Lecture Notes in Networks and Systems 770

Paulo Novais · Vicente Julián Inglada · Miguel J. Hornos · Ichiro Satoh · Davide Carneiro · João Carneiro · Ricardo S. Alonso *Editors*

Ambient Intelligence – Software and Applications – 14th International Symposium on Ambient Intelligence

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Preface

Ambient intelligence (AmI) represents a cutting-edge paradigm in computing and artificial intelligence that aims to create an interconnected, adaptive and unobtrusive environment that seamlessly integrates technology into our daily lives. The core idea of AmI is to build intelligent environments capable of sensing, understanding and responding to human needs, preferences and behaviors without the need for explicit user commands. This technology envisions a world in which diverse devices, sensors and systems work together intelligently, creating a harmonious, context-aware ecosystem that enhances our overall experience and well-being.

The main application areas of ambient intelligence are diverse and far-reaching, spanning numerous sectors. In health care, ambient intelligence can revolutionize patient care by monitoring vital signs, detecting abnormalities and providing personalized medical care. In smart homes, AmI technologies can self-manage household tasks, adjust lighting and temperature according to user preferences and enhance security through smart surveillance systems. In addition, AmI has applications in retail, entertainment, education and many other sectors, all aimed at creating seamless, intuitive and efficient human–technology interaction.

In this regard, ISAmI is the *International Symposium on Ambient Intelligence*, which seeks to bring together scientists working in all areas related to AmI, as can be seen in the articles included in the conference. This year, we are proud to tell that ISAmI is in its 14th edition, including several papers focused on the different key aspects of the AmI. Among others, interested researchers can find works on the recognition of emotions and life conditions; smart applications for improving people's quality of life and safety; AmI for smart cities and territories; research in distributed architectures in AmI scenarios; as well as advances in data semantics, data organization and data privacy.

In total, 23 articles for the main track and 4 for the doctoral consortium have been selected from a total of 51 submissions (44 for the main track and 7 for the doctoral consortium) from many different countries (Japan, Italy, India, Nigeria, Lithuania, Ecuador, UAE, Palestine, Burkina Faso, Senegal, Cameroon, Spain and Portugal).

As in previous editions, there are special issues in JCR-ranked journals such as *Sensors*; *Electronics*; *Systems*; as well as *Advances in Distributed Computing and Artificial Intelligence Journal*.

The symposium is organized by the Universidade do Minho (Portugal), the Universitat Politècnica de València (Spain), the University of Granada (Spain), the National Institute of Informatics (Japan), the Instituto Superior de Engenharia do Porto (Portugal) and the Universidad de Salamanca (Spain). The present edition was hosted by the LASI and Centro Algoritmi of the University of Minho in Guimarães, Portugal, from July 12 to 14, 2023.

We would like to thank all colleagues who submitted their research, all the members of the Program Committee for their work, and the sponsors (AIR institute and Câmara

Municipal de Guimarães) for their support. Without their efforts, it would have been impossible to put together such an interesting and actual program.

Finally, we appreciate the efforts of local organizers, for hosting and organizing these events, without which ISAmI could not have taken place.

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Contents

ISAMI'23 - MAIN TRACK

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Sharing Human Seeing and Hearing and Their Annotated Portfolio

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Abstract. The paper describes the use of an annotated portfolio for extracting their possibilities and challenges from "CollectiveEyes and CollectiveEars" to document abstract features of these digital platforms that are meant to engage human visual and auditory perception. This proposed annotated portfolio offers two different perspectives: the sociomateriality perspective and the pleasurability perspective. After introducing the background of our approach and providing an overview of CollectiveEyes and CollectiveEars, we present their annotations and the process to document them. Additionally, we share some early experiences with these annotations, which were used to analyze the platforms. These experiences demonstrate that this approach effectively highlights the abstract qualitative properties of the platforms, thereby facilitating the identification of potential opportunities for their future refinements.

Keywords: Material Aspects · Sharing Human Seeing and Hearing · Annotated Portfolio · Sociolmateriality · Pleasures

1 Introduction

In recent decades, research on digital technology has mainly focused on utilitarian advancements that prioritize functionality and practicality. However, there is growing concern about the limitations of this heavily utilitarian approach. Some researchers in the design-oriented human-computer interaction community argue that an excessive focus on utilitarian aspects may hinder efforts to understand the complex relationships between humans and technology, as well as how human experiences are shaped by technology. This overemphasis on practicality has raised questions about considering broader issues in the relationship between research and design. To address these concerns, innovative digital technologies have given rise to designerly approaches, encouraging human-computer interaction researchers to actively engage in design practices, exploring digital artifacts within real-world contexts [15]. Through this practical process, they gain new insights into domain use cases and design perspectives that go beyond mere functionality and utility. To bridge the gap and disseminate the knowledge acquired through the design of such artifacts, several proposals have been introduced to document the findings [6, 13]. One promising approach is the use of annotated portfolios [1, 4], which effectively captures the knowledge gained from the design of artifacts.

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This paper introduces annotated portfolios designed for digital platforms that cater to human senses - vision and hearing. These portfolios incorporate insights from two distinct disciplines to develop a structured annotation method. One discipline is the "sociomateriality" approach, which examines the interactions between humans and non-human on an equal level [11, 12]. Another discipline is the "four pleasures" approach, which goes beyond a rationalist perspective to design the non-functional pleasurable aspects of digital artifacts [7]. After providing the background of our approach, we present the annotations and explain how these two disciplines contribute to their specification. Furthermore, we share early experiences with these annotations in analyzing the platforms. These experiences demonstrate how the approach effectively highlights the platforms' essential properties, allowing for the identification and exploration of potential opportunities for their future refinements.

As modern digital platforms for smart space services become increasingly complex, it is crucial to understand their basic features and to refine and incorporate new requirements for the future. The abstract descriptive power of the annotations represented by the annotated portfolio method has proven promising for analyzing digital platforms and investigating a variety of complex issues among stakeholders with diverse expertise. These annotations are a powerful means to shed light on the complex interrelationships and requirements of digital platforms. As platforms evolve, new features and requirements are likely to be added. The annotations allow for a clear understanding of these requirements and the ability to effectively manage the evolution of the platform. The annotations can also be a useful tool when stakeholders with different expertise collaboratively explore a platform. The power of their abstract description enables the integration of the different perspectives of experts and users to gain insights into the operation and improvement of the platform. Furthermore, the annotations are important not only for analyzing the platform, but also for refining and incorporating new requirements for the future. As new technologies and usage scenarios may emerge, a flexible and sophisticated approach to the fundamental characteristics of the platform is required. The annotations allow new requirements to be understood quickly and appropriate improvements to be implemented. The abstract descriptive power of the annotations can be a very useful tool in understanding and improving digital platforms. Proactive use of the annotations in investigating complex issues and incorporating new requirements will contribute to the development of future smart space services. By leveraging the potential of the annotated portfolio method, we can ensure that digital platforms continue to evolve and meet the changing needs of users and stakeholders in the smart space environment.

2 Annotated Portfolio, Sociomateriality and Pleasures

Gaver and Bowers developed the annotated portfolio as a method to express novel knowledge acquired from research-oriented design practices [4]. This approach serves as a means to uncover the similarities and distinctions within a collection of artifacts [1]. Originally, the concept of this method involved selecting a set of artifacts, identifying suitable representations, and combining these representations with concise textual and pictorial annotations. Ultimately, the annotated portfolio serves as a methodology for publicly communicating extracted insights and knowledge.

The annotated portfolio method has been the subject of several previous studies [2, 5]. In [2], the authors extended the original concept of the annotated portfolio method to encompass designs for new domains. Another study demonstrated this extension by creating an annotated portfolio of Research through Design artifacts inquiries, specifically from the postphenomenological perspective [5], where Research through Design is a discipline that expands design practices and processes to generate new knowledge [15]. Design Exposès [3] employs an annotated portfolio method to extract knowledge. In the approach, a deliberate decision was made to omit the specified "value" layer in the reflection part. The primary emphasis of Design Exposès is on the "utility" aspect of the object, rather than assessing the specific value of the object.

Sociomateriality explores the interconnectedness of technology and society, seeking to comprehend how the social and material aspects are inextricably intertwined in everyday life. This perspective often employs the term "material" instead of "nonhuman" to refer to the tangible elements of this entanglement. It has emerged from various perspectives and discussions about technology, technology-in-use, and sociomateriality, all of which have contributed to its foundation [12, 14]. Sociomateriality is a perspective that emphasizes concrete practices integrating materiality with institutions, norms, discourse, culture, and other social phenomena. This approach is invaluable in understanding how nonhuman elements influence human attitudes and behaviors by focusing on the relationship between humans and technology. By exploring the interaction of human and nonhuman elements, sociomateriality allows for a deeper understanding of the complex interactions between humans and technology. This perspective is particularly relevant in today's technologically advanced world, where the influence of technology on human behavior and society is ever-increasing. Through sociomateriality, we gain insights into the intricate dynamics that shape human-technology relationships and how these interactions impact various aspects of our lives.

The pleasure that users derive from using goods and services is often based on the perceived benefits they provide. However, there is a need for a new approach to designing products and services from a deeper perspective than mere functional efficiency and ease of use. To provide such a perspective, Jordan introduces a framework that encompasses four types of pleasures that should be considered in the design of goods and services [7]. These pleasure categories are physio-pleasures, socio-pleasures, psych-pleasures, and ideo-pleasures. Physio-pleasure is derived from bodily sensations, including tactile and olfactory experiences related to goods and services. As socio-pleasure, enjoyment arises from social interactions and the status or identity that goods and services confer in social situations. Psycho-pleasure is of a mental nature, encompassing cognitive and emotional responses to goods and services. Finally, in ideo-pleasure, involves pleasure rooted in collective values, where goods and services reflect personal values, such as environmental consciousness or sustainable living. Each of these pleasure categories represents a unique and conceptual aspect of the user experience, providing a multifaceted pleasure that is not merely functional. Incorporating these pleasure elements in the design of products and services has the potential to create a more satisfying user experience.

3 Using Annotated Portfolio for Analyzing Digital Platforms for Sharing Human Seeing and Hearing

3.1 CollectiveEyes and CollectiveEars

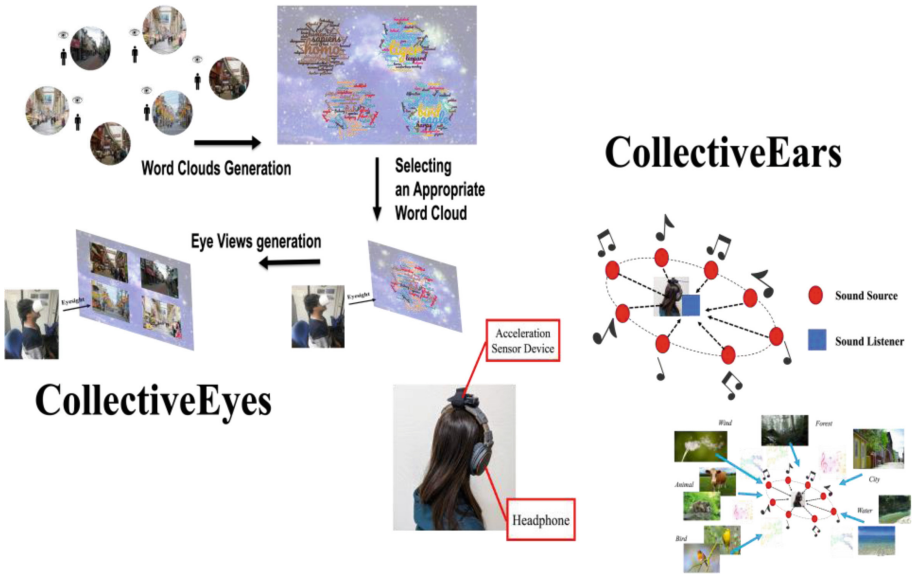

Fig. 1. CollectiveEyes and CollectiveEars

The digital platforms, CollectiveEyes and CollectiveEars, are centered around the collaborative sharing of specific human physical body parts, namely, eyes and ears, as depicted in Fig. 1.

CollectiveEyes [8] is a platform designed to capture and share collective human eyesight. The platform assumes that a user is equipped with a wearable display device, typically wearable glasses which equip cameras and microphones, allowing them to capture what they see and hear at any time and location. It enabling users to offer the ability to share some aspects of their visual perception with others. As wearable technology advances, the concept of virtually renting out body parts may become a reality. The CollectiveEyes platform uses a head-mounted display with a built-in camera and microphone positioned in front of it. Users can switch their own eyesight to view the current eyesight of others through their head-mounted displays. Additionally, they can view multiple users' eyesights simultaneously in a 3D virtual space, projecting them onto their HMDs. The platform facilitates searching for specific eyesights based on keywords and locations.

CollectiveEars is a digital platform designed to facilitate the sharing of a diverse collection of audio experiences, allowing users to listen to what others are currently hearing, thereby enriching their imagination of the world around them [9]. In the fast-paced and

stressful modern urban life, we often overlook various essential aspects that contribute to our well-being, such as connecting with nature or envisioning future possibilities. By capturing and sharing various sounds from around the world, CollectiveEars opens up new opportunities for us to appreciate the diversity of our world and expand our chances to experience it more fully. CollectiveEars gathers sounds heard by people worldwide, which users can then listen to. These sounds are positioned in a 3D sound space around the user and presented simultaneously. To interact with the platform, users can employ a novel method called "theme channels". This interaction technique allows users to select multiple sounds from the database, much like changing TV channels, using head gestures. Additionally, CollectiveEars implements a sound focusing function, enabling users to hear sounds more clearly by tilting their heads in the direction of interest.

3.2 Annotation Process

Developing digital platforms like CollectiveEyes and CollectiveEars comes with the challenge that their specific requirements and potential opportunities might not be clear until they are designed. As a result, an iterative approach involving designing, prototyping, and evaluating these platforms is crucial for refining or specializing them. However, traditional methods for developing and evaluating prototypes can be costly. To address these challenges, there is a need for a more efficient tool that can quickly reveal the possibilities and challenges of these platforms in a simple and cost-effective manner. As a solution, we proposed a novel annotation strategy to create annotation portfolios, which can effectively exploit and unveil the untapped opportunities of digital platforms. This annotation method offers visually structured annotations, facilitating the identification of diverse unexplored design aspects. The annotated portfolio serves to broaden the participants' perspectives in a participatory design process. To explore the abstract qualitative features of digital platforms, our annotation strategy for creating the annotated portfolio adopts two perspectives, one is representing the human aspect and the other is the nonhuman or material aspect of these platforms. By employing these two aspects also from the utilitarian perspective, we aim to gain deeper insights into the possibilities and challenges posed by these innovative digital platforms.

The first step in the process involves sociomateriality [12, 14], which prompts us to consider both human and nonhuman aspects. In this approach, we classify annotations into two categories: domain annotations and interaction annotations. The domain annotations, labeled as "Domain", encompass a set of fundamental items aimed at identifying domain use cases and defining the target goals of the platforms. On the other hand, the interaction annotations, labeled as "Interaction", consist of a set of basic items that describe the interaction methods the platforms offer to engage with users. An essential contribution of our strategy is explicitly introducing both perspectives, human and non-human, in our structural annotation approach. By doing so, we can effectively capture and highlight the interconnectedness between these perspectives, leading to a comprehensive understanding of the digital platforms' potential and capabilities.

In our annotation method, in the second step of the process, we also adopt the four pleasures to exploit the non-utilitarian perspective as described in Sect. 2. For our digital platforms, it is crucial to describe abstract values from both human and nonhuman visual and auditory perspectives. By investigating the potential values offered by digital

platforms based on the domain and interaction annotations, we can categorize them into the four pleasures and present them as annotations, referred to as the pleasure annotation.

The pleasure annotation is divided into two categories. One is the material side and the other is the human side. In Fig. 2 and Fig. 3, the left parts in the annotations represent the pleasure annotations on the material side, located below the interaction annotation. Conversely, the right parts of the annotations display the pleasure annotations on the human side, positioned under the domain annotation. To enhance visual clarity, material side annotations are emphasized in the red color, and human side annotations are denoted in the green color. Additionally, specific pleasure annotations are assigned distinct colors' texts, facilitating quick and easy identification.

3.3 Using Annotations for Demonstrating the Analysis of Digital Platforms for Sharing Human Seeing and Hearing

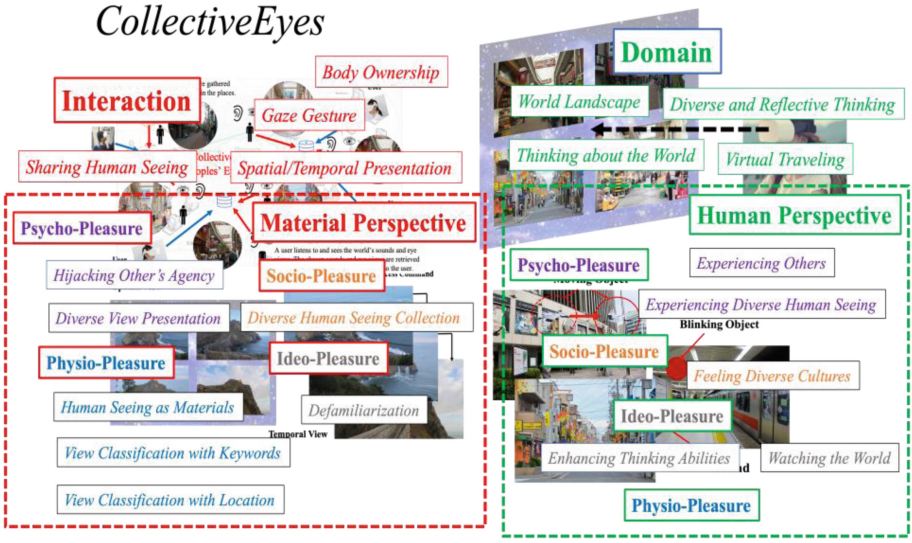

Fig. 2. Annotations for CollectiveEyes

Figure 2 illustrates the annotations for CollectiveEyes, while Fig. 3 displays the annotations for CollectiveEars. The pleasure annotation on the material side reveals the essential features offered by each platform. In the material perspective, psycho-pleasure represents the platform's features that cater to individual users. For instance, in CollectiveEyes, the feature "Diverse View Presentation" enables the presentation of multiple eye sights in a virtual space. On the other hand, socio-pleasure in the material perspective represents features related to multiple users. For example, in CollectiveEyes, the feature "Diverse Human Seeing Collection" allows the collection of people's current eye sights. Ideo-pleasure in the material perspective encompasses features that resonate with the collective users of the platforms. For example, in CollectiveEyes, the property

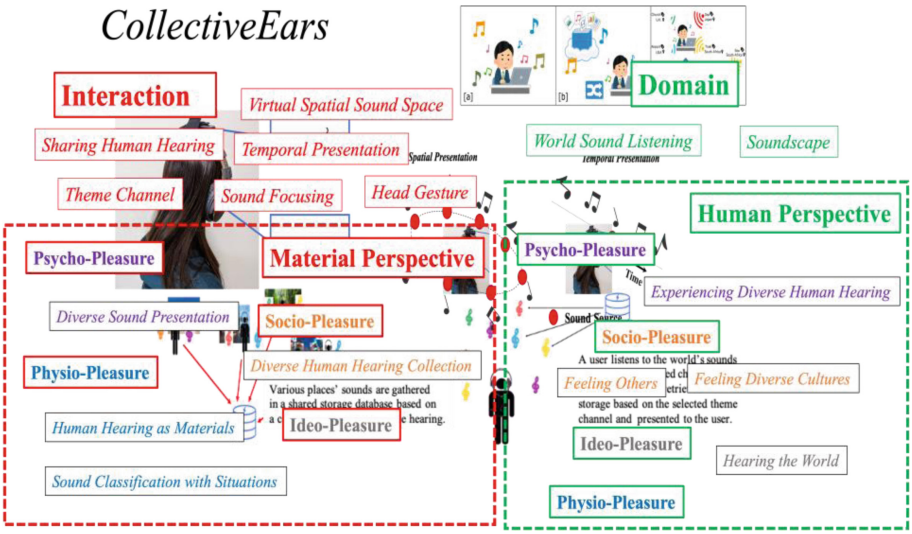

Fig. 3. Annotations for CollectiveEars

of "Defamiliarization" empowers all users [8]. Lastly, physio-pleasure in the material perspective represents the core abstract objects offered by the platforms. For instance, in CollectiveEyes, the feature "View Classification with Location" enables users to select eye sights presented in a virtual space simultaneously.

The pleasure annotation on the human side reflects the user experience provided by the platforms. Psycho-pleasure in the human perspective represents the individual user's experience. For example, in CollectiveEars, "Experiencing Diverse Human Hearing" signifies that the platform offers a wide range of human auditory experiences captured from various locations worldwide. Socio-pleasure in the human perspective represents the social user experience. For instance, in both platforms, "Feeling Diverse Culture" indicates that the platforms enable users to immerse themselves in diverse cultural atmospheres worldwide through human visual and auditory perspectives. Ideo-pleasure in the human perspective pertains to the collective user experience within the platforms [8]. For example, in CollectiveEyes, the annotation "Enhancing Thinking Abilities" signifies the platform's ability to encourage users to think critically by comparing multiple human visual perspectives. Physio-pleasure in the human perspective represents a user's physical experience. Currently, there are no items in this category in the annotations. However, the absence of items in this category presents new opportunities to explore potential physical experiences for users within the platforms.

3.4 Four Takeaways

Based on the annotations presented in Fig. 2 and Fig. 3, there following four key points that deserve attention to showcase the merits we discovered during the creation of these annotations. This highlights the effectiveness of our annotation strategy in revealing the potential opportunities and challenges of CollectiveEyes and CollectiveEars. The

current investigation of the annotations is still ad-hoc, and we need to explore new ways to extract more opportunities in a more systematic manner.

1) The four pleasures framework provides an opportunity to explore concealed aspects in our design process. For instance, during the first development of the platforms, we may not have placed strong emphasis on socio-pleasures. Our study's discovery prompted us to recognize the importance of exploiting socio-pleasures. We realized that incorporating collective visual and auditory perspectives could create new opportunities. When users feel that others also share the same visual or auditory experiences, a sense of closeness and connection is fostered. This aspect highlights the potential for enhancing the social experience within the platforms.
2) It is instructive to compare annotations across platforms. For example, CollectiveEyes prioritized the "Experiencing Others" annotation, which aims to provide users with a sense of becoming other through design. Conversely, CollectiveEars did not firstly focus on this particular annotation. While considering the annotation, we thought that it might be difficult to achieve the "Experiencing Others" annotation in CollectiveEars. As a result, however, we discovered the possibility of "Feeling Others" annotation, a newly discovered opportunity in the CollectiveEars design process that opens up new possibilities for improving the user experience.
3) The limited number of domain annotations for CollectiveEars suggests that during the platform's design phase, several domain use cases were initially considered. However, after the creation of CollectiveEyes, the designers became intrigued by the concept of collectively sharing human hearing experiences with a group of people. As a result, CollectiveEars was developed by extracting interaction methods and creating scenarios in various situations [9]. The fact that only a few items are included in the domain annotation highlights the opportunity to explore and find more fun in order to discover new domain use cases for CollectiveEars. Therefore, our focus was specifically on video pleasure to uncover new possibilities. The insights obtained from this study were integrated into the refined design of Artful CollectiveEars, where its aims ate to provide an artistic sound presentation [10].
4) Currently, the annotations do not include physio-pleasure from a human perspective. This is because both CollectiveEyes and CollectiveEars do not manipulate human's physical eyes and ears, and eliminate the need for physical movement to access others' current visual and auditory experiences. However, integrating physio-pleasure presents a promising opportunity to enhance human well-being. People's physical movement is an essential aspect to achieve a happy society, and providing location information of others' current visual and auditory perspectives might encourage users to explore what others are experiencing, especially when the locations are relatively close. These findings indicate that annotations can play a vital role in recognizing new opportunities to foster richer user experiences.

4 Conclusions

Our approach emphasizes the importance of adopting a hedonic perspective to effectively explore potential opportunities for digital platforms. While traditional approaches focus on the human experience through human-centered design, which is valuable for

developing improved digital platforms, they may not fully capture the impact of each aspect within the platform on the overall user experience. In contrast, our platforms, CollectiveEyes and CollectiveEars, provide a diverse range of user experiences, which in turn, enhances human thinking skills and opens up new opportunities. Throughout the process of creating annotations for both CollectiveEyes and CollectiveEars, we recognized the significance of the hedonic perspective that these digital platforms offer, considering both human and non-human perspectives. This understanding has unveiled novel opportunities and possibilities within these digital platforms. By embracing this hedonic perspective, we can better leverage the material aspect of human visual and auditory experiences to extract new opportunities and enhance the overall potential of these platforms.

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IoT Security and Privacy Challenges from the Developer Perspective

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Abstract. Internet of things (IoT) is a highly-demand technological sector that can be applied to most of our life aspects, such as home, work, transportation, health, education and other important areas. At the same time, its heterogeneous nature, dynamism, intelligence, and mobility makes it vulnerable and unsafe in terms of security and privacy. Finding complete answers to the existing security and privacy concerns is a very challenging task for security experts due to the variety of platforms where the IoT is available. This paper demonstrates the major and critical challenges that facing developers through their journey of building and developing solutions for IoT-based systems (IoTSs). Developers are among the key players who directly engage with the IoTSs, along with manufacturers and users. Consequently, the goal of our study is to shed light on the main difficulties that developers have while attempting to manage the aspects related to security and privacy when they create and develop an IoTS.

Keywords: Internet of Things (IoT) · Security · Privacy · Developers

1 Introduction

The Internet of Things (IoT) is vying to become one of the information and communications technology (ICT) landscape's most prominent paradigms. The concept of integrating computing and communication capabilities into everyday objects or *things* encourages the creation of a wide range of solutions that might be applied in different scenarios like healthcare, smart homes, transportation systems, agriculture, industry, and tourism, to name only a few of them [1, 2]. Those great examples of IoT benefited from the latest advancements in technology, which offered a smart and intelligent sensor network to be used for collecting and transmitting data constantly over the internet for further analysis [3, 4].

Furthermore, IoT has profoundly revolutionized how information technology and communication environment operate [1]. However, it is still a developing and increasing paradigm. A recent research in privacy and security reveals there is limited unification

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and integration of security and privacy into IoT, which may hinder user acceptance of the technology, due to concerns about the exposure of personal data [1].

Moreover, according to other study [5], security is among the most important problems and concerns in the IoT ecosystem that must be addressed and should be given top attention for many present and future IoT applications. Furthermore, enforcing security regulations and creating proper security standards for IoT have become not only a crucial issue but also a responsibility, given that main elements of the IoT network are essentially resource-constrained devices it terms of computation, power, memory, and bandwidth. Unfortunately, there is not an exhaustive list of specifications for an IoT security architecture that fully meets every demand of an IoT system [6, 7], making it extremely difficult to implement IoT applications and services in a safe, reliable, and scalable manner [8].

Additionally, other important factors including high performance, low power consumption, resistance to assaults, tampering with the data, and end-to-end security are used and considered to design and create security and privacy strategies for IoTSs [3].

Studying and investigating security and privacy challenges, difficulties and pain points of developing a safe IoTS can be done from different angles or viewpoints corresponding to different types of actors: (i) IoT device manufacturer; (ii) IoTS users; and (iii) IoTS developers. This study is mainly focusing on the developers' perspective. As a result, we will summarize the main challenges related to IoT privacy and security facing by IoTS developers, highlighting some of the top skills the developers should have, and the countermeasures for the attacks.

The rest of this paper is structured as follows: Sect. 2 briefly sketches out the background of the topic addressed. Section 3 talks about IoTS developers and the required skills for them. Section 4 presents our proposal and recommendations extracted from the analysis carried out. Finally, Sect. 5 outlines the conclusions and future work.

2 Background

Despite the spread of IoTSs across a range of industries, from embedded systems to smart homes, there has not been a thorough research to comprehend IoTS development issues from the point of view of developers [9, 10]. For that reason, many scholars started to study how to tackle with security and privacy concerns during the development of IoTSs. For instance, Macedo et al. [11] emphasized how crucial it is to follow a security by design approach to protect an IoTS. They also focused on having a holistic security approach in order to safeguard IoT building blocks. Moreover, they found that there is not a clear architecture that considers security and privacy while developing IoTS security solutions. Another important work has been done by Javed et al. [5], who examined applications of IoTSs, their potential in the future, and their biggest obstacles, to provide designers and developers with design considerations that will result in security by default. That study concludes that IoTS embedded security can increase the effectiveness of the security mechanisms and make control transparent to the end user. Moreover, embedded security offers increased performance, dependability, and cost.

Other scholars stressed on following the security by design approach for the development of IoTSs, such as Corno et al. [12], who firmly think that it is the greatest method

to increase the reliability of every software system. Moreover, they stated that fundamental security concepts must be in the thoughts of programmers from the start of the development cycle. Consequently, the demand for more skilled and knowledgeable IoTS developer will be increased.

Sequeiros et al. [13] talked about the absence of succinct techniques that developers may use to address key security vulnerabilities. Besides, there is no integration between different solutions and approaches that used to solve some security vulnerabilities.

For those reasons, our study intends to discuss security and privacy challenges and difficulties to be addressed in IoTSs, as well as skills required for developers building quality IoTSs.

3 Existing Techniques to Achieve Security and Privacy in IoTSs

Nowadays, an increasing number of IoTSs are being created and put into operation on open networks, without implementing proper security. A tiny user research indicated that inexperienced IoT programmers in particular had a tendency to ignore security risks [14]. For example, Arduino, due to its open-source design and user-friendly interface, it is now widely used by hobbyists and inexperienced programmers, particularly to develop IoTSs.

As many developers begin working on IoT platforms without having a thorough understanding of the most important security concepts in ICTs, there is a huge propagation of insecure IoT devices. As a result, IoT applications used at the open networks, which are frequently publicly accessible on GitHub (or other code-sharing sites), can be downloaded and used by novice users as well as other developers, spreading these vulnerabilities to other projects [15].

Programming Skills. Developer skills needed to design and implement IoTSs ranging from standard programming skills, like any other software developer, to the advanced and broad skills in different areas of IoTS development. Corneliu et al. [16] discovered that most application developers have had training in either web development or mobile development. Some of those developers tend to believe that their expertise would be immediately transferable to IoTS development [16]. This is not actually the case, since there are a number of very specific features of IoTSs that are usually not addressed when developing a mobile or web system. Along with being embedded, IoT devices and gateways also have highly distributed architectures, which have unique needs. Therefore, developers need training and expertise not only in web and mobile software development, but also in other important areas of software development, including embedded and cloud systems, in order to create safe and secure IoTSs. Moreover, distributed programming abilities are essential due to the ubiquitous nature of IoT devices [16].

Robust Cloud-Based Systems. Some researchers considered that appropriately using cloud-based IoT platforms, such as Amazon Web Services (AWS), should increase robustness and provide easier to implement, maintain and deploy back ends. But, even while such a platform could be secure on its own [17], inexperienced developers might have neglected to close some security holes that could be exploited by unauthorized users [12]. Therefore, in their opinion, the greatest technique to increase the dependability of