My Smart Remote: A Smart Home Management Solution for Children

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***Abstract*—In this study, a concept is presented that extends the My Remote previous project to a smart home solution, or the My Smart Remote. The concept extends its management capabilities for children's lives in the home, while at the same time safely and securely sharing collected data about children's activities with external parties including educationalists, health care professionals, psychologists and marketers of products and services used by children. Sharing data not only benefits these external parties but also the children themselves as solutions can be tailored to their needs. Because the My Smart Remote is for children, security and privacy concerns are paramount. A contribution of this concept that is primarily derived from the need for safety and security, and also efficiency in processing, is a solution where much of the sensor data of the My Smart Remote is processed locally, in addition to the cloud. This solution is based on the idea that smart solutions, such as smart cities and smart homes, generate a large amount of sensor data which can be more efficiently processed locally rather than depending on the cloud. The My Smart Remote using sensor data from around the home to manage television viewing, video gaming, activity on PCs, mobile phones and tablets, all in terms of time spent and types of activity. Additionally, the My Smart Remote will monitor these activities which will also include other activities such as taking drinks from the fridge and homework activities and collect, and share the associated data with external parties.**

***Index Terms*—Internet of Things (IoT); smart city; smart home system; embedded computing; Cloud data mining; Fog Computing; Distributed Data Analytics;**

I. Introduction

Homes, the devices in the home and the activities that take place in the home are increasingly connected to the Internet. This has spurned the arrival of the smart home whereby appliances, lighting, heating, entertainment and security are integrated and can communicate with each other. While this has been a revolution in managing the home and life in the home, it has neglected the potential benefits of managing the life of children in the home. Most activities that children engage in their daily lives involves a device that is connected and therefore, has the potential to be integrated towards a smart management for children.

The concept is an extension of the previously developed My Remote which is a remote control for children that was designed to control viewing content on the television, time spent watching the television, encourage safe distance from the television, volume control, in additional to managing children's lives through scheduling, homework reminders and encouraging positive and productive behavior. While the My Remote was effective, it did not take full advantage of the potential of full interconnectivity as part of a smart home concept.

The management of the child can include health, education and general organization of daily routine. Information from the device about children's activities can be used by designated data consumers to further improve the daily life of the child, such consumers include health care professionals and educationalists, or the data can be used more generally by marketing organizations and government, these consumers include those who provide goods and services for children. The different activities of children that are managed by the My Remote will produce data that is useful to various parties. One example could be what the children are taking from the fridge, this information could be useful marketing, health care professionals and foods and drinks manufacturers. Another example would be educators, such as teachers, who would be interested in data related to homework activities.

The contribution of the concept is that the integrated system in the home, of which the My Remote is a central component, and the associated processing of data for data management takes place in the home and not in the cloud, this has two contributory implications. The first contribution is that such an approach offers more security and privacy than the public cloud which is the usual location of data processing for smart systems. One of the main concerns about the public cloud is security and privacy and this a particularly an issue where data about children and their activity is concerned. Where data is sent to the cloud it will be only data that is required to be processed in the cloud, it will be anonymised to protect children's identities and will not contain any real-time information so the location and activities of children will remain private. The second contribution is that because data is processed locally in the home, So, that reduce using the cloud resources as much possible, it will be more cost effective and consume less energy which is beneficial for the environment.

II. Related Works

The review of the literature was concerned with literature about the need to manage children at home, especially in terms of the need to manage children's viewing time and content for media and video games. Moreover, there is a review of data processing in ubiquitous systems and the need for micro-controller middleware and the importance of security and privacy. All of these reviews are relevant to a system that needs to manage children in the home and offer data about their behavior to external parties, while simultaneously supporting the security and privacy of the data.

A. Inappropriate content and its effects

There is evidence that inappropriate viewing has detrimental effects on children's behavior, attitudes, knowledge and beliefs [1] and especially, exposure to violence has a negative effect from childhood to adulthood [2]. In fact, [2] recommend controlling viewing. [3] said too much viewing of television affected how children interacted with other children, and [4] said that viewing can have negative effects on learning development. In addition to content that may be viewed on the television or the Internet, the My Remote will also manage video gaming. Video gaming has now become increasingly popular with children and is mostly done competitively through the Internet. There is a sufficient amount of evidence in the literature that video gaming, especially too much, has detrimental effects on children both psychologically and physically.

[5] says that gaming has an effect on appetite in children and their energy levels. [6] brings attention to the fact that negative outcomes of video gaming include aggressive thoughts, aggressive feelings, aggressive behavior and desensitization. There are even physical effects mentioned in the literature, [7] say that increased gaming time can have a negative impact on health. [8] highlighted the difference between cooperative gaming which can have positive effects and competitive gaming which can have negative effects.

It is also important to note that children are vulnerable to being victims of cyberbullying or being the bullies themselves, this has also been associated with aggressive behavior as a result of video gaming exposure [9]. However, it is important to note that there are some non-violent video games that have been associated with positive learning outcomes and improvement in certain types of visual cognition [6]. While in My Remote we assume that video gaming is a tool that may affect children behavior in acceptable or unacceptable way depend on the content of the game.

B. Data

Because ubiquitous computing and the Internet of Things (IoT) is rapidly developing in our everyday lives, there has been a significant increase in the context data can be used for further purposes [10]. This has especially been the case with context aware systems where a large volume of data is generated that can be used for other applications [10].

[10] say there needs to be an emphasis on security and privacy because private and sensitive data is used, and this can be achieved through the functionality of middleware device which can include the ability to detect and measure anomalies and unauthorized data access. [10] make two suggestions as solutions which are to encrypt the data during transmission and to implement access control.

In reference to how the large amount of data that is generated from various sources is processed, this remains an unresolved issue [10]. [10] review Semantic Web-Based Context Management (SeCoMan) where privacy protection is achieved at a 'location limited level'.

The concept of the My Remote in the home has a certain ability to be context aware, something that is enhanced when the My Remote is integrated into the smart home. Therefore, there is a large amount of data that will be generated from device different devices around the home and according to [11]. Specifically, raw data from context-aware computing can be valuable and understandable if it is collected, modeled and reasoned [11].

C. Middleware

The large amount of data has been attributed to advances in sensor technology which has led to large scale deployment. However, this has led to large amounts of data being generated which is too difficult to manage in the traditional application-based approach (where sensors are connected directly to applications) and the solution to this problem is middleware IoT device [11]. There are a range of capabilities of the IoT middleware including interoperability, context-aware, Discovery and Management of Device, control data volumes, privacy and security.

An important consideration of the problem of processing large amounts of data in the cloud that has been generated by numerous sensors in a smart systems, has been addressed by [12]. In their study, they say that although pushing data to the edge, or Fog computing, may be a solution to the limitation posed by the cloud, this solution has limitations in terms of limited computational capabilities and a proposed solution combines Fog with the cloud to take advantage of the strength, and alleviate the weaknesses of both [12].

D. Security and privacy

The My Remote concept is designed for children and it generates a large amount of data about children, and therefore, security and privacy is an important consideration. [11] say that security and privacy is a serious issue in context aware computing which has been intensified by the IoT paradigm, where such data includes physical and conceptual data which includes preferences, location, medical information and calendar data.

In the My Remote concept a certain amount of data is processed in the cloud, but holding personal data in the cloud create privacy risks for the data's subjects [13]. Due to the aforementioned privacy risks associated with the cloud, [13] suggest that computation should be done with the data rather

than moving the data to the cloud in order to reduce privacy risks. However, this brings significant challenges in terms of resource constraints of devices in the IoT because of the limitations of processing locally.

E. Localized data processing - The benefits

Another advantage of the local in-network level processing of data is that the data is isolated from the Internet, because it is processed locally[14]. In addition, in our smart remote in the smart home, the network will consume high volume of data which will show limitations when sending everything to the cloud for data aggregation. This might be even worse while applying data fusion for image [15]. In this case, the distributed data processing will play an important role to fuse the data locally, and then send the processed data to the cloud for further processing. This will reduce the data transmission cost over network.

III. DEVELOPMENT OF THE CONCEPT

The main intention of the concept is to connect the My Remote to the Internet of Things, so that its functionality is extended from a device that simply helps to manage children's lives to a device that processes and shares data about the children through the Internet. The information that is shared with the various parties is limited. Therefore, towards understanding what data can be shared and what data should be protected it was necessary to reveal the opinions of parents.

The My remote is intended for use in both normal and smart homes. Where the My Remote is used in the smart home it will be integrated into existing smart home functionality. Therefore, there was consideration of existing functions of the My Remote that can be implemented using smart home functionality, and consideration of existing smart home applications that could be relevant to managing the child in the home. The fridge for example is something that now integrated into smart home technology and in our current study would be useful in managing the child's eating and drinking habits. Current smart home fridge technology monitors use of food stuff in the fridge. This can be integrated with the My Remote to monitor what children drink. For example, parents can set their preference for their children to drink more juice and milk and less fizzy drinks and the fridge smart home application can manage this. Moreover, in reference to data that is shared for marketing purposes, this application can send data to the relevant parties such as family doctor, factories and for enhancing research purposes.

A. Interviews with families

Towards the further justification and development of the overall concept it was important to gather the opinions of those parents. Specifically, there is a need to know what parents' concerns are about data related to their children's activities being shared with healthcare professionals, teachers and companies. Additionally, the proposed solution is an essentially a device that will have a lot of information about a child and will be involved in various aspects of the child's life in order to manage the child better in the home. Therefore, there will be a significant amount of data that is sensitive that parents would not be comfortable with being processed in the cloud or being shared with various parties. Thus, it is the aim of the research methodology was to reveal concerns of parents. Therefore, a semi-structured interview was chosen. This interview included questions to reveal opinions about the overall proposed concept, the associated concerns of parents, privacy concerns and opinions about data use including processing and data sharing.In total, 56 interviews were conducted with families who have children in the Leicestershire county in the English Midlands of United Kingdom.

IV. MOTIVATING SCENARIO

a) Children activities at home: in this section we will give a scenario where children's activities are monitored, tracked and controlled in a smart home environment. The smart system includes smart objects, smart remote, fog (IoT Device), other parties using the approved data to share and mobile application. We assume that there are a number children with different age groups and their parent are set preferences for each of them, so the parent are the administrator of the system. The house has several smart objects including smart fridge, smart coffee machine, smart thermostat and smart TV, and smart remote.

The parent can set the children's preferences by using either the mobile application or smart remote. For example, the children can watch TV for two hours, when the children open the TV the fog computing will send information to the smart remote, then the smart remote will send the preference which is close the TV in two hours. The fog will process the data locally and send the important information to the cloud such the TV opened and closed at certain time for future use. When one of the parents out range of the home, then he/she can control, monitor and track remotely by using mobile application.

b) Monitor and Control Home Remotely: In the absence of the family members, there might unintended movement at home, temperature problem, forgotten opened devices which can cause to disasters. To tackle these, there is a need to smart home system without user intervention. The parent can check the status of the home remotely by using the mobile application. They can use the application to check for example if there any movement in the home or if there any devices forgotten open. Therefore, the mobile sends request to the cloud and the cloud forward this to the fog device in the home, then as the fog has the capability to sense and act it replies to the user if there is a movement int the home or not and for the other example the fog will replay if one of the home machines are forgotten open or everything is fine. In case of problem, the fog will immediately send the issue to the parents even if they did not request which is important. The fog process the data locally and sends only the important data if there is no request from the parents, but in terms if there is any request it replies immediately to the parents.

V. APPROACH TO THE DESIGN

Understanding the function of the My Remote is essential to understand how it can help in managing the child in the home, produce data that can be used by various parties and how it can be used in the home and integrated into the smart home. The Remote Control platform is based on our previous My Remote [16] with the additional inclusion of IoT middle-ware for devices with resource constrained that allows to combine and process the receiving data from distributed sensors in the home without programming efforts.

A. Functional of My Remote

The My Remote is a hardware device that monitoring television viewing for children for the purpose to protect them from inappropriate content appears on the television. It also monitoring viewing time and keeps children at a proper distance from the television screen. For security purposes, the remote control device is activated by a fingerprint recognition system. There is an emphasis on the overall creative design of the remote, to consider the practically and ergonomically of the design and interactivity through the use of a sound, screen and lights.

This design has technical innovation and aesthetic innovation. There are three elements of the design which are 2D which is the graphics on the screen, 3D which is the shape of the remote control and 4D which is about the functionality, each of these will now be presented individually.

The remote control is also designed to encourage children and educate them with the use of an interactive element, this is a voice that supports the child when they choose a correct channel, and lets them know when they choose an inappropriate channel. This will form part of the 4D element. The fingerprint recognition system allows each child and the parents to have their own profile set up on the system. A parent can use their fingerprint to open the settings menu and the child's fingerprint will be able to change channels and volumes as well as activating that child's profile.

The design incorporated a 4D element in the form of a feedback mechanism. These feedback mechanisms help to solve a number of problems which were identified in the research. When a child switches on the remote by activating the fingerprint recognition there is a welcome screen. If a child is sitting to close to the television when the child switches on the remote control it will ask them to move away from the television, when they have moved back the remote control will give them feedback and tell the child that they can now watch the television. A very important part of the remote control is that it can control the content, so if a child chooses a channel they will be told if it is a good or bad channel.

Also, it is a problem that children watch too much television so the remote control will give them feedback about their viewing time. Children also like to have the volume too loud, this will affect the atmosphere in the house; therefore, the remote control will teach the children to reduce the volume which also teaches them good manners to respect other people in the house.

Moreover, there will be an automatic warning to log out of the remote control after a set period of time, if no one logs out the device will automatically log out this person. The reason for this is because maybe an older child is logged into their profile and then they leave the room and a younger child enters the room they will be able to view programs that are not suitable for the younger child's age. If for example a child logs in again to the system and they are again too close to the television the system will ask them to move away from the television. Overall, it is not only the intention of the remote control to control content but also to educate the child indirectly about good behavior.

Mood Lighting : Another 4 D aspect was the lighting of the remote control, these different color lights create the mood of each of the feedback response; for example when a child is not allowed to enter a channel the light will turn red, when they are given a positive comment such as the distance from the television being enough the light will turn green and yellow is a neutral color for general actions such as the time. The My Remote also has gender-specific themes, this includes different graphics, sounds and colors for boys and girls. Moreover, the My remote has a vibrate function as part of the 4 D experience.

Additional features of the My Remote include that it is multilingual, offers functions to help children with prayer times and teaching them morals and positive behavior as well as personal organizer functions such as a calendar and reminders about important days such as national holidays and reminder to take medicine and also television reminders about favorite programs. Moreover, the My Remote offers a function that will manage childrens school work and is integrated into the school homework portals and is accessible to parents.

Television viewing has been held responsible for obesity in children; therefore, the My Remote includes a function that manages childrens exercise and healthy eating. Moreover, children can receive updates about their favorite sports teams. Additionally, the remote will include a temperature and heart rate monitor that can be used by parents.

Not only does the My Remote manage television viewing it can also control other devices in the home such as computers and games consoles. Furthermore, the My Remote can be integrated into smart home systems to manage user preferences such as controlling volume or time allocated for playing games. Because the My Remote contains a large amount of user data and user preferences it will use cloud backup technology, this will be useful in the event that the My Remote is damaged or lost, or when newer versions are released.

B. Proposed Architecture using the Internet of Things

In this section, we demonstrate the structure of smart home system which includes smart home devices, my smart remote, Fog node (the IoT middleware device), and cloud. In addition, there will be smart phone application that can monitor and track the activities and devices at home remotely. The functionalities of the My Remote has been discussed in the previous section. In terms of communication wireless

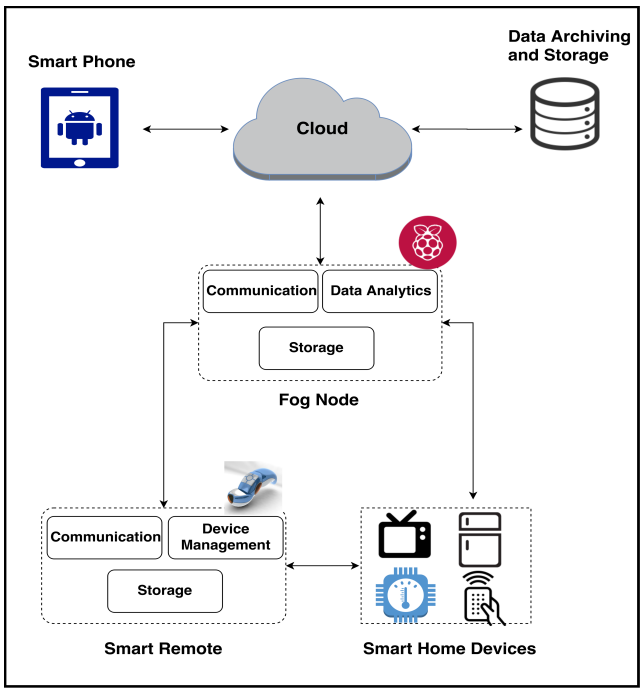

Figure. 1: Smart Home System Architecture.

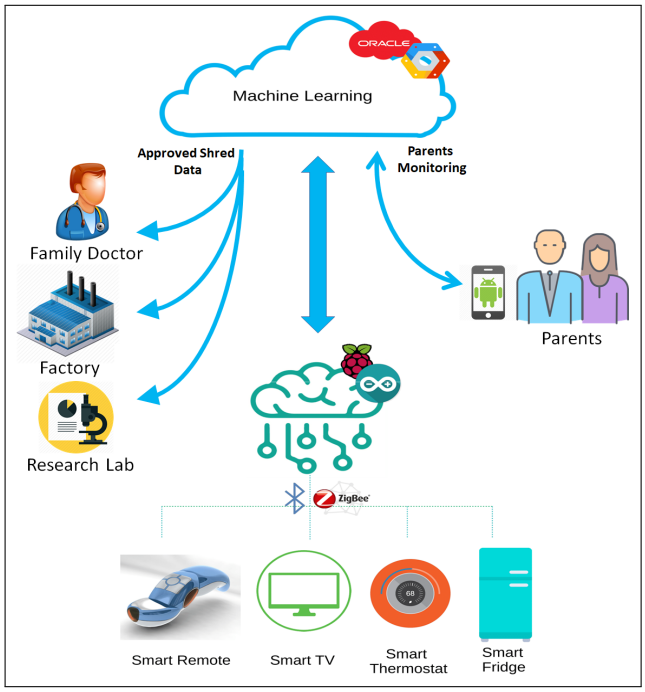

Figure. 2: Functionalities of Smart Home Management.

communication is used between sensors and smart objects based on technologies such as Bluetooth, ZigBee and WIFI.

We propose an approach that will split the processing between the cloud and the fog. Firstly, we are processing sensors data in in-network level (fog middleware device) particularly applying data filtering and data fusion techniques to minimize the data volume before sending to the cloud. Fog will act as IoT middleware which will handle communications between devices, data analytics, privacy and security. Then, we send the transformed data to the cloud for further analysis and processing by applying machine learning algorithms.

"Data fusion and mining present an efficient way to manipulate, integrate, manage and preserve mass data collected from various things" [17]. Data Fusion is a technique that integrates sensors data to minimize, enrich and have the full picture of the environment. In addition, it reduces the sensors data by using most common data aggregation techniques such as moving average, Binned distribution, absolute average and other Algorithms to extract features which will be sent to the cloud. A good illustration of this is in [18] performed an experiment to show how effective is applying data fusion techniques on the raw data before sending to the cloud for minimizing data volume while maintaining the accuracy as much as possible. In this case, we are not sending all the raw and useless data to the cloud which will improve the data processing process in the cloud.

Most homes in the world have appliances and devices such as fridge, TV and so on. Recently, some of them have a smart system in terms of showing the status of device, monitoring and controlling the device. However, they do not analyze the data that is hidden in daily activities at home. Thus, some people might argue that just turning on and off the devices remotely is not smart enough. Therefore, it is important to have a smart home system that deals with these issues and understand the environment better to give good services to households. The smart home will be equipped with Fog, Smart Remote, Smart Home devices and sensors. Figure 1 and 2 show the architecture and functionalities of the system respectively, and the details are explained below.

a) Smart home devices: These devices including smart fridge, smart coffee machine, smart TV and smart thermostat have built in intelligence by most of the famous companies, they can sense and act for specific purpose. For example, in smart fridge, it is possible to know what is inside the fridge by built in sensors. In addition, it is possible to get data like no milk, no cheese and others householders need. In following section, there will be scenario to show how these devices are involved in a users daily life.

b) Smart Remote: The functionalities of the My Remote has been discussed in the previous section. However, in this section, the smart remote concept is introduced and how the functionalities of smart remote are connected to the fog and smart home devices is discussed. The smart remote has the capability to monitor, track and control the devices at home by getting information from the fog. It can be considered as a mediator between the user and the fog. This means that the functionalities of My remote that are discussed in the previous section will be feasible because the smart remote will get information from the fog, then according to the preferences it will provide the features to the users at home. Moreover, the smart remote will continue working without the Internet inside the home because it gets the data from for locally.

Furthermore, the Smart Remote can control all the sensors and can send commands to every component inside the home through the fog node.

c) Fog Node: The fog is the main component of the system which acts as a middleware to help the users to do their daily activities easily. It communicates with all sensors, smart home objects, smart remote and cloud. In the fog, we focus on data filtering and fusion techniques which helps us to enrich and minimize the data before sending to the cloud.

d) Cloud Node: As one of the enablers of IoT the cloud is important because of the unlimited power and global view. The cloud will get the processed data to create inferences by applying machine learning algorithms. This step is crucial for training the data for future prediction and other purposes. Moreover, the cloud is important for remote control, monitor and track.

e) Smart Phone Node: parents outside the home will use a mobile application. It became a crucial requirement in most worlds including cyber, physical and social to get benefit of the smart phone. The mobile application will help parents to monitor, track and control the home remotely. For example, one of the parents uses the mobile application to monitor his/her home from outside the home by checking the status of the home such as if there is any suspicious movement in the home. And also to monitor their children behaviors and habits in the same time.

VI. RESULTS

Parents were interviewed to reveal their opinions and concerns about the proposed concept and also to reveal ideas and justification for the development of the concept.

In terms of their concerns, privacy was found to be the most important, all of the parents mentioned that they were concerned about data about their childrens behavior was being given to outside parties. The researcher probed further into this concern in order to find out if it was concern about the outside parties themselves having data about the child, the responses showed that they were fine with this as long as security and privacy were assured and only necessary and anonymised data was shared. The real concern was unauthorized, unknown parties gaining access to data about their children. Therefore, providing the external parties with data that parents approve of would be fine as long as there were security and privacy assurances provided.

These expressions of security and privacy concerns justify the two main elements of the proposed system which are first, to process data locally rather than in the cloud for added security for children as well as efficiency in data processing, and secondly, the distribution of data to authorized external parties in a safe and secure way.

Other views that were raised by the parents were associated with the concept itself. Some of the parents, in addition to the type of data shared, were concerned about the extent to which the My Remote managed childrens lives. Generally, parents were not concerned about controlling viewing content, time spent on video gaming, organizing and reminding children about homework and monitoring their eating and drinking habits, these were all seen to be beneficial by the parents. However, where there were concerns were in relation to ideas about monitoring movements around the house, when children come and go from the house and information about external activities and their timings.

VII. DISCUSSION

The previously developed My Remote has been extended through a new concept, namely the My Smart Remote, through integration into the smart home. Through this integration into the smart home the management capabilities, designed to manage and improve the daily lives of children, have been extended. This has been achieved through connecting the My Smart Remote to existing devices in the home.

In the development of the concept there were a number of problems that were successfully overcome. Specifically, these problems included the security and privacy that should be afforded to children by such a system, and problems associated with the processing of large amounts of data which is also sensitive. Both of these problems were overcome by a solution that retained data to be processed locally.

The smart home data management system is a provided way to tackle with high energy consumption, high data consumption over network. One of the main advantages of the system is that less user intervention is required which means it is automated. Additionally, using distributed data processing will increase the privacy by analyzing data locally before sending to single source which is cloud. However, using our approach on wider scale might result in variety trade-offs such as involving with localized processing or dealing with the cloud more. It is notable that there should be balance on cost of resource, data and energy consumption. After discussing the strengths and weakness of the system, we can say that it is convenient for smart home systems. However, it might be expanded to different smart city projects by adapting the architecture to deal with different applications. We are planing to implement data fusion approach depending on Java platform, then we are going to evaluate the energy consumption, bandwidth usage and accuracy of fused data.

VIII. CONCLUSIONS

Here a concept has been presented and therefore, the future direction is to actually implement the My Remote into a smart home system. Initially, this would include the assessment of current smart home technology that would be suitable to manage the functions of the remote.

This paper has considered an architecture to manage the data that are hidden in the home to improve the lifestyle of individual at home. The most obvious finding to emerge from this study is that we proposed a data processing approach that can be added to a middleware IoT device which can process sensors data in localized way before sending to the cloud to give the owner of the data a full control of the data. Also, to reduce the consumption of energy and data. We showed the proposed architecture our system and its relevant functions. In

addition, we gave a scenario to show how our work maps to the architecture.

On the basis of the promising findings presented in this paper, work on the remaining issues is continuing and will be presented in future papers. Future work will involve developing the data fusion approach and produce results to test them. Finally, creating a mobile application that will allow users to interact with the system remotely and easily. Overall, the My Smart Remote takes advantage of the IoT to improve the lives of children in a safe way, not only through managing their daily lives but also through the development of tailored solutions by external parties.

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