IoT-enabled Smart Child Safety Digital System Architecture

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Abstract – Safety of a child in a large public event is a major concern for event organizers and parents. This paper addresses this important concern and proposes an architecture model of the IoT-enable smart child safety tracking digital system. This IoT-enabled digital system architecture integrates the Cloud, Mobile and GPS technology to precisely locate the geographical location of a child on an event map. The proposed architecture model describes the people, information, process, and technology architecture elements, and their relationships for the complex IoT-enable smart child safety tracking digital system. The proposed architecture model can be used as a reference or guide to assist in the safe architecture driven development of the various child tracking digital systems for different public events.

Keywords – Digital Architecture; Internet of Things; Salesforce; GPS Tracking; Android Application.

I. INTRODUCTION

Public community events has always attracted children of all age groups. While these events have been entertaining to children, parents must be on a close look-out so that they don't miss out on their child's whereabouts in crowded places. It is a common practice to attach paper label, with their contact information, on the child's wrists or provide the child a cellphone to contact in an emergency [1]. Despite these measures, keeping children safe in a public event is extremely challenging and is one of major concern for event organizers and parents. The research question is:

RQ: How to effectively ensure the safety of a child in a large public event?

This paper addresses the above mentioned important research question and proposes an architecture model of the IoT-enable [2] smart child tracking digital system to assist with the safety of a child during public events. The proposed model includes a number of technologies from the digital ecosystem such as IoT (Internet of Things), Cloud, Mobile and GPS (Global Positioning System) [23]. The structure of this paper is as follows. Firstly, it discusses the research background and related work. Secondly it discusses the research method applied in this paper. Thirdly, it presents the proposed smart child tracking digital system architecture model. Finally, it concludes with a discussion on further work in this important area of research.

II. Research Background and Related Work

This section provides the research background and discusses the integrated digital ecosystem of Internet of Things (IoT), Cloud, Mobile and GPS technologies followed by the design science method applied for this research.

A. IoT and Cloud Technology

The concept of IoT is getting significant attention from both researchers and practitioners [24]. The history of IoT can be traced back to 1990s, when Kevin Ashton projected the idea of "network of objects" (to be Internet of Things) and mentioned that "Things" are interconnected to the "Internet" with minimal or no human interference [2][25]. Once things are connected to the Internet, data can be collected through sensors and labels based on the certain constraints. The collected data then cab be processed and analyzed for extracting useful information or insights, which can then be delivered to interested stakeholders or users or systems [3][26].

Cloud computing provides a platform to accommodate virtual infrastructure that allows necessary computing along with the integration of IoT devices [21]. Cloud computing offers a range of software, platform and infrastructure services that can be provisioned on demand for the collection, storage, processing and visualization of the IoT-enabled smart system data.

B. Mobile and GPS Technology

Modern digital systems go beyond traditional computing and include a number of portables and smart mobile phones, with WiFi and 4G Internet access, for souring, processing and disseminating data. There is constant increase in the use of

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smart mobile phones, which allow the availability of various mobile applications that can be connected to a range of IoT devices, cloud for real-time situation awareness and analysis [4][27][28].

A range of digital technologies have been proposed for estimating the position of an object, which is known as a location based services (LBS). GPS is one such service that is offered to determine the geographical location of an object. An important aspect of GPS is its ability to accurately determine an object ranging from 15 – 100 meters [7]. There are a number of use case of GPS such as GPS is used in Fleet management, scientific research, navigation, law enforcement, health and fitness [8]. Cars have been designed with in-built GPS devices that assist the driver in finding the best route from location A to point B. Scientists use GPS to measure earth's atmosphere, monitor volcanic activities as well as calculate the movement between arctic sheets and tectonic plates [9]. GPS can be used to monitor the movements of people who suffer from Alzheimer's and dementia [10]. Offenders released on parole can be also be monitored with the use of ankle monitors that determine their geographical position [5, 11]. GPS can be used as a performance appraisal tool in sports that can closely monitor the movements of a player in game [12][33][34].

Location tracking of the child in a large public event is one of the key aspect of this research. We propose that GPS technology can be used for child tracking as well [13-17]. When children are outdoor, there is a natural drive to freely move around. This free-spirited behavior will provide room for safety concerns. It's a natural tendency for parents to feel that their children need to be safe. Thus, we can use GPS technology to track the location of a child in a large public event [5]. Location data can be collected, stored, processed and shared via integrated cloud and mobile applications.

III. RESEARCH METHOD

The purpose of this research paper is to develop an architecture model to support the situation-specific development of the various smart child tracking digital systems that ensure the safety of a child in a large public event. Design research (DR) method [6] has been applied here to develop the proposed architecture model [6][29][30][31][32]. DR method is considered appropriate when the research is about generating an artefact, which is the proposed architecture model in our case. DR method covers both the development and evaluation aspects of the artefact.

IV. SMART CHILD TRACKING DIGITAL SYSTEM ARCHITECTURE MODEL

In order to address the child safety concern, an architecture model for smart child tracking digital system has been developed based on the earlier work of James Ward [18]. James work is mainly about multi-sensory application that assists in tracking rental bikes. However, here, our context is different and focuses on tracking of child. James work provided us a starting point and foundation to enhance his work and build the proposed architecture model, which has following major elements:

- People
- Information
- Process
- Digital Technology

Figure 1 provides an overall integrated view of these four elements in a conceptual architecture model.

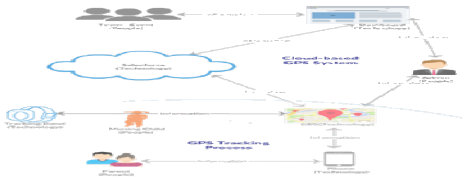

FIG. 1 CONCEPTUAL ARCHITECTURE MODEL FOR THE SMART CHILD TRACKER DIGITAL SYSTEM

A. People

Figure 2 details the key people or stakeholders of the system. Parents are the smartphone users who can monitor their child's activity. This is supported with an android application - that maps out their child's geographical location in an event. Children are the point of interest and wear the tracking device during the event. Event Organizers are the tracking service providers who can be further categorized based on their role and involvement with the system and event, i.e. Salesforce Admin, Event Staff and Volunteers.

Fig. 2 People: Key Stakeholders

B. Information

Digital technology connects people with the information. Information is a key element in our proposed digital system architecture. Figure 3 presents the data model that was created in the Salesforce cloud for capturing the relevant information. Master-detail and look-up relationships for various data objects are discussed below:

Master-detail relationship created between:

- Child Information and Child Registration.
- Child Information and Parent.

This master-detail relationship is more of a parent-child relation. For instance, if the record of a child registration is deleted, then the corresponding records related to it are also automatically deleted.

Look-up relationship created between:

- Tracker inventory and Smart Child Tracker.
- Child Registration and Smart Child Tracker.
- Event and Contact
- Staff and Contact

Unlike the master-detail relationship, a look-up relation has no effect on the deletion of a record. Thereby, allowing the admin to retain certain sensitive information.

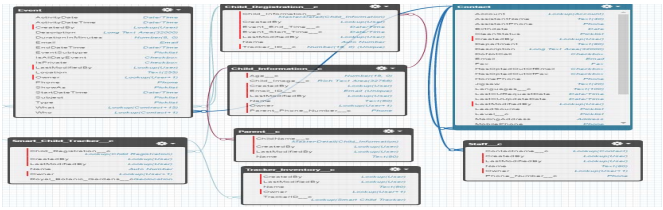

Fig. 3 Data Model

C. Process

Figure 4 presents the process element details of the proposed architecture. Process element demonstrates the necessary steps that need to be considered for child tracking. This process and related stapes are created based on first-hand observations and experience during a missing child situation while volunteering for VIVID Sydney-festival of lights in 2016.

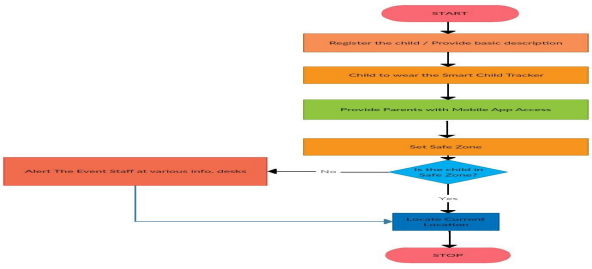

Fig. 4 Process

Step 1: Events need to hold a registration desk that will allow children to be registered. A record is created on a Salesforce cloud application that holds the child's personal information along with the child's picture (see Figure 3 for data model).

Step 2: Upon successful registration of a child, a GPS tracking band is placed on the child's wrist.

Step3: Parents are provided an access to an android application which is installed over their smartphones.

Step4: Based on the activities offered in the public event a desired safe zone is set. The purpose of constructing this safe zone is to closely monitor a child's activity. If the child is in the safe zone the real-time tracking would continue to return the current location of the child.

Step 5: But if the child gets off the safe zone, an alert needs to be sent to the event staff at various information desks who can accordingly to retrieve a missing child.

A. Digital Technology

Digital technology is the key enabler of the proposed smart child tracking digital system. The technologies opted for the proposed architecture are:

- Salesforce Cloud (IoT-based cloud platform)
- Android Mobile Application
- GPS Technology

Salesforce: An important aspect to be considered is the data storage. These days, cloud technology has been widely accepted for remote data storage. Cloud's data storage has been selected because it is more appropriate to address the concern in hand in contrast to the locally relied data storage. Cloud platforms such as Salesforce cloud allows scalability for data storage and its access via Internet. This enables the Internet connected devises and applications to easily access and share the data about the child location from anywhere [19-20]. Real-time GPS information about the child location is transmitted to the Salesforce cloud, which is monitored by a system admin as well as by other employees.

Fig. 5 Android Mobile Application Wireframe

Android Mobile Application: An android application has been included in the proposed architecture. This would allow parents to closely keep a track of their children's activities during the whole time they are present in the event. Figure 5 shows the screens that can be designed and developed to deliver a simple, yet a very useful android application and user experience. Including the application screen, a total of seven screens are listed. Login Screen allows the user to enter the login credentials, which is provided at the time of child registration. Home Screen contains two main icons

GPS Module: Adafruit released a version 3 of ultimate GPS breakout. Based on our research, we found that this GPS chip (shown in Figure 6) would be appropriate for child tracking because of its low – power consumption, high- sensitivity receiver of-165 dB, built-in antenna - that allows up to ten location updates [18]. While this powerful chipset costs only $39.95, event organizers can have a bulk purchase discount from economy scale perspective.

Fig. 6 Adafruit's GPS Breakout V3

V. EVALUATION, DISCUSSION AND CONCLUSION

We performed a walk through and peer testing of the proposed architecture model and its four integrated elements of people, information process and digital technology [22]. Based on this initial evaluation, it can be stated that proposed architecture model is simple in design and thus it is easy and cost effective to extend and implement according to the needs of different stakeholders.

It is anticipated that the proposed integrated digital technology architecture such as the Salesforce cloud, Mobile Application and GPS can be easily used for tracking a missing child in an event. This work is a first steps towards the development of a working software for a Smart Child Tracker. There are a number of options for customizing the architecture such as the use of tracking pin, which can be easily clipped on to the child's clothing. Thus, future researcher can be conducted to analyze alternate tracking options and architecture design patterns that could replace GPS with low cost RFIDs or iBeacons. For instance, RFID tags can be a very good option for active tracking.

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