4
The basis of the proposed methodology

During this research work on pervasive games, we had the following goals:

- Discover common features in pervasive games;
- Investigate how technology[62] enabled or influenced the realization of pervasive games, and player experience;
- Provide guidelines for development of pervasive games using mobile phones; and
- Develop some pervasive game prototypes.

We used the following sources of knowledge elicitation to pursue those goals: literature review; pervasive game definitions (Chapter 3); analysis of games considered as "pervasive games" by the industry and academy; the experience in game design of the author of the present work and his associates[63]. From this work we came out with a methodology for conceptual design of pervasive mobile games.

This chapter presents the basis for this methodology. Chapters 5, 6, and 7 present the methodology details.

This chapter is organized as follows. Section 4.1 presents an overview about the proposed methodology, introducing its main parts. Section 4.2 discusses the domain boundary criteria – boundaries for delimiting the class of games we are interested in. A game that falls inside these borders (called "boundary criteria") will be referred as a "pervasive mobile game" in this work. The boundary criteria define the domain upon which we can apply our methodology. Section 4.3 presents a list of games that we have studied in this research work, as part of the process of domain mapping. Finally, Section 4.4 presents how our prototypes fit in the domain boundary this chapter defines.

62 With "technology", we are mainly concerned with aspects related to computing issues, mobile devices, wireless networking, and sensors.

63 Luis Valente has been appointed as a *Forum Nokia Champion* (now *Nokia Developer Champion*) since 2007 and has collaborators from the first game development academic laboratory in Brazil. His game prototype, *The Audio Flashlight*, was awarded in 2008. (Valente *et al.* 2008).

4.1 Methodology overview

Basically, our methodology comprises two main parts:

1. Domain knowledge mapping;
2. A domain specific language (DSL) specification for designing activities in pervasive mobile games.

In general terms, this research work considers an activity as a set of actions involving players, (mobile) devices, sensors and actuators[64] to reach some goal in the game. The activity concept is of central importance in our methodology.

The remainder of this section introduces each part of our methodology. Section 4.1.1 provides an overview for the domain mapping (and its components), and Section 4.1.2 provides an overview for the DSL specification and its components.

4.1.1 The domain knowledge mapping

The domain knowledge mapping is provided in five levels:

1. A boundary criteria for approaching the problem domain – the pervasive mobile games;
2. A feature list (called "pervasive game features" in this work) which characterizes pervasive games, along with the description of each item;
3. A checklist (*verification questions*) for each pervasive game feature;
4. A list of perspectives that group pervasive game features into certain views;
5. A categorization scheme for the concept of *pervasiveness.*

The pervasive features and perspectives can be useful for discovering or defining functional and non-functional requirements for the software part of the pervasive mobile game. As an example for levels two and three, a pervasive game may present the capacity of "*Local Space Redefinition*", that is: the capacity of

64 Chapter 6 defines in detail the concepts of activity, actions, devices, sensors, and actuators.

transforming the physical space where the game happens by bringing the space into the "game world". Some of the items in the checklist for this feature are:

- Does the game help players to have alternative views of the physical environment?
- Does the game use "live characters"[65] to reinforce the mixed-reality overlay?
- What physical resources does the game use as game elements?

The checklists are useful for verifying the presence of a feature in an existing game, or to provide guidance on how to add a feature to a pervasive mobile game. Appendix B presents other checklist items, for all pervasive game features.

In the fourth level, the pervasive game features are organized in terms of perspectives that are relevant for pervasive mobile games, as Figure 4.1 illustrates.

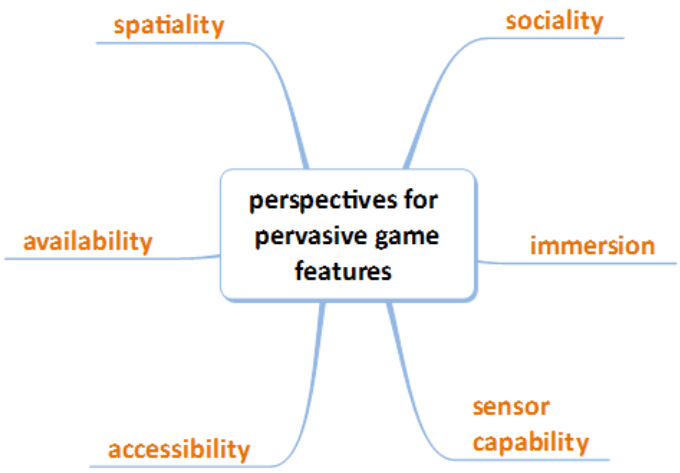

Figure 4.1: Perspectives for pervasive game features

For example, "Local Space Redefinition" is part of the spatiality perspective. The perspectives are a way to group features that are related to a specific aspect of the pervasive game. Every perspective groups a set of features. Some of the features appear in several perspectives, as they influence those perspectives in different ways. The perspectives also have relationships.

65 Real people as characters (as in theater).

In the fifth level, we propose a first attempt for a categorization scheme for the pervasiveness concept. This categorization scheme takes into account the idea of pervasive game features.

4.1.2 The domain specific language specification

The second part of the methodology corresponds to the specification of a DSL for designing activities in pervasive mobile games. A DSL (Mernik *et al.* 2005) is a language designed for a particular application domain, comprising specific types and constructs that encode the domain knowledge.

The DSL specification has two levels: an ontological level and an operational level.

The ontological level defines concepts that have basic properties. These concepts support the specification of activities in pervasive mobile games. As an example, Table 4.1 lists a basic property of *activity*[66], which is a central concept in our methodology:

Activity property	Arguments
Interaction Granularity	"discrete", "continuous"

Table 4.1: Example of a basic property for activities

As an example, an interaction has discrete granularity when there is a finite set of interaction options. This would be the case of a game where the player needs to position a device in some (finite) pre-defined positions to trigger commands. This is the case of our prototype *The Audio Flashlight* (Appendix C.2).

Also, there is a list of consistency rules for the ontological level concepts. An example of a rule is: "interaction granularity in activities must be compatible with the type of sensors". In this case, an inconsistency arises when a continuous player movement is using a discrete scheme of four keyboard keys. Chapter 6 presents the definitions of activity and the details on the ontological level, along with the consistency rules.

66 Activities are discussed in Section 6.2.10.

The main concept in the operational level corresponds to *scenarios*, which represent concrete activity specifications (as text and/or diagrams) using the ontological level concepts. Chapter 7 presents the details on this DSL operational level.

This idea of having a DSL with two levels (ontological and operational) is similar to the approach by Leite and co-authors (2000), where they define a lexicon (a controlled vocabulary) for the ontological level, and a scenario view for the operational level. However, their scenario view (which uses their ontological level concepts) is more concerned with aspects from Requirements Engineering, such as capturing requirements and traceability.

4.2
Domain boundaries for pervasive mobile games

Chapter 3 discusses different definitions and viewpoints for pervasive games. In order to understand this field and to provide reusable assets to support the development of pervasive games, we define boundary criteria that characterize *pervasive mobile games*, which are the target of this research work. The boundary criteria comprise four conditions. These boundary criteria comprise four conditions:

1. Games using mobile devices (*e.g.* smartphones, tablets): mandatory
2. Games that are context-aware: mandatory
3. Games that access remote data[67] on the move: optional
4. Multi-player games: optional

Next section discusses the boundary criteria.

4.2.1
Discussion on the boundary criteria

Condition 1 is mandatory because many pervasive games share the concern of "bringing games back to the real world". This means having game activities out in open areas or at least not confined to the static nature of using desktop com-

67 For example, the scope could be global (*e.g.* internet) or local (*e.g.* WiFi, Bluetooth).

puters. This relates to moving in space, being either small ("restricted")[68] spaces or large urban areas. In this sense, we consider mobile devices like smartphones, tablets, and PDAs as the main devices. We give more emphasis to smartphones, as they are able to make Condition 3 possible due to the widespread availability of mobile phone networks.

Context-awareness means the game is able to adapt the gameplay according to the current environment conditions. This involves sensing the environment, and using this information as source for game content or to provide customized experiences. One of the often cited references for *context*, (Dey 2001), defines it as:

> "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves"

Existing research on Human-computer interaction as (Schmidt *et al.* 1999) suggests that the concept of context can be boarder enough to consider the ways a user interacts with a device (on the hand, on a table, etc.) as context information.

Context-aware applications are able to create the integration between the virtual and physical worlds that many pervasive games present, by sensing the environment and incorporating those data in the gameplay. We see this as an essential characteristic of pervasive games, so Condition 2 is mandatory.

Condition 3 relates to the ability of pervasive games to access remote resources while players are located anywhere. This relates to single-player games (where the game data is remote) and multi-player games where players are not co-located. However, not all pervasive games use networking; hence this is why Condition 3 is optional.

Condition 4 relates to the social nature of pervasive games, by integrating many players into the game. This distribution can be local (players are co-located) or global (players are not co-located), or both. We consider players as "co-located" when they are able to interact inside an area defined by a local network (like Bluetooth and WiFi). In case of players not being co-located, Condition 4 also implies Condition 3. However, not all pervasive games are multi-player games, hence Condition 4 is optional.

68 For example: a room, an open basketball court.

As consequences of these criteria, games that are only “portable” or “mobile” are not necessarily part of this domain. A “portable game” satisfies Condition 1 only, while a “mobile game” satisfies Conditions 1 and (3 and/or 4).

4.3 Games list

During the domain mapping process, we have studied a number of games that had been labeled as “pervasive games” in the literature, or that could be considered a “pervasive mobile game” candidate according to our boundary criteria. Table 4.2 lists these games according to the boundary criteria that this chapter defines – including games that are not part of the domain, borderline cases, and games satisfying a combination of conditions.

Condition	Games
Out of the domain	Day of Figurines
Borderline cases	Can you see me now?, Uncle Roy all around you, Mogi, Epidemic Menace, Botfighers, GPS Mission, Manhattan story mashup
1 and 2	The Journey, Ere be dragons, Pervasive Clue, REXplorer
1 and 2 and 3	-
1 and 2 and 4	Pirates!, PAC-LAN, Feeding Yoshi
All conditions	Songs of north, Tycoon, Hitchers, GPS Mission, Mythical: The Mobile Awakening, Seek n' Spell, Gbanga Famiglia, Gigaputt, GEO Hunters, Insectopia, and borderline cases.

Table 4.2: Analyzed games according to boundary conditions

Table 4.3 provides the complete game list, including platforms, sensors, networking technologies that the games use (when applicable), and main references. More detailed descriptions about these games are in Appendix A, which this research work included to make it easier for the reader to get to know those games in a central reference.

The game *Day of Figurines* is not part of the domain as it is does not satisfy Condition 2.

The borderline cases in Table 4.2 group games that use mobile devices along with other kinds of devices (as desktop computers) to deliver the game experience.

Name	Platform	Year	Sensors	Network	References
Can you see me now?	PDA, web	2001	GPS	WiFi	(Benford *et al.* 2006a)
Pirates!	PDA	2001	proximity[69]	WiFi	(Björk *et al.* 2001)
Pervasive Clue	PDA	2001	proximity[69]	WiFi	(Schneider and Kortuem 2001)
Botfighters*	phone, web	2001	GPS	SMS	(Sotamaa 2002)
Uncle Roy all around you	PDA, web	2003	self-reported	WiFi	(Benford *et al.* 2004a) (Benford *et al.* 2004b)
Mogi*	phone, web	2003	GPS, cell-id	operator	(Joffe 2007)
Songs of north	phone	2004	cell-id	operator	(Lankoski *et al.* 2004) (Ekman *et al.* 2005)
The Journey*	phone	2004	cell-id	-	(Jakl 2004)
Tycoon	phone	2005	cell-id	operator	(Broll and Benford 2005)
Ere be dragons	PDA	2005	GPS, heart-rate	-	(Davis *et al.* 2005)
Epidemic Menace	cross-media	2006	GPS, soft-sensors[70]	WiFi	(Lindt *et al.* 2007) (Lindt *et al.* 2006)
Hitchers	phone	2006	cell-id	operator	(Drozd *et al.* 2006)
Manhattan story mashup	phone, web	2006	camera	operator	(Scheible *et al.* 2007) (Tuulos *et al.* 2007)
PAC-LAN	phone	2006	RFID	operator	(Rashid *et al.* 2006)
Feeding Yoshi	PDA	2006	WiFi	WiFi	(Bell *et al.* 2006)
Day of figurines	phone	2007	-	SMS	(Flintham *et al.* 2007b) (Flintham *et al.* 2007a)
Insectopia	phone	2007	Bluetooth	operator	(Peitz *et al.* 2007)
REXplorer*	phone	2007	GPS, camera, Bluetooth	-	(Ballagas *et al.* 2007) (Ballagas and Walz 2007) (Ballagas *et al.* 2008)
GPS Mission*	phone	2008	GPS	operator	(Orbster 2008)
Mythical: The Mobile Awaken-ing	phone	2008	Bluetooth, soft-sensors[70]	operator	(Saarenpää *et al.* 2009) (Korhonen *et al.* 2008) (Paavilainen *et al.* 2009)
Seek n' Spell*	phone	2009	GPS	operator	(Retronyms 2009)
Gbanga Famiglia*	phone	2010	GPS, cell-id	operator	(Gbanga 2010)
Gigaputt*	phone	2010	GPS	operator	(Gigantic Mechanic 2010)
GEO Hunters*	phone	2011	GPS	operator	(YD Online 2011)

Table 4.3: Analyzed games list. The asterisk denotes commercial projects

69 Sensors able to detect nearby objects without physical contact.

70 "Software sensors", that use real-world information (weather, moon phase, etc.) to influence the gameplay.

For example, *Botfighers* and *GPS Mission* use a web module (not available for the mobile devices) to provide a configuration interface for game. In case of *Botfighers*, players are able to equip their avatar for each mission. In *GPS Mission*, the web interface makes it possible to create custom missions for other players to play. In *Can you see me now?*, players from around the world can use a web module (in desktop computers) to interact with players that are out in the streets with their mobile device. Games that follow this approach are known as cross-media games[71]. Cross-media games use different devices to deliver different ways to interact with the game, in the sense that players will be able to handle some game aspects only when using specific devices (provided by the game).

The *Insectopia* game satisfies all conditions (theoretically), but the game has strong emphasis on single-player activities. Therefore, we can also say that is more adequate to classify it as satisfying Conditions 1, 2, and 3 only.

Although *Day of Figurines* is out of the domain, this game has features that other pervasive mobile games share (as *Game Pacing*, *Daily life interleaving* and *Persistency*)[72]. Hence, the discussion on those specific features cites this game as an example of applicability of the discussed feature.

4.4 Example: domain boundaries

During this research work on pervasive mobile games, several prototypes have been developed, such as: *Location-based Quiz Game*, *Pervasive Word Search*, and *The Audio Flashlight* series (5 games). The reader is encouraged to explore Appendix C to find out how the prototypes work.

Table 4.4 lists the prototypes according to the boundary criteria for pervasive mobile games presented in this chapter.

71 This concept is discussed in Section 5.1.9.
72 These features are discussed in Section 5.1.

Condition	Prototypes						
	Loca-tion-based Quiz Game	The Audio Flashlight 1*	The Audio Flashlight 2*	The Audio Flashlight 3*	The Audio Flashlight 4	The Audio Flashlight 5	Pervasive Word Search
1		x	x	x	x	x	x
2	x	x	x	x	x	x	x
3							
4	x		x	x		x	

Table 4.4: Prototypes and the boundary criteria for pervasive mobile games. The asterisk denotes borderline cases. Conditions 1 and 2 are mandatory

We consider the first three versions of *The Audio Flashlight* as borderline cases because we are considering using the device accelerometer for interaction as the "context-aware" part of those games, which is something up to debate. Referring to Table 4.4, none of the prototypes are considered as out of the boundary criteria. Also, none of the prototypes satisfy Condition 3, as none of them use global networking. The *Location-based Quiz Game* uses a WiFi connection to communicate with a (local) server, while *The Audio Flashlight 2*, *3*, and *5* use Bluetooth networking for peer to peer playing (co-located)

4.5 Summary

This chapter has presented an overview of our methodology, which comprises two main parts:

1. Domain knowledge mapping;
2. A domain specific language (DSL) specification for designing activities in pervasive mobile games.

The methodology defines a boundary condition for characterizing the domain of "pervasive mobile games" – the games we are interested in. We have analyzed a set of games and categorized them as such: being part of this domain, borderline cases, and games not being part of the domain.

The first part of our methodology, the domain knowledge mapping, is provided in five levels:

1. Boundary criteria for approaching the problem domain – the pervasive mobile games;
2. A feature list (called "pervasive game features" in this work) which characterizes pervasive games, along with the description of each item;
3. A checklist for each pervasive game feature;
4. A list of perspectives that group pervasive game features;
5. A categorization scheme for the concept of *pervasiveness.*

The second part of our methodology corresponds to the specification of a domain specific language (DSL) for designing activities in pervasive mobile games. This DSL has two levels: an ontological level and an operational level. The ontological level defines concepts and properties to support the specification of activities. The operational level defines a language for designing activities using the ontological level concepts, templates and activity diagrams.

The proposed methodology has been devised after a research work that included a detailed analysis of a set of games. Appendix A provides descriptions of all analyzed games, working as a general reference for those games in this work.

As an example, this chapter presented how our prototypes fit in the boundary criteria for pervasive mobile games that this chapter has defined.