expectations of digital service users [3]. The web services technology is being used more and more to realize e-services. A customized experience for clients in a Web service installation depends on meeting the e-service quality requirements [4]. Assigning quality expectations for an e-service to the quality of service (QoS) features of its component Web services is not a simple task, though. This study suggests an approach to this problem that maps the fuzzy expectations of the client from the e-service to Web service QoS factors using fuzzy linguistic approaches. With this method, different service quality elements may be effectively customized for each particular consumer, resulting in efficient e-service customization.

B. Personalization and Customization

Personalization has emerged as a vital component of E-Service Quality (ESQ), particularly in the context of mobile applications. The significance of personalized experiences in enhancing customer satisfaction. They demonstrated that customization could significantly impact user satisfaction, particularly in travel apps where user preferences vary widely [5]. The fundamental ideas, supporting techniques, and exceptional results of the most recent approaches. It acts as a one-stop resource for readers who want to apply fuzzy-based autonomous learning in various scientific disciplines and practical sectors, or who are studying the core methodology and foundations of fuzzy systems [6]. The strategic impact of personalized marketing on online businesses in Thailand, focusing on individuals' behavioural intentions towards Information Technology Use Theory [7]. Information Search Theory, and Technology Acceptance Model. Data was collected from online shopping users in Thailand, and the findings suggest that strategic marketing should enhance e-commerce quality and create targeted personalized services. To evaluate how user engagement is impacted by system, information, and service quality as well as how these factors affect user happiness, love, and behavioural intentions with regard to smartphone travel applications. The findings show that user engagement with smartphone travel apps is very positively impacted by system, information, and service quality [8]. Additionally, behavioural intentions, app love, and smartphone app pleasure are all positively and significantly impacted by user involvement. The authors propose a personalized travel planning system that considers all user requirements and offers a service similar to automation. The system uses a novel algorithm to plan travel schedules, with a user-adapted interface and adjustable results design [9].

C. The Role of Technology and user Engagement

Technology's role in shaping user experiences in the travel industry has been explored extensively. The impact of perceived quality of service and price on post-purchase perceptions, satisfaction, intention behaviour, and loyalty in the tourism and hospitality industry [10]. It investigates how online tourists' reviews influence travel agencies and hotel booking decisions in Egypt. The quantitative approach provides insights into the influence of TripAdvisor on satisfaction, loyalty, and the mediating effect of positive online tourist intentions. A scale to measure e-service quality and its impact on consumer satisfaction and website loyalty. The validation process found that perceived quality is a multidimensional construct, influencing satisfaction and loyalty. Practical implications include creating user-friendly websites, enhancing service loyalty, ensuring security, and ensuring correct product delivery. Most studies on perceived quality in the internet focus on web design, but this article aims to analyse the benefits of higher perceived quality in terms of user satisfaction and loyalty [11]. The specific features of mobile apps that impact user engagement and satisfaction. They identified user interface design, ease of use, and functionality as critical factors that enhance the quality of mobile travel services [12]. A theoretical framework for understanding technology acceptance, which is crucial for evaluating how users perceive and interact with travel apps [13].

D. Customer Satisfaction and Loyalty

The relationship between e-service quality, customer satisfaction, and loyalty has been a central theme in the literature. The service quality influences brand loyalty in online environments. Their findings are particularly relevant to travel apps, where maintaining high-quality service is essential for fostering customer loyalty [14]. The specifics of how service quality can enhance customer satisfaction and loyalty in online settings. They provided detailed insights into how the dimensions of E-Service Quality (ESQ) can be effectively applied to travel apps, offering practical implications for improving service quality [15]. A scale for measuring perceived e-service quality, emphasizing the multidimensional nature of the construct [16]. They identified key dimensions such as web design, customer service, and order management, which are crucial for improving customer satisfaction and website loyalty in the context of travel apps.

E. Emerging Trends and Challenges

Recent studies have highlighted emerging trends and challenges in the field of quality of e-service for travel apps. The role of personality traits and perceived risk in customer engagement with travel apps. Their study underscores the importance of trust and perceived ease of use in enhancing service quality perceptions [17]. A comprehensive analysis of factors influencing e-service quality, including website aesthetics, content quality, and mobile app functionality. They developed a framework for effectively measuring these aspects, contributing to a deeper understanding of how various factors impact the overall quality of travel apps [18]. The critical role of user interface design and customer support services in determining customer satisfaction and loyalty. Their research highlights the need for continuous improvement in these areas to maintain a competitive edge in the travel app market [19].

F. Fuzzy Set Theoretical Approach

Acracy in tourism recommender systems using a fuzzy C-means algorithm for user-based and item-based models. The method uses Pearson Correlation and Cosine similarity measures and Mean Absolute Error (MAE) as evaluation metrics [20]. Experimental results on the TripAdvisor dataset show a significant improvement in user-based model predictive accuracy, making the recommender system a promising solution for item recommendation tasks [21].

Assessment of travel time performance of Indian cities' multimodal transportation systems [22]. It proposes three steps: identifying factors, generating individual indices, and evaluating the Multimodal Transport System Travel-Time Performance Index [23]. The study found a travel-time performance index of 0.79 in Bhopal, indicating potential improvements in efficiency and user satisfaction. A predictive approach for aspect-based extraction and classification in travel and tourism, aiming to estimate users' optimal travel destinations [24]. The model uses the Random Projection ensemble classifier to reduce the complexity of multivariate data. The article also proposes Multinomial Logistic Regression (MNLR) with a Fuzzy Domain Ontology (FDO) algorithm for aspect-based sentiment analysis [25]. The model considers factors like weather, starting ratings, and environmental factors to predict travel destinations [26]. The study uses performance measures like F1-score, recall, precision, MAE, MSE, Cohen Score, and Matthew Score to evaluate the model's accuracy [27]. The proposed strategy outperforms in terms of classification accuracy, according to simulated results and real-world data analysis. A Fuzzy-AHP-ORD approach for optimal RSU deployment in VANETs, improving network coverage and efficiency by considering static and dynamic road and traffic parameters, outperforming existing methods in coverage ratio, connection time, packet delivery ratio, and delay [28].

III. WORKING OF APP BASED TRAVEL PORTALS

The work of app-based travel portals is a complex and dynamic process that integrates various technologies and services to deliver a convenient and efficient user experience. By continuously innovating and adapting to the changing needs of travellers, these portals, such as Make My Trip, play a crucial role in the modern tourism industry. They provide users with easy access to a wide range of travel services, making travel planning and management more accessible and enjoyable.

A. User Interface and Experience

The user interface (UI) of app-based travel portals is designed to be intuitive and user-friendly. It allows users to easily navigate through different sections, search for travel options, compare prices, and make bookings. The UI typically includes features like search bars, filters, and sorting options to help users find the best deals and services that suit their preferences.

B. Search and Comparison Engine

A critical component of these portals is the search and comparison engine. This engine aggregates data from various airlines, hotels, and service providers, presenting users with a comprehensive list of options. It enables users to compare prices, amenities, and other key factors, empowering them to make informed decisions. The search results can be customized based on criteria such as date, destination, budget, and user ratings.

C. Booking and Payment System

Once users select their preferred travel options, they proceed to the booking stage. The booking system is designed to be secure and efficient, often offering multiple payment options, including credit/debit cards, net banking, and digital wallets. The system ensures that user transactions are protected through encryption and other security measures. Additionally, the portal may offer features like fare alerts and price tracking to notify users of potential savings.

D. Customer Support and Service

Customer support is an integral part of app-based travel portals. These portals typically provide 24/7 customer service to assist users with booking issues, cancelations, and modifications. Support is offered through various channels, including chatbots, live chat, email, and phone support. This accessibility ensures that users have a smooth and hassle-free experience.

E. Personalization and Recommendations

To enhance the user experience, app-based travel portals use data analytics and machine learning algorithms to personalize recommendations. Based on users' search history, preferences, and past bookings, the portal can suggest destinations, hotels, and activities that align with the user's interests. This personalized approach not only improves customer satisfaction but also increases the likelihood of repeat bookings.

F. Review and Feedback Mechanism

The user reviews and feedback are valuable for both the service providers and future customers. App-based travel portals often include a review and rating system, allowing users to share their experiences and rate the services they received. This feedback mechanism helps maintain quality standards and provides valuable insights for continuous improvement.

G. Integration with External Services

App-based travel portals often integrate with external services to enhance the overall user experience. This includes partnerships with airlines, hotel chains, car rental companies, and travel insurance providers. By offering a comprehensive range of services, these portals provide a one-stop solution for all travel-related needs.

H. Security and Data Privacy

Given the sensitive nature of personal and financial information involved in travel bookings, app-based travel portals place a strong emphasis on security and data privacy. They implement robust security protocols, including SSL encryption, secure authentication processes, and compliance with data protection regulations, to safeguard user data.

IV. FACTORS AFFECTING E-SERVICE QUALITY OF TRAVEL PORTALS

E-Service quality in travel portals is influenced by several key factors, including website functionality, ease of navigation, and the availability of comprehensive and accurate information. User-friendly interfaces, secure payment options, and efficient customer support are crucial for enhancing the overall user experience. Additionally, personalization and responsiveness to user queries contribute significantly to customer satisfaction and trust in the service. In this paper, we enumerate the factors of strategic importance of various market dynamics, target market characteristics, promotional strategies, and communication

channels in shaping the competitive landscape of the online travel industry. By examining factors such as industry growth rates, customer trends in e-ticketing, and increasing internet penetration, the research emphasizes the potential for market expansion and the necessity for informed decision-making. The paper also highlights the significance of targeting specific demographic segments, including urban males with disposable income, internet-savvy individuals, deal seekers, and early adopters, who are crucial for driving market penetration and long-term engagement. Promotional strategies, including money-back guarantees, brand partnerships, and reward programs, are analysed for their role in enhancing customer trust, loyalty, and sales volume. Furthermore, the allocation of resources across diverse media channels is discussed to demonstrate the effectiveness of a comprehensive and data-driven marketing approach. Collectively, these elements provide a robust framework for understanding the interplay between market factors, consumer behaviour, and promotional tactics in achieving competitive advantage and sustained growth in the online travel sector. On the basis of past research highlighted in Section 2.0, we delineate the following six major factors and their sub-factors, contributing towards the performance of E-Service Quality of a travel portal:

1. Products/Services Offered (Online), P
2. Market Drivers, D
3. Market Segments, S
4. Target Market Characteristics, C
5. Promotional Offers, O
6. Communication and Promotion Media Channels & Budget Allocation, M

A. Products/Services Offered (Online), P

i. A Search, Compare, and Book Air Tickets from any Airline

This factor is crucial as it provides users with the flexibility to choose from a wide range of options, ensuring they find the best deals and routes that suit their needs. This enhances user satisfaction and loyalty to the platform.

ii. Realtime Hotel Reservations with Discounted Rates in Over 1,500 Hotels

Offering discounted hotel rates in real-time increases the attractiveness of the platform, allowing users to secure immediate accommodations at competitive prices, thereby improving the overall user experience.

iii. Special Pricing for Car/Taxi Bookings for Airport Transfers and Other Trips

Special pricing for transport services adds value by providing cost-effective and convenient options for travellers, making the platform a one-stop solution for all travel needs.

iv. Holiday Packages for Destinations Within India or Abroad

Comprehensive holiday packages cater to diverse customer preferences, simplifying the travel planning process and ensuring that the platform can meet a wide array of user demands, both domestically and internationally.

v. Road Trip Options from all Major Cities in India with Interactive Maps

Offering Road trip options with interactive maps enhances the user experience by facilitating trip planning and navigation, catering to the growing trend of road travel, especially in the post-pandemic era.

vi. Weekend Getaway Packages for Short Stay Holidays

Short stay packages cater to the demand for quick, affordable, and convenient travel options, targeting busy professionals and families looking for brief escapes without extensive planning.

vii. B2B Services

Local agents worldwide can access these products through its extranet: Providing B2B services expands the platform's market reach and revenue streams by engaging local agents, who can offer these services to their clients, enhancing the platform's global presence. Each of these factors is important as they collectively create a comprehensive travel solution, catering to both individual and business needs, enhancing user convenience, and expanding market reach.

B. Market Drivers, D

i. Growth Rates in the Industry and Market

Understanding growth rates helps assess the potential for future expansion and profitability, making it a critical factor for evaluating the feasibility and attractiveness of entering or expanding within a market.

ii. Customer Trends Indicate Potential in the Ticketing Business

Analysing customer trends is essential to gauge market demand, preferences, and the likelihood of adoption of e Ticketing services, which can drive strategic decisions and product offerings.

iii. Increasing Internet Penetration

Internet penetration is a key enabler for digital services like e-Ticketing, and its growth signifies a broader customer base and easier access, thus driving market expansion.

iv. Rising Numbers of Online Bookings for Tickets and Hotels

The increasing frequency of online bookings reflects consumer behaviour shifts and validates the growing reliance on digital platforms, making it a crucial indicator of market potential.

v. Previous Experience in the Same Business Model

Leveraging prior experience provides a competitive advantage, reducing risks associated with market entry and operational execution, thereby enhancing the chances of success.

vi. Successful Operations in the US Market

Success in a mature and competitive market like the US serves as a strong precedent and benchmark, demonstrating the viability and scalability of the business model in other regions.

Each of these factors is important as they collectively provide a comprehensive understanding of the market environment, customer behaviour, and operational viability, helping to shape strategic decisions and ensure successful market entry or expansion.

C. Market Segments, S

i. Personal Travel and Tourism

The personal travel and tourism segment is vital as it represents a significant portion of the overall market demand, driven by consumer leisure activities, holiday planning, and cultural experiences. This segment is often more price-sensitive but also highly responsive to promotional offerings, making it a key focus for revenue generation and customer retention strategies.

ii. Business Travel

The business travel segment is essential due to its consistent demand and higher spending patterns. Business travellers typically require more frequent, flexible, and premium services, making this segment crucial for maintaining steady revenue streams and offering opportunities for up selling and loyalty programs. Considering these segments allows for targeted marketing, product differentiation, and tailored service offerings, ensuring that the business can effectively meet the diverse needs of its customers and maximize its market reach.

D. Target Market Characteristics, C

i. Urban Males Aged 24-44 Earning Rs. 30,000 Per Month

This demographic is important due to their purchasing power and propensity for frequent travel, both personal and business. They represent a key segment with disposable income and a higher likelihood of using online services for convenience, making them a prime target for marketing and product offerings.

ii. Internet-Savvy Individuals

Targeting internet-savvy individuals is crucial as they are more likely to engage with and use digital platforms for bookings, ensuring a higher conversion rate for online services. This group is also more likely to spread positive word-of-mouth and engage with digital marketing efforts, amplifying reach.

iii. Deal Seekers

Deal seekers are a significant target as they are highly responsive to promotional offers and discounts, which can drive volume sales and customer acquisition. Capturing this segment helps in generating repeat business and increasing market share through competitive pricing strategies.

iv. Early Adopters

Early adopters are critical for gaining initial traction and market penetration, as they are typically more open to trying new technologies and services. Their feedback and engagement can provide valuable insights for refining offerings and they often influence subsequent customer segments through their experiences. These characteristics help in defining and understanding the target market, allowing for the development of focused marketing strategies and tailored product offerings that align with the specific needs and behaviours of these segments, thereby maximizing the effectiveness of business operations and customer engagement.

E. Promotional Offers, O

i. Money Back Guarantee

A money back guarantee builds consumer trust and reduces the perceived risk of trying new services, encouraging more users to make purchases. This offer can significantly increase customer confidence and conversion rates, especially in competitive markets.

ii. Visa-Kingfisher Offer

Partnering with brands like Visa and Kingfisher provides added value to customers through exclusive discounts or benefits, enhancing the appeal of the service and leveraging the credibility and reach of established brands to attract a broader audience.

iii. I Mint Consumer Reward Program

The I Mint consumer reward program incentivizes repeat purchases by offering points or rewards for transactions, fostering customer loyalty and increasing the likelihood of long-term engagement with the platform.

iv. Super Saver Program

The Super saver program targets budget-conscious customers by offering bundled discounts or special deals, making it attractive for deal seekers and helping to drive volume sales, especially during off-peak times.

v. Super Tipper Offers

Super tipper offers provide additional incentives for users to make purchases, such as bonus rewards or extra discounts, encouraging immediate action and boosting short-term sales while also enhancing customer satisfaction through perceived added value. These promotional offers are important as they help to attract and retain customers, increase sales, and differentiate the platform from competitors by providing tangible benefits and creating a positive user experience.

F. Communication and Promotion Media Channels & Budget Allocation, M

i. TV (40%)

Allocating 40% of the budget to TV ads on channels like NDTV, CNBC, and Discovery targets a broad and diverse audience, including both English-speaking and Hindi-speaking viewers. TV remains a powerful medium for building brand awareness and reaching a wide demographic, particularly in India, where television consumption is high.

ii. Internet (30%); Outdoors (5%)

The 30% allocation to Internet advertising reflects the growing importance of digital channels for reaching tech-savvy, younger audiences who spend significant time online. The 5% for outdoor ads helps maintain a physical presence and visibility in high-traffic areas, reinforcing brand recognition.

iii. Print (5%); Below-The-Line (BTL) Activities (5%)

Print ads and BTL activities target specific market segments, such as business professionals and deal seekers, through tailored, localized campaigns. These methods are effective for reaching audiences that might be missed by digital or TV ads, providing a more personalized touch.

iv. Analytics and PR (15%)

Investing 15% in analytics and PR is crucial for measuring the effectiveness of campaigns and maintaining a positive brand image. Analytics allows for data-driven decisions, optimizing future marketing efforts, while PR ensures sustained visibility and

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credibility in the market. These factors are important as they ensure a balanced and strategic approach to communication and promotion, maximizing reach and impact through a mix of traditional and digital media, while also allowing for precise targeting and measurement of campaign effectiveness.

V. FACTOR CONTRIBUTION

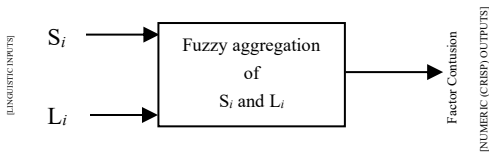
When viewed from a systemic viewpoint, a flexible system such as Travel Portal can be observed to transit through various states, where the 'state' of the system is essentially a set of parametric values of the system's sub-components that define it completely at a specified point in time. Typically, the observed values of various performance measures are often used as indicators to define the system state at a given point in time. The object is to improve the system's state by improving the performance of each of these performance measures. It is seen that past research has highlighted the significance of the following three factors for measurement of E-Service Quality: the state change required with respect to the existing system state, and the relative weight age or significance between tasks. We view the contribution of any factor towards the E-Service Quality to be dependent upon the following three variables: First, its relative significance vis-à-vis other factors, i.e., the extent of change that it can bring about in the system. Therefore, if the relative significance of a factor is high it has the potential of causing a significant change in the system's performance, even though it might presently not be manifest. Second, a factor's present observed level in the system, i.e., an assessment of the state in which it presently exists. Accordingly, if the observed level of observed is low, it will require a commensurately large change in its present state in order for it to be deemed effective. The above variables are now expanded for exposition purposes.

A. Significance of a Factor

The significance or weight age of a factor, S_i, determines its relative significance level vis-à-vis other factors. Clearly these weight ages would be situation specific and would therefore differ from case to case.

B. Observed Level of a Factor

The observed level of a factor, L_i, establishes its current state level with respect to the desired level that would epitomize the target level attainable with respect to a specific factor. Based upon the above concepts, the next section provides the implementation details of the ESQ measurement approach developed in this paper. The schematic shown in Figure 1.0 captures the essence of the conceptual approach described above when quantifying the factor contribution Δ_i for a specific factor.



[Fig.1: Quantification of Factor Contribution]

Details of the fuzzy aggregation operation performed inside the box shown in Figure5.1 are described in the following section. Importantly, it is noted that this fuzzy aggregation procedure essentially takes linguistic inputs for each of S_i, L_i and delivers a crisp 'numeric' output denoting the factor contribution Δ_i if or a specific factor "i" towards the ESQ factor FLX under consideration.

C. Measurement of E-Service Quality of app Based Travel Portals

Measuring the E-Service Quality (ESQ) of app-based travel portals involves evaluating various factors that contribute to the overall user experience. The proposed research framework utilizes a linguistic mathematical variables-based approach, incorporating fuzzy logic to assess and quantify the quality of e-service provided. The measurement framework is based on the premise that the quality of e-service can be represented as a system transitioning through various states. Each state is defined by a set of parametric values corresponding to specific service attributes. The goal is to assess the current state, identify areas for improvement, and enhance the overall service quality.

D. Key Variables

The measurement of ESQ is influenced by three primary variables:

i. Significance of a Factor (S_i)

This variable represents the relative importance of a specific factor in influencing the overall service quality. The significance is determined based on the potential impact a factor can have on the system's performance. Higher significance implies a greater ability to affect the quality of service.

ii. Observed Level of a Factor (Li)

This variable assesses the current state or performance level of a specific factor. It reflects the actual experience of users with respect to the service attribute being measured. A low observed level indicates a need for significant improvement to meet the desired service standards.

iii. Factor Contribution (Δi)

The contribution of each factor towards ESQ is calculated by combining the significance and observed level. This quantification provides a clear indication of how much each factor contributes to the overall quality of service.

E. Fuzzy Aggregation and Linguistic Inputs

Given the subjective nature of service quality, the measurement framework employs fuzzy logic to handle linguistic inputs and subjective assessments. The fuzzy aggregation process involves the following steps:

i. Input Collection

Linguistic inputs are collected for each factor, describing the significance and observed level. These inputs are usually qualitative, such as "high," "medium," or "low."

ii. Fuzzy Mapping

The qualitative inputs are mapped to quantitative values using fuzzy sets. This process involves defining membership functions that convert

linguistic terms into numerical values.

iii. Aggregation

The numerical values representing the significance and observed levels are aggregated using fuzzy rules. These rules are designed to model the relationship between significance, observed levels, and their contributions to ESQ.

iv. Defuzzification

The final step involves de-fuzzifying the aggregated output to obtain a crisp numerical value for each factor's contribution. This value provides a clear, quantifiable measure of the factor's impact on the overall service quality.

F. Quantifying Overall E-Service Quality

The overall ESQ is quantified by aggregating the contributions of individual factors. This aggregated score provides a holistic measure of the portal's service quality. It allows stakeholders to identify strengths and weaknesses, prioritize improvement efforts, and benchmark against industry standards.

VI. THE ALGORITHM

The user end algorithm for E-Service Quality measurement procedure is as follows:

1. For 'i'th factor, assign its Significance in the overall E-Service Quality, as perceived by you, S_i
2. Determine the Observed Level for 'i'th factor, as perceived by you, L_i
3. Calculate the individual factor contribution, Δ_i, using a standard fuzzification-defuzzification procedure to compute its numeric value.
4. Repeat steps 1 through 5 for each factor to compute a numeric estimate for each.
5. Compute the overall E-Service Quality as a summation of the numeric estimates computed in step 6.

A. Notations

Variable i
Description 'i'th factor of E-Service Quality

Values [Products/Services Offered (Online), P / Market Drivers, D / Market Segments, S / Target Market Characteristics, C / Promotional Offers, O / Communication and Promotion Media Channels & Budget Allocation, M]

Variable S_i
Description Significance of 'i'th factor in the overall ESQ
Values Linguistic [Low (L), Somewhat Low (SL), Medium (M), Somewhat High (SH) and High (H)]

Variable L_i
Description Observed level of 'i'th factor for the overall ESQ
Values Linguistic [Low (L), Somewhat Low (SL), Medium (M), Somewhat High (SH) and High (H)]

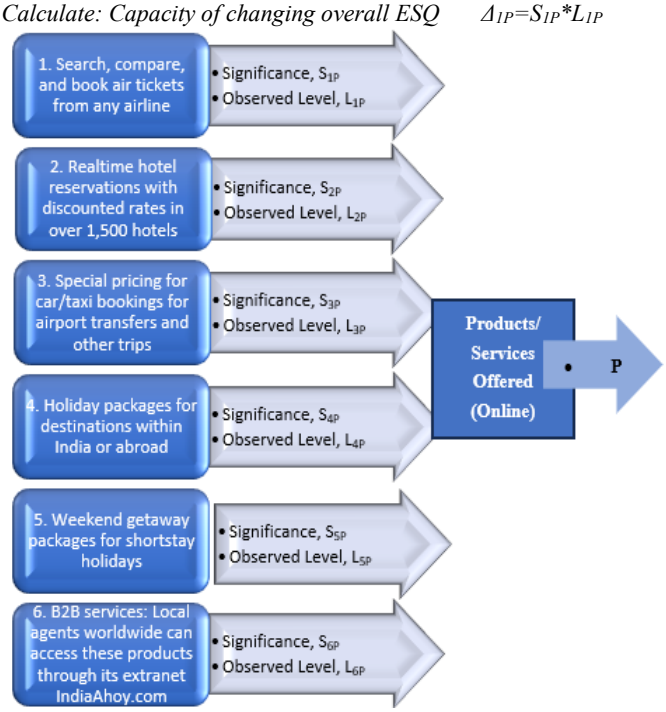
Variable Δ_i
Description Capacity of 'i'th factor of changing overall ESQ
Values Numeric [0.000 - 1.000; L.C. 0.001]

VII. PROCEDURAL DETAILS OF E-SERVICE QUALITY MEASUREMENT FRAMEWORK

A. Products/Services Offered (Online), P

1. Search, compare, and book air tickets from any airline
2. Realtime hotel reservations with discounted rates in over 1,500 hotels
3. Special pricing for car/taxi bookings for airport transfers and other trips
4. Holiday packages for destinations within India or abroad
5. Road trip options from all major cities in India with interactive maps
6. Weekend getaway packages for short stay holidays
7. B2B services: Local agents worldwide can access these products through its extranet.

Assess: Significance in the overall ESQ S_{IP}
Observed Level for the overall ESQ L_{IP}
Calculate: Capacity of changing overall ESQ $\Delta_{IP}=S_{IP}*L_{IP}$

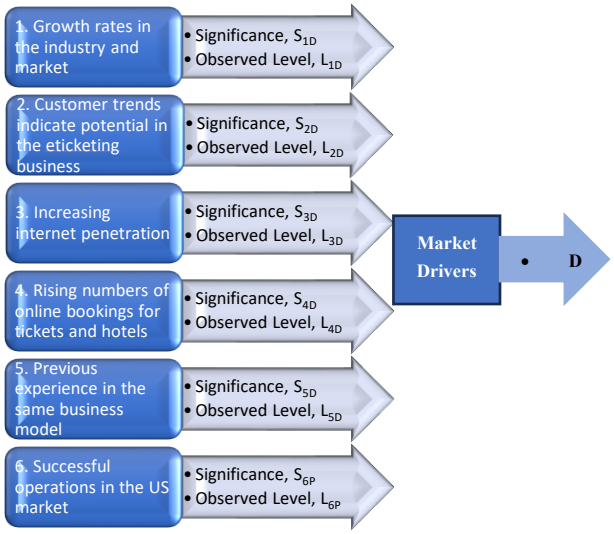


[Fig.2: Products/Services Offered (Online), P]

B. Market Drivers, D

1. Growth rates in the industry and market
2. Customer trends indicate potential in the e-ticketing business
3. Increasing internet penetration
4. Rising numbers of online bookings for tickets and hotels
5. Previous experience in the same business model
6. Successful operations in the US market

Assess: Significance in the overall ESQ S_{ID}
Observed Level for the overall ESQ L_{ID}
Calculate: Capacity of changing overall ESQ $\Delta_{ID}=S_{ID}*L_{ID}$

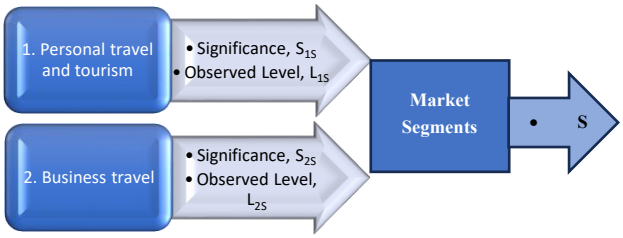


[Fig.3: Market Drivers, D]

C. Market Segments, S

1. Personal travel and tourism
2. Business travel

Assess: *Significance in the overall ESQ* S_{1S}
Observed Level for the overall ESQ L_{1S}
Calculate: Capacity of changing overall ESQ $\Delta_{1S}=S_{1S}*L_{1S}$

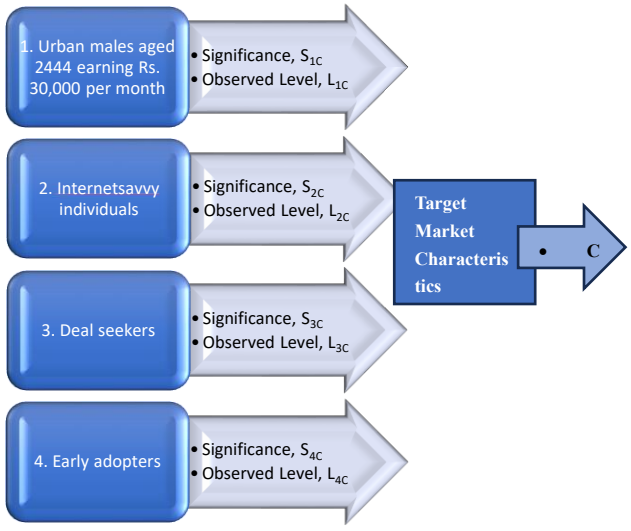


[Fig.4: Market Segments, S]

D. Target Market Characteristics, C

1. Urban males aged 2444 earning Rs. 30,000 per month
2. Internet savvy individuals
3. Deal seekers
4. Early adopters

Assess: *Significance in the overall ESQ* S_{1C}
Observed Level for the overall ESQ L_{1C}
Calculate: Capacity of changing overall ESQ $\Delta_{1C}=S_{1C}*L_{1C}$

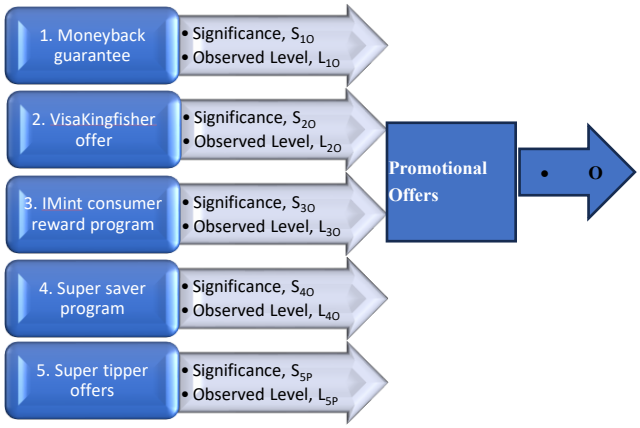


[Fig.5: Target Market Characteristics, C]

E. Promotional Offers, O

1. Moneyback guarantee
2. Visa-Kingfisher offer
3. I Mint consumer reward program
4. Super saver program
5. Super tipper offers

Assess: *Significance in the overall ESQ* S_{1O}
Observed Level for the overall ESQ L_{1O}
Calculate: Capacity of changing overall ESQ $\Delta_{1O}=S_{1O}*L_{1O}$

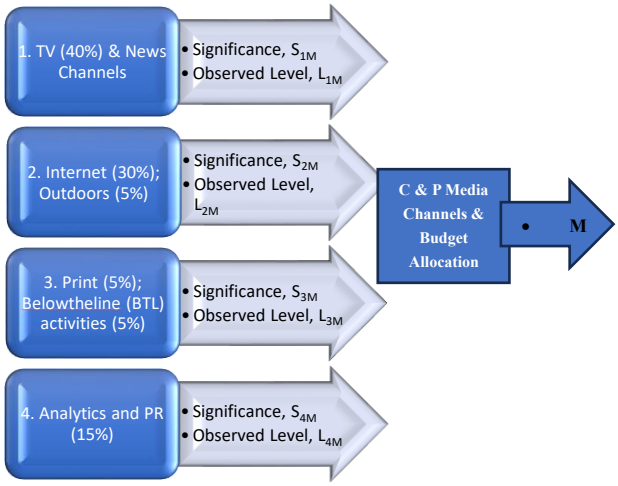


[Fig.6: Promotional Offers, O]

F. Communication and Promotion Media Channels & Budget Allocation, M

1. TV (40%): English news channels NDTV, CNBC, Infotainment, National Geographic, Discovery, Discovery Travel and Living, AXN; English movie channels – Star Movies, HBO; Hinglish entertainment – Star One; and Hindi movie channel Zee Cinema
2. Internet (30%); Outdoors (5%)
3. Print (5%); Below the line (BTL) activities (5%)
4. Analytics and PR (15%)

Assess: *Significance in the overall ESQ* S_{1M}
Observed Level for the overall ESQ L_{1M}
Calculate: Capacity of changing overall ESQ $\Delta_{1M}=S_{1M}*L_{1M}$



[Fig.7: Communications and Promotion Media Channels & Budget Allocation, M]

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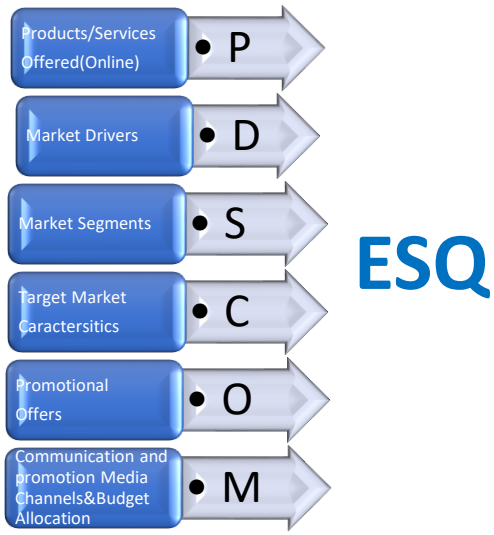
G. Measurement of Overall E-Service Quality

$$ESQ = \sum_i \Delta_i$$

$ESQ = \Delta_P + \Delta_D + \Delta_S + \Delta_C + \Delta_O + \Delta_M = [S_P{}^\circ L_P] + [S_D{}^\circ L_D] + [S_S{}^\circ L_S] + [S_C{}^\circ L_C] + [S_O{}^\circ L_O] + [S_M{}^\circ L_M]$



[Fig.8: Measurement of Overall E-Service Quality]

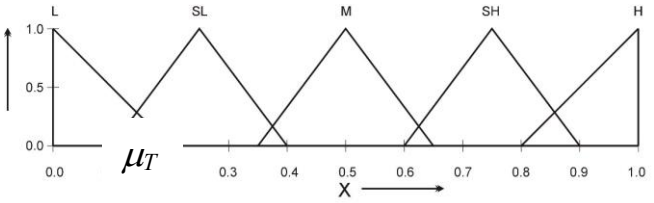
VIII. IMPLEMENTATION DETAILS OF THE APPROACH

The initial step in the implementation of the suggested approach is to develop a fuzzy expert system for the problem domain of study. Fuzzy expert systems (FES) emulate the reasoning process of a human expert within the required knowledge domain and are built for the purpose of exploiting the experience and problem-solving capabilities of experts available to others (Klir and Yuan, 1995). An FES primarily comprises of the following:

1. Knowledge base: contains knowledge about the problem domain, usually represented by a set of fuzzy rules connecting antecedents (or premises) with consequents (or conclusions)
2. Database: for storage of data
3. Inference engine: performs the inferencing procedure through standard operations on the fuzzy rules stored in the knowledge base
4. Explanatory interface: facilitates communication between the user and the FES

In the present context, the fuzzy rules to be embedded into the FES's knowledge base would comprise of several logical rules that exhaustively capture relationships between S_i, L_i and Δ_i for each factor of each ESQ factor on the basis of the observations made by the domain experts (i.e. the shop managers). These rules are most effectively captured via an appropriate software platform. The next step entails actual observations of S_i, L_i and Δ_i within the test Travel Portal wherein the E-Service Quality measurement is desired. The observed conditions S_i, L_i and Δ_i are then compared with the predefined fuzzy rules relating S_i, L_i and Δ_i already captured within the existing knowledge base of the previously developed FES. Thus, a numeric estimate of contribution of the factorΔ_i towards the specific ESQ factor *FLX* is then computed as Δ_i by the inference engine based on the synthesis of the input values. For this paper, an exhaustive fuzzy rule base created in Das (2006) was referred, comprising of rules with five classes of the linguistic labels namely:

Low (L), Somewhat Low (SL), Medium (M), Somewhat High (SH) and High (H). The membership curves for the fuzzy sets corresponding to the above linguistic labels are assumed identical for each of S_i, L_i and Δ_i as shown in Fig. 5.1



[Fig.10: The Membership Curves for Si, Li & Δi]

The membership functions for each of the above variables S_i, L_i and Δ_i are defined on identical universe(s) of discourse (X) constrained to lie within a unit interval [0,1] such that:

$\mu_T : X \rightarrow [0,1]$ where T = {L, SL, M, SH, H}.

The discrete membership functions for each of the linguistic labels are defined as follows:

$\mu_T(x) / x$, $x \in X$ where μ_T is the membership grade of point x on universe of discourse (X)

Typically, a fuzzy rule base maps possible combinations of antecedents to their respective consequents. The individual values of S_i, L_i and Δ_i decide the *outcome*, i.e., the value of contribution of a factor Δ_i for a specific E-Service Quality type. An unqualified conditional fuzzy proposition p of the form

p: If X is A, then Y is B

is determined by

{X, Y} is R,

Here A, B are fuzzy sets on X, Y and X, Y are variables whose values are in sets X, Y, respectively (Klir and Yuan, 1995). R expresses the relationship between the variables X and Y involved in the given proposition. For each $x \in X$ and each $y \in Y$, the membership grade R(x,y) represents the truth value of the proposition

p_{xy} *: If X = x, then Y = y*

and involves a fuzzy implication in which A(x) is the truth value of the antecedent and B(y) is the truth value of the consequent. In accordance with the generalized modus ponens (Klir and Yuan, 1995), given a fuzzy proposition of the above form and a fact " X is A'," it is concluded that " Y is B' " by the compositional rule of inference:

$B' = A' \circ R$,

where '$\circ$'is the max-min composition suggested by Zadeh (1975).

The form in which the general schema is expressed is as follows:

Rule 1 : If $S_1(Factor_{i\_1})$ *is* S_1 *and* $L_1(Factor_{i\_1})$ *is* L_1 *then* $\Delta_1(Factor_{i\_1})$ *is* B_1

Rule 2 : If $S_2(Factor_{i\_2})$ *is* S_2 *and* $L_2(Factor_{i\_2})$ *is* L_2 *then* $\Delta_2(Factor_{i\_2})$ *is* B_2

……

Rule n : If $S_n(Factor_{i\_n})$ *is* S_n *and* $L_n(Factor_{i\_n})$ *is* L_n *then* $\Delta_n(Factor_{i\_n})$ *is* B_n

Observation : $S_z(Factor_{i\_z})$ *is* S_z *and* $L_z(Factor_{i\_z})$ *is* L_z

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Conclusion : $\Delta_z(Factor_{i\_z})$ *is* B_z

This can succinctly be expressed in the following notational form:

$\Delta_{iM} = S_{iM} \circ L_{iM}$

As stated previously, the developed rule base contains rules with five classes for the linguistic labels. However, and more generally, the actual observations may not always be limited within this range, and may contain semantic variations called "linguistic hedges" (Klir and Yuan, 1995). The hedge 'H' may be interpreted as a unary operation, h, called a modifier on the unit interval [0,1]. Linguistic hedges are special linguistic terms used for modifying fuzzy predicates, fuzzy truth values and fuzzy probabilities (Klir and Yuan, 1995). Given a fuzzy proposition

$$p : x \text{ is } F$$

and a linguistic hedge *H*, the modified proposition is given as

$$Hp : x \text{ is } HF$$

where HF denotes the fuzzy predicate obtained by applying the hedge H to the given predicate F. It may be interpreted as a unary operation, h, called a modifier on the unit interval [0,1]. In the equation

$$H\,F(x) = h\,(F(x))$$

h (a) < a for all a ∈ [0,1] for a strong modifier, and h (a) > a for all a ∈ [0,1] for a weak modifier, the value being:

$$h_\alpha\,(a) = a^\alpha$$

where $\alpha \in P^+$is a parameter for distinguishing between individual modifiers: $\alpha < 1$ when h_α is a weak modifier and $\alpha > 1$ when h_α is a strong modifier.

Some typical input values of α for different linguistic hedges are as follows:

Extremely – $\alpha = 4.00$
Very – $\alpha = 2.00$
About – $\alpha = 0.75$
More or less – $\alpha = 0.50$
Just about – $\alpha = 0.25$

For these cases where the observations contain such "hedged statements" not explicitly mentioned in the rule base, the rule that best matches the observation is chosen.

The original membership function is then modified by the appropriate modifier "h" to obtain a relation between the actual observation and its outcome. The outcome is in the form of a modified membership function which is subsequently de-fuzzified using standard centroidal defuzzification method. In this method, each membership function is simply multiplied by its corresponding weight. The scaled down membership functions are aggregated to give a final crisp estimate of the factor contribution (d) as follows:

$$d = \frac{\int_{-\infty}^{\infty} \sum_n \alpha_n x\ \mu_{n-FLX\_i}(x)\,dx}{\int_{-\infty}^{\infty} \sum_n \alpha_n\ \mu_{n-FLX\_i}(x)\,dx}$$

where the summation is over all of the consequent membership functions, $\{\mu_{n\text{-}FLX\_i}(x)\}$, and their corresponding weights $\{\alpha_n\}$. In a likewise manner, the individual contributions of other factors are also obtained. The resulting numerical values for the contributions of individual factors then decide the magnitude of the considered ESQ factor for the Travel Portal using the standard fuzzification-defuzzification procedure.

IX. RESULT AND DISCUSSION

The implementation of the Fuzzy Expert System (FES) for measuring the E-Service Quality (ESQ) of app-based travel portals has yielded several key insights and quantitative assessments. By employing a comprehensive fuzzy rule base, derived from domain expertise and extensive observations, the study was able to quantify the contributions of various factors to the overall ESQ. The use of fuzzy logic enabled the accommodation of linguistic nuances and the subjective nature of service quality evaluation. Key findings from the implementation include:

A. Quantification of Factor Contributions

Each factor's contribution to the ESQ was quantified using the developed fuzzy rules. The resulting numerical values provide a clear and measurable understanding of how each factor impacts the overall service quality. For example, factors such as system reliability, user interface design, and customer support were found to have significant contributions.

B. Handling of Linguistic Hedges

The system effectively handled linguistic hedges (e.g., "very high," "somewhat low") by modifying the membership functions accordingly. This flexibility allowed for a more precise matching of real-world observations with the fuzzy rules, leading to more accurate assessments.

C. Application of Defuzzification

The defuzzification process, particularly the centroidal defuzzification method, successfully translated the fuzzy outputs into crisp numerical values. These values represent the final estimates of the factor contributions, facilitating clear decision-making and prioritization for quality improvement.

D. Practical Utility

The system's practical utility was demonstrated through its application to a real-world app-based travel portal. The results provided actionable insights into areas requiring improvement and highlighted the strengths of the service offering. This practical application underscores the relevance and effectiveness of the FES approach in real-world scenarios.

X. CONCLUSION

The study presents the Fuzzy Expert System (FES) for assessing E-Service Quality (ESQ) in app-based travel portals, utilizing linguistic and mathematical factors to quantify key performance indicators and convert complex language data into useful insights. While FES accurately measured customer service, system dependability, and UI design, improving accuracy and providing clear guidelines for future development. Therefore, our study reveals the effectiveness of fuzzy logic in enhancing the quality of e-services through a flexible, quantitative, and methodical performance evaluation approach on a travel platform. Additionally, the usefulness of the framework in evaluating service quality in various businesses is enhanced by extending the fuzzy rule base,

adding real-time data, and utilizing machine learning.

XI. SCOPE FOR FURTHER RESEARCH

While the developed FES has proven effective in measuring ESQ, there are several avenues for further research and refinement:

A. Expansion of the Fuzzy Rule Base

The current fuzzy rule base, while comprehensive, can be further expanded to include additional factors and more nuanced linguistic labels. This expansion would enhance the system's ability to capture a wider range of service quality attributes and provide even more granular assessments.

B. Integration of Real-Time Data

Future iterations of the FES could incorporate real-time data inputs, allowing for dynamic and continuous monitoring of ESQ.

This would enable travel portals to respond swiftly to changes in service quality and user feedback, ensuring consistently high standards.

C. Incorporation of Machine Learning

The integration of machine learning algorithms could further enhance the FES by enabling automated learning and adaptation of the fuzzy rules. Machine learning could identify patterns and trends in the data, optimizing the rule base and improving the accuracy of ESQ measurements.

D. Cross-Platform Comparisons

Expanding the scope of the study to include multiple travel portals and platforms would provide valuable comparative insights. This comparative analysis could reveal industry benchmarks, best practices, and common challenges, contributing to a broader understanding of ESQ in the travel industry.

E. User-Centric Enhancements

Further research could explore user-centric enhancements, such as personalized service quality assessments. By considering individual user preferences and expectations, the FES could provide more tailored recommendations for service improvement, enhancing user satisfaction.

F. Exploration of Additional Domains

The methodologies and findings from this study can be extended to other domains beyond travel portals. Industries such as e-commerce, healthcare, and finance could benefit from similar ESQ measurement frameworks, offering a broader application of the developed techniques.

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