

The increasing development of smart technologies offered many 10 opportunities for objects in the real world to communicate using sensors and 11 communication networks. One of the application areas is the smart campus for 12 campus **Informatization**. The construction of smart campus based on the smart 13 technologies such Bigdata, cloud computing, mobile computing, network 14 infrastructure need the role of these technologies in the development. This 15 conceptual paper **explores** the roles of the smart technologies for smart campus 16 development toward a smart city information system. Through the analysis of 17 the key concepts, the architectural layers for the smart campus was proposed 18 hoping to promote campus **Informatization** for a sustainable intelligent campus 19 towards smart city campus information system.

1. INTRODUCTION

22 The progress in smart technologies have influenced educational sphere and 23 **offer** opportunities for objects in our conventional campus to communicate 24 with each other via communication technologies. Intelligent campus (i-campus) 25 refers to a holistic intelligent campus environment, in which initiatives such as 26 cloud and mobile-powered learning, mobile apps, RFID (Radio-Frequency 27 Identification)-based security management are established to support holistic e-28 learning, networking, administration, and governance. These objects like doors, 29 windows, printers, projectors, books, poles, benches, and complex objects like 30 buildings, campus, laboratories and parking are converted into smart objects by 31 attaching sensors and are given a level of intelligence to communicate to each 32 other (Kwok, 2015; Snehal, et al, 2017). Smart campus creates an environment 33 for learners, teachers and learning devices to interact for the purposes of 34 learning. The rise of information and communication technologies in education 35 has quietly changed the traditional role of teachers, with a shift of emphasis 36 towards an autonomous and innovative learning, and a fusion of diverse 37 pedagogical methods and strategies (Klimova, 2016). 38 The development of local area network (LAN) on campus makes it much easier 39 and efficient to get the needed service and desired requirements (Bernabas & 40 Sengupta, 2017), however, campus technologies are limited in providing direct 41 communication between objects. The idea of objects making sense and 42 communicate with each other refers to the internet of things. The Internet of 43 Things (IoT) is a rapidly growing network of a variety of different 'connected 44 things'. The use of IoT in campus is like a new wave of change that has 45 brought new opportunities and possibilities for the improvement of both 46 teaching-learning process and educational institutions' infrastructure (Shahla, et al., 2017). The number of connected devices is increasing enormously and 48 many predictions have been made with this concept (Gul, et al., 2016; 49 Elyamany & Alkhairi, 2016). 50 The IoT technology has a great impact on campus. IoT has not only changed 51 the traditional teaching practices but has also brought changes in the 52 infrastructure of educational institutions (Mohanapriya, 2016). It adds values to 53 students, teachers and other academics to enhance communication for the 54 purposes of improving learning on smart campus. A smart campus may have 55 many other smart features like smart campus, smart parking, smart inventory, 56 smart lighting, and smart tracking of students, goods, and equipment using 57 RFID technology (Cata, 2015; Kaushal, 2015). The smart education institute has 58 the smart campus, smart corridors with info boards and datacenters for 59 processing all types of data (Simic, et al., 2015). At present, the design and 60 construction of the smart campus is still at the exploration stage. A number of 61 studies have proposed different models for smart campus. Many advanced and 62 innovative concepts are being proposed or introduced in education like 63 introducing IoT technology with Bigdata technology in e-education can be 64 effective for improving learning and teaching processes and communications in 65 smart campus 66 **This conceptual paper presents a**

proposed design of smart campus by67 incorporating different smart technologies in the development. (REPETITION!!!!) The paper is68 organized as follows: Section 2 presents the conceptual technologies; section 369 presents related works; section 4 presents the components of smart campus70 design and conclusion in section 5

2. IDEA OF A SMART CAMPUS 73 A Smart campus is a subset of smart city embedded with sensors and intelligent74 terminals on the concepts of cloud, Internet of things technology and related75 technologies synthesis. The idea is for administrators, teachers, and students76 through a more sophisticated environment can smartly communicate to enhance77 learning experiences and communication (Jian, 2015; Kumar, 2015). A typical78 smart campus is depicted is shown in figure 1 where each of the devices can79 communicate with each remotely using smart apps.

Figure 1: SmartSchool, 201484 The related technologies of smart campus related to the following smart85 technologies:86 87 Smart Apps88 This is mobile as well as a web application that facilitates communication89 between devices in a smart campus. The smart apps act an interface between the90 user and the devices to facilities communication and sensing.91 The Internet of Things92 The Internet of Things are sensors, controllers, machines, people, and things in a93 new way to realize intelligent identification, location, tracking, monitoring, and94 management which integrates intelligent sensing, identification technology,95 wired network and mobile Internet for smart communication.96 Cloud Computing97 The cloud computing as a new model of computing has brought a paradigm98 shift in education. This new technology attracts the interests of academics and99 industrial experts. Cloud computing is a model for enabling ubiquitous,100 convenient, on-demand network access to a shared pool of configurable101 computing resources (e.g., networks, servers, storage, applications, and102 services) that can be rapidly provisioned and released with minimal103 management effort or service provider interaction.104 Cloud computing was built on existing technologies as like grid computing,105 high-performance computing, parallel computing, distributed computing,106 powerful integrated computing, only the use of open, integrated, collaborative107 information architecture and dynamically configurable resources, high108

scalability, on-demand services that can provide communication in a smart109 campus settings(Kumar, 2015; Wang, 2017).110 Big Data111 Big data is the driving force for mass data storage, analysis, and processing. A112 Smart campus is connected with different intelligent technologies and terminals,113 information systems and sensing devices generate a large volume of data. This114 new technology can collect such large data, stored, analyze and process for115 intelligent applications and devices for smart communications to support116 decision-making processes.117 SmartKnowledge Management118 Knowledge management is the prime technology of smart campus. It is the most119 important and the most common activity of knowledgeable person and campus.120 This is the planning and management, creation, processing, and application121 knowledge.

3. RELATED WORKS123 Sagar, et al., (2016), developed an android academic web portal for the smart124 campus environment to help in interaction. Proposed system helped the college125 to manage records and save natural resources and job gets done in less time126 compared to an existing system. Users get the information without delays127 because of real-time use of the proposed system. It helps to reach to every128 student and faculties in the college in very less time. The data is stored on129 database helps the management to take major decisions on the suggestion

and ideas. Creating smart learning environments needs to understand the characteristics of such environments, combine formal and informal learning, and take learners' perceptions and learning behaviors into account, to exploit more effective learning methods and tools, and design space more appealing to personalized and autonomous learning (Gros, 2016). The Smart learning environment is not simply about the application of technology, but more significantly enables the fusion of pedagogy and technology to create an ecosystem in which educators and learners are able to interact more efficiently. There is a need for pedagogical innovations to support smart learning as well as emerging technologies that offer endless learning opportunities and communication in a smart campus environment (Kinshuk, Chen, Cheng, & Chew, 2016). The Smart education deals with better learning in a digital age. A conceptual framework of smart education was proposed, containing three essential elements: smart environments, as technological support; smart pedagogy, as methodological support; and smart learner, as the goal of smart education (Zhu, Yu, & Riezebos, 2016). The authors studied the impact of smart campus, a major role in building e-education system, on transforming universities to part of the e-society vision. The positive aspects include developing new talents, shifting education towards democracy, enabling learners to apply theoretical knowledge into practice, and boosting blended learning. However, there are

some considerations as well, such as a need for redefining educational models and ability to make use of the smart design (Aguilar, 2016). Antevski, Redondi, ., & Pitic, (2016) present an approach to encourage group collaborations in smart libraries by creating study groups through a mobile application, locating the groups using hybrid Bluetooth Low Energy technology and Wi-Fi indoor positioning system, and recommending the groups to other students via a server-based infrastructure. A prototype of a campus-wide supersensory network was developed and deployed around the campus of the University of Glasgow to support different groups of end users including staff, faculty, and students. The super-sensors, are sensors with powerful compute capability, believed to empower more flexible data collection, processing, and reaction (Hentschel, Jacob, Singer, & Chalmers, 2016). This technology offers a smart campus environment for smart education. Sruthi, et al, (2017): proposed Smart Campus Using Android based Smart Phone, the idea of constructing a "Smart field" implies that the establishment can adopt advanced ICT (Information Communication Technologies) to mechanically monitor and management each facility on campus. The smart campus includes portal architecture, management, and service, smart management, infrastructure, etc. The Smart campus system integrates hardware device of digital school, and cloud storage as the means of data storage is applied to enhance communication in a campus. The results of the simulation show that the system can be accessed without the internet, possess a low power consumption, user-friendly, mobile controllable, and fault detection can be easily identified with the short span of time.

The above literature shows that smart campus is in the process of development, experimenting, and implementation. This new computing paradigm offers a more intelligent environment to enhance intelligence on campus. A number of architectures have been proposed each having a degree of design with different layers of implementations. The next section discusses the five layers conceptual architecture for a smart campus geared toward smart city information systems

4 CONCEPTUAL DESIGN LAYERS FOR A SMART CAMPUS

183 A typical smart campus integrates the physical space and the digital space184 (Kumar, 2015; Jian, 2015). The big data interface between the smart devices185 (intelligent device layer & application layer) and the communication layers186 (cloud computing and network layer) to achieve personalized and collaborative187 interaction for the business of smart campus toward smart city information188 system. The layers of the proposed architecture are discussed as follows:189 Smart Device Layer190 Smart campus integrates smart devices and existing application systems to use191 the application layer to achieve smart campus information system. A variety of192 terminal access technologies, including traditional mobile apps, web-based, 193 PCs, smart terminals, self-service devices and wearable devices, provide users194 with a seamless, adaptive environment, personalized human-computer195 interaction model for specific application scenarios based on different196 environments, enhance user access to campus information service experience197 for campus information technology applications to provide integrated, seamless198 access and support(Wang, 2017)199 Cloud Computing Layer200 This provides a computing paradigm based on related technologies such as201 virtualization, distributed computing, high-performance computing, centralized202 storage, distributed storage and other storage technologies to achieve efficient,203 transparent and reliable infrastructure. The campus's big data processing and204 intelligent applications provide universal, on-demand computing and storage205 support (Wang, 2017).206 Big Data Layer207 The Big data layer is a prime mover toward smart campus. The information208 gathered in the campus environment, activities, business, interaction and other209 information needs to follow the information standards and standardization,210 establish the data sharing and exchange mechanism, the database infrastructure211 theme, the unified data platform application construction, connect in cyberspace212 and campus Intelligent virtual images(Wang, 2017). This technology provides213 the capturing, storage, analysis and processing of data for the decision-making214 process in a smart campus environment.215 Network Communication Layer216 This composes of campus wired network, WIFI wireless network, 4G mobile217 network and other communication technology, for the intelligent perception218 layer to collect various types of environmental and activity data for teachers and219 students anytime, anywhere using the Internet to provide high coverage220 transmission services to provide high-speed access services(Wang, 2017). This221 layer provides communication in a smart environment towards smart campus222 information system.223 System Security and Operations224 These segments provide safety operations and security for a smart campus225 environment. The support system is the basis for the continuous provision of226 high-quality services on the smart campus, including the information security227 system to ensure campus information security and reliability, and the system228 operation and maintenance service system to ensure the stable operation of the229 park infrastructure and application system. Safe, stable and efficient operation to230 provide practical protection (Wang, 2017)