



## **SPWID 2022**

The Eighth International Conference on Smart Portable, Wearable, Implantable  
and Disability-oriented Devices and Systems

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**SPWID 2022 Editors**

Pascal Lorenz, University of Haute Alsace, France

# SPWID 2022

## Forward

The Eighth International Conference on Smart Portable, Wearable, Implantable and Disability-oriented Devices and Systems (SPWID 2022), held between June 26<sup>th</sup> and June 30<sup>th</sup>, 2022, continued a series of events dealing with specialized implantable, wearable, near-body or mobile devices, including artificial organs, body-driven technologies, and assistive services.

Mobile communications played by the proliferation of smartphones and practical aspects of designing such systems and developing specific applications raise particular challenges for a successful acceptance and deployment.

We take here the opportunity to warmly thank all the members of the SPWID 2022 technical program committee, as well as all the reviewers. The creation of such a high-quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and effort to contribute to SPWID 2022. We truly believe that, thanks to all these efforts, the final conference program consisted of top-quality contributions. We also thank the members of the SPWID 2022 organizing committee for their help in handling the logistics of this event.

We hope that SPWID 2022 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of Smart Portable, Wearable, Implantable and Disability-oriented Devices and Systems.

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# Exploring Smart Watch Ecosystem Value Co-creation Experience: A Qualitative Case Study

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**Abstract**—Internet of Things (IoT) is a technology paradigm comprising physical objects such as smart watches embedded with sensors, software, and networking technologies that are used to connect and exchange data with other devices such as smart phones and systems over the Internet. Smart watches and other wearables are emerging at a rapid speed, and they have engaged the users in redefining their interaction with mobile and pervasive technologies by creating an ecosystem of relevant devices. This research work focused on the issue of value co-creation and better understanding of smart watch consumer’s adoption and appropriation process which can highlight the factors motivating or demotivating the consumers to use the smart watches to achieve different objectives. Through a qualitative research method, empirical data was collected by observation, written questionnaire, and interviews. Using a thematic analysis scheme, the following four themes were generated from the collected data: (1) Getting motivated and maintaining motivation, (2) Usefulness – value-in-use and value-in context, (3) Technical issues with smart watch resources, and (4) Information security and privacy concerns about smart technologies.

**Keywords**- Internet of Things; smart watch; ecosystem; value co-creation; service dominant logic.

## I. INTRODUCTION

The Internet of Things (IoT) is envisioned as a huge global network of machines and smart devices capable of interacting with each other, with an overall purpose of enabling human-centric pervasive application development to facilitate people’s daily lives [1]-[4]. Diverse and powerful embedded sensors make a ubiquitous platform to acquire and analyze data in order to monitor human activities for health and wellness, for activity recognition and tracking, as well as to provide a safe environment for the users [1]-[3].

These IoT devices, such as smart watches and other wearables, are emerging at a rapid speed and they have engaged the users in redefining their interaction with mobile and pervasive technologies by creating an ecosystem of relevant devices [5][6]. Researchers believe that in this era of IoT the inter-networking of physical devices such as smart watches and smart phones, enables these objects to collect and exchange data over the Internet to accomplish different objectives including real time continuous monitoring of physical activity and physiological measures[7][8].

Apple, Xiaomi, Samsung and Fitbit are leading the wearable device industry with Apple holding 34.1 percent, the highest market share of wearable device unit shipments worldwide until 2020 [9]. Fashion accessories, smart watches, fitness trackers, gaming devices, and navigation tools are among different types of wearable devices. Smart watches are one of the most popular wearables categories globally and are expected to reach shipments of more than a quarter of a billion units by 2025, currently, with the Apple watch installed base reaching over 100 million users worldwide in 2020 [10].

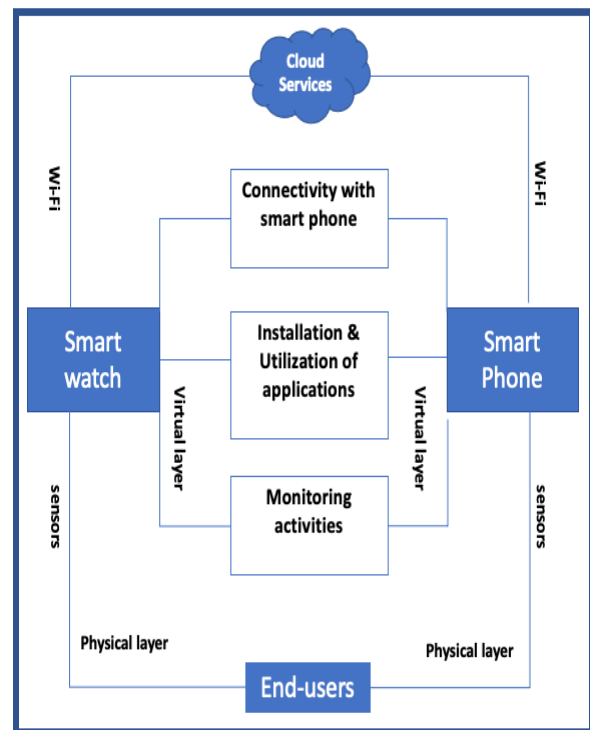


Figure 1. Smart Watch Ecosystem

Figure 1 above shows the smart watch ecosystem consisting of end-users, a smart watch, and a smart phone. The devices in the physical layer of this ecosystem are embedded with electronics, software, sensors, actuators, and network connectivity. The users need to connect the smart watch with the smart phone using Bluetooth connection. It is

recommended that the phone should have the updated software for better connectivity and experience. Once both devices are synchronized, the users can receive notifications from smartphone, receive phone calls, read emails and messages, and view their calendar appointments. Additionally, users can also install third party applications such as the popular chatting application WhatsApp. A smart watch helps users to monitor and measure their daily activities, including sleep patterns, exercise routines, number of steps during walk, as well as calorie burned during both indoor and outdoor workouts.

It is considered that “smart watches have the potential to support health in everyday living by: enabling self-monitoring of personal activity; obtaining feedback based on activity measures; allowing for in-situ surveys to identify patterns of behavior; and supporting bi-directional communication with health care providers and family members” [8]. However, there is still a lack of studies on the social, behavioral, economic, and managerial aspects of the IoT applications in different areas [6]. There is still a need for investigation about factors that determine the customer acceptance including customer perception of IoT and wearable technology [7][11]-[13]. Researchers argue that considering the recent development of IoT [6], there are still very few studies to address the specific characteristics that enhance the confirmation, satisfaction, and continued use of the smart watch [14]. This research work focuses on the question: how do different users interact with the smart watch ecosystem to participate in the value co-creation process through their expectations, skills, and abilities? Hence, this research work attempted to bring insights into the adoption, value co-creation and appropriation process of a wearable device, through a qualitative study on smart watches. This research work focuses on the better understanding of smart watch consumers' adoption and appropriation process which can highlight the factors motivating or demotivating the consumers to use the smart watches for different activities /objectives. Consequently, the results can be useful for the smart watch or other wearable users and developers to understand their consumer's needs and experiences.

Service science can be used as a conceptual framework to study the dynamics of systems, where human actors co-create value, when they collaborate and interact with innovative technology, this process is called value-in-use [15]-[17]. Service providers make value propositions by offering access to service, i.e., wearable devices and systems, but they cannot define how individual users perceive the value of the service [18]. It is also important to acknowledge that each user's value creation process and its outcomes depend on both the user's needs and condition, as well as the current circumstances. This is referred to as value-in-context [18].

The rest of the article is arranged as follows: Section II describes the method. Section III describes the results. Section IV presents the discussion of results and ends the article with further research suggestions.

## II. METHOD

This research work adopted a qualitative research method. We selected the sample users belonging to different professional / educational backgrounds to gather responses from a wider audience. Table 1 shows the details of data collection.

TABLE I. PARTICIPANTS OVERVIEW

Respondents	User groups/Profession	Experience
3	MSc students	Novice
3	Local Gym participants	Novice
2	Police department / trainee students	Novice
1	Professor	Novice
1	PhD student	Novice
1	Under-graduate student	Novice
1	Associate professor	Novice
1	IT Technician	Expert
1	Associate Professor	Expert
1	PhD Student	Expert

Purposeful sampling was required to select project participants who own an iPhone since the Apple smart watch is only compatible with an iPhone. Another salient feature was that the participant must be technology literate to understand and operate both devices successfully without any tutorial provided. Two types of participants were targeted based on their experience with smart watch. The first type that are called 'novices' consisted of users who own a smart phone, they have a desire to use the smart watch, but they did not yet experience any smart watch. This research work gives us the opportunity to explore the value co-creation process of the novice users, their expectations from the smart watch, their user experience, transformation of their thought process after the practical experience of smart watch usage, and consumer-device interaction. The second group of participants consisted of three experts who already use the Apple smart watch regularly. Their input was important to understand the factors motivating them to adopt and continue using their smart watch.

We could manage to buy five Apple smart watches of series 5 with the available budget. The watches were ordered and received before June 2020. Due to the coronavirus pandemic, it was a bit challenging to recruit the required sample participants. The data collection activity for smart watch adoption and use spanned between August 2020 and January 2022. Every participant used the watch for minimum two weeks. The participants were informed that they can use the smart watch as they wish. We did not bind them to



anything specific to make sure that the participants were not influenced in any way. The freedom to let the participants choose when and how they want to use the smart watch was also important to keep them motivated and engaged during the entire test period.

We had the chance to observe some of the users after their permission in their natural settings. This observation was conducted in the gym. A written questionnaire was prepared for the evaluation of the Apple smart watch by participating users. All the users' consents were obtained by informing them that the data will be used solely for research purposes keeping the participant's identity confidential. The questionnaire (see Appendix) included 5 sections based on the Likert scale around topics of motivation and comfort for using a smart watch, value creation, some usability heuristics including perceived service and system quality, user satisfaction, and perceived smart watch performance. In addition to that, the participants were asked to write answers on questions pertaining to the overall experience of using an Apple smart watch during this project under ongoing pandemic conditions for minimum two weeks' time. Short interviews based on open ended questions were also held with the participants ranging between 15-20 minutes each. As the number of participants was small, all collected data, questionnaire answers, interview transcripts and observation notes, were considered as textual data and analyzed using qualitative methods.

Lichtman's thematic analysis [19] technique was used to analyze the findings. This qualitative analysis technique is composed of systematic identification, organization and understanding of repetitive patterns within the textual data, through successive construction of codes, categories and themes (concepts) [19][20]. This approach was mainly inductive, as the themes were generated based on the collected data. Moreover, the analysis was semantic and descriptive, i.e. the result was a descriptive summary of the explicit content of the data [14].

### III. RESULTS

The following four themes were generated from the data collected from the participants: (1) Getting motivated and maintaining motivation, (2) Usefulness – value-in-use and value-in context, (3) Technical issues with smart watch resources, and (4) Information security and privacy concerns about smart technologies. In the following section, the empirical findings are presented under each theme.

#### A. Getting motivated and maintaining motivation

For the novice users, it was quite easy to initially get motivated; they were very excited to use the smart watch since they did not own and have never used one before this project. The majority of the participants agreed that the setup was easy, whereas three participants needed help to complete the setup and pair the watch successfully with their smartphone.

Maintaining long-term motivation was possible for the majority of the participants. They agreed that they do not face any problems using smart watch applications and they were able to integrate smart watch easily in their daily routine habits. However, a couple of participants mentioned during

the interview that they lost their motivation to use the smart watch after the first week because of various factors, which included the charging of the watch, feeling the watch is an accessory rather than a complete communication device in the presence of a smart phone, and using it rarely, only during walks or exercise.

One participant mentioned that the overall experience of using the watch has been great but also mentioned that "I use and carry my phone with me everywhere I go. Therefore, these two weeks with the smart watch have not changed my life tremendously". A few participants noticed a change in habits such as checking the phone again and again for notifications, messages. Another participant felt more comfortable with the smart watch and wrote "Seamless experience of using the ecosystem of Apple Smart watch, iPhone and Mac book which makes the sharing of data, application resources easy and user friendly".

It was also interesting to note that the majority of the participants did not agree that the smart watch has supported their memory or helped them to enhance their cognitive capabilities. Only two participants agreed that they got the memory support in some form.

#### B. Usefulness – value-in-use and value-in-context

The majority of participants felt that the use of the smart watch added value to their smart devices experience to achieve certain objectives." I found the device very useful for me and I got used to using a lot of its functions for these two weeks. That device can upgrade my daily routine with a way more immersive experience, and I enjoyed it so far. It is not cheap, but it is a high-quality and hi-tech device for sure. The durability and materials are good enough though."

Several appreciated features were related to health and wellness, and especially in relation to activity recognition and tracking. Many of the participants mentioned that they used the smart watch during exercise and other health related activities, and six of the participants agreed that the smart watch supported their health and well-being. For instance, one of the participants wrote that "While training, I was able to monitor my heart rate (beats per minute) and then every training goes to training diary, with the information of length, calories, average Beats Per Minute (BPM), type of training. I also noticed that the watch was able to monitor my activity and suggest that I am training – it happened twice, while I was riding my bike to the city center and when I was walking fast outdoor around the lake. These functions made my usual sports activities way more immersive – I do like to monitor my status and create a sports statistics journal". One of the expert users wrote "Regarding health support from a more medical perspective, I think the Heart Rate (HR), Heart Rate Variability (HRV) and blood oxygen levels can be very useful; these data can support the users in detecting changes or deciding when they need to seek health care."

Special usefulness was experienced during the pandemic: "It can be recommended for people of different age since it has both entertainment and health functions (also, it can make emergency calls for the elderly people). Especially now, in the time of the pandemic, a lot of that contact-less and health functions can help us to stay healthy!". One of the expert users

mentioned during interview that “I am quite happy with this watch because it reminds me to be more active specially during this pandemic when you are sitting at home. I usually get stuck in front of the computer and watch reminds me to stand up.” Another of the expert users told during interview “I have bought this watch for measuring blood oxygen level. In the beginning, I was afraid of getting covid, so I felt more safe when I had the smart watch as it was measuring my blood oxygen level since it is a very early sign that your blood oxygen level goes down so this was the reason I upgraded to the latest version of the watch”.

Although the question regarding an award system was ignored by the majority of the participants, two expert users mentioned that the award system can motivate people to achieve something extra. “I also think that, last year, when the pandemic was there, I had a monthly challenge with myself. If I fill up the ring, I can get this reward. I had this new year resolution to fill all the goals I setup on my watch. This was something that challenged me just to get some fun out of it and hopefully that could have made my isolation less boring and hopefully effect my health.”

Some other important functions within the smart watch such as sleep care system, Pay Pass, breath and mediate, wash your hands etc., were also appreciated by users, for instance, “Secondly, I really like the sleep care system. I set up the time when I want devices to shut down and notify me to go to sleep. Both phone and watches started night mode automatically and notify me to go to bed. In the morning, the watch starts the alarm with the haptic vibration and light sound – I am sure that it was the best experience for me because I do not like loud noisy alarms”. Another user commented “Functions like “Take a breath and meditate”, “Stand up for a minute every hour” and “Wash your hands thoroughly” are cool and caught my attention for that simple, but important routine. Also, my lovely Pay Pass function”. Setting up the Apple pay on the smart watch application makes it easy for the user to pay without the need of an iPhone in hand.

Also, some shortcomings were identified during the test period. One expert user wrote that “The HR measure is valuable for detecting stress, and I’ve been a bit more attentive to changes in my health, etc. Now, I also have data on HRV, but I would like to be able to filter between sedentary HRV and HRV during physical activity. I see some spikes, but I can’t interpret them. This measurement should vary a lot depending on what you do, so a mean value is useless”.

#### C. Technical issues with Smart watch resources

It is possible for a person to receive Short Message Service (SMS), Multimedia Messaging Service (MMS), or push notifications from third-party applications on the cellular Apple smart watch without having their phone with them, however, the paired iPhone must be switched on and connected to a Wi-Fi or cellular network. Health related applications, such as Electrocardiogram (ECG) application, is considered useful by some participants. A participant mentioned during the interview that he could not use the ECG app because “there was a problem with the software update, and it took quite long time”. In general, users are advised to keep software updated to use such applications appropriately.

However, according to Apple, the ECG app is not available in some countries. One participant mentioned “Apple makes you choose their smart watches to be able to use an eco-system of your devices but there were some restrictions due to law policy in Russia, that is why ECG, and some health functions were disabled in my home country”.

One of the expert users wrote “Not really technical issues, but low reliability in the tracking features and a lot of design issues. It seems to have a low sensitivity regarding exercise, and a low specificity regarding physical activity”.

#### D. Information security and privacy concerns about smart technologies

This theme emerged as part of the data collection activities. Generally, some participants felt comfortable using the smart watch and considered the information security and privacy issues like their iPhone. One of the expert users mentioned “I use Apple’s stuff and they are famous for their privacy policy and things are locally stored. I am not sure about the security and privacy policies of different apps, if I download other health apps and give them access to the data I collect from the watch.” Another expert said during the interview “I trust the information from Apple that they use the data from the smart watch for internal purposes and do not share it with other companies. I think they use it for their own purpose. I have accepted to share my data with Apple”.

The researchers noticed that many young participants in the project have shown their information security and privacy concerns regarding the use of the smart watch. For instance, a group discussion with participants from a local gym, together with the contact person at the gym (facilitator for recruitment of participants) revealed that at least 3 young people ranging between the ages 20-25 refused to use the smart watch due to privacy concerns. They thought their usage of the smart watch could be monitored or their activities could be tracked.

## IV. DISCUSSION AND FURTHER RESEARCH

The research question is: how different users interact with the smart watch ecosystem to participate in the value co-creation process through their expectations, skills, and abilities? The answer is slightly different for the two types of users, the novices, and the expert users.

It seems that the novice users’ intrinsic curiosity about the new technology was an important contribution to getting motivated in the beginning. However, as the novelty has worn off, the advantages of the smart watch functions must be proven to maintain the long-term motivation of the users. In this value creation process, users’ different needs and requirements, as well as their different settings become more central, i.e. value-in-use is integrated with value-in-context [15]-[18].

For both user categories, smart watch functions that help the users to monitor and keep record of health and performance related parameters seem to be the most popular features [15]-[18]. Especially, these functions can be anticipated to create value when the users are training and exercising, and when they need an extra push to get started. During the data collection period of this study, the pandemic created a special context: as the gyms still followed strict

criteria of keeping distance between people due to ongoing covid-19 pandemic issue, most of the people kept themselves busy with their IoT enabled devices, such as a smart watch. This may have given them the feeling of belonging by tapping on the watch every now and then either to check the calories burned, goals achieved, or in terms of other interactions such as reading quick messages without opening their phones.

For the novice users, the main reasons for quitting to use the smart watch seemed to be related to an abundance of mobile and pervasive technologies in the everyday life [15]-[18]. Consequently, for some participants, the smart watch did not create any significant extra value in addition to the smart phone, and so they only used the watch on specific occasions, such as during exercise. In such cases, when the users could not easily integrate the new technology in their daily routines, both value-in-use and value-in-context were not perceived high enough to maintain long-term motivation [15]-[18]. The results show that the value co-creation process with the smart watch ecosystem requires individuals to be motivated to interact with the resources available in the ecosystem, possess nominal digital skills for appropriate interaction, and to pursue collaboration with other actors with individual objectives.

The results show that the active consumers of the smart watch can experience the value-in-use and value-in-context in several different ways such as: feeling motivated for physical activities during the pandemic (this feeling is not only keeping the users busy but also challenges them in several ways including comparison of their own previous records for a higher reward and providing them with a feeling of companionship), seamless sharing of data in the ecosystem including music and documents etc., between watch, phone and computer, using the watch in different contexts as a quick and safe payment resource, keeping an eye on vital health related issues via appropriate digital measurements such as breathing rate, HR, HRV, oxygen levels, and ECG, among others. These factors play an important role in the change of behavior for the end user's smart watch adoption and appropriation process in the longer period. Hence, research results suggest that the value created by the individual users through interactions within the smart watch ecosystem may enable them to make smart decisions and provide necessary support to improve their quality of life while performing regular activities. For instance, if someone notices low oxygen levels by using a smart watch, he/she can opt for a covid test to find out if he/she is suffering from asymptomatic covid.

Proliferation of wearable and hand-held devices, such as smart watches, has not only enticed huge number of end users but at the same time created fears of data privacy and information security. The results show that, on one hand, some of the young novice users thought that their activities can be tracked, and data could be compromised. However, on the other hand, more mature novice users and expert users considered that the security of the smart watch has the same privacy and security standard as their associated smart phone. Conclusively, novice user's privacy concerns could fall under the more general phenomenon of "fear of unknown technology".

This research work contributes to the existing research by presenting the smart watch ecosystem based on service dominant logic. This research work shows how different users have different value creation processes that are defined through their expectations, skills, and abilities. These results provide necessary insights and awareness to encourage both researchers and practitioners to keep pace with the rapidly evolving digital transformation process and the emerging smart ecosystems. Consequently, they will help to understand the shifting focus from product centric ideology to more customer centric system where value co-creation process is highly important [15]-[18].

We concur with Reeder and David [8] that, despite some shortcomings, the smart watches have the potential to support health related interventions, such as focusing on exercises, and monitoring a person's own health activities. In this study, the sample size was small, hence, large scale studies with a larger number of participants are required in the longer run to validate the claims regarding technical functionality, adoption, and effectiveness in supporting health and well-being of the individual users, particularly those with specific health issues. An IoT based smart watch ecosystem can support people in several areas of their daily life to achieve certain objectives in a smart way that includes physical fitness and well-being, entertainment, shopping, and socializing with other people through communication.

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## Appendix

### Questionnaire for the Evaluation of Apple smart watch

The information will solely be used for the purpose of research activities, and no unauthorized persons will have access to the response. By answering this questionnaire, you provide your consent to use this data for research purposes. The text-based answers will be analyzed based on common themes, and quotes may occur in the reporting, but no names are revealed in the report. The quantitative results will be analyzed statistically and reported at the group level. No personally identifiable data will be used anywhere.

#### Section 1: Personal Information

Age:                      Gender:

#### Section 2: Motivation and Comfort with smart watch

Items	TA	A	NN	D	TD
I was motivated to use the smart watch.					
I didn't face any problems using smart watch applications.					
I was able to integrate smart watch easily in my daily routine habits					

Put an X, TA= totally agree, A = agree, NN = neither nor, D = disagree, TD = totally disagree

#### Section 3: Value creation

Items	TA	A	NN	D	TD
I understood what I could expect to learn by using smart watch.					
It was easy to learn and operate different applications on smart watch.					
The smart watch enhanced cognitive capabilities Should be specified, for instance:					
Using the smart watch supported my memory.					
Using the smart watch improved my attention span.					
Using the smart watch supported my health and wellbeing.					
Using the smart watch helped me to keep motivated.					

Put an X, TA= totally agree, A = agree, NN = neither nor, D = disagree, TD = totally disagree

**Section 4: System quality and Service Quality, User satisfaction:**

Items	TA	A	NN	D	TD
I am satisfied with the smart watch					
I enjoyed the experience of using the smart watch					
I believe the smart watch system is successful					
The smart watch is easy to use					
The smart watch is user friendly					
The smart watch is stable					
The smart watch is secure					
The smart watch meets my needs					
The smart watch is responsive					

Put an X, TA= totally agree, A = agree, NN = neither nor, D = disagree, TD = totally disagree

**Section 5: Smart watch performance**

Item	TA	A	NN	D	TD
It was easy to install and establish a connection with phone.					
I didn't face any difficulties while working with smart watch.					

Put an X, TA= totally agree, A = agree, NN = neither nor, D = disagree, TD = totally disagree

**Section 6: Please write short answers.**

1. What type of applications did you use most on the smart watch?
2. Describe your experience of using smart watch during the covid-19 pandemic.
3. How can the smart watch support individuals' health and wellbeing and keep them motivated during the pandemic?
4. In your opinion, what was the greatest benefit when using the smart watch?
5. How confident are you at using the smart watch?  
Not at all confident..... confident.....very confident.....
6. How does the award system help in motivating smart watch users?
7. If you experienced any technical problems when working with smart watch resources, please provide details here:
8. Any other comments?