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Academic Admission Process: An IoT-based Indoor Location Case Study

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Abstract

Nowadays, individuals belonging to different demographic segments and social categories are surrounded by a large variety of devices, serving to facilitate comprehension of complex phenomena and enabling access to ideas that were previously perceived as intangible. Technology produces a positive impact in people's lives by inducing a sense of control, usually backed by solid fundamentals, that changes an individual's perception of the world and the tasks that can be accomplished with its aid, having implications in various spectra of life: personal, social, educational, and professional. Within the academic environment, digitalisation engenders heightened interest from students, prospective candidates, and stakeholders alike, with respect to the potential advantages that a university can provide, appreciating its openness to innovation, and projecting a mindset oriented towards performance and continuous progress, enabling the institution to provide outstanding education standards. The university's emphasis on student's integration within the academic environment outlines its underlying principles, highlighting the significance of setting up a smooth collaboration, starting from their initial interactions. In this context, the present paper proposes an indoor location ecosystem that integrates specific IoT technologies, built in a Big Data processing scenario, to assist applicants' desire of enrolling in a university, with the aim of facilitating the discovery of buildings and venues covered by the often-complex admission process, through the utilisation of the devices that they possess. The solution provides timely and up-to-date geospatial data regarding essential landmarks such as the admissions office, financial service, or academic departments. Furthermore, the application has the ability to furnish precise information concerning the availability of personnel accountable for counseling candidates, and simultaneously guide them through the campus. Last but not least, users can receive personalised recommendations regarding courses, labs, and extracurricular activities suited to the student's interests, giving applicants confidence and support throughout the admission process, helping them make informed decisions and paving the way for a future partnership between the university and the student.

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1. Introduction

A person's education commences in early life and continues, if he has the desire to pursue it, throughout the lifespan. During childhood, fundamental abilities such as walking, writing and reading are acquired, along with social interactions within the community. Subsequently, one gains the ability to cultivate new proficiencies, explore various domains and develop critical thinking skills, useful to differentiate and comprehend methods that yield benefits to both themselves and others.

A part of an individual's life is under the umbrella of mandatory undertakings, which are administered by the government and allow each person to acquire a basic level of understanding, thereby enabling them to conduct themselves appropriately within the society norms to which they belong. However, a truly enlightened society cannot solely rely on the acquisition of the minimum necessary knowledge, as the presence of professionals proficient in various fields is essential to sustain continuity and promote innovation (Pelinescu, 2015). Therefore, the importance of higher education institutions in ensuring a complete education process is indisputable; they represent a necessary and recommended extension of the mandatory stages that a person goes through, starting from the first years of life. Higher education is what shapes pioneering professions, brings novelty, allows evolution and innovation, and supports people involved in a development process to continue research, encouraging them to raise questions and pursue for discovering answers (McMahon, 2009).

The manner in which recent high school graduates or individuals with an interest in academia engage with the relevant institutions frames the future, offering insight into those individuals who will take responsibility for undertaking actions across various sectors of the economy and their level of readiness to navigate the multifaceted nature of life. In this context, various duties are identified that both parties must assume and treat seriously. If the viewpoint of the student is considered, it becomes clear that there is a mandatory aspect in comprehending and mastering the requisites of the domain in which they seek to specialise. Conversely, from the perspective of the academic milieu, the significance of adapting to the demands of the students, to the unique characteristics and evolving trends of each generation is outlined.

The world is in constant motion, technology emphasising the speed with which it takes place and redefining the way certain routines are implemented. Young generations live in the technological sphere and this represents an extension of their lives. They learn through digital components, make their purchases online, chat with friends virtually and have redefined many activities, knowing that they can find answers to their questions through the Internet, mostly using their mobile phone to manage different circumstances. Consequently, for academia it is necessary to adapt

to the youth's preferences in order to facilitate the partnership between the university and the student, ensuring complete transparency in implementing an educational framework that is attuned to contemporary exigencies and demands.

In this context, the initial interaction between the student and the university occurs during the admission procedure, signifying a juncture where mutual expectations are established, and the probability of their realisation is evaluated. The student wants an easier interaction during the admission process, benefiting from the openness of the university to answer numerous questions and to guide him in solving all the bureaucratic aspects related to this step. However, the management of a large volume of registrations and all the documents necessary to complete this process can be problematic in the absence of automated solutions or elements that can replace human work, thus increasing the waiting time for handling each participant in the admission process and the possibility of generating frustrations or human errors caused by fatigue, the large volume of work, and the lack of necessary time.

The need for the implementation of an automated solution has been recognised. Such a solution would provide benefits to future students by aligning the university with their preferred ways of interaction. It emphasises the digitalised and interconnected aspects that they can rely on throughout their years of study. Additionally, it would also provide benefits to the staff involved in the admission process by facilitating a more efficient and expeditious management of the necessary documents required to complete all the steps involved in processing the data of individuals participating in the admission process.

The idea mentioned above outlines the central question that this paper aims to address, as identified in the chapter dedicated to the research purpose. Moreover, building upon the presented elements, the subsequent objectives are anticipated, with the intention of incorporating technological advancements to achieve desired outcomes such as reduced processing time and cost to complete the admission process.

Furthermore, it aims to guide students through all stages by assisting them in locating relevant points of interest, thus allowing them to effectively manage their time spent at the university during the registration process. The estimation of waiting times based on location would help identify areas where additional personnel are required more swiftly, while also determining areas where personnel allocation is unnecessary.

The significance of acclimatising to the working patterns of the younger generations is outlined by adopting and integrating technological elements to expedite a faster admission procedure, based on the utilisation of the most common devices, such as the mobile phone, to facilitate the fulfillment of specific steps, thereby minimising human intervention and enabling the handling of a sizable influx of applications concurrently. It also introduces the need for communication through the Internet and the transmission of information between various components that can manage this situation, thus outlining a framework often encountered in other spheres of activity, namely the Internet of Things, further referred as IoT.

2. Problem Statement

Currently, the admission processes automation degree in universities around the world varies, depending on the specifics of each one and the manners in which they manage to adapt to the students' expectations and their requirements regarding the interaction with the academic environment. Most of the time, the admission process is partially digitalised, consisting of the online submission of documents for registration, and a series of steps to be physically implemented, following the selection. However, the bureaucracy and the need to obtain documents, signatures or stamps to complete the admission and registration process presupposes the inability to move these activities to the online sphere, students being invited to interact physically in order to obtain the necessary documents, an interaction that must be facilitated by different people involved in the process, as instructions are needed to complete all the steps, in the absence of an automated option. These processes can be difficult to complete in certain contexts.

For example, in recent years, universities have faced novel challenges concerning the execution of their operations. These challenges were profoundly influenced by the global coronavirus pandemic and its profound implications. Consequently, certain processes were cancelled, while many others were reorganised to transition into the online sphere. During a period when physical interaction became impractical, education had to persist, compelling universities to identify alternative approaches that would ensure the uninterrupted progression of educational activities. Regarding the admission process, hybrid options were predominantly adopted. Initially, the necessary documents were uploaded online to a secure platform provided by the institutions. Subsequently, when limited physical interaction became permissible, sessions were arranged to facilitate the submission of the required documents. Institutions strived to manage these processes as efficiently as possible in the context of the pandemic. Situations such as the one described above further justify the need for automated solutions. Such solutions would streamline participant flow, enable the monitoring of student numbers within campus buildings, and gauge crowd density at various stages of the registration process. Consequently, they would enhance the staff and participants' sense of safety and trust, demonstrating a conscientious approach to the health context and the meticulousness with which the admission process is handled. These solutions would effectively manage the flow of individuals, restrict access as necessary, and foster an optimal environment.

An illustrative example is the University of Medicine and Pharmacy in Bucharest. Considering the specific requirements of the entrance examination, the university physically organised both the exam and documents submission during the July 2020 session, amidst the initial year of the pandemic. To ensure the exam's secure administration, a substantial number of students were allocated to different locations. Subsequently, during the documents submission period, the program spanned several days, from July 28 to August 3, 2020. Students were expected to adhere to a predetermined schedule based on alphabetical order, effectively managing the flow of individuals (UMFCD, 2020). In this context, the utilisation of a solution that facilitates tracking participants' location within the faculty and monitors the number

of attendees would have addressed the challenges associated with physically managing the admission processes.

Transitioning to a broader viewpoint to identify the most effective methods for enhancing the admission procedure, an initial step involves the domain analysis, its significance, and the impact that a slight alteration in the process could yield in heightening the visibility and academia's level of openness vis-a-vis the prospective candidates.

Subsequently, this study placed particular emphasis on the importance of education in diverse domains, aiming to justify the idea that the outcome of the initial interaction with the educational environment can engender far-reaching implications in the manner in which an individual engages with activities in the future and their level of preparedness to navigate them successfully. In the context where the student feels comprehended, drawn to the respective field, and assured of receiving all necessary resources to progress within the university, the effectiveness of the academic process can be evaluated by measuring the student's self-confidence and his desire to achieve professional success, being encouraged from the beginning and evolving within an environment that was conducive to growth (Hanushek, Woessmann, 2012). Otherwise, in the situation where discrepancies in the approach are identified and there are communication gaps from the first interactions with the academic milieu, a decrease in the student's engagement with the chosen field can be discerned, potentially exerting an impact on the future trajectory and the professional sphere in which he will operate.

2.1 The Education and the Society

The significance of education is obvious in every facet of society, be it the economic, personal, or social domain. A country that encourages study and has in its composition a large number of people interested in their development in various areas represents a country that opens the way to innovation, raising curious people, willing to experiment and test ideas, thus ensuring an increase in the economic growth by providing jobs and creating businesses that can solve different challenges (Aghion, Howitt, 2008).

In discussions concerning a society that strives towards prosperity, it can be linked to the concept of a community where individuals are well-educated, possess diverse interests and passions, comprehend their own needs and those of others, evince respect, exhibit inclusivity, and view the world through a collective lens. A society characterised by erudition is one where the rights of every individual, irrespective of their social status, ethnicity, religion, colour or any other distinguishing attribute, are accorded due reverence (Hanushek, Woessmann, 2008). In the context of such an environment, one can talk about social inclusion, about protecting the neighbour by understanding and respecting diversity, by reducing discrimination and firmly condemning inequality. Through integration and collective help, the usefulness of such behaviours and the generalised impact they induce are identified, emphasising the idea that in a society where education takes precedence, people have more knowledge about various fields of activity and present

a greater trust in specialists, with the aim of improving or maintaining a harmonious lifestyle. As such, any branch of the economy tends to develop through the involvement of competent people who want to produce a positive change, and, by investing in education, one invests in the future of the country, in the existence of more productive processes and a more prosperous life for the citizens (Teixeira, Queirós, 2016). Education is a fundamental component of society, which guarantees the transmission from generation to generation of the principles of co-existence and beneficial functioning of the community, providing people with the necessary tools to analyse and understand the needs, impediments, and methods by which their solutions can be ensured. By implementing functional education processes adapted to current generations, the future of a country is shaped by the way in which children, currently involved in training activities, will contribute to progress, develop skills, and be able to maintain and manage in a fair and efficient manner the challenges they will encounter along the way (Hanushek, Wößmann, 2007).

In this context, the implementation and constant updating of educational processes is justified, whether teaching methods, educational content, or interaction with the economic environment are discussed. The key to individual and collective success lies in the controlled and effective management of educational implementation, beginning with the initial interactions, such as the university admission process, as demonstrated in the current research.

2.2 Internet of Things in Academia

Currently, universities worldwide are undergoing a constant process of reinvention and adaptation to keep up with technological advancements. This facilitates the implementation of certain processes faster, safer and at a lower cost, while also benefiting from positive publicity through openness to innovation. Intending to translate some processes that are implemented manually and need human intervention to ones managed digitally, there are a multitude of technologies and components that can be used to reduce the complexity of the process.

A relatively new and widespread technology in a variety of fields is the Internet of Things, which allows the use of different physical elements, with the goal of retrieving data and interconnecting components via the Internet. In the academic context, the possibility of using sensors in different situations is illustrated by identifying a person's location in order to measure the level of congestion from a point of interest, monitoring climatic elements to provide the best environmental conditions, managing costs and consumption through intelligent components, or even performance analysis by retrieving data and processing them for intended purposes. IoT, unlike other technologies, presented a timid initial interest from the university area, but recently it is gaining momentum, by managing to solve problems of a logistical nature or by stimulating students' interest in how the university identifies innovative solutions to known impediments.

Considering the admission process, multiple universities which implement different activities with the aim of automating and streamlining the steps involved were identified. A concrete example is the City University of Science and

Information Technology, which uses multiple technologies in order to present the campus and the educational offer to candidates and interested persons (Habib et al., 2021). Other ways of using technology have been approached by universities in Europe such as Oxford University, which manages the admission process through an online portal, the University of Amsterdam, which supports admission interviews in an online video system, or the Saudi Arabian University, which offers an application for preparing the enrolment prerequisites and implements e-services for academic organisational processes (Brdese, 2021). Last but not least, other universities in the USA use sensors through IoT technology to monitor the environment in the examination areas and to properly manage crowded spaces during the admission process. Hence, it is feasible to recognise several directions that can be enhanced as general perspectives of an admission process, regardless of the university in which it is implemented.

First, the possibility of using online platforms was identified in order to submit the necessary documents and monitor their status. It is also possible to identify here the possibility of online registration and schooling fees payment, for situations where this is a step in the admission process. Generally speaking, digitalisation played a key role in the last decades, and its influence is experienced more and more profoundly, even in academia (Bygstad et al., 2022; Díaz-García et al., 2022).

Second, the sensors can be used in multiple scenarios, such as monitoring temperature, air quality, humidity, or controlling resources, to provide a comfortable environment or in the desire to reduce costs through saving and responsible consumption (Becerik-Gerber et al., 2022).

Third, an important perspective is the integration of indoor location concepts in the use of IoT technology, in hope of gaining multiple benefits, a subject extensively analysed in the specialty literature (Asaad, Maghdid, 2022; Hayward et al., 2022; Khan et al., 2022; Tonggoed, Panjan, 2022). This last option will be explored further in this paper.

2.3 Indoor Location Perspectives in Universities

Implementing various approaches from the Internet of Things sphere in universities can yield numerous benefits. Although technical improvements may be required to accommodate this type of technology, the costs are outweighed by the benefits, and can be recouped within a relatively short period of time if the IoT implementation is focused on cost-saving measures.

Components that are commonly found in most universities, such as Wi-Fi networks or video monitoring systems, may be adequate to support the implementation of certain IoT concepts in specific relevant scenarios. In this context, all the information taken from these devices can be integrated by centralising them via the Internet, applying localisation algorithms and generating different reports regarding sites, degree of occupancy, flow of participants.

Some of the universities that use similar approaches in their operations are Stanford University or the University of Bologna (Prandi et al., 2021). The purpose of indoor location within a university campus is to improve the educational

experience by identifying buildings or halls, by quickly and efficiently decongesting crowded spaces in different situations, including evacuations for fire simulations or urgent matters through which the use of technology can contribute to the significant reduction of the action time.

Other components that can be used in the context of indoor location are motion sensors, which can be placed on campus in order to transmit information in real time and determine the position or direction of movement. A similar approach can be achieved through components that emit radio or Bluetooth signals, with the goal of target pin-pointing. Localisation can also be accomplished through visual recognition techniques, which analyse images to identify an individual, or by strategically placing QR codes in areas of interest and by utilising algorithms to retrieve information about their position after being scanned.

A concrete example in the admission process is implemented at the Technical University of Munich, where students can download a mobile application that allows them to locate inside the campus and guide them to different points, with the aim of reducing the waiting time (Nikoohemat, 2013). An improved approach to this scenario could involve the provision of access to the university's internal Wi-Fi network, thereby eliminating the requirement to use a specific application, an idea that defines the purpose of the current research.

3. Aim of the Research

The hereby study advocates for the implementation of an internal IT-based localisation system to streamline the university admission process. The use of this solution is done through a mobile device, accessing a dedicated web page, visible only within an internal network of the university. Accessing the web page by connecting to this dedicated network and accessing it directly from the phone's browser, without requiring the installation of additional applications, is desired. Thus, the university has a modern and effective support system, while applicants go through the stages of the application process faster, informed, and with a greater degree of independence.

The research question this paper is trying to answer is: How can a university admission process be optimised in terms of costs and resources using an IoT-based indoor location application?

The assumptions underlying the development of this article can be grouped into two distinct categories. The first category corresponds to the quantitative factors that tend to characterise the admission process. Specifically, in a relatively short time horizon, typically 8 to 12-hour intervals, spread over one or more days, very large volumes of applicants follow a repetitive process. Each person has to go through the same sequence of steps in order to successfully enroll in the university. From the previously described idea, the following problem's coordinates stand out: limited time horizon, large volumes of requests, parallel processing, and repetitiveness. Hence, the proposed solution aims to optimise two characteristics, namely providing optimal and efficient information to the large number of applicants about the

admission process they are required to undergo and providing guidance to them during the process in case of any ambiguities.

A second category is associated with the human factors involved in the admission process. To ensure that the admission process runs smoothly, universities often resort to co-opting volunteers or senior students to coordinate applicants, answer their questions and guide them along the way. In addition to the support staff, the admission process requires the presence of university employees from various departments. By analogy, the human factors highlight the following coordinates of the problem: costs and availability problems in the acquisition of auxiliary staff, overload in conditions of overcrowding, uneven character of the information transmitted to the applicants. As a consequence, two other features eligible for optimisation are the standardisation of the information available to applicants during the admission process, respectively, the instant access to an information and assistance vector.

In this context, the proposed solution highlights the following objectives:

- Objective 1: The facilitation of an indoor location platform based on the Internet of Things, with the purpose of enabling the precise localisation of individuals within the premises of the university;
- Objective 2: The development of an indoor navigation module within the platform, aiming to enable efficient movement inside the university premises, allowing the user to autonomously complete the registration process;
- Objective 3: The mean of average duration required to finalise an enrolment;
- Objective 4: The decrease of total costs involved in the admission process.

4. Research Methods

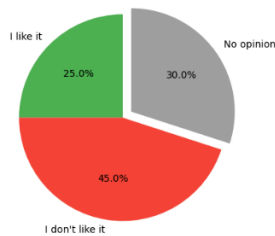
To attain the stated objectives, the present paper utilises a case study approach as the research methodology. The case study is based on the findings of a survey conducted on a sample of students from various universities, identified through online means of crowd observation around campus groups. The survey results were interpreted to develop the argumentation, explanations and implementation of the proposed solution.

In order to define and analyse in a correct manner the basic idea of this research, the answers given by the students to the applied survey were processed, with the purpose of observing the ways in which they perceived the first interactions with the university environment. 45 responses were collected from students enrolled in different study programs and universities, intending to obtain a realistic picture of the current admission process in Romania's academic environment. In the survey, 10 questions were asked about the steps of the admission process, the advantages and disadvantages of digitalisation, and the need to use indoor location solutions to facilitate faster movement within the campus. The first question was addressed with the aim of isolating a representative time horizon, considering the pandemic context of the last years which led to the forced digitalisation of certain processes in most fields of activity.

60% of the respondents stated that they were involved in the admission process in the last 2 years. Part of them, 25 %, considered that the traditional admission process, which involves recurring movements to the campus to complete the defined steps, is well structured, 45 % mentioned that it can be described as a tiring process, and 30 % did not express their opinion regarding this question, as can be seen in Figure 1. Moreover, 80 % of the respondents considered that the admission process can be digitised, mentioning the following among the expected benefits: 40 % believed that there would be a higher accessibility, 30 % believed that it would result in a reduction in costs and time allocated, 20 % appreciated the possibility of carrying out certain steps online and 10 % mentioned other benefits.

Figure 1. Survey results - traditional admission process opinions

Opinions on traditional admission process



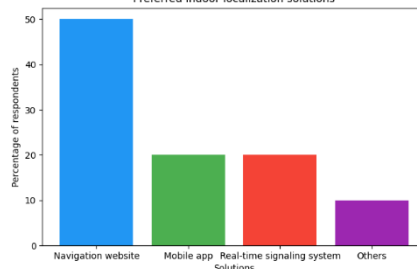
Source: Author's own contribution.

But, from the perspective of the disadvantages, 40 % mentioned their concern regarding the increased risk of fraud, 30 % presented doubts regarding the protection of data confidentiality and the remaining 30 % considered that a possible discrimination of people who have no technology access or knowledge may occur.

Regarding the way they interacted physically during the admission process, 70 % of the respondents mentioned that they had difficulties in identifying the rooms and 90 % mentioned that an interior localisation solution would be useful in solving this problem. Thus, from the list of proposed solutions, 50 % agreed to the use of a website for location identification and route suggestion, 20 % preferred the use of a mobile application, 20 % mentioned the signaling systems deployed in the building, and 10 % preferred other solutions, as can be seen in Figure 2.

Figure 2. Survey results – indoor location solutions preferences

Preferred indoor localization solutions



Source: Author's own contribution.

Therefore, the study identified students' willingness to adopt a new approach in navigating the university premises and their preference for independent functioning during the enrollment process, with the aim of reducing time, serving as additional motivation for the implementation of this case study.

As such, the following section presents an overview of the necessary steps for conducting the case study, which will be further discussed in detail. But, in order to mark the transition to this, some theoretical perspectives can be presented now. So, the process of conducting a case study involves several steps. Firstly, it is necessary to identify a case or situation that is relevant to the research question and provides enough information for a detailed analysis. Next, it is recommended to collect data on the case, using various methods such as interviews, surveys, and document analysis. After collecting the data, it should be organised and interpreted to identify patterns and underlying causes and effects. Using the analysis, some conclusions may be drawn about the case and may identify best practices and recommendations. Finally, it is suggested to clearly and concisely communicate the findings and recommendations to stakeholders (Feagin et al., 2016; Heale, Twycross, 2018).

5. Findings

Starting from the prerequisites of a case study mentioned earlier, the stages of identifying a situation to be analysed and collecting data tend to portray the unfolding of an admission process within a university. In general, this process involves the physical presence of a candidate on the university premises, at a specific date and time. The candidate has prepared in advance a file containing a series of necessary documents, among the most common ones being an admission form where the options are specified, the legalised copy of the birth certificate, the legalised copy of the identity document, the diploma of Baccalaureate or an equivalent certificate issued by the graduated pre-university education institution, the medical letter, as well as other documents, which may vary from one institution of higher education to another, depending on the specifics of each one. The registration fee payment proof is typically included in these documents. The payment process, and the manner in which payment is made, depends on various factors, including the university's level of digitalisation, the ease of payment, and the candidate's willingness. The payment may either be made in advance, with the payment proof being attached to the documentation, or it may be paid in person, at the institution's cash desk.

Once the application file is completed, it is evaluated by a university representative, and the candidate is usually registered in an electronic platform, optionally in order to take the entrance exam at a later date, but most often to collect a series of identification data, such as name, birth date, personal numerical code, a bulletin-type photo taken on the spot, data that will later be found on the student ID, in the event of admission. After collecting the identification data, the candidate physically submits the registration file to the secretariat. In the context of an impeccably managed admission process, the educational institution makes available to applicants, in addition to the departments and necessary staff for the previously presented stages, a counseling office, where undecided applicants or those with

incomplete files can benefit from consultation, can be referred to the appropriate departments and get help to complete the registration process. Also, considering the large volume of applicants, the university can set up a temporary medical office, where people who need medical assistance can be examined and receive immediate care, as well as sanitary facilities, vending machines of various types, or chargeable printing services. Traditionally, the candidate can talk throughout the application process to the university staff, who are previously trained to be able to answer any uncertainties associated with the admission process. Given the large volume of applicants that a university faces in a relatively short time frame, the number of the involved staff tends to be large most of the time.

From a graphic point of view, the distribution of these elements of interest is illustrated in Figure 3, based on different colour schemes: the offices actually involved in the admission process are highlighted in orange, the medical office and sanitary facilities in blue, the vending machines area in red, in dark purple the printing services, and in green an office for the preparation and evaluation of files, where candidates can benefit from the advice of academic staff. For ease of interpretation, the access and evacuation points from the building were also shown in Figure 3.

Figure 3. University floor plan



Source: Author's own contribution.

By chronologically analysing the development of an admission process, it is identified as a repetitive pattern, characterised by a linear increase, directly proportional to the number of applicants, the completion of at least 3, often 4, mandatory stages in the admission process: fee payment at the cash desk, as an optional step, file evaluation, electronic registration, file submission. In atypical situations, the registration process may involve attending the other points of interest marked on the map. Since the previously highlighted pattern has a linear complexity, meaning that the more applicants there are, the longer the admission process and the

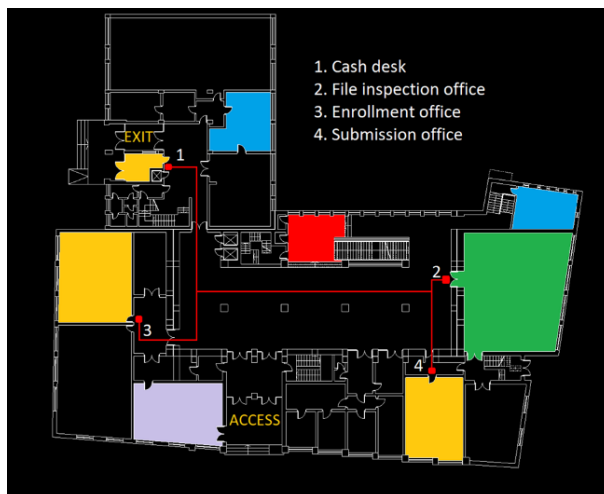
higher the associated costs, a relatively small optimisation in this pattern will cause a substantial impact on the bottom line, due to the high degree of multiplication.

An IT solution developed in this sense could be represented by a web application accessible from the university's intranet. When candidates present themselves for registration, they connect using their mobile phone to the Wi-Fi network and access a dedicated web page. It contains details regarding all the necessary steps in the registration process, which are the documents that a file must contain, where they are issued and where the registration fee can be paid. The application also displays a map of the main points of interest in the application process and a section with the most frequently asked questions. The indoor localisation module also allows the identification of a candidate's coordinates relative to a reference system, represented by the architectural plan of the university, and the calculation of optimal routes.

The candidates can scan a nearby QR code using their mobile phone to determine their starting position and choose from a predefined list of options a destination. The application determines, based on previously stored metadata about the location and distribution of QR codes and main points of interest in the premises, using algorithms specialised in calculating the distances between two nodes in a graph, an optimal route between the user's position and a point of interest, between two points, as well as complex routes oriented more towards objectives. Objective-oriented routes are those routes which, followed, lead to the achievement of an objective.

The application has a series of predefined routes, but it also allows the creation of customised ones, in which the user defines the places he wants to visit and the sequence in which he intends to do it. Figure 4 illustrates an example of a predefined route where potential candidates can outline the distribution of departments they need to visit in order to complete the application process.

Figure 4. University floor plan – predefined route



Source: Author's own contribution.

6. Conclusions

The proposed architecture in this paper is distinct from the existing solutions discussed in the literature review, as it does not require the installation of additional applications on the candidates' devices. The architecture is developed through a comprehensive case study to address a specific problem. The implementation of this IT solution enables a significant number of applicants to operate autonomously, without the need to wait in queues to interact with dedicated staff. Consequently, this autonomy significantly reduces the workload of support staff, allowing them to focus on critical tasks, rather than spending time repeating informative yet routine matters. As a consequence, it can be inferred that the proposed solution offers benefits such as cost reduction and increased efficiency in the admission process by reducing the involvement of unnecessary personnel and enabling higher parallelisation through a staged plan available on the web page.

Regarding the financial aspects associated with the admission process, costs are notably high during this period due to the necessity of employing additional staff to ensure the successful execution of all required activities. Consequently, costs such as recruitment expenses may arise, involving consultations with specialised companies that provide temporary assistance. Moreover, a common practice observed in Romanian universities is the recruitment of students during the admission period to assist new colleagues in navigating buildings, halls, providing document templates and addressing inquiries. These recruited individuals receive a predetermined compensation for each day they contribute to the admission process. However, with the implementation of this automated solution, the costs can be significantly reduced or even eliminated altogether, as all the information students require can be readily accessed through their mobile phones. Hypothetical, for 20 students that get paid 20 euros per day, for a week, such an application would bring 2000 euros in savings. Furthermore, the integration of a live chat module, managed by a small team of employees, enables online responses to inquiries, eliminating the need for on-campus presence and allowing for a temporary staff addition only when necessary.

Another cost-saving aspect facilitated by the proposed solution is the empowerment of students through automation, guiding them seamlessly through the necessary steps, and minimising the time spent physically present at the faculty. The implementation of such tools in the admission process justifies the analysis of the time required to complete the predefined steps, which can be reduced by simplifying the activities. Therefore, the capabilities of using the proposed solution would fulfil the mentioned objectives. Consequently, an estimate of the time required for the admission process integrated with an automated solution suggests a reduction in the number of days needed, leading to decreased expenses. This concept offers potential avenues for future research.

With regard to the risks associated with implementing the proposed solution, the most significant ones are related to the IT infrastructure. This type of solution requires a secure and stable internal network capable of accommodating a large number of parallel connections. Additionally, the server hosting the application must

possess sufficient computational resources to enable parallel processing of a considerable number of requests. Finally, reliance on an IT solution requires consideration of potential risks such as power outages and cyber-attacks and these risks should not be overlooked.

In terms of opportunities for further development, the rudimentary architecture described above can be extended over several horizons. To begin with, the application can adopt a gamification character, instead of recommending from the very beginning a predetermined route for applicants to follow, candidates can embark on a kind of treasure hunt, in an interactive exploratory experience. When accessing the university premises, they scan a QR code, and the application directs them to the cash desk or to the file evaluation office. Once the application fee is paid or the file is assessed, they scan a separate QR code, which marks the completion of a stage. The application records the progress and continues with the next stage in the registration process. In this way, in addition to the actual usefulness of the application, the entire registration process also acquires social values, it induces some relaxation, which relieves the sometimes-tense atmosphere specific to an admission process. In addition, such an approach allows recording the times when the QR codes were scanned, which gives the university enough data to calculate waiting times, occupancy rates in certain departments, average times to complete the application process, and based on these metrics it can later make informed decisions.

However, the translation of processes into a gamification experience requires a thorough analysis of their advantages and disadvantages. While the dynamic nature of such an approach is evident, capturing the student's curiosity and engagement by involving them in an interactive journey to explore and discover the university while completing necessary tasks, it is essential to consider the potential limitations and methods to mitigate them.

The proposal of such an interactive experience may be more suitable for scenarios with a limited number of participants or when registration locations are numerous and dispersed across a wide area, potentially spanning different buildings. In such contexts, integrating this solution is justified as it maintains interest and enthusiasm through interactive activities, even if they require participants to navigate between various locations.

It is crucial to recognise that implementing a treasure hunt-style approach within a large-scale event and a constrained framework can result in disorder and confusion. Therefore, in scenarios involving a significant number of participants and a restricted developmental context, a limitation of the current proposal is identified and additional automated solutions are necessary to ensure the smooth execution of processes, as part of a future research.

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