it to?

diplo

You have chosen diplo, diplo now owns the marble.

trex chases you

This shows the presentation of a dilemma to the user, the user's decision (in italics) and the subsequent utility-based response.

5.1.1 Story

Following achievement of a story goal the user is able to see an output of their experience, in third person form. This output will be produced throughout the experience as a story and will be available to the user as a record of their personal narrative.

In the following story examples, the user selected actions and dilemma decisions are shown in bold. The dinosaur actions are shown in italics and dilemma points are underlined. Goal communication points are given in italics and underlined for clarity.

5.1.1.1 Billy's story

The relation of the story experienced by a user, Billy, is shown in full here.

Billy is playing with Timothy.

Timothy has a new toy, which he says is a time machine.

He says that he will show Billy, says *"Try to get ptero to like you!"*, grabs Billy's hand and presses a button...

Billy is in a forest! The forest is densely packed with trees.

Billy can see diplo but can't see Timothy anywhere

Billy asks diplo to play

diplo decides to play with Billy

Billy finds whaley's nest

diplo is encouraging Billy to steal an egg from whaley's nest

Billy likes diplo and decides to agree to steal an egg

Billy now owns this egg

ptero goes to the forest extremely grumpily and clumsily

Billy says ptero looks nice

ptero is pleased and becomes Billy's friend

'Wake up Billy!'

It's Timothy. Billy is at home, and Timothy has just arrived.

5.1.1.2 Lucy's story

The relation of the story experienced by another user, Lucy, is shown in full here. In this case achievement of the first story goal becomes unlikely, so a new goal is chosen and communicated to Lucy.

Lucy is playing with Timothy.

Timothy has a new toy, which he says is a time machine.

He says that he will show Lucy, says *"An egg might be a portal"*, grabs Lucy's hand and presses a button...

Lucy is suddenly alone in a forest!

The forest is densely packed with trees.

Lucy looks around

Lucy moves to the mountain

The mountain is very rocky, and has beautiful views

Lucy finds whaley's nest

Lucy asks diplo to play

diplo decides to play with Lucy

ptero agressively asks Lucy to play

Lucy decides to play with ptero

ptero throws a stone at diplo agressively

ptero and diplo both want to play with Lucy

They refuse to play together

Lucy chooses to play with diplo.

ptero leaves the mountain agilely

Although Lucy has now found whaley's nest, she has shown no interest in taking an egg from it. Since achievement of this goal now looks unlikely, a new goal is planned for and the story continues accordingly. There is no break.

diplo says 'See if you can get ptero to throw a stone at you'

Lucy moves to the forest

Lucy draws a picture for whaley

whaley likes the picture so whaley and Lucy become friends

Lucy asks whaley to go with them to the desert

whaley decides to join Lucy in moving to the desert

Lucy and whaley are now at the desert

trex wants to be Lucy's friend

Lucy and trex become friends

Lucy likes diplo and whaley

Both of them want Lucy's marble

Lucy decides to give the marble to diplo

diplo now owns the marble.

ptero throws a stone at Lucy angrily

Lucy hears a wooooosh! and before there is time to blink is back at home.

Lucy never found that marble

5.1.2 Automated user

It is possible for the user to choose not to interact in the storyworld but to see a story created in which the computer directs the protagonist. The character is assigned traits and pre-dispositions which mean that they act autonomously and not necessarily in accordance with the story plan.

As the story is short, initial impressions will be of high importance throughout. The automated user is thus assigned an initial precedence ordering for their feelings towards other characters. In addition they will have a value reflecting how well disposed towards each character they are, which reflects the precedence ordering.

The automated user will also have a personality which takes values for how nice, outgoing, generous, giving, happy, peaceful, forgiving and honest they are. These determine how they act throughout the story and the decisions they make when presented with dilemmas.

6. CONCLUSIONS AND OUTLOOK

In this paper we presented the GADIN system for the generation of interactive narratives. These are dynamically created based on user decisions and actions and incorporate dilemmas to add dramatic tension. In order to apply the GADIN system to the creation of a finite story, it is necessary that there be a clear ending to the story so that the user experiences a sense of closure. However if this ending is pre-defined then the user's actions cannot have a long-term effect on the narrative experienced. In this paper we discussed a method for the provision of a changeable and dynamically determined story goal. This means that the ending changes fundamentally depending on the user.

The characters have dispositions which are reflected in and affect the way they act. This increases their believability and thus the user's attachment to them. It is possible for the user to act in a way which causes these dispositions to change.

In this interactive experience the user is very much a part of the story creation process, they can act at any time in a way which violates the old goal and means that a new goal must be selected. The story is original each time, depending not only on the selection of the story goal, but also on the utility-based character actions, the next dilemma chosen to present, the user actions and the user's decisions when presented with dilemmas.

The main limitation of this story creation method is the size of the knowledge base. The number of actions, dilemmas and characters made available for use within GADIN limit the potential scope of the experienced interactive narratives.

The chosen implementation, which involves a very short story suitable for children, is very limited. However the modular nature of this system means that it is easily extendible to the creation of a narrative which is sustained over a longer time period, and to a domain which is not for children. In this it may be necessary for other characters to experience dilemmas, and certainly they will need to interact with one another to a greater extent. However the potential for this has already been demonstrated for the GADIN system in the soap opera genre [2] and can be applied for use in this domain. With a longer story it may be appropriate to take advantage of Field's [8] structure and his use of plot points and mid points, which could be planned for as story goals and designed to involve dilemmas.

If the storyworld is applied in more complex domains more complex disposition dimensions can be added. It is possible in a narrative which involves human characters that a personality model similar to the Myers-Briggs type indicator [4] could be adapted. However this would have to be carefully considered depending on the exact circumstances.

In previous work [1] a user model has been used with the GADIN system. This could be applied within this domain in order to select the future goals and plans to achieve them in a manner specific to the user and the way they are expected to act. The way in which the user responds to varying character dispositions can also be used in creation of the user model. For example if they respond positively to an aggressive character asking them to play it is likely that they are intimidated and this gives a clearer impression of the user.

The user model could also be used to predict whether or not the user will achieve the story goal (whether this be directly or as a side effect of the goal they are modelled to be aiming for). This would enable GADIN to re-plan – for a new or existing story goal as appropriate – accordingly.

There is the potential for a multi-user version of GADIN. For example there could be two users who are friends and can see each other's actions and collaborate to achieve a common goal. There are more possibilities, such as the users not knowing whether or not there were other human controlled characters in the storyworld. If the users do know about each other how they act within the storyworld will be affected by their relationship in the 'real' world and how this translates into their relationship within the GADIN world. In the control-based system it would be possible to add 'turns' for another user, where each must pass back control before GADIN will be able to select actions.

A story such as that described here could be utilised as a component of a larger computer game. For example, it could be that at some stage in the game the user will be transported into a storyworld. The outcome of this will not necessarily affect the

main game (because there are so many possibilities) but will give the user an experience and a dramatically interesting storyline.

A storyworld such as the dinosaur adventure could potentially be adapted for use as an interactive display in an environment such as a museum. In this the visitor would be able to imagine that they are part of a story involving the dinosaurs of which they have just seen skeletons. They would be able to find out information about the dinosaurs in the story. Being involved in a story means that they are likely to be more receptive to this learning. The user would experience a story which is entirely original.

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