****

**DESIGN AND IMPLEMENTATION OF A WEB-BASED RADIO AUDIENCE MEASUREMENT SYSTEM**

**BY**

**AYEGBA JESSE-JOSEPH, ANIBE**

**(16CK020793)**

**SUBMITTED TO**

**THE DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING,**

**COLLEGE OF ENGINEERING,**

**COVENANT UNIVERSITY**

**IN PARTIAL FULFILLMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING (B.ENG.), ELECTRICAL AND ELECTRONICS ENGINEERING, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA**

**JANUARY, 2021.**

**DECLARATION**

I hereby declare that the work detailed in this report was completed by me under the supervision of Engr. Omoruyi Osemwegie in the Department of Electrical and Information Engineering, Covenant University. Also, I affirm that as far as I could possibly know, no piece of the report has been submitted here or somewhere else in an earlier application for the honor of a degree. All sources of information utilized thus have been properly recognized.

…………………………………….

AYEGBA JESSE-JOSEPH ANIBE

16CK020793

**CERTIFICATION**

This is to certify that the project titled "Design and Implementation of a Web-based Radio Audience Measurement System” by AYEGBA JESSE-JOSEPH, ANIBE , meets the requirements and regulations governing the award of the Bachelor of Engineering, B.Eng. (Electrical and Electronics Engineering) degree of Covenant University and is approved for its contribution to knowledge and literary presentation.

|  |  |
| --- | --- |
| **Student:** | Name: AYEGBA JESSE-JOSEPH ANIBE  Sign: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| **Supervisor:** | Name: Engr. Omoruyi Osemwegie  Sign: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| **HOD:** | Name: Prof. Emmanuel Adetiba  Sign: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| **Internal Examiner:** | Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Sign: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| **External Examiner:** | Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Sign: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

**DEDICATION**

This project report is dedicated to God Almighty my Creator, who has been my rock, guide, source of inspiration, wisdom, knowledge and understanding. He has been my strength and in his arms I have been sheltered. I also dedicate this work to my lovely siblings who have encouraged me every step of the way and whose encouragement has made sure that I give it all it takes to complete that which I have started. To my parents Mr. and Mrs. Ayegba who have been affected every step of the way by this quest, the words that will express how much appreciation I have for you have not been invented yet. So, in all sincerity I say thank you and God bless you.

**ACKNOWLEDGEMENT**

My sincere appreciation goes to God Almighty for enabling me to complete this project. I would also like to express my deepest gratitude to the members of my family for their unending support.

I would like to express my appreciation to my project supervisor, Engr. Omoruyi Osemwegie, for providing me with the necessary guidance needed to complete this project.

# INTRODUCTION

## BACKGROUND OF THE STUDY

The classical view of audience measurement is the estimation of the number of viewers who are tuned to a particular TV program or channel, or the number of listeners who are tuned to a particular radio program or channel. Audience measurement takes into account, the behaviour of the audience as well as its demographics [1]. Direct and indirect methods of measurement are used and, usually, results from a carefully chosen sample are extrapolated to produce figures for the whole population. Audience research is an important aspect of television and radio production broadcasting as well as newer forms of media material. Internet, IPTV, mobile phones, and personal computers are all examples of delivery methods. Audience measurement can be used for everything from self-promotion to fine-tuning a service [2].

One of the solutions that audience measuring technologies strive to bring about is content consumption measurement. One of the most common approaches used by service providers or broadcasters to get important data for improving service offerings or setting advertising rates is to evaluate content consumption. Its uses are much broader than that. Without accurate audience data, many firms may be reluctant to join in the new delivery platforms.

### BRIEF HISTORY OF AUDIENCE MEASUREMENT

First launched in the late 1940's soon after the start of commercial broadcasting, the audience measurements allowed radio broadcasting business to flourish through networks which offered advertisers, who paid for the estimated number of ears listening on commercials, a way to quantify the financial value of radio audiences. The first measuring techniques had several limitations because the acquisition of reliable, large-scale data was costly. Despite the limitations, standards for measurement remained largely unchanged for years until the explosion of digitally accessible data resulted in such devices as cable boxes, video on demand boxes and cell phone as well as web apps, internet browser clicks, web queries, and social media activities. Radio listeners now leave digital footprints that may be used to follow practically every part of their everyday lives, enabling large-scale aggregation across data sources for individual users and groups, as well as tracking of more individuals on more dimensions for more programs. Data is now more substantial, real-time, and less expensive to get, allowing for precise and fine grained radio audience monitoring [1].

### AUDIENCE MEASUREMENT IN DIGITAL SIGNAGE

Digital signage service provides advertisements and useful information using terminal equipped with electronic displays, and it is also possible to aggregate information using various kinds of sensors including camera. In comparison to standard DID (Digital Information Device) services, which only supply one-way content, digital signage services can offer more advanced features like user interactivity and audience measurement. It is feasible to give appropriate material to users and boost advertisement effects by measuring audience behavior. Digital signage services are becoming more popular these days for a variety of reasons allowing for increased contact and intelligence services especially now that digital signage devices are being put in a variety of locations including public spaces [3]. Bus stops, hallways, and shopping malls are examples of public spaces. Static signs are losing their impact, but digital signage, on the other hand, are designed to capture consumers' attention and convey messages that are tailored to improve their experience. It is useful for obtaining audience and environmental data to aid the kind of content to present to then. This project presents a web-based approach for gathering these data, using machine learning to accurately predict and identify different sound data.

Diagram

Description automatically generated

Generic digital signage architecture with audience measurement [3].

## PROBLEM STATEMENT

With the rapid technological advancements that the world is experiencing, a shift from the traditional way of doing things to a more efficient way is required. Currently, radio audience measurement is done in a way that requires full human input by recalling their listening patterns which is prone to some inaccuracies. It has been noted that humans are inherently fallible, and errors are highly inevitable. Therefore, there are high possibilities of errors gotten from data taken from human inputs to lead to errors in the calculation of radio audience listenership.

## AIMS AND OBJECTIVES

This project aims to design and build a web-based audience measurement system that will be used in the estimation of the number of people who are tuned to, and actively listening to radio stations. The implementation of the application was done as a modern system that would reduce all forms of human error and, also make the data gotten from the system reliable.

The objectives of this project are to:

1. To design a mobile and web application using figma.
2. To build out the mobile and web application using javascript, with frameworks like React native and React js respectively.
3. To use a cloud storage platform like firebase to store the audio recordings of participants.
4. To use machine learning to accurately predict the nature of the recordings that participants have uploaded.
5. To determine the effectiveness of the system by comparing the results to a predetermined set of results.

## SIGNIFICANCE OF THE PROJECT

The data gotten implementation of this project will be beneficial to the following groups of people:

1. **Advertisers**: Data gathered from this project could be used by advertisers to target a specific audience to advertise their content to.
2. **Researchers**: Researchers are constantly looking for ways to improve the spread of good and reliable information. The data gotten from this project could be of tremendous help to achieve this goal.
3. **Students**: The project provides more information for further works and research on the subject area.
4. **Data analysts**: Data analysts need data sets to analyze, to predict future problems as well as solutions. Data gathered from this project could aid them.

The implementation of this project will also be inline with the sustainable development goal(SDG) 9. Which is to “build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation”.

## MOTIVATION FOR THE STUDY

With the rapid increase in the population of the world today, there is also a progressive increase in the demand for good and quality information content. Advancements in technology are gradually bringing about a change in what people engage in as well as their interests. It is clear, that what people listened to some 40 years ago on radio stations are not what they are interested in listening to these days. Thus, the need for some way to accurately determine what people are really interested in listening to. This project tries to measure the listening patterns of radio audiences and predict people are interested in listening to.

## METHODOLOGY

Two client-side applications were built- a web application for administrators and a mobile application for participants. The mobile application sends audio data to a server-side service called firebase. The server-side service handles things like user authentication to allow participants sign up and login. The mobile and web application were built using javascript with frameworks like React native and React js respectively. A javascript library called ml5 js handles machine learning on the administrators’ dashboard, to predict the kinds of recordings that participants have sent to the server. These results are then analyzed and used to estimate the listening audience.

## PROJECT ORGANISATION

**Chapter 1**: Contains a general overview on the project, the background information, the aim and objectives of the project, what problems the project seeks to solve as well as a brief outline of the methodology.

**Chapter 2**: Gives the literature review, it discusses the past related works on the project subject area. It contains theoretical background and other concepts necessary to make the project well understood.

**Chapter 3**: Contains the methodology of the project, how the project is going to be carried out, design of the project, it contains all components required for the design and block diagrams and software design.

**Chapter 4**: This chapter describes the implementation phase of the project as well as testing. The functional system design will be shown in detail as well as real pictures of the project undergoing testing. The results of the project will be analyzed in this chapter.

**Chapter 5**: This is the last chapter of the project report, and it contains conclusions and recommendations for the project. It also shows the results the project was able to achieve.

# LITERATURE REVIEW

## INTRODUCTION

With the growth of data, the question of what to quantify in terms of radio listeners and their habits has become increasingly crucial. Multiple radios are frequently used at the same time. This necessitates cross-platform measuring. Furthermore, the fact that radio users are adjusting their listening habits at an increasing rate suggests that more effective radio audience measurement techniques need to be employed.

This chapter covers a proper description of concepts in this work, it delves into radio audience measurement systems, its history, evolution and the use of audience measurement systems in various nations and economic settings. Finally, a review of previous research and projects relating to the concept of radio audience research, web-based and machine learning systems is considered. The information garnered from this review will be very vital to the situation of this project.

* 1. definItion of key terms

Some key terms related to this project, audience research and radio audience measurement are described below.

1. **Audience:** An audience is a group of individuals who are watching, witnessing or listening to something, such as a television program, a live speaker, or radio program, or it can refer to people who have similar tastes in entertainment.
2. **Audience measurement:** Audience measurement refers to the number of people in a group, usually in terms of radio listeners and television viewers, but also in terms of newspaper and magazine readers and, increasingly, website traffic. Audience measurement is sometimes applied to practices that assist broadcasters and advertisers in determining who is listening rather than how many people are listening. The resulting relative statistics are referred to as audience share in some parts of the world, while market share is used in other locations. Audience research is another term for this broader meaning.
3. **Radio**: A Radio is a device that makes use of electromagnetic radiation to transmit electrical signals across long distances without the use of cables, such as in sound transmission, television, and radar. The number of oscillations of electromagnetic radiation per second is referred to as MHz in the context of radio.
4. **Machine Learning**: Machine Learning is a sub-discipline of artificial intelligence that refers to the ability of computer systems to find solutions to problems on their own by recognizing patterns in databases, enabling computers make successful predictions using past experiences [4]. To put it another way, Machine Learning allows IT systems to discover patterns using current algorithms and data sets and build appropriate solution concepts. As a result, artificial knowledge is developed based on experience in Machine Learning.

### Problems facing the wide adoption of web-based audience measurement systems

## HISTORY AND EVOLUTION OF AUDIENCE MEASUREMENT

### Birth (1950): phone surveys

Systems have been in place to measure what audiences are listening to since the introduction of commercial radio streaming in 1947 [5]. These ratings systems relied heavily on phone calls to the public and used methodology designed for measuring radio audiences. By developing a survey methodology that asked only what listeners were tuned into at the time they received the call, plus demographic information about who was listening [6], Clark Hooper eliminated bias and problems with earlier random survey methods that had respondents recall what they had listened to. Many of the standard statistics used by television ratings businesses, like as audience shares, were created as a result of these calls, which are known as telephone coincidentals. By 1950, when Nielsen bought Hooper's company and launched the Nielsen Radio Index to track national radio audiences [5], the technique had been much developed.

### Infancy (1953): meters and diaries

Nielsen largely used metering devices to monitor audiences, which is a technique for tracking radio listeners that was created by Nielsen. These audimeters were used to measure what was being listened to on radio. This system reduced reliance on frequently faulty and untrustworthy sources of information. expensive phone surveys [7], but the system merely gathered data about what was on the radio, not who was listening. To close this gap, Nielsen began collecting more precise data. thanks to a subgroup of the individuals in the sample who Nielsen Diaries maintained track on listening patterns. The data is demographic. As a result, the data collected by the audimeter was supplemented. Nielsen released their rendition of an American in 1971. Data from a Research Bureau meter could be obtained via phone lines, reducing the time it took to prepare data for the market. This storage instantaneous audimeter stored data during the day, and ensured they were transmitted overnight [8]. This newfound quickness ratings and reporting from Nielsen, made Nielsen ratings become increasingly vital, as demographic data of listeners influenced advertising decisions [9]. This system has mostly stayed untouched until 1986, when the peoplemeter was brought into action and first introduced. Individual data gathering from several members of a household was possible with this unique listenership measurement technology; individual users logged their listening patterns as well as demographic information on this device. This significant shift in data collection resulted in a massive, easily accessible database with far more specific information about who was watching what, than had previously been available. Companies could now target their advertising messages more precisely.

### Childhood (1986): cable TV and VCRs

With the rise of cable television, the types of data collected for audience measurement and how they were used changed even more.

In the 1940s, cable television was introduced to provide television broadcasts to rural areas. Operators collected signals from regions with good reception and transmitted them to subscribers through coaxial cable. Cable systems could handle more stations, and beginning in the 1970s, networks tailored exclusively for cable distribution were formed, with increasingly diverse programming. In 2011, there were around 5300 systems in operation in the United States, with around 60 million members. The ability of the peoplemeter technology to assess tiny, demographically targeted audiences allowed programming content and show development to be tailored to specific populations. At the same time, cable's ad-supported networks could gather the granular information needed to entice niche product advertisers to put advertising specifically targeted at specific demographic groupings. The development of cable networks increased the importance of TV ratings and increased the value of user data for advertisers. They could now

stop catering to the lowest common denominator and focus on the groups most likely to be interested in their products.

In the 1980s, the widespread use of VCRs marked yet another revolution in television viewing habits. People could now record television shows and watch them later, a practice known as time shifting. Time shifting transformed how data is collected and used in programming and advertising decisions substantially after the introduction of digital TV recorders.

### Adolescence (2000–2010): the internet and social media

The early 2000s saw the rise of the Internet, which changed how people listened to radio and incorporated it into other aspects of their lives. Companies realized that clicks, searches, geolocation, tweets, purchases, and demographics could all be measured reasonably easily at a big scale in real time as consumers spent more time online. The public's entry into the new world of the Internet ushered in a new era of data. This might be used to assess the influence of radio streaming and advertising on listeners in terms of attention, what they ‘‘thought" while listening, and what they bought. This can be accomplished in a variety of ways. Since its inception in 1999, comScore has developed to track demographics, clicks, and sales across a variety of platforms (e.g., both home and mobile Internet). Keyword searches can be tracked over time and by geographic region using Google Trends. Despite the fact that customers are more likely to seek for a brand online after hearing it advertised on radio, the earliest online measuring systems were unable to account for radio listenership due to data inaccessibility. This is no longer the case. Since the establishment of a chat site for discussing the show The Prisoner in 199512, a slew of social radio platforms have sprung up, with usage rates skyrocketing. According to specialists from Viacom and Mass Media, users are now more engaged with radio programming since they encourage two-way dialogue.

## REVIEW OF RELATED WORKS

### Review on An Architecture for Real Time Television Audience Measurement

Currently, television audience measurement reports are only available after a long length of time, such as a daily report [10]. This study presents a system for measuring television audience in real time. Real-time measurement can provide channel owners and advertisers with valuable data that can help them grow their businesses [10].

This study demonstrates how set-top box devices that identify the channel logo and transfer viewership statistics to a server via the internet can record television viewing. The viewership data is processed by the server and shown in real time on a web-based dashboard. It also offers the ability to provide hourly and location-based viewership trends as well as TRP (Television Rating Points) reports online. In-memory databases, reporting and graphing libraries, and a J2EE-based application server make up the server infrastructure.

The popularity of a television channel or program is measured in Television Rating Points (TRP). TRP is a figure between 1 and 100, with one rating point equaling 1% of the population of a target television audience. TRPs are measured from a target population utilizing statistical sampling procedures [10].

Television broadcasters, media companies, advertising agencies, and advertisers all value TRP ratings. It has a significant impact on ad spending and television show scheduling. Each year, media firms and organizations buy and sell hundreds of billions of dollars worth of air time.

Current automated TRP measurement methods rely on the placement of “People Meters” in the houses of the sample population. These are connected devices that track viewing patterns and provide reports to a backend system on a regular basis. The following are the current methodologies employed by "People Meters."

1. **Audio Matching** - In this example, the People Meter records the audio content of a television program, compresses it, and sends it to a backend server. The audio samples are compared to stored program audio data on the server, and so viewership data is calculated. This strategy is difficult to deploy and necessitates significant backend system investments.
2. **Frequency Measurement** – This is used with analog transmission systems, where the People Meter monitors the frequency of the tuned TV channel and communicates the data to the backend. The backend associates the acquired frequency with channels and programs, allowing viewers' behavior to be tracked. This method is the most widely utilized in the country, but it is also the most prone to errors and inaccuracies because local cable service providers are not regulated or monitored in terms of transmission frequency.
3. **Watermarking** — Watermarks are added in the program feed at the broadcaster's end, and the People Meter detects them. The discovered watermark and timestamp are subsequently sent to the backend by the people Meters. This method has the disadvantage of requiring each program aired to be watermarked and active cooperation from all broadcasters.
4. **Visual recognition** - In this situation, the People Meters examines the displayed screen for visual patterns and images in order to determine the program being viewed. This approach is used in the suggested system.

Some software, such as Trumedia [11], assists advertisers in providing tailored adverts by assessing the present audience using video analytics on the faces of the audience taken by a camera, for example. The audience data is delivered back to a backend server, which aids in the display of current audience reports. The real-time information about the audience can be utilized to pick the next message to play via TruMedia's interface with Cisco Digital Media Player, providing tailored advertising. Other participants in this industry include Quividi [12] and CognoVision [13].

### Review on Audience Measurement Technologies for user Centric Media

When compared to traditional media, how can you tell which is the consumption and which is the generation of content in a new media world where the user can be a consumer or a creator/distributor? How appealing is it to the end users? Which new viable business models may be found in this scenario, and what is the market and technology's potential evolution? Perhaps it will never be possible to adequately answer these questions, but the development of new audience measurement reference models for the new media world [14], and their adaptation to user-centric media using combined metrics, are the most promising ways of achieving these goals. This paper outlines an end-to-end system proposal based on the afore mentioned reference model for the new media world, which is then applied to user-centric media to answer some of the above questions and generate the necessary figures [14].

The collection of the necessary figures using testbeds or complete panels of households/individuals to obtain reliable figures of media consumption is a necessary mechanism in the media industry, particularly in the user-centric media, to validate the impact and interest of service offerings, new technology developments, or even to predict new viable business models. Many firms may be hesitant to engage in new platforms without trustworthy consumption data, stifling the development of new media technologies or services [14]. Not all of the characteristics of audience measurement for traditional media can be applied to the user-centric media paradigm, where the user has the ability to create-distribute-consume audiovisual content, and the situation becomes increasingly complicated when consumption or creation occurs in user communities, where not only individual consumption but also collective consumption is important. This study proposes an end-to-end system for acquiring the afore mentioned figures on both traditional and user-centric media channels. The following are the components of the system:

1. To begin, a model for convergent media consumption in a range of terminals and networks, such as broadcasting to Set-Top-Boxes, mobile and portable devices, or broadband IPTV distribution, will be presented.
2. Second, the model's adaptation to user-centric media and collective consumption is discussed.
3. Then, to integrate the results, a set of metrics is formalized.

To address user usage, many measures have been established to address possible program recommendations to users[3]. However, when users are linked in communities, one of the primary issues is the adaption of metrics for measuring audience interest and impact.

### Review on Investigation of Spectral Centroid Magnitude and Frequency for Speaker Recognition

Mel-scale filter bank cepstrum coefficients (MFCC), Linear Prediction Cepstrum Coefficient (LPCC), and Perceptual Linear Prediction are some of the most common spectral envelope characterizations used in speaker recognition (PLP). Because of its popularity, the MFCC has become a de facto standard feature for speaker recognition. Alternative features, such as frequency modulation (FM) and subband spectral centroid characteristics, have been proposed to transmit information other than the average subband energy [15]. The characterization of subband energy as a two-dimensional feature, consisting of Spectral Centroid Magnitude (SCM) and Spectral Centroid Frequency (SCF), is investigated in this paper (SCF). Empirical investigations utilizing SCF, SCM, and their fusion on the NIST 2001 and NIST 2006 databases reveal that the combination of SCM and SCF is somewhat more accurate than traditional MFCC, and that both fuse efficiently with MFCCs. We also show that frame-averaged FM features are fundamentally centroid features, and we present a SCF implementation that enhances both subband spectral centroid and FM feature speaker recognition performance [15].

Speaker recognition relies on the separation of speaker dependent properties from speech signals, and because of anatomical and behavioral differences between participants, the speaker's vocal tract configuration has been found to be very speaker-dependent [1]. Mel-frequency cepstral coefficients are the most successful vocal tract-related acoustic characteristic (MFCC). However, information on the distribution of energy across the band is not efficiently captured during the MFCC extraction procedure. MFCC conveys the average energy of the subband as a single dimension for a subband speech stream (the overlapped triangular filters capture some information from neighbouring bands, but this can be considered an inter-band rather than an intra-band information). In this study, we look at how to turn this one-dimensional data into two-dimensional data that includes both the average energy and additional information on the energy distribution inside each subband. Phase or frequency related properties may be complimentary to MFCCs, according to research published in [2, 3, 4, 5]. The computational cost of applying frequency modulation (FM) extraction in actual applications is one issue [6]. The efficiency of frame-averaged FM components extracted using the second order all pole approach [2] on speaker recognition, as well as their complimentary nature to magnitude-based information, has recently been established [3]. When these frame-averaged FM components are compared to the deviation of the subband spectral centroid [7] from the subband's center frequency, as illustrated in Figure 1, it is clear that both the subband spectral centroid and the frame-averaged FM components provide identical information. Estimating the subband spectral centroid, on the other hand, is more efficient than estimating frameaveraged FM components. [7] shown that the formant-related information is carried by the spectral centroid frequency. It was also suggested that, while formant locations are resistant to additive noise, formant frequencies should not be employed as features directly due to the difficulty in estimating them accurately. Other features that convey formant related information, such as spectral centroid frequency, can be used to solve this problem, as shown in [7]. The use of subband spectral centroid in recent literature has demonstrated some success in noisy voice identification [8, 9]. Spectral centroid frequency was previously employed in [7] for speech recognition. In contrast to FM features, spectral centroid frequency has recently been employed to enhance cepstral based features for speaker recognition [10, 11]. The minor advantages over MFCC in speech recognition applications appear to be an oddity, given the similarity with frame-averged FM shown in Figure 1. We study the efficiency of combining Spectral Centroid Frequency (SCF) and Spectral Centroid Magnitude (SCM) characteristics for speaker recognition in this paper, and show how subband spectral centroid can be enhanced. SCM, like MFCC, conveys magnitude-related information, but SCF carries the SCM's frequency bias, as illustrated in Figure 2. The NIST2001 and NIST2006 speaker recognition datasets will be used to test these functionalities.