

Building an Ontology of Boardgame Mechanics based on the BoardGameGeek Database and the MDA Framework

Joshua Kritz^{1*}

Eduardo Mangeli^{1,2}

Geraldo Xexéo^{1,2}

¹Universidade Federal do Rio de Janeiro, Programa de Engenharia de Sistemas e Computação / COPPE, Brasil

²Universidade Federal do Rio de Janeiro, Departamento de Ciência da Computação / IM, Brasil

ABSTRACT

This work intends to build a Game Mechanics Ontology based on the mechanics category presented in BoardGameGeek.com *vis à vis* the formal concepts from the MDA framework. The 51 concepts presented in BoardGameGeek (BGG) as game mechanics are analyzed and arranged in a systemic way in order to build a domain sub-ontology in which the root concept is the mechanics as defined in MDA. The relations between the terms were built from its available descriptions as well as from the authors' previous experiences. Our purpose is to show that a set of terms commonly accepted by players can lead us to better understand how players perceive the games components that are closer to the designer. The ontology proposed in this paper is not exhaustive. The intent of this work is to supply a tool to game designers, scholars, and others that see game artifacts as study objects or are interested in creating games. However, although it can be used as a starting point for games construction or study, the proposed Game Mechanics Ontology should be seen as the seed of a domain ontology encompassing game mechanics in general.

Keywords: Mechanics, MDA framework, ontology.

1 INTRODUCTION

Board Game Geek (BGG) is one of the biggest and most used boardgame forum on the internet. One can say that BGG is for players what IMDb[10] is for movie fans. Furthermore, because of its extension, the BGG database has become a source of information used also by scholars and game designers. One of its main features is to provide a very comprehensive list of boardgames that ever existed, maintaining a historical record of games.

On 22th July, 2017 BGG listed 92018 games, over 2536 families, 84 categories and 51 mechanics. In face of the huge and constantly growing amount of games registered, one could wonder about the small number of mechanics, which is also very stable. Two questions immediately arise: first, does these 51 mechanics sum up the set of all possible boardgame mechanics? Secondly, are these really mechanics, in the sense proposed by Hunick, Leblanc, and Zubeck [9]?

This article aims to answer the second question as a way to give insight into the answer for the first question. We also aim to get an insight into how players think about game mechanics, and how do they think that they work. Even more, the primary goal of this work is to supply a tool to game designers, scholars, and others that see game artifacts as study objects or are interested in making games. Although it can be used as a starting point for games construction or study, the proposed sub-ontology should be seen as the seed of a domain ontology encompassing game mechanics in general.

To accomplish that, this work groups the original mechanics provided by BGG, based on observed similarities, propose some

*e-mail: email@somewhere.com

adjustments on the descriptions and use this settings to better understand why they are stated as mechanics and how they can be detected in some games. We need to organize and normalize this knowledge because even though broadly used the BGG database it is not free of defects and problems.

We normalize the BGG mechanics into mechanics as stated by the MDA framework. This is done by revising the BGG mechanics descriptions and from them extracting the associated mechanics which will then be used to create the ontology, thus whenever we state BGG mechanic it will mean the original BGG description for it, and mechanic will stand for its normalized definition in the MDA sense. This is necessary because without this normalization we would have many possible interpretations in BGG mechanics's descriptions and thus have no structure to work with.

As a final result, we propose an ontology of game mechanics that reflects both the theoretical proposal of the MDA framework and the player understanding of boardgame mechanics represented in the BGG list.

The Game Mechanics Ontology was written with Protégé [14] and an OWL version is available for comments as a GitHub project in <https://github.com//added/after/revision>

2 INTRODUCTION TO THE MDA FRAMEWORK

MDA is an acronym that stands for Mechanics, Dynamics and Aesthetic, besides identifying a framework proposed by [9]. This framework, in addition to establishing a classification of the game components, sets up a causal relation between these classes that are foundational to this work. The MDA framework was built intending to comprise concepts that help designers, researchers and scholars perform the decomposition of games into coherent and understandable parts. Although being short, the paper had a wide impact in the game community, showing 1143 citations in Google Scholar in August, 2017.

The game elements are classified into three distinct components that are briefly described in Table 1.

Table 1: MDA components description [9]

Mechanics	The particular components of the games, at the level of data representation and algorithms.
Dynamics	The run-time behaviour of the mechanics, acting on player inputs and each others' outputs over time.
Aesthetics	Emotional responses evoked in the players.

As one can see, mechanics are the only components directly accessible to game designers or developers. This concept comprises the items created, changed or manipulated by who builds the game. Hence, an ontology of game mechanics can be seen as a boilerplate to build games. On the other hand, dynamics and aesthetics components are not accessible to designers. Game dynamics originate from players interacting with mechanics. Thereby, if the rules

allow the exchanging of resources by players in order to reach a common objective, this can lead towards a collaborative dynamic. As for aesthetics, they emerge from dynamics, as another layer of components, and are the emotional responses of players.

The view of the classes as superposed layers of components in which mechanics, the support layer, act as a base for dynamics that, in turn, originate aesthetics is proper to the designer’s perspective. On the contrary, aesthetics play the major part in the player’s perspective, it “is born out in observable dynamics and eventually, operable mechanics” [9]. Figure 1 shows the components of the MDA framework as well as their relations under designer’s and player’s perspectives.

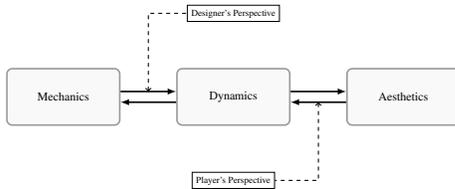


Figure 1: MDA diagram

Each one of the MDA framework components comprises a model that describe it. Therefore, as noted earlier, a ontology of game mechanics can describe the mechanics component for a particular game.

This work uses the propositions of the MDA framework in the sense of the segmentation of game elements into subsets and proposes a game mechanics ontology that can be used as a model for the mechanics component.

3 THE BOARD GAME GEEK MECHANICS LIST

User collaboration is possible on most of the BGG database. Currently, users can directly contribute by including or modifying games, families, persons, publishers, podcasts and accessories. Every contribution must pass through the verification of the site administration. Mechanics, however, cannot be contributed directly, instead they were slowly added over time by the site managers.

Although there are some complaints in the BGG fora that the list is somewhat “broken”, it is the *de facto* standard for most discussions in the site and elsewhere.

It is interesting to notice the discussion of a suggested new mechanic, “Role Selection”, in the fora “Recommendations”[21] and “BGG Suggestions”[16], where there is what seems to be a final answer from user *tuckerott*: “Because Role Selection isn’t a game mechanism, it is a thematic veneer over the top of different game mechanisms” [21], and then a description over the supposed mechanic in various games and how they are actually better described by an already existing mechanic. Further on, after user *herace* suggests that this new mechanic can be added as a family, saying that “In reality it has been a long time since BGG added a new mechanic or category. The new method has been to add a family.”, user *jcr13* answers “With the result being that there are 2500+ families now, making Family unsuitable for advanced search. Also, Families seem to be mostly games that are grouped under a similar title (like all the expansions or versions of Settlers).”[16]

From these opinions one can infer that there is a subtle balance between create new mechanics, and increase the difficulty of using them as reference, and describe one possible mechanics as a more basic one.

4 RELATED WORK

There have been some attempts to build game related ontologies, mostly primarily aiming at video games.

Acting	Action / Movement Programming	Action Point Allowance System
Area Control / Area Influence	Area Enclosure	Area Movement
Area-Impulse	Auction/Bidding	Betting/Wagering
Campaign / Battle Card Driven	Card Drafting	Chit-Pull System
Co-operative Play	Commodity Speculation	Crayon Rail System
Deck / Pool Building	Dice Rolling	Grid Movement
Hand Management	Hex-and-Counter	Line Drawing
Memory	Modular Board	Paper-and-Pencil
Partnerships	Pattern Building	Pattern Recognition
Pick-up and Deliver	Player Elimination	Point to Point Movement
Press Your Luck	Rock-Paper-Scissors	Role Playing
Roll / Spin and Move	Route/Network Building	Secret Unit Deployment
Set Collection	Simulation	Simultaneous Action Selection
Singing	Stock Holding	Storytelling
Take That	Tile Placement	Time Track
Trading	Trick-taking	Variable Phase Order
Variable Player Powers	Voting	Worker Placement

Table 2: The 51 mechanics listed on Board Game Geek[1]

The most visible ontology is the Game Ontology Project (GOP), “a framework for describing, analyzing and studying games” [23, 6]. It provides a structure to study games elements based on four top-level elements: interface, rules, entity manipulation and goals. It is a collaborative work, open to contributions, but currently stalled. Some of its elements can be classified as mechanics. This ontology makes the same decision we did by separating goals in a specific generalization of game elements. Entity Manipulation is a more restricted version of our Actions, and Rules are similar with our Ruleset class. GOP was remodeled and used to similar analysis in game design activities [13], in a work that, although use a different methodology, has some resemblances to our approach of remodeling a current used set of concepts.

Roman, Sandu, and Buraga constructed an ontology for role-playing games (RPG) in a work inspired by GOP. Their proposed ontology focus on characters, their quantitative features, items, races, and equipment in the realm of an RPG fantasy game [17]. That work uses the OWL language to describe the ontology and intends to facilitate designers’ activities like character creation, NPC generation, simple battle system configuration, etc.

The domain of RPG was also the subject of a slightly more comprehensive ontology [22]. Although using a specific game (The Mana World [20]) as the source of concepts, the authors claim that the resulting ontology is applicable to massively multiplayer online role-playing games (MMORPG).

More recently, GOP and MDA were also used to provide a model for innovation in digital games [3]. In this case, however, all models were used as-is. This can also be an application for our methodology on board games.

Three Hundred Mechanics is a video game oriented catalog of game mechanics, with examples [8]. It provides five collections: Comp-grid, Procedural, Tactics, Tiny Crawl and Misc. It is very comprehensive, maintained by a single person, but also seems to have ceased to evolve.

5 METHODOLOGY

This article uses a Methodology based on MENELAS [2, 11]. Game mechanics is a domain in which “knowledge is descriptive, mainly expressed in natural language, and not formalized”[2] in the same way the original domain subject of MENELAS, Medicine, is. Also, MENELAS was built upon a common-sense knowledge, which is exactly what BGG is. As there is no single correct method to create an ontology[15] we choose this approach based on its simplicity and adequacy to the domain subject of this work.

The MENELAS methodology consists of creating a taxonomy tree based on four principles. Those principles are stated as:

1. Similarity: The subclass must be of the same type as its parent.
2. Specificity: A subclass must have some difference from its parent.

3. Opposition: The sub-classes of a concept are incompatible with one another.
4. Unique Semantic Axis: The sub-classes of a concept can be constrained to differ from the parent in some common propriety.

Using these principles on every class and subclass definition will guarantee that the whole taxonomy created is a tree, with a unique root, which in this article is mechanic. Together with a mereological relations among the classes of this tree becomes an ontology. In this article we will make use of the first three principles to group up some BGG mechanics in super-classes and also breaking them in sub-classes which will naturally create the tree structure, while the normalization of the BGG mechanics will help with this structuring it will play an important role in understanding the natural mereological relations that define this ontology.

5.1 Overall rules used to delimit scope

To delimit the scope of our ontology, we used the following rules:

1. only concepts identifiable in the BGG mechanic list, including the mechanics descriptions, should appear as leaves of the ontology;
2. for every one of the 51 mechanics listed in the BGG mechanic list there should be a decision if it is a mechanic, many are indeed mechanics, or not a mechanic accordingly to the MDA Framework [9];
3. higher level concepts should be based on the MDA Framework; [9] or in references that acknowledge it or are compatible with the with it, or found in the BGG mechanic list itself, and
4. compound mechanics should be broken in their constituents.

6 ONTOLOGY CONSTRUCTION

This section defines the concepts that compose our ontology. We analyze the BGG mechanics and normalize them into mechanics that will become the classes of this ontology. Also there are some mechanics, not present on BGG listing, that we need in order to structure the ontology and here we also define them accordingly. We consider that game mechanics instances are their materializations in game artifacts. So, examples of games that implement the mechanic are provided in its definition.

The first level of our architecture is composed of two very general mechanics, directly extracted from the MDA Framework[9]: Algorithm and Data Representation. They are further divided based on how the previous ones are explained in the framework, and also with references in the literature, such as seminal articles found in the anthology [19] and in [12].

Figure 2 shows the top concepts in the Game Ontology besides the relations between them.

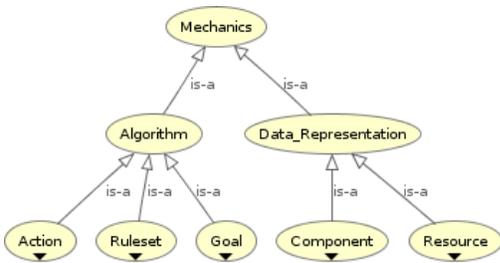


Figure 2: Top concepts in the Game Ontology

6.1 Algorithm

This is the general mechanic for the processes that happen in the game. As Data Representation, it comes from the definition of mechanics in the MDA Framework[9], and shows an understanding that games are information systems.

Action These are the rules for the actions of a game, how and when a player can interact with the game state, directly or indirectly. A very natural general mechanic, as most game definitions [18, 19] require or imply actions to classify something as a game. Although it does not exist explicitly in BGG mechanics list, the concept exists in many mechanics described. Figure 3 shows the action concept branch in Game Mechanics Ontology.



Figure 3: Action ontology branch

Action Programming With this mechanic, every player must secretly choose their next number of actions, and then each player execute their actions according to the choices made. Thus the BGG mechanic Action/Movement Programming is simplified, movement in this concept is only a type of action, so it can be removed from the name. In this description we needed to correct the term turns, used in the BGG description, to action, as there is no need to restrict to program a whole turn. In Diplomacy, all players must program their actions before the movements are resolved.

Auction In this mechanic players bid something, usually a currency, in order to get some benefit. This may occur the same way an real life auction can, but can also be modified to better fit the game. What is important is that it maintain the concept of an Auction. This is a mechanic inspired by the BGG mechanic Auction/Bidding, which description[1] has the concept, but it focus too much on limitations of how and when it happens, which are not so important to understand its concept, thus our reasoning to not use it. In Monopoly,

if players do not want to buy a property where they landed, it is auctioned to the others. Modern Art is a game in which players auction artworks to get the most money at the end.

Chit-Pull This mechanic is such that phases does not happens orderly, there is a chit, token or card draw from a stack or bag, that dictates which phase occurs then another one is draw and this repeats until all phases are completed. This mechanic is derived from the Chit-Pull System BGG mechanic, where its description[1] is heavily biased to its wargame origins. In example the World at War board game series use this mechanic.

Collection A game where players need to collect something, a component, points, resources etc.

Pool Building With this mechanic players start the game with a predetermined pool of components and add or remove components to this pool throughout the game. Players use the components of this pool in other aspects of the game, they can be used as resources to fuel other actions or as a scoring. This mechanic derives from the Deck/Poll Building BGG mechanic which mix two mechanics, which we split in Pool Building and Deck Building. Deck building is a composition of Poll Building and Card mechanics. As example, in Quarriors you build a pool of dices which you roll each round to battle and try to get points, in Dominion you build a deck of cards from which cards you use to collect more cards and to score points.

Set Collection In this type of Collection, what players collect need to be part of a pre-defined set, in order to complete their objective in collecting. The main idea is that players collect the sets by collecting the parts of the set. Pit is a game where players must collect all cards of the same type.

Commodity Speculation It consists of purchasing and selling commodities while their value changes throughout the game This change of value may be directly conducted by players or it may happen independently of the players. This BGG mechanic has a wrong description, "in which in-game money is bet on different commodities in hope that that particular commodity will become the most valuable as the game progresses." [1] This simplify it as a simple betting type, but it is not, as betting requires you to gamble with other players while Commodity Speculation is about reading and predicting the changes of the game. Modern Art is a successful example.

Stock Holding This BGG mechanic "Stock holding is a subcategory of Commodity Speculation, in which instead of purchasing or selling an entire commodity, players purchase and sell (or hold) a share in a given company, commodity or nation." [1] is a mechanic. It is good to emphasize the difference between Stock Holding and Commodity Speculation lies in the concept of what is negotiated, the real commodity in the first and a value indirectly related to the commodity in the second, which can create different behaviours in the game. A successful example, quoted from [1] is Imperial.

Draft In this games players choose to pick a component from some limited set. This set should be available to other

players at some time, during the game, but not necessarily to all players at the same time. It is important to note that when a player picks something it will be unavailable to other players, at least for some time.

Card Draft This mechanic happens when you select and pick cards from one or more pools. Cards values can be hidden or known to the player [1]. In 7 Wonders players draft cards from a hand of cards, while in Ticket to Ride players draft cards from an open offer.

Action Draft This is the mechanic when players draft actions from the available ones. While the name is different, it comes from the Worker Placement BGG mechanic, which has a clogged description [1] nonetheless this description does clarify the chosen name. Traditionally the games with this mechanic used the thematic idea of workers doing their actions, but for our purpose of understanding the concept the name Worker Placement may lead to unwanted confusion about the concept. A successful example is Caverna, the 10th game in BGG ranking list.

Expression This mechanic require players to express themselves in specific ways to play the game. The core idea here is to express in more ways then verbally. The possible objectives could be many, from actually expressing information to fulfilling a requirement to progress in the game.

Acting a mechanic that "require players to use some form of mime or mimicry to communicate with the other players." [1]. Charades is an old example, where one member of a team must use non-verbal clues to allow the other members to guess the solution.

Role Playing With this mechanic players need to interpret characters during the game. They should then act, speak, behave as their character, which can be designated, chosen or created, and not necessarily be the same throughout the game. The BGG mechanic with the same name has a unexpected and confusing description[1]. It is unexpected as it's inspiration, tabletop Role Playing Games, are mainly about players taking the role of a character in a story and in the description it is only mentioned as a possibility. The confusion happens as it only states possibilities and those possibilities are very different ones, which could easily happen separately in a game. A good example is Captain Sonar, where players interpret different members of a submarine crew.

Singing a mechanic that "require[s] players to hum or sing familiar songs." [1]. In Encore players get a word and need to sing a song with that word.

Storytelling In this mechanic "players are provided with conceptual, written, or pictorial stimuli which must be incorporated into a story of the players" creation." [1]. We should note though that the examples in the BGG page are inaccurate when they state that games in which players experience a story are Storytelling games. In Once Upon a Time players get cards with texts and need to tell a story with those texts.

Gamble This mechanic is present when players need to gamble in the game. Usually making a choice which out-

come depends on other players choices or a random event.

Betting This mechanic require players bet some currency on certain outcomes of the game. This mechanic comes from the BGG mechanic Betting/Wagering but its description “Betting/Wagering games are games that encourage or require players to bet money (real or in-game) on certain outcomes within the game. The betting itself becomes part of the game.”[1] includes real life betting which is not of interest to this work. In Spartacus players bet on possible results of a combat.

Trick-Taking This mechanic require players to play a trick, a card from their hands, then a player is determined the winner of the trick following the game rules and cards played by all players. The winner of the trick gets an advantage when taking the cards played in the trick. The description[1] of this BGG mechanic captures well the idea of the mechanic, but we needed to take out the requirement for the tricks being played in turn order, this is not necessary as many games, considered to be trick-taking games, are simultaneous and there is no loss on the concept to allow it and we soften the restriction where the trick winner takes all the cards played, in some games the winner has the first opportunity to take a card played, and then other players take the remaining cards. In Honshu players play numbered terrain cards, the winner is the highest number, then each player, starting with the winner, takes a card and put the card on his territory.

Voting In this games players are presented with a vote to collectively make a choice that influences the game directly. This BGG Mechanic described in [1] is quite confusing, it discourse too much minor details rather then specifying how the mechanic is presented.

Line Drawing this mechanic “involve the drawing of lines in one way or another.”[1].

Network Building In this mechanic there are nodes that need to be connected by lines, it can be done by each player alone or in conjunction with others. This mechanic derives from the BGG mechanic Route/Network building, its description[1] has the concept of the mechanic but overextend itself when limiting the objectives of the mechanic and mentioning another name for the same concept. A successful example is Ticket to Ride.

Movement This mechanic happens when components move around the play area during the game, this movement may be dictated by rules or chosen by players.

Point-To-Point Movement With this mechanic the components that move have specific spaces it can occupy, those spaces has some indication of connection between them and movement is only allowed from a space to a connected one. Also the pieces can never be in the middle or between two different spaces, it need to be in a single space at any time. This BGG mechanic description[1] tries to distinguish it from similar BGG mechanics, but in doing so it fails to grasp the concept of it and miss the similarity it need to have with those other mechanics.

Area Movement This mechanic happens when the spaces in Point-to-Point Movement are Areas, and their connection is determined by their adjacency and possibly other artificial connections. We do not follow the BGG description that asks for “areas *of varying size*”[1].

Grid Movement This is the mechanic when the areas of Area Movement are polygons of the same type and size, normally squares or hexagons. Connection is defined through sharing edges and sometimes by sharing vertex. Creating then a Grid structure for movement on the game. The original BGG description[1] although not wrong, lacks information. A natural example is Chess.

Pattern Building This mechanic “is a system where players place game components in specific patterns in order to gain specific or variable game results.”[1]. Carcassone is a successful example for this mechanic.

Press Your Luck With this mechanic you repeat an action, or part of an action, until you decide to stop due to risk of losing points or your turn or is forced to stop due to some event. We won’t make use of the BGG description[1] as it is confusing and it does not disagree with our definition. In Port Royal a player draw cards from a deck until there are two ships, and he loses his turn, or he stops, then he can buy cards.

Random Draw Different mechanics found in [1] use some random mechanism to generate a random object or value, such as number or a card. This general mechanic group these mechanics for the sake of understanding when and why they are interchangeable or not.

Dice Rolling a mechanic that requires players to roll dice of any kind. From the original BGG description[1] we excluded using dice as markers or token and the reference to the quality of the dice. The main concept is to use such components to generate randomness creating unpredictable results in the game. The original definition has many concepts mixed, so we split the definition and selected a simple definition. In Monopoly players roll dice to move around the board.

It is important to note that when using the words dice and rolling we are extending them to the notion of the class Dice. That is, dice should be understood as any instance of Dice class and roll should be the action of using this instance analogously.

Deck In this mechanic a group of items are stacked and shuffled then players can pick the top item from it never knowing which item they would pick. This is a common way to deliver random objects to players creating unpredictability in acquisition of these object. Most games that have Card use this mechanics stacking cards in a deck. As example in Rise of the Phoenixborn players start the game with a pre-assembled deck of cards from which they draw cards to be used in the game.

Secret Unit Deployment It is the mechanic where the players secretly choose which units and where they will be deployed when they need to be deployed. We had to rewrite this BGG mechanic, that has a unclear description[1] that clearly not fit the name, but rather

describe Hidden Information. In Captain Sonar the initial position of each team's submarine is chosen secretly from other teams.

Simultaneous Action Selection This mechanic, "In simultaneous action selection games players secretly choose their actions. After they are revealed, the actions resolve following the rules of the game"[1]. In Race for the Galaxy players secretly chose one of the available 6 actions to activate.

Take-That This mechanic allow players to directly influence other players states intending to hinder their progress within the game. This mechanic is a restatement of Take-That BGG mechanic. Although it has a good description[1] we provide a simplified version as definition and change the name to better fit the concept. In Captain Sonar teams shoot missiles at other team's submarine to damage them and eventually destroy it, winning the game.

Tile Placement BGG defines it as "placing a piece to score VPs, with the amount often based on adjacent pieces or pieces in the same group/cluster, and keying off non-spatial properties like color, "feature completion", cluster size etc."[1]. The only change needed is to not restrict the placement to win Victory Points (VPs) as it can be any type of benefit not only VPs. A successful example is Carcassone.

Trading "In games with a trading mechanic, the players can exchange game items between each other."[1]. This exchange can be freely made between players, or regularized and limited by the rules. In Settlers of Catan players can exchange resources freely throughout the game.

Goal This mechanic is the objectives the players try to achieve during a match. Goals include victory conditions or transient goals. They are a widely recognized characteristic of games [18]. The Figure 4 shows the goal concept and its children that are described as follow.

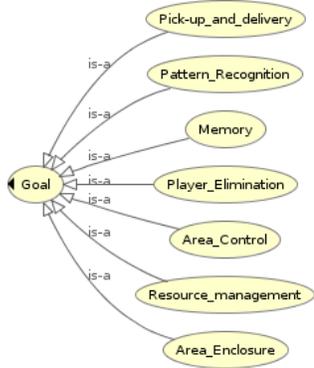


Figure 4: Goal concept and its children

Area Control "The Area Control mechanic typically awards control of an area to the player that has the majority of units or influence in that area."[1]. The change in the name is because the idea of influence here is to control with influence, hence the same as just control. in Diplomacy players control countries by having armies in their territory.

Area Enclosure "In Area Enclosure games, players place or move pieces in order to surround as much area as possible with their pieces"[1]. A traditional example of this mechanic is Go.

Memory This mechanic is "the Memory mechanic require players to recall previous game events or information in order to reach an objective."[1]. In Letters of Whitechappel investigator players need to remember steps taken by the Jack player to corner him and win.

Pattern Recognition In this mechanic game components are organized in the play area in which they may form patterns, the players then need to identify specific patterns to receive some benefit in the game. This BGG mechanic has a confusing description[1] we rephrase it to be clearer. In the game SET players need to find patterns in cards in order to collect them and win.

Pick-up and Delivery "This mechanic usually requires players to pick up an item or good at one location on the playing board and bring it to another location on the playing board. Initial placement of the item can be either predetermined or random. The delivery of the good usually gives the player money to do more actions with. In most cases, there is a game rule or another mechanic that determines where the item needs to go."[1] In Istanbul players move around the board getting materials and delivering them to gather gems.

Player Elimination This mechanic "Player elimination occurs in multiple-player games (>2) when a player can be eliminated from the game and play continues without the eliminated player."[1] In Monopoly a player is eliminated if he goes bankrupt.

Resource Management A mechanic in which players are presented with one or more types of resources which they gather and then spend to achieve benefits. Although an important mechanics and for many scholars a defining aspect of games, as for Costikyan[4, 5], it is not present on the BGG listing. However, it is clearly a concept to be extracted from the definition of the term **resource** in this ontology. In Settlers of Catan players have resource cards which they use to build cities and roads.

Ruleset This mechanic is the abstract rules that control the game, what player can and cannot do, how the game components behave, and many other aspects of the game. The ruleset concept bottom hierarchy are shown in Figure 5 and explained as follow.

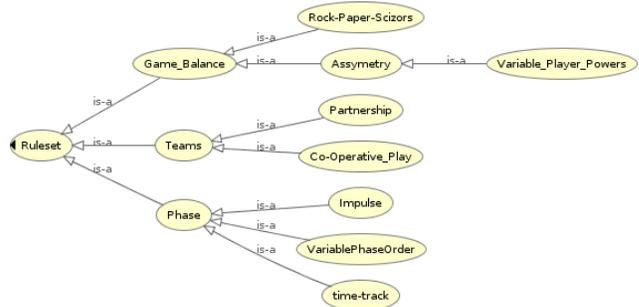


Figure 5: Ruleset ontology branch

Game Balance This mechanic is direct manipulation of the game balance. It may be used to achieve disparities between players or to make them equally possible to win the game. Also it can only relate to different game components and their interactions without directly affecting a player but changing the balance between those components.

Asymmetry It is a mechanic in which players have different capabilities and/or objectives. The core idea of this mechanic is to make the gameplay different for each player, giving them different perspectives within the game.

Variable Player Powers In this mechanic players are awarded with different capabilities. Those disparities can be present since the start of the game or be awarded during the game. This BGG mechanic description does capture the concept of the mechanic, but has a statement that does not fit the concept "paths to victory to the players." [1] thus our adaptation, it is not wanted as the concept here lies in the players possibilities not their objectives. In Captain Sonar each player has different actions based on his role.

Rock Paper Scissors The core idea is that there is a circular non-transitive hierarchy of advantage between game components. It is not limited to a simple hierarchy, one component may have advantage over more than one other component and in different degrees. The name and concept of this mechanic comes from the namesake children game. This derives from the BGG mechanic with the same name, which it has a confusing description [1] that does get away from the desired concept when comparing it to other mechanics. In Yomi players have card which are a attack, block/dodge or throw, and attack win throw, throw win block/dodge and block/dodge win attack.

Phase With this mechanic games are divided into phases which have different events, actions or active players. The concept here is to have gameplay segregated in different sections, and that each part of the gameplay happens in a specific section.

Impulse This mechanic subdivides a phase in small phases in which the active player alternate between the players and there is a small amount of actions allowed to the active player. Players keep alternating until both player pass, due to exhausting their resources, or an game event force this face to stop. Normally when the phase ends by both players exhausting their resources, the game has a refresh phase when players refill their resources or get new ones to use in the next phase. This is a mechanic derived from the Area-Impulse BGG mechanic [1] which has the concept of the mechanic but limit it too much for our purpose. For our work we remove the area limitation and the unit activation restrictiveness, which came from its wargame origins. In Rise of the Phoenixborn, players have a refresh phase where they replenish their resources, roll their dices and draw cards, then follow into the action phase where they alternate doing actions until both player pass and a new round begins.

Time-Track "A time track mechanism is a variable player-turn order mechanism by which the player who is last on the time track goes next. The function of this mechanism can allow a player to have multiple sequential turns due to being last after each one. The basic premise is that you can choose to do a longer, slower task in the game, but in the meantime, a player taking shorter, quicker actions might change the "landscape" of the playfield" [1]. In Tokaido players have pawns in a track and the last player on the track moves his pawn forward, activating his new location ability.

Variable Phase Order With this mechanic the set of phases of a round are not played always in the same order, or may not happen at all. It is important to note that a defining aspect of this concept is that you have a predetermined set of phases that happens in a turn or round and which of them happens and the order they actually happen change from round to round. This BGG mechanic has an unclear description [1] and we needed to explain it thoroughly. In Race for the Galaxy the game has 5 phases which only happen if a player chose this phase to activate.

Teams With this mechanic players divide themselves in teams. These teams have different objectives, in example when they compete against each other, and/or have different capabilities, this is they interact with the game in different ways. Teams may change during the game or even cease to exist.

Co-operative play Co-operative play encourages or requires players to work together to beat the game. There is little or no competition between players. Either the players win the game by reaching a predetermined objective, or all players lose the game. This BGG mechanic description [1] is shortened to keep the focus on the concept. A successful example is Pandemic, where players collaborate to eradicate diseases.

Partnerships in this mechanic players may have teams or create teams during the game and may undo such teams as well. This BGG mechanic has an unclear description "Games with partnerships offer players a set of rules for alliances and teams. Partners are often able to win as a team, or penalties are enforced for not respecting alliances." [1]. At first it looks like Teams, but when it state that is not always possible to players to win the game together or they can break the teaming with consequences, we see that it have a different idea. In Diplomacy players may form alliances during the game to join forces to reach an objective.

6.2 Data Representation

This is the general mechanic to store and convey information in games. As Algorithms, it comes from the definition of mechanics in the MDA framework [9], and shows an understanding that games are information systems.

Component This concept comprises the game elements that players manipulate and possess during a match [12]. Components may materialize other game elements, as points or energy. Figure 6 shows the component concept Game Mechanics Ontology branch.

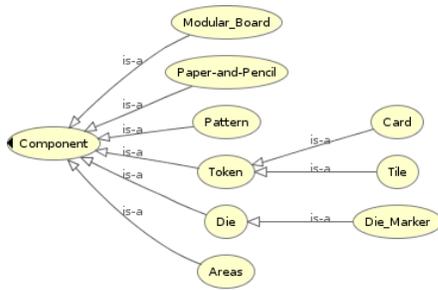


Figure 6: Component ontology branch

Areas This mechanic takes place when the play area, or a part of it, is divided into areas. Some card games show a discard area, for example. In Settlers of Catan the board is divided in hexagonal areas.

Modular Board With this mechanic “Play occurs upon a modular board that is composed of multiple pieces, often tiles or cards.”[1] we add that the whole of the play area does not need to be modular, just a portion of it, and this modular area may be determined before the game starts, or it can be expanded during the game, as events require the board to further develop. Settlers of Catan has a modular board that is built before game starts and remains static through the game. In Takenoko one possible action is to add a new garden to the board.

Paper and Pencil With this mechanic “The game is developed using paper and pen to mark and save responses or attributes that, at the end of the game, are used to score points and determine the winner. A game that merely keeps track of score on a sheet of paper does not use a paper-and-pencil mechanism.”[1] Of course, pen-and-pencil is an abstract name that can be implemented as other writing technology. In Diplomacy, for example, players must state their movement order in writing, while most RPG forces the use of a character sheet.

Pattern With this mechanic some components have intentionally created patterns representing relations between them, which are used in the game to some purpose. Tic-tac-toe, for example, pieces has two possible symbols on them, which are used in the game to achieve victory, aligning 3 pieces of the same symbol.

Die The mechanic in which games uses a die, or equivalent object, as a component. The idea for using such components can be many, to track numbers, to generate random numbers, a throwing object. We emphasize that when referring to Die we intent to abroad all such objects that can be used with the same possible intents, like spinners. Most boardgames use dies for random number generation, such as Monopoly.

Die Marker This mechanic is the other concept of the Dice Rolling BGG mechanic, that is, to use Die as a marker. In Praetor dices are used as workers and are never rolled.

Token This mechanic is any component the player may manipulate directly[4, 5]. Mentioned many times in descriptions of the BGG list as pawns, player pieces, and many other manifestations.

Tile This is the mechanic for using tiles as a component. Although not mandatory many games use this concept as a main feature in the game, with all

gameplay involving the tiles. Carcassone use tiles to dynamically build the board.

Card This is the mechanic for using cards in the game. This is a very basic concept, but cards are a versatile component and have great expression within the game. Cards are used in many ways in games, going far beyond traditional card games, such as random event generator, power-ups, limited resources, etc. They can be found in many games, varying from Poker to Settlers of Catan.

Resource Besides representing data, resources are a kind of game element that is directly linked to game goals. So, the player has to manage these elements “in pursuit of your goal” [4]. Figure 7 presents the ontology branch of this concept.

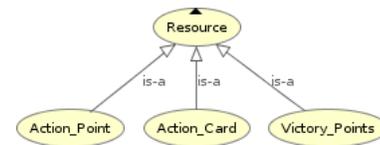


Figure 7: Resources ontology branch

Action Card The mechanic Action Card implies that players have a hand of cards and each action performed uses a card from his hand, where the card restrict which action is performed. The BGG mechanic Campaign/Battle Card Driven[1] is actually a concept that does not need to be restricted to wargames and to remove this we also adapt the name to better fit its broader concept. Memoir 44 uses action cards to limit the kinds of actions the player can do.

Action Point In Action Point mechanic, each player has a certain amount of points per round. These points can be spent on available actions, until the player does not have enough remaining to purchase any more actions. Many games limit the player to one action, which is a very simple form of this mechanic. This mechanic derives from the BGG mechanic Action Point Allowance System we rephrase its description[1] and adapt the name to the concept. In Takenoko, for example, players have 2 action points to choose among different possible actions.

Victory Points This is a game element directly linked to a game goal. It is an abstract measure of victory, a way to track how close a player is to victory, many times it is relative to other players, measure distance between players, but can also be directly related to victory distance, when a player achieves a defined amount of Victory Points he wins. In Takenoko players complete objectives that award Victory Points.

6.3 The Part-of Relations

In this section we describe the part-of, or mereological relation. Due to lack of space, this paper provides only a overview of this relationship, which creates a great amount of data, but their full description can be found in the ontology itself.

There are many part-of relations which were easily found during the creation of the ontology, due to the fact that the algorithm clearly need a data representation to happen. Among them, Die being part of Dice Rolling; Tile of Tile Placement; Card of Action Card, Card Drafting and Trick-Taking; Area of Area Control and

Area Enclosure. Many of them actually came from the BGG mechanic which derived the related classes. As some of these classes were only in the descriptions, we needed to define them as mechanics. Thus, leading to a natural relation between them.

Other Part-of relations need more effort to analyze if they really occur in specific instances. For example, the relation between Gamble and Random Draw is a quizzical one. On a first look, one might state that Gamble is a part of Random Draw, which is mostly true. However, when going into details of Gamble, we perceive that a choice which is affected by the Random Draw is needed for this assertion to hold. Although a rare occasion, there exists situations in which there is a Random Draw without a Gamble. An example is to choose the starting player through a die roll: there is no choice affected by it and thus no Gamble.

Another Part-of relation which a similar issue is Area to be part of Movement, it is clear that for the Movement children this is the case. However, for Movement, although it seems to be, there might be Movement independent of Area. An example is when the movement is continuous rather than discrete, like in throwing or flicking games, and there is only a play area on which pieces are thrown or flicked, or X-Wing and HeroClix, which are continuous movement games. Such tight relations may drive us to find the border of when there is the relation or not, and to explore it to better understand the behaviour of such mechanics.

Since we avoided compound mechanics, there will be much more Part-of relations when those are included in the next interactions.

6.4 BGG mechanics that were left out

There are some BGG mechanics that not appear in the Game Mechanics Ontology concepts listing nor in its definition. Hex and Counter comprises the mechanics Grid Movement and Token, and as such it did not feature in the previous section. Another composite mechanic is Deck Building, which is made of Pool Building with Cards. It was mentioned in BGG mechanic Deck/Pool Building decomposition but does not feat as a class of the Game Mechanics Ontology. Crayon Rail System is also a BGG mechanic comprising two others, Network Building and Paper and Pencil.

Besides the BGG definitions that are, in fact, a combination of mechanics, there are such ones that are not mechanics as settled by the MDA framework thus were left out of the Game Mechanics Ontology. Hand Management is not a mechanic because, as stated by its BGG description, it relates to how the player should play cards during the game: optimizing based on other players plays. Thus, it states a run-time behaviour so is a dynamic rather than a mechanic. Simulation, according to its BGG description, is rather an ideal, an objective, for the game artifact as a whole than a mechanic. Even when we think of mechanics that try to model real life events, the mechanic has the objective of simulate, but the simulation is not the mechanic itself. It could be a grouping for mechanics that has this ideal, or even a set of mechanics that together model a real life event, but not a mechanic by itself.

6.5 Some notes on the ontology

The proposed ontology is an ongoing work, and must be dynamically improved over the time, since it aims to cover a wide spectrum of games that are subject to innovations.

We started, intentionally, with a limited view: a widely known but short list of mechanics, which is also controversial. Our first step was interpreting all its definitions and reorganizing them in a meaningful ontology. From now on, this ontology should be enhanced in coverage, in complexity of relations, and with introduction of rules.

Aiming for a single inheritance tree is somewhat limiting. The discussion about multiple inheritance is a known one, and it is clear

to us that the ontology should evolve, as it matures, to encompass more sophisticated structures, such as mixins [7].

Other important aspect is that, although most concepts are standalone, there are a group of hybrid or composed mechanics that can be easily detected in existing games, but are not listed in [1]. For example, in Memoir 44 you pick a card from a face down pool, put in you hand and later select some to partially program your moves. This is known by many as the *Command and Colors System*, and it is a compound mechanic.

7 CONCLUSION

This work describes the steps towards the construction of a domain ontology for game mechanics starting by the BGG list of mechanics. The ontology presented must be improved with the addition of more classes and concepts as well as the inclusion of relations between them, other than the shown *is-a*.

The methodology used in this work can be reproduced using other information sources in order to extract more terms or concepts related to game mechanics.

Also, as a future work, one may combine the Game Mechanics Ontology with other concepts already presented in ontologies that were built targeting games as the ones in [23, 6], [17], [22], and [8]. In order to support this work, the proposed Game Mechanics Ontology is available in a GitHub repository (OMITTED), in the OWL format.

This ontology creation process and its results indeed shed some light to answer the first question stated in Section 1. In the sense of the MDA Framework, the original 51 mechanics of BGG are very much lacking in coverage of the possible game mechanics. We needed to create mechanics indirectly listed in BGG in order to build a meaningful basis for the Game Mechanics Ontology, and to deconstruct many of the existing BGG mechanics. We even concluded that two of them were not mechanics at all.

We could perceive how the players' view of mechanics is biased by the game artifacts in which they see them. This is interesting, but not surprising, as players have contact with the mechanics through those artifacts, and thus their interpretations of them are made through the game. We notice this in many cases, there are some BGG mechanics which are defined because of a type of game or the way it is used in a specific one, such as Hex and Counter, Area-Impulse, and Crayon Rail System. Their names and descriptions have features of the games not related to the mechanic itself. Other BGG mechanics are, as a matter of fact, melded mechanics which are commonly used together, like Dice Rolling which mixes rolling dice with using dice as marker, Deck/Pool Building as the most common form of Pool Building is with a pool of cards, Roll/Spin and Move as it is very common to move according to a random generated number.

Another strong indication of this player bias is the amount of BGG mechanics that are Actions. In fact, more than a half of the BGG mechanics are Actions. This lead us to think that players perceive more easily those mechanics they interact directly. So, they should think about the game more as the gameplay felt than the artifact. Even some mechanics that are not actions were described in BGG based on how they appear during gameplay.

An interesting inquiry would be to understand why Hand Management, being described as a dynamic, and actually compatible with the concept of Dynamics in the MDA Framework, is considered a mechanic. As players interact with mechanics through the games, it is actually easy to believe they will be confused about what is mechanic and what is dynamics. Dynamics are the run-time behaviour of mechanics in a game, they are the result of the interaction between the player and a mechanic, it is only natural to confuse them and take one for another. Further investigation on this reasoning may bring light upon the players perspective of games and eventually improves our understanding of games.

To improve this ontology, we will be looking for other sources of mechanics to expand it. Due to the BGG mechanics list limits, we already know that we missed some mechanics, thus our need to establish many concepts required to structure this ontology. To compensate this lacking we currently search for more sources of mechanics to broaden our ontology. Altogether, we aim to improve our existing ontology through establishing more relations and augmenting the existing ones. However, as already stated, we consciously decided to only include mechanics that are recognized in some accepted source.

We expect, with time, that this ontology will cover enough ground to be a tool used by scholars and designers alike.

REFERENCES

- [1] BoardGameGeek. Boardgamegeeklgame mechanics. <https://boardgamegeek.com/browse/boardgamemechanic>. (Accessed on 07/28/2017).
- [2] J. Bouaud, B. Bachimont, J. Charlet, and P. Zweigenbaum. Methodological principles for structuring an “ontology”. In *Proceedings of the IJCAI’95 Workshop on “Basic Ontological Issues in Knowledge Sharing*, pages 19–25, 1995.
- [3] F. Calado, L. Vasconcelos, A. M. Neves, F. Narto, and M. Guimarães. Modelo para avaliação do grau de novidade de jogos digitais. In *Proceedings of SBGames 2015*, 2015.
- [4] G. Costikyan. I have no words and i must design. *Interactive Fantasy: The Journal of Role-Playing and Story-Making Systems*, 2, 1994.
- [5] G. Costikyan. I have no words and i must design. In K. Salen and E. Zimmerman, editors, *The Game Design Reader: A Rules of Play Anthology*, pages 192–211. The MIT Press, Oxford, 2005.
- [6] gameontology. Main page — gameontology., 2015. [Online; accessed 6-August-2017].
- [7] G. Guizzardi. *Ontological foundations for structural conceptual models*. PhD thesis, Telematica Instituut / CTIT, 10 2005.
- [8] S. Howard. Three hundred mechanics, 2014. [Online; accessed 6-August-2017].
- [9] R. Hunicke, M. LeBlanc, and R. Zubek. Mda: A formal approach to game design and game research. In *In Proceedings of the Challenges in Games AI Workshop, Nineteenth National Conference of Artificial Intelligence*, pages 1–5, 2004.
- [10] IMDb. Imdb. <http://www.imdb.com>. [Online; accessed on 05-August-2017].
- [11] D. Jones, T. Bench-Capon, and P. Visser. Methodologies for ontology development. In *Proc. IT&KNOWS Conference of the 15th IFIP World Computer Congress*. na, 1998.
- [12] A. Järvinen. *Games without Frontiers: Theories and Methods for Game Studies and Design*. Tampere University Press, 2008.
- [13] F. Malcher, A. M. M. Neves, and L. Falcão. Aplicação do game ontology project no processo de análise de similares para design de jogos. In *Annals of the VIII Brazilian Symposium on Games and Digital Entertainment*, 2009.
- [14] M. A. Musen. The protégé project: a look back and a look forward. *AI matters*, 1(4):4–12, 2015.
- [15] N. F. Noy, D. L. McGuinness, et al. Ontology development 101: A guide to creating your first ontology, 2001.
- [16] J. Rohrer. New mechanic or category? secret player roles.
- [17] M. Roman, I. Sandu, and S. C. Buraga. Owl-based modeling of rpg games. *Studia Universitatis Babes-Bolyai*, 56(3):83, 2011.
- [18] K. Salen and E. Zimmerman. *Rules of Play: Game Design Fundamentals*. The MIT Press, 2003.
- [19] K. Salen and E. Zimmerman. *The Game Design Reader: A Rules of Play Anthology*. The MIT Press, 2005.
- [20] the Mana World. the mana world. [Online; accessed 6-August-2017].
- [21] A. Tucker. Looking for a good list of role selection games.
- [22] B. O. Đuric and M. Konecki. Specific owl-based rpg ontology. In *Central European Conference on Information and Intelligent Systems*, page 185. Faculty of Organization and Informatics Varazdin, 2015.
- [23] J. P. Zagal and A. Bruckman. The game ontology project: Supporting learning while contributing authentically to game studies. In *Proceedings of the 8th International Conference on International Conference for the Learning Sciences - Volume 2, ICLS’08*, pages 499–506. International Society of the Learning Sciences, 2008.

ACKNOWLEDGMENTS

This work was partially supported by CAPES and CNPq. This work was conducted using the Protégé resource, which is supported by grant GM10331601 from the National Institute of General Medical Sciences of the United States National Institutes of Health.