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Study of Internet of Toys – An IOT Applications.

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Abstract: This document offers an in-depth explanation of the concept of "Internet of Toys" within the realm of "Internet of Things", covering both social and technological dimensions. We analyse existing Internet of Toys structures from various sources and suggest a novel architecture/framework that facilitates the integration of intelligent toys into intricate amusement settings, allowing for data exchange, experiential learning, and enhanced understanding of children's cognitive growth. Furthermore, we identify the obstacles common to the broader Internet of Things landscape, as well as those unique to the Internet of Toys.

Index Terms **- Internet of Toys, Framework, Cognitive Growth, Landscape and Novel Architecture.**

I. INTRODUCTION

Children's everyday lives are filled with numerous examples of how they utilize cutting-edge technologies. They engage with tablets, interact with smart toys in complex learning environments, and even encounter humanoid robots that can convincingly mimic human behavior while monitoring their development [1]. At the heart of these applications lies the "smart toy," which refers to a toy equipped with a processor, memory, and sensing unit. These toys have the ability to detect physical phenomena and react in predetermined ways. Depending on their processing capabilities, they can perform simple or more intricate tasks. It is important to note that smart toys or intelligent toys do not necessarily need to record or transmit data, as most of them lack communication modules. In the context of the emerging field of Internet of Toys (Internet of Toys), a "smart toy" encompasses software that enables the toy to connect online (via Wi-Fi and/or Bluetooth) or with other toys [2]. These toys are equipped with various sensors and engage in one-on-one interactions with children [3]. Consequently, the Internet of Toys can be broadly categorized into two groups: Internet of Toys that simulate human interaction (such as sensor-based toys like the well-known Barbie dolls with voice recognition capabilities) and Internet of Toys that do not simulate human interaction (known as toys-to-life). The most advanced toys, such as Cozmo and Leka robots, are not only smart and connected but also allow for programmable actions beyond what the producer initially provides. The term "Internet of Toys" was first introduced in a conference paper in 2010 [2]. Since then, there have been other related research endeavors, although not extensively covering this specific topic. Internet of Toys, as a relatively new concept, emerged as a sociologically based approach complementing the well-established and more widely known concept of the "Internet of Things" (IoT). However, it is worth noting that most of the existing state-of-the-art Internet of Toys approaches are tailored to specific toys and create unique learning or entertaining environments. Regarding the challenges associated with designing solutions for Internet of Toys, the literature primarily focuses on data privacy, including the generation, sharing, and risks of data for children involved. However, there are numerous challenges related to Internet of Toys that have not yet been identified and analyzed. This paper aims to address the gaps in the literature and advance our understanding of the Internet of Toys paradigm. Firstly, we will provide a comprehensive definition of "Internet of Toys" that encompasses all relevant sociological and technological aspects of this paradigm. Secondly, we will review the existing literature and extract Internet of Toys frameworks and architectures that have already been proposed. By considering domain-specific characteristics, we will identify common features to construct a foundational architecture that can facilitate the interconnection of smart toys, unlocking their full collective potential as Internet of Toys. Furthermore, we will identify and examine the relevant challenges associated with developing Internet of Toys solutions as documented in the state-of-the-art literature, determining the most significant ones. This overview will serve as a comprehensive roadmap for parties interested in utilizing the Internet of Toys paradigm for business, industrial, educational, or research purposes. To the best of our knowledge, this is the first paper in the literature that defines the term "Internet of Toys" from an engineering and data science perspective, in contrast to other publications that approach the topic from an educational and socio-economic standpoint. The paper is structured as follows: the second section outlines the research methodology employed in our survey, while the third section provides a summary of the Internet of Toys architectures found in the surveyed papers, including their historical evolution, state-of-the-art status, and future general framework. The fourth section provides in-depth analyses of the challenges present in developing successful Internet of Toys solution, defining from technical and non-technical perspectives. This paper is concluded in section five.

II. METHODOLOGY

To summarize the most recent and relevant developments related to the Internet of Toys paradigm, a search was conducted using Google Scholar (GS) (https://scholar.google.com). In addition to the search term "Internet of Toys", other search terms were allowed to appear in the text of the publications. The total number of articles found for each search phrase is presented in Figure

1, with overlapping articles being removed from the list. Only articles published in reputable journals and conferences were considered. The results of the search engine reflect the focus of this article on toys capable of data processing and artificial intelligence, with limited attention given to their intercommunication. The literature on smart toys within an Internet of Things framework is also scarce. Two main challenges identified from the selected articles are the interactivity of smart toys and data security and privacy issues. Other important aspects that require attention include big data issues, knowledge extraction, data reduction, and interoperability.

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III. INTERNET OF TOYS

In the section on Internet of Toys architectures, a historical perspective on the evolution of toys over the past few decades is provided, along with a common framework that serves as a foundation for future Internet of Toys solutions.

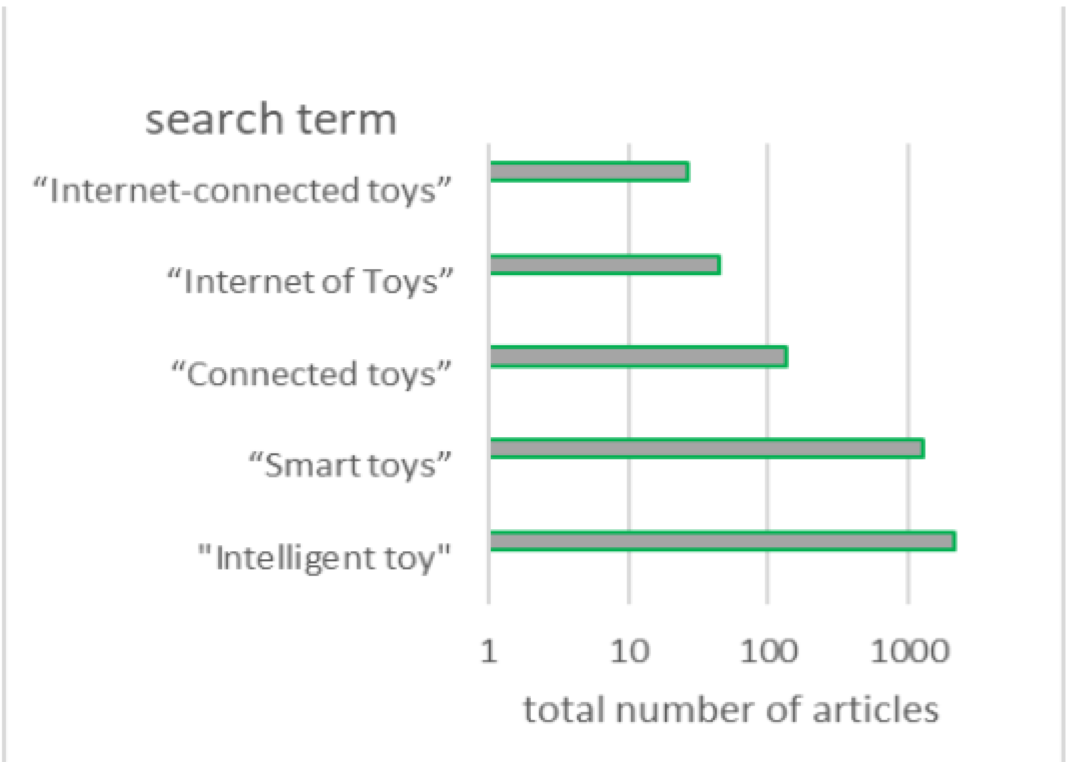

Figure 1 Statistics in search engines

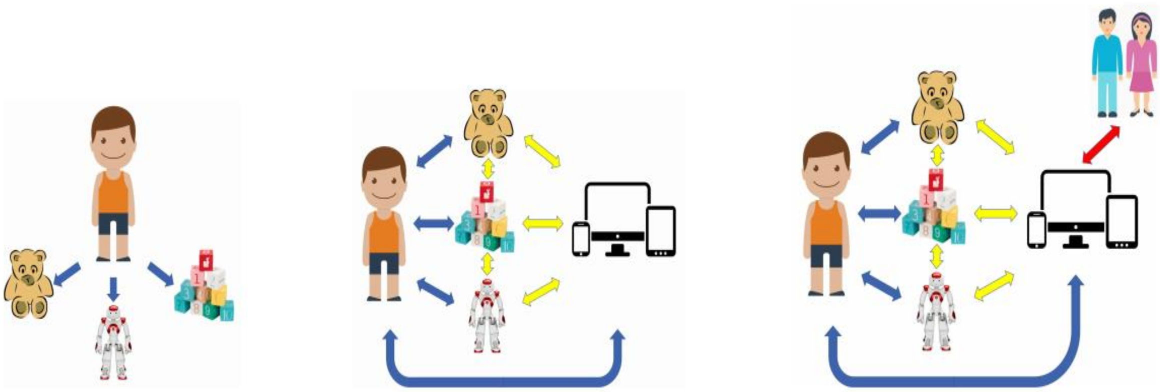

Figure 2 Smart Toys

The inception of the "Internet of Toys" concept dates back nearly four decades, with the emergence of the first intelligent toys in the market. These toys were pioneers in engaging with children through interactive features. Over time, toys have advanced to possess more sophisticated capabilities, enabling remote control via smartphones, tablets, or computers. Information and communication technologies (ICT) play a crucial role in enabling this second generation of toys. A key characteristic of this generation is the ability for toys to communicate with each other, a defining aspect of the "Internet of Toys" concept widely acknowledged in literature. The fundamental requirement for the "Internet of Toys" is the capacity for toys to communicate and share data among themselves. The latest generation of toys introduces intricate learning and entertainment environments where multiple children can interact with numerous toys. Adults, such as parents and teachers, play an active role in this system by monitoring children's habits, abilities, and needs through devices. The most cutting-edge solutions strive to belong to this advanced generation. A study by [6] delves into the realm of parental monitoring of infants in a digitally connected society. Infant wearables used for monitoring share similarities with the internet of toys, as both leverage Internet connectivity to offer personalized feedback and interaction while gathering substantial data about the child. The study emphasizes that data collection and intimate monitoring of children are becoming integral aspects of caregiving culture and a standard for nurturing parenting. In adhering to these societal norms, parents often overlook concerns such as the appropriate medical or scientific utilization of collected data, as well as the critical issue of data privacy. The educational potential of the Internet of Toys is explored by the authors of [7]. They find that young children are highly interested in the digital capabilities offered by physical play objects. These toys enable children to engage in various activities that promote play, creativity, and learning. The study also suggests that Internet of Toys can facilitate social play, which is an integral part of their digital and physical features. The authors emphasize that the connectedness and digitally-enhanced aspects of these toys enhance their educational benefits. In [8], the concept of visible light communication (VLC) is introduced in the context of networking toys and smartphones. The implementation of VLC using existing toy components is cost-effective and enables seamless communication between toys and smartphones. The authors argue that advancements in standards such as IEEE 802.15.7, updates in the IrDA standard, and lightweight IPv6 protocols for the Internet of Things make it possible to create an Internet of Toys without unnecessary complexity or resource requirements. [9] focuses on the design and implementation of a sensor-based smart toy system that is affordable. This system collects data on children's play activities using a mobile computing platform, which can then be analyzed by professionals to identify developmental delays. The authors propose a centralized collector-based architecture that allows non-technical users to easily interact with the toys, conduct experiments, and gather data without directly interacting with the underlying sensors. The perspectives of both children and parents on toys that listen are examined in [10]. The study investigates the interaction models between the toys and children/parents, as well as their expectations regarding the toys' intelligence. Additionally, it explores children's perception of privacy while engaging with these toys. A ToyBridge serves as a middleware platform that links physical-world smart toys with online activities. The communication between browser applications and external devices is facilitated through sockets. The interface between ToyBridge and toys varies depending on the type of toy being used. If the toy utilizes IrDA, the ToyBridge utilizes Visible Light Communications (VLC) technology. The interface between toys and browsers allows for the transfer of toy complexity to the computer, enabling the easy development of applications that can fully utilize the radios, sensors, and actuators of smart toys. The EDUCERE project is dedicated to exploring, developing, and evaluating innovative solutions for detecting changes in psychomotor development in children through their natural interaction with toys and everyday objects. An ethical impact assessment related to data protection rights was conducted as part of the EDUCERE project. Smart toys were utilized to detect developmental difficulties in children, with privacy protection measures implemented to safeguard children's health data through legal and technical means. The authors focused on transforming bulk data (such as acceleration and jitter of toys) into health data when identifying patterns of atypical development. By implementing a "privacy by design" approach, they addressed ethical and legal requirements. A Hello Barbie companion leverages Internet connectivity and speech recognition technologies to provide an engaging and interactive experience, including two-way conversations, playing games, and sharing jokes. Children can form strong bonds with the Hello Barbie toy and engage in meaningful conversations on topics like bullying, religion, and friendship. The authors of a study aimed to identify sensitive personal information shared by children and proposed a solution to balance privacy rights with the obligation to report (as per the proposed amendment to COPPA). The proposed solution aims to protect abused children without shackling smart toy manufacturers with heavy burdens and expenses. A ToyBridge serves as a middleware platform that links physical-world smart toys with online activities. The communication between browser applications and external devices is established through sockets. The interface from ToyBridge to the toy is dependent on the type of toy being used. In cases where the toy utilizes IrDA, the ToyBridge incorporates Visible Light Communications (VLC) technology. On the other hand, the interface from the toy to the browser allows for the transfer of toy complexity to the computer, enabling the easy development of applications that can fully utilize the smart toys' radios, sensors, and actuators. The web-based Clinical Decision Support System (CDSS) addresses the issue of early diagnosis of language disorders for the early detection of language pathologies. Through the utilization of this monitoring tool, nursery school educators can evaluate the level of language acquisition in their students (children aged 0 to 6 years). The methodology involves two consecutive phases: first, the observation of the child's language abilities to aid in the assessment of language acquisition level by a language therapist, and second, the same language therapist evaluates the reliability of the observed results. An important outcome of this evaluation was the identification of 7 out of 146 children with potential language delays that had not been previously detected by either the NSLT or their educator. These cases necessitate a formal diagnostic process to compare the system's decision with traditional methods. The concept of "Internet of Toys" emerged as a specific application domain within the realm of the "Internet of Things". Consequently, the commonly accepted definition is deemed incomplete. To ensure technical accuracy, it is imperative to expand the fundamental Internet of Toys definition as follows: "Internet of Toys pertains to a future where toys connected to the internet not only interact individually with children and other toys in intricate learning/entertaining settings/environments (LESE), but all LESEs are wirelessly linked to other LESEs through cloud architecture. A more formal presentation of the framework can be found in Figure 4.

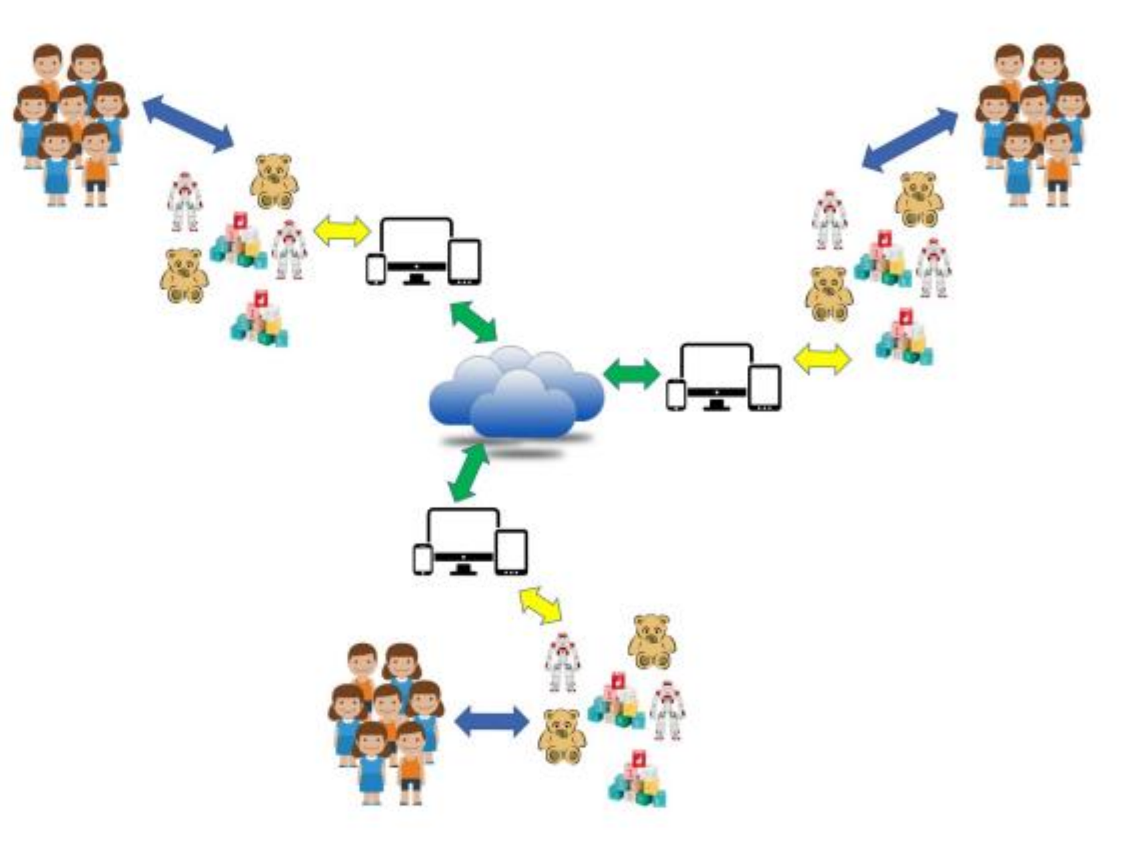

Figure 3 Framework for Proposed Methods

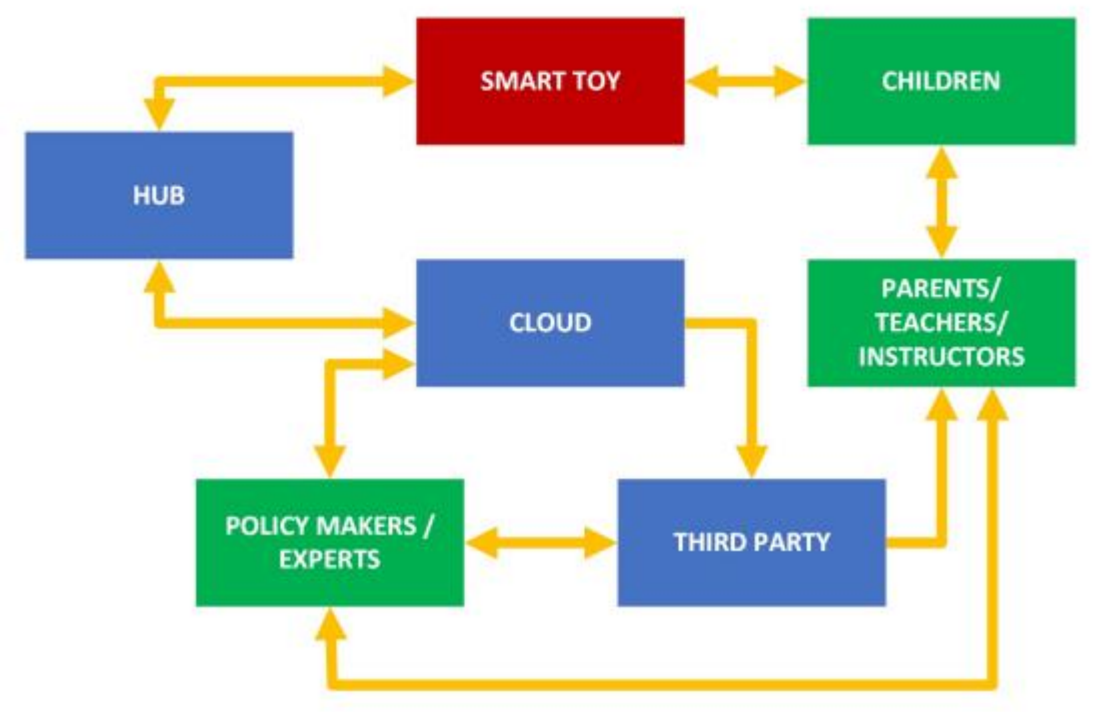

Figure 4 Internet of Toys Architecture

The majority of the components within the framework are derived from the IoT architecture, with some entities being exclusive to Internet of Toys. One key distinction is the active participation of individuals at various levels within the framework, setting it apart from other application-specific IoT architectures that are predominantly machine-based. This hierarchical framework necessitates that data from the toys, acting as sensing units, cannot be directly transmitted to the cloud; instead, it must pass through gateways or hubs. This approach is primarily driven by energy efficiency considerations, as toys typically utilize low-energy protocols like Bluetooth and infrequently rely on GSM or Wi-Fi communication. Each Low-Energy Sensing Entity (LESE) must be equipped with at least one hub capable of facilitating communication between the toys and the cloud simultaneously. The data flow operates in both directions, from the cloud to the hub, and from the hub to the toys. The insights gained from this framework can prove beneficial not only for children but also for society as a whole, including policymakers, education experts involved in children's learning, and businesses interested in developing new toys, applications, or services. Specific knowledge about children encompasses identifying their abilities, talents, requirements, needs, and desires. This information can be valuable for parents, enabling them to adapt to changes in their child's behavior, interests, maturity, and more. For more significant relationships and complex issues, parents may be advised to seek guidance from professionals such as teachers or psychologists. Is is explained in 15 to 20 clearly internet of things, from 21 to 25 IOT applications and from 26 to 30 usage and functions of IOT.

IV. Challenges

In the subsequent sections, the challenges identified in the literature will be discussed and analyzed within the context of the proposed framework. These challenges can be categorized into two main classes based on their background. A. Technical challenges Within the first class, the main challenges are similar to those associated with other IoT-based solutions. Interactivity in Internet of Toys encompasses various features that need to be implemented or provided in the framework, all of which involve some form of interaction. The initial aspect involves enabling end users, specifically children, to interact with the smart toy in the most natural way possible. This interaction should ideally rely on sounds, facial expressions, gestures, and movement. To achieve this, different sensors such as microphones, cameras, touch sensors, accelerometers, etc., can be integrated into the smart toy. One key distinction between Internet of Toys and IoT lies in their response to sensed data. While IoT primarily operates in a passive sensing mode, proactiveness is crucial in Internet of Toys. This introduces the second aspect of interactivity in Internet of Toys, which is the smart toy's ability to provide feedback and interact with the child. This concept of active sensing combines the toy's artificial intelligence and its data to guide the play scenario, enhance child engagement, and create a more natural overall experience by giving the toy an artificial personality. To enable this, the smart toy requires a database and AI technologies in addition to its operational hardware. In the proposed framework, this potential issue can be mitigated by transferring the smart toy's data and AI to the hub. The final aspect of interactivity involves toy-to-toy interaction, which can be achieved physically but even more so virtually. The ultimate objective of such interaction is to facilitate the interaction between children using the toys. The proposed cloud-centric framework has the capability to easily offer this functionality by connecting toys (children) either automatically through an expert system or under the direct supervision of a human expert. Not all Internet of Toys necessarily have this third aspect of interactivity. Toys interoperability is seen as the most crucial requirement that needs to be met for the toys to be able to communicate with each other. It serves as a common language that the devices can understand so they can interact with each other. Currently, the existing protocols for smart objects are not yet fully developed to communicate with other devices operating under the same protocols but with different versions. The situation becomes even more challenging when two devices operating under different protocols need to communicate. The only communication protocol that has achieved complete interoperability within itself is Insteon with Z-Wave behind it, while Zig-Bee is considered the least effective. Data security and privacy concerns in Internet of Toys mainly arise due to the large amount of children's information collected by smart toys. Users consent to data collection and sharing due to the potential decrease in user experience if they opt out. While there are methods to enhance data protection, such as routing all data transfers from smart toys through the hub and establishing security policies there, there is a need for laws and regulations governing the legality of collecting, processing, and monetizing data from toys. In IoT applications, where connected devices are accessible from anywhere, security concerns should not be overlooked. The security of smart devices is increased by addressing device vulnerabilities, which pose a risk of threats that could devalue the devices. Internet of Toys are inherently susceptible to common wireless network attacks. Security lightweight cryptographic primitives could potentially offer a cost-effective security policy by ensuring the authenticity of entities within the framework and maintaining data integrity.

The EU General Data Protection Regulation mandates that a data subject's consent (whether an individual, child, or parent) is required for a third party to lawfully process their personal information. This means that citizens must fully understand how their personal data will be utilized by the system, which is particularly challenging in the pervasive and ubiquitous context of the Internet of Things. Ethical concerns arise when managing clinical or sensitive data related to the psychological development of children involved. The potential for business opportunities in creating advanced Internet of Toys services is vast, especially in larger countries

V. Conclusions

Research on the Internet of Toys is still in its early stages, with only a few EU groups exploring this topic, primarily from an educational standpoint. This paper aims to address the gaps in the literature on this subject. Firstly, we offer a comprehensive definition of "Internet of Toys" from sociological and technological viewpoints. Secondly, we identify three generations of toys currently available on the market and propose new Internet of Toys frameworks/architectures to serve as a strong foundation for connecting smart toys that have not yet fully realized their collective potential as Internet of Toys. Lastly, we outline the key challenges associated with developing Internet of Toys solutions. This overview should serve as a detailed guide for individuals or organizations looking to implement this paradigm for business, industrial, educational, or research purposes

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