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Litrature review on IoT Communication and Computation

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Abstract

This paper provides an overview of fog computing and embedded systems platforms, highlighting their significance as foundational elements of the Internet of Things (IoT). It delves into the diverse concepts surrounding IoT architectures, accompanied by illustrative examples. Additionally, the paper presents a comprehensive examination of a conceptual layered architecture for IoT from a computational standpoint, integrating fog computing to tackle several challenges inherent in cloud computing. However, it underscores that the choice between fog and cloud computing is not strictly binary. The proliferation of sensors and actuators within physical objects, interconnected through communication infrastructures and governed by computational algorithms, is transforming various aspects of daily life, including healthcare, energy management, and transportation. This paradigm shift is facilitated by IoT sensor networks and embedded systems, which are reshaping societal interactions with technology. To cater to the computational demands arising from these advancements, a diverse array of models and frameworks are employed. Consequently, this paper seeks to synthesize current research in IoT, cloud computing, and fog computing, aiming to streamline the utilization of these models in practical applications.

Keywords:

Fog Computing;
Cloud Computing;
Embedded Systems.

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1. Introduction (12pt)

The concept of the Internet of Things (IoT) has captured significant attention within the realm of Information Technology. There are differing perspectives on whether we are rapidly approaching the era of IoT or if it has been underway since the early 21st century. While the exact origin of the term remains uncertain, it is often attributed to Kevin Ashton, who introduced it in a presentation in 1999 at the Auto-ID Center at MIT. Ashton connected radio frequency identification (RFID) to the physical world, envisioning a new phase of the Internet driven by data generated from everyday objects. Various industry players have adopted different names for IoT, with examples such as Cisco Systems, Accenture, and IBM referring to it as Internet of Everything (IoE), Internet of Me (IoM), and Smarter Planet, respectively. At the core of IoT lie sensors and actuators, forming the basis for a vast network generating copious amounts of data, thereby escalating computational demands.

In discussions such as IEEE Talks Big Data with Chris Miyachi, chair of IEEE Cloud Computing, the challenges of processing and analyzing massive volumes of unstructured data emerge as significant hurdles for Big Data, IoT, and Cyber-Physical Systems (CPS). The emergence of pervasive computing revolutionized computation's nature and location, leading to the introduction of products aligned with the concept of ubiquitous computing, such as Microsoft Azure and IBM's SmartCloud *2018* International Journals of Multidisciplinary Research Academyframework. Innovations like fog computing and mist computing aim to extend cloud services to the network's edge, with implementations like IOx illustrating this trend. Global

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efforts to standardize IoT and its applications have resulted in initiatives like the Web of Things (WoT), which aims to facilitate services aligned with the OSI model's application layer. Moreover, IoT enjoys support not only from industry giants like IBM, HP, Intel, Microsoft, and Cisco but also from consumer-oriented Internet pillars like Apple, Google, and Amazon. Interest in IoT extends beyond the realm of technology, as demonstrated by its multidisciplinary exploration by economists at forums like the World Economic Forum collaborating with Accenture to explore the potential of connected services within the Industrial Internet of Things (IIoT). The concept of ambient intelligence envisions an electronic environment capable of sensing human presence and responding accordingly.

IoT's proliferation sees various hardware platforms gaining popularity, often as prototypes in DIY projects. These platforms support different communication modes, including Machine-to-Machine (M2M), Machine-to-People (M2P), and People-to-People (P2P), facilitating applications ranging from smart factories to consumer data analysis and real-time collaboration tools. A comprehensive analysis of IoT must consider its limitations, including concerns regarding security, privacy, and cost-effectiveness. It's essential to contextualize discussions of IoT within specific industries to ensure their relevance and applicability.

2. Litrature Review

Y. Li et al. [7] introduced a theoretical framework highlighting the increasing demand for IoT applications across diverse contexts and industries. The surge in programmability of hardware components reflects an industrial trend driven by consumer needs. This transition to IoT necessitates engagement with various societal groups, including students. To actualize IoT's potential, a range of programmable hardware platforms have gained traction. Among these, Raspberry Pi, introduced in February 2012, stands out as the most popular and cost-effective platform, offering modularity and flexibility for both real-world applications and educational endeavors. C. Edwards et al. [8] were among the pioneers showcasing a multitude of Raspberry Pi applications. For instance, S. Joardar et al. [9] developed a biometric system for human subject recognition based on palm vein patterns using Raspberry Pi, while S. Sivaranjani et al. [10] implemented a model for extracting fingerprint and footprint data from newborn babies.

Raspberry Pi finds novel applications in smart homes, with V. Sandeep et al. [11] proposing a remotely-controlled automation system for home electrical appliances utilizing cloud technology. Similarly, N. Agrawal et al. [12] introduced a proof of concept drip irrigation system for residential use, extendable to agricultural fields and gardens, with commands sent via email. Raspberry Pi's versatility extends to modeling cloud computing clusters [13][14] and constructing virtual supercomputers [15]. Its adoption in K-12 education further cements its role in IoT's future, providing extensive support for school projects.Partitioning IoT devices into communities can enhance information management and organization. Pirouz et al. [16] proposed an optimized distance-based metric to prioritize similar nodes within IoT networks.

IoT networks leverage traditional and newer networking protocols spanning physical and data link layers. Standards such as 802.15 wireless personal area networks (WPANs), including Bluetooth (802.15.1) and ZigBee (802.15.4), facilitate short-range communication. NFC supports close-range interactions, while IPv6 over Low power Wireless Personal Area Networks (6LoWPAN) offers energy-efficient connectivity. Efforts towards interoperability, such as integrating 6LoWPAN with IPv4 networks, enhance IoT network flexibility [17].Security considerations are paramount in IoT, with IPv6 offering inherent advantages over IPv4, including enhanced security features such as extended options in headers [20]. Concepts like Link-Local Addresses (LLAs) and anycast packets mitigate various attack vectors, including flooding attacks and reconnaissance attempts. Classifying smart objects based on attributes aids in implementing security measures, with examples including DoS attacks, eavesdropping, and Sybil attacks targeting IoT networks.

The evolution of networking devices, from hubs to switches and routers, has bolstered security measures at lower OSI layers. Techniques like Dynamic ARP Inspection (DAI) and port security enhance network integrity. Short-range wireless protocols, like 6LoWPAN, further contribute to IoT security efforts.IoT applications span various domains, including smart homes, connected health care, smart cities, and enterprise solutions. Projects like Sintelur waste management, Thingful's discoverability engine, and Streetline's parking guidance system exemplify IoT's transformative potential in smart city applications [21]. Additionally, IoT plays a pivotal role in enhancing healthcare services [22].Smart objects consist of embedded systems, actuators, and sensors, each equipped with varying CPU, memory, and operating systems. Typically designed for single-function tasks, these devices often feature network connectivity. Many are situated remotely or in inaccessible areas, making modifications or reconfiguration impractical. Their inherent resource limitations and power constraints contribute to their frequent insecurity.

Given the diverse and often unreliable nature of smart objects used in network construction, there's a pressing need for a dependable design model capable of supporting high-throughput applications. These smart objects range from compact wearable technologies with limited power to large-scale embedded systems deployed in smart city infrastructure.From a security perspective, the design of this layer must not only address security risks but also provide adaptable security guidelines for the next generation of both small and large embedded sensor systems. The App Execution Platform (AEP) stands out as one of the virtualization paradigms facilitating the interaction and communication among such objects [23].

3. Research Challenges

In It's widely acknowledged that the foundational infrastructure, technologies, and applications of the Internet of Things (IoT) are expansive but still in their early stages. The lack of standardized protocols poses a significant hurdle for IoT advancement. To address this, standardization bodies like ITU-T have launched initiatives such as IoT-GSI and IoT Study Group 17, specifically focusing on security and privacy for tag-based applications. The ITU-T's "Ubiquitous Sensors Network" report from February 2008 serves as another valuable resource in this domain.The ever-expanding array of IoT-connected devices and services complicates the development of a cohesive framework. However, the proposed hierarchical framework introduces modularity, which enhances scalability and accommodates future growth. Nonetheless, scalability issues may arise, particularly concerning data transmission and processing due to the sheer volume of physical objects involved.

The proliferation of heterogeneous smart objects will generate copious amounts of streaming and real-time data, leading to both anticipated and unforeseen challenges. Not all generated data will prove useful, necessitating decisions on whether to retain or discard it. While storing data can potentially yield future benefits, it also presents a laborious task.

4. Conclusion

This paper examined different IoT concepts and the current computational methods through an industrial lens. It began with an overview of IoT hardware, protocols, and select applications. Subsequently, it introduced a structured framework for IoT computation, delineating the necessity of each layer. Various computational strategies like fog and cloud computing were integrated into this framework. Additionally, a mathematical model for securing these paradigms, taking into account the inherent security measures of IPv6 is needed.

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