Blockchain for Industry 4.0: A Comprehensive Review

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ABSTRACT Due to the proliferation of ICT during the last few decades, there is an exponential increase in the usage of various smart applications such as smart farming, smart healthcare, supply-chain & logistics, business, tourism and hospitality, energy management etc. However, for all the aforementioned applications, security and privacy are major concerns keeping in view of the usage of the open channel, i.e., Internet for data transfer. Although many security solutions and standards have been proposed over the years to enhance the security levels of aforementioned smart applications, but the existing solutions are either based upon the centralized architecture (having single point of failure) or having high computation and communication costs. Moreover, most of the existing security solutions have focussed only on few aspects and fail to address scalability, robustness, data storage, network latency, auditability, immutability, and traceability. To handle the aforementioned issues, blockchain technology can be one of the solutions. Motivated from these facts, in this paper, we present a systematic review of various blockchain-based solutions and their applicability in various Industry 4.0-based applications. Our contributions in this paper are in four fold. Firstly, we explored the current state-of-the-art solutions in the blockchain technology for the smart applications. Then, we illustrated the reference architecture used for the blockchain applicability in various Industry 4.0 applications. Then, merits and demerits of the traditional security solutions are also discussed in comparison to their countermeasures. Finally, we provided a comparison of existing blockchain-based security solutions using various parameters to provide deep insights to the readers about its applicability in various applications.

INDEX TERMS Blockchain, consensus algorithms, cyber-physical systems, IoT, smart grid, supply chain management, intelligent transportation.

I. INTRODUCTION

With the wide popularity of Internet and related technologies, various Industry 4.0-based applications have been used across the globe in which sensors and actuators sense, compute and communicate the data for industry automation. As in Industry 4.0-based applications, data between different locations flows using an open channel, i.e., Internet, so threats to security and privacy has also increased manyfold [1]. Such applications

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deal with data in large volumes and hence, so it is necessary to consider issues such as-data heterogeneity, data integrity, and data redundancy alongwith the security and privacy concerns. Moreover, different applications require datasets from different domains in different formats. Therefore, it is also needed to standardize the data format so that it can be used by different Industry 4.0-based applications.

The usage of smart phones and smart applications for personal, professional, and social activities is increasing exponentially across the globe. It results an increase in both the network data traffic (in GBs) and overall expenditure (in