Abstract

Although the Internet of Things (IoT) is rapidly connecting more devices to the internet, managing large volumes of sensitive data securely and affordably remains a challenge. Most IoT systems use centralized infrastructures, which require expensive servers and raise trust concerns. This makes the decentralization of IoT a critical research area. Blockchain technology, originally developed for Bitcoin, offers a promising solution for building a decentralized, secure, and trust less IoT environment. However, integrating blockchain with IoT presents challenges. For instance, while blockchains provide auditability, they can compromise privacy, especially in sensitive IoT applications. Additionally, traditional computing architectures must evolve to better utilize unused resources and meet scalability demands. With multiple personas interacting with IoT systems, each with unique use cases and governance needs, effective data modelling is essential to ensure uniform data access and governance. This thesis proposes a novel blockchain-based software architecture to address IoT device interoperability and trust management. It leverages self-managed identities, whitelisting, and decentralized trust mechanisms to securely manage sensitive data cost-effectively. To support near real-time processing, an agent-based microservices architecture is introduced, capable of handling data surges with minimal cost and strong performance. A graph-based data modelling and governance approach is also proposed to ensure consistent access levels for different personas while maintaining a high degree of control. Privacy-preserving techniques are integrated to balance auditability with user privacy in a decentralized environment. The architecture is scalable, efficient, and adaptable for various IoT use cases. Experimental evaluations validate its ability to manage large-scale data securely and cost-effectively, and its application to industry use cases highlights potential for future business models and growth.