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GuideMe: A system for Indoor Orientation and Guidance

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Information about the presenter

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Outline

- Introduction
- Motivation
- Related Work
- System Architecture
- System Modules
- Conclusion and Future Work
- Acknowledgments

Introduction [1/2]

- The GuideMe project involves the design and development of an indoor tracking and navigation system for people suffering from blindness.
- The core of the system is a device which will provide the ability to navigate through voice instructions.
- These instructions are based on the positioning and orientation capabilities of the device.
- For outdoor navigation and pathfinding, the Global Positioning System (GPS), is the most commonly used technology, among others. GPS though is only applicable for outdoor localization because issues arise when is about indoor localization.
- In the context of GuideMe project, this paper presents the architecture and the modules of the GuideMe system that were used and developed for indoor navigation.
- The GuideMe system consists of the following modules:
  - *Indoor positioning and navigation algorithms: For indoor positioning, the trilateration method was selected because of the UWB technology.*
  - *UWB technology provides very good position estimation, thus trilateration provides sufficiently precise localization*

Introduction [2/2]

- For navigation, the A* algorithm was implemented. It is a heuristic algorithm, finding the shortest distance. It searches for the minimum optimal path, among all possible paths to the final node (destination).
- As far as the Text-to-Speech module is concerned the Google's text-to-speech (TTS) was selected.
- Using the Google platform and the corresponding API, the application creates an audio mp3 file from the text that will be the input to the specific text-to-speech functionality of the platform.
- Wearable device and anchor module: Wearable is a device that the user carries and works with other system entities to determine the location. Anchors are devices in specific locations inside the buildings which are used for the wearable device to locate itself.
- In addition to communicating via UWB with the wearable device, the anchors communicate with the local server via Wi-Fi.
- Mobile application: The smartphone that the user carries is informed by the system about the route that must be followed by the user and converts this information into audio messages in the user's headphones.
- Servers: Local server has multiple roles; it communicates with the host server via MQTT protocol messages. It also communicates with fixed devices via Wi-Fi for the relative distance of each mobile device.

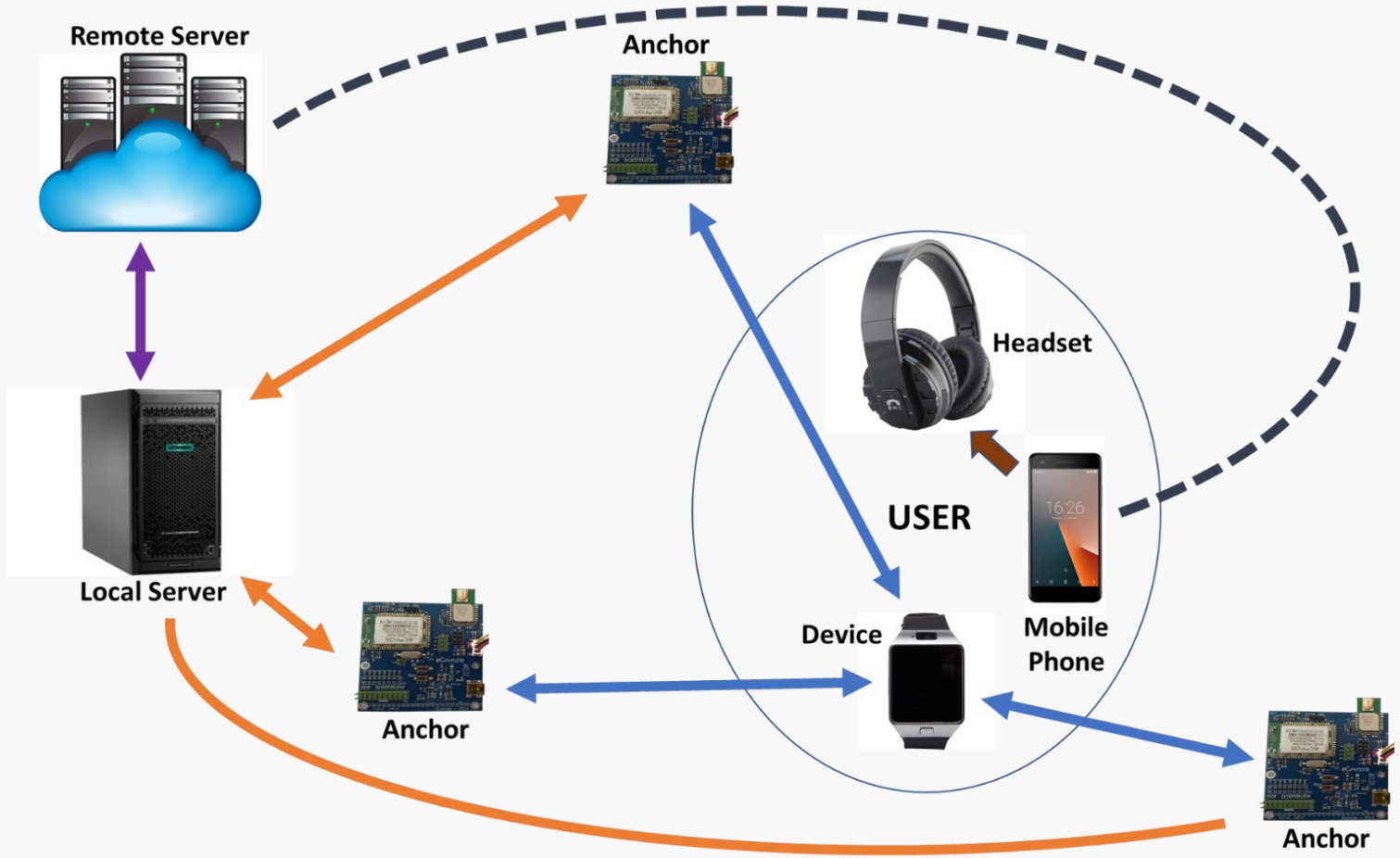
Related Work

- Previous works focus on the need to study the general way of positioning and then they propose algorithms and methods for indoor positioning while others propose a different way of system architecture to achieve efficient indoor navigation.
- Significant work regarding indoor navigation for people with special needs is available. For example, a comprehensive solution was provided by Kishore et al. for indoor public transport for people with disabilities.
- As far as the localization algorithms:
  - *Peltola et al. present an architecture design using GNSS and UWB technologies simulated in MATLAB using multiple users, methods, and sensors.*
  - *A survey of the latest indoor positioning technologies is provided by Alarifi et al., who analyze UWB technologies with an analysis of Strengths, Weaknesses, Opportunities, and Threats (SWOT).*
- As far as the path finding algorithms:
  - *Using A* algorithm, a study in order to reduce the time that is required by a user to get to its destination is conducted by Goel, et al. etc.*

System Architecture [1/4]

- The architecture consists of the following parts:
  - *the wearable device that the user is wearing, the anchors that are devices located inside a building that helps in the positioning process.*
  - *the mobile application (installed in the end-user mobile phone), the wireless headset that provides the user with the audio commands for the navigation inside the building.*
  - *a local server*
  - *and a remote server*
- In this project, the main component is a small wearable device that helps in the user's positioning through UWB technology.
- This technology provides perfectly accurate positioning, with an error of up to 10 cm
- This device, apart from the ability to locate the user, can also determine the orientation of the user, receive voice commands, and transmit voice instructions to guide the visually impaired people

System Architecture [2/4] – Architecture overview



System Architecture [3/4]

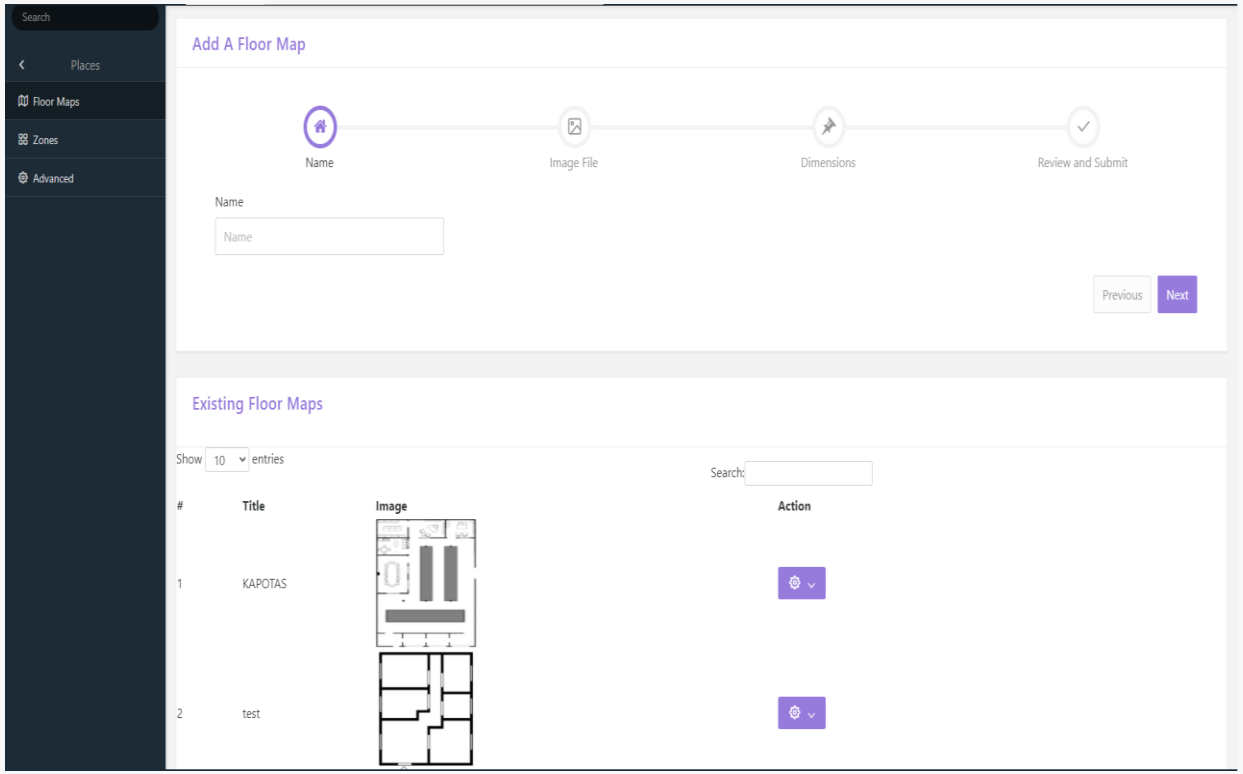
- In GuideMe system, our smart device can communicate to anchors via UWB technology, in order to locate the user.
- This device has the ability to provide route and navigation information to the user via voice commands.
- The anchors are calculating and measuring the distance between the user and the anchor. The distance data (between the user and the anchors), is transferred to a local server to measure the exact position and run positioning algorithms, which in our case will be based on the trilateration approach.
- The communication between the anchors and the local server is done using Wi-Fi technology and as far as the communication protocol is concerned the Message Queuing Telemetry Transport (MQTT) is used.
- Furthermore, there is a remote server that has a floorplan of the building. This remote server, having the details of the building, the position of the user, and the destination of the user, can guide the user by giving directions.
- Also, the communication of the local servers with the remote server is done over REST API that ensures seamless communication, speed, and scalability.

System Architecture [4/4]

- The navigation directions are given by the smartphone to the user through wireless headphones, using voice commands.
- Specifically, the communication between the wireless headset and the smartphone is based on Bluetooth technology.
- The mobile application is responsible to provide the navigation commands. The audio commands are extracted in the remote server and transmitted through the Wi-Fi network to the mobile application.

System Modules [1/6]

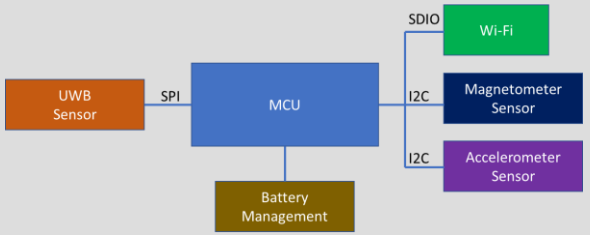
- Indoor positioning and navigation algorithms
  - *The algorithm was implemented following these steps: a) for each UWB anchor with which the user connects, a circle is created, with the center the position of the user, and with a radius the distance between the user and the anchor. To locate the user, the user must be connected with at least three anchors.*
  - *Regarding the navigation algorithms, the A* algorithm was implemented. A* algorithm is a heuristic algorithm for pathfinding, that can "discover" the optimal path, under some circumstances. This algorithm depends on the structural graphs. An initial node is defined as the start point on the graph and tries to find the endpoint with a minimum cost.*



System Modules [2/6]

- Text-to-Speech
  - *The navigation commands to the end-user are provided through the Android application, using the Google Cloud TTS platform. The commands extracted from the TTS procedure are provided to the user via the SSML language.*
  - *SSML language is a part of a greater set of markup specifications for voice commands. The flow of the TTS conversion is the following: TTS operates by converting SSML input into audio data. Audio data is in human speech. The process of translating the text into human speech is called synthetic speech.*
- Wearable device and Anchors
  - *As far as the wearable device is concerned, the processor that is chosen is the EC32L13 module developed by Econais.*
  - *The EC32L13 is a 32-bit processor of the product family STM32 processors.*
  - *A WiFi module is also integrated into the wearable device. For the connectivity through UWB, we have chosen the module DWM1000 of Decawave.*

SYSTEM MODULES [3/6]



System Modules [4/6]

- Mobile App
  - *As far as the mobile application is concerned, we focused on creating an Android-based application. The application is responsible for several functions:*
    - Connection to the local server via a Wi-Fi network and receive on-site navigation commands. The application receives the commands in a format defined by the communication protocol between the server and the defined application, converts them into voice commands, and transmits them to the headset.
    - Interface through which the user enters his passwords and is verified that he has the right to use the service. The authentication process is based on the Cognito platform of Amazon Web Services.
    - Interface for the wearable-application pairing. The wearable device was programmed to transmit to Bluetooth Low Energy (BLE) beacons, and particularly iBeacons. iBeacons is the technology standard that enables mobile apps to listen to signals from Bluetooth devices.

System Modules [5/6]

- Local and Remote Server: Finally, project GuideMe consists of two types of servers, the local servers, and the remote server. The server offers device management functionality.
- There are different types of devices and each type is managed differently. Specifically, the devices that the local server manages are:
  - *Mobile UWB devices that users carry (tags) and are responsible for locating them indoors.*
  - *UWB devices that located in specific areas and communicate with both mobile stations and the local server.*
  - *The local server is located on the building premises.*

System Modules [6/6]

- As far as the remote server is concerned, the main responsibilities of the remote server are the following:
  - *Offer user management functionality. Different levels of users are provided, each with different capabilities and rights.*
  - *Users log in to the platform using a username/password. Modern user authentication methods incorporate additional mechanisms in parallel with the password-based methods, to verify the identity of users.*
  - *In the GuideMe project, the Amazon Web Services' Cognito platform was used. We generalize authentication into two common steps, which are implemented through two APIs provided by the platform: InitiateAuth and RespondToAuthChallenge.*
  - *Manage the information of buildings, such as maps (floorplans).*
  - *Gather the information sent by the devices, provide previous information, e.g., the previous locations of the user. (d) Provide information concerning the use and cost of the use of the system (accounting/billing).*
  - *Capture the position of the devices in the space on the floorplans.*

Conclusion and Future Work

- This work refers to the project of GuideMe. The state of the art of existing approaches and the system modules that were implemented to complete the above-mentioned project in terms of navigation and indoor routing were presented.
- The system provides a wearable device, and the project's purpose is the contribution to indoor navigation and positioning assistance for people with difficulties.
- The user is guided from the wearable device for the indoor orientation through voice commands and help him to avoid obstacles.
- This work is the final phase of the project that relates to transmitting the correct instructions to the user using the information and modules of the aforementioned through voice commands.
- Future work will include the participant-based evaluation of the GuideMe system and study the impact of such a system in museums.
- Also, future work may include an extension of this current work by also covering outdoor areas through the application.

Acknowledgments

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Thank You!

Questions?

Remarks?

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