# A Methodology for Gamifying Smart Cities: Navigating Human Behavior and Attitude

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**Abstract.** We are now living in smart cities, where information technologies enhance our everyday life. For example, our energy management and traffic management have become smarter, making our daily lives more convenient and efficient. However, from a citizen's point of view, a person's happiness needs to be more important than achieving efficient and convenient smart city infrastructures. This is, in particular, an essential issue for achieving human-centered smart city design. In this paper, we present our methodology to gamify smart city services. Our methodology consists of three tools, one model and two infrastructures. The tools contain the *value-based design framework*, the *personality-based analysis framework*, and the *reality-based analysis framework*. The model is named the *GamiMedia* model, and the infrastructures include the *Virtual Form* infrastructure and the *Digital-Physical Hybrid Role-Playing* infrastructure. The methodology to gamify smart city services is extracted from our long experiences with building applications services and middleware infrastructures for ubiquitous computing environments.

**Keywords:** Human behavior and attitude, Agency, Immersion, Procedural rhetoric, Transmedia.

## 1    Introduction

When designing future smart cities, maintaining a desirable lifestyle from a citizen's point of view is an important research topic. There have been many previous studies focusing on efficient physical resource management in underlying smart city infrastructures, such as traffic management systems and energy management systems [3]. However, in a future aging society, a person's happiness is more crucial than achieving efficient smart city infrastructures, and this is an essential issue for human-centered smart city design.

Information technologies have made our daily lives safer and more reliable. For example, the progress of bioinformatics makes it possible to develop better medicine and to make our life healthier. The progress of low-power technologies has reduced

the consumption of natural resources. However, only considering the recent progress in information technologies limits our ability to address critical social, health, and environmental issues. The limitation can be overcome by taking our ordinary daily life activities into account when navigating human attitude and behavior.

The design of past information technologies typically assumes that human decisions are always rational. For example, studies on usability or ergonomics are based on human rationality in terms of physiology and psychology. However, recent discoveries on cognitive biases in behavioral economics and self-efficacy and positivity in social psychology have shown that information design based on rational thinking is not sufficient to navigate human attitude and behavior [9].

There are two issues in developing gameful smart city services. The first issue is a lack of tools to design the services [4]. The second issue is a lack of software infrastructures to simplify the design of smart city services. These two issues are very critical to make our daily environment smarter [25]. The goal of our project is to solve the issues by offering a set of tools and software infrastructures. Additionally, we provide a model to integrate these tools and infrastructures within one unified methodology.
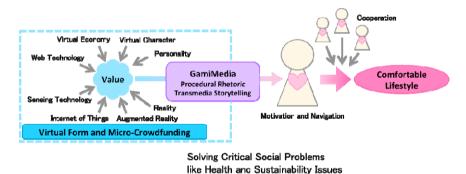


**Fig. 1.** An Overview of Gamifying Smart Cities

As shown in Fig. 1, our approach proposes a set of design tools, a model, and infrastructures to navigate human attitudes and behavior to tackle critical social problems. In our approach, the central idea is the value-based design framework, which is a tool to design gamified smart city services based on the perceived human values of the services. The value can be translated into the real world by using various information technologies. The GamiMedia model allows people to develop gameful services that are fragmented into multiple pieces of visual expression distributed in multiple virtual forms. A virtual form is an abstraction to show dynamically changing visual information in daily artifacts. Additionally, our approach focuses on modifying the attitudes and behaviors of a community, rather than an individual, by using a micro-crowdfunding concept. Each community can select desirable activities that solve targeted social problems in their communities and help members lead a comfortable lifestyle.

The paper is organized as follows. In Section 2, we present and define the properties of agency and immersion to exploit the procedural rhetoric concept. Section 3 presents three design frameworks as tools to gamify smart cities. Specifically, the value-based design framework is explained in detail, and we show how to use the framework to design smart city services. In Section 4, we propose a model and two infrastructures for gamifying smart city services. Section 5 presents several related studies; finally, we conclude the paper in Section 6.

## 2     Agency and Immersion in Procedural Rhetoric

Future smart cities will include a large amount of embedded computing power, and the real world will be enhanced through efficient physical resource control and information generated from the embedded computers. In particular, such ubiquitous computing technologies as public networked displays and augmented reality technologies make it possible to physically represent virtual information generated from the embedded computers. In [14], we present that a gaming concept is a useful tool for maintaining a desirable lifestyle; thus, we believe that the concept is also useful for designing future smart cities. As presented in [1], procedural rhetoric allows us to develop a new type of media and services based on a game concept, and the procedural rhetoric effectively navigates human attitudes and behaviors via its persuasive nature. The combination of the procedural rhetoric and ubiquitous computing technologies allow us to develop a strong tool to enhance our daily lives by immersively integrating virtuality into the real world.

In this paper, we first define agency and immersion, essential properties for defining video games, and characterize the concept of procedural rhetoric based on the two properties. In the original definition, agency means the player is able to participate in computer simulations or video games, and immersion is understood as suspension of disbelief [5]. Ubiquitous computing technologies allow these properties to be enhanced as follows: the agency property is enhanced such that each person plays a fictional role augmented through a fictional story in which the role enhances the player's actual abilities in the real world. The story is embodied in our real world through a transmedia storytelling technique [20]: the story is fragmented into several different pieces and presented through different various media, such as networked public displays or projectors. When each person adopts a virtual role that enhances his or her actual abilities, he or she may increase self-efficacy, increase positive thinking, or modify his or her behavior toward a desirable lifestyle. The immersion property is also enhanced; virtual goods are represented in the real world through networked public displays and projectors. When virtual objects offer a simulation property, whereby people can manipulate them similar to real objects, the feeling of immersion is further enhanced. Additionally, the current environmental situation and people's behavior can be reflected in the visual expression presented on ubiquitous displays as procedural rhetoric by extracting the information about the real world with sensors. As shown in [14], the ambient information presentation can be used to shape people's attitude and behavior towards more desirable lifestyle.

# 3      Design Tools for Gamifying Smart City Services

The above vision promises to realize gameful smart cities by navigating people's attitudes and behaviors toward their desirable lifestyle, but one of the current problems is a lack of good design tools for gamifying smart city services. To successfully engage people, they need to feel some values of the agency and immersion properties offered by procedural rhetoric embodied in the visual expressions on ubiquitous display or projector technologies. If they do not value the services, their attitude and behavior cannot be changed. To solve the problem, we have developed three design frameworks as tools to gamify smart city services, as shown in Fig. 2. The first framework is named the value-based design framework [16, 17, 25], the second is the personality-based analysis framework [19] and the final one is the reality analysis framework [21, 24]. These frameworks enable us to design an effective procedural rhetoric that a variety of people value by designing services offering persuasive visual expressions through the participatory design technique. The frameworks have been extracted from our experiences with building several case studies [6, 14, 18, 20, 28], and organizing workshops and field studies [21, 22, 24].
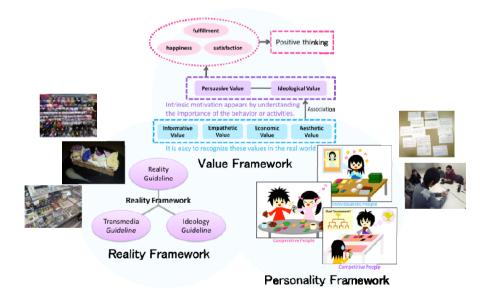


**Fig. 2.** Design Frameworks

Fig. 3 illustrates the value-based design framework to use the proposed six values to increase people's intrinsic motivation and to make them think positively when incorporating a fictional story into persuasive transmedia storytelling[1].

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[1] The values are originally proposed in [16, 17]. The current definition of the values is enhanced from the experiences with *Augmented TCG* and presented in [20, 25].

The empathetic, economic, and aesthetic values offer people extrinsic incentives, and the informative value provides the reason to change a person's attitude or tips and tactics for making a better decision. The four values are used as tools in the model to change people's current behavior by emphasizing the importance of changing their behavior and encouraging this change at an early stage. In contrast, the ideological value makes people's dreams and expectations explicit and demonstrates how changing people's attitude helps to realize their dreams. Additionally, the persuasive value delivers the importance of the ideological value to people through stories or procedural rhetoric embodying the ideological value. The values are used to increase the intrinsic motivation to change their attitude in the latter stage of the transtheoretical model [15]. In our approach, we assume that each person already knows the story; thus, the persuasion in the latter phase becomes faster than using traditional methods [25].



**Fig. 3.** Value-based Design Framework

In our project, the value-based design framework is used with the participatory design. We assume that participants with different personalities cooperate to design services based on the GamiMedia model described in the next section. They usually choose different values because each person prefers a different value. The personality-based analysis framework helps to choose participants who have different personalities. Thus, if they cooperate to design a service together, various values will be embodied into the service, and the service will satisfy a large number of people. The values defined in the value-based design framework also become a good tool for participatory design. When using the value-based design framework in participatory design, the ideological value is an essential value to increase people's intrinsic motivation related to a service. When intrinsic motivation is increased, people's

activities are encouraged regardless of their personalities; thus, it is easy to develop attractive services that do not depend on their personalities. If they understand the importance of the ideological message embodied in the service, their increased intrinsic motivation encourages them to perform activities that satisfy the ideological message [23]. When procedural rhetoric is embedded into the ideological message or a story to explain the ideological message is offered, the persuasive value is increased, persuading people that the ideological message is important to them by increasing their self-efficacy or positive thinking. However, people who are not interested in performing the activities can be activated by values that increase their extrinsic motivation. For example, some people like to collect rare objects that offer the economic value, or other people may like to see a beautiful landscape that offers the aesthetic value. When cooperatively designing a smart city service, different people will incorporate the values they prefer.

The services based on the GamiMedia model are represented on multiple virtual forms. By presenting the visual expressions of virtual forms on various daily artifacts, virtuality can be embedded into our real world [24]. The reality analysis framework ensures the reality when using virtual forms. In [21], design patterns that increase extrinsic motivation without losing the reality are proposed; in [24], design patterns that increase intrinsic motivation without losing the reality are proposed. The frameworks also propose design patterns protect the reality when multiple stories are composed. These design patterns are very important when developing services based on the GamiMedia model. Each person may prefer different stories, but many people usually simultaneously watch virtual forms shown on public ubiquitous displays. Thus, the respective person's stories should be combined into one story and be shown on virtual forms embedded into our real world without losing the consistency among the respective stories.

## 4     Experiences from Case Studies and Extracting Insights to Develop a Model and Infrastructures for Gamifying Smart City Services

In this section, we present our ongoing work on developing a model and two software infrastructures to gamify smart city services. The GamiMedia model is a model for developing multimedia digital content based on transmedia storytelling [22]. The Virtual Form infrastructure coordinates various public displays and projectors; it is implemented on various distributed software infrastructures for ubiquitous computing [21, 24]. The Digital-Physical Hybrid Role-Playing infrastructure offers a way to navigate human attitudes and behaviors [18, 23].

In our current project, as shown in Fig. 4, the GamiMedia model, the Virtual Form infrastructure, and the Digital-Physical Hybrid Role-Playing infrastructure have been developed based on the previous infrastructures from our project. The proposed model and infrastructures have been designed based on insights extracted from experiences with these case studies.
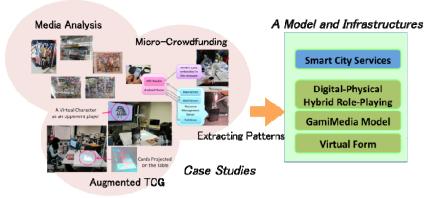
**Fig. 4.** Extracting Common Patters to Design a Model and Infrastructures

From our experiences with the case studies, we found that one visual expression offered by a smart city service should be easily distributed on multiple displays and projectors. The software infrastructure needs to locate them in a spontaneous way. Additionally, a service programmer using the infrastructure should hide network programming to make it easy to develop distributed visual expressions containing procedural rhetoric. Furthermore, navigating human attitudes and behaviors is difficult to implement as an application program. We need a model to develop distributed visual expressions based on a transmedia storytelling concept, which is executed on virtual forms. In this section, we explain an overview of the model and software infrastructures.

Because we believe that procedural rhetoric is one of desirable tools in persuasive technology, we propose the GamiMedia model to navigate human attitudes and behaviors based on procedural rhetoric. The model has been developed by experiences with analyzing various media contents in workshops and field projects, as shown in one of our case studies [20]. The GamiMedia model allows us to develop services presenting visual expressions based on a transmedia storytelling concept by incorporating a game concept. The model is useful to develop gameful services for advertisements and news that have the purpose in the real world. The value-based design framework and the personality-based analysis framework enable us to develop visual expressions to increase both intrinsic and extrinsic motivation based on the GamiMedia model systematically. The model also enables us to design cultural digital multimedia contents that can be accepted in other cultures. In the model, each GamiMedia object contains at least one element from the following three elements: Dynamics, Visual and Story, where Aesthetic in the MDA Model [8] is divided into Visual and Story in our model. Additionally, a GamiMedia object has a link to another GamiMedia object, with the meaning of a GamiMedia object being explained in another GamiMedia object that is connected with a link. The purpose of the GamiMedia model is to define the semantics of digital multimedia contents, such as Krippendorff's product semantics [11], a methodology to define the meanings of products. The approach can well explain various Japanese fanfic and gamified

phenomenon and offer a guideline that allows us to discuss how to export such cultural phenomenon to foreign countries.

The Virtual Form infrastructure has been developed based on a case study named the Augmented Trading Card Game (Augmented TCG) [20]. Augmented TCG monitors the opponent's behavior using an MS Kinect and models his or her behavior as a virtual character's behavior. Additionally, the opponent's card is projected on the table in front of a player. Thus, a player has the feeling that he or she is playing with the opponent face-to-face; moreover, virtual cards allow us to add more information to the game play. To enhance Augmented TCG, we also discuss the idea of adopting a concept called transmedia storytelling [20]. In particular, our approach introduces fictionality in daily artifacts to enhance their value.

Virtual forms offer the potential to integrate fictionality into products and services to offer immersive experiences [16, 21, 24]. These virtual forms show dynamical-ly generated visual expressions containing information that both encourages a person to feel that the artifacts have some additional value and enables him or her to consider the activities that use the artifacts as more attractive. For example, incorporating visual expressions into a display or projecting some information onto an artifact adds computational visual forms to existing daily artifacts. A virtual form can be used as an abstraction to incorporate procedural rhetoric in the real world to gamify smart city services. As described above, the procedural rhetoric incorporated through the GamiMedia model is effective to incorporate virtuality in the real world by exploiting the agency and immersion property.

To present distributed visual expressions for smart city services, which is based on the GamiMedia model, we need a software infrastructure to fragment the visual expressions in distributed virtual forms. There are several software infrastructures in previous studies that satisfy these requirements, such as Personal Home Server [13], FedNet [10], or Mirage [26], which federate a large number of Internet of Things. We have also developed persuasive ambient mirrors [14] and playful training systems [28] to offer infrastructures to use ubiquitous displays and projectors. The Virtual Form infrastructure reuses these software infrastructures, offers a virtual form abstraction and represents distributed visual expressions based on the GamiMedia model. The Virtual Form infrastructure also adopts the ambient feedback techniques proposed in [14] to offer people a psychological incentive. To increase the persuasiveness of the ambient feedback, we also consider adopting an approach used in documentary games [5] to incorporate ideological messages represented as procedural rhetoric [1].

The Digital-Physical Hybrid Role Playing infrastructure is a direct enhancement of a case study named micro-crowdfunding [18]. In micro-crowdfunding, each community manages the sustainability of its shared resources by using a micro-level crowdfunding method. One of a community's members proposes a small mission to improve the sustainability of shared community resources. Usually, the mission is trivial and easy to accomplish, such as clearing a shared garbage box. In our approach, a crowdfunding concept is adopted to increase each community member's awareness, learning which activities are effective for increasing the social sustainability. He or she owns some amount of virtual money, and the money is used

to invest to support the proposed mission. Through the investment, he or she can know why the mission is important. The above basic approach to offer a social and economic incentive is encourages people to support missions that are more related to the sustainability of their communities.

Micro-crowdfunding focuses only on social sustainability, but the Digital-Physical Hybrid Role Playing infrastructure can be easily enhanced for other activities for tackling critical social problems. The infrastructure is a higher-layer infrastructure top on the Virtual Form infrastructure to navigate human daily activities. This makes it easy to gamify smart city services by navigating human attitudes and behaviors. In the infrastructure, we assume that many daily artifacts in various locations are made as an Internet of Things. A user can use his or her NFC-capable mobile phone to register a new mission by touching on any artifacts related to the missions with his or her phone. Additionally, a community member invests in the missions from his or her mobile phone. The approach is radically different from traditional crowdfunding systems, such as Kickstarter, Indiegogo, RocketHub, Fundable, and Crowdfunder, because a crowdfunding concept is used to encourage a community to act to solve critical social problems. In the infrastructure, we also need to consider how the payment transaction is light-weighted to lower the threshold to accept ubiquitous payment [27].

In the near future, we believe that we need another infrastructure to analyze the data extracted from human behavior to design better ambient feedback. Currently, we use information extracted from the Digital-Physical Hybrid Role Playing infrastructure. The information includes how and by whom missions are performed and funded. However, to monitor human behavior we need more information from social media [29] and physical sensors [7]. The monitoring infrastructure gathers information about each person's activities, and the information can be used to reflect their current attitude and behavior on virtual forms. Specifically, sensing information from each person's mobile phone is promising to extract accurate human behavior. Because the infrastructure requires a large amount of computational power, the infrastructure will be developed in a cloud computing environment.

## 5     Related Work

MINDSPACE, proposed in the UK, is a framework that adopts some concepts from behavioral economics to affect human attitudes and behaviors [9]. However, using public policy to modify behavior has a significant disadvantage; it takes a long time to formulate the policies. Therefore, it is effective to use technologies that have strong effects on our mind to navigate human attitude and behavior. In fact, information technologies can be used to solve health problems by increasing people's self-efficacy. For example, Re-mission[2] is a game in which a player finds cancer cells and destroys them in an accurately modeled virtual body. A cancer patient who plays the game believes that he can overcome the cancer in the real world and tackles the

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[2] http://www.re-mission.net/

treatment positively. This is evidence that information technologies can encourage people to make their behavior more desirable.

Maslow claims that human motivation is based on a hierarchy of needs [12]. In Maslow's hierarchy, the basic needs include such needs as physiological needs and food. Other needs are safety, attachment, esteem, cognitive needs and aesthetic needs. At the highest level, when all other needs are satisfied, we can start to satisfy self-actualization needs. Because people value products when they satisfy their needs, satisfying needs is closely related to defining values. Boztepe proposes four values: utility value, social significance value, emotional value and spiritual value [2].

There are several distributed infrastructures to integrate multiple appliances or smart daily artifacts. For example, a Personal home server makes it possible to coordinate a variety of home appliances spontaneously, such as televisions and video recorders [13]. Because each person has a different personal home server, it allows him or her to personalize how to use the appliances according to his or her preferences. FedNet is a distributed infrastructure for building distributed pervasive computing applications [10]. FedNet adopted a document-centric design using a RESTful approach to modularize system components and to support seamlessly building end-user interaction tools. Mirage [26] is a software infrastructure to build distributed augmented reality applications. Mirage offers a high level abstraction to control distributed continuous media data.

Playful training systems superimpose necessary information on the real world [28]. The basic technology behind playful training systems is augmented reality. The systems make hidden information visible to the user to make a decision more rationally. In particular, less skillful users do not have enough abilities to find useful information embedded in our environment. If information technologies can make more useful information explicitly visible to users, they can make more desirable decisions. The approach is useful to project information support our decision making on daily artifacts. The approach offers a possibility to make every surface of a daily artifact a virtual form. Additionally, a persuasive ambient mirror monitors people's current attitude and behavior by using sensors and presents visual expressions reflecting their current attitude and behavior [14]. For example, in Virtual Aquarium the condition of the Virtual Aquarium reflects people's daily toothbrushing behavior. Additionally, in Mona Lisa Bookshelf, people's housekeeping of their public bookshelf is reflected in a Mona Lisa picture.

# 6    Conclusion and Future Direction

Our daily lives have becomes increasingly complex. The current progress to develop smart cities helps us to make our lifestyle more comfortable because a variety of automation in smart cities reduce the complexities in our world. However, as describe in the paper, simply reducing the complexities does not create a truly desirable lifestyle. We believe that directing human attitudes and behaviors towards more desirable lifestyle is more important. The paper proposes three design frameworks for gamifying smart city services: the value-based design framework, the personality-based analysis

framework and the reality-based analysis framework, the GamiMedia model, the Virtual Form infrastructure, and the Digital-Physical Hybrid Role Playing infrastructure.

In the future, we also need to discuss the ethical issues of modifying human attitudes and behaviors because, if misused, the approach makes it possible to control humans unintentionally or maliciously. We will investigate the issue by introducing a concept called the magic circle, which is widely used in game studies.

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