Puppet Blueprint

on

Concepts and Plans for Year 3

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Preface

To understand how useful this document is to the consortium and why, the main characteristics of the project background and the two first project years are briefly reviewed.

Background. Virtual Reality technology of today presents the possibility of creating artificial worlds with arbitrary props and inhabited by autonomous agents. These agents may be programmed to show life-like behaviours, to perceive the surrounding (virtual) world, and to interact in real time with one another. The events of such a virtual world (VW) are potentially intriguing as the actions of the autonomous agents may be unpredictable but still rational, and they may be observed at any time and from any viewpoint. Hence it may be considered as some kind of theatre.

The technology may also enable the possibility of an observer participating in the events of the VW through an avatar representation. An avatar is like an agent but without autonomy, as it is controlled by the user (here the "participating observer"). The user may achieve an experience of being immersed in the virtual world with its props and autonomous agents. He/she may interact in real time with the autonomous agents, and hence consider them as playmates.

In the light of the ESE call for proposals the above was associated with children's play with a Puppet Theatre, and how children may learn and educate themselves through such play. A multidisciplinary consortium was formed to develop and experiment with "The Educational Puppet Theatre of Virtual Worlds", based on the theoretical early learning framework of "Learning through Externalisation".

The Project Programme of the PUPPET Project boldly suggested development of ambitious "Virtual Puppet Theatres" (VPTs) including a new agent technology, which allowed agents to be either fully autonomous, fully "hard" scripted, or any combination there between on continuous scale.

First Year. The early learning team (EL team) developed and thoroughly described an EL framework, which was mapped into a detailed specification for a first VPT. This framework, and hence the VPT specified, mainly relied on the more explicitly scripted version of the agents, and consisted of an explicitly constructivist 'conceptual model' for the system, based in the original PUPPET proposal, describing a farmyard (chosen for familiarity and age-appropriateness) with 'levels' of activity that the child could engage in, e.g. constructing character appearance, emotions and behaviours. Extensive field work went into this model, to ensure that it was appropriate for the children of the age envisaged.

The construction team (CON team) developed a system design intended to meet these specs, but based on the philosophy that the newest aspect of the technology, the autonomy, was to be implemented as a base, and subsequently extended with the graduated scripting capability. The system comprised a platform with the world model and a visualiser, a communication and action layer, a layer of Low Level Agents (LLA) for the "mechanical" and re-active capabilities, and High Level Agents (HLA) for the reasoning and active capabilities.

However, the full implications of real time perception, planning, and action, for active and interacting autonomous agents were to be learned the hard way. Further, the ambition of combining the full autonomy with full pre-scripting within the same agent architecture appeared to challenge an inherent contradiction, autonomy versus pre-scripting, for which there was no obvious resolution. In practice, the development of the VPT with its life-like autonomous agents, was hampered by technical difficulties and hence delayed, and the extension with pre-scripting appeared as an unlikely achievement within the project.

The potential of the capabilities of autonomy (when they eventually would work as intended) and its impact for EL and drama were very hard to imagine. Since the constructivist basis for the first prototypes were not going to be realised at this stage we had to rethink the EL basis for the work.

Second Year. During the second year of the project, the analysis of the elements involved by the drama team, provided a categorisation of these elements. The virtual theatre with autonomous agents can be construed as corresponding to a sort of improvisational theatre, and when complemented with an avatar representing a child, this child could experience a situation of improvisational play with the agents, alike the situation of playing with other children in the real world. This formed the basis for the development of a dramaturgical framework providing a structure that enable some control of and directions for the improvisations likely to take place, when a child was playing with the VPT.

The dramaturgical framework constitutes one possible “Trinity” of the project’s: Technology, EL, and Drama, and forms the basis for the project’s third year with prospects of results of great interests for all partners and for the ESE initiative.

1 Introduction

The purpose of this document is to review the conceptual status of the project, describe the development of a framework for uniting the project's multidisciplinary efforts, and plan the work of the project's last year.

From the project's "Project Programme" we have the following definition:

> The objective of the PUPPET project in the field of early learning, E L, is to develop and investigate the value of a new virtual reality environment, the "Virtual Puppet Theatre", (VPT), based on a theoretical framework of "learning through externa lisation and improvisation". Hence PUPPET aims at extending the current forms of early learning through play by developing a range of novel individual as well as collaborative interactive environments - using a theatre metaphor.

This interdisciplinary ESE project brings together partners with different fields of expertise: technologists developing "new tools" from current technology, psychologist developing new methods for early learning, and dramaturgs concerned with structure for drama paedology.

The project has had two busy and turbulent years, where the turbulence for a gre at deal can be attributed to questions of "goals versus means", or, what is the outset and driving force, and what is supporting effort. Such questions when not resolved create polarisation and tension between participants. More concretely the questions may be coined as:

> (Q1) Do we have specific aspects of new technology initially selected on a vague understanding of EL, that we want to develop for EL goals defined on the basis of this technology,

or

> (Q2) Do we have new EL goals defined initially on a vague understanding of new technology, for which we want to develop technology defined on these EL goals.

These two questions point to two different approaches to the above common project objective, where the leading ideas are different and the roles of partners are different. The formulation of the objective is "cleverly" (or unfortunately) designed ambiguous and open to both interpretations. The first question relates to the philosophy underlying how the project came about asenvisaged by a technologist, and the second question relates to what developed naturally during the first year.

The following sections describe in more detail the rationale behind each of these approaches, and how they are united through and with a dramat urgical framework into a trinity. Subsequently the requirements to technology are drafted and EL goals are formulated to emphasise the aspects particularly facilitated by the framework. Eventually a plan for implementation and evaluation of the final VPT is developed, and expectations to project results are discussed and concluded with hints on future perspectives.

> Hence we try to put together the emerging perspectives of the potential of the technology for learning, e.g. the value of agents for interaction , with a different kind of dramaturgical perspective in the context of construction of innovative 3D interactive worlds. This is the interdisciplinary perspective that partners are aiming at.

In the sequel we refer to VPT -A as the system evaluated by the e nd of year two, and to VPT-B as the system available at the end of the project.

2 An ESE Trinity: Technology, Early Learning, and Drama?

The purpose of this section is to discuss relevant essence of each field to find a commonality, - a **Trinity** of Technology, EL, and Drama, you might say – which enable the three disciplines to mutually reinforce one another to optimise the results of the interdisciplinary endeavour.

Technologists want to explore the potential of 3D -VR and real time autonomy of agents, and feel strongly that this, including emergent behaviours via interaction, has much to offer for EL.

Psychologists are resolutely enthusiastic about the potential of new technology, but feel strongly that it is essential for the child to be able to interact with the system in more than an 'explore' mode if the EL/ESE goals of PUPPET are to be met. They are at one with partners in wishing to iteratively develop the technology by involving users as key technical developments occur. They have consistently argued for autonomous agents as a means for developing narrative in the Virtual World.

Drama people are intrigued by the aspects of the autonomy and have the urge and the skill to find or create dramaturgical structure, that keeps the likely events to the point.

We expand on these different points of departure in the search for our trinity

2.1 Technology and a Virtual World of Autonomy

The core technology exploited in the PUPPET project is that of autonomous agents (AA's), living within a real time 3-D virtual world, continuously sensing this world, and continuously acting upon it by holding together the agents' accumulated knowledge of the world, and the agents' goals and desires. The technological aim is to design the AA's to be interactive, and unpredictable, yet rational:

1) Interactive

> AA's must have a behavioural repertoire, which enable them to engage in meaningful interactions with other agents and avatars.

2) Unpredictable/non-trivial

> AA's must perform actions within their behavioural repertoire in such way that it is not possible for an observer in every detail to predict what an AA will do in a certain situation.

3) Rational

> AA's must be designed to act in response to situations such that the actions performed by the AA can 1) be read/understood by an observer, and 2) in retrospect make sense to the observer, or at the very least show consistency.

Put briefly, these three requirements will result in a virtual world where events will happen, the events will be interesting or even unexpected/surprising, but there will also be structure. I.e., over time it will be possible to infer relationships between causes and effects, by trying to characterise situations and understanding what caused an agent to do something.

Virtual worlds inhabited by such AA's can be experienced in two different main modes

(i) as a purely passive experience, simply by watching the events that take place, and

(ii) as an interactive experience, by communicating/interacting with the world through an embodiment (avatar) in the virtual world.

The interactivity and unpredictability of AA's have the potential to make experiencing the virtual world interesting. Experiencing the virtual world in the interactive mode, through an avatar, holds the special promise of making it possible for the user to:

- systematically test the cause-effect relationships, and
- provoke actions and influence overall story development by play ing off and utilising either intuitively expected cause -effect relationships, or cause -effect relationships which have been inferred from past experience.

A virtual world populated with such AA's will exhibit an illusion of life and a chain of events will take place forming a story. The story can evolve in several directions, but will be framed by and composed from the innate behaviours in the AA's. In the interactive mode the user can, via its avatar, 'push' the story in certain directions.

A different mod e of experience, which can be combined with any of the two main modes mentioned above, is that of allowing the user access to influencing/setting various parameters which form the premises for the story that evolves from the actions of the AA's. Such premi ses include the cast of agents (adding or removing agents to/from the cast), and influencing the personality of agents (e.g. making an agent predisposed to anger). Using this mode of experience the user can explore other dimensions of the cause-effect relationships within the agents.

In view of the above the main technological challenge becomes that of designing AA architectures and associated AA scripts (behaviour specifications plus cause -effect relationships). These architectures and scripts must be suf ficiently general to support interesting story developments regardless of the exact cast of agents, regardless of whether the user is interacting through an avatar, regardless of the actions of the avatar, regardless of the personalities of the agents in the scenario etc. If this challenge is met, the virtual world can be said to show emergence. I.e., things may happen which were not explicitly planned a priori, and 'the whole is more than the sum of the parts' (where the whole represents the stories that c an evolve and the parts represent the individual behaviours of the agents). Agents become flexible building blocks, which can be used evolving a wide range of story lines.

The life of such AA's, and users' interaction with them, requires the support from a suitable Virtual Environment (VE) platform - a simulated virtual world. This platform must

- communicate the dynamic virtual world to users through real -time 3D graphics and sound rendering,
- support AA's by enabling them to sense the virtual world and to act on/in it, and
- provide the user with a range of interface facilities enabling the user to control various aspects of what events take place in the virtual world.

We elaborate more thoroughly on the subjects of AA's and the VE platform in section 3.3 and on, but first let us analyse the relationships between on one hand a virtual world populated with autonomous agents, as sketched in this section, and on the other hand concepts related to theatre and dramaturgy in order to get an understanding of the kind of interaction that can be supported or achieved.

2.2 Avatars, Autonomous Agents, & Improvisational Theatre

Interactive, unpredictable and rational agents co -operating with the unpredictable behaviour of an avatar to produce stories, seems to be a tall order. Emergence of narrative within a virtual environment populated by agents and avatars is a question of finding a balance between what is pre -scripted and what emerges. The above description of agents and their needs could be met by suggesting the use of theatre and improvisation as point of departure.

Theatre FOR an a udience means A impersonating B while C looks on. Theatre WITH an audience means that C joins the fictional universe by impersonating D. Agents can be seen as actors given a specific range of possible actions and scenarios in which they can act. Hence, the user may relate to the VE in alternative modes as suggested above.

SPECTATING MODE: The user might observe the agents act in the virtual environment, the user becomes a spectator.

ACTING MODE: The user could also be invited to join the stage represented by an avatar and act together with the agents.

While acting stories emerge, the user may both be acting and devising a story. But because we have the avatar as our representation in the virtual world and are not using our own body and voice, the relation between actor and character is complex. There is a simultaneous double perspective of identification and distance in this third mode:

DIRECTING MODE: The user might also, almost as a director prior to the acting out, make choices in terms of the agents' cha racters/numbers/appearances and thus influence the story, or it might be possible to edit elements together in a storyline after the acting out has taken place and has been recorded by the system.

2.2.1 Theatrical improvisation

One possible model for the agent/avatar interaction is the theatrical improvisation:

Improvisation means not foreseen, or prescribed. Theatre is usually seen as a highly structured event that has been rehearsed many times, and can b e repeated. Improvisational theatre is typically not really rehearsed. No one knows what might happen next. To participate in an improvisation has been described (by Keith Johnstone) as walking backwards. You can see where you have been walking, but not where you are going. Very muck like our everyday life, only this happens in the protected world of fiction.

To improvise is to play. When children play they improvise. In the play there is a suspension of any one rational cause, aim or direction, in other wo rds one can observe a certain suspension of disbelief. Improvisation can, just like a play or a game, be kept alive as long as there are interesting initiatives that surprise and give new impulses for the players to continue. It is our experience that chil dren are highly skilled improvisers who at times can keep up their games and playing for hours on end.

Improvisation means that one interacts constantly. So the use of improvisational theatre must rely on a very high frequency of interaction. One can, of c ourse, influence the situation in many different ways. The range of interactive impulses is wide. In addition to this one can add that the significance of contributions often will be fairly unpredictable which again means that improvisation depends on the participants' abilities to take initiatives and accept impulses from the partner(s), in short, the ability to say: "Yes" to almost any situation and act in response to the actual input to further the play/story - building of a situation or character etc. So significance is being built accumulatively. Looking back one might begin to get a notion of the road one has been walking on and thereby some hints as to which direction the improvisation can go.

To improvise then, can mean to create stories through inter action. Together with the agents and the virtual environment the user and the avatar create what we tend to consider as material. Building material is like putting money in the bank. One might want to let it stay there for some time while one considers how to get the best interest from the investment. An improvised story is most often uninteresting as a plotline in its raw form. A story gradually built on improvisations might become very interesting, though. The possibility to record and edit the material c an improve the pleasure of storybuilding. Material can be used and recycled several times to build an interesting plot or story. The actual editing is also, of course, usually very exiting for the user, who is in the position to decide what material to use and what to throw away.

A good improvisation demands that the participants become immersed in the fictional here and now. So one aim is simply to learn to be present in what is happening here and now. This might mean to work towards avoiding as many dist racting factors as possible, i.e. interface or navigational problems that can interfere with the experience of acting in a flow. This flow is probably best described as an ability to master a kind of double consciousness; something is happening to me in th is fictional universe here and now and I am able to sense my own contribution, to "select" something that make things happen. It goes without saying that we see a strength in thinking about improvisation from such a phenomenological approach and perspectiv e. The avatar provides a significant third position: The avatar is manipulated by me, the user, but it is not really "me" in there in the virtual environment; there is thus a distance between me and my representative. It is not me, but it also is not not -me.

To improvise means to be able to sustain this double consciousness; simultaneously to be in the situation, to exper ience the other agents and their action and to interpret these actions. One has to be aware of ones own reactions to notice what is happening in order to be able to react in a qualified way

(which could be seen as a kind of "planning" for new actions) and then re-act. So in improvisation one would look for and feel the impulse; judge the situation - and react - a "strategy" very much like what we rather unnoticeably do in everyday life, but with a higher awareness of choice making. This means that theatrical improvisation usually has a slower flow than normal conversation or action-reaction output. Or to put it in a different way: Improvisation usually would allow the participants some more time to consider the situation before and after each action. It might feel like tens of a second, a very important (and enjoyable) possibility to "stretch" time and space all the same. This stretch is enforced by the avatar-position in the virtual puppet theatre: pending between identification: I am the avatar and at a distance (I am observing what happens to the avatar).

Improvisations means to train ones power of judgement. One must get an idea of what one wants to investigate. If you have a notion you learn to be able to follow it. The notion is only a vague idea of the contours of a story or a plot, but one need to follow ones notion to find the right time to invest a particular action; an action that can further the story in what feels like a meaningful way.

2.2.2 Rules and differences

Improvisation is based on a set of rules. These rules can be very close to real life rules or rather far away from them. What is important is, that the participants learn to obey the rules and negotiate the rules and the possibilities of a story or plot from within - or rather in the flow of interaction. It goes without saying that in improvisational theatre a lot of what happens has not been preplanned. This is, of course, what makes improvisation different from a full performance. Leaving a lot of decisions to the performers makes a difference. This difference is what we would like to see as a difference between theatrical and dramatic fiction.

However, there is another difference, which is as important as the one between theatre and improvisational theatre. From the fact that improvisation is relatively opened it would be wrong to infer that it is completely uncontrolled and thus without dramaturgical significance. It is important to insist on this point. As much as improvisational theatre differs from a theatre performance, it differs from events happening in real life which unfolds without dramaturgical constraints. Thus, improvisational theatre represents a middle field of order between the contingency and openness of ordinary life and the fixed form of the work of art. Why? Because even in improvisational theatre you have to set up constraints in the form of rules for possible actions. Everything is possible - anything is not.

We need to point out a third difference of kind which may very well be the most important for our thinking about VPT A and B. Improvisation may be purely situational, and it may turn towards the narrative. In the latter case you have entered the causal-linear time whereas the situational improvisation is concerned with events that have no definite telos. Or phrased a little differently; events that are so interesting in themselves that the final outcome is not what makes them dramaturgical poignant. If one goes for the purely situational, one simply needs to outline characters who can interrelate in interesting ways, i.e. they can pursue different projects that will conflict with one another. If one takes a step into the narrative, one will attempt to make constraints that produce developments in the cause of events. In this form of improvisational theatre, one has to do with a continuum with many differences of degrees: from a very open-ended through a semi-closed to an almost closed narrative. As we believe that the construction of intelligent autonomous and semia utonomous agents beg for an investigation of the purely situational type of improvisation, we have tried to stay in this area when constructing the concept for a “VPTA+”.

These arguments form our basis for suggesting that the virtual puppet theatre could be developed according to rules for improvisational theatre.

2.3 Improvisation and Children’s Play

The possibility of having an ‘agent world’ underpins many of the potential EL benefits of the PUPPET project. During the normal course of improvisational play the child is dealing with ephemeral actions: they occur and are gone and the child has no time to reflect on them. In addition, they are, by definition, products of the child’s own cognition. By contrast, autonomous agents offer the possibility of characters, inside play, which are not of the child’s making. These agents are imbued with a ‘personality’ of lesser or greater complexity, demonstrated/discoverable e.g. through their behaviours.

This means that they offer the potential for the child to 'read' the motivations and intentions of the characters in situations, which are still 'playful'. The cognitive benefits of this can be referred to the child's developmental transition to decentred allocentric thought (c.f. Piaget). Thus, for PUPPET, we hypothesised that reading of agents will be a useful means for exposing the child to situations where decentring skills can be polished. In terms of the development of the VPT this requires a sufficient expressivity, e.g. expressions, behaviours, vocalisations (speech and non-speech) to allow adequate legibility of internal states. This is what is intended by the technological aims of section 2.1.

At the same time there is a distinction to be drawn, prima facie, between the situation of 'just' observing, as when the child watches agents behave within the 3D world, and interacting with the agents in a more direct fashion. In terms of the modes mentioned in section 2.2, we can see how these will reflect a spectrum of cognitive complexity – from spectating to acting. This has two possible forms, along a spectrum as previously pointed out.

The first is that of direct engagement, by allowing the child to act through an avatar. We do not claim here that the child 'becomes' the avatar (cf. Bowers), but that such assumption of character lends itself more naturally to, something like, first person involvement in the ongoing play. Thus we retain the benefit of playfulness, through the situation, but also – we hypothesise – increase the motivation for reading others, ipso facto, because of greater involvement. A central idea here is the dual consciousness of the observer/participant. We know that this is a key component of the move towards cognitive decentring – experiencing and cognisance of 'own experience' and 'other experience'. In this context the elusive sense of telos engendered by the improvisational ethos of the VPT development has a particular interest. In everyday problem-solving – pretty much the whole of life – there is an inherent nomological processing bias: we seek the elusive rule, the cause-effect link that will produce a semblance of order from chaos. As section 2.2 points out, there can be a differently-situated phenomenological imperative in PUPPET. The constraint satisfaction that goes on in PUPPET is not the 'normal' problem-solving one, rather it partakes of the existential skittishness that one can see in young children – an interest in the 'here and now' and not an outcome-oriented leitmotif. Thus PUPPET has moved toward capturing the essence of improvisational play, but through the device of reconfiguring the potential of a new and powerful technology.

The second kind of move towards active involvement reflects our emphasis on externalisation as a route to cognitive mastery. Recalling the emphemeral nature of a lot of real-world play we believe that the child might benefit from 'stepping back' from the action. Just as dramaturgy offers a taxonomy of roles, such as actor/director, we believe that allowing the child access to the product of his/her imagination by allowing some degree of authorial control as well as direct participation. Thus acting in the world, e.g. by altering the states of characters/settings in a play, allows a reflection on the overall structure. This is a metacognitive skill, a kind of 'learning to learn'. In turn, this requires of the PUPPET environment, some provision of authoring/directing tools, in addition to the autonomous agent/avatar provisions of VPT-A. Here we begin to see the centrality of the 'Directing Mode' of section 2.2. However, we have to be alert to the potential for interesting cognitive effects of the child taking on multiple projects which might not all fit with each other – with the necessity for identifying constraints that will solve these dilemmas. Again PUPPET's emphasis on the value of externalised cognition for dealing with such problems should be flagged in this regard. Of particular relevance, when discussing specific tools, would be comparison of those for altering external parameters (e.g. appearance/setting) as opposed to internal ones (e.g. the happiness levels) of agents. We know from previous work, e.g. Hayes-Roth, that children who use external controls for affective agent states seem to understand the concept of affect better. Here we extend this to complex interactions over which the child has control and to see their possible effects on the child's ability to handle improvisational modes – situational and causal-linear, cited above. For example, one hypothesis is that tool-provision will vitiate the sense of improvisation, but, again, as the dramaturgs point out, improve is not 'merely' anything-goes, but rather carefully worked in terms of its underlying structure. Will the children see this?

3. "The Black Sheep Scenario", A Trinity Framework

A framework is developed from dramaturgical observations, and it is analysed from an EL as well as a technical viewpoint.

3.1 Framing Improvisational Play in a Dramaturgical setting

The art of improvisational theatre is the art of framing: creating interesting scenarios for the improviser to be and act in. One could suggest that our programme should be able to create frames that could set up some kind of progression that would allow the user to experience that s/heis making a story emerge. To do this, we try to think in terms of framing significant units of improvisational theatre and build in a succession of frames until there is a story created.

When the user has experienced more than one improvisational unit, he/she will start to combine the two units in a way that seems meaningful to the user, in other words s/he will experiment with the relation between the two stories.

Meaning emerges for a user in small units. When one tries to assemble many units in complex relations one is making up a fable. The way in which we establish such a fable depends on the overall dramaturgy of the entire task specified in the session. One might either follow one strict story line (high level of narrative prescripting) - which will satisfy a need for CLOSEURE, or one might discover that there are differences emerging that can not be solved easily, which make it clear that there is no single story at hand, which could lead to a consideration of new strategies, i.e.: DISSEMINATION.

The scenario that we have suggested for the first situational improvisation is leaving some possibilities open. The user must decide. This might sound abstract, but will hopefully become clearer as we present the concrete example. In order to produce our first improvisational scenario, it is important to consider how one might frame an improvisation.

3.1.1 Framed improvisation

In order to improvise, one should know who am I playing, where are the events taki ng place, what happens and when (e.g. what time on the day) These W's should be considered when one starts an improvisation.

The questions can be answered with different levels of detail but it is important that the actor - improviser does not get lost. S/h e needs clues to what is happening. The freedom to improvise and ability to make things happen depends on the framework. It must provide an adequate amount of information. One does not want to waste energy to discover or construct everything. One wants to focus on something, i.e. explore the material and its frames. So there has to be a fine balance between what is told and what is to be discovered. One of the tools to tune this balance is the way in which we apply specific rules and regulations of conduct.

In improvisational theatre the person who is responsible for starting the improvisation make up his or her mind as to what the actors/participants must know. One can have rules that are

EXPLICIT: clear descriptions of the improvisational task: e.g. you mu st help the Farmer to feed the Cow.

IMPLICIT: everybody must know that one has to discover the task while one improvises: e.g. Explore the farmyard and notice what happens.

Further, the rules can be:

SHARED: all participants are getting the same informati on. I.e. "At 12 o'clock something terrible is going to happen."

DISCRETE: some improvisers get some information that others do not get; i.e. Character A: "You want to stay very close to character B" and to B: "You think that character A stinks, so stay away! "

Different tools or techniques create different kinds of improvisational set ups - and thus different possible actions. A main task is, of course, to make sure, that there are some possible conflicting wills. To make it clear: It is quite possible to provide actors with non-conflictual improvisational tasks. We suggested this in our first draft of a VPT scenario "Fluffy Firehart", which might have been an improvisation aiming at some kind of a meditative experience of time or space. Simply being in the space. We would very much like to experiment with autonomous agents and environments that would provide the user with such possibilities. However, we opted for another strategy in our first VPT experiments. Due to a need for interactivity and plot and some stress on realism and recognisability, we decided to investigate a conflict orientated dramaturgical structure.

In a dramaturgy based on conflict one will usually have one or more characters who try to achieve something specific (a goal) at nearly all costs. All obstacles met on the way will be dealt with in order to make sure, that the protagonist can fulfil his or her goal. In classical dramaturgy will is the king of matters. If there is no character with a far reaching will, there is no action. If there is no second character with a contradicting, or at least another will, there will be no conflict. Thus, as Hollywood tell us: What is more important than anything else is that the main characters have clear intentions, aims or projects. Drama is seen to appear when the protagonist meets resistance or obstacles as s/he tries to fulfil his or her intention(s) and so becomes the driving force of action.

In drama obstacles will most likely take the form of another character's action, i.e. the antagonist attempts to fulfil another intention. This is how conflict is created: When the antagonist acts according to a main intention, it will represent a difficulty for the protagonist and vice versa. This is where dramatic structure differ a lot from real life as we only rarely set our minds to work towards the achievement of one particular project to which all our small actions (like brushing teeth, watching movie and the like) can be referred.

Constructing significant dramatic structure means to find the interesting clashes of opposed wills. Principally this also goes for improvisational theatre, even if one is looking for the development of situations. To create situations in which interesting action can emerge one usually establish possible relations between the characters along a conflict axis.

3.1.2 Dramatised actant model

At this point our study of functions in conflicting worlds might prove helpful. Based on studies of Folk Tales the Russian formalist Propp observed structural dynamics as possible driving forces in such tales. The French narratologist Greimas simplified Propp's model and described an Actant model. In its simple version the actant model describes the dynamic forces and their positions in a narrative economy. The dynamic force is called an ACTANT, which should not to be confused with an actor playing a concrete character. There are three axes in Greimas' system. A PROJECT-AXES where a given subject (a Protagonist) wants to achieve an OBJECT. On a CONFLICT-AXES the protagonist meets opposition from someone or something, an OPPONENT, which tries to prevent him from achieving this but he might also have a HELPER. On the AXES OF TRANSPORT we are dealing with those elements of the narrative economy that concern dynamic forces providing the protagonist or another receiver with the desired object. This might be illustrated in the following narratological model, which is primarily constructed to describe epic narrative. In order to apply it to our needs, we have made some adjustments. This has been done to arrive at a more dramatic model.

We have named this a DRAMATISED ACTANT MODEL. The model is a result of actual work with a) the development of a concrete scenario (Black Sheep) and b) trying to formalise and describe the principles inherent in such a construction process. We have chosen to present the formal model first, and then exemplify it with our concrete Black Sheep Scenario.

The main rationale behind our modified actant model is a drive to combine the pro- and antagonist on the same project-axis. We have also seen a need to appoint both the protagonist and the antagonist each with a helper. The helpers will of course be the opponent of the opposite part. This system is basically symmetric, and it should provide us with the most basic needs in a simplified dramatic conflict.

3.1.3 Black Sheep Scenario

The first step towards a concretisation of this model is an attempt to provide the protagonist with a will: Here we have chosen a will for order. This choice could of course be commented in many ways, we might say, that our interest in this has to do with our ideas on narrativity: that we are constantly struggling with our wish to create order out of the elements of the narrative what we call CLOSEURE. But a given text might try to" prevent" us from such closing and insist on opening the narrative again thus creating new differences and DISSIMINATE meaning. So it might be interesting to investigate how children would choose in a universe dealing with order and chaos. So we see the Farmer as our protagonist trying to create order on the farm. His helper is his faithful Dog. Order to the Farmer means herding his animals to keep them in their stables and within fences, to feed them and make them stay in their folds. The Black Sheep, however, wants to challenge this order. This is probably why it has become the Black Sheep of the farm. So whenever the Black Sheep gets a chance, it will try to destroy the order established by the Farmer. The Grey Sheep is a willing helper in this project of the Black Sheep.

Where should the avatar now be positioned in this narrative economy? In terms of complexity we distinguish between four types of agents:

INTERACTIVE AGENTS: agents that are able to respond to other agents and their actions, but primarily they are able to create their own actions based on their goals. (Farmer and Black Sheep).

ACTIVE-REACTIVE AGENTS: agents that are able to perform a set of given actions when given the right cues. They are able to act out actions, not only as reactions on what happens to them. (Grey Sheep and Dog).

REACTIVE AGENTS: agents that are able to react to other agents with a very limited amount of reasoned alternative strategies and actions.

NEUTRAL AGENTS: agents with actions completely neutral to the narrative economy.

We believe that the user should be able to inhabit all different types of agents. So even if the user chooses to be a neutral observer, the system should be able to operate. In order to achieve this goal it seems important to make the scenario like a type of perpetual machine so that it can provide the user with something to look at. We would of course hope that the actions were attractive enough for the user to go in and position herself in one of the other types of agents.

In a first version of the Black Sheep, we advocated that the user was positioned as the antagonist. So the avatar was the Black Sheep. As we do not want to prescript the user in this improvisation it should be possible to let the user decide whether s/he wants to go along and help the Farmer instead. If this happened the Grey Sheep would take over the position of the Black Sheep. We imagine that this decision could also trigger the Black Sheep so that it changed colour and became white. Exploring what it means to be a Black Sheep might also be stimulated. This also influences the way in which we might introduce the rules of the improvisation to the children.

It might prove to be an interesting field in terms of early learning, how different tasks give different learning results.

3.2 Early Learning Perspectives within the Framework

The previously stated rationale leads us naturally to a number of empirical questions about the two major EL goals which map into the dramaturgical/agent framework. These are:

- *Children's perceptions of virtual characters and decentring.*
  - Can children understand, 'read', the motives of agents?
  - How far do they treat (i.e. represent) virtual characters in ways similar to real-world ones?
  - What are the expressivity characteristics of successful readings of internal states?
  - Does interaction through avatars effect the above and can children take different avatar roles?
- *Externalisation and promoting metacognition*
  - What kinds of authoring/editing tools are children able to work with easily and what are hard, considered from the point of view of their current level of cognitive development?
  - Will there be different benefits from tools to modify external/internal states of the system?

In technical developments we plan to experiment with various conventions for depicting agent movements and expressions. The simple ones, such as gaze, personal space and speed of movements, will form the basis for this experiment. We plan to use characters with different motives in the initial scenarios, such as the Cow, who may help or oppose the Farmer in his/her goal of herding the animals. In addition the scenario allows for the provision of a variety of roles, such as 'helper' which are initially defined for the child but which may change as the scenario unfolds. Here it is of major interest to see if the child, firstly, picks up on the basic motif of 'achieving order' and, secondly, begins to construct his/her own narrative around the interactions. A further test of the child's appreciation of the scenario will be the switching of personalities between agents, e.g. the Dog goes from helpful to unhelpful.

The child's use of avatar mode will be an obvious focus, given the above. Here we plan to extend the avatar's range of expressions, an interesting proposition since it begs the question of how far capabilities between avatar and agent should be equivalent, an issue that underlines the difference between the PUPPET situation and everyday play.

Initially the child is involved in situations over which it has no control, vis-à-vis the initial settings. Gradually, however, we plan to allow some alteration of the affective dispositions of the actors as well as some of their appearance. For example setting the happiness levels of particular agents, to allow even more emergent properties for the agent-agent interactions. In this context a good test of the cognitive complexity of the system can be had by increasing the numbers of agents involved in a scenario. Here there may be issues, such as cognitive load, inherent in 'simply' adding complexity, but we also hypothesise that children may be capable of evolving metacognitive strategies for handling this by provision of the necessary tools for segmenting and replaying parts of the action, e.g. casting all sheep in a herd as similar to facilitate group behaviour.

3.3 Technological Challenges of the Realisation of the Framework

In this we first describe the overall technological requirements relating to the kind of experience-based, real-time interactive virtual environment needed for PUPPET in general and for the Black Sheep scenario in particular. Relative to these overall requirements we then describe the status of the PUPPET virtual environment platform as of the end of Year 2, and subsequently we list the technological developments that need to be performed in Year 3 to support the Black Sheep scenario.

3.3.1 General requirements

The requirements concerning the VE platform can be divided into four main areas:

- real-time virtual environment server,
- autonomous agents,
- interaction capabilities and facilities, and
- artwork.

Real-time virtual environment server

The VE server must support a complete, real-time simulation and maintenance of a dynamic 3-D virtual world. To allow the consortium sufficient freedom in developing scenarios, the platform must support that the model of the world (landscape) can be easily changed. Similarly, the looks and positions of fixed structures and props should be changeable.

Importantly, the server must provide services in support of agents acting on and perceiving the virtual world. To support the Black Sheep scenario agents must be able to move around, perform animations, utter sounds, and change facial expressions. Conversely, the agents must be able to perceive the virtual world in terms of positions of any object, and activities of other agents (movements, animations, sounds, and facial expressions). Here we mean that agents should sense these activities using a representation that allows them to react to them. I.e., it is necessary to create an illusion that is corresponding to this, and not require that the agents should perform actual analysis of body language and uttered sounds.

Finally, the VE server must be able to produce a real-time 3-D graphics rendering of the virtual world from arbitrary (but controllable) viewpoints. Similarly the sounds of the virtual world must be relayed to the user by distance-based attenuation.

Autonomous agents

Each agent in the PUPPET platform must be capable of complete autonomy. By complete autonomy is meant that each agent decides upon its actions solely based on its own representation of the world, and on its own list of goals and capabilities (behaviours). Complete autonomy is required to support changes to the cast of characters in a scenario, and changes to the behaviours/personalities of other characters (changes either performed by developers in a development/initial testing phase, or changes performed by the user as a part of a special purpose interaction).

Complete autonomy requires that each agent is capable of sensing the spatial, auditory and dynamic properties of the world. Further, each agent must accumulate and continuously maintain a model of the agent's own perceptions of the world using representations that suit the agent's processes of deciding upon actions in the world. This includes being able to sense the activities of other agents in order to respond intelligently to them.

On top of all the raw functionality of agents, each scenario developed for the PUPPET platform (e.g. Black Sheep) entails writing scripts for each character in the particular scenario. General requirements to such scripts were described in the section on "Technology and a Virtual World of Autonomy". In

view of the categorisation of the interaction as framed improvisation (sections 2.2 and 3.1), and to the support the EL goals of the platform (sections 2.3 and 3.2) it becomes relevant to use terms such as 'lifelike' and 'expressive' to describe the requirements to the behaviour of agents. In fact a technological goal becomes that of finding a way of embedding narrative structure in agents' behaviour planning, and script them to act as characters in interactive stories. Furthermore, the agents should support that the user can select behaviours for them to engage in and set internal states in them. I.e., personality traits and emotions.

Interaction capabilities and facilities

To allow the user to experience the virtual world, interact with it, and act (through an avatar) in it, the platform must give the user control over a range of degrees of freedom using appropriate interfaces (involving both hardware and software).

The user must be able to freely move the viewpoint around from which the world is rendered (graphically and audiotorially). A special PUPPET feature, which must also be supported, is arbitrary choice of avatar at arbitrary points in time. When embodied as an avatar the user must be able to perform avatar actions, in principle similar to those agents can do (navigate, utter sounds, perform animations, and change facial expression).

Furthermore, in response to the dramaturgical and early learning goals of the particular scenario, the user must have access to determining various pre-conditions for the stories occurring in the world. This includes control over the cast of characters, and their personalities.

As mentioned above this functionality has a knock-on effect on the agents as well, but in this context we are talking about the need for appropriate user interfaces, to enable the user to perform this control over the scenario.

Artwork

To complete the PUPPET platform, or rather to complete a particular scenario, a large range of artistic material needs to be produced. This includes design and 3-D modelling of landscape, fixed structures, props and characters. The latter need a range of animations, and a range of facial expressions.

Additionally, the artistic material for a scenario includes sound files for ambient sounds, and the communicative sounds (utterances) of each character.

3.3.2 Status and capabilities of current VPT-A

A PUPPET VE platform and a scenario that runs on it (together referred to as VPT-A) existed at the end of Year 2. The status and capabilities of this incarnation of the platform are closely related to the scenario, so a brief description of this also gives an understanding of the platform's current capabilities.

A scenario has been developed by the consortium, which involves 6 characters (a Farmer, a Dog, a Pig, two cows, and a sheep). Each character is behaviour-wise developed to exhibit either positive or negative attitude towards the other characters, i.e. each character either likes or does not like each of the others. These attitudes are displayed in the scenario in the way characters respond to each other when they meet. The user can at any point in time assume any of the characters as an avatar.

Real-time virtual environment server

A VE server has been designed and implemented which can load a scene description file, and can perform a real-time rendering of this scene from arbitrary viewpoints. The user can navigate in the scene using a computer mouse. Furthermore autonomous agents can connect to the server and have full control over their 3D model in the scene. The 3D models of agents are visually rendered together with the rest of the scene. Agents can produce sounds, which are also rendered to the user by applying distance based attenuation. In addition to allowing agents to perform actions (movements, animations, and sounds), the server also provides each agent with constant (10 Hz) up-to-date sensory information,

by simulating vision, auditory and tactile senses. The VE server can support any number of agents, but due to limited computing power the maximum number of simultaneous agents is approximately 10.

The server supports attaching the visual and auditory rendering point to any object in the virtual world, allowing the user for example to experience the world from the perspective of any agent.

Autonomous agents

The VPT-A is designed and implemented using a two-layer architecture for autonomous agents. This has been done in realisation of the fact that there is a substantial amount of functionality, which is the same for all agents/characters. Thus each agent consists of 1) a general-purpose functional layer, 2) an individual behaviour modelling layer. One can say that the behaviour layer decides what to do, when and why, and the functional layer decides how to do it.

The general purpose layer provides each agent with a capability to accumulate and maintain a spatial memory giving each agent its own representation of the virtual world. Based on the memory this layer provides functionalities for moving around in the virtual world avoiding obstacles, and other primitive actions such as following or avoiding other agents. In addition the agent can perform animations and utter sounds.

The behavioural layer is in two-way communication with the functional layer, and can for example trigger behaviours based on conditions relating to the spatial memory of the agent. The behavioural layer is designed so that it executes scripts which describes the behaviour of a particular agent. For the VPT-A scenario, scripts were developed which entailed default behaviours, greeting behaviours and special avatar-response behaviours for each of the 6 characters in the scenario.

The behavioural layer is implemented so that any agent can become the user's avatar at any point in time, which entails a temporary halting of behaviour planning. But the functional layer maintains full perceptual capabilities to support re-engaging the behavioural layer (and thus re-starting full autonomy) when the user selects another avatar. Additionally, the behavioural layer is designed so an agent can change scripts at run-time, supporting user-controlled changes to each agent's behaviour.

Interaction capabilities and facilities

For the VPT-A scenario user interaction consists of being able to choose avatar at will, move around as the avatar, and make the avatar utter sounds. All these functionalities are controlled using the computer mouse (plus very limited use of the keyboard).

A substantial effort was put into designing an graphical interface paradigm, and implementing a version of this paradigm. Yet, this interface was not a part of VPT-A, as it fitted poorly with the chosen scenario (the scenario did not require any functionality provided by the interface).

Artwork

A full 3D scenario has been modelled specifically for VPT-A, including farmyard, farm buildings, fenced areas, and animal sheds, plus surrounding landscape including a stream, a bridge, numerous trees and enclosing mountains.

Additionally, models plus three different animations were produced for each of the 6 characters in the scenario. The visual artwork for each character was supplemented with a number of sound files for each character. The animations and sounds were produced so that each agent could express negative, neutral, and positive attitudes towards other agents (and the avatar) in compliance with the dramaturgy of the scenario.

3.3.3 Challenges and Realistic Possibilities for VPT-B

In order for the PUPPET platform to support the Black Sheep scenario further technical developments are required, the gist of which are presented in this section.

Compared to the VPT-A scenario the Black Sheep scenario has a much stronger focus on expressing emotions and motivations. Emotions and motivations of agents need to be relayed to the observer (user), but must also be communicated among agents as they are used explicitly in the agents' behaviours. The technical support for this is one major challenge for VPT-B.

Another challenge is the support for the extended interactive capabilities the user will have in the Black Sheep scenario. Below we expand on how the requirements of the Black Sheep scenario reflect on the various elements (server, agents, interaction facilities, and artwork) of VPT-B, pinpointing the major developments to be accomplished during the 3rd year.

Real-time virtual environment server

Development on the VE server for VPT-B consists of two parts: 1) generalising or expanding on existing functionalities to comply with special needs (particularly for agent-agent and agent-avatar interaction and communication) of the Black Sheep scenario, and 2) development of additional functionalities and support tools to comply with requirements relating to EL goals.

Regarding agent-agent and agent-avatar interaction the VE server must be modified to support that agents can sense the activities of other agents (or the avatar). Each agent's activities (the intentions, or the meaning, of animations, facial expressions, and sounds) must be communicated to other agents via the sensory system. Providing this functionality is a direct extension of already existing functionality, but requires development work on the server, as well as on both layers of the autonomous agents.

Regarding support tools and additional interaction functionalities, it is envisaged that design and implementation work is required on the VE server to produce facilities for letting the child user have some authorial control over the scenario, as well as letting the child record portions of its interaction with the system. More detail on these issues is provided in section 5.1.3, 6.4 and especially 6.5 ("Adding facilities explicitly supporting reflection and externalisation").

Autonomous agents

As explained in section 3.3.2 there are two layers of each agent; 1) a functional layer which is the same for all agents, and which handles sensing, spatial memory maintenance, and performs actions such as collision free movements and following of other agents, and 2) a behavioural layer which decides what the particular agent must do in a certain situation.

For VPT-B development on the functional layer primarily involves expanding existing functionality, for example more complex navigation strategies for herding. But new functionality is also required, for example ability to change facial expression, and ability to communicate the intentions of activities to the VE server so it can be passed on to other agents via the sensory information. For example communicating that a certain animation expresses anger towards a particular other agent.

To support VPT-B scripts for each character in the Black Sheep scenario must be developed, i.e., scripts for the behavioural layer to execute. The Black Sheep scenario involves agent scripts that are vastly more complicated than the ones developed for VPT-A, especially work is required on the scripting the central characters in the scenario: the Farmer, the Dog and the Grey Sheep. The ability of each of these characters to assess the status of the universe in terms of order and chaos is absolutely central to the scenario, and will require much scripting work.

Interaction capabilities and facilities

In relation to the Black Sheep scenario additional functionality (interface function) is required to provide the child with extended ways of expressing him/herself via the avatar. For example perform animations, change facial expression, and utter sounds. This functionality needs to be developed as well as a suitable interface for controlling it.

As mentioned above in the section concerning the VE server there are plans for various ways (interaction modes) in which the child can interact with the system. This functionality involves work on both the server and the interaction facilities. Again we refer the reader to subsequent sections 5.1.3, 6.4 and especially 6.5 ("Adding facilities explicitly supporting reflection and externalisation").

Artwork

It is envisaged that the VPT -B scenario requires designing a complete new virtual world, including landscapes, buildings, props, etc. The need for this is a knock -on effect from the need to redesign the visual appearance of the character models. The models designed for VPT -A are not sufficiently captivating, and it has been decided to adopt a caricatured visua l design instead of the present realistic design. And when all characters are re -modelled in a caricatured expression, the rest of the virtual world must be changed to have a consistent visual appearance of the whole.

For VPT-B models and a large array of animations designed to convey the relevant emotional states of each character is required. Similarly sounds must be produced for each character. As opposed to VPT -A, VPT-B also involves different facial expression for each character.

To achieve a sufficien t level of expressiveness and liveliness all character models, animations, facial expressions and sounds must be tested on children during the artwork production phase.

4 Early Learning Goals

The previously -stated rationales (sections 2.3 and 3.2) have laid out the major EL challenges and theoretical underpinning of the syste m. Here is a brief summary of what we would expect of EL benefit from the proposed developments.

- An exposure to situations that promote the child's understanding of 'others' , i.e. classical decentring. This would come from the reading of agent behaviours and motivations and from role-shifting via the avatars.
- A burgeoning and sophisticated representation of the virtual characters and the 'plot' structures, based on increa singly subtle readings of the virtual characters – this corresponds partially to an increased narrative fluency.
- The development of new strategies for externalisation, through the use of tools and talk, pertinent to the kinds of dramatic play the system allows. This could, with time, become generalisable to a variety of other settings, such as organising drama outside of the virtual space.

5 Concretising "The Black Sheep Scenario" as VPT-B

From the context of the framework developed and analysed above, more concrete requirements and specifications are defined.

5.1 Dramaturgical Requirements

5.1.1 Levels

When presented to new users the Black Sheep scenario may be preceded by three different levels gradually introducing the user to the universe:

LEVEL 0.1: Fly through the world as a moving cameraman.

LEVEL 0.2: Find the characters, and make them come alive. Characters start moving, when all are identified.

LEVEL 0.3: Interact with characters in a greeting scenario as avatar. It might be an idea to implement a possibility to be the invisible came raman - taking a film of some of the greetings that could later be played back.

LEVEL 1: The Black Sheep Scenario. The user should be able to shift between different ways of interacting with the programme. See "Modes" below.

5.1.2 Characters

FARMER - protagonist. This is a day in his life, where he wants to create order. Everything should be in its proper place on the Farm. The animals should be fed, watered and in their stables. No wandering around. The reason why the Farmer want s to establish order has to do with his plans to shear all the white sheep. They are gathered somewhere (invisible) on the farm.

BLACK SHEEP - antagonist. There has been a lot of (white) sheep on the farm. Now they are gone. The Black Sheep is angry with the Farmer. It wants to create disorder.

DOG - helper to Farmer. Likes his master. Likes his job. He has just successfully shepherded all the white sheep to their secret hiding place. If the Farmer is not successful in achieving order, the Dog takes over and becomes very efficient.

GREY SHEEP - helper to Black Sheep. The Grey Sheep wants to create disorder too, but awaits to see what the Black Sheep does before it takes any action. If the Black Sheep is not efficient in creating disorder, the Grey Sheep takes over.

PIG - likes to stroll around on the farm. When agitated has this peculiar habit of performing a very spectacular jump. Insists on having both water and food at the same time. If not it will not eat.

COW - is a somewhat phlegmatic and erratic charac ter. But it definitely dislikes the Dog. It is to noisy and to fast. Whenever inside its fence it wants to have water and be milked. In this succession. And no dogs inside the fence. If anything displeases the Cow it tumbles the water over.

THE WANDERING HAY-STACK - A clever agent that is able to help animals hide from the Farmer, or able to help Farmer feeding the animals if that is necessary. Wants to play hide and seek with the Dog and the sheep. Or to stand still in the sun and be warmed.

THE SLY WATER BUCKET - Another clever agent. Appears from the well and disappears in to it if it is not needed. It helps the Farmer to put water in the troughs of the animals. Or it splashes water on the Dog if that is needed to cool it down. It is also very curious an d follows Characters and avatars around for a sustained time.

5.1.3 Modes

ACTING MODE: (Inter)acting as avatar with characters. The user should have to different degrees of freedom:

A) Fixed position as avatar "Black Sheep".

B) It might be possible to let the user shift avatar randomly e.g. in exploring the VE and the agents.

RECORDING MODE (video): The child chooses to record the events on the screen in a given interval (say 1 minute). During recording the child should be abl e to act as avatar in the scene.

RECORDING MODE (audio): It might be possible for the child to record sounds for each of the characters, sound files that could be added to the existing files, and used (randomly) by the system in the continued work.

PLAY BACK MODE: The child should be able to instantiate a playback of the recorded session.

During playback it should be possible for the child to record audio inputs. There should be a possibility to identify where (in time on the "tape") the audio file should be played.

DIRECTING MODE:

A) Changing the looks of characters (COSTUMES)

B) Changing parameters of

ATTITUDES - behaviours (Pig changed from liking Cow to disliking Cow) or

FACIAL EXPRESSIONS (moods) (angry Farmer to smiling).

Whether this can be done on a sufficiently high level of formalism remains to be investigated, so does the question of how these changes should relate to the scripts of the characters.

5.1.4 Reading an Avatar

The basic improvisational idea in the Black She ep Scenario is to position the user/avatar in such a way that a dilemma arises: as Black Sheep the user might either try to prevent the Farmer in creating order, or it may join the Farmer project. In either case the system should be able to read the intent ions of the avatar and act accordingly.

5.1.5 Achievement Machine

Creating an achievement machine for measuring the Farmer's achievements in terms of his projects should make it possible to create a system that will allow the user such freedom of interaction. The task is to find a rationale for defining "order" on a continuum, say from –1 over 0 to +1. One working hypotheses is to divide this continuum in to five sections:

-1 [---a---][---b---][---c---][---d---][---e---] +1

and then to script agent actions inside these five different sections.

a) is close to chaos and e) is close to order

Scripting: For each agent we need to specify what kind of actions and interrelations are possible within each section. We could change relation s between agents. They could be sent of to different parts of the world. They might be given specific tasks in order to force the balance to shift in negative or positive direction, respectively. We also need to be able to balance their "strength" accordin g to the previous history of the system.

Transition: In this section (as well as in section e) we should be able to specify what need to be done in order for the Farmer to shift from his order -project into failure mode (or in section e, success mode).

While the system displays the Farmers failure (or success) animation (one of three) all is locked. The system can the restart, and the Dog take action. If it happens for the third time, one could choose to end the programme by having the screen flooded with white happy, released hairy sheep (or newly sheared sheep) . This depends on how badly we want to give a sense of closure.

b) and d) is between a equilibrium and chaos or order section.

Scripting: Here we need to feel things moving in a specific direction, that we can make sense of. Hence we need a lot of clear focused activities that has a reasonable amount of success. Things should change rapidly in this section.

Transition: When entering or leaving this section there should be a clear "marker" of this. It might be a small tune (a jingle - in section b) rapid piano music as in silent movies, in section d) pleasant and tranquil piano as in Chopin). It might also be visual, but this would demand a control of an intelligent camera that we do not have here, which is the reason for the audio -suggestion.

c) is pending around an equilibrium.

Scripting: Here we need to be able to express the main theme of the situational improvisation. So we need to focus actions. In order to this, we might have to start with animals (Cow and Pig) in very different corners of the environment. And then come up with a device that will make it possible for the Farmer to follow the avatar (or vice versa) long enough to show the Farmer taki ng the Pig to the Through and the Grey Sheep trying to interfere. There is a need for this section to be calm, and focused and provide a clear picture of the struggling forces. Underscore music might function as a marker of being in section c.

Transition: Might be marked by a jingle. In "0" some things are in place and some are not. We must figure out what functionalities we need to be in place.

There are further needs to experiment with ways in which the agent architecture can cope with establishing these achievements machines.

5.1.6 Actions, Animations and Sounds.

Working with the VPT-A scenario we have learned that in order to succeed with the emotionally much more complicated VPT -B scenario we need an extended repertoire of body movements and tempos (turning around, moving forward etc.), formal action patterns (ma intain a fixed distance to other agents), camera perspectives, animations, facial expressions, and sounds in order to achieve a sufficient level of expressiveness, and sufficiently sophisticated behaviours for the agents.

Another important observation re gards the actual behaviour patterns of agents, the scripts as it were. During tests with VPT -A it became clear that each agent needs to respond explicitly and with no hesitation to the avatar. This in order for the user not to feel "transparent" or indiffe rent, while moving around as the avatar. Therefore it is necessary for each agent to sometimes temporarily suspend an ongoing behaviour, react in a certain way towards the avatar thus acknowledging its presence, and possibly resume the suspended behaviour. This requirement greatly influences the agents' scripts. I.e., in addition to employing narrative structures and dramaturgical considerations in the behaviour planning, they must also take explicit actions to communicate themselves to the audience (the av atar) to function properly as actors in a framed improvisation.

In view of the above, and combined with the fact that the user should have free choice over which character is chosen as avatar, it may be necessary to effectively have two versions of an agen ts behaviour towards another character/agent: a version employed the other character is an agent, and a version employed when the other character is the avatar.

5.2 Early Learning Requirements

We plan that the children will be working in pairs, as we expect that their talk will reveal important aspects of their ongoing cognitive constructions. A challenge for us will be utilising evidence such as this to inform further iterative design. The most fundamental provision, from an EL perspective, is for some simple interactivity in the system allowing the child to reflect on what is happening. As previously mentioned this will be, something like, a spectrum of control possibilities from (stop/start, avatar adoption, selection of agents), through (changing the states of agents and the competencies of avatars) to (being able to edit and arrange segments of actions as well as act in them). This, in effect, moves on from the powerful autonomous system with its errant telos to a more linear-causal model (section 2.2).

The necessity for increasing interactivity is, in fact, also a manifesto for increasing cognitive complexity. The child needs to be:

engaged, e.g. by continual variation in agent states where scenes are repeated or by the provision of suitably fun props for story-bridging in more linear narratives

challenged, e.g. by the necessity of inferring motives on the basis of appropriately legible characters (i.e. there should be better models and expressions)

enabled, e.g. by being given the tools to allow some degree of externalisation. The minimal set of tools for externalisation would involve some replay and edit functionality and would have to be accessed via a child-friendly interface (e.g. mouse buttons are not likely to be the best here; pull-down menus may have a memory overhead).

These developments will promote the presence of 'talk' and 'creativity' which we need to promote interaction and to index what the child is doing/learning.

6 Stepwise Implementation of VPT-B, "The Black Sheep"

To optimise efficiency and synergy from collaboration, a stepwise strategy for extending VPT -A into VPT-B is adopted. I.e., a series of self -contained sub -goals is defined to govern the development efforts. This also allows the evaluation with children to be carried out for each step providing important feedback to the design and implementation process.

The overall idea behind the step-wise approach is to develop the Black Sheep Scenario in an inside-out manner. This is organised such that each step represents a self -contained sub-scenario, which explores a specific element (be it technically, dramaturgically or learning oriented) of the overall scenario.

The development plan sketched below at a certain point leads to a bifurcation where the main emphasis can either be put on

1) expanding the range of user interaction possibilities in direct support of identified learning goals, by incorporating elements of RECORDING and DIRECTING modes (section 5.1.3), or
2) expanding the dramaturgically routed elements of the scenario within a purely improvisational interaction (ACTING mode, section 5.1.3).

At present it is not possible to foresee which direction will prove more successful to the final outcome of the project. In reality the chosen development path will probably jump between the two branches.

6.1 Step 1: Order/chaos nucleus

The Black Sheep Scenario is designed to be a perpetual machine, being able to feed itself without the user/avatar necessarily pushing or provoking the events (section 3.1.3, and section 2.1). The first step is thus aimed at developing a scenario where there is no avatar, but which explores the simplest possible incarnation of the order/chaos project axis of the Blac k Sheep Scenario. The child is supposed to experience this sub-scenario in a SPECTATING mode.

The Step 1 scenario contains two characters: the Farmer and a Cow.

The Cow is constantly trying to get out of its pen. The Farmer is idling around in the general area. When the Cow gets out, and this is spotted by the Farmer, the Farmer takes measures to get the Cow back in the pen.

The challenge is to make even this simple scenario interesting to watch, requiring explicit agent behaviour developments aimed at comm unicating their respective positions on the order/chaos axis. Furthermore, this step requires development of how the dramaturgically derived concept of the "achievement machine" (section 5.1.5) maps to reasoning internally in each agent. It remains to be decided whether the achievement machine functionality will reside inside every agent, or whether it will be a centralised functionality shared by every agent in the scenario.

6.2 Step 2: Reading the avatar

The main purpose of thi s sub-scenario is to explore the area where the child, as avatar in ACTING mode (section 5.1.3), is interacting with, and influencing, a 'story' which unfolds between two agents. Experiences with this will provide valuable input on letting the child position its character/avatar on the project axis in the actant model (section 3.1.3).

The Step 2 scenario contains three characters: the Farmer, a Cow and the Black Sheep (avatar). The scenario is as Step 1 with the following additions: The avatar can lure or h erd the Cow out of the pen, and if outside the pen the avatar can lure or herd the Cow back inside. Furthermore, the avatar can lure the Farmer to follow him, or the avatar can distract/annoy the Farmer. This will give the child the following possibilities to influence the 'improvisation':

scare the Cow out of the pen (causing Farmer to react)

lure the Cow to stay inside the pen (allowing the Farmer to remain neutral)

lure the Farmer away to let the Cow escape the pen

help the Farmer to get the Cow back in the pen (by assisting the Farmer in luring or herding the Cow)

obstruct the Farmer from getting the Cow back in the pen (by luring or herding the Cow in another direction)

The challenge is to create sufficiently general agent behaviours to allow for them t o respond properly (within the framing of the improvisation, section 3.1) to the child's (avatar's) choice of action. I.e., enabling the agents to read and respond to the avatar, within the Black Sheep actant dramaturgy.

6.3 Step 3: exploring the balance of power

The Black Sheep scenario contains a character, the Grey Sheep, which has dual role in the scenario. If the avatar (Black Sheep) decides to help the protagonist (Farmer) the Grey Sheep should take over the role of antagonist, rather than be the antagonist helper. Thus the Grey Sheep character has some degree of freedom over where it positions itself on the main project axis in order to achieve balance.

Thus, the main purpose of this sub -scenario becomes that of developing agent behaviours for the Grey Sheep character, such that it will autonomously position itself on the project axis, in response the avatar's choice of role (acting as antagonist helper, or as antagonist)

When this sub -scenario has been developed and can be e xplored successfully by children, the absolutely essential elements of the Black Sheep Scenario are available for testing by the consortium.

6.4 Step 4: Branches in further development

As described in the introduction of section 6 there will at a certain point in the development towards VPT-B arise a situation, where further work can be divided into two branches: a branch focusing on developing facilities in support of giving the child some measures of authorial control, e.g., DIRECTING mode, and a branch focusing on extending the range of things the user can do while in ACTING mode.

We foresee that this bifurcation will naturally occur after having completed step 3. All work involved in step 1 through 3 is in all essence focused o n developing flexible scripts for various character categories within the dramatised actant model (section 3.1.2) and specifically the Black Sheep scenario (3.1.3). This can be considered as developing the dramaturgical 'meat' for the Black Sheep scenario, or the 'frame' for the framed improvisation.

In order to arrive at a functional VPT -B that supports the EL requirements it is necessary to add functionality on top of this basic frame. This functionality can be divided into the above mentioned two branches.

Each branch contains several elements comparable to steps in the sense this concept has been used in the section thus far. At present it is meaningless to exactly map out in which sequence these elements, or steps, will be addressed. In fact the development will most likely jump from one branch to another, not at least in response to continued small scale te sting with the VPT. Below we describe the main elements in each branch.

At a certain time it will become necessary to stop developing along the branches and enter a refinement phase, where the at that time available functionality is iterated towards the final VPT-B, to make sure the consortium has a self-contained product for final testing.

6.5 Branch 1: adding facilities explicitly supporting reflection and externalisation

To properly support the EL goals it is vital that the VPT be equipped with functionalities that force/encourage child users to 'step back' from the ACTING and SPECTATING modes that are the hub of the VPT-B. The child user should be given opportunities to have authorial control over the events that take place, and to reflect on them, (see section 2.3, final paragraph). This branch is focused on developing such functionality.

Step 4.1: allowing the user to cast the 'play'

This functionality belongs to the DIRECTING mode of section 5.1.3. EL perspectives for this functionality are described in section 2.3 and 3.2. It is aimed at developing a support tool for the VPT platform, which allows the user to exercise control over, in the first instance, the visual appearance of the characters in the scenario. The child will be able to choose between different appearances of the Farmer and the respective animals.

In a more developed instance of this functionality the visual appearance may be linked to a special version of the script for the character in question. For example selecting a viciously looking Dog will cause the Dog to assist the Farmer in a more concrete and efficient manner, than if a timid looking Dog was selected.

This casting tool would be used prior to an actual engagement with the VPT in ACTING mode. The child will be able to interact with the scenario multiple time using different casts.

Step 4.2: allowing the user to record character 'voices'

This functionality also belongs to the DIRECTING mode. It is aimed at extending the above described platform support tool, so as to take the user through a process of speaking and recording utterances for each casted character. For each character there will be a range of moods, and possibly activities, represented by facial expressions, icons of body postures, or animations. An utterance must be recorded for each mood or activity. These utterances will subsequently, during ACTING mode, be used by the autonomous agents in real-time during interaction.

Step 4.3: allowing the user to directly affect agent moods

Similarly to the two above elements this is also a DIRECTING mode functionality. Yet, whereas the two above are seen as activities performed prior to engaging in ACTING mode, and thus interacting with the created setting, this element is thought of as an activity performed during ACTING mode. I.e., the functionality should allow the user to, while in ACTING mode, directly influence the moods and thus also the activities and preferences of other characters.

Step 4.4: enabling RECORDING and PLAYBACK modes

Recording and playback may take on many forms in the context of the VPT. It may be a comparatively simple '3D film' of the events that have occurred within a time window which can later be played back as a film using the viewpoint the user had during interaction (ACTING mode), or played back as a dynamic 3D scenario that can be viewed from arbitrary and changing viewpoints. Alternatively it may be an actual temporal map, along which the user can navigate, for example go back in time, change something, and proceed from there to experience the effect of the change. These three alternatives also represent different complexities from an implementational point of view, and should thus be addressed in a step-wise manner, to gradually gain experience with the potential regarding children's cognitive benefit.

In addition to letting children record and playback sequences (in any of the above forms), the child could be allowed to perform dubbing (adding new speech), foleying (adding sound effects), and in principle also scoring (adding music); (see section 5.1.3).

6.6 Branch 2: extending the avatar action repertoire

This branch focuses on furthering the depth of the user's experience and his/her engagement in the ACTING mode.

Step 4a: extended avatar expressionability

This functionality is aimed at closing the gap between how agents can express themselves (movement, animations, facial expression, and sounds), and how the user, via its avatar, can express itself (in current VPT only movement and very few sounds). The main difficulty in providing this functionality lies in designing a suitable interface for the (child) user, allowing him/her to command the avatar to perform e.g., animations and change facial expressions.

Step 4b: extending scenario to complete Black Sheep frame

The scenario as of Step 3 (section 6.3) is not the complete Black Sheep scenario, neither in terms of the number of characters, nor in terms of the depth of their roles (scripts). This element is focused at enlarging the number of agents, and extending their scripts to complicate the improvisational frame of the Black Sheep scenario as it is intended (section 5.1). This extension can be performed in a highly gradual manner, and will typically occur e.g. when other functionality is being tested. The development will to a very high degree depend on feedback from tests with children regarding what agent behaviour is understood, or what is misunderstood (or even overlooked).

Step 4c: free choice of avatar during interaction with VPT-B

In the current version of the VPT the child user has the ability to choose avatar freely among the available characters. I.e., at any point in time the child can switch from one avatar to another. We wish to retain this functionality for VPT-B, but the complexity of the characters' scripts in VPT-B makes it an issue in itself to design the scripts such that they are resilient towards avatar changes. This functionality will be kept in mind during initial script development (steps 1 through 3), and then expanded when this element of Branch 2 becomes the focus of attention.

6.7 Refinements towards the final VPT-B

The main advantage envisaged from the step-wise and branched development process is that it will encourage a process focusing on elements that maximise the potential of the VPT-B and the project as a whole. The process of rather closely spaced milestones, combined with some freedom in the order in which steps are developed, enables feedback from preliminary tests to guide the development. And the process should ensure that VPT-B will be a self-contained system where all functionality has a well-known root in dramaturgy and EL goals, regardless of how much functionality is achieved before the end of the project.

It may happen that not all elements from the two branches become fully developed. The finalisation phase is intended to maximise the full potential of the VPT-B and its functionalities, importantly including the setting and/or circumstances under which the VPT-B is used. For example step 4.4 (enabling RECORDING and PLAYBACK modes) of branch 1 (authorial control) may not be fully functional in time for extensive testing. But important EL elements of this functionality may be captured by adding a specifically designed session or exercise to the use-situation: while the child user is interacting with the VPT a video camera may record the actions from the computer screen. The child can then subsequently be asked to perform dubbing and folyeing (add speech/utterances and sound effects) to the recorded video.

7 Stepwise Evaluation of VPT-B

7.1 Evaluation in Context of Development

Evaluation by psychologists with children is an essential part of the development process, as the feedback has a decisive impact on design considerations. Implementation and evaluation must thus go hand in hand in the rest of the year. However, under the condition of constantly developing new technology for a new context, the proper synchronisation of developmental results for evaluation and a practical plan for evaluation to be carried out is very hard to obtain. We therefore propose a series of evaluations at fixed time intervals, and perform the evaluation of the system at the level of development as it may be at that time, assuming substantive development between sampling points. This allows a stable action plan for the "standard" evaluation procedures, but leaves us with some degree of flexibility as to which specific aspects will be the focus of evaluation at particular points. In what follows we use the 'step' labelling from section 6.

7.2 Evaluation and EL Goals

In what follows we use the 'step' labelling from section 6, briefly reprising the essence of the step and summarising the aims of the evaluation with respect to what are likely to be key foci considered in the light of the EL requirements (vide section 5.2).

7.2.1: Step 1:

This represents a system where the child is spectator for the simplest example of the Black Sheep Scenario.

Approximate Timing: End FEB

Evaluation parameters: Here we shall assess the child's *engagement* with the scenario – does it interest them? What sorts of comments do they make? Do they form hypotheses (mental models) of what is going on in the order/chaos model?

7.2.2: Step 2:

This represents a system where the child is actor within a simple incarnation of the Black Sheep Scenario.

Approximate Timing: End MAR

Evaluation parameters: Here we shall again assess the child's engagement with the scenario, using the same approach as for step 1. But in addition we will be looking for evidence that the situation involving avatar-generated actions are legible and meaningful to the child, e.g. that they can produce comprehensible accounts of what kinds of cause-effect relations occur as a result of their actions.

7.2.3: Step 3:

This completes the development of a system for the minimum complete implementation of the Black Sheep Scenario.

Approximate Timing: End APR

Evaluation parameters: Here we shall assess the child's engagement with the scenario, using the same approach as above. But in addition we will be looking at the *challenge* offered by the arrival of the grey

sheep. In lending a degree of (short-term) unpredictability to the scenario the grey sheep challenges the child to continually revise its model of what is happening. We shall look at the evidence that children do this and see whether the dramaturgical concepts, e.g. balance of power, protagonist/antagonist are realised as a result of the interaction. In steps 1-3 we shall both observe the children as they use the system, noting interactions and language, and debrief them afterwards as to their 'take' on the system.

7.2.4: Step 4 (1-4) (Branch 1):

Here we have the implementation of a system that will allow us to test the externalisation hypothesis (section 3.2) by providing tools for casting, recording, playback etc.

Approximate Timing: May-Aug (depending on links with branch 2)

Evaluation parameters: Here we are looking specifically for the benefits that should accrue from being able to 'step back' and reflect on the play – the challenge of *enabling* the child. The four functionalities envisaged here all, in different ways, enable the child to take different points of view on the scenario. Thus we expect to see evidence in discourse of the 3rd person or 'narrator's' voice, of rehearsing in role of the various characters created (e.g. in terms of prosody of recorded voices), of coordination of perspectives of the different agents (e.g. spotting potential conflicts). These are all indices of decentring by the child, not typical of spontaneous play and, thus, one of the EL goals of PUPPET. In addition we see evaluation of the success of recording/playback as indicative of the metacognitive appreciation of play/narrative-construction roles, i.e. the actor/director/author distinctions. This is another major EL goal and is crucially important in the project's ambition to map the dramaturgical taxonomy onto that derived from EL.

7.2.5: Step 4 a –c (Branch 2):

Here we have a system with a much richer dramaturgical potential than in steps 1-3. The development path, however, is highly dependent on the evaluation process itself.

Approximate Timing: May-Aug (depending on links with branch 1)

Evaluation parameters: Here we are looking for the same kinds of evidence for engagement and challenge as for the steps above but focussing on issues such as the optimal degree of complexity (e.g. of numbers and states of characters), of expressivity (e.g. do we need to go beyond cartoon facial expressions?) and of switchability (e.g. of taking multiple roles – as avatar – during a session). Beyond this we see the evaluation as interacting strongly with the specification of the *form and extent* of the facilities being developed in branch 1. Thus there will undoubtedly be limits on the degree of complexity – multidimensional processing – that children can reasonably undertake within the system. This sort of cognitive limitation, as well as the potentiation of other processes, is a vital objective for the evaluation.

7.3 Final Evaluation

Timing: Early SEP

Evaluation parameters: This will, necessarily, build on the evaluations listed above and key questions, from this distance, are how much the system will allow the children to do mostly by themselves and whether there is any strong evidence of the potential for EL advances. Here we shall solicit the opinions of parents and teachers where possible, as well as the feedback from the children. In the light of the goals (section 4) we shall evaluate whether PUPPET has shown that development of this kind of innovative VE does have learning potential.