Runtime Tracking System for Student Security, Performance and Attendance in the Smart Schools of Saudi Arabia

Amr Jadi

Department of Computer Science and Software Engineering
University of Hail, Hail, Saudi Arabia
a.jadi@uoh.edu.sa

Abstract—The Smart School concepts are introduced in Saudi Arabia (SA) for a long time and due to various factors still the progress in this direction is very little. In this paper various issues, limitations and constraints are discussed. By considering various real-time factors a runtime monitoring system with checker is presented. Various policies and rules are tested for a smooth performance of smart schools to give a realistic approach which suits for the environment of SA with respect to culture, religious sentiments and traditions. A sensory based robotic device was tested earlier to monitor the premises of a school environment in terms of fire accidents, temperature tests and pollution ranges. This research established a policy based rules to ensure fast and wide range of communication with custodians so as to ensure the safety of students and kids are at top priority. These policies are working as a middle ware between the database of smart schools and the hardware devices.

Keywords – runtime monitoring; security; tracking; performance ;attendance; smart schools

I. INTRODUCTION

The government of Saudi Arabia (SA) is constantly motivating the citizens to educate the children with useful technologies and striving hard to enhance the standards of education to compete with global demands. Recent crisis for oil in the Middle East have an impact on various policies, budget allocations and overall restructuring process is being considered in almost all governing departments. Apart from that, increasing challenges due to terror activities in the Middle East is considered to be one of the serious concerns to protect its citizens, pilgrims and children at schools. Directly or indirectly the students in various institutions are being affected seriously. Overall war like environments along with the extremist people trying to attract the youth into anti-national or anti-social activities seems to be a greater challenge for the educational institutions and parents to track the students and their performance. The security of the students along with their performance and evaluation became an important area of focus to be considered in present regional conditions. Usage of internet applications using mobile phones by parents and kids can ensure a speedy updating process towards security and performance report updates. Recent reports of UNICEF on SA reveal the literacy rate of 99 and 97 percent by male and female students respectively and usage of mobile phones also seem to increase by 185 for each 100 people [1].

Many schools functioning in SA to achieve these goals are failed due to lack of proper planning and security issues. Apart from that, these schools are lacking with appropriate tracking and communication systems. Most of the schools are focusing only towards integrating the teaching and learning methodologies; but are found to be performing below the range of expectations. The government of Saudi Arabia spending huge amounts in the area information and communication technologies (ICT) for improving the technological infrastructure [2]; however, the increasing threat of accidents, terrorist activities, etc. demands more security and tracking system for the students, their performance and activities at various levels. Such demands can be fulfilled by various applications of ICT in an efficient manner. Almalki and Williams made several recommendations for integrating the primary schools of KSA using ICT [2].

Another major drawback identified is to improve the communication between the parents and school staff. Various reports highlighted the communication as a serious problem due to uneducated and working parents from different parts of the country. Here in this research possible method to build a smart school for obtaining the better results is proposed. Such smart school helps the parents to know each and every activity of their ward in terms of their progress in studies, attendance, time-tables, learning outcomes, activities, etc. of the school. Also the proposed method helps the parents and teachers to safeguard and monitor the children from any sort of accidents, disasters and thefts.

A. Background

The school system in SA is classified into five major categories as: i) Primary, ii) Middle, iii) Secondary, iv) Vocational and v) Tertiary. As per the reports of UNESCO the percentage of both boys and girls is about 99% and 96.3% respectively [1]. However, these percentages are decreasing rapidly in the case of girls by the time

they reach middle education by 47 % of total 95.9%. This case is getting more worst at the time of secondary schools as the enrolment rate is still dropping to 91%. Considering such records the government of SA is trying seriously to get more number of educated citizens for a bright future of the country. Due to recent oil crisis the overall population of SA is about to depend more on various technical jobs and business institutions to ensure a stable economy for which the SA government is establishing more than 150 vocational training institutions with an overall target of creating more than 3 million jobs in Kingdom of Saudi Arabia (KSA) within the next 10 years. However, increased threat from various wars like conditions in neighboring countries generated a threat to the students visiting various educational institutions in KSA. Especially the girls are being targeted by various extreme terror groups and boys are being influenced for joining terror activities. As a whole the students learning environment in the schools is under a serious threat. Now it is the high time in KSA and the government needs to motivate the citizens to educate the children and providing a secured environment.

Now the other important area to address is about lack of awareness of student performance and attendance by the parents (i.e. lack of communication, awareness, etc). Most of the students ignore their education or activities at the primary level due to various reasons such as guidance at home, lack of educated parents or siblings, etc. make the students more ignorant towards their studies and performance in the schools. Such uncontrolled habits lead to more number of dropouts at the very early stage and it needs to be addressed seriously.

B. Motivation

In the recent times, many cases of student missing were reported in KSA and other neighboring countries. Various reports and news reveal that KSA needs to establish a stable environment for the students and the consistency must be maintained throughout the country to maintain literacy percentages. As a whole nation decrease in the literacy rate of both boys and especially girls is a matter of serious concern and precautionary measures at this level is a must for a culturally rich nation like KSA. To avoid worst scenario's for the coming generations it is better to design, develop and implement more number of smart schools, by which students, parents and teachers feel that they are in safe environments.

II. RELATED WORK

Smart Schools are proposed and are functioning effectively in various Western and Asian countries irrespective of their global status in terms of development. Due to religious extremism and cultural limitations many people criticized, ignored and opposed the concepts of smart schools in the past. However due to the impact of globalization, modernization and socio-economic crisis people started realizing the importance of withstanding to the competition by adopting advanced technologies in the area of education. Such initiation to use ICT was earlier taken by a country like Malaysia where majority of population follow the Islamic rules [3]. A step towards developing multimedia educational (ME) content based on local languages was initiated to communicate effectively with local communities and students. Similar attempt was made by Soltani and Aliyev in the same direction with a detailed analysis of smart schools features, characteristics, advantages, limitation, etc. using ICT [4]. The barriers related to the development of smart schools were explored and a special attention was given towards cultural beliefs, societal priorities and communications among teachers and parents.

However, to establish a safe environment for the students, teachers and staff at the schools was not included in the above discussions and proposing a model in this direction is fruitful. Such a scenario can be obtained from the system proposed by Shigeta *et al.* [5]. The smart office system proposed can recognize the individuals, their mental and physical states so as to ensure necessary requirements at the school premises. The arrangements of devices proposed may be an expensive deal in the current circumstance but few of the modules can be utilized. Later SMART Table technology using ICT was introduced by Almalki *et al.* [6] to improve the flexibility and to assist both teachers and students. The authors strongly recommended such strategies at national level for the benefit of education system in SA. However, their focus was limited to assist within the school environment. Various threats due to environmental changes, child kidnappings, disasters, etc. were not focused in the early stage of smart school evolutions.

In a country like SA, the energy consumption is also another area of consideration as the temperature will be very hot and a strong review on the energy conservation is very important. To run a smart school successfully constant energy supply is needed to operate the air conditioners, computers, etc. A technology to visualize the energy consumption was developed by Kuzume and Okada can be promoted as an important tool for energy saving [7]. This tool helps to improve the energy-saving activities, reduce the price and complexities involved in constructions. Additionally it also includes a warning system to turn off the lights, and air-conditioners when no one is around. Also includes remote maintenance and monitoring system with easy operational approaches.

There are varieties of systems available in the market such as barcode and smart card systems to track the kids and staff in a school environment. However these systems cannot track the exact location person within the school premises. To deal with such scenarios radio frequency identification (RFID) technology is more suitable and can also ensure the security of students and staff with regular updates in a runtime environment. RFID tag detection system using a smart antenna was introduced by Khanam *et al.* [8] to provide updated information to

all custodians (see Fig. 3). This technology will help in the detection, monitoring and communicating effectively. However, RFID systems need a careful optimization technique to maintain the distances from the reader for efficient tag detection. Similar attempt to secure and safeguarding students was made by Sunehra *et al.* using a monitoring system based on Google maps using global positioning system (GPS) [9]. This child module was built on ARM7 LPC2148 Microcontroller and a commercial GPS receiver will compute position of child continuously. The school monitoring system consists of global system for mobile communications (GSM) along with a database using Visual Basic 6.0. The advantage of such system is to cover long range as compared to the RFID systems and provision of faster communication using SMS, emails and voice message alerts is flexible irrespective of distance and location. For group detection and tracking the environments of schools and gatherings Li *et al.* suggested location-based services (LBS) for better monitoring system [10]. Similar attempt to monitor kids using wireless, wearable nodes to help the parents is suggested by Giovanelli *et al.* using Bluetooth low energy [11].

Monitoring the kids and staff will not ensure the objectives of smart schools; but the need to monitor the events and laboratory environments is also an important area of consideration. In this direction an event monitoring system based on various sensory device applications was suggested by Novitskaya *et al.* [12]. Such systems will ensure the safety of school environment from various accidents (viz. fire, short circuits, etc.) and helps to control some of the abnormal events (viz. overflow of water, gas leakages, etc.). Similar experiment to ensure air quality in the school surroundings was carried out by Ali *et al.* [13]. Solar powered ZigBee based wireless sensor network system was used to monitor the real-time data of carbon monoxide (CO), nitrogen dioxide ($NO2$), dust particles, temperature and humidity. Such an arrangement is very much helpful and needed in deserts like places of SA.

Now the smart schools need to use the technology and devices very effectively so as to ensure that the students are convenient and happy to use. Most of the students at university levels are efficiently using various electronic gadgets but the challenge is with respect to the children at elementary and primary is a serious challenge. Amin *et al.* proposed a smart wearable learning technology for the students (~84%) at school level considering the improvement of time spent (~31%) in a day to play games and watch various programs [14]. There are various electronic goods such as mobile phones, tablets, digital books, watches, etc. are the source of information and communication. In traditional learning the assessment process will be limited to the periodical assessments and Attia *et al.* suggested various impacts of tablet based learning and suggested to have a continuous assessment (CA) process in the schools and educational institutions [15]. Role of internet of things (IOT) in such practices to reach most of the students by motivating them for learning new subjects in the schools were critically experimented by ur Rahman *et al.* [16]. IOT plays a key role in connecting all the things together for establishing an efficient smart school which is self-controllable.

III. EXISTING EDUCATION SYSTEM IN SAUDI ARABIA

There are so many limitations in the present model of education system of KSA are given in Fig. 1 is based on following four categories:

- *Students*: influenced by environmental factors
- *Parents*: influenced by socio-economical factors
- *Teachers*: influenced by institutional factors
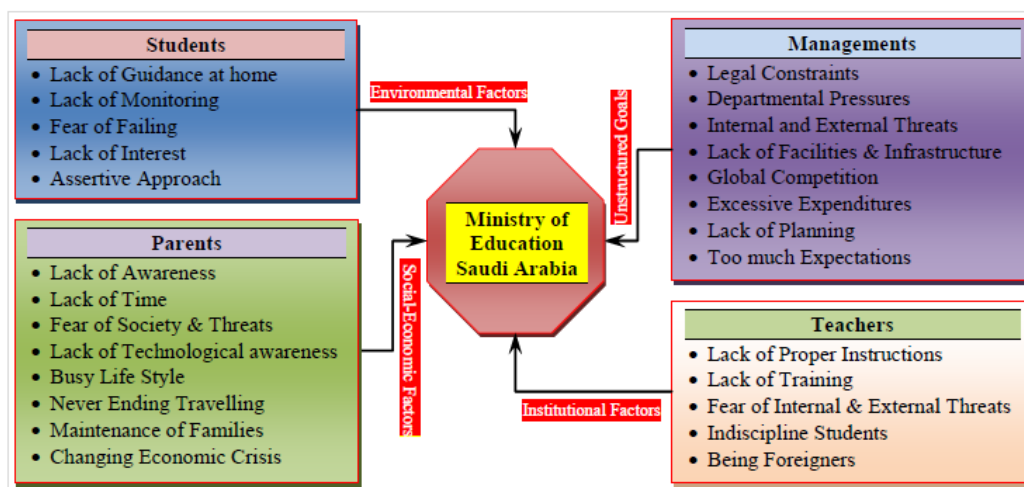- *Managements*: influenced by unstructured goals

Fig. 1. Constraints in the Existing Structure of Educations System in SA

Each and every entity in the above discussion is having independent issues which are in some way related to other entities; however, they are influencing the education system of SA as a whole nation. The urgency of being competitive with other global markets and for the welfare of its own citizens the entire education system in SA needs to address various challenging elements carefully and systematically. Otherwise in the coming years with oil and financial crisis the rate of unemployment and illiteracy will cause a serious damage to the nation. Hence in this research the author focused on various scientific methods to build a strong education system by building efficient smart school systems. The smart school environment from the above discussions summarized to meet with six important factors as shown in Fig. 2 is listed below:

1. Facilities and Technology

2. Training and Teaching

3. Interest and Behavior

4. Energy and Maintenance

5. Monitoring and Security

6. Communication and Alerts

Fig. 2. Important Factors to be addressed in a Smart School Environment

IV. PROPOSED TECHNIQUE

The proposed technique is based on various technical factors from interdisciplinary areas. The sensor devices to monitor various arrangements and facilities in the smart schools were designed and tested successfully using embedded applications [17]. This arrangement successfully tested with robots and sensors to monitor the premises of educational institutions. However, in this paper only monitoring system design with checker operations is proposed to ensure that the monitoring process is continuous.

To ensure a smooth education system the flow of student activities with respect to their attendance, performance levels, health conditions, discipline, etc. must be carefully monitored. The teachers need to communicate student performance based on grading system with the custodians as shown in Fig. 3.

Considering the flow process of a smart school in Fig. 3 with different factors and parameters a runtime monitoring system with runtime checker is being introduced in the next section. This will help to ensure all the components and entities are working efficiently to run a smart school smoothly.
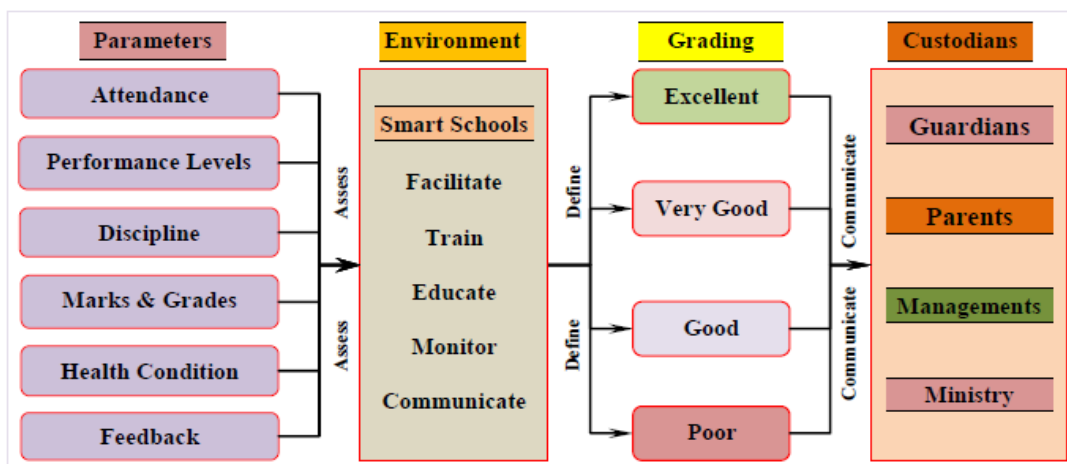

Fig. 3. Flow process of a smart school and parameters to be addressed

Some of the important policy rules are being framed for a successful smart school structure and they need to meet the following criteria of Fig. 4:

✓ *Rules and Regulations*: The managements need to ensure that the rules and regulations are considered to adopt latest technologies and models in the schools.

✓ *Facilities*: Ensuring all kinds of facilities such as buildings, computers, audiovisual equipments, air conditioners, furniture, etc. are sufficient enough for the students, teachers and support staff.

✓ *Technology*: Ensuring the latest software's and modified curriculum are available at the school with audio and video contents. A monitoring system to ensure that the technology used is latest and they are supposed to be monitored by technology experts.

✓ *Training and Teaching*: The teachers and supporting staff must be well trained and regular training sessions must be conducted to ensure the knowledge is up to date.

✓ *Interests and Behavior*: The teachers need to interact with the students, understand their behavior and take necessary steps to improve their skills. This must be carefully implemented and is totally related with children psychology and a sensitive matter which defines the behaviour of student. Hence, careful attention from all teachers is very much essential.

✓ *Energy and Maintenance*: This is another important aspect which demands careful attention as complete smart school environment is driven by energy. Hence a good methodology to maintain the premises with automated controlling systems must be installed with runtime monitoring systems.

✓ *Monitoring and Security System*: The monitoring system for avoiding various accidents such as fire and short circuits is tested positively. The kids are monitored continuously using RFID technology along with some of the applications of GPS.

✓ *Communication and Alerts*: The communication is established between school databases to all custodians (see Fig. 3) using GPS applications for long range applications. However, within the school environment the student activities, the exact location within the school, and tracing their time to time activities can be monitored and assessed using ZigBee based communication protocols [17].
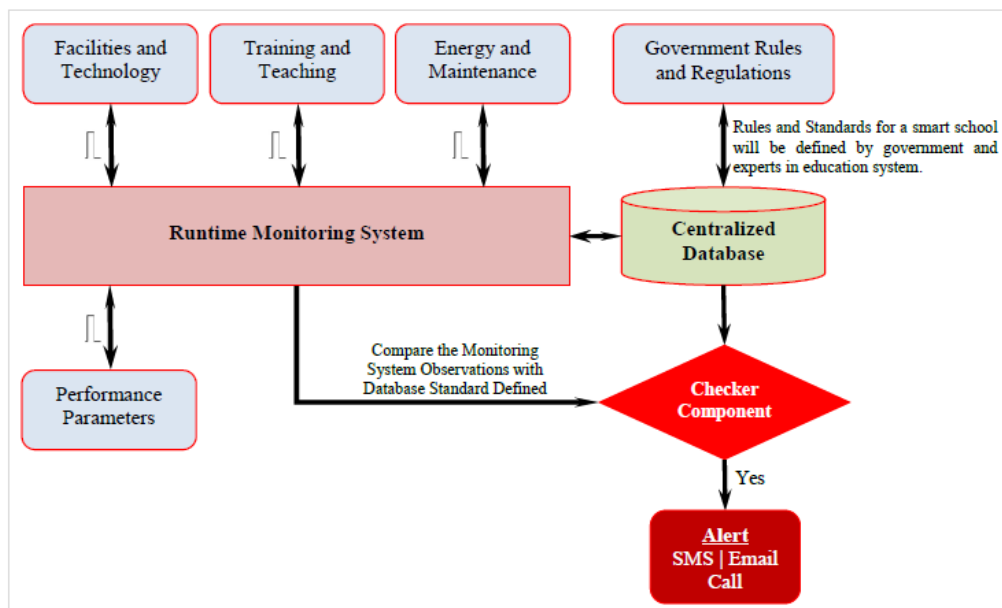

Fig. 4. Runtime Monitoring and Checker Component design for a Smart School

The checker component in this setup will ensure that the rules and regulations are tested for each entity in the proposed method as shown in Fig. 4. The runtime monitoring system included with various sensory devices and derived functional programs which test each defined criteria of hardware and software entities performance at each level. For any inappropriate response from these entities will be giving a negative clock to show an error in with respect to the entity at the checker component.

Some of the formalized policies are defined for smart school. The following policies will establish a communication between different entities and parameters of the proposed smart school design.

The smart school (*S*) needs to address the requirement rules (*R*) and regulations (*R1*) defined by the local government of KSA are formalized here:

$$Policy1 \triangleq$$

$$\begin{pmatrix} fin(SmartSchool) \wedge \\ Facilities(R, Module) \wedge \\ Technology(R1, Module) \wedge \\ \bigwedge_{i=Environment}^{t=Rules\&Reg} done\ (R, R1, Submit) \end{pmatrix} \longrightarrow \left(Authorize^{+}(R, R1, Approve\ for\ S)\right)$$

The smart school (*S*) needs to address the requirement of providing various facilities (*F*) and software's related to various technologies (*T*) are formalized here:

$$Policy2 \triangleq$$

$$\begin{pmatrix} fin(SmartSchool) \wedge \\ Facilities(F, Module) \wedge \\ Technology(T, Module) \wedge \\ Buildings\ (B, Module) \wedge \\ \bigwedge_{i=Environment}^{t=Facilities,Tech} done\ (F, T, B\ Submit) \end{pmatrix} \longrightarrow \left(Authorize^{+}(F, T, B, Approve\ for\ S)\right)$$

Now the smart schools need to fulfill the training and guidance (*G*) part and appropriate methods of teaching (*L*) policies needs to be tested carefully based on the criterion of some defined standards. These standards need to be addressed by the management, government and subject experts.

$$Policy3 \triangleq$$

$$\begin{pmatrix} fin(Training, Teaching: AcademicNeeds) \wedge \\ Training\ (G, Module) \wedge \\ Teaching(L, Module) \wedge \\ \bigwedge_{i=0}^{i=Fulfilled} done\ (G, L, SubmitReports) \end{pmatrix} \longrightarrow \left(Authorize^{+}(G, L, QualityMaintained)\right)$$

Now to avoid possibilities of power supply shortage and required energy (*E*) must be addressed to ensure smooth functioning of smart schools throughout the school timings. The monitoring of the premises to save energy by switching off the lights and air conditioners in the absence of students and staff in the classes will be taken care by automated devices.

$$Policy4 \triangleq$$

$$\begin{pmatrix} fin(Energy, Maintain: Essential) \wedge \\ Training\ (E, Module) \wedge \\ Teaching(M, Module) \wedge \\ \bigwedge_{i=0}^{t=Matching} done\ (E, M, SuccessfulReview) \end{pmatrix} \longrightarrow \left(Authorize^{+}(E, M, Maintained)\right)$$

Here the student's performance will be tested for different parameters as listed in Fig. 3. This policy will ensure to grade the overall performance of the students in their academics and their behavioral aspects with other students.

$$Policy5 \triangleq$$

$$\begin{pmatrix} fin(StudentPerformance) \wedge \\ MarksPercentages(P, Module) \wedge \\ Behavior(B, Module) \wedge \\ \bigwedge_{i=Environment}^{t=Marks,Behavior} done\ (P, B, Submit) \end{pmatrix} \longrightarrow \left(Authorize^{+}(P, B, InitiateAlerts)\right)$$

The above defined policies will ensure a smooth functioning of the smart schools by working as a middleware between the hardware and software tools within the environment.

V. CONCLUSIONS

The proposed system to establish a runtime monitoring is tested with positive results to establish a fast communication with parents and other custodians at the time of emergencies. The policies defined in this research helped to reduce the complexities of the hardware environment by ensuring a clear structure and programming support to initiate alert at the faster rate. Still the research is under progress in term of establishing the small school environment with cost effective measures. Such measures are possible by establishing the new technologies in terms of building sophisticated devices and with multiple functionalities and advantages.

VI. ACKNOWLEDGMENT

The authors are thankful to the almighty and the management of University of Hail for their support and motivation. The authors acknowledge M. Yerragolla and S.N. Palleboina for their support in the area of embedded systems and designing the sensory and robotic devices.

VII. REFERENCES

[1] UNICEF. Saudi Arabia – Statistics. [Online] <https://www.unicef.org/infobycountry/saudiarabia_statistics.html>, accessed on October 12, 2016.
[2] G. Almalki and N. Williams. "A strategy to improve the usage of ICT in the Kingdom of Saudi Arabia primary school." International Journal of Advanced Computer Science & Application 3 (2012).
[3] H. B. Zaman, N. A. Mukti and A. Ahmad. "Indigenous multimedia content development for next generation smart schools: A cognitive instructional design approach." Proceedings of the Fifth IEEE International Conference on Advanced Learning Technologies. IEEE Computer Society, 2005.
[4] M. Soltani and A. Aliyev. "Study the establishment of smart Schools." 2012 IV International Conference" Problems of Cybernetics and Informatics"(PCI). 2012.
[5] H. Shigeta, J. Nakase, Y. Tsunematsu, K. Kiyokawa, M. Hatanaka, K. Hosoda, M. Okada, Y. Ishihara, F. Ooshita, H. Kakugawa and S. Kurihara. Implementation of a smart office system in an ambient environment. InVR 2012 Mar 4 (pp. 1-2).
[6] G. Almalki, G. Finger, and J. Zagami. "Introducing SMART Table technology in Saudi Arabia education system." Editorial Preface 4.2 (2013).
[7] K. Kuzume and M. Okada. "Sensor network system to promote energy conservation realization of energy smart school." Pervasive Computing and Communications Workshops (PERCOM Workshops), 2014 IEEE International Conference on. IEEE, 2014.
[8] S. Khanam, M. Mahbub, A. Mandal, M. S. Kaiser and S. Al Mamun. "Improvement of RFID tag detection using smart antenna for tag based school monitoring system." In Electrical Engineering and Information & Communication Technology (ICEEICT), 2014 International Conference on, pp. 1-6. IEEE, 2014.
[9] D. Sunehra, P. L. Priya, and A. Bano. "Children Location Monitoring on Google Maps Using GPS and GSM Technologies." Advanced Computing (IACC), 2016 IEEE 6th International Conference on. IEEE, 2016.
[10] S. Li, Z. Qin, and H. Song. "A temporal-spatial method for group Detection, locating and tracking." IEEE Access 4 (2016): 4484-4494.
[11] D. Giovanelli, B. Milosevic, C. Kiraly, A. L. Murphy, and E. Farella. "Dynamic group management with Bluetooth Low Energy." In Smart Cities Conference (ISC2), 2016 IEEE International, pp. 1-6. IEEE, 2016.
[12] Y. V. Novitskaya, A. S. Strekalovskiy, and A. V. Gavrilov. "Event monitoring system of smart school laboratory." 2015 16th International Conference of Young Specialists on Micro/Nanotechnologies and Electron Devices. IEEE, 2015.
[13] H. Ali, J. K. Soe and Steven R. Weller. "A real-time ambient air quality monitoring wireless sensor network for schools in smart cities." Smart Cities Conference (ISC2), 2015 IEEE First International. IEEE, 2015.
[14] R. ul Amin, I. Inayat and B. Shazad. "Wearable learning technology: A smart way to teach elementary school students." 12th Learning and Technology Conference, 2015. 35752 2015.. IEEE, 2015.
[15] M. Attia, S. B. Fadhel, and L. Bettaieb. "Impact of tablet based learning on continuous assessment (ESPRIT smart school framework)." 2016 IEEE Global Engineering Education Conference (EDUCON). IEEE, 2016.
[16] M. ur Rahman, V. Deep, and S. Rahman. "ICT and internet of things for creating smart learning environment for students at education institutes in India." Cloud System and Big Data Engineering (Confluence), 2016 6th International Conference. IEEE, 2016.
[17] M. Yerragolla, K. Pallela and I. P. Gera. "Intelligent Security System for Residential and Industrial Automation." (Conference), 2016 3rd IEEE Uttar Pradesh Section International Conference on Electrical, Computer & Electronics Engineering, December 9-11, 2016.

AUTHORS PROFILE

Amr Jadi was born in Madinah of Saudi Arabia, on January 1, 1981. The author is involved in various scientific research activities of the Department of Computer Science and Software Engineering, University of Hail. Dr. Jadi received honorary degrees from De Montfort University and Master Degree from Bradford University, UK. The author is specialized in Software Engineering with an area interest in Early warning systems, Risk management and Critical Systems. Presently the author is also involved in various development activities within the University of Hail and abroad as a consultant.