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journal homepage: www.elsevier.com/locate/compelecengLightweight authentication protocols for wearable devices[☆]Ashok Kumar Das^{a,*}, Sherali Zeadally^b, Mohammad Wazid^a^a Center for Security, Theory and Algorithmic Research, International Institute of Information Technology, Hyderabad 500 032, India^b College of Communication and Information, University of Kentucky, Lexington, KY 40506, USA

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ABSTRACT

In the wearable communication environment, wearable devices are used for various applications including fitbit flex tracks steps, sleep cycles, workout stats, and recording health-related sensitive information. The decreasing costs and increasing performance of Information Communication Technologies (ICTs) have made wearable devices more cost effective. Different types of wearable devices are being used today by citizens to improve their health and lifestyle. However, the data (such as health-related or movement data) generated from the user's daily activities is often private and therefore, ensuring the security and privacy of this data is important. First, we present some emerging trends of wearable devices followed by a discussion of the main security and functionality requirements along with the threats to the wearable communication environment. We then present a review of some of the recently proposed lightweight authentication protocols for wearable devices based on performance metrics such as computation cost and communication cost. We also compare these authentication protocols in terms of various security features they support. Finally, we discuss some future challenges in the area of security protocols for wearable devices that need to be addressed in the future.

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1. Introduction

Wearable technology, which uses wearable devices, is an emerging technology in which computing devices such as smart watches, sports watches, fitness tracker, glasses, smart fabrics, smart jewelry, etc., are incorporated into clothing items and accessories, which can comfortably be worn on the body [1]. Wearable devices are used by various applications including fitbit flex tracks steps, sleep cycles and workout stats. These devices typically send the tracked information to a user's smartphone [2]. Some wearable computing devices are also being used in the medical field, because these devices can monitor patients' vital parameters such as heart rate, blood glucose level, etc., and send the information to the user's smartphone [3]. A google glass gives a reality experience to the user and supplies information on demand [4]. Many more wearable devices are also available in the market and people are using them for various types of applications.

1.1. Emergence and trends of wearable devices

A wearable device is very popular because it is light, small, convenient to use and carry and has dressing characteristics. The operation and usage of wearable devices are typically different from common computers and mobile phones. For in-

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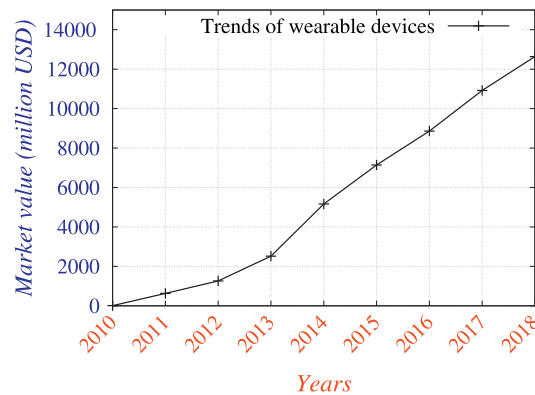


Fig. 1. Market value trends of wearable devices (Source: [7]).

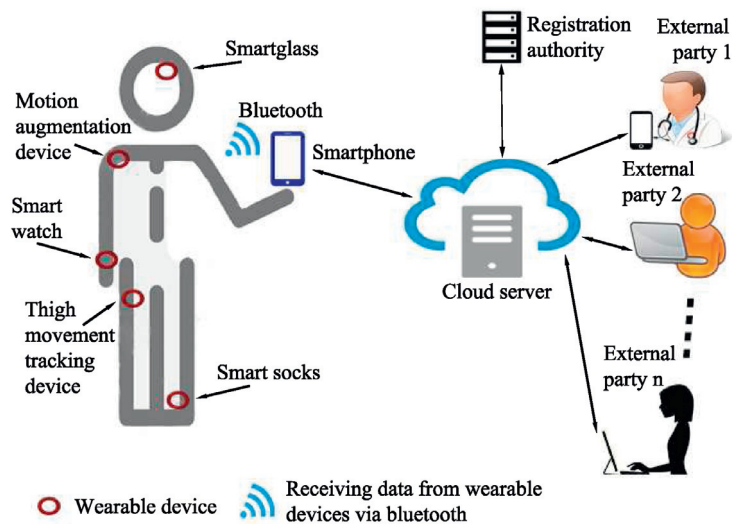


Fig. 2. Authentication model for wearable devices (adapted from [8]).

stance, for a scenario where a computer is needed, but because of the space restriction an actual computer cannot be used. In this case, wearable devices will be useful. Today, wearable devices are not only being used for tracking the fitness of a person/patient, but they are also being deployed in other applications such as contactless payments. For example, Near Field Communication (NFC) wearable payments are being integrated into fitbit device [5], and android pay is being made possible with android wear watches. According to Juniper research [6], mobile and wearable payments will reach \$100 billion by 2018.

Wearable technology has made a great impact on daily life. The sales of wearable devices is expected to reach 177 million from 22 million in the next five years [7]. As the market develops, wearable devices are being extensively deployed and used by all kinds of users, who are connecting them to the Internet through other devices such as smartphones and tablets. Fig. 1 illustrates the latest rising trends of wearable devices (market value in million USD) [7].

1.2. Authentication model of wearable devices

A typical authentication model for wearable devices is depicted in Fig. 2, which is adapted from [8,9]. Initially, the registration of various users and different devices such as wearable device, smartphone and cloud server is performed by the trusted Registration Authority (RA). After the successful registration of these entities, the information such as pseudo-random identity, pseudo-password and secret keys required for the various authentication steps, are stored in these devices and is also provided to the various users. In the model shown in Fig. 2, a person can wear several wearable devices, such as a smartglass (eyes), smartwatch (wrist), a motion augmentation device on shoulder, smart socks (feet), and movement tracking device (thigh). All these wearable devices track the corresponding physical phenomena (e.g., heart rate, blood pressure, distance tracking, calories burnt, etc.) and send the tracked information to his/her smartphone by using some wireless communication technology (for example, Bluetooth). The smartphone communicates with a cloud server, where the data will be

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