Qualifying Dissertation
Directed Emergent Drama

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Abstract

Substantial research effort has been put into creating a truly interactive drama that is not only entertaining but also gives the player a sense of coherency and that she is an active participant in the unfolding drama. A fully interactive drama has the potential of revolutionising entertainment, gaming, education, therapy and news coverage.

If pre-authored stories are directly implemented into an interactive virtual environment then there is a call for authoring all possible story twists which is an intractable problem for the authors.

One philosophy for tackling this problem is to use planning and narrative structures to reduce the authoring. The problem with this approach is that due to the complexity of planning it is infeasible for real-time application, the games do not scale well because the computation quickly becomes intractable. Additionally, this approach has not managed to sufficiently reduce the authoring problem.

A simpler and more computationally feasible way is to have the drama emerge from the play of autonomous actors. This means that the computation has been distributed amongst the actors and that the interaction of the player is responded to dynamically and in context by the actors. The main problem with autonomous actors in emergent drama is that they are unlikely to play out the preferred plot structure, for example a murder mystery without some direction.

To tackle these problems we propose to divide the drama into narrative episodes which we call schemas. Schemas are used by a director and a set of actors to structure the drama so that it emerges into a fully developed drama that adheres to a specific genre. The schemas are pre-authored in an abstract way such that they can be deployed multiple times in the same drama, which removes the authoring bottleneck. The schemas are not dependent on events having taken place in a specific pre-determined way. This means that the schemas greatly reduce the planning complexity.

The director oversees the dramatic structure of the emergent drama and chooses schemas to deploy in the emergent drama based on the needs of the characters in the drama, the plot progress and observed interaction of the player. The actors use the schemas to guide their play and to coordinate their actions with other actors.

We will define and implement our solution in the Second Life virtual environment to play out typical English murder mystery dramas. We will use Second Life players to test the implementation. We will also examine whether the implementation adheres to the English murder mystery genre and whether the system execution time is acceptable.

Contents

1 Introduction **2**

2 Field Survey and Review **6**
2.1 Story Based Systems 6
2.2 Emergent Systems 11
2.3 Narratology and Drama 17
2.3.1 The Murder Mystery Drama 18
2.3.2 Narratology 19
2.4 Goals from related work 22
2.5 Summary 26

3 Proposal **28**
3.1 Measurement 30
3.2 Plan 31

4 Preliminary results **34**
4.1 Structuring Schemas 34
4.1.1 The External Structure of Schemas 35
4.1.2 The Internal structure of Schemas 37
4.1.3 Schemas vs. Structures in Other Systems 38
4.2 Agents Decision Algorithm 38
4.3 Dynamic Plot Generation 38
4.4 Implementation 39

Chapter 1

Introduction

In recent years computer technology has evolved sufficiently to create vibrant virtual worlds that offer high quality graphics and sound effects. Worlds so vast that a player can roam around for months and still find new places to explore, new creatures to fight and new quests to tackle. Morrowind and Guildwars are examples of such worlds. There are social virtual environments such as Second Life full of players that are seeking an alternative lifestyle or simply friendship. Some are even running a full time business, creating goods that they sell to players and then exchange the game world currency for real world currency on E-Bay.

Still lacking in these virtual worlds is a fully interactive drama where the drama emerges around the actions of the player and Non-Player Characters (NPCs), adhering to a specific genre and containing a dramatic arc, where the player is the protagonist or at least a key participant and the players actions directly affect the drama and where the player can interact with NPCs such that the course of the drama changes but still holds true to a known genre.

Creating such a truly interactive drama is a significant challenge that is fully worthwhile as it has the potential of revolutionising entertainment, gaming, education, therapy and news coverage.

Imagine an interactive emergent murder mystery where the player is the lead detective interviewing suspects and examining clues until the true perpetrator is revealed. Imagine a mystery that really tests the players skills and intelligence, where the player interacts with characters that have a full set of characteristics, emotions and a life history and respond to player interactions fluently in a believable way with respect to their distinct personalities.

Education can be evolved to accommodate for each students actual abilities. The classroom will be transformed to a virtual reality class room where the student has unlimited access to teachers guidance, extra help and advanced material all in direct relation to the students actual performance, skill set, intelligence, motivation and abilities.

Therapy sessions could be greatly enhanced by re-enacting actual social challenges of the patient allowing the therapist to better appreciate the patients difficulties and giving the patient relevant advice that they can then test and exercise in an interactive drama under professional guidance.

Envision news coverage being portrayed in an interactive drama such that the player can step into the aftermath of situation being covered, look at events

and talk to NPCs that believably portray the individuals covered in the news event. The player could even become one of the key figures in important series of events, such as the process of creating the human rights treaty or the Iraqi war, where people could see the process from both sides.

Although some of these visions appear very distant, they all share a distinct common ground which is the core of this proposal. They all call for interactive drama where a player can actively participate in point to point action experiencing each event first hand as it transpires and where the player can affect the dramatic action such that the course of future events is altered. This means for example to play Saddam Hussain and see if the war with the west could have been avoided. Play through a job interview and see if anxiety can be reduced by changing key behaviours.

Creating a truly interactive drama that is not only entertaining but also gives the player a sense of coherency and that she is an active participant in the unfolding drama is a challenge. The response of actors needs to be believable, i.e. it needs to be contextual to what has transpired immediately before and the characters state of mind as well as the unfolding drama as a whole. At the same time the unfolding drama should follow a dramatic arc with the expected rise and fall in suspense for the player to fully immerse her in the ongoing drama. We see that there are two basic areas of interactive drama that need to be successfully mastered. The first is to create characters that respond fluently to interactions from the player so that the player feels that she is directly influencing the unfolding of the drama and is more likely to become immersed. The second is to have the drama follow a dramatic arc and to contain a prologue, epilogue and a middle part, it needs to have a complication with a climax after which the complication is resolved [Pri03]. Additionally it should conform to a known drama genre such that a majority of players recognizes which drama genre it belongs to.

Former systems that attempt to create an interactive drama followed either a *story based* philosophy or an *emergent based* philosophy. The story based philosophy emphasises a need for a pre-authored story that is then used as a basis for implementing an *interactive narrative* rather than an interactive drama. This means that the player is playing a pre-authored role through a narrative rather than an actual role where she can shape the character to her own liking. The characters in the drama need to follow the intended narrative and to entice the player to do the same. This means that extensive planning needs to be carried out to ensure that the characters will play out the intended narrative and to ensure that the player does not destroy the plot either purposefully or inadvertently. Planning poses tractability problems because planning such as STRIPS, which is the most common planning algorithm used in these systems is PSPACE-complete [Byl94], which effectively means that these systems face well known tractability and scalability problems.

This leaves existing systems such as IDA [Mag06] or MIMESIS [YRB+04] showing few actors a short story line and limited options of interactivity for the player simply in order to reduce complexity. Because if the complexity is not kept low then the system becomes intractable. This is further enhanced by the realization that in order to have the characters follow the pre-authored plot then the best way is to keep them simple and have them strictly follow orders of a central manager. Which means that the planning is done by a central manager rather then being distributed amongst many agents, further increasing

tractability problems.

Additionally these systems face an authoring problem coined the *authoring bottleneck* [MS05b, RY06], for instance Facade took three man years to author, it contains one scene, two characters and each drama takes approximately 25 minutes [MS05b]. The main reason for this authoring problem is the need to author actions of the characters in sufficient detail so that the characters are able to both act out the narrative correctly and respond to a fair number of interactions from the player.

An alternative to the story based philosophy is to have the drama emerge from character and player interactions rather than follow a pre-authored story. Emergent drama calls for more engaged characters that need to be able to both engage the player and to act out a coherent drama, the drama should emerge into a specific drama genre recognisable by the player. Because of the increased demand to the characters of an emergent drama, the characters there are a lot more complex than in the story based method and computation is divided up between the characters. This is much more feasible than having it done by a central manager because then each agent is only computing a portion of the overall structure and drama play that is relevant to her current status and recent interactions from other characters and the player. Additionally this enables the characters to respond more fluently to player interactions because they do not need to wait for instructions from a central manager.

The main danger in emergent drama is that it does not emerge as intended. Emergent systems such as FatiMA [AFL$^+$06] and Gadin [BK07] tackle this by using simple scenes with distinct goals for the characters, using STRIPS planning to plot character actions. This means that they face the same tractability issues as story based systems in that the planning will not easily scale.

Still the benefits of emergent drama are very clear, it is more responsive to player interactions as is clearly shown in Gadin by creating dilemmas for the player in response to the players actions and choices and it increases immersion as is shown by FatiMAs test results, it greatly reduces the authoring bottleneck because character actions do not need to be authored to the same detail as in the story based methodology.

We base our system on emergent drama and propose to resolve the difficulty of directing the emergence with schemas, i.e. narrative episodes that are used by a centralised command, *the director*, to guide the drama. We call the system Directed Emergent Drama (DED). The director chooses schemas during the unfolding of the drama dependent on how the drama plays out and the actions of the player. The director is not following a pre-authored script that she needs to fulfil similar to a film director. By the term *directs* we mean that the director guides the actors on how to develop the drama and engage the player.

The schemas that we have drawn out are a novelty in this area. The idea behind schemas is drawn from narratology [Pro68, Pri03] and drama [Ess76]. Autonomous characters use the schemas to play out a drama and try to engage the player. This is an architecture that uses a central manager with distributed computing which is well known and widely applied in industry because it is very efficient, scalable and highly maintainable. Additionally we will use Multi Agent Influence Diagrams (MAIDS) [KM03] which are extended Bayesian networks to allow agents in multi agent environments to make rational decision. MAIDS are linear with respect to number of decisions which far exceeds the complexity of planning. Using MAIDS in this domain is also a novelty in this area.

The reason for choosing MAIDS rather than other methods is a decision reached after a two and half year research and careful testing of the MAIDS performance in a similar sample domain where the MAIDS where used by agents to compute a rational sentence to speak, the results where published in [Ari07]. The results show that the MAIDS greatly outperform both planning and search algorithms for the problem area. Our biggest challenge will be to structure the Bayesian nets such that the computation is sufficiently fast to indicate that it could be applied in real-time systems and still retain sufficient complexity. This can be achieved by having many small Bayesian networks, (Object Oriented Bayesian Networks). By small Bayesian networks we do not mean to cut down on the complexity of the drama by for instance reducing number of characters, scenes or the knowledge base. We mean instead that the Bayesian nets will be divide into many subnets that handle specific calculations, this allows for only calculating a few relevant subnets rather than one huge net each time which greatly reduces computation time.

We will measure whether we can reduce authoring time as an $authoring\ index = \frac{authoring\ time_{months}}{playing\ time_{minutes}}$ with respect to other interactive drama applications. We will also measure whether we can reduce execution time as measured in terms of $efficiency = \frac{execution\ time_{seconds}}{world\ complexity}$. Where world complexity is a weighted sum of the number of characters, number of actions and number of interactive objects. To ensure that the emergent drama does conform to some known drama genre then we will do player experience tests where the players are specifically asked whether they recognise the drama genre and how well they believe it holds true to the intended genre in addition to asking about entertainment value, immersion, etc.

We aim to create a virtual mystery world where the player becomes immersed in a murder mystery drama full of interesting and believable characters. In our example domain the player will have the opportunity to solve a murder mystery, similar to that of an Agatha Christie novel, by interacting with the characters of the world. These characters are played by autonomous actor agents which we call actors. The actors' main goal is to entertain the player by providing an engaging murder mystery. In order to accomplish this the actors performance needs to be collaborative and unified to give the player a consistent and coherent drama experience. If one of the actors started to play in a different direction to the other actors it could disrupt the player's experience and the unfolding of the drama.

Chapter 2

Field Survey and Review

There is a number of systems that have attempted to provide interactive drama. These systems can be roughly divided into two groups; *story based systems*, discussed in section 2.1, and *emergent systems*, discussed in section 2.2. Both of these systems have similar goals but view those goals through a different perspective as discussed in section 2.4. Sections 2.5 summarizes the strength and shortcomings of various systems in order to promote the motivation for the approach taken in DED.

2.1 Story Based Systems

The story based systems have a pre-authored story and are to a large degree scripted. They frequently use planners and search trees and the more advanced of them have divided the story up into more manageable sections. Most of them have a central manager that commands agents either directly or through structures and this manager can take complete control over the agents. The agents are sometimes equipped with shallow AI to be able to walk around and occupy themselves when the manager is not giving them orders. The systems covered in this section are: *Mimesis, IDA, Façade, BARDS* and *U-Director.*

The Mimesis system [YR03, RSY03, YRB+04] uses planning to reconstruct a pre-authored narrative where the player plays the protagonist. The system is designed to allow for the player to be able to choose from a wide range of actions but at the same time the system goes to great lengths to hinder the player in actually affecting the intended narration. In order to ensure that the player plays the protagonist as the author intended then the system can use the following story mediations:

- *Accommodation*, the system re-plans to allow for this action.
- *Intervention*, an action by the player is unsuccessful, such as shooting a character misses or the gun is jammed.

Mimesis controls all actions with a plan. When the system receives a plan request then it draws a directed acyclic graph (DAG) with respect to the actions needed for the intended narrative to play out correctly. If an action does not

execute correctly then this DAG needs to be redrawn or mended [RSY03, RY06]. Generating a DAG in this way is feasible for very short stories with very limited range of actions. Due to the state explosion of planning in general then this is infeasible for any real size problem. Planning for conjunctive goals is intractable [Cha87] and STRIPS as they use in Mimesis is PSPACE - complete [Byl94].

Interactive Drama Architecture (IDA) IDA is comprised of an author, director agent, synthetic characters and a player see Figure 2.1 [Mag06, MLA+04, ML04, Mag05]. Their test bed is Haunt 2, built in Unreal Tournament where the player as a ghost needs to find his murderer and manipulate other characters into finding the body and the murderer. IDA is in collaboration with the Soar Games Group and draws heavily from Mimesis.

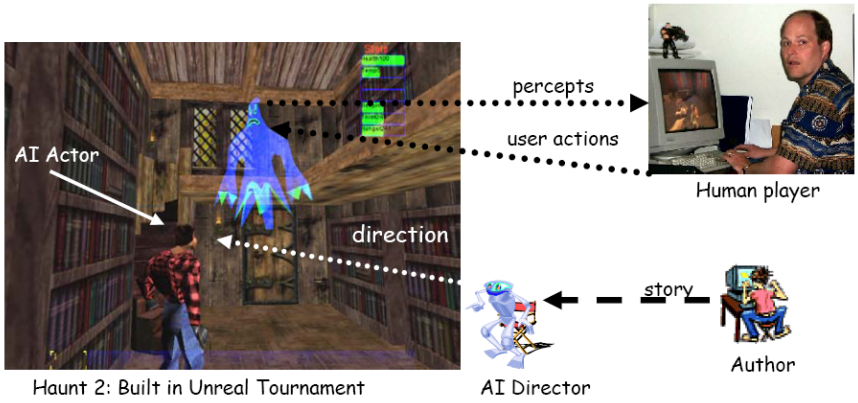


Figure 2.1: IDA Architecture

The author or group of authors needs to author the story, any domain-dependent functions of the director, the environment and art content, as well as characters behaviours. The characters are semi-autonomous in that they are able to occupy themselves when they have no instructions from the director. They can for instance light a fire and eat, drink and chat. Most of the time they take commands from the director which takes priority over all other goals. These can be high level such as *explore* and also very specific "*perform dialogue #131 with John in the library and then run away to another room*" [Mag06].

The story itself is drawn up as plot points in a partial ordered graph using STRIPS with pre and post conditions. It faces the same complexity issues as other planning attempts. To give a perspective of how simple the story plan of the test base was then in Figure 2.2 is the entire plan for Haunt 2. It can be clearly seen that the story is so short and simple that it never actually tests the planning algorithm used, it never pushes its limits and it remains an open question how they are going to scale this solution.

IDA also uses story modifiers as Mimesis to correct the plot if the player does not play as intended. IDA philosophy is slightly different as they recognise that to much direct interaction compromises believability, thus they emphasize on director actions that shift or modify the plot to accommodate for player actions.

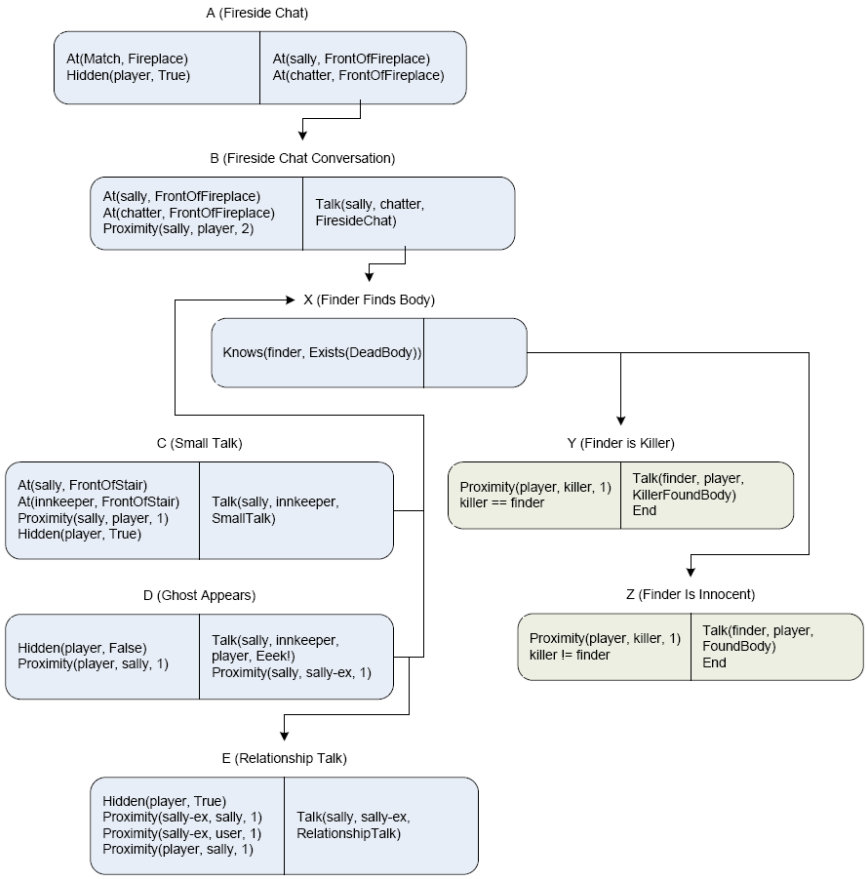


Figure 2.2: The entire partial ordered plan for Haunt 2

- *Deniers*, permanently or temporarily make certain plot points inaccessible.
- *Causers*, the system initiates a plot point.
- *Creations*, new things appear in game to replace destroyed items.
- *Shifters*, plot points are moved around to aid the player.
- *Hints*, some noise from a room or an NPC says something.

Façade The player finds herself in a dreadful situation where her old friends Trip and Grace who have just invited her over are clearly on the brink of a marital breakdown [Mat02, MS05a].

As seen in Figure 2.3 then Facade is comprised of a Drama Manager, beats, characters, story values, actions and natural language processing. The beats are explicitly pre-authored in such a way that all actions within the beat are authored explicitly and that actions of all roles are strictly coordinated to allow for multi-agent coordination [Mat02], p.45. Additionally all higher level goals and behaviours that drive a character are located in the beats rather than the character. Still the character retains some autonomy when it comes to base

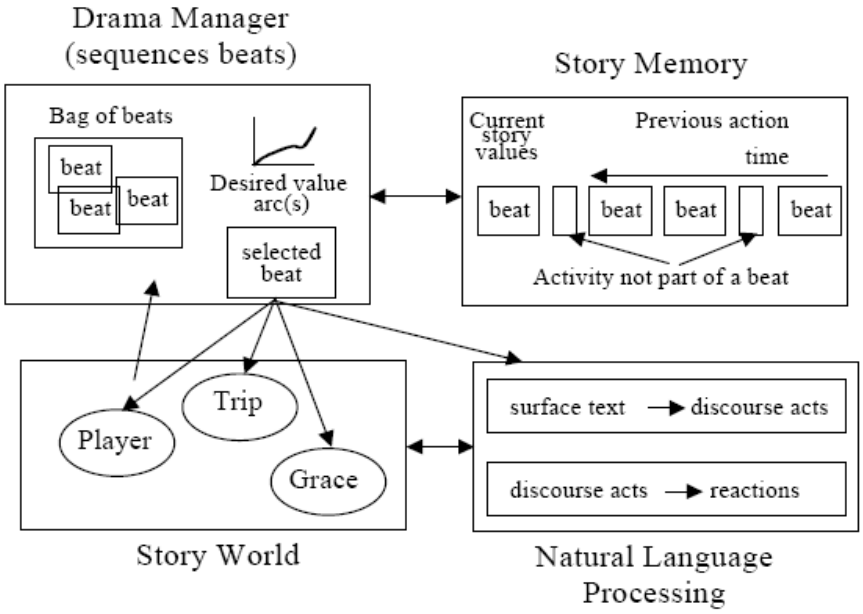


Figure 2.3: Facade

level goals and actions such as facial expressions or personality moves [Mat02], p.45. The authoring of Facade took 3 man years and included 27 beats [MS05a] and the result is a 20-25 minute long game that you can play through 3-4 times and get some novelty. The writer of this dissertation has managed to see four possible endings to the story: being thrown out by Trip, being thrown out by Grace, seeing Grace walk out and seeing Trip walk out. There is a possibility of getting Trip and Grace to reconciliate although the writer of this dissertation has never managed it.

Facade has been applauded as the *first completely implemented interactive drama*. I would hesitate to agree with that claim mainly due to the lack of actual interactivity despite claims to the contrary. The player can move around the scene and point to things at which the characters will be given beats that are centred around the objects that the player pointed at. The player can also talk to the characters via a shallow natural language processing. This gives an appearance of interactivity that is apparently not in place and the average player realizes this quite quickly. This means that many commercial RPG, where the player can bargain, attack, kill, steal, flirt, manipulate, form friendships, accept/reject quests etc. offers greater amount of interactivity than Facade. The writer of this dissertation has for instance spent months in RPG Morrowind as three different characters and experienced far greater interactive drama than Facade offers.

Facade is one of the last project from the *OZ group* and it is thus necessary to point out that it does not build heavily on earlier OZ group findings, in fact it goes to the other side so to speak. M. Mateas in his thesis on Facade ranks the earlier OZ project work around 30, on a scale of 0 to 100 where 0 is *strong autonomy* and 100 is *strong story*, and Facade around 70 [Mat02], p.45. Our work ranks around 30 on such a scale because we contrary to Facade opt for

strong autonomy.

The beats that Facade uses are certainly a novelty and they enable a the characters to carry out their marital dispute and accommodate for player interactions up to a degree.

BARDS Has a Heuristic Search Planner (HSP) with RTA* as its underlying search algorithm to plan emotional development in the characters rather than actions [PCLC07, PC07]. They use an ontology created by Gustave Flaubert to create their planner and use his novel Madame Bovary as their test base. A user can interact with the story by natural language in such a way that user comments can cause emotional reaction with the characters. For instant a woman in love with someone else than her husband can feel guilt when she is reminded of her children.

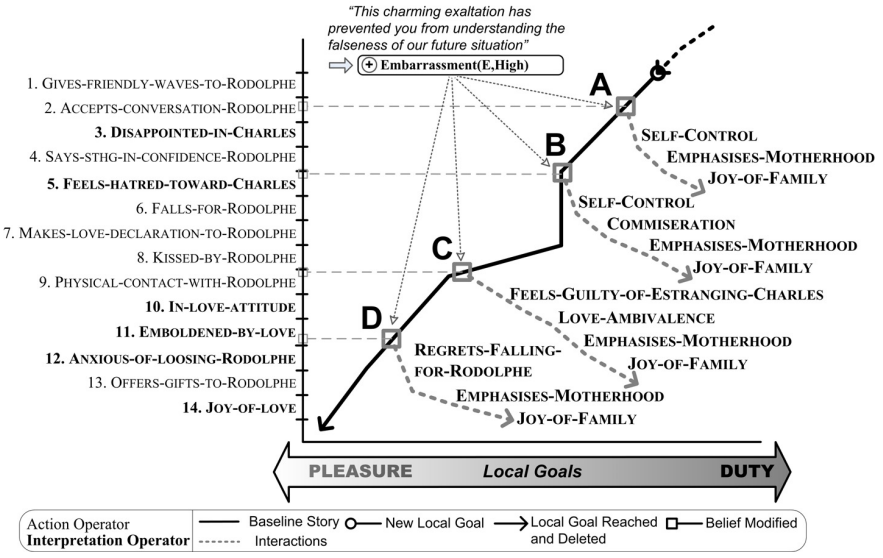


Figure 2.4: Bards: influence of a NL utterance on the unfolding story

In Figure 2.4 the emotional plan can be seen and actions and feelings develop by Flaubert's ontology. As seen in the plan, user utterances will have different effects depending on what the character is feeling and will alter the story line.

This is certainly a novel approach. There is no player in this system, instead there is a user or audience. The users interaction has the feel of the audience shouting at their hero "beware behind you".

The system is not very interactive in the sense that there is no actual player. The system is also fairly emergent more so than any other system in this section and it is debatable whether it should not rather be in the emergent section. Still it uses planning and has pre authored story lines or ontology as other systems in this section.

U-Director uses HTN planning and dynamic decision networks to implement a medical mystery story that takes place in a secluded island [ML06]. The story is pre-authored and follows a fairly strict plot. The idea is very similar to IDE

except that they use a Bayesian inference mechanism in stead of planning when deciding how to manipulate the player into following the plot. The general architecture for the director agent can bee seen in Figure 2.5.

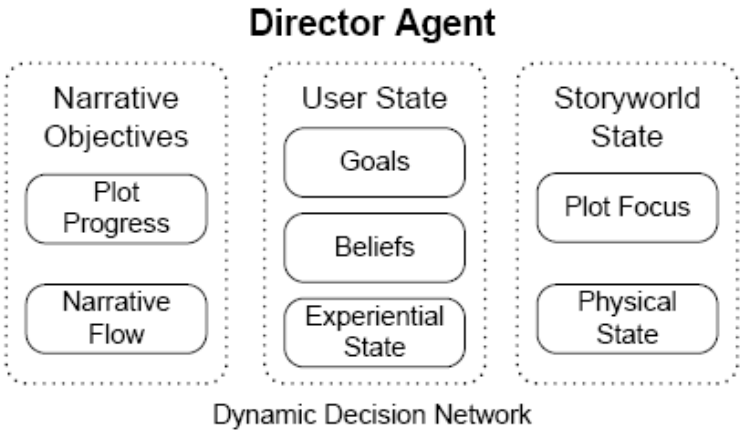


Figure 2.5: U-Director architecture

The director agent is constantly evaluating user actions and comparing them with the plot. The director will attempt to engage the player in the plot by giving hints that steer the player in the right direction. If the hints are not sufficient then the director will use more force and for instance have a character take the initiative rather than wit for the player to ask. The director uses extended Bayesian networks to evaluate what directive action to take based on maximising expected narrative utility. This means that the directors primary goal is to progress the narrative and get the player to play along with it.

Using inference diagram in this way is a novelty. Still their implementation is fairly small, the Bayesian net had around 400 nodes it remains to be seen how it scales.

2.2 Emergent Systems

The emergent systems do not have a pre-authored story or scripts. Instead they emerge by the actions of the characters and players in the drama. These systems frequently have goal driven agents that use either planning or belief systems to determine how to interact with the environment. Some of these systems have some central manager but she typically does not give direct orders, instead she manages the environment or initiates scenes or plot points that then are developed by autonomous characters and the player. The systems covered in this section are: *Gadin, FatiMA, Nolist, OPIATE, The virtual storyteller, The Virtual theatre project* and *IDtension.*

Gadin is an emergent system for creating clichéd dramas as are commonly found in soaps [BK07]. The system uses STRIPS planning to generate actions for characters in the game world with respect to the characters personality and current interests. A drug addict will want to drug and may find herself in

prison while a non-drug addict is far less likely to have such bleak prospects. The architecture can bee seen in figure 2.6.

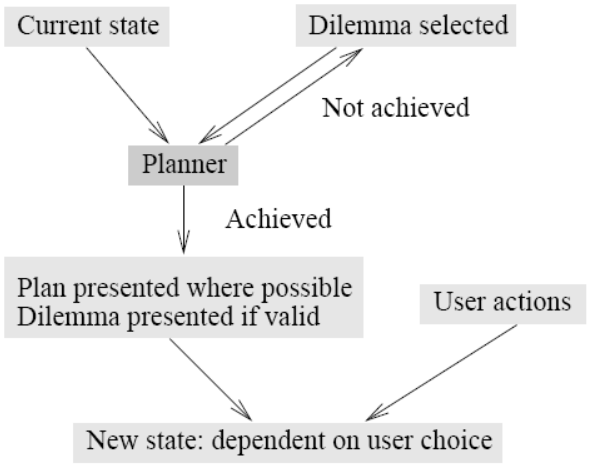


Figure 2.6: Gadin architecture

The system will periodically generate dilemmas to create conflicts in the unfolding drama. The possible types of dilemmas are:

- *Betrayal*, To betray their partner or close friend.
- *Sacrifice*, take damage for the good of a friend or partner.
- *Greater Good*, Do something that is good for many including the players enemy.
- *Take Down*, Damage your self but also damage your enemy even more.
- *Favour*, choose which friend or close partner is favoured.

Dilemmas are chosen with respect to player actions and the current story line in order to maintain a coherent story. Characters are presented with dilemmas with respect to their actions and place in the current drama. This is to make the character based decision making seem more realistic.

FatiMA (Fearnot Affective Mind Architecture) is a character based emergent drama system [AFL$^+$06]. The drama emerges around character actions. The test base is Fear Not! an educational game for children aged 6 - 12 to learn to handle bullying. The characters are reactive to interactions from other characters, the environment and the player.

When reacting, they use a set of emotional reaction rules, based on appraisal values such as: desirability, desirability-for-other, praiseworthiness etc. The rules have preconditions that are matched with the current situation and the optimal match is chosen.

The characters are also deliberate or goal driven for which they use STRIPS-based partial-order continuous planner. They evaluate the probability of success and the importance of the actions as to whether the actions are expected to

generate hope or fear. The action likely to generate the strongest emotion is chosen. This architecture can be seen in Figure 2.7.

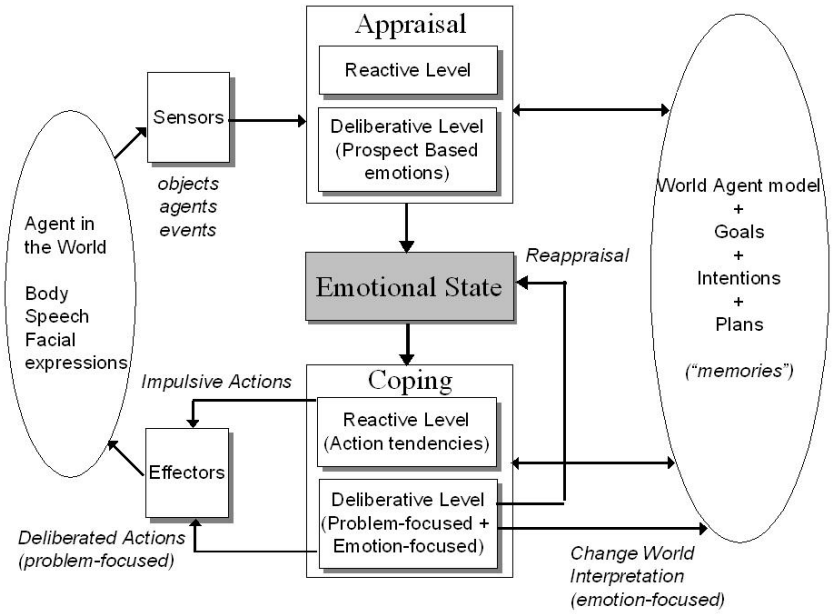


Figure 2.7: FatiMA architecture

FatiMA uses a Game Manager (GM) that uses *narrative actions* that affect the environment and are primarily dedicated to story management [ALT+08]. These narrative actions are comprised of selecting episodes with respect to a plan of episodes that can be represented as a state machine. The episodes are structured as follows [ALT+08], p5:

- *Name*, a unique name for the episode.
- *Set*, the set is the location in the virtual environment where the events of this episode will take place.
- *Characters*, the characters of the story, defined through a set of properties like their name, position on the set, etc
- *Preconditions*, a set of conditions that specify when is the episode eligible for selection.
- *Goals*, character goals that are communicated to the agents in this particular episode.
- *Triggers*, a condition that when satisfied will cause the execution of a set of narrative actions.
- *Finish Conditions*, a set of conditions similar to the preconditions that when satisfied indicate that the episode is finished.

- *Introduction*, a set of narrative actions introducing the episode and characters, some introductory text.

FatiMA also applies *theory of mind* [LA07, AL08], first it does a *double appraisal* in that when the agent has chosen the action that would cause the strongest emotion, she feeds all the actions generated back into her appraisal system to determine which of the actions evokes the strongest emotional response from her. Additionally, the agent does a *re-appraisal* by feeding the actions into the emotional systems of all other characters in the scenario to determine which action causes the strongest emotional reaction in others.

Fear Not was tested by an empirical study on 345 children, 172 male (49.9%) and 173 female (50.1%)of the age of 8 to 11 [HWA+05]. Results show that the children where able to emphasize with the characters. There was a positive correlation between the children believing in the characters and finding them interesting and empathizing with them. Also if they believed that they had an high impact on the characters behaviour then they where more likely to empathise with them. Girls where more likely than boys to feel sorry for victims that they where successful in helping.

Nolist [BJJ+04] In the non-linear interactive storytelling game engine (NOLIST) [BJJ+04] they utilize a Bayesian network to determine the culprit of a murder mystery; the Bayesian network is dynamically changing in response to actions and observations made by the player. It is not preset but rather it uses the player's moves and the logical inference of the net to determine the culprit. For example if the player finds a body and a gun lying beside the body then the probability that the murder victim was shot with the gun increases. The proposers of NOLIST do this to be able to construct an engine that will create a dynamic emergent storyline with respect to player actions and choices. The plot and the culprit are not known by the game engine in the beginning but are determined in the course of the game. Thus NOLIST creates the past in reaction to player interaction.

Although NOLIST is highly adaptive to player interaction it might actually be too reactive. Players are likely to play games in similar manners each time and are thus not good at surprising themselves.

Open Ended Proppian Interactive Adaptive Tale Engine (OPIATE) The engine creates interactive emergent drama and is in a large part based on Propp's Morphology [Pro68]. The game engine uses a story director that guides a set of actors by giving them goals relevant to events in the storyworld [FC04, Fai04]. The overall architecture can be seen in 2.8. The story emerges both from character interactions and by events initiated by the story director. An interesting part of this engine is a gossip system that connects the NPCs together and spreads news and opinions about the current player character with respect to his actions. The characters also relate news of storyworld events between them.

The story director uses Proppian functions to generate an open ended story world and chooses functions based on case based planning that uses current state of the story world to find the most suitable goals to advance the story.

The test bed for OPIATE was fairly limited with pre-scripted puzzles, it thus unknown how it would scale both with respect to the complexity of planning

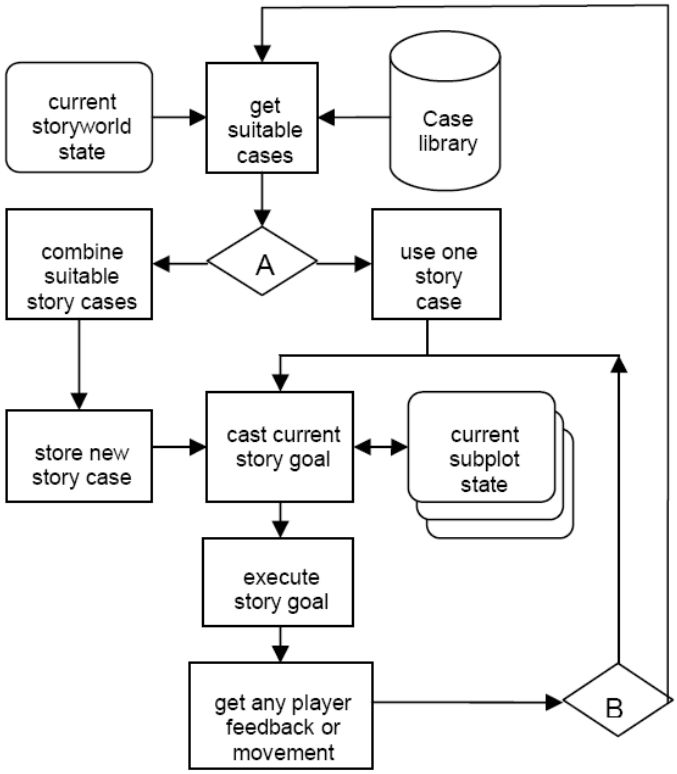


Figure 2.8: Opiate archtecture

used and whether the characters would be able to keep functioning as expected from the goals that the story director hands them.

The Virtual Storyteller [SV07, SVB07] creates emergent stories from character interactions with an emphasise on emergent improvisational theatre that are told by a narrative agent, (see Figure 2.9).

There is a plot agent to ensure proper plot development. Autonomous character agents that have individual emotions and beliefs inhabit the story world and by their interactions a story emerges. The characters improvise using techniques from improvisational theatre. The world agent keeps track of current world states. The story is processed by a natural language processor and then synthesised. Special rules have been developed to transform the synthesised speech into storyteller speech, e.g. with the expected emphasis that a story teller will use to provoke suspense, excitement, etc.

The Virtual Theatre Project use what they call *directed improvisation* meaning that improvisational actors receive directions or constraints that they use to centre their improvisation on. For example an actor can be told to walk to a table but not how to do it. This means that the actor can rush to the table when playing an energetic character and shuffle when portraying laziness. This they tried in Computer Animated Improvisational Theatre (CAIT) which

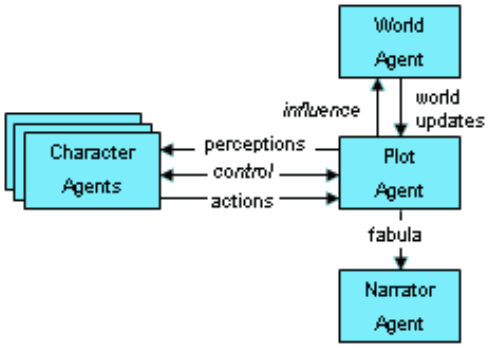


Figure 2.9: The Virtual Storyteller

is aimed at children between 9 - 12 [HRSB+94]. In Cybercafé [RHR96, RHR97, RHR98] Which has two or more players as customers in a café interacting with an autonomous waiter. Also in a Master-Servant scenario where servant Gregor through series of postures switches places with his master Otto and becomes master himself [HRvGH97].

IDtension [SMR03, Szi03, Szi04] bases it's approach on narratology such as Propp's functions Bremond's process, Greimas actant's model and Todorov's transformations. The interactive narrative is divided into three layers:

- *The discourse* layer which carries the message or theme of the story.
- *The story* layer which is succession of events and character actions, following certain rules that are based on structuralism and narrative sequences.
- *perception* layer a discourse on how the narrative is perceived during reading/viewing/listening

The IDtension system is authored by defining and scripting a set of tasks that need to be completed in a causal order to complete a certain goal. There are several such causal pathways to complete each goal. This is a bit similar to the type of books that are event based and require the reader to jump between pages with respect to how she replies to certain questions. For example the reader will be asked whether she wants to open a door, if yes go to page 10, if no go to page 35 see Figure 2.10.

In a similar way as an author envisions a certain type of reader when writing a novel then IDtension models the narrative by a user model that uses the following criteria as seen in [Szi03], p6:

- *Ethical consistency:* The action is consistent with previous actions of the same character, with respect to the system of values.
- *Motivational consistency:* The action is consistent with the goals of the character.
- *Relevance:* The action is relevant according to the actions that have just been performed. This criterion corresponds to one of the Grice's maxims.

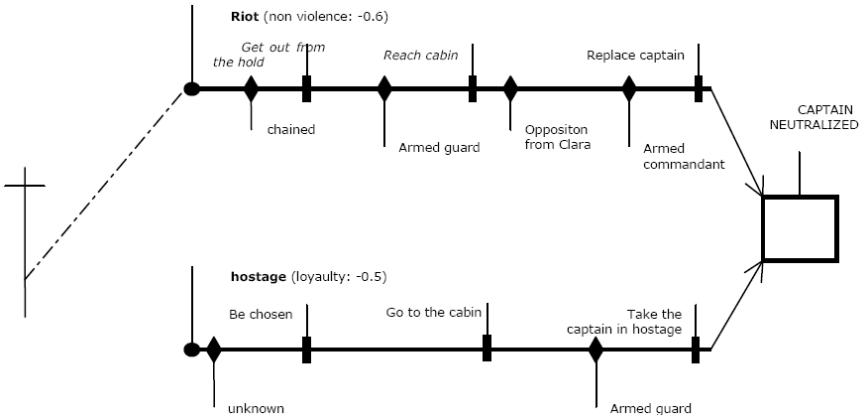


Figure 2.10: IDtension task-goal structure

- *Cognitive load:* The action opens or closes narrative processes, depending on the current number of opened processes and the desired number of opened processes (high at the beginning, null at the end).
- *Characterization:* The action helps the user to understand characters' features.
- *Conflict:* The action either exhibits directly some conflict (like for example an incentive that is in conflict. with the inciting character's values), or the action pushes the user towards a conflicting task (for example by blocking a non-conflicting task, if a conflicting task exists)

Although the idea has certain novelty in CS, it is not really solving the problems of the authoring bottleneck as the author needs to design all the possible tasks for the goals completion and the author is unlikely to anticipate all the expectations of the player and so the author can not possibly fathom which tasks to include. An author that attempted to author a story for IDtension experienced problems in authoring due to a high degree of abstraction used which alienates the author from being able to author the characters personality properly. This method also poses the same intractable planning problems as in Mimesis and IDA if the intention is to have certain predefined goals reached with each story that is defined in the discourse layer. Results are lacking to be able to say whether IDtension works.

2.3 Narratology and Drama

Interactive media is a new form of media and there has to a large extent been made the same mistakes as in the first films when they simply filmed theatre productions without adapting them to the altered viewpoint of the camera lens. We should rather seize this chance to evolve drama into this new media, creating new genres in drama, education, therapy, entertainment and news coverage.

We propose to use interactive media for drama that emerges into some known genre. We will use the English murder mystery as our test base. We use the Dynamic Plot Generation Engine (DPGE) [Ari08] to create plots for our system.

2.3.1 The Murder Mystery Drama

A typical English murder mystery can be divided into 3 acts, a prologue, a large middle part and an epilogue [Tod77].

In act I, the prologue, the characters are introduced, the scene is displayed including any secret drawers, hidden compartments and any readily accessible stacks of poisons or lethal apparatus. Additionally the body is discovered in act I, traditionally in one of the last scenes after the victim has been properly introduced.

In act II the detective, played by the player, interviews all suspects and observes all clues. This means that all clues need to be revealed to the player by the end of act II, some are revealed in act I. The motives, means and opportunity of all suspects need to be revealed either through dialogue or by physical evidence.

In act III, the epilogue, the murderer is revealed by showing that only the murderer had motive, means and opportunity.

We can see by this that there are certain definable goals that need to be fulfilled before progressing from act I to act II and from act II to act III.

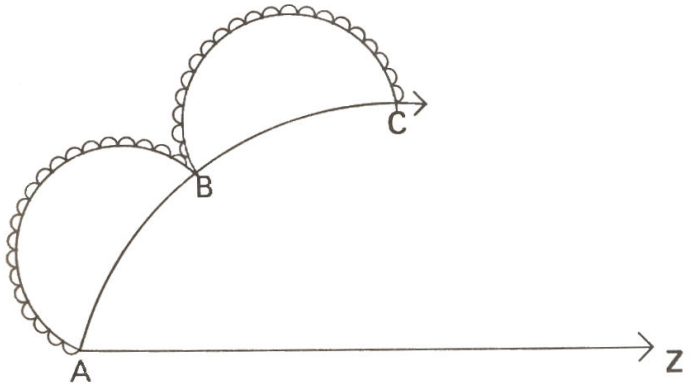
Drama has five basic sections that form the dramatic arc: exposition, complication, climax, fall, and closure [Pri03]. In the English murder mystery the exposition or prologue is the first act. It serves the purpose of introducing characters and scenery and has at its end a murder which serves as the inciting moment of the drama. The second act contains the complication of the plot where many facts about the characters and their relationship to the murder surface. This happens first in a seemingly disparate way, but as act II progresses the facts become clearer and the actual sequence of events that took place prior to the murder becomes increasingly revealed. The final act sees the climax of discovering the murderer and the closure of proving that no other could be the murderer.

Parts of the murder mystery can get monotonous, specifically act II and the player can easily loose interest and leave. It is necessary to have a continuous engaging drama unfolding in order to keep the player immersed. The five basic sections can be further divided into even smaller sections or sub-dramas. We call these sub-dramas schemas. Schemas have a much quicker rise and climax than the main drama, albeit less intense and thus serve to keep the player engaged [Ess76]. Additionally the schemas need to be divided into engaging events so that the players attention is kept through each schema. The structure that we have just described can be seen in Figure 2.11 and is from [Ess76].

It should be stressed that the schemas are not strictly sequential as Figure 2.11 shows, although it may appear to be so from the players viewpoint. We use multiple overlapping schemas to structure all episodes of the drama. This means that each actor will find himself playing through multiple schemas at any given time: one being the life history of the character he is playing, another being one or more sub-dramas that he is engaged in.

The English murder mystery genre is a game of *spotting the piece that does not quite fit* [Kno92, Tod77]. A good mystery has all clues in the open easily observable but not obvious. The detective needs to recognise their significance in relation to the mystery. The clues blend into the background and if the detective where not specifically looking for them, they would not be seen as out of the ordinary at all.

Figure 2.11: The Structure of Drama



It is a game of pretence, characters are shown as being manipulative and devious without the viewer recognising it because they do not see the true motive for the characters behaviour. The viewer sees intelligent devious characters frequently as being carefree, superficial and rather silly because the characters do not reveal their true motives [Van92, Ess76]. This is usually done by the character doing something intelligent, such as recognizing poisons but stating a rather silly or simple reason for the feat, e.g. that the character just read the labels and looked it up in a book that was lying nearby for fun. The attention of the viewer is skilfully diverted from the reason of why there was a book on the subject nearby in the first place.

There is a pretence of normality in the murder mystery surrounding the abnormal incident of having someone brutally murdered in your midst. The suspects are portrayed as good standing citizens that we would normally not consider capable of murder in the first place [Fre92, Van92, Ess76]. Clues such as opportunity and means are artfully hidden as normal run of events, that is if someone had not just been murdered.

When we talk about revealing characteristics of characters then we refer to this pretence. Namely characteristics are revealed but not in direct connection to the true motive behind the characters actions. The player will need to connect motives with actions and characteristics of the suspects. The same applies for revealing clues. The clues should be clearly observable but the player needs to understand how they can be a piece in the puzzle and how to put the pieces together to make a whole picture.

2.3.2 Narratology

The word narrative derives from the Latin verb narrare, which means ”to recount”. The narrative is a concept, composed by an author to be delivered in any medium. A narrative describes a sequence of real or unreal events [OED07]. By its very definition a narrative does not refer to events that may or should come to pass in the future. This means that a narrative is not an appropriate structure to use in a highly interactive game where the player is to have an active say in how the game and the game story unfolds. It is very difficult *to recount the future*. This conflict between the narrated pre-authored plots and

interactivity is known as the narrative paradox [AL03].

This does not mean that we can not use many of the tools from narratology. The reason for this is that these tools are intended to aide in both analysing and in generating narratives. In order to introduce these structures I will start by describing the work of Vladimir Propp a Russian structuralist That made quite a contribution in this area, this has been published in [Ari08].

Propp´s Morphology Vladimir Propp [Pro68] a Russian structuralist observed that the Russian fairy tales, classified by Aarne index 300 to 749 [Aar11], are constructed of repetitive themes where actions and functions stay the same but the names and attributes of the persons change. In this case a function is defined as an act of character and viewed for its significance in the course of an action. This means that each function is independent from the rest of the narration and is only recognized for its effect on characters each time and for its part in completing an action. From his careful observations Propp was able to propose the following 4 rules for the morphology of the set of Russian fairy tales, [Pro68]:

1. Functions of characters serve as stable, constant elements in a tale, independent of how and by whom they are fulfilled. They constitute the fundamental components of a tale.
2. The number of functions known to a fairy tale is limited.
3. The sequence of functions is always identical.
4. All fairy tales are of one type in regard to their structure.

Propp numbers the functions and states correctly that no function may happen after a function of a higher number has happened. This is to ensure a coherent time line. Propp managed in this way to map a sort of unintentional logical time line for the fairy tales. Note that a function can take place with out a function of a lower number having taken place. Some of Propp's functions are paired such that one will logically follow another. Yet the functions are rarely causally dependent such that the former has to have come before the latter. The latter function can happen independently from the former [Pro68].

Example 2.3.1 (The Proppian function.)**.** *Fairy tales frequently start with an interdiction that is addressed to the hero:*

- *you dare not look into this closet or*
- *don't pick the apples*

This is followed by a violation, the hero does what he had been warned or forbidden to do. If there is no prior interdiction then the hero is seen either violating some common norm, like being late or oversleeping, or he ventures out because of need or because of the urgings of some other character.

The functions and roles of Propp's Morphology are suitable to create a Russian fairy tale. A murder mystery has little in common with a Russian fairy tale and so a completely new set of functions and roles needs to be defined with respect to Propp's rules.

The functions and roles of Propp's Morphology are suitable to create a Russian fairy tale. A murder mystery has little in common with a Russian fairy tale and so a completely new set of functions and roles needs to be defined with respect to Propp's rules. The roles that have been implemented are first described and then the rules as implemented in the engine are detailed.

There are three roles defined in the murder mystery morphology; *victim, murderer* and *suspect*. The murderer alone will satisfy the constraints that define a murderer. These constraints are: all evidence match, has motive, is connected to the victim and had opportunity. There is only one murderer in the generated plot. Each suspect that is not the murderer will fail to satisfy one or more of the constraints that define a murderer. All of the characters are either related to the victim or have a motive to kill the victim or both.

There is no detective role defined because the detective commonly enters the scene after the murder takes place and this solution does not address that specifically.

Rule #1 The first rule of Propp's Morphology asks for functions that are stable, constant elements in a tale, independent of how and by whom they are fulfilled. A murder mystery has a different set of functions than a Russian fairy tale. I have defined the following necessary functions for a murder mystery: motive, means, opportunity and murder.

The *motive* function joins motives with the murderer and some suspects. Below is a description of each of the motives implemented in the engine.

The *means* function joins the murderer and some suspects with a some weapons. Such that that the murderer and some suspects will be connected to a weapon through evidence such as their hair or fingerprint being on it.

The *opportunity* function joins the murderer and some suspects with on scene evidence, such that that the murderer and some suspects will be connected to the scene by for instance a footprint or some hair found. This would show that they where indeed on the scene and thus had opportunity.

Finally the murder function ascertains that only the murderer has motive, means and opportunity to commit the murderer and that each of the suspects will be found lacking in one or more of these conditions.

Rule #2 It is clear from the description of functions for rule number one that the functions are limited in number.

Rule #3 The DPGE creates the past for the game and thus the sequence of functions do not follow a time-line but it still holds that a murderer would first need to have a motive then means and opportunity before being able to kill the victim. This sequence of functions is readily apparent if the resulting plot is recounted. Meaning that the plot can always be used by a human to create a narrative.

Rule #4 All the mysteries are created from the same Bayesian network with the same set of function and thus the mysteries are all structured in the same way.

In order to have a set of probable motives some of Agatha Christie's murder mystery novels where used. The result from a light review are the following motives:

Swindle. Either the murderer is swindling the victim and the victim threatens to tell or the victim was swindling the murderer and the murderer wanted revenge. Either way the swindler should be rich.

Blackmail. Either the murderer was blackmailing the victim and feared that the victim would reveal it or the victim was blackmailing the murderer. In either case it is necessary that the one being blackmailed has some dark secret or else he would not be blackmailed.

Wedlock. In Agatha Christie's time it could sometimes be difficult and or bad publicity to get a divorce. This can also apply today that people do not wish to go through the divorce process and lose half their belongings and possibly custody of the children. The constraints in the net for wedlock is that the murderer is the victim's spouse.

Inheritance. This is self explanatory and has the necessary constraint that the victim must be rich and the murderer must be an heir.

Adultery. The victim was having an affair with the murderers spouse and the murderer kills because of pure jealousy.

Revenge. The murderer believes that he has just cause for revenge. The victim must have harmed the murderer in some sense in the past.

Debt. The murderer owed the victim lots of money and could not pay. This has the necessary constraint that the murderer is not rich.

2.4 Goals from related work

The goals of the developers that implement narratives in games are many and diverse, it is good to discuss them before discussing the strengths and shortcomings of previous systems.

Artistically complete and finished story This has two sides to it. First there is the opinion that if you have an artistically complete story initially that then you should be able to transfer it into a good game and that the game would then contain an artistically complete story. This opinion does put qualifiers on the game implementation in that the game needs to be sufficiently skilfully implemented as to preserve the aesthetics of the original story. This is what many story based system do, (IDA, Haunt 2) and is also common in adventure games such as Agatha Christie's *And then there where none* and *The Oriental express*.

Another similar opinion is that a story should be authored for each game and then it should be possible for a good designer to create an artistically complete

game. Especially if the author gets a lot to say in the actual implementation, (Facade). This is quite frequent in Role Play Games, for instance *Morrowind* and *Baldurs Gate* and in adventure games for instance *Monkey Island* or *Gabriel Knight*. As with any design, there is no guarantee that the player will find the interactive narrative as engaging as intended, in fact it can be guaranteed that a certain percentage of players will not find the interactive narrative to be artistically complete, engaging or even interesting. They may even find it to be irritatingly ill structured while others may find the same interactive narrative thrilling. This is because peoples taste, intelligence and prior exposure to literature, theatre and arts in general varies a great deal.

Emergent systems have an opposite stand on this and generally believe that it is important that the drama emerges into the expected genre or story type, for instance Fear Not! generates drama where bullying takes place in school settings. There the drama emerges into two bullying scenarios because the characters are goal oriented into creating that drama. The bully has goals corresponding to a bully etc. Gadin is also a good example. The danger of this approach is that the drama may not emerge into an interesting story or a story from the expected genre. This danger is far more pronounced in more complex drama than the bullying scenario in Fear Not!.

Believable Most systems are aiming for believable characters with emotions that have a personality and respond in a believable manner.

Although story based systems put a high emphasise on believability the characters are not given a robust AI system to respond in such a dynamic way. The characters are implemented as broad shallow agents with mostly pre-scripted dialogs and pre-defined or pre-authored set of behaviours and actions. Most story based systems directly control the agents, for instance Facade and Mimesis. The reason for this is that when you have a pre defined story then it is difficult and an unnecessary complication to use autonomous characters because they will only add to the complication of enforcing the drama into the expected plot line [Mat02]. Still having pre-scripted characters makes believability suffer because the characters are prone to repetitive behaviour and have a limited set of responses to player interactions. No matter how many times you play through the drama you always get a similar or identical response which reveals that it is scripted and not actually reacting to the players personality.

Emergent systems apply exactly the opposite methodology believing that characters become believable when acting in response to the environment based on their internal characteristics and emotional systems, for instance FatiMA and Virtual Story Teller. This is why emergent systems use autonomous characters and use goals to guide them into developing a drama that conforms to the expected drama genre.

Making memorable characters would also be very good, characters such as the detective assistants, Watson and Hastings, or the mischievous Gollum and the powerful Gandalf in Lord of the Rings. Such characters can be so powerful that they seem to have a life of their own and they make the novel memorable. In the story based approach where the characters are very shallow and repetitive then this is very difficult. The designer needs to script the characters actions such that she manages to have the agents stay in character at all times. In emergent systems then this is much simpler as then the designer creates the

actual character and it is then the autonomous agent that takes care to stay in character as in Virtual Story Teller and Fear Not!.

Interactive A high emphasis is frequently set on interaction but resulting systems are frequently not very interactive. By interactive then it is generally taken to mean that the player should be able to significantly influence the story or characters in the story or at least have the perception that she is.

In Bards, the user can speak to the system and it may react to it, but the player is not a participant in the story and the characters do not reply to her speech. In Mimesis, IDA then the player is allowed to interact but frequently the system will try to interfere with the players actions either by luring them away or by completely stopping them as in jamming a pistol so that the player can't shoot. In Facade, the player initially has a feeling of actually interacting with the characters but about 10 minutes into the drama the player realizes that spelling mistakes get similar responses as actual comments and that quite frequently the player only manages to interrupt a conversation and not contribute to it. Replaying the drama completely shatters the pretence.

In emergent systems this is completely different as they depend on interaction for the drama to unfold. This means that the player becomes an active participant in the unfolding drama. FatiMA and Virtual Theatre Project are good examples of this since the actions of the characters and the development of the drama completely relies on interactions from the players. Not all emergent systems have players, for instance Virtual Story Teller.

Immersion Most games aim for some sort of immersion, meaning that the player becomes engaged, is willing to spend a large amount of time in it, becomes emotionally affected and even becomes so *immersed* in the game that she feels as if she is *in the game world*. There are three levels of Immersion, engagement, engrossment and total immersion [BC04]. Engagement is reached if the player is willing to play the game, learn the controls and such, and is willing to invest time in the game to advance towards the end or goal of the game. Engrossment is when the player is not only engaged but is also becoming emotionally affected by the game, e.g. enjoys the level of detail implemented or feel emotionally drained after playing. Total immersion is when the player becomes one with the game completely loosing awareness of her immediate surroundings.

Since measuring immersion is very difficult then it is really difficult to determine how successful games are at being immersive [CCB$^+$06]. We can still assume that games that attempt to to be engaging by drawing the player into an unfolding drama and by having the player play a leading role of which actions directly affects the unfolding drama are more likely to immerse players. We can also see that if the player feels that she is an active player in the drama that then she becomes so immersed that she will overlook inconsistency's that she would otherwise notice [KWB92]. This strongly suggests that emergent interactive dramas are more likely to fully immerse the player than story based dramas are.

Plot Most systems aim at some sort of coherent plot developing. The story based systems do this with planning algorithms using narrative functions to create plans that conform to the stories plot points and intended story lines.

This carries with it a computational problem because the planning algorithms used such as STRIPS are PSPACE-complete [Byl94], (BARDS and Mimesis are examples of such systems). Many story based systems also aim at having multiple endings although that is not a novelty it is fairly common in commercial computer games, for instance Deus Ex and Baldurs Gate.

The necessary pre-authoring, for story based systems, carries with it a severe authoring problem which greatly limits the sizes of systems that can be created in this way. Each scene and plot point or beat need to be authored to allow for all possibilities and all prior developments of the plot so that the plot does not become inconsistent. In Facade which is the largest of these systems authoring 27 beats for a 20 minute game play took 3 man years.

Emergent systems rarely have the exact same plot line for two individual runs of the drama and so they clearly have the upper hand in that area. This is also where the weakness lies in emergent systems because not only is the ending unknown but it can also be indeterminable, meaning that it can be difficult to keep the emergent story on track with respect to the type of story that it should generate. The characters could start doing something unexpected or inappropriate that does not conform to the expectations of the intended audience. This is for instance a worry of the Virtual Storyteller. Emergent systems also use narrative functions in order to have some control of how the drama emerges, for instance Gadin and IDTension.

Critics of emergent systems claim that it is necessary to pre-author the plot and story to ensure that the expected story plays out instead of some unexpected story that the designers did not intend to happen. If we look at Fear Not! then it is clear that emergent drama works for limited domains while the story based approach has not yet been able to meet its goals for such limited domains. A story based approach to the bullying educational game, that Fear Not tackles, would both limit greatly the interactivity and the sense of control that the players feel when playing the drama and it carries infeasible planning requirements. It would require scripting of all the scenes and what each character should do at each scene and how characters can interact with each other. The reason why there are only 2 characters in Facade is because all of their actions are specifically scripted and coordinated in the beats and adding another character would greatly increase the authoring time [Mat02]. The third character would need to be added into all the beats and her actions scripted with respect to Trips and Graces actions and the players action. Additionally the designers would need to script all actions of Trip and Grace in respect to actions of the new character.

Protagonist, Embodiment A prominent design goal is that the player becomes so immersed in the drama that she emphasizes with the character that she is playing and consciously or subconsciously becomes embodied in the character. For instance a player playing a ranger in a RPG senses herself as being that ranger and thus has the ranger behaving as she would behave if she was the ranger. It is even better if the player becomes the protagonist of the story identifying with the role such that she really feels that she accomplished to resolve the complication of the drama and that the drama was centred around her character. Preferably this happens when the player is pursuing her own goals.

Making the player be the protagonist is fairly simple she just gets to play the

leading role, for instance the detective in a mystery game. This is regardless of whether it is emergent or story based, Gadin, IDTension, Mimesis and IDE do that. Sometimes the game design does not really invite it as in Facade of Fear Not!. It is more difficult to have the player reach embodiment to feel herself taking an active part in the drama. It can be seen from two experiences that the key to embodiment and invoking empathy with characters in the player comes when the player truly is interacting with characters such that she finds herself having an actual affect on the course of the drama. This can be seen in the real life drama experience in [KWB92] and in the test results of Fear Not! [HWA+05]. Since this type of interactivity is essentially lacking in story based systems then it is clear that emergent systems that are built around this very type of interactivity are far ahead in providing embodiment and allowing the player to feel of actually taking part in the drama.

Replay-ability Another common goal with interactive drama is replay-ability, players should want to play the game at least a few times and the game should offer sufficient variety in both possible story lines and in interaction with characters and environment in the game to encourage the player to replay the game. This is of course more difficult with the pre-authored story in story based systems than in an emergent drama system. It comes naturally in an emergent drama but in story based systems then each alternative branch needs to be considered. Additionally if a player has solved a mystery then what should entice her to start again and try to solve the same mystery again by following a different story branch? Of course if there is a promise of a few different solutions to the mystery each with a distinct ending then that is somewhat plausible but getting a completely new mystery is is far more enticing. This is even more true for other types of drama, for instance role play adventure, the player does not want to replay quests or main stories she would rather advance and discover new territories.

2.5 Summary

As can be seen in the story based system, they rely heavily on pre-authoring, on planning story graphs, and on modifying player actions. This carries complications. First, the authoring problem has been appropriately coined by Facade as the authoring bottleneck because even if they try to reuse scripts the implementation per story is so domain specific that the authoring becomes intractable for any reasonably sized interactive narrative. All actions need to be authored in context to the story and all possible plot points need to be authored including all variants and all domain dependent director actions. Even in Facade which is drawing on narrative structures to tackle the authoring problem the 20 minute play took 3 man years to author and only included 27 beats. It should be noted that the beats in Facade are sequential in the sense that they can only occur at specific points in the drama which means that when scaling the solution the number of beats needed will grow exponentially. The schemas that we propose contrary to the beats are not strongly dependant on a specific point in the drama and they are not sequential. The schemas occur in parallel and most schemas can be used multiple times throughout a drama. This greatly reduces the authoring problem as they are simpler to author, they are more abstract and they

can be fewer in number to accomplish a complete drama.

Another problem is that of planning which carries many obstacles and is in general intractable [Cha87]. The most popular algorithm STRIPS is PSPACE - complete [Byl94]. This strongly indicates that any algorithm that is less than PSPACE - complete would be an improvement for this domain. This is exactly what the MAIDS is, it has linear growth with respect to the number of decisions to make [KM03]. Using MAIDS and reforming the problem with Bayesian nets allows for a more scalable solution. This means that the effort will go into having the Bayesian net reasonably small and storing calculations to be used when needed.

Esslin [Ess76] states that it is important to divide the drama into many small sub-dramas to engage the audience and that characters and short term motivations are essential to capture the audience. This suggests that what is needed is a proactive play on behalf of the actors in order to move the drama along with respect to the intended genre. In this sense, IDA is on the right track in emphasising non-intrusive modifiers, such as hints and shifting plot points, but a better option is to go all the way and release the restrictions caused by scripts and pre-authored story and have the system actively seek ways to engage the player with respect to the players interactions as is done in emergent systems.

Story based systems are too intrusive even though they make bold claims of a high level of interactivity. They go to extraordinary lengths to prevent the same level of interactivity. Recall that they themselves define interactivity such that the player should have an actual chance of influencing the storyline and plot development. Still these systems introduce a central manager that for the most part actively removes the players chances of altering story lines by direct or indirect intervention effectively causing a narrative paradox [AL03].

The narrative is not the only medium of stories. There are many ways of creating engaging game plays that contain a high level of drama and empathy for the player and other characters. Such games tend to evolve and create stories as they unfold. The nearest example of such games are RPG that are played without computers. There you have a Dungeon Master that leads the story and a set of players that play all the heroes in the game. Such games are sometimes written up into complete novels and published, for instance novels in the Forgotten Realms series.

With modern computer technology it has become feasible to move such games into a computer implemented game where agents interact with a player and through that interaction an engaging drama emerges. This new media has opened up possibilities to extend narrative and drama into new genres of games, new tutoring opportunities, new tools for therapy and a more insightful news coverage. It is our responsibility to seize these opportunities and develop them.

Chapter 3

Proposal

We have identified the problems in current interactive drama systems; In the story based systems these are: the narrative paradox, the authoring problem, the complexity of planning. In emergent system the primary problem is the danger that they will not emerge into the intended or even an interesting drama. Some emergent systems also use planning and suffer the same planning complexity as story based systems.

Emergent systems clearly have an upper hand in 5 of 8 of the design goals: believability, Interactivity, protagonist, embodiment, replay-ability. Additionally emergent systems can be expected to totally immerse the player such that she really feels as if she is *in the game* rather than just *playing* a game because player interactions play a big part in the emergence of the drama. Story based systems have not been able to show an undisputed upper hand in any of the design goals discussed although commercial adventure and RPG games are clearly engaging and appeal to a large audience. It should be noted that there is no commercial equivalence of an emergent drama system and thus it is really not easy to determine whether such a system will appeal to a large audience or not.

This noticeable upper hand that emergent systems have over story based systems is a primary premise for our hypothesis. We propose a system where emergent drama is directed into a drama genre of choice by a director agent that uses narrative episodes named schemas to guide the performance of actor agents. We also propose to distribute the computing between actor agents and substitute planning with Multi-Agent Influence Diagrams (MAIDS) [KM03] which extends Bayesian networks and influence diagrams to represent decision problems involving multiple agents and has a linear growth with respect to number of decisions being evaluated. Initial results of using MAIDS are published in [Ari07].
We expect:

- That having the drama emerge from character and player actions within schemas deployed by a director agent will greatly reduce the authoring problem.
- That having the computation distributed between actor agents and a director agent and that the agents use MAIDS as their primary decision model will result in computation times acceptable for real-time commercial applications.

We name this system the Directed Emergent Drama system (DED).

In order to check our hypothesis the following three statements will be verified:

- The emergent drama should achieve high similarity between its emergent drama arc and the intended drama arc. Moreover there should be high similarities between the intended drama genre and the emergent drama.
- The use of schemas should manage to reduce the authoring problem such that authoring schemas is at least linear or less with respect to the number of schemas and adding characters does not result in the need to re-author schemas.
- The use of distributed computation and MAIDS should result in acceptable computational times with respect to real-time commercial application.

DED will be composed of a Schemas, Director Agent, Actor Agents, Agent Decision Engine, Dynamic Plot Generating Engine, Second Life Implementation.

Schemas. In order to structure the drama such that it emerges into a drama genre of choice we have designed schemas which are abstract narrative episodes, (in narratology called *motifs* [Pri03]). The schemas are not sequentially ordered, each actor will find herself in more than one schema at any given time, for instance she can be playing bridge with her friends, (one schema), and be engaged in a conversation with her daughter, (another schema). Some schemas are deployed multiple times during each drama, for instance the schema for interrogation in a murder mystery. The schemas contain all information relevant to the actors to play out the schema, these are: *actions, knowledge base* and *roles*. The schemas also contain all information for the director requires to choose a relevant schema that is likely to progress the plot, these are: *place in drama, roles, theme or type of message carried* and a set of *portrayable characteristics*.

Director Agent. We use a central agent, the director, that directs but does not prescribe actions of a set of autonomous actor agents. By the term directs we mean that the director is giving general directions that guide the actors on how to develop the drama and engage the player. The director accomplishes this guidance by deploying schemas relevant to the current state of the drama, the characters of the drama and observed interactions between player and characters. The director is not following a pre-authored script that she needs to fulfil like a director in a theatre has.

Actor Agents. We use autonomous actor agents to play out the schemas that they are assigned to by the director agent. The actors extend their own knowledge base with the knowledge base that they get from the schemas. The actors also add any new knowledge gathered from the environment to their knowledge base, for instance from observing player interactions. In this way the actors always have up-to-date relevant information of their environment.

The actors get the sets of all actions that are applicable to each schema and to their roles from the schema. They use these to decide on actions appropriate to the character that they are portraying. This use of autonomous actors

that are up-to-date with the environment is the key to provide for greater believability as we expect that they are better able to respond fluently to player interactions than pre-scripted characters. Additionally this is a key element in the distribution of complexity.

Agent Decision Engine. The agents primary decision algorithm is MAIDS because it is linear with respect to number of decisions. Additionally Bayesian networks are used for the agents knowledge base because they compliment the use of MAIDS and because it allows the agents to think in terms of a *degree of certainty* rather than in absolutes as if we used first order logic. For details on the knowledge base and decision mechanism see [Ari07].

Dynamic Plot Generating Engine (DPGE). In order to get a novel mystery for each played drama then we use the DPGE [Ari08] which is able to generate new mystery plots complete with motive, opportunity and means causally connected. This means that if the murder weapon was poison then with respect to the type of poison a smell could possibly be sniffed from the lips of the deceased and possibly some trace of the poison is in the dregs of her wine glass. We also use the DPGE to create the initial make up of the characters. The DPGE is essentially our Bayesian net design tool.

Second Life Implementation. The virtual reality Second Life [sl08] is our test base. There exists a library called Libsecondlife [lib08] that enables the programming of bots that has available all the functionality of an avatar in Second Life. Second Life provides access to a vast pool of testers and it is an excellent opportunity to gouge whether the application is sufficiently robust for real time application. This is both because of the access to testers and due to the extra trial of having it running in a real-time environment on live servers.

3.1 Measurement

We intend to design a system that can emerge into a certain drama genre and can execute in times acceptable to commercial applications. All evaluation will be quantitative except for an initial pilot study to provide feedback and guidance for the initial testing.

Player Experience of Drama Emergence. We will do full player experience tests with questioners, asking players for how entertaining and immersive they find the drama. We will specifically ask them whether they think that the drama conform's to the English murder mystery drama.

Authoring Problem. We will measure whether the authoring of the schemas carries no more than a linear growth with respect to the number of schemas designed. Specifically there should not be a need to re-author schemas due to adding or changing scenes or characters.

We will estimate by how much we manage to reduce the $authoring\ index = \frac{authoring\ time_{months}}{playing\ time_{minutes}}$ with respect to other interactive drama applications.

Execution Time. We will measure execution time to gouge whether actors are able to decide on actions fast enough to execute them with out a noticeable hitch in the fluency of the drama. This will of course be measured independently of time lag that is common on the Second Life servers. We will also measure whether the drama as a whole runs in an acceptable time period with respect to content and whether each act completes in reasonable time. Meaning that the player is able to follow the drama and does not become frustrated due to to slow drama progress or execution times.

The execution time is measured in terms of $efficiency = \frac{execution\ time_{seconds}}{world\ complexity}$. Where world complexity is a weighted sum of the number of characters, number of actions and number of interactive objects.

3.2 Plan

In this section the major milestones are listed and tasks are detailed, the estimated number of days that they require along with at what dates they are expected to start and finish.

Deadlines. As listed by The University of York:

Progress Report	30.01.09
Thesis Outline	30.06.09
Thesis Audit	29.01.10
Thesis seminar	09.04.10
Submitting Thesis	30.06.10

Table 3.1: Ph.D. Course Deadlines

Publishing. We expect approximately three conference articles and a journal article as follows:

1. A conference paper has been submitted to the 1st Joint International Conference on Interactive Digital Storytelling.
2. A conference paper can be written on the authoring and implementation of schemas in September.
3. A conference paper can be written on actors in DED in November
4. When final testing has been successfully completed we can write a journal article and submit to an appropriate journal.

Implementation. The implementation is in two layers; a top layer which is the Second Life (SL) implementation and a bottom layer which is the DED engine. Since SL is the test base then implementation and adjustments will be made to the top layer (TL) constantly during the whole time of implementation.

In the plan in Figure 3.1, the letters in the boxes correspond to letters in brackets in the text. Note that "1m" refers to the line preceding it, as in one month has passed. The plan starts from beginning of July so that when 18

months are shown to have passed on the plan then it is January 2010. The Plan is showing the first 20 months, after which there should only be the writing up of the thesis left.

The bottom layer implementation is in four parts:

- (CE) Character Engine, A rewrite of the dialog engine from Java into C# some re-factoring and preparation for the extended use, (1 month).
- (S) Schemas, formalizing and authoring schemas, implementing schemas in DED, (2 months).
- (DE) Decision engine, formalizing and implementing the decision engine for director and actors, connecting character engine with schemas and SL, (2 months).
- (C) Characters, Authoring and implementing a collection of characters, (1 month)

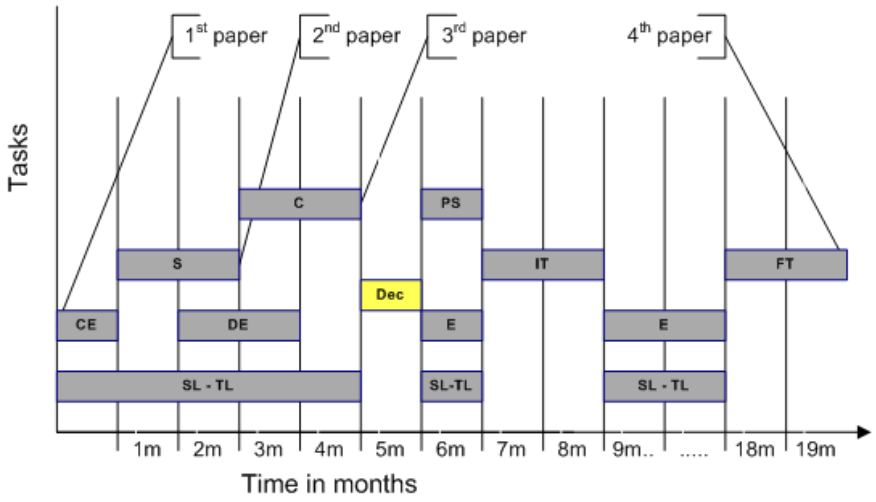


Figure 3.1: Plan in months

Testing will be in three stages:

- (PS) First a pilot study with two users a PhD student and an MSc student. Their aim will be to play the drama a few times and give feedback on what should be tested or asked of users, what needs to be adjusted before testing and what may be expected from the initial test.
- (E) The engine will be adjusted with respect to feedback from PS.
- (IT) The initial test should take place in February - March and the main purpose is to check for bugs or faults and discover what needs to be adjusted.
- (E) The engine will also be adjusted with respect to feedback from IT.

- (FT) Final testing is expected in January - February 2010. Then we test the engine completely: does it generate a murder mystery, do the actors adequately portray their characters, does the story advance at acceptable times, is the characters response time sufficiently fast for real-time application.

After final testing we will review results, write a journal article for publication and write a thesis.

Chapter 4

Preliminary results

Work is already well under way on formalizing schemas with initial work submitted for publication at the *1st Joint International Conference on Interactive Digital Storytelling*, Erfurt, Germany, $26^{th} - 29^{th}$ of November, 2008, pending acceptance on 15^{th} of August, (see Section 4.1).

The decision algorithm that the agents use has been implemented in an initial test application and the result published in [Ari07], (see Section 4.2). We also use the Dynamic Plot Generation Engine (DPGE) [Ari08] to create the initial plot and make up of the characters, (see Section 4.3).

4.1 Structuring Schemas

The drama is in three acts and each act is composed of multiple overlapping schemas. The director overlooks the emergence of the drama and uses schemas to direct the drama by giving the actors appropriate schemas to play out.

The schemas do not occur in a strict sequential order. Instead the schemas are overlapping and actors are typically playing out multiple schemas at any given time. The actor uses the schemas to determine which action to carry out.

The type of centralized command of independent processes that we use can be seen in many large computer systems where there is typically a scheduler that runs independent processes in a predefined order. The processes handle some tasks that can be everything from simple data loads up to a very intricate program that filters and manipulates data in complex algorithms. The processes contain the algorithms for carrying out their tasks and the centralized command is completely ignorant of how the processes work. The only job of the centralized command is to run the processes. This architecture is used because it is highly maintainable, easily extendible and very scalable.

In our solution the central overseer, i.e. the director, is more intelligent than the scheduler just described. The director takes active part in scheduling the schemas in response to the emergent drama. Our actors are also more complex than most batch processes but the architecture remains the same.

To better understand the structure of the schemas and how they are used to structure the emergent drama, we will first look at their external structures and how the director uses schemas to direct the emergent drama. We will then look at the internal structure of the schemas and how actors use schemas to aid

their performance.

4.1.1 The External Structure of Schemas

The external structure of the schemas are tailored to the needs of the director when the director is deciding which schema to deploy.

The drama has a finite set of actors that each plays a specific character $\mathcal{C} = \{c_1^l, ..., c_I^l\}$ and each character is of a specific level $\mathcal{L} = \{1, 2, 3\}$. Level 1 is a key character that plays a greater role than any of the other characters, the murderer and typically two suspects are level 1 characters. Level 2 are secondary characters that are important but have a shallower live story than the key characters and do not take as great a part in the drama. level 2 characters are the victim and those suspects that are not key characters. Level 3 characters are the servants, shopkeepers etc. they will have very limited live history and roles to play.

This simplifies computation because the director only needs to deploy schemas that sufficiently satisfy the key characters goals and the lesser second level character goals rather than needing to satisfy the goals of the whole set of characters. Also, this results in that the director can progress the drama as soon as she has deployed schemas that satisfied the current goals. This means fewer schemas and a faster more engaging pace for the overall drama.

As described in the section "The Murder Mystery Drama", the drama is in three acts. The drama can not move between acts until the objectives of the acts have been adequately satisfied.

Act I. The body of the murder victim must have been discovered and the key characters must have had their key characteristics exposed. For example if a key character c_1^1 is to be intelligent, playful and curious then c_1^1 needs to have played out actions that are intelligent for a value above a given threshold $\mathcal{T}$, and the same for playfulness and curiosity.

Skilfully winning a chess game or making 3-4 correct estimates about for instance the age of old furniture or calculating something on the fly would be sufficient. The algorithm summarizes the percentiles to see if it has reached the threshold $\mathcal{T}$. If it is a level two character c_1^2 then it would not need to show its characteristics for as high a threshold $\mathcal{T}$ as a level one character. A level 3 character c_1^3 does not need to show his characteristics over a given threshold $\mathcal{T}$ because they are intended as a possible fill in when and if needed.

The directors part is to give the actors opportunity to show their characteristics by choosing schemas that would be a good fit for the actors.

Act II. All relevant clues must have been revealed by the end of act II. Specifically the motive, means and opportunity of the murderer and the other 2 key characters. Additionally clues must have been revealed that show that none except the murderer had all three, motive, opportunity and means. when we say revealed then we do not mean that the clues are explained in detail such that the player immediately picks up on them. We mean that for instance when a suspect is being interviewed then there is perhaps a gap in her recount of where she was at the time of the murder that could have given her the opportunity. The player needs to pick up on the gap herself.

The directors aim is to deploy schemas that enable the actors to reveal relevant clues and many clues that are liable to sidetrack the player.

Act III. The murderer needs to be clearly shown to be the only one to have the motive, means and opportunity. At the very climax then the true motive is completely revealed and she is shown to have means and opportunity by step by step deduction. Here the director needs to deploy schemas that direct the actors to start this final sequence of the murder mystery drama.

Each schema has a finite set of roles $\mathcal{R}$ and each role is annotated as being essential or non-essential $\mathcal{R} = \{r_1^e, ..., r_n^e\}$. Essential roles (annotated by superscript e) are needed to play out the schema and non-essential roles can be filled to add to the entertainment value or because then the schema better satisfies the current needs of the drama.

Each role r is annotated with a finite set of characteristics $\Theta = \{\theta_1, ..., \theta_m\}$ that it supports. The characteristics also have a numerical value attached to them that represents how highly that characteristic is supported by the role. For example the role of a suspect in an interrogation is good to show characteristics such as $\Theta = \{0.8 * intelligence, 0.7 * gullibility, 0.9 * arrogance$ $, 0.3 * playfulness, 0.1 * competitiveness, ..., \theta_m\}$. This is just an imagined example and it will require a skilled author and serious testing to set these parameters right for the drama.

The director uses the set of characteristics Θ to match the roles to actors trying to deploy schemas that best compliments the various characteristics of the characters. The director is not in a good position to make decisions about direct interaction with the player. Because the director would need to be constantly aware of everything that takes place including the internal state of every character in the drama. This would quite rapidly escalate into an intractable computation problem for the director.

The schemas themselves are annotated by what type of clue they can reveal and which act they belong to. The director uses these annotations to filter away schemas that are not appropriate for the current part of the drama. For instance, the director will not consider deploying the *find the body schema* until the victim has been properly introduced.

Let's take the interrogation schema as an example of the external structure of schemas. There must be a suspect to interrogate and there can be some witnesses and some policemen present, This schema would be deployed multiple times during the drama:

- Drama annotation: can be used in act II only, reveals motive and opportunity to a large degree and means to a small degree.
- $\mathcal{R} = \{Suspect^1, Witness^0, Witness^0, Witness^0, Police^0, Police^0, Police^0\}$.
- Suspect: $\Theta = \{0.8 * intelligence, 0.7 * gullibility, 0.9 * arrogance, 0.3 * playfulness, 0.1 * competitiveness, ..., \theta_m\}$.
- Witness: $\Theta = \{0.4 * intelligence, 0.8 * gullibility, 0.9 * arrogance, ..., \theta_m\}$.
- Police: $\Theta = \{0.8 * intelligence, 0.8 * gullibility, 0.9 * arrogance, 0.9 * competitiveness, ..., \theta_m\}$.

4.1.2 The Internal structure of Schemas

As we defined in the subsection on external structure of schemas, each schema has a set of essential and non-essential roles $\mathcal{R} = \{r_1^e, ..., r_n^e\}$. Each of theses roles has a finite set of actions $\mathcal{A} = \{a_1, ..., a_I\}$. Each action is annotated by what characteristics and feelings if any it would show. We say that there is a finite set of characteristics $\Theta = \{\theta_1, ..., \theta_m\}$ and a finite set of feelings $\Phi = \{\phi_1, ..., \phi_k\}$. Each action has a set of feelings and a set of characteristics. Each set can be empty because some actions do not show any specific characteristics or feelings.

For instance the action a_1 = taunting shows characteristics θ_1 = playful, θ_2 = arrogant and the feeling of ϕ_1 = superiority.

The actors use the characteristics Θ of each available action a to choose an action that best match their characteristics Θ and they use their set of feelings Φ to choose between actions dependent upon the situation each time. They match their sets of Θ and Φ with the available actions sets of Θ and Φ and pick the action a that is the best match. The only available actions are the ones that the actors have access to as part of the roles they are playing each time.

The actors are *on the spot* and are able to decide on an appropriate action with respect to the current state of feelings of their character and the current interactions from other actors and the player.

We see a man feeling ϕ_2 = *angry* as being θ_3 = *aggressive* character if he shakes someone and we see a man feeling ϕ_3 = *happy* as a θ_1 = *playful* character if he shakes someone. The action of shaking another person will be annotated with both aggressive and playful and the actor can choose it both when she wants to show an angry character being aggressive and when she wants to show a happy character being playful. The player can be safely trusted to interpret it as intended because the player will have seen a happy character laughing, smiling and in general showing happy actions, equivalently the angry character is showing other behaviour descriptive of anger.

It may be that a character should show playfulness when happy but not when she is angry. This is done with a Bayesian net that the actor uses to gouge the current status of the character she is playing. The author designs the characters by drawing a Bayesian network. In this network the author can specify a positive correlation between happiness and playfulness, i.e. the character will be more playful when happy. In addition the author can for example specify a further negative correlation between anger and playfulness, and thus create complex interactions between character traits.

The actors goals are to engage the player and to support the drama progression. The actor is trying to show the characteristics of the character that she is playing above a given threshold $\mathcal{T}$ and to meet any other goals that she needs to meet with respect to the unfolding drama. Because the actor is responding directly to the player then she may find that showing other characteristics than the director intended will better serve these goals. This is good because it increases the probability that the goals of the act will be reached in fluent response to the actual interaction from the player and other actors.

4.1.3 Schemas vs. Structures in Other Systems

Since Facade uses narrative structures called beats which coordinate the characters then it is good to distinguish beats from schemas. The schemas are not authored in the same way as the beats. The schemas do contain all actions that go with that schema but these actions are not explicitly coordinated as in Facade although they are in some instances structured with partial ordering. It is still up to the autonomous actor to decide which actions to execute and in which order, time and manner to execute them in. The actors in DED, in contrast to Facade, are playing in more than one schema at a time. It could result in a deadlock in many cases if they where explicitly coordinated by one schema, as described in Facade, because it could lock resources needed to execute actions from other schemas. Additionally many of the schemas will be deployed multiple times in any single run of the drama, for instance the *interrogating suspect* schema.

FatiMA structures the emergent drama with narrative episodes which can be represented with a state machine. This is contrary to the schemas in DED which take place concurrently. An actor is playing in more than one schema at any given time and not all the actors are sharing the same schemas. Additionally some schemas will span the whole of the drama, for instance actors background story, and are difficult to view as states that are entered or exited. Although it may be theoretically possible to draw a state machine of the schemas then in praxis it is infeasible.

4.2 Agents Decision Algorithm

The schema also contains a Bayesian net that stores any knowledge that is necessary or useful for the actors to play the drama. The actor uses Bayesian networks as a knowledge base and to describe her beliefs of other characters and the player and the state of the drama environment. The Bayesian networks are extended to represent a Multi Agent Influence Diagram (MAIDS) which the actors use to decide on which action to play out.

This has been tested on actors with a knowledge base of over 3000 nodes in a project called Rational Dialog in Interactive Games (RDIG) that was published in [Ari07]. The actors use their knowledge base to generate sentences and replies and use MAIDS to calculate an equilibrium according to game theory [FT91].

Tha actors are able to evaluate the set of possible actions not only by what they themselves think but also by how they expect other characters may think and act, they have *theory of mind*. Moreover the agents add new knowledge from their environment to their knowledge base.

The MAIDS have a linear growth [KM03] with respect to the number of actions considered each time.

4.3 Dynamic Plot Generation

To create the initial plot of the drama each time and to create the initial knowledge base we use the Dynamic Plot Generation Engine (DPGE) which has been published in [Ari08]. The engine has been tested in various contexts and proves to be easily connected to other applications and flexible to divers needs.

The first test of the applicability of the engine was to create a limited application that showed the plot created each time and provided a simple "who dunnit?" game. That game showed clearly that each new plot generated was distinct and complete.

The "who dunnit?" game provided the player with predefined logical conclusions based on the plot and showed that each plot was consistent such that the murderer and murder weapon could be discovered by deduction.

The engine was also connected to the Hexia dialog control system [WI04]. Hexia provided means to interact with the engine through MSN Messenger. This provided an interactive mystery where the player could talk with a NPC named Theresa and ask her to perform actions on scene such as "open drawer", "read letter" and "look at desk".

At the beginning of each game Theresa greeted the player and described the scene. The player then needed to tell Theresa what to do next and she then told the player the results of her actions.

As an example the player could have asked Theresa to look at a desk and Theresa then informs the player that there is a drawer in the desk. The player can then ask Theresa to open the drawer. The player does not need to indicate which drawer as the Hexia dialog control system is contextual, it is able to preserve context in a dialog. Theresa will then attempt to open the drawer and if she is successful then she will describe the content of the drawer, otherwise she will describe the problem, e.g. "the drawer is locked!" At any given time the player could frame a suspect and get informed by the engine whether she was correct or not. The player can only frame suspects that she has become aware of in the game.

This implementation of the engine was demonstrated at the Reykjavik Artificial Intelligence festival (2006). Those who tried it where successful in playing the game and deducting who the murderer was after a few attempts. It should be stated that no formal tests where done that would prove this.

Authoring the dialog for NPC Theresa took less than three 40 hour work weeks.

The DPGE has also been used to provide a knowledge base for autonomous agents in RDIG [Ari07]. It created a background and common understanding of the world for the agents created and defined relations to other characters.

When creating the agents then first the plot is created and then the plot is used as the initial configuration of the world. Each agent is created from the plot. The agents knowledge can be configured such that the murderer knows everything about the murder but that other agents are fairly clueless but still have the sufficient knowledge base to realize that if they find a bloody knife then that knife is likely to be the murder weapon, especially if they know that the wound looks like a knife wound. This is essential so that the characters can decide on what to say when chatting with other agents or the player.

4.4 Implementation

Implementation has started in Libsecondlife [lib08], which is a library to program bots that can log in and act in every way as an avatar in the Second Life virtual world [sl08]. Second Life is a good test bed as there we have access to a very large

pool of testers and because of Libsecondlife which we have tested sufficiently to determine that it is sufficiently robust to support our implementation of DED.

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