Games as Information Systems

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ABSTRACT

In this work, we formally build the construct of games as information systems. Starting from models and definitions that describe them, we present models that show game elements: components, players, environment, and their relations; as information systems elements. This paper also presents the analysis of five games and their elements based on that premise. As a ratification of our rationale, we present tools and visions shared by both fields.

The presented premise and rationale could be easily linked to video games but, moreover, they are valid to all forms of games like tabletop games or sports.

CCS CONCEPTS

• **General and reference** → General conference proceedings; • **Applied computing** → **Arts and humanities**; • **Information systems**;

KEYWORDS

games, information systems, board game, video game, card game, game design

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1 INTRODUCTION

Game design and development turned out to be a legitimate profession and industry. There are undergraduate and graduate courses in Game Design, Art, Programming and all others aspects related to this endeavor. Some schools even adopted the term Game Engineering, recognizing that games are engineering artifacts[33].

Meanwhile, there is not yet a set of widely accepted standard of practices for game conception, development, maintenance and study [1, 41]. As happened to software development, a new body of knowledge is being defined by borrowing from other areas such as administration, management, art, narrative studies, and, of course, by creating new models, tools and practices both from empirical evidence and scientific investigation.

One of such areas is Information Systems (IS). Many of its elements are already used in the game industry, mostly due to the fact that video games are software artifacts, but without any formal or theoretical approach.

In this paper we propose a specific interpretation of games as Information Systems, which allows for some insights on games and their development process that we claim to be of uttermost relevance.

2 RESEARCH METHOD

This work aims to state that games are IS and uses a mixed approach to develop its research proposals [4, 16, 44, 50, 59]. First, we examine models that describe both games and IS, and analyze game artifacts. We also present a formal conceptual model that relates the concepts and models of both games and IS using theories, frameworks, schemes and techniques that, together with the cases presented, shows the analysis of games *vis-à-vis* the concepts presented of IS.

The analyses of games were carried out by six researchers, who work in fields such as Games, Engineering and Simulation with different levels of research experience. First, the researchers carried out their analyses individually. Afterward, joint discussions confronted these individual analyses. During these discussions, a descriptive, interpretive, positivist perspective was used during the work. Our analysis and interpretation were guided by semiotics, which are evidenced by the use of case study and action research for selecting historical material and participant observation.

3 WHAT ARE INFORMATION SYSTEMS

An Information System (IS) is “an arrangement of people, data, processes and information technology that interact to collect, process, store and provide as output the information necessary to support an organization” [58]. However, we must emphasize the meaning of the word “system” to better understand this definition.

According to Bunge [9], a system has “a defined composition, a defined environment and a defined structure”. In addition, he defines the structure as “the relationships between its components, as well as between those components and the environment”. In his definition, the elements of the systems need to act on each other. What he calls a connection is actually a stronger relationship instead of a simple association. There are two types of connections: the action of one element on the other, in which case one is the agent and the other is the patient, and the interaction, in which there are reciprocal actions [9].

The basic idea that underlines the importance of systems is the Aristotelian famous quote “the whole is greater than the sum of its parts”. The system has new properties that emerge from the actions and interactions between the parts and that do not exist in the parts when isolated.

IS can be understood from a technological and business perspective [34], and also from a social and process view [6]. Typically, most systems are components of larger systems, for example, an organization. They can be organized in a hierarchical or even more general structure. Some systems, like the amorphous “internet”, connect other systems and end up building a much larger one.

Sommerville [51] discusses the social issue of systems. He points out that artificial systems are developed to support human activities - work, communication, protection of people and the environment, etc. Systems interact with people and their design is influenced by human and organizational issues.

One of the most important improvements in understanding, modeling and development of IS was the advent of Structured Analysis around 1978 [21], which was later refined with concepts brought by McMenamin and Palmer [38]. In these seminal works, the IS abstract components were broadly divided into external agents, processes, memory and data flows.

Davis and Yen [13] explains that a system is a set of interrelated components that work together in a meaningful way. In addition, a system is bounded from its environment by a limit, and the system accepts inputs at its limits. A process is an activity, within the system, that changes it in some way. At the end of the process, the output flow back across borders. The control and feedback mechanisms allow the system to determine whether it is achieving its objective. Figure 1 summarizes these concepts.

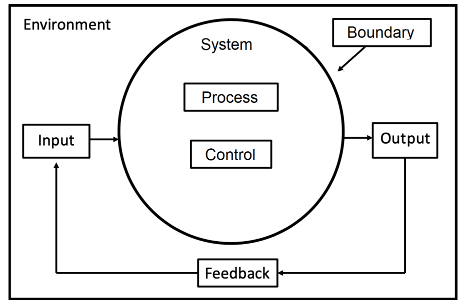

Figure 1: System concept adapted from Davis and Yen [13]

Therefore, from the definition provided by Whitten and Bentley [58] and the components proposed by Gane and Sarson [21] and McMenamin and Palmer [38], a group of component classes can be derived to describe IS. These components interact, acting on each other, within a environment, such as an organization, a complex of organizations, a subset of society, as a group of people interested in some subject, or society as a whole.

Some verbs can describe the services provided by the IS, such as: receive, store, present, process, interact. These verbs are somehow present in the IS definition of Laudon and Laudon [34]. They explain an IS as a set of interrelated components that collect (or retrieve), process, store and distribute information to support decision making and control in an organization. Therefore, IS contain information about people, places and things within the organization or in the surrounding environment.

We can assume that Laudon and Laudon [34] also extend the systems concepts in the Figure 1 to IS, although they have not cited Davis and Yen [13] in their book. Laudon and Laudon [34] explain that IS entries capture or collect raw data from within the organization or its external environment. A process converts raw input data into meaningful information. The output transfers processed information to the people who will use it or the activities for which it will be used. IS also requires feedback as the output that is returned to the appropriate organization members to help them assess or correct the entry stage.

4 THEORIES FROM GAME STUDIES

4.1 The MDA Framework

There are some seminal approaches proposed to understand games and describe their elements, such as [25], [27] and [49]. Although all of them are useful, we understand that the MDA framework [25], which stands for Mechanics, Dynamics and Aesthetics, has a higher abstraction level, and is originally defined using terms from Information Science, such as ‘algorithms’ and ‘data’.

Mechanics describe the particular game components, at data representation and algorithms level. Dillon [15] tries to clarify that Mechanics are the basic actions by which the game is played.

Dynamics are the run time behavior of the game. They rise from the players’ actions over game mechanics [25]. Dynamics are related to the game’s context, constraints, choices, chance, consequences, competition and cooperation [32].

Finally, aesthetics describe the desirable emotional responses evoked in players, when they interact with the game system [25].

The causal relationship between the three components of the MDA framework can be seen from two perspectives. The designer's perspective results from the mechanics chosen to build the game. Dynamics and aesthetics are not accessible to designers. Dynamics originate from players interacting with mechanics [31]. Players' perspective results from their engagement and the emotions that arise during their gameplay experience.

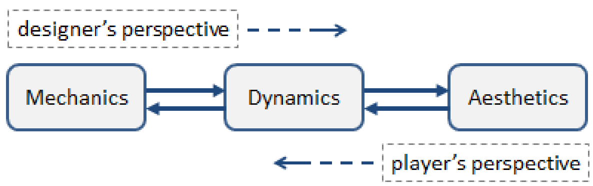

Figure 2: MDA framework

4.2 Järvinen's Game Elements

Järvinen [27] presents a classification of game elements that can be seen as an illustration of the prior assertions about IS as an amalgam of elements, their relations, connections, functions and goals, as well as their behavioral and environmental components *vis-à-vis* the segmentation proposed by the MDA framework.

His work classifies all game elements in three categories and nine classes as shown in Table 1. So, games can be seen as a system that comprises a set of components, including the players, contexts and information.

Table 1: Järvinen's game elements taxonomy

Categories	Classes
Systemic	components, environment
Compound	ruleset, game mechanics, theme, interface, information
Behavioral	players, contexs

4.3 Classical Game Theories

The choice of the MDA structure and elements of Järvinen is not exhaustive and does not imply the negation of other theoretical approach to games. We recognize that, mathematical Game Theory has proven to be useful for several areas where IS are also used. A useful theory is defined by Kreps et al. [30] as an aid to understanding, studying and predicting about the behavior of individuals and their interactions in real or imagined situations (proposed or future scenarios).

Rasmusen [46] uses the term strategic interaction to refer to Game Theory applied to areas such as political science, administration, biology, physics and a wide range of applications. He puts strategic interactions as a situation between the choice and the informative feedback obtained by "players" in each "move", in order to make optimizations to understand the complicated scenarios that are exposed. In this way, both classical game theory and our choices present games as interactive and complex IS. Most games, such as Chess, tic-tac-toe, and the more modern ones like Catan [54] and Ticket to Ride [40], are examples of strategic interaction.

4.4 Procedural Rethorics

Games make statements about how the world works through their processes and models. This is the basis of Bogost's theory of Procedural Rhetoric[7], which seeks to explain how people learn through rules and processes, and through the so-called "art of persuasion". His main argument is that games convey a specific ideology, through their rules-based representations and interactions, rather than spoken or written words. Frasca [20] uses the term "simulation rhetoric", but its statements are identical to the concept of procedural rhetoric. The rhetoric of simulation consists of modeling a system using another system that must maintain and reinforce some behaviors of the original system. These definitions by Frasca and Bogost present a series of possibilities that can be explored through the importance of systemic procedures [7, 20].

Procedural rhetoric is becoming increasingly relevant as it is a way of making judgments about software systems, and allowing greater sophistication in the search for systems' expression and persuasion, becoming a form of statement about how things work. This becomes clearer when we judge the fact of incorporating certain processes and not others in an attempt to create an experience around particular rules and logic [28]. In this way, games make statements about how the world works, doesn't work, or should work. Procedural rhetoric is widely observed in games because they have processes that depend on the players' understanding and adaptation to the games' rules and logic to play. As an example, in board games, we have the precursor to Monopoly [22], The Landlord Game (Magie, 1903), which was designed to educate players about the negative effects of capitalism. This shows something that is not spoken or written, but rather understood, perhaps in a subconscious way, while playing. By analyzing the game, one can explicit that message. One form of doing this analysis is to use the MDA framework[25].

5 DEFINING GAMES AS INFORMATION SYSTEMS

5.1 Games Are Made of Interactions

Caillois discusses play as a foundational culture constituent [10]. From Huizinga's [24] theory of play, Caillois developed a systematic analysis of that phenomenon in different cultures and categorized types of play and games: *agon* (competition), *alea* (chance), *mimicry* (simulation), and *ilinx* (vertigo). A continuum that goes from the spontaneous *paidia* to the calculation of *ludus* is the second dimension of this classification.

More recently, mostly due to the pervasive presence of video games on our lives, we saw the emergence of Game Studies, at some point marked by the division between narratologists and ludologists, which are now somewhat settled. New definitions started to use words as"systems" [48] and "state".

Most authors agree that among the most important characteristics of games that made them different from other activities or entertainments is the existence of the voluntary willingness to accept the rules, what Suits [52] defined as the "lusory attitude".

Thinking that play is the appropriate verb to the noun game, this work uses Huizinga's and Caillois rationales as a cornerstone to understanding games as events embodied in human existence. Playing a game results in an experimental interaction [29].

5.2 Games Are Systems

Egenfeldt [19] says that "Create and play is a basic impulse of Homo sapiens". According to him, the world changes, people change, culture changes and technology developments bring new tools to support human needs.

Through these transformations, human relationships also change, as well as the world around them. However, it is possible to identify that even the most primitive man possessed one based game system rules. Such systems served several purposes, such as to educate, compete or even have fun [19]. Games are recognized as hedonic IS, which focus on the fun-aspect of their use [55]. Thereby, Warnars [57] discusses a game information system architecture.

Salen and Zimmerman [48] pointed out that games are systems and, even further, there is little disagreement about this. Notwithstanding, the term system is a broad concept and must be refined to allow practical use. An application domain, the types of components, the types of relations among them, or the purpose of the system *per se* are used to achieve that refinement [23].

Computers offered new possibilities of relationship between man and the world we live in, "capable of impartial processing of even the most complex and concurrent rules" [19]. As a consequence, complex rules have been developing and new mechanics, dynamics and aesthetics have emerged in games.

Therefore, the increase in new theories, approaches and models dedicated to games has brought new perspectives to understand and assess games. New terms, operations and programming frameworks have emerged to meet these new demands.

5.3 Games Are Information Artifacts

Information artifacts are schemes used by people or executable models. Games are basically abstract models that are instantiated to an observable artifact during the different phases of their life cycle, that is, they need to be in use to exist as a game. In the other hand, games are simulations, and simulations are an attempt to explain a sequence of information processes. However, the game as an artifact exists in various formats since its conception, as indicated by Chandler [11] analysis, who makes recommendations for documents to be developed during the various phases of game construction.

This view of games as a sequence of processes allows us to return to the first definitions of IS, i.e., structured analysis and essential analysis. Structured analysis considers that data and processes are two distinct entities in a system. Processes manipulate and transform data objects through the system [45]. Essential analysis assumes that a system responds to events triggered by external agents. Events are described by data flows and data stores [60].

In addition to assuming that Laudon and Laudon [34] had extended the systems concepts in Figure 1 to IS, our analysis goes further. We propose that those concepts can be extended to games, that is, games can be understood as IS.

One can understand that players enter the game inputs; mechanics control the players' actions, just as dynamics reflect the processes that establish the players' progress towards achieving the game goals; game outputs throughout gameplay provide players with feedback to make decisions about their next actions; and game space is where the game takes place and is the boundary between the game and the game environment. Figure 3 represents the games as IS, being a game oriented version of the system model proposed by Davis and Yen [13].

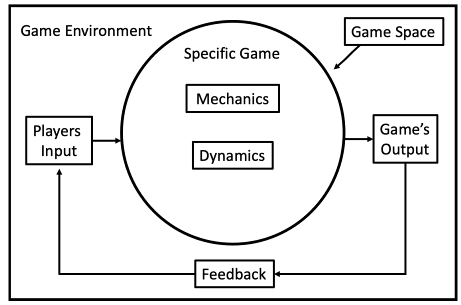

Figure 3: Concept of games as IS

The conceptual model in Figure 4 denotes the relationships among game concepts in the literature (and previously introduced in section 4) and components of IS from Davis and Yen [13] (Figure 1). Some terms can be directly translated from the realm of games to the domain of IS.

We call **game environment** what Järvinen [27] defines as *contexts* so "the time and place where the game takes place" in addition to the social factors that influence that game, like, for instance, "[its] popularity, tradition, players, national histories" [27]. The **game space** is limited by the system's boundaries and could be seen as "which keeps the game world apart from real world" [43]. **Game output**, **feedback** and **player input** could be simply mapped to their counterparts: output, feedback, and input.

As defined by Hunicke et al. [25], **mechanics** are the rules, the allowed player actions, "behavior and control mechanisms", and the "concepts that formally specify the game-as-system" [35]. Therefore, they define the boundaries of the game space, the internal

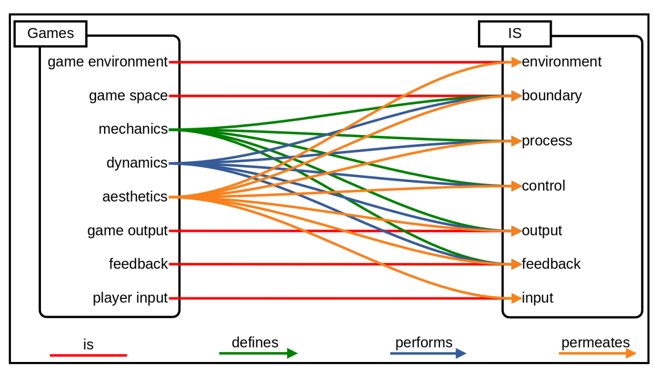

Figure 4: A conceptual model denoting the relationship among components from games and IS

processes that changes the game state, the controls, the output, and the feedback. **Dynamics**, as the "run-time behavior of the game-as-system" [35], perform what mechanics define. **Aesthetics**, as "the emotional responses evoked in the player"[25], permeates the elements defined by mechanics since they emerge from dynamics and, besides that, influence the players' inputs and are influenced by the environment.

6 PRACTICAL EXAMPLES

From the premise that games are IS, in this section, we represent video games, board games and card games as IS. We seek to identify, in these types of games, the components of the conceptual model proposed in Figure 3. We use some classic games as practical examples to identify these components and explain their relationships.

6.1 Analyzing Video Games as IS

IS often involve information technologies, both software and hardware. Video games are games played in electronic devices. Since video games are associated with technology, they must be easily recognized as IS.

Players interact with the video game through input devices, such as joysticks, keyboards or touchscreens. The visual images of the game are sent to an output device like a TV set, a computer screen, a smartphone screen, a portable console screen or even a 3D visualization device.

Players usually control an avatar or player-token throughout the game space in video games. Game space guides the player and establishes boundaries and constraints that limit the player's freedom of movement [43]. A more abstract view of the game boundary would be related to the magic circle [24], that is, the fictional world where the player would be immersed. The game space is a part of the magic circle [24].

We chose two classic video games to analyze them as IS: Pac-Man (Namco, 1980) and Super Mario Bros. (Nintendo, 1985).

In Pac-Man, the player controls a yellow circular token who must eat all the dots in a maze to reach the next level. The token must also escape from four ghosts that chase it through the maze to fulfill the objective. If the token eats the bigger blinking dots, the situation changes temporarily, so that the token can attack and eat the ghosts. The player gains points when the token eats the dots, ghosts, and fruits that appear for a shot time in the maze.

Pac-Man's game space is the maze itself. Player's input moves the token through the maze. The game has two simple mechanics: move and eat. Game dynamics are basically chase and escape. Dillon [15] also include attack and reach as dynamics. Game outputs are the game score, the level and the position of the token and the ghosts. Game feedback informs the position of the remaining dots in the maze, so the player must look for the best way to eat them and worry about getting away from the ghosts.

Super Mario Bros. is the first game from Super Mario series. Players controls Mario or his brother Luigi. The objective of the game is to save Princess Peach, who was kidnapped by the antagonist Bowser. These plumber brothers must defeat the enemies in many stages. The last challenge in the game is to defeat Bowser.

The game space is the Mushroom Kingdom. The avatar must overcome many stages within the kingdom. Player's input moves the avatar towards the end of the stage and face enemies. Game mechanics are mainly move and attack. Game dynamics are jump, throw fireballs, hit or break bricks. Game outputs are the game score, the number of coins collected, the number of lives and the avatar progress through the stage. Game feedback reveals whether Mario is at a safe distance from enemy attacks and level threats.

Pac-Man and Super Mario Bros. were video games released in the 1980s and are very simple compared to current video games. But it is possible to understand them as an IS. Current video games can offer many possible inputs to players, process and control a lot more information, have more mechanics and dynamics, as well as can display many outputs and manage a lot of information to return feedback to players.

6.2 Analyzing Board Games as IS

In this section, we draw a parallel between IS and board games. We describe Monopoly and Chess, one of the widest known commercial board games in the world [42] and the probably most studied game in the Occident, as a IS.

The components of Monopoly are: "the board, 2 dice, player tokens, 32 houses and 12 hotels. There are also Chance and Community Chest cards, a Title Deed card for each property and play money" [22].

The state of the game, at any point, can be computed by analyzing the ownership of Title Deeds, houses, hotels and money by the players, and also the position of tokens, houses and hotels in the board. Unknown to the players, and probably of very little significance to this state, is the order of Chance or Community Chest cards in their piles.

The processes contained in Monopoly are represented by the mechanics that keep the game going. They are combined in the dynamics created by the players.

For instance, when a token lands into a Chance space, the player must pick up a Chance card, which may result in positive or negative consequences as described in the card.

Likewise, if a player rolls his dice, moves his token and it lands in an property already controlled by another player, he will need to pay a sum of money to the controlling player, which is taken from his ownership and added to the ownership of that property owner.

Thus, one can identify in Monopoly the requirements that categorize an IS and can understand how the board games would meet the concepts contained in Figure 3. As a feedback example, one can identify it as a positive one, since the money spent to buy property is returned with a profit, therefore more property will generate more income. [17].

Chess is a discrete game for two players, with no hidden information and simple rules, but with an estimate game-tree complexity of 10^{123} moves[2]. The game space is a board compose by 8 rows and 8 columns of squares of alternate colors. Players provide information to the game processes by moving pieces, mostly. In some traditions and casual games, there are verbal announce of *check* or *checkmate*, but it is not in the formal game rules. The game controls limit the course of actions in many ways, for instance: distinct way of moving for each type of piece, a player can move only one piece at a time, each player can move only pieces from one set.

In Chess, after a player moves, game rules guide how the internal processes change the game state by moving the pieces. The rules also direct the controls to limit the actions of the player. For instance, they can only move the bishop diagonally.

A capture occurs when the moved piece takes the place of another one from the opponent. The captured piece is then removed from the board. The changes in positions and the removal of the captured pieces are examples of outputs. The players use the returned information as a feedback and could adjust their future actions that will change the game state.

Thereby, Chess is an IS as it captures data from players' moves, process them using their rules, store and shows the results as a new placement of pieces in its board. Although this is not immediately obvious in the tabletop game, since players must act to perform the actions of the system, it is visible when Chess is played in a computer.

While an IS, in its formal definition, seeks to support an organization, board games support the activity of play. Game's data, processes and equipment help to identify the outcomes of the game and who is the winner. But there are cooperative games too, which aims is to identify whether the players won as a group or not.

6.3 Analyzing Card Games as IS

Like board games, card games have at least one player. The main difference, however, is that the components of a card game are just its cards. So, it is necessary to identify what characterizes each card game. Although there are traditional card games like solitaire or scopa, we chose UNO for its popularity and variants [47].

UNO has 4 sets of 19 cards, each with a different color. There are also 8 skip cards, 8 reverse cards, 8 draw 2 cards, 4 wild cards, 4 wild draw 4 cards [37].

The objective of each round is to be the first player to discard all of his/her cards in their hands [37]. Therefore, it is possible to identify the state of each round at any time, since it suffices to know how many cards each player has in his hands.

Each player's score, calculated at the end of each round, is made by adding up the card values of all his opponents who lost. The first player to reach 500 points, wins [37].

As an example of mechanics, it's only possible to use one card per player turn. However, for this card to be discarded, it must be either of the same color, or have the same number, or be the same type, as the top card of the discard pile. If the player cannot discard a card, he must draw a new card.

Players have been creating their own dynamics since UNO's release. For instance, players make the effect of some special cards cumulative. So, if a player discards the card 4, and the next one discard the card 4 too, the third player would need to draw 8 cards, and so on.

Table 2 summarizes the games analyzes in this section.

7 USING IS IN GAME DESIGN

Information Technology has tools and techniques for analyzing, describing, designing, building and evaluating IS. Game designers commonly aim to reproduce and formalize their own process, although there is no standard process to design and build games [1, 41]. Therefore, they have been using these tools, which support IS development, to design games.

The intersection between the communities of game developers and software developers, due to video games, enabled their members to influence each other's mindset. Thus, besides the tools, the methodologies, and the way of thinking from IS community led to attempts to document, plan, design and validate games in an iterative player-centric process. For her turn, the IS community could make use of the knowledge and tools that emerge from game development, seizing the efforts and monumental funding spent on its improvement. Also, as the game community endeavors to a better comprehension about how its subject could change the emotional state of players, and how designers can control this, it contributes to understood how IS act in their users.

The Game Design Document (GDD) is the initial documentation of a game project. There is no template, neither other type of pattern, widely accepted, to build a GDD. So, it can be a single document containing all mechanics, dynamics, concept arts, and whatever the designer team suppose needed, or a set of documents with even more detailed information. However, for the same reasons that boost the adoption of agile methods in the realm of software development, this kind of time-consuming and rock-solid documentation is not always desirable. So, one-page GDDs or Game Canvas, comprising only initial and transient information, have been used to suit an iterative building game process.

IS implement and improve the execution of business processes by providing information that helps managers to make better decisions [34]. Classe et al. [12] proposed to design serious games that described business processes to explain these processes in a ludic (playful) way to the players. The authors present a method for mapping the elements of business process models using BPMN and describing the process itself for digital game design elements.

Games have a history of proposals for the adoption of patterns [3]. This use emerged as a result of the development of the games industry through a series of methods and concepts from different areas of study, such as: sociology, pedagogy, literature, media, computers and IS. Björk and Holopainen [5] suggest addressing game design patterns. Such proposal agrees with the recognition, analysis, description, testing and evolution of games as IS.

Software Product Line (SPL) is another approach to encourage software reuse. SPL is indicated when a company has to support a number of similar but not identical systems, which have a common architecture and share components [51]. An SPL architecture was proposed to support the design of educational games. This architecture has components that can be integrated into the games according to the characteristics of each game. [36].

Unified Modeling Language (UML) also demonstrates solid adherence to game design. UML diagrams allow to view, specify, build and document complex system artifacts in order to standardize and facilitate understanding. UML is not a methodology, but it allows to model the components and the behavior of the systems, including their processes. Many proposals for using UML in game design refer to serious games [14, 18, 53]. Some cases describe the use of UML diagrams to represent game elements: characters, scenarios, actions and etc. UML diagrams could model games as finite state machines, which requires the use of variables for a more suitable

Table 2: Analyzing games as IS

Game	Type	Player's Inputs	Mechanics	Dynamics	Game Outputs	Feedback
Chess	Board Game	Move pieces, remove captured pieces, choose the pawn promotion piece, return the pawn promotion piece, communicate check and checkmate	Board setup, Move, Castling, Capture a piece, *en passant*, Pawn promotion, Resign, Tie, Fixed Turn Order, Punch Clock, Loss by Clock, Draw rules	Protect/threaten a piece or area, gambit, center control, resign, propose a tie, communicate check and checkmate, x-ray attack, Openning Strategies	Positions of the game pieces on the board, situation of the king (checked or stalemate)	Removal of pieces from the board, verbal communication (not mandatory) of check and checkmate, changing pawn promotion piece
Monopoly	Board Game	Move token, roll dice, draw a card, buy property card, build houses and hotels	Move, roll dice, draw a card, build, trade	Choose to buy or sell a property, pay and receive rent, negotiate	amount of money, number of properties that each player has, position of each token	Chance of landing in an owned or available property and knowing whether the opponents are getting more money and properties
Pac-Man	Video Game	Move character through the maze	Move, eat	Escape, chase, reach, attack	Game score, level, number of lives and the position of pac-man and the ghosts	Best way to eat dots and worry about getting away from the ghosts
Super Mario Bros.	Video Game	Move character, face enemies	Move, attack	Jump, throw fireball, hit and break bricks	Game score, number of coins collected, number of lives and avatar progress	Reveals whether Mario is at a safe distance from enemy attacks and level threats
Uno	Card Game	Draw and discard cards, say UNO	Hand management, losing turn, matching, take that	Accumulate special card powers, create alliances between players, accuse someone of not saying "UNO"	Number of cards each player has in hand, top card of the discard deck	knowing how many card the opponents have

representation of the game state. But authors point out UML should also support dialogues, music, inventories and other elements.

Dormans et al. [18] proposed a formal framework to represent discrete game mechanics called Machinations, which was inspired by the Petri Nets.

Quality is a fundamental aspect in the game design process. One could understand quality as a two-fold concept that classifies intrinsic characteristics of products or services as one of its parts, and the properties that emerge from its use as the other. However, one must always view quality as dependent on the relations between object and observer. Beyond being an abstract concept, quality is a technical subject for standardizations, such as those presented by ISO, IEC, and Qualinet [8, 26].

The ISO/IEC 25010:2011 standard describes a quality model for systems and software that can be applied to games, although it hardly describes game evaluation heuristics such as "enjoyment". Vargas et al. [56] presented a systemic review of Serious Game Quality. They mapped ideas and thoughts addressed by 112 papers on that subject to quality concepts of ISO/IEC 25010 standard.

The Qualinet model for Quality of Experience (QoE) defines an application as "a software and/or hardware that enables usage and interaction by a user for a given purpose". Its definition also states that "such purpose may include entertainment or information retrieval, or other"[8]. So, besides viewing them as systems, one can more comprehensively see games as applications. The QoE model uses the terms quality and experience defined from "an individual's point of view"[8]. Thus, this model is strongly consistent with the notion of quality as dependent on the observer and their relation with the object. Moller et al. use the Qualinet QoE concept as a base to a taxonomy of factors, aspects, and features that are relevant to games. This taxonomy set an organized way to view games and analyze their quality [39].

8 CONCLUSION

This work state that games, both digital and analog, can be understood as IS. First, we present the definition of a system as a set of interrelated components that function together in a meaningful way [13], in which the whole system is greater than the sum of its components, since new properties emerge from the actions and interactions among them. These properties do not exist in the parts when isolated [9]. From that, Whitten and Bentley [58] defined IS as an arrangement of people, data, processes, and information technology that interact to collect, process, store, and provide as output the information needed to support an organization.

The contributions of this work were the formulation of two conceptual models. The first model (Figure 3) presents the game components, which was extended from a conceptual model of systems (Figure 1). The second model correlates (Figure 4) the IS concepts with game elements, which have been described in theoretical models of games, for instance, the MDA Framework [25].

We analyzed five classic games as IS. We seek to identify in these games the components and its relationships according to Figure 3.

Finally, we describe cases where tools and techniques for modeling and developing IS have already been used for game design. We intend to continue investigating recognized techniques in IS to incorporate them into the game designs and set of tools developed by our research group in LUDES – Ludology, Engineering and Simulation Lab, in future works. Also, we assume this paper can guide future works that lead towards a better understanding of the game design process and the emerging game engineering.

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