

Guardian Angel

Rishitej Yadav Pallapothu, Kavya Chandrika Vempalli, Asish Addanki

{rpallapo, kvempall, aaddanki}@asu.edu

IMPACT Lab, CIDSE, Arizona State University, Tempe, AZ

ABSTRACT

Guardian Angel is a personalized context-aware application aimed at improving the quality of life and safety of individuals with diabetes, enhancing rider safety and emergency response. The project's primary objectives are to develop a comprehensive system that monitors and manages blood sugar levels in real-time and enhances rider safety through an autonomous vehicle advisory controller. This project includes blood sugar management, autonomous vehicle safety and emergency response. In the case of Blood Sugar Management, the "Guardian Angel" system continuously measures and regulates blood sugar levels. The system uses this data to provide personalized recommendations for hotel bookings with appropriate meal options and purchasing travel tickets tailored to the user's health condition, requirement, and schedule. For Autonomous Vehicle Safety, the project features a level 3 autonomous vehicle with an advisory controller. This controller is capable of seamlessly switching between automated and human-controlled braking to prevent impending crashes and ensure passenger safety. Moreover, in Emergency Response situations where an accident is imminent and unavoidable, "Guardian Angel" is designed to contact emergency services and provide the user's medical history, enabling timely and appropriate medical intervention.

1. INTRODUCTION

Guardian Angel, our customized context-aware application, stands as an initiative designed to elevate the well-being and safety of individuals with diabetes while also bolstering rider safety and emergency response systems. This multi-faceted project encompasses several pivotal components. Firstly, it features an emergency services notification system, fortifying safety measures for riders, and offering health-centric food recommendations. Additionally, it provides tailor accommodation suggestions and reliable advisory controls, creating a comprehensive safety and health-oriented ecosystem. The project unfolds across three core sections: the initial phase involves collecting user information via a mobile application, encompassing vital data such as heart rate, respiratory rate, blood sugar levels, user schedules, travel bookings, and medical record, all meticulously stored within a secure database. Subsequently, the second phase centers on acquiring vehicle and travel specifics, including details on distance between vehicles, car speed, travel origins, destinations, and road conditions. Finally, the third phase integrates an advisory controller, utilizing data from the prior sections to evaluate whether a user should switch conditions. Should the output indicate a need to switch, the system triggers an alert through the mobile app, while in the event of a potential crash, emergency services are promptly contacted.

2. ARCHITECTURE

The architecture of the Guardian Angel project is better explained by segregating them as system components, Data Flow and Process Flow. The database manager uses firebase. It is integrated with the mobile application. It utilizes SQLite DB to store user-entered data like heart rate, respiratory rate, blood sugar levels and symptoms. The API Manager consists of Google Maps API and Think Speak API. The google maps API is utilized for Directions and places. Places API is used to provide precise location data. The Distance Matric API calculates paths, traffic evaluation, average speed, and current speed. Think Speak API is used to update channels in MATLAB for data integration. The channel manages six parameters, with the last one

(collision status) calculated by MATLAB. The resource manager describes the UI Manager and other hardware components. The UI Manager manages UI app pages including login, vehicle information, source and destination inputs. It integrated Google Maps API to determine traffic conditions for MATLAB. Camera, Flash and Gyroscope are the sensors required for the project. Camera and Flash are used to measure the Heart rate. A gyroscope is used to measure the respiratory rate.

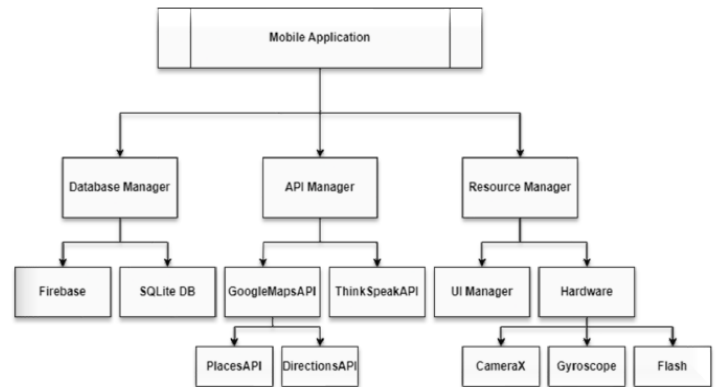


Figure 1: Application Architecture.

The user data from the mobile application is channeled to Think Speak as shown in Figure 2. The Channel includes HeartRate, RespRate, Speed, Distance, Road Condition and collision status. The matlab file receives the first five fields to calculate reaction time and simulates LaneMaintainSystem.slx based on speed and distance values. It determines the collision time and generates collision status based on simulation results.

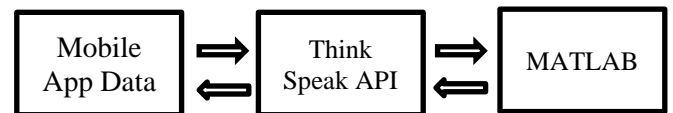


Figure 2: Data Flow from Mobile Application to MATLAB

3. THE APPLICATION SUITE

The Guardian Angel Application Suite is a cutting-edge and comprehensive solution designed to enhance the well-being and safety of individuals managing diabetes. This suite seamlessly integrates multiple components to create a holistic and personalized experience for users. At its core is the Guardian Angel Mobile App, serving as a central hub for health monitoring and travel safety. The suite extends its capabilities through MATLAB Scripts, leveraging advanced analytics for collision prediction and advisory control.

Firebase Integration ensures real-time data synchronization, keeping the app constantly updated with the latest user information. Local Database Management enhances the app's performance by efficiently storing and retrieving user-specific data. Google APIs contribute advanced mapping and location-based services, enriching travel-specific features. Additionally, ThingSpeak Integration facilitates

seamless data transmission for real-time analysis in the MATLAB suite.

Together, these components form a symbiotic ecosystem, empowering users with a personalized, context-aware solution. The Guardian Angel Application Suite transcends the conventional boundaries of health monitoring apps, actively contributing to user safety, peace of mind, and an elevated quality of life.

3.1 Guardian Angel Mobile Application

The Guardian Angel Mobile App stands as the central pillar of the user experience, catering specifically to individuals effectively managing diabetes. With a design focused on user-friendliness, the app's intuitive interface seamlessly integrates crucial aspects of health monitoring and travel-specific features. Users are presented with a platform where effortlessly inputting health metrics, tracking symptoms, and receiving instant collision risk assessments become second nature. This amalgamation creates a comprehensive solution that not only prioritizes user convenience but places a paramount emphasis on safety.

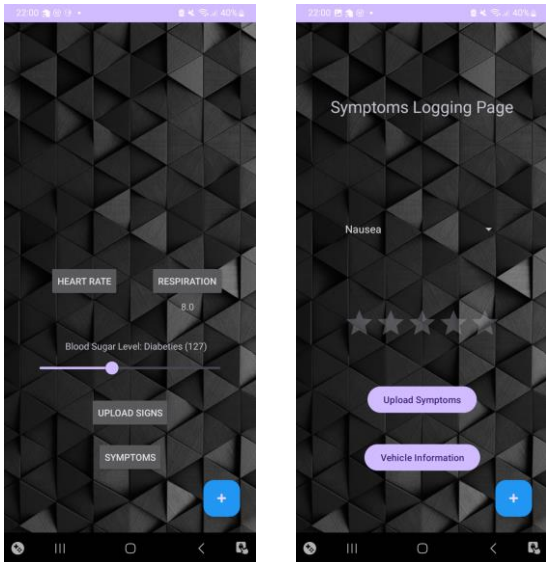


Figure 3: User data and Symptoms activity

Empowering users with personalized insights is a key hallmark of this application. By offering real-time assessments and tailored information, the Guardian Angel Mobile App goes beyond conventional health management tools. It redefines the landscape of well-being management, enabling individuals to proactively and effectively navigate their health journeys. In essence, this app becomes more than a tool; it transforms into a companion, reshaping how individuals engage with their health on a day-to-day basis.

3.2 MATLAB SCRIPTS

MATLAB Scripts, operating as the analytical backbone within the Guardian Angel suite, undertakes a multifaceted approach by processing intricate datasets encompassing user health metrics, travel information, and GPS data. Specifically, these scripts intelligently factor in variables such as heart rate, respiratory rate, and real-time road conditions. Leveraging the capabilities of MATLAB, these scripts utilize advanced algorithms to conduct complex analyses, extracting meaningful patterns and trends from the amalgamated data.

The integration of heart rate and respiratory rate enables the system to assess the physiological state of the user, contributing valuable insights into their health. Simultaneously, the consideration of road conditions, including real-time data from GPS, provides a comprehensive understanding of the user's travel environment.

```
AdvisoryController.m
1 %Reading Input From Channel
2 channel_id=2363661;
3 read_key='5BQFWKMSHY7F44M';
4
5 user_data=thingSpeakRead(channel_id,'ReadKey',read_key,Fields=[1,2,3,4,5],NumMinutes=4);
6 %user_data=[55,8,25,12,1];
7 Hr_lcw=user_data(1,1);
8 Hr_hcw=user_data(1,1);
9 Rr_lcw=user_data(1,2);
10 Rr_hcw=user_data(1,2);
11 initSpeed=user_data(1,3);
12 dist_limit=user_data(1,4)*(-1);
13 Case=user_data(1,5);
14
15 %% Initializations
16 Update = 0;
17 Control = 0;
18 Switch = 0;
19 Crash = 0;
20 Collision_count=zeros(2,1);
21 switch_count=zeros(2,1);
22 p = 1;
23 lcw_count=0;
24 hcw_count=0;
```

Figure 4: MATLAB script

Through seamless communication with the Guardian Angel Mobile App via ThingSpeak channels, the MATLAB Scripts deliver real-time assessments and predictions. This includes not only collision risk evaluations but also the generation of proactive safety measures. The bidirectional flow of information ensures that the app remains updated with the latest analytical insights, allowing users to make informed decisions regarding their well-being during travel.

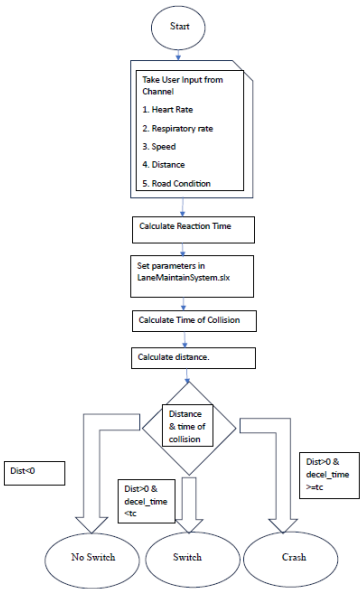


Figure 5: MATLAB workflow

In summary, these MATLAB Scripts operate as a sophisticated analytical engine, synthesizing diverse health and travel data to enhance the Guardian Angel suite's capabilities. The communication through ThingSpeak channels ensures a dynamic and real-time exchange of information, contributing to the app's ability to provide personalized and proactive safety measures for individuals managing diabetes.

3.3 Database Integration

The synergistic integration of Firebase and Local Database Management establishes a comprehensive and technically sophisticated data management architecture within the Guardian Angel suite.

Firebase Integration, serving as the real-time synchronization engine, operates as a dynamic link between various components of the

Guardian Angel ecosystem. From the initial authentication process on the login page to the intricate advisory control responses, Firebase acts as the conduit for transmitting and receiving data. It intricately handles the recording of crucial health metrics—such as heart rate, respiratory rate, blood sugar levels, symptoms—and intricate travel details like source (src), target (tgt), and destination (dest). Firebase, functioning as the central repository, ensures that the Guardian Angel system maintains an up-to-date and accurate dataset.

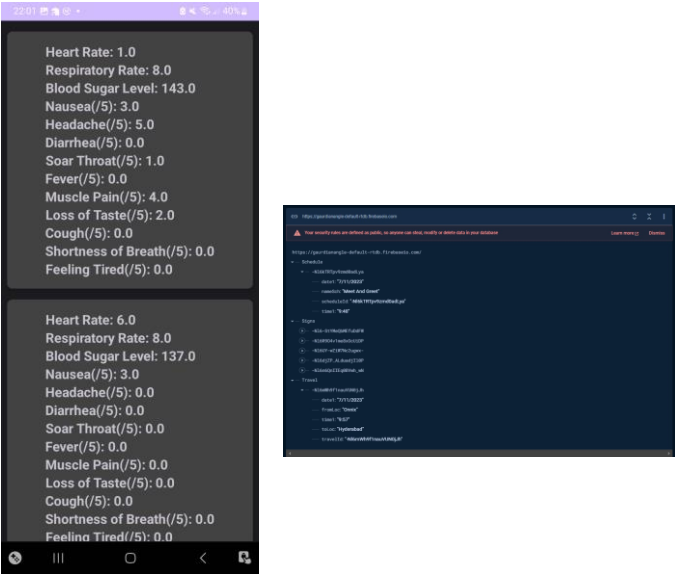


Figure 6: Database information and firebase

Simultaneously, Local Database Management takes an active role in optimizing data access and retrieval efficiency. This component acts as a sophisticated and localized storage solution, efficiently managing the historical health metrics and intricate travel details. The local database not only serves as a reliable repository but also plays a crucial role in minimizing latency during data access. Whether retrieving past health readings or accessing advisory responses, the local database significantly contributes to optimizing the overall performance of the Guardian Angel Mobile App.

In a technical context, Firebase's role extends beyond conventional data storage; it acts as a real-time synchronization orchestrator, facilitating seamless communication between the Guardian Angel Mobile App and other integral components. On the other hand, Local Database Management, with its optimized schema and indexing strategies, ensures that the Guardian Angel suite can rapidly access specific datasets. This becomes particularly critical during real-time scenarios, such as collision risk assessments or emergency responses, where data access speed is paramount.

3.4 Google maps API

Together, Firebase Integration and Local Database Management form a robust technical foundation, ensuring the reliability, responsiveness, and streamlined operation of the Guardian Angel suite by efficiently managing the flow of data throughout the application's lifecycle.

Google APIs Integration stands as a pivotal and technically sophisticated component within the Guardian Angel suite, leveraging advanced mapping and location-based services to enhance user experience significantly.

The incorporation of Google Maps APIs within the Guardian Angel Mobile App ensures a heightened level of accuracy in location tracking and road condition assessments. Google Maps APIs, renowned for their precision, provide the backbone for the app's mapping functionalities, allowing users to receive real-time insights into their surroundings. The integration goes beyond mere mapping; it facilitates a dynamic and interactive user experience, enabling users to visualize their travel environment with unparalleled accuracy.

Wireless Health '13, November 1-3, 2013, Baltimore, MD, USA.
Copyright 2013 ACM 123-4-5678-90000 ...\$15.00.

One of the standout features of Google Maps API integration is its real-time calculation of road conditions based on the traffic conditions between source (src) and destination (dest) locations. The API taps into Google's extensive traffic data, dynamically analyzing congestion levels and travel times. This real-time data is seamlessly integrated into the Guardian Angel suite, enriching the travel-specific features of the app. Users can make informed decisions about their routes, taking into account the current traffic conditions, ensuring a safer and more efficient travel experience.

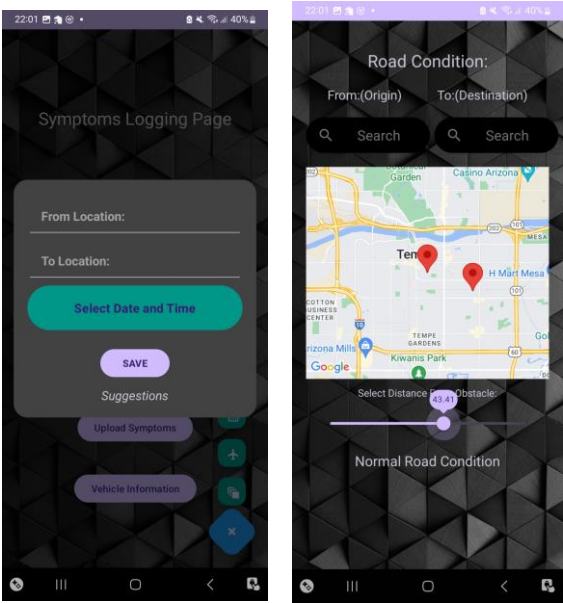


Figure 7: Map Activity in the app

The significance of Google APIs Integration in Guardian Angel extends beyond mapping; it becomes a dynamic tool for empowering users with a comprehensive understanding of their travel environment. The real-time calculation of road conditions not only enhances the app's functionality but also contributes to the overall safety and efficiency of the user's journey. By tapping into the wealth of data provided by Google Maps APIs, Guardian Angel ensures that users have the most accurate and up-to-date information, fostering a heightened level of situational awareness during their travels.

3.5 ThingSpeak Integration

ThingSpeak Integration plays a pivotal role in the Guardian Angel suite's analytical framework, serving as a robust bridge for seamless data transmission and real-time analysis, particularly within the MATLAB component.

At its core, ThingSpeak serves as the IoT analytics platform that facilitates the creation of specialized channels for data collection. The MATLAB scripts within the Guardian Angel suite are intricately linked to these ThingSpeak channels. These channels act as conduits for transmitting and receiving vital data, including user health metrics encompassing heart rate, respiratory rate, and even intricate travel details such as source (src) and destination (dest). The integration ensures that the MATLAB scripts are continually fed with the latest information, creating a dynamic and responsive data ecosystem.

The real-time data transmission facilitated by ThingSpeak is instrumental in achieving accurate collision prediction and advisory control within the Guardian Angel system. Through the setup of dedicated ThingSpeak channels, the MATLAB scripts receive timely

updates, enabling them to perform sophisticated analyses based on the most current data. This integration contributes significantly to the overall reliability and precision of the collision prediction model, ensuring that the Guardian Angel suite operates with the utmost accuracy in assessing potential risks and initiating appropriate responses.

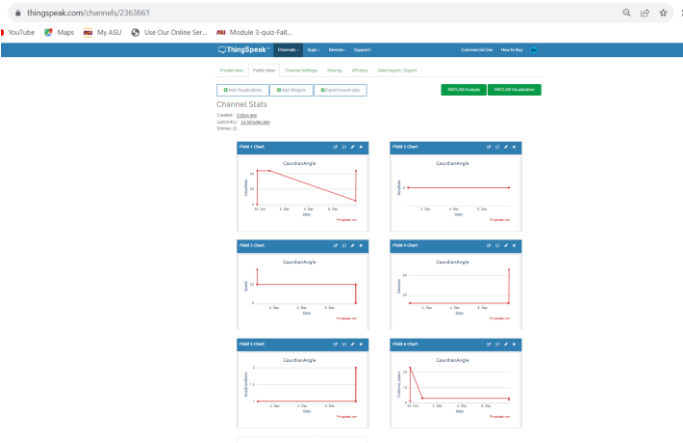


Figure 8: ThingSpeak API channels

From a technical standpoint, the integration with ThingSpeak introduces the concept of asynchronous data flow, where the MATLAB scripts interact with the ThingSpeak channels without direct dependencies or delays. This asynchronous architecture ensures a continuous and uninterrupted flow of data, a critical factor in achieving real-time analysis. By leveraging ThingSpeak's capabilities, the Guardian Angel suite ensures that data synchronization is not only efficient but also near-instantaneous, laying the foundation for accurate and proactive decision-making within the MATLAB analytical framework.

4. IMPLEMENTATION

The Guardian Angel project was meticulously executed, focusing on diverse facets such as health monitoring, user experience enhancements, data acquisition and processing, user authentication, vehicle information, database management, and collision prediction. A pivotal addition to the health monitoring aspect was the inclusion of Blood Sugar Levels as a sign measurement, enabling users to manually input fasting blood sugar test results. Moreover, the Health Condition Indicator, influenced by Blood Sugar Levels, was adeptly integrated to notify users of potential diabetes risks. Additionally, the incorporation of Food Suggestions based on health conditions aimed at bolstering overall well-being by offering tailored dietary recommendations.

An essential user-centric feature, the Floating Button, was strategically implemented across Android activities, providing swift access to three key options: Schedules, Travel Plans, and Medical Records. This intuitive addition facilitated the creation and management of schedules, including comprehensive date/time details. Travel planning functionality was seamlessly integrated, empowering users to input origin, destination, and date/time preferences. Leveraging the Places API further enhanced user convenience by suggesting nearby hotels. The Medical Records section proved beneficial, offering a repository of prior sign measurements and symptoms, facilitating more accurate diagnoses and treatment by medical professionals. The inclusion of Date and Time Picker for schedules and travel plans improved the overall user experience.

Efficient data acquisition and processing mechanisms were achieved through strategic utilization of Google Maps API for precise location data and streamlined calculations of average speed and path length. The Think Speak API played a crucial role in enabling seamless data exchange between

Android and MATLAB, establishing a robust communication channel for effective data transfer and further analysis.

User authentication and login functionalities were seamlessly integrated, featuring an avatar selection, Gmail address input, and password fields. Leveraging Firebase database integration enabled seamless Google account login, prioritizing enhanced user convenience and security.

The vehicle information and traffic monitoring segments were comprehensive, capturing vehicle specifics like distances between cars and individual car speeds. Integrating Google Maps API for real-time traffic maps, classified by traffic intensity, elevated user awareness about road conditions. This data was also shared with MATLAB, enhancing decision-making capabilities related to driving safety.

Database management was meticulous, establishing a reliable connection through Firebase for consistent and accurate data storage. Implementing data persistence practices ensured the safety and reliability of stored data, guaranteeing uninterrupted accessibility.

In the context of MATLAB integration and collision prediction, a dedicated Think Speak channel facilitated seamless data transfer between the mobile app and MATLAB. The development of a MATLAB script processed critical input data and simulated collision scenarios based on various parameters. Utilizing LaneMaintainSystem.slx model aided in determining speed and distance limits, crucial for collision predictions. The simulation of the HumanActionModel predicted lane-switching possibilities based on reaction time. Calculating collision status based on time metrics and deceleration requirements ensured accurate predictions, with the results communicated back to the mobile app through the Think Speak channel.

In summary, the Guardian Angel mobile application's comprehensive implementation encompasses a wide array of functionalities focused on health monitoring, user experience enhancements, and driving safety. Leveraging cutting-edge technologies such as Google Maps API, Think Speak API, and MATLAB, the application empowers users with valuable insights, promoting overall well-being and safety.ratio from BrainHealth.

5. DEMONSTRATION AND FUTURE WORK

The demonstration setup will include Camera and Flash, that will be turned on. They take the finger readings and calculate the heart rate. The respiratory rate is supposed to be calculated using an accelerometer, but because of the limitations of mobile application under usage, the data required for respiratory rate calculation is taken from a csv file. The blood sugar levels input is expected to be given from the user, after fasting blood sugar test. The app can be future enhanced to take blood sugar levels post lunch and used for appropriate calculations.

6. CONCLUSION

In the Guardian Angel project, we epitomized a pioneering endeavor focused on augmenting the well-being and safety of individuals with diabetes while revolutionizing rider safety and emergency response systems. This innovative application integrates cutting-edge technologies and multifaceted functionalities to create a comprehensive system that encompasses blood sugar management, autonomous vehicle safety, and emergency response mechanisms.

The project's inception aimed at developing a real-time blood sugar monitoring system and an autonomous vehicle advisory controller. Within the domain of Blood Sugar Management, Guardian Angel continuously measures and regulates blood sugar levels, offering personalized recommendations for hotel bookings and travel arrangements tailored to individual health conditions and schedules. Additionally, it provides a Health Condition Indicator based on Blood Sugar Levels, alerting users to potential diabetes risks and integrating food suggestions to improve overall well-being.

Efforts were directed towards meticulous implementation across diverse aspects, including health monitoring, user authentication, vehicle information, and collision prediction. Notable enhancements included the integration of Blood Sugar Levels for health monitoring, real-time traffic monitoring using Google Maps API, and the simulation of collision scenarios for predictive safety measures. The project's culmination highlights a holistic ecosystem that prioritizes user well-being, safety, and efficient emergency response mechanisms.

The Guardian Angel project serves as a testament to innovation in health technology and transportation safety, offering a comprehensive and proactive approach to improving the quality of life for individuals with diabetes and enhancing overall rider safety.

7. REFERENCES

- [1] Joseph Milazzo, Priyanka Bagade, Ayan Banerjee, Sandeep K.S. Gupta, Demonstration Paper: bHealthy: A Physiological Feedback-based Mobile Wellness Application Suite.
- [2] Ayan Banerjee, Sunit Verma, Priyanka Bagade and Sandeep K.S. Gupta, Health-Dev : Model Based Development of Pervasive Health Monitoring Systems. 2012 Ninth International Conference on Wearable and Implantable Body Sensor Networks
- [3] Ayan Banerjee, Member, IEEE and Sandeep K.S. Gupta, Senior Member, IEEE, Analysis of Smart Mobile Applications for Healthcare under Dynamic Context Changes, IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 14, NO. 5, MAY 2015