Event Synchronization for Interactive Cyberdrama Generation on the Web: A Distributed Approach

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ABSTRACT

The digital generation of a story in which users have influence over the narrative is emerging as an exciting example of computer-based interactive entertainment. Interactive storytelling has existed in non digital versions for thousand of years, but with the advent of the Web the demand for enabling distributed cyberdrama generation is becoming increasingly common. To govern the complexity stemming from the distributed generation of complex plots, we have devised an event synchronization service that may be exploited to support the distribution of interactive storytelling activities over the Web. The main novelty of our approach is that the semantics of the cyberdrama is exploited to discard *obsolete* events. This brings to the positive result of speeding up the activity of drama generation, thus enabling an augmented interactivity among dispersed players.

Categories and Subject Descriptors

H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – *artificial, augmented and virtual realities, evaluation/methodology.*

General Terms

Human Factors, Design, Measurement.

Keywords

Cyberdrama Generation, Interactive Storytelling, Computer-based Entertainment, Web-based Multiplayer Games.

1. INTRODUCTION

A digital cyberdrama represents an interactive form of literature in which humans (with the help of synthetic agents) actively participate and assume a role in the story. This kind of computer-based entertainment, also termed interactive storytelling, is making significant advances into the world of entertainment, hence becoming an interesting alternative to the traditional linear narratives of TV, radio, movies and magazines. However, to the best of our knowledge, the most noteworthy aspect of interactive storytelling prototypes is that they are implemented within a centralized scenario where synthetic agents (governing virtual characters) are hosted in the same machine [1, 3, 4]. Instead, to allow interactive storytelling to blossom into a new and significant medium, distributed (Web-based) technologies must come into the picture. To distribute all the activities concerned with the generation and management of a digital cyberdrama, the basic idea is that of resorting to a loosely coupled distributed architecture where several servers (named *CyberDrama Servers* or *CDSs*) are geographically distributed over the Web. Each *CDS* maintains a local, replicated representation of the state of the cyberdrama. With each new action performed by users/agents connected to a given *CDS,* the *CDS* collects the corresponding event, updates the drama state, and finally, notifies these updates to each other *CDS*. Needless to say, sophisticated event synchronization schemes have to be adopted so as to maintain the consistency of the distributed cyberdrama state. To this aim, these synchronization schemes employ complex strategies aimed at guaranteeing the reliable delivery of all the generated events to each *CDS*. Unfortunately, the problem here is that these schemes may introduce large computational and communication delays, thus disrupting the interactivity in the cyberdrama generation. To overcome this kind of problem, we have designed an event delivery service which may be used to synchronize events for governing the interactive generation of cyberdramas over several *CDSs* on the Web. Our event synchronization scheme is based on the idea of dropping those events which become *obsolete* according to the cyberdrama's semantics. This allows to speed up the interactive generation of the cyberdrama, hence ensuring an augmented interactivity for players. We report on measurements taken from a deployed simulation that confirm the efficacy of our approach. The reminder of this paper is organized as follows. Section 2 introduces our event synchronization service. Section 3 reports on some simulation results obtained in an experimental study we developed and, finally, Section 4 concludes the paper.

2. PROBLEM STATEMENT AND A POSSIBLE SOLUTION

It is well-known that a totally ordered event delivery scheme is sufficient to ensure state consistency across different servers (i.e. *CDSs*). However, the communication complexity derived from such an approach may drastically slow down the dynamic evolution of a cyberdrama, thus impairing interactivity. We propose a novel approach to event synchronization among different *CDSs* that allows to relax the total order delivery requirement for augmented interactivity. Our scheme rests upon the idea of exploiting the semantics of a cyberdrama during its generation/evolution. An important aspect to be investigated here is whether events may be discarded that have lost their relevance during the cyberdrama evolution. This may be the case when subsequent events have the effect of making irrelevant "older" events [2]. For example, knowing the position of a given virtual entity active in a cyberdrama at a certain time may be no longer important when the position of this virtual entity changes as time passes. In essence, events may exist whose importance diminishes when "fresher" events are generated. We denote this kind of relationship among events as *obsolescence*. A possible obsolescence example is the following. Denote with e_1 the event "*move the diary to the bedroom*" and with e_2 the event "*move the*

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diary to the living room". Both events are generated by the character *Alice* in the following order: first e_1, then e_2. Suppose that a given *CDS* does not receive e_1 but receives e_2 straight after. In this case, still a consistent cyberdrama state is maintained at that *CDS*, as the execution of e_2 (without the execution of e_1) brings to the same final state in the story. Based on the notion of obsolescence, we devised an event delivery approach that guarantees that each non obsolete event is reliably delivered at all the *CDSs* on the Web. Instead, in the case when an event *e* has become obsolete due to the occurrence of a "fresher" event, then our scheme ensures that either *e* or the event that has made *e* obsolete is delivered at each *CDS* on the Web. By exploiting obsolescence we may gain interactivity. The idea is as follows: for each delivered event, each *CDS* measures the time difference elapsing between the generation of an event and its delivery time (we term such time difference as *cyberdrama Time Difference*, or *TD*). If this value exceeds a predefined interactivity time threshold value *IT*, then obsolete events are automatically dropped as their execution is no longer important for the state consistency of the cyberdrama. Summing up, dropping obsolete events brings to the positive result of speeding up the execution of "fresh" events, thus obtaining interactivity. Also other relevant information may be extracted from a plot to alter the delivery order of events. We introduce here the notion of *correlation*. In essence, an event e_1 is correlated to an event e_2 if the execution of e_2 after e_1 brings to a different state of the story with respect to the case when e_1 is executed after e_2. Based on this notion, our event synchronization service ensures that only correlated events are delivered in the same order at each *CDS*. Instead, different delivery orders are possible when a sequence of *non-correlated* events has to be delivered to different *CDSs*. The idea is that non-correlated events may be processed by different *CDSs* according to different orders without affecting the state consistency of the cyberdrama, as they are semantically independent. We have implemented our *correlation-based* event delivery service scheme on the top of a simplified version of the Time Warp algorithm. This means that events are executed at a given *CDS* as soon as they are received. Then, in the case when two (or more) correlated events are identified that have been executed out of the correlation-based order, a rollback procedure is invoked, i.e. a rollback is executed only if correlated events have been processed out the correlation order. This approach reduces the number of rollbacks performed at each *CDS*, again improving interactivity.

3. EXPERIMENTING WITH OBSOLESCENCE AND CORRELATION

We report results obtained from an experimental evaluation we conducted to assess the efficacy of our approach. We evaluate the benefits derived from the use of: i) our correlation-based event processing strategy; ii) our obsolescence-based event delivery strategy. To evaluate our correlation-based event processing strategy, we simulated a distributed architecture composed of five *CDSs*. The values of the network latencies where drawn from a lognormal distribution where the parameters were obtained through experimental measurements. As to the frequency according to which events were generated at a given *CDS,* we adopted a lognormal distribution with an interarrival time between events of 62 ms and a standard deviation of 12 ms. We conducted experiments with event traces containing as many as 1000 events. The average size of the messages containing an event was equal to 200 Bytes. We evaluated a distributed scenario with different values of the event correlation probability. This scenario was contrasted against the execution of the same event trace performed without any correlation check. Figure 1 reports the obtained rollback ratio. The higher the correlation probability, the higher the rollback ratio, as only non correlated events may be processed with different orders at different *CDSs*. Our approach reduces the number of events subject to a rollback w.r.t. a classic approach based on the Time Warp algorithm. The reduction of the computational delays due to the containment of the rollback ratio brings to an augmented interactivity degree.

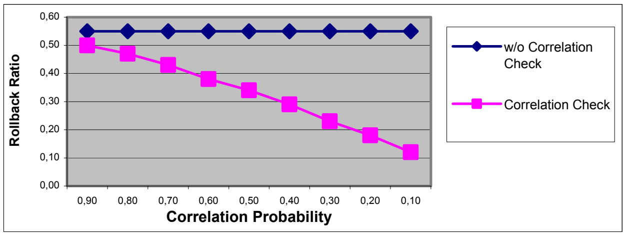

Figure 1: Rollback Ratio with Correlation Check

Another experiment was conducted to assess the efficacy of our obsolescence-based event delivery strategy. We measured how many obsolete events must be dropped to maintain *TD* below *IT*. This experiment was carried out by simulating an *IT* violation rate varying in the following range: [0%, 15%]. The *IT* value was set equal to 150 milliseconds. Results are reported in Table 1 where the amount of non obsolete delivered events is shown depending on the *IT* violation rate. As lower *TD* values correspond to higher interactivity degrees, we conclude that our approach is effective.

Table 1. Non Obsolete Delivered Events (%)

IT Violation Rate	*0%*	*1%*	*5%*	*10%*	*15%*
Non Obsolete Delivered Events (%)	100	99,7	97,7	94,5	91,3

4. CONCLUSIONS

We presented an event delivery service devised to support the distribution of cyberdrama generation activities on the Web. Our synchronization service may be also adopted to deploy over any loosely coupled distributed system any kind of Massively Multiplayer Online Role Playing Game [2]. Results obtained from an experimental assessment confirm that reliability in event delivery may be traded for an augmented interactivity without any effect on the story evolution.

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6. REFERENCES

[1] Cavazza M., Charles F., Mead S.J. "Emergent Situations in Interactive Storytelling", *Proc. of SAC2002*, ACM, Madrid, Spain, 1080-1085, 2002.

[2] Ferretti S., Roccetti M. "A Novel Obsolescence-Based Approach to Event Delivery Synchronization in Multiplayer Games", *International Journal of Intelligent Games and Simulation* 3, 1, March/April, 2004.

[3] Metan J. "Talespin, An Interactive Program that Writes Stories", In *Proc. of the 5th International Joint Conf. on AI*, 91-98, 1977.

[4] Riedl M.O., Young R.M. "Character-Focused Generation for Execution in Virtual Worlds", *LNCS 2897*, Springer Verlag, 47-56, 2003.