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Game Time

Modeling and Analyzing Time in Multiplayer and Massively Multiplayer Games

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Game time is a core feature of game design and study, and forms part of the gaming experience on a variety of levels. It can be viewed from multiple perspectives, for example, the time of the playing of the game or the flow of time in a game world. In this article, a comprehensive game time model based on empirical research as well as recent theory is presented. It proposes various perspectives on game time and integrates them to allow coherent representation of the same events in the different perspectives. The model has been tested across tabletop and digital formats, and its applicability across game formats is demonstrated. Emphasis is placed on multiplayer and massively multiplayer role-playing games because these feature complex game time behavior not previously evaluated. The model considers game time as an interactively created and nonlinear feature of games and game play.

Keywords: *time; mapping; game world; time layer; viewpoints of time; game speed; playing game; role; game*

Time and the Magic Circle

Games are inherently linked with perceptions of time. One of the original game criteria of Huizinga (1955) is that a game takes place in its own boundaries

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of time and space. Similarly, Caillois (2001) emphasized that games take place in a separate, circumscribed area limited by space and time that are fixed in advance. As noted by Salen and Zimmerman (2003), games take place in a "magic circle," separated from the everyday life of the real world. Although the boundaries of the magic circle may be eroding, for example, with the blurring of the lines between the economies of massively multiplayer online games (MMOGs) and that of the real world, one of the basic criteria of a game is that it takes place in its own specific time. Because of its closed nature, the magic circle also acts as a marker of time, and the concept is therefore important in defining the first level of game time—that of the time of the playing.

From the perspective of game design and development, game time takes on a more practical dimension. Time is involved in many features of design, from balancing game mechanics, pacing of the game story, and defining the game world, to the timing of events and trigger conditions. It is also used as a direct game play element, for example, temporal pressure in racing games, or the control of time can be placed partly in the hands of the player. Similarly, time is integrated in game design terminology, for example, in the consideration of game speed or game play speed. Games can also be classified based on their use of time, for example, real-time or turn-based games (TBGs). In nondigital games, overall game time is often logical, specifying the ordering of events, whereas in digital games, time is often used in a chronological fashion, notably as a balancing tool in multiplayer and massively multiplayer games (e.g., Bartle, 2003; Crawford, 2004; Hallford & Hallford, 2001; Rollings & Morris, 2004; Salen & Zimmerman, 2003).

Within game research, time in games is a key concern because it is an avenue for understanding not only what takes place inside the game but also the interaction between the game and the players and, importantly, how the game is experienced. Despite the integral nature of time in games, the subject has received limited attention, and there have been few contributions toward developing a comprehensive theory of time in computer games (Juul, 2004, 2005), although some of the key works within games studies involve time in one form or another, for example, the transformation of time in the flow model of Csikszentmihalyi (1991). Several contributions to understanding game time have been made (e.g., Crogan, 2003; Eskelinen, 2001; Hitchens, 2006; Juul, 2004, 2005; Lindley, 2005), and these have shown that game time is not a simple construct. Time in games can be described and modeled using different approaches. Examples include semiotic approaches from literature studies (Lindley, 2005), relations with physics (Rau, 2001), transferring or modifying narrative models to games (Eskelinen, 2001), or basing models directly on the user–game interaction (Hitchens, 2006; Juul, 2004, 2005).

In contrast to games, time is a subject that has been well studied, classified, and used as a basis for design, analysis, and study in other branches of entertainment, for example, film, literature, and theater, and methods from some of these fields have been integrated into games studies (e.g., Eskelinen, 2001, Lindley, 2005). This emphasizes the potential uses of time as an avenue for game study.

The purpose of this article is to provide a model of how time operates and flows in single-, multi-, and massively multiplayer games, derived from empirical experiments as well as existing relevant literature and previous studies. As a recurrent case study, the model is applied to and discussed in the light of the four major formats of role-playing games (RPGs). The application of the model to RPGs demonstrates the versatility of the model and provides guidelines for the use of the model in other contexts. The model presented is equally applicable outside this game form, and examples from tabletop and computer games outside the RPG sphere are included in the model description.

The model presented here extends the single-player model presented by Hitchens (2006), itself an expansion of that of Juul (2004, 2005), to include multiplayer and massively multiplayer games. The interactions of multiple players create a relatively larger degree of complexity compared with single-player games and require explicit inclusion in the model. For example, the actions of one player can affect another, and players can be engaged in different activities at the same time. Previous models were based on theory and/or ad hoc observation; however, the current model was developed via an iterative, empirical experimentation process covering digital and nondigital formats, based on an initial theoretical model. Multiplayer pen-and-paper RPG (PnP) and computer RPG (CRPG) experiments were used to test and refine the game time model and provide a test bed for practical application. Although the model represents a further step toward a coherent game time theory, it is not the final word on the subject. The model advances current theory by including multiplayer games, and an option for scalability and adaptation to specific purposes. The use of segmentation of the activity and interactions of the players (Hitchens, 2006) allows the interactive nature of games to be mapped and different levels of granularity to be represented. Also included are considerations of TBGs.

The Test Bed: Role-Playing Games

Role-playing games exist in an incredibly large variety of forms and formats, including both digital and nondigital, and can demonstrate very intricate temporal behaviors. Digital RPGs (Hallford & Hallford, 2001) themselves vary extensively, ranging from single-player games such as the ULTIMA series, through group-based, or at least group-capable, games (Neverwinter Nights, Dungeon Siege) to massively multiplayer online RPGs (MMORPGs) such as EverQuest and World of Warcraft. RPGs may be classified into four major formats, the traditional PnP, physically embodied ones, collectively referred to as live-action RPGs (LARPs; Tychsen, Hitchens, Brolund, & Kavakli, 2006) and digital variants, single or small number of player CRPGs, and large player number MMORPGs. The variations between forms have so far prevented the definition of RPGs in the broad context, except for defining a few shared characteristics such as character-based storytelling and often a strong social element (Tychsen, 2006). However, the same variations present an interesting test of any theory of game time and make RPGs an ideal experimental test bed for this purpose.

In RPGs, a player typically controls one character, evolving it over time within a narrative setting (Edwards, 2001; Salen & Zimmerman, 2003). Many RPGs include one or more games masters (GMs), players with much greater control over the game world, although these are typically less important in the digital world, being replaced entirely by software in most single-player games. RPGs often provide players with very high degrees of freedom in the operation of their characters within the fictional world and in affecting the game story. This means that these games can demonstrate complex temporal dynamics. For example, the activities of the characters need not follow the flow of time in the fictional world. In multiplayer games, characters can exist in different instances of the timeline of the game world or even form personal perceptions of time that operate completely or partially in the mind of the player.

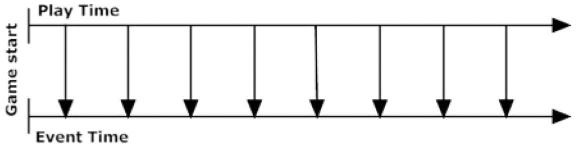
Game time provides one venue for cross-platform analysis. Although the viewpoints and use of time in these games varies between formats, time is a point of view of analysis that can be applied to all games across formats. For example, a coherent model of game time can be used to model collaboration and other player interactions in multiplayer RPGs.

Related Work on Time in Computer Games

Juul (2001) presented the notion that a game is comparable to the notion of a state machine from computer science. A state machine consists of states and transition functions, which define the new state of the machine based on the current state and the input. Juul (2004, 2005) adapted the notion of game state to the possibly first model for game time, from the viewpoint of the playing experience, proposing that game playing is fundamentally a transposition between game states. Playing a game thus becomes an interaction with and progression of the game state. Transferring information or taking actions require nonzero amounts of time, and this must happen in the different frames of reference of player and game, giving rise to the notion of game time. Whereas the game as an emergent system changes its state over time, the different viewpoints of game time do not necessarily change at the same rate.

Juul (2004, 2005) chose to model game time in the form of layers, which can also be taken to represent viewpoints of time in games. Different such views can

Figure 1
Mapping Player Actions Between Two Layers of Time on a 1:1 Basis; the Model Allows Interactions Between the Player and Game to be Represented



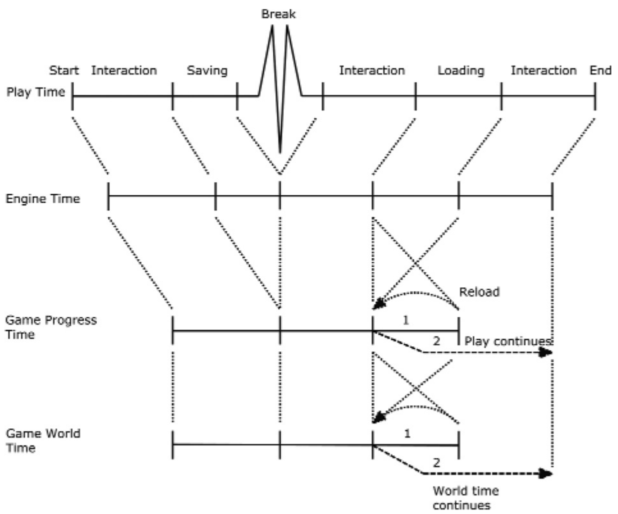
Source: Tychsen and Hitchens (2007).

be readily observed, for example, the real-world time in which game playing occurs and the time within the game world. The layers of time are represented by two timelines in the model: (a) play time, that is, the actual real-world time spent playing and (b) event time, that is, the time of the fictional world of the game. Using the state machine concept, the model describes the interactions between the game and the player via these two layers (Figure 1). The model further allows the identification of games that define none of, either of, or both these temporal layers, with the majority of contemporary computer games defining both (Juul, 2005). The model allows for the projection of time between the two layers by a mapping process, describing the actions of the players and the resulting game state change, and vice versa.

Hitchens (2006) adopted the approach outlined by (Juul, 2004, 2005), redefining the two existing layers and adding two new viewpoints (time layers) from which time can be viewed in the context of a game, for a total of four: playing time, engine time, progress time, and world time, most importantly allowing the nonlinear nature of game time to be modeled (Figure 2). Games are inherently nonlinear in that they contain choices and often allow the player to abandon the current path and revisit previously discarded ones. Nonlinearity in games (Aarseth, 1997) is expressed as branches in two of the time layers (progress time and world time). These branches represent the ability of players to make choices or, for example, return to an earlier point in a game, experiencing content more than once with the benefit of knowledge gained from previous exposure and thus effectively turning back the event time of Juul (2004).

By integrating the nonlinear nature of games, the model of Hitchens (2006) provides a correlation between the player's experience of time in the real world and progress within the game, allowing an investigation of this potentially complex relationship. Nonlinearity can in some games be modeled directly to the time of the game world; however, not all games include indications of the duration of time within the game world—for example, Pac Man. However, by adding a logically defined game progress time layer or viewpoint, nonlinear progress

Figure 2
The Four Layers of Time in the Game Time Model of Hitchens (2006)



Note: Temporal segments are shown separated by vertical lines. Dotted lines represent the correlation of segment breaks between layers. An example of branching is shown in the two lower layers, describing the reloading of a saved game (dotted arrows), with play continuing along a different path (stippled arrows). The loading of the saved game is instantaneous in the lower two layers (a break), whereas time passes in the playing time and engine time layers (a segment).
Source: Tychsen and Hitchens (2007).

through a game can be described and modeled. As in the model of (Juul, 2004, 2005), the model of Hitchens (2006) maps interactions and changes in game state by linking points on the timelines. Whereas the playing and engine time layers are linear, the progress time and world time layers represent the views of game time that can be nonlinear in nature. For example, loading a saved game and trying a different solution to a problem represents a branching in progress time as well as world time. This is illustrated in Figure 2 by creating a branch in the time layer.

Other approaches to game time include the adaptation of concepts from narrative theory for the description of temporally related phenomena in games by Eskelinen (2001), and time in a virtual world context has been discussed by Ryan (2001) and Murray (1997) and from a physics point of view by Rau (2001), for example, separating relative and reversible time. Crogan (2003) considered time in computer games from an aesthetic perspective. Lindley (2005) created a framework for ludic semiotics based on the recognition of different temporal semiotic systems: simulation, game, and narrative, each with their own design principles and ways of engaging the player. Although a novel approach, it is engineered toward structuring events when designing a game rather than the actual experience of time when playing a game. Therefore, it is not directly comparable with the approach adopted here. Concepts from these works are included in the current game time model where appropriate.

Approach and Methodology

A combination of theoretical work and case-based empirical study (experimentation and observation) was used to develop a game time model that was tested and sufficiently broad in scope to encompass the various viewpoints of game time. By modifying a theoretical model with empirically derived data, a range of benefits are gained, notably advancing the current models beyond anecdotal observation and theory. At the same time, the game time model is tested and evaluated in practice, providing evidence that the model is applicable to the often complex interactions of time in multiplayer RPGs. The development process was based on an iterative development strategy including two cycles of model development, refinement, and testing.

Game Selection for the Experiments

Of the four major RPG formats, PnPs and CRPGs are most amenable to empirical experimentation as they involve a limited number of players. They can therefore be placed in a readily observable environment. For MMORPGs a substantial body of material exists from research as well as design (e.g., Bartle, 2003; Yee, 2006). This makes it the best described and analyzed RPG format, alleviating the need for empirical experimentation when developing a model for time inclusive of MMORPGs and MMOGs. To supplement the theory and assess model applicability, several different MMORPGs were play tested, including the currently popular World of Warcraft. Previous experience with MMORPGs (Tychsen & Hitchens, 2006) was also used. In comparison, very few research or design publications cover LARPs (Söderberg, Waern, & Åkesson, 2004; Tychsen et al., 2006). However, in recent years, the Scandinavian LARP environment has yielded several contributions produced by experienced LARP writers and players (e.g., Bøckman & Hutchison, 2005), forming a valuable resource of LARP knowledge.

The potentially very large number of players involved in LARPs hinders empirical experimentation. The question for the current study is whether LARPs contain game time features that necessitate separate empirical experimentation.

PnPs and LARPs are difficult to separate and define because there is a gradual boundary between what most people would recognize as a PnP and a LARP (Tychsen et al., 2006). PnPs and LARPs share many similarities in overall form and format, for example, players take control of fictional characters, the interaction between the players is based on rules, all lines of communication are available, and there are generally one or more GMs present. This means that it would be expected that what can be done with game time in a PnP is possible in a LARP and vice versa. However, the potentially large numbers of players and GMs in a LARP provide practical limitations on the manipulation of game time. Whereas in a PnP, typically having only one GM, variance in where the characters currently exist temporally can be managed, the large numbers in LARPs limit the possible temporal variances because of coordination difficulties between the GMs. These restrictions are also a feature of the high player to GM ratio typical of LARPs (Peinado & Gervás, 2002; Tychsen et al., 2006). In theory, with enough game resources, a large-scale LARP could manipulate game time in the same way as PnPs, although this would require excellent coordination between GMs. In practice, these restrictions are similar to those faced by MMORPGs, who are additionally limited by the use of a virtual world as the game platform. The solution for both LARPs and MMORPGs is to run in real time with a low level of live control to ensure a fair gaming environment to all the players.

As small-scale LARPS are comparable to PnPs, and large-scale LARPs appear to be more restricted users of game time than PnPs, it was chosen not to run experiments on LARP games, relying on the available literature to provide any special cases that might need consideration. The experiments were therefore conducted using multiplayer PnP and CRPG games. The presence of multiple players substantially increases the number of variables involved in a game; however, the multiple shared features (number of players, character-based play, etc.) across the two game formats examined minimize the variables operating in one format alone, enabling assessment of the impact of the actual game format.

Model Development Process

Following the construction of an initial model based on existing theory, applicable research, and play testing, two rounds of experiments were run to refine the model. The initial theoretical model extended that of Hitchens (2006) by adding an extra layer, server time, to account for the distributed nature of multiple-player games (both digital and nondigital). All layers are fully discussed below but, in brief, server time models time from the point of view of the central server of a multiplayer computer game. It was also recognized that modeling a multiplayer game in practice would require multiple iterations of engine time, one for each copy of the client software. These were considered to be the minimum extensions necessary to model multiplayer situations and, although the exact definitions were refined, survived up to the final version of the model. Importantly, as a further development of the models of Juul (2004, 2005) and Hitchens (2006), the model rests on the assumption that game time can be represented as a coherent system of distinct layers, each representing a specific viewpoint of game time, and that player activities can be mapped between these layers in a logical fashion.

The primary requirements on the experimental game setups were that (a) they were typical of the two formats, so as to justify the assumption that the sampled games were representative of PnPs and CRPGs in general; and (b) they allowed as much freedom as possible for the participants (players and GMs) to use and manipulate game time across the various viewpoints (story, world, etc.).

Both game formats used the D20 rule system, developed for the original Dungeons & Dragons PnP, with the current version being the 3.5th edition. This rule system is currently the most used PnP and CRPG rule system and is found in the greatest variety of RPG games across formats. The D20 rule system is used (in various versions) in the CRPG used in the experiments, Neverwinter Nights, and other representatives of the format—namely, Baldur's Gate, Icewind Dale, Pools of Radiance, and older graphical CRPGs such as Eye of the Beholder. It has also, indirectly, influenced the systems of MMORPGs such as EverQuest and World of Warcraft. The CRPG experiment was created using the Neverwinter Nights AURORA engine, which includes a toolset for creating new game modules and editing existing ones and allows a human GM extensive control of a playing session. Neverwinter Nights provides each player with his or her own monitor, and thereby interface to the virtual world, which is the closest one can possibly come to the individually perceived game worlds of PnPs. Using the D20 rule system allows the experiments to be as representative as could be expected given the range of RPGs.

Both experimental setups featured game stories involving similar themes of revenge and reversal, and the characters were written specifically for the game modules, according to the same five personality templates (using the EPAQ personality model; Helgeson & Fritz, 1999), including the unmitigated communion extension of Fritz and Helgeson (1998). Opportunities were provided within the stories for the characters to separate, allowing variations in time in the story and the game world as experienced by the various participants.

The first limited, experimental round was to evaluate the experiment design setup and provide initial feedback on the theoretical model. As a result of the pilot experiment, the time layer model was refined; for example, the need to separate game progress time into two distinct layers (game progress time and game story time) was realized at this point. The second round of experiments comprised a series of 10 PnP and 10 CRPG game sessions, each with five players (plus one GM in the PnP sessions). The game sessions lasted between 3 to 7 hours, with the PnP games being the longest. The same groups of players carried over between the two game formats. Players were situated around a table with full visual and verbal access in both types of games. All players were adults. All game sessions were recorded on video, and game logs were extracted from the CRPG sessions showing all text-based chat. Selected sections of the verbal communication between the players were transcribed. The recordings and transcriptions formed the basis for revising the game time model, notably whether it encompassed the full variety of player actions. Substantial revision of the game time model occurred after the first and second rounds of experiments, notably in redefining the boundary between the engine time and server time layers (see below) and in introducing the notion of perceived time. This last came from an analysis of the group discussions following the second round sessions (Figure 3).

Core Definitions

Before describing the model itself in detail some definitions of basic concepts are required.

State of the Player

Analogous to the concept of game state (Juul, 2005), the state of the player describes the situation of the player for a given segment of time. This identification is relevant when considering how multiple players can affect the game time of each other and how the game uses time (Figure 4). Three forms of player state are defined here and are given below.

Active. The player is interacting with the game and/or other players within the game framework, for example, the magic circle. The player is actively playing the game. Information flows in both directions between the game and the player(s).

Passive. The player is playing the game but in an observatory mode, not engaged in the actual game play—for example, a player in a TBG who is observing one of the other players taking their turn. In digital games, the passive state includes watching cut scenes and the use of macros, bots, and similar programs that allow the player to interact with and/or observe the game content without actually touching the controls. Information is flowing from the game to the player but not, or only to a limited degree, from the player to the game.

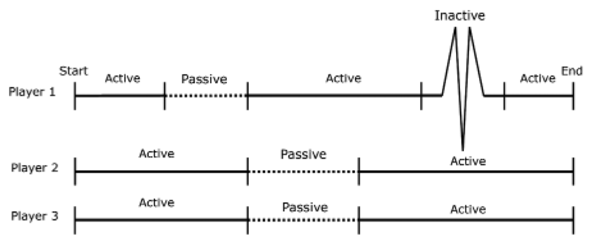
Figure 3
Examples of RPG Play: Top Left, A Screenshot From the MMORPG World of Warcraft; Top Right, A Screenshot From the CRPG Neverwinter Nights; Bottom Left, a Group of Experiment Participants Playing Neverwinter Nights, DM Screen Inserted Bottom Left; Bottom Right, Two Experiment Participants Engaged in a Discussion in a PnP; The Left Player Is Consulting Her Character Sheet, Which Contains Information About Her Character Stats and Abilities as Well as Background and Personality

Inactive. The player is not playing the game, no direct interaction is taking place, and no information is flowing between the player and the game. During inactive states, neither the player nor any avatars or characters are active in the game (unless controlled by a different, active player).

Time Flow

This term is defined here as the progression of time within a given framework, for example, the real world, the game, or a specific time layer. Time flow can be

Figure 4
The Division of Playing Time According to Player State; The Inactive State Represents a Break From the Gaming Activity; However, as Long as Any Player Remains Active Or Passive, the Specific Instance of the Game Remains Operational



Source: Tychsen and Hitchens (2007).

said to be fast or slow but only in a specific relationship as defined in the next subsection.

Relative Game Speed

The term relative game speed (or ratio of time flow difference) is defined here as the ratio of time flow between two specific temporal layers. This definition is aligned with that of Juul (2004), who defined game speed based on two layers of time. A useful relative game speed in game analysis is the ratio between playing time and world time.

Game Pace

Game pace is a subjective measure of how fast the game feels to the player, for example, in terms of how quickly the player needs to react to new input. Turn-based board games such as Axis & Allies, Chess, or Twilight Emperium are generally low-paced unless specific rules are adopted to increase the pace. In computer games, the pace often varies, for example, in Space Invaders, where the alien invaders increase speed and descent rate as they diminish in number. In FPSs (first person shooters) like Serious Sam, Quake, or Doom, the relative game speed between playing time and world time is generally 1:1; however, the game pace can vary. For example, in a play sequence where the player avatar is forced to move quickly because of time constraints (see below) or where there is a higher-than-normal influx of enemy MOBs (stands for "mobile," a moving entity in a game), the game pace is high, whereas in cut scenes, the game pace is usually slow. Game pace is important to game design in defining the player experience.

Temporal Pressure and Limits of Time

Related to game pace, a common feature of digital and tabletop game design is temporal pressure and limits, which can operate explicitly or implicitly. A classic example is Lightning Chess, where each player has a total of 3 minutes to complete a game that normally does not feature any limits to the playing time. Racing games such as the Burnout or Pit Stop series are typical examples of games where temporal pressure forms a key game play element. Temporal pressure can also be applied indirectly, for example, in the board game Lord of the Rings, where the inclusion of a tile deck with a series of events that affect the players, creates a time pressure on the individual scenarios of the game. Time pressure can also arise within the magic circle but as a social phenomenon. In playing Diplomacy or Twilight Emperium, both strategy games where a player needs to apply tactical thinking, a turn can take a substantial amount of time. If the other players feel that the player taking the turn is being too slow, they might voice their irritation to speed up the player in question. This kind of socially induced temporal pressure can affect the decisions of the player taking the turn (Salen & Zimmerman, 2003). Time pressure can also be projected from the real world into the magic circle, that is, the players may only have a certain amount of hours to play in. This kind of external pressure can certainly affect playing behavior, for example, skipping of nonvital content to get to a specific point in the game story.

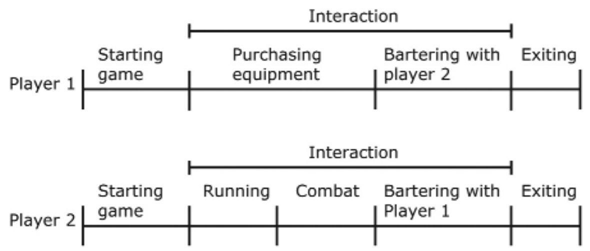
Cut scenes

Cut scenes are common in computer games and are generally used to advance the game story without the interaction of the player. Cut scenes represent segments of time within the game world and would normally map on a 1:1 basis with playing time and engine time.

Lag

Lag is the time it takes for a specific packet of data to be sent from the sending to the receiving application, including both the transit time over the network and the processing time at both the source and destination computers. This becomes an issue of digital game play when the lag time becomes a hindrance to game play. During a period of extended lag, a player of a computer game will not be able to interact actively with the game, but the avatar, however, remains within the virtual world. This means that other players can affect the avatar, for example, in combat, but the player will not be able to defend in turn. The lag situation is similar to a passive player state because the avatar can be active

Figure 5
Variation of Player Activity Within the Playing Time Layer, Represented by Different Temporal Segments and Breaks; Two Levels of Segment Granularity Are Included, Represented by the Breakdown of the "Interaction" Segment Into Smaller Component Segments of a Higher Level of Detail. Each Timeline Represents One Player



Source: Tychsen and Hitchens (2007).

within the game world, but information is not flowing from the player to the game—the player is not in control.

Model Granularity and Scalability

The interaction between players and the game is rarely homogeneous during the entire period of game play. Players perform different actions—rolling dice, moving game pieces, discussing tactics—over the course of the real-world time it takes to play the game. These various modes of engagement can be integrated in the game time model by dividing time layers into segments and breaks, allowing the mapping of different modes of engagement (or activities) directly onto the relevant viewpoints of game time (Figure 5).

Segment. This represents a specific span of time defined via one temporal layer. During the segment, the activity of the player(s) is homogeneous for the level of detail used in the specific analysis being performed (e.g., loading a saved game).

Break. This represents a change in the activity. Breaks do not have a temporal dimension and should not be confused with periods of inactivity, which have a nonzero distribution of real-world time.

Segment granularity. The segmentation of game time can be defined at different levels of granularity. A period of active game playing can simply be labeled "interaction," or a more detailed description of the player activities can be defined, to the definition of minute actions such as keystrokes. The level of detail *must* thus be tailored to the purpose of the game analysis in question because even something as common as the actions of loading and saving exist in many different ways and have varying impact in different games (e.g., conditional saving as in Animal Crossing or server save/load "roll-backs" in MMOGs). Analysis of the transcription data collected for this study indicates that the finer the resolution applied to segment definition, the higher the chance of multiple players performing different actions within the same segment, depending on what the players are engaged with at that specific segment of time—for example, all players running from point A to B is homogeneous down to the level of comparing minute variations in running path.

Scalability of model. In the figures presented in the current study, one timeline corresponds to one player; however, in studies considering multiplayer and massively multiplayer games, it can be useful to consider the timelines as representatives for multiple players, for example, a group or guild of players. This approach enables interactions between player groups or organizations to be mapped rather than individual players.

Linear Representations of Time

Modeling time in multiplayer games requires that not only the player–game interaction but also the interaction between players can be modeled. The impact that one player can cause on another player varies from game to game. To accommodate this feature of multiplayer gaming, concepts such as player and game state are needed. Furthermore, additional viewpoints of game time other than those presented in Juul (2004, 2005) and Hitchens (2006) need to be integrated—namely, server time, story time, and perceived time—and the existing four layers of the model of Hitchens (2006) refined. Although not all the 7 viewpoints of time are applicable to all games—for example, tabletop games do not feature a server time—the model is intended as a flexible toolkit for use in game play analysis.

Playing Time

Playing time (Figures 2, 4, and 5) is a measure of game time from the viewpoint of the player. It is defined as the objective real-world chronological time experienced by a player during and between game play sessions. Playing time has a specified beginning and end, between which game playing occurs. During playing time, the player(s) affects the game state via interacting with other players or the game itself, using various input devices (verbal, game pieces, human-computer interaction devices, etc.).

The specific activity of players while playing can vary—for example, loading or saving a game, active interaction, or reading a briefing screen or card. In multiplayer (MP) and massively multiplayer (MMP) computer games, players may not be undertaking the same activities in the same segments of real-world playing time. For example, in MMORPGs, one player can be loading the game while another is actively playing. In a PnP, one player can be rolling dice to determine combat damage while another is talking to the GM, who is acting the role of a nonplayer character (NPC). In a LARP, one group of players can be engaged in combat, another in negotiations.

Playing time includes the period of real-world time where at least one player is in an active or passive state. Persistent games such as MMORPGs could be argued to form an exception because these games in a sense keep running even if no players are present. However, it would seem that these games are not then actually being played but are merely a game framework on standby.

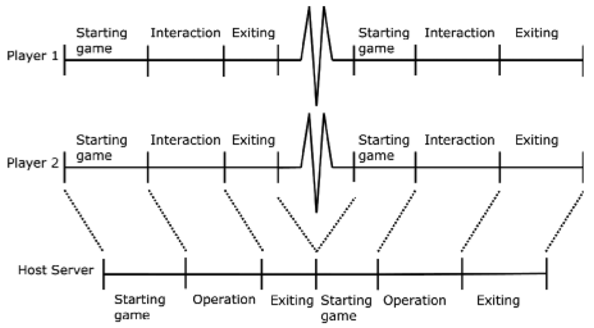
Engine Time

Engine time represents the perspective of the game engine or application software running the gaming application. This viewpoint of time is defined by the objective, linear, and chronological real-world time in which the game engine executes. Engine time can be very similar to playing time; however, there are subtle differences: For example, periods where players are in an inactive state (i.e., not playing) are represented as breaks because engine time does not recognize time flow when it is not operating (Figure 2), although in some games, such as Animal Crossing, it may be able to detect that such periods occur and even note their length. In MPs and MMPs, conversely, the game engine or software can remain operative even if one or more players become inactive. This necessitates the introduction of server time, discussed below.

In multiplayer games, players can be performing different actions at the same point in real-world time, which means that engine time is specific to the individual player except in the case of hot-seated games. Under all circumstances, engine time in the digital arena refers to the game time as it is experienced by the client software for a particular player because the client software for different players will potentially include different activities within the same segment of time because of the nature of distributed computing systems (Figure 5).

Outside the digital medium engine time represents the viewpoint of time for the game itself—for example, the viewpoint, for board or card games, of the

Figure 6
The Mapping of the Playing Time of Two Players to Server Time; In This Example a Local, Hosting Server That Operates for Roughly the Same Length of Real-World Time as the Clients (Players) That Log On to It



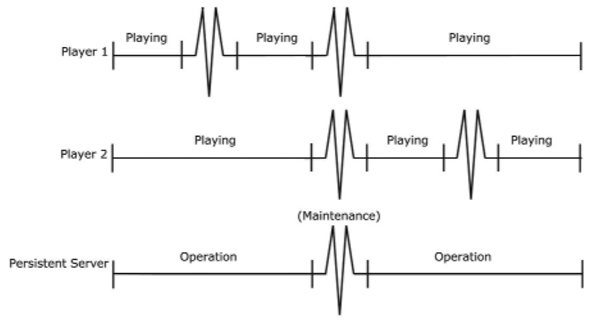
game equipment, or for nondigital RPGs, of the game environment. More generally, it can be considered as the time within the magic circle. Mapping to playing time occurs following the same guidelines as for digital games.

Server Time

MP and MMP digital games are generally run via a game server, which hosts the server-side software. This also means that software on the separate machines in the network do not share the same view of time (Lamport, 1978), necessitating a viewpoint of game time for correlation of the involved computers: server time. This is defined as the chronological, real-world time in which the game server executes. Server time allows the reconciliation of the activities of the players as modeled in their individual playing time and engine time layers (Figure 6). Normally, for each MP or MMP, there will be one server time layer mapping to multiple playing time and engine time layers. Note that in games such as Counterstrike and Battlefield, where the computer of one player can act as both game server and engine host for that player, the engine time of that software is mapped directly to server time. Although game designers put substantial effort into the network code of games (e.g., Bettner & Terrano, 2001), they still have to cope with the vagaries of processing time and network lag, making precise synchronization and a shared clock impossible and producing variations when each piece of software receives information about events in the others.

Server time is particularly useful in modeling persistent-world games (e.g., World of Warcraft, EverQuest, Ultima Online; Figure 7), which can remain in

Figure 7
Persistent Digital Games and Server Time; The Playing Time Is Represented for Two Players, With the Server Time Layer Representing Game Time From the Point of View of the Persistent Server



Note: The server can be in operation before the initiation of the playing time and can continue after a specific player stops playing the game.
Source: Tychsen and Hitchens (2007).

operation for years, with servers being almost continually active. Players are free to log on and off as they choose, leading to a complex mapping between player and server time. For example, players will rarely start playing the game at the same real-world time as the server time initiates. From the perspective of server time in a MMORPG, players can therefore be viewed as having a finite temporal duration that can be mapped as segments. When players are inactive, the server continues, even if the player avatar is effectively removed from the game (some MMORPGs allow certain repetitive activities such as crafting or transportation without the player needing to actively interact with the game). The gap in playing time is therefore mapped to a segment in server time, as opposed to a break in engine time (Figure 2).

Whereas engine time is readily applicable to games outside the digital environment, server time is most useful in modeling MP or MMP games implemented using distributed software. MP games that are not implemented via a client/server software (e.g., as peer-to-peer software) and most nondigital games do not generally require this layer for analysis (the engine time layer is usually sufficient). Server time may, however, be useful in the study of games featuring a large number of players operating independently and/or in multiple groups. For example, in a large-scale LARP, it can be of use in considering time from the perspective of overall game events, with engine time modeling discrete groups.

Nonlinear Representations of Game Time

The viewpoints of time discussed above are all linear and chronological; however, games contain several features that make them a nonlinear experience (Aarseth, 1997), which is a term that can have multiple meanings in a games context:

1. Multiple paths and choice: Games feature choices, meaning that there is more than one possible path through a game, referring to the topology of nodes that make up the game structure. At each node, players have choices about how to proceed, and these choices have an impact on the gaming experience.
2. Revisiting paths: Whereas games afford players the ability to choose between several options for progressing the game, digital games often provide the opportunity to save and load games. This enables the player to revisit previously chosen paths and experience content again, in all likelihood with a different experience the second time around. In these cases, because the same game world time is experienced multiple times, but playing time proceeds linearly, loading a saved game leads to a branch in time (Figure 8).

In developing a viewpoint of time that models the nonlinear progress of the player through the game, it would be tempting to simply use world time. However, world time is a highly variable feature of games, and not all games indicate the meaning and duration of time within the game world (Space Invaders and Pac Man), if a game world is present at all (card games such as Poker and Bridge). Furthermore, the same segments of world time can be experienced multiple times in some computer games, with possibly different amounts of game progress occurring. World time does not capture all aspects of nonlinearity, such as the progress of a player within a game.

Progress Time

Players rarely expect to remain static in terms of their position within a game. MMORPGs invite players to level their characters, Space Invaders requires the player to complete level after level, and Bridge requires the accumulation of points. Progress time is an abstract view of game time, specific to an individual player, which models the progress of the player through the game. What constitutes progress may vary from game to game, as just noted, and multiple aspects of it may be modeled in the same game (e.g., character advancement and quest completion in an RPG). Regardless, there are defining features of this view of time. It is an abstract, not chronological, measure that is quantified in terms specific to the particular game and with the events modeled subject to "happens-before' and "happens-after" relationships. It is individual to each player because

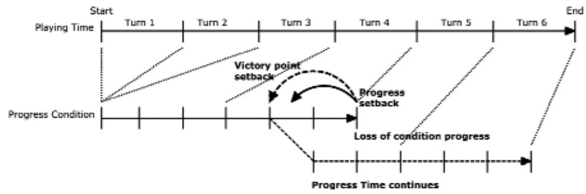
Figure 8
An Example of Mapping Between the Three Nonlinear Viewpoints of Game Time and Playing Time, in a CRPG Featuring a Chronologic World Time and a Game Story

Note: Dashed lines, mechanic progress; dashed/dotted line, story progress; dotted lines, mapping between layers; bold dashed arrows, reload; thin dashed arrows, branch continuation.
Source: Tychsen and Hitchens (2007).

each may progress at a different rate. It is nonlinear, in that player choices and/or reloads may cause branches (Figure 8) in the timeline. Separate branches can represent similar intervals of time in the game world; however, they do not influence the future progress of the player(s) except in the form of increased knowledge of the replayed section of the game.

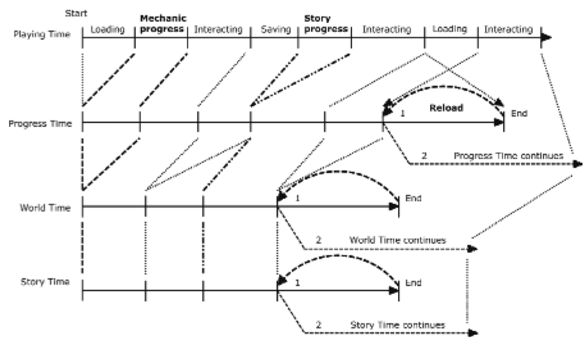
Two examples of how progress time can be used are *mechanic progress* and *task progress*. Mechanic progress changes the game state in terms of the rules, for example, gaining a character level in a MMORPG such as Star Wars Galaxies, the accumulation of money in Monopoly, or upgrading a village to a city in Settlers of Catan. Progress in these terms can obviously be lost via a reload and nonlinearity introduced, but even in nondigital games, this is possible where the basis of the measurement can be lost and regained. For example, in Settlers of Catan (Figure 9), the goal is to reach a certain amount of points, which are scored by reaching specific conditions, such as controlling the longest

Figure 9
The Settlers of Catan Tabletop Game



Note: Image © Mayfair Games.

Figure 10
Mapping Game Progress as a Feature of Progress Conditions, for Example, Victory Points in Settlers of Catan



Note: Branching occurs as a player looses progress already gained; the solid arrow indicates a progress setback as it could have been mapped if a more detailed measure of progress than victory points were used.

road. However, points scored for controlling the longest road can be lost if another player builds an even longer road, causing a setback in game progress, which can be regained by extending the road or accomplishing other point-giving conditions (Figure 10).

Task progress is where players have to complete certain tasks (objectives, quests, etc.) to advance in a game. Examples of this include the stages in the quests of most RPGs or the levels of FPSs and games such as Space Invaders and Donkey Kong. Note that some games (such as many PnP RPGs) have no defined completion conditions (unlike most single-player RPGs), but the progress of players from one point in the game to another can still be readily observed.

Granularity of measurement may change depending on the complexity of the game and the detail of the study in question. Game progress can me measured to a fine detail, all the way to mapping the individual atomic tasks associated with the game and relating them with progress conditions (Eriksson, Björk, & Peitz, 2004).

Story Time

Story time is defined as the logical or chronological time of the actual dramatic story of the game. *Story* is used here in a loose sense because game story features can vary substantially and, in some cases, even be nonexistent. Story time is chronological if world time for the specific game is chronological and otherwise logical, although the latter is very rare. Story time models the sequence of events that make up the story in the game (if any). It is ordered by the presentation of those events to the players, so although it usually consists of chronological segments, the order of presentation of those segments to the player may not be in strict chronological order. The mapping between story time and other layers, such as playing and world times (Figure 8), can demonstrate many of the narrative tools used in storytelling. These include contracted time (e.g., Civilization and similar TBGs), extended time (e.g., the bullet time of Max Payne), flashbacks, and foreshadowing.

Story time is closely related to progress time, especially if the latter is modeled as task progress. Many, and in some cases all, events represented in progress time would also be represented in story time. For example, talking to an NPC and learning a vital clue to the conspiracy of the world of Deus Ex advances both progress within the game and its overall story plot. Gaining a level in a MMORPG is mechanic progress and may be regarded by the player as part of their character's story. However, talking to an NPC who provides a point of humor may not bring the end of the game any closer but may form part of the story. In more technical terms, most events that take nonzero progress time would take nonzero story time, although the reverse would not hold as consistently—namely, the humorous NPC. It is also worth remembering that progress time is a logical, not chronological, time, with events not measured in minutes and seconds, whereas story time is typically a chronological measure. This allows the two to model different aspects of the same game play. For example, in the planning of story-based versus mechanics-based rewards, this would be the measurement of the rate with which players progress through the game story, locating "dead" story elements that the players ignore, and so on.

World Time

World time measures time as it occurs within the game world. Within its own frame of reference it is linear and complete, not being subject to, for example, the variations in story time possible through the use of techniques such as ellipsis and foreshadowing. When modeled, however, world time can demonstrate nonlinearity. The use of reloading, for example, can return a player to a previously experienced point of world time, which then proceeds along a separate branch (Figure 8). World time is a variable viewpoint of game time and can refer to either the chronological or abstract time of a game world. This definition is somewhat comparable with the event time layer of Juul (2004, 2005), with the additional aspect of nonlinearity.

The mapping between world time and other chronological times can be synchronous or asynchronous (Juul, 2004, 2005). Whereas the mapping between playing and story times is almost always synchronous (the story must be experienced in play for it to be communicated to the player), their relationship with world time is more varied. The world time experienced by a player may be unbroken, subject to the world time gaps between levels of many FPSs, or represented by the chapter interludes as in the CRPG Neverwinter Nights, making the relationship asynchronous.

The exact chronological progress of world time can sometimes be difficult to understand. A perceived one-to-one relationship between world time and real-world time is typical of game genres such as CRPGs, adventure games, and first person shooters. The actual relationships can vary because world time can be represented differently within the same game world. The complexity of this representation may depend on the logical consistency of time representation. For example, although world time and real-world time appear synchronous in Quake and Hexen, the in-game sky does not change throughout the game. In Serious Sam, the sky changes, however, with no apparent temporal logic. This is in contrast to games such as Saga of Ryzom, where the seasons change (every 4 days of playing time) and with it the weather, including rain, snow, and wind. Tied to season and weather changes are the movements of animals and availability of harvestable materials, creating a direct link between the timing and behavior of the environment and the game play.

In some cases, such as Civilization or the strategic aspects of the Total War series, the relationship between world time and playing time may be simply understood in terms of the relative rate of time flow between the two layers; in other cases, the relationship is more subtle. Many single-player CRPGs appear to have the characters acting in real time. However, days within such games often last much less than 24 hours of playing time, even when that is the ostensible length of a day in the game world. This effect is not typical of PnPs, and this variance in the nature of world time between game forms was apparent from analysis of the experiments. This effect can also be seen in the compressed time observed in many sports games, for example, FIFA 2002, where one match takes 8 minutes of playing time, not 90 as a normal soccer match (Crogan, 2003). In such cases, world time may need to be mapped separately for the world itself and for the characters acting within it.

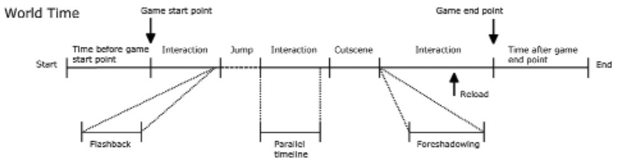
The exact nature of chronological world time can be even more difficult to understand, for example, in the trading card game Magic: The Gathering, set in the fantasy world of Dominia. The cards are themed by the historical periods of the world, which are logically ordered but only loosely so in terms of a world chronology. The game gives the impression of a chronological world time, which is however so imprecisely defined that the world time takes on the aspect of a logical time best understood in terms of individual segments, typically one per expansion. The nature of world time within an individual playing of Magic: The Gathering operates at a different level again.

World time in computer games such as Pacman Tetris and Space Invaders as well as in card games and board games such as Monopoly, Kalaha, and Chess is abstract in the sense that there is no definitive statement about the duration of events in the game world in terms of chronological time; however, the events can be mapped logically. It might even be argued that in some cases no world time exists, which is certainly the case for traditional card games such as Poker and Blackjack.

Even in games where the nature of world time is readily understood, such as in most PnPs, its modeling can be complex. The relationship between playing time and world time will often be asynchronous, for example, player characters can travel between geographical locations spending weeks of world time in seconds of playing time. Worse, player characters can also become distributed at different points in the game world chronology. In essence, each player operates within a specific instant of world time, which parallels and interacts with the world time of other players (i.e., internally within the game). The players are in these cases typically plesiosynchronously placed in the world time chronology (almost synchronized, with the variation in rate being constrained by specific limits, e.g., the temporal limits of a combat sequence) while retaining an asynchronous relationship with playing time. An example observed during the PnP experiments found the group of player characters separating geographically within the game world. As the GM focused on events unfolding at one geographical area or on one player at a time, variably advancing the player character through the game, the other players were effectively frozen at an earlier point in world time. The players not currently in focus were limited in their ability to move their characters in terms of world time; however, they would generally remain in the active state, maintaining story progress, rather than reverting to a passive state (observing the interaction of the GM and the player(s) in focus; Figure 11).

World time is also a complex notion in games with large numbers of players. In theory, these games could use time-manipulating narrative tools. In practice,

Figure 11
Features of Game World Time: Mapping Flashbacks, Parallel Timelines, Foreshadowing and Temporal Jumps to World Time



Note: Loading a saved game maps to a zero time in world time (bottom vertical arrow).

in a game with hundreds or thousands of players interacting in real time, manipulating world time becomes a quantitative problem. For example, transporting a guild of MMORPG players back in time and afterward having to calculate their effect on the present, and implementing these effects to the entire game structure requires massive resources. In comparison, moving a group of five CRPG players back in time as part of a game story is computationally a much simpler task. This affects the nature of world time in LARPs (Figure 12; Bøckman & Hutchison, 2005; Tychsen et al., 2006) and MMOGs/MMORPGs (Figure 13; Bartle, 2003). Time flow in the fictional game world of large-scale LARPs is in most cases equal to the flow of time in the real world.

Time keeping in LARPs can vary: Some record events within a world chronology, whereas other games occur in temporal segments that are unspecified or only generally defined in terms of the world chronology. In the latter case, the world time is reasserting, forming a loop from game start to game end.

Many, if not most, contemporary MMORPGs appear to operate on a real-time relationship between playing and world time. Some, such as World of Warcraft (Figure 13), even incorporate a 24-hour day/night cycle. However, this is essentially a cosmetic layering over a more-or-less static world or, more precisely, a rapidly reasserting game world and world time. Whereas players operate within the world, advancing their position in terms of mechanic and task progress, the world itself, in games such as World of Warcraft and EverQuest, remains unchanged for large portions of time or at least between expansion packs. Some MMORPGs permit players to cause permanent changes to the game world of minor game impact (Tychsen & Hitchens, 2006), for example, in the form of constructing structures (e.g., A Tale in the Desert) or the creation of in-game items. But for the most part, the players' progress and story occurs within a frozen moment (or very short recurring period) of the world time.

The above discussion has not exhausted the complex nature of world time. Any or all of its aspects can be modeled when analyzing a game from this point of view, and each may need to be mapped separately to other time layers.

Figure 12
The MMORPG World of Warcraft Features a 24-HourDay-Night Cycle; However, Time Does Not Actually Pass Within the Game World, and the Night Sky Is Always the Same in Hellfire Peninsula, One of the Game's Many Zones That Each Feature Different Skies Irrespective of Geographic Logic

Perceived Time

Perceived time represents game time viewed from the perspective of the individual player. playing, engine, and server times are in themselves chronological and objective; however, what a player experiences during a game is subjective—for example, one player may feel that time flows rapidly while playing a specific game, whereas another feels time passes slowly. Although such features of game time are related to questions of immersion, engagement, and enjoyment, perceptive differences in game time are integral to the understanding and analysis of the playing experience, and they are comparatively complicated to describe and analyze objectively. Importantly, world, progress, and story times are subject to perceived differences between players (Figure 14). Perceived time is defined as the individually perceived versions of these three temporal layers and is useful in mapping, for example, the individual understanding of game progress. Note that

Figure 13
Scenes From the DragonBane LARP, Which Was Held in Sweden in 2006; for the Game, a Commercial Foresting Vehicle Was Converted Into a Full-Size Controllable Dragon, and a Village Built From Scratch

Note: Images courtesy of the photographers; left and top right, Saara Kähönen; bottom right, Janne Ilmari Björklund.

this is in opposition to the objective definition and description of these layers of time in a game, for example, by a researcher.

Perceived time can relate to both logical and chronological levels. For example, game progress can be measured or understood in different ways—in terms of items, experience points, victory points, NPC contacts, and reputation—and different players emphasize these progress conditions differently. The duration of world time events whose temporal length is not explicitly specified (as is often the case, e.g., between a cut scene and the start of a new level) is prone to differences in perceived duration.

Perceived time is especially important to PnPs, which are based on a shared understanding of an imagined fictional world (Tychsen, 2006). In PnPs, each participant takes the textual contributions of themselves and the other

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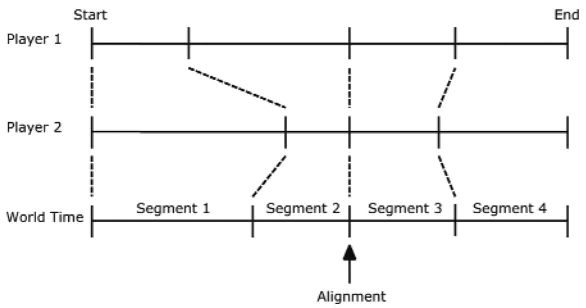
Figure 14
Differences in Perceived Time in a PnP; Segments of World Time Not Specified in Terms of Chronological Length to the Players Are Perceived as Having Variable Length; the Process of Alignment Brings the Players to the Same Point in the Perceived World Time



Source: Tychsen and Hitchens (2007).

participants, adds their own imaginings, and updates their view of the story. As an effect of this process, one of the major challenges in running a PnP game is to ensure a sufficiently similar perception about the game events among the players in order to avoid confusion. The PnP experiments provided many examples of perceived differences in world time, for example, in a scene where the player characters are being flown in a military drop ship from their base of operations to the inception point of a specific mission. Most GMs did not explicitly specify the duration of the flight, because it was not important to the game story or mechanics. Therefore, each individual player could perceive the flight time differently. In the group discussions following the game, the players expressed very different perceptions about the length of the flight scene as well as other similar scenes.

Even in scenes described in explicit detail, players can still develop their own perceptions of the temporal duration of events, though the variations between the player perceptions are usually smaller. For example, in one of the PnP sessions, the player characters were trapped inside an armory, which is being besieged by aliens (Fulzans). The GM notes “The Fulzans come, lumbering into the doorway, using one hand to push the door aside, and squeezes themselves into the doorway” (Session 41, Scene 1). As specific as this description is, there is substantial room for perceptual differences in the minds of the players, as emerged in the postgame discussion. For example, to one player, the door was rapidly forced open, and the Fulzans come lumbering into the room. Another player perceived the situation in a more cinematic fashion, with the door to the armory being slowly pushed open. These two perceptions of the game event take a different amount of world time; however, the perceptual differences are relatively small when compared with the drop ship example.

To avoid confusions as to where the player characters are positioned in world time, the PnP groups in the experiments would regularly perform an alignment (also called a time stop in LARP context) where all players were brought up to the same point in world time, either by the GM or each other (Figure 14).

Perceived time operates within the cognitive mind of the individual player. This means that it is difficult to extract and objectively describe and map to other viewpoints of time. For example, interviewing players about their perception of the temporal duration of events in terms of world time is bound to produce incorrect data because the perceptions of the players could have been altered between the time of the event and the time of the interview. Furthermore, articulating in verbal form what has been perceived in the “mind’s eye” can be difficult and result in a lack of precision. Whereas perceived time is important to the personal experience of games (especially collaborative and interactive narrative games), the cognitive functionality governing the perception of game time in PnPs remains unexplored, and it is therefore difficult to describe in detail.

Turn-Based Games

Tabletop games such as Poker, Magic the Gathering, and Diplomacy commonly use a turn-based structure (or other discrete unit of time) optionally, with various forms of turn interruption or effecting mechanics, whereas physical games, including many types of sports (Soccer, Rugby, etc.) as well as LARPs, occur in a real-time context. A notable exception to turn-based tabletop games is PnPs, which rarely specify a turn order.

TBGs may be structured, with each player making and resolving their turn in sequence, or the players may give their turn orders, which are then resolved together. Examples of both forms can be found in both digital and nondigital environments. Sequential TBGs include chess, most card games, Monopoly, and computer games such as The First Blitzkrieg. Games with simultaneous turn resolution include Diplomacy and Master of Orion 2. Some games feature a mixture of the two approaches, for example, the board game Twilight Emperium, where players can negotiate and interact between their turns, or various card games, where players can interrupt another player’s turn. Many digital TBGs can be played hot-seated, where one player is active, and the others are passive and unable to influence the game. TBGs are usually restricted to single or MP forms because a large number of players makes imposing a turn-based order time consuming and slows down the game speed. There are some examples of massively multiplayer strategy games, such as Space Civilizations and War

Online, but they are relatively rare. All these introduce their own complexities to time analysis, of which space prevents us giving more than an overview.

Time in TBGs is broken up into discrete units by the turn structure. Games such as Civilization (both the computer and tabletop versions) represent known amounts of world time per turn, resulting in a straightforward relationship between progress time and world time, if the former is judged by analyzing the progress made within a complete turn. However, because the majority of the interaction between the players and the game takes place within the turns, that is, without world time advancing, mapping from progress time to within a segment of world time corresponding to a turn can only be in the form of logical time. Finally, players can, in some games, take as much time as they like on their turn, and this affects the amount of playing, engine, and server time spent. This means that the mapping between these times and world time is in a state of flux. This is further complicated by turns being normally taken in sequence, but the turns of all players in a round occupying the same world time, thus, mapping different playing times to the same world time.

As noted above, PnPs are not, in their entirety, TBGs; however, many of them use a turn-based system to resolve combat. The comments in this section apply to this aspect of them. As observed in the PnP experiments, players tend to organize a form of unofficial turn order in situations where it is important to specify whose character performs which action at which time. Other situations such as high-intensity social situations also often resulted in player groups imposing a more structured approach to their actions. The same was also observed in the CRPG sessions, notably in situations where the group would benefit from imposing a structured turn order, for example, while planning a difficult combat situation.

Conclusions

In the above, a model for game time has been presented that correlates the complex nature of game time across separate viewpoints of time and is intended to be a useful tool in game studies, comparison of play styles and game design, and for studies of the gaming experience.

The model illustrates how the timing of events in a game can be viewed from several different positions, presenting game time as a representation of game play. The model allows the objective analysis and study of game time, and for relationships to be drawn between the various viewpoints of game time. It also incorporates the important game feature of nonlinearity, which is important in mapping game progress, the time of the game world, and the game story. The nonlinear viewpoints of time can, using the model presented, be related to linear measures of game time: the time of the playing of the game and, for digital games, the viewpoints offered by the game engines and game servers.

The model is substantially wider in scope than existing theoretical models and is based on existing work on game time and empirical experimentation and observation, with a focus on multiplayer games and notably RPGs. Empirical experiments were used to advance the current theoretical concepts, by capturing contextual data, exploring and confirming the theoretical concepts of, for example, Juul (2004, 2005) and Hitchens (2006), and mapping the complexity of the interacting viewpoint of game time. It is not, however, the final word on time models for games; for example, future work should include comparisons with parallel studies in film studies and psychology, such as Csikszentmihalyi (1991).

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