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A Systematic Requirement Analysis for Dynamic Pricing in Retail E-Commerce

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Abstract: ***Retail e-commerce has been exploding recently, with billions of people using the internet to buy goods and services. Due to the vast number of vendors selling similar products to consumers and the high degree of price transparency enjoyed by purchasers, the e-commerce sector is fiercely competitive. Vendors frequently use dynamic pricing, also known as discount pricing, to ensure they generate a healthy profit. In this paper, we present a systematic analysis of the requirements for a modern e-commerce dynamic pricing system. We cover the business, stakeholder, functional, and non-functional requirements of e-commerce dynamic pricing. We additionally offer a generic architecture blueprint based on what we have learned about the requirements for dynamic pricing.***

Keywords: E-commerce, Dynamic Pricing, Requirement analysis, functional requirements, non-functional requirements.

I. INTRODUCTION

A. Growth of E-commerce

IT growth over the past two decades has fuelled the internet and digital economy. The total value of all online retail transactions was over US$5.2 trillion in 2021, and this number is only likely to grow. By 2026, this amount is expected to have increased by 56%, to almost $8.1 trillion [1]. With nearly five billion people online today, e-commerce is only expected to grow in popularity. Enhancements to the user experience, product visualization, and service quality have changed how consumers behave [2][3].

B. Competitive Nature of Retail E-commerce

The rise of e-commerce has resulted in a remarkable increase in the number of online stores, which has led to a significant increase in competition. Sellers find it easier to set up a shop online, as it can save time and effort. Rent, heating, energy, warehousing, and inventory management. The number of potential buyers is finite in a physical shop while the reach of e-commerce spans the globe [4]. The internet market place has become increasingly competitive as more and more sellers try to establish a presence there, and they battle among themself for the market as they buyers take advantage of the many options available to them and their ability to easily compare prices [5].

C. Dynamic Pricing: A competitive tool

As a core element of Revenue management, dynamic pricing (DP) enables firms to alter prices swiftly and appropriately to demand fluctuations for different market conditions, thereby maintaining a healthy supply and demand balance

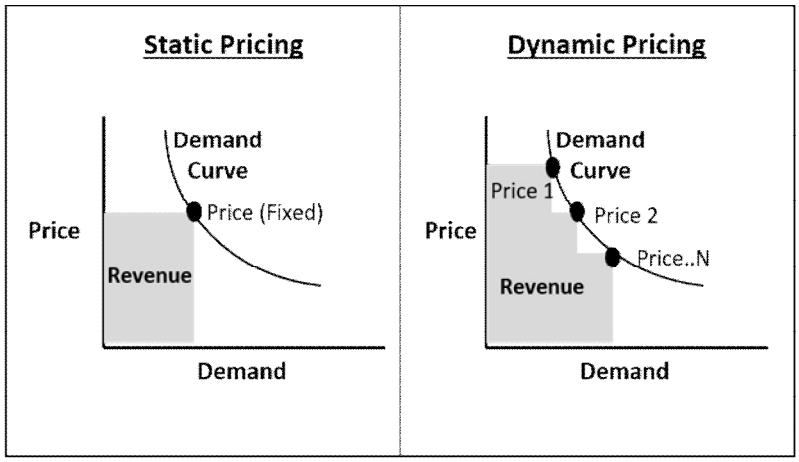


Fig. 1. Dynamic vs Static pricing revenue difference

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DP's goal is to maximize profits by categorizing clients based on the timing of their demand [6]. A product's pricing, for instance, would be lower in a low-demand market than in a high-demand one. In Fig. 1, we can see that offering multiple pricing rather than one increases the likelihood of a higher total revenue, assuming the same number of customers and the same proportion of fixed to variable expenses [7].

D. Requirement Analysis

The goal of the requirements analysis and specification phase is to clearly understand the customer requirements and to systematically organize the requirements [8]. There are multiple requirements classification schemas proposed, e.g., FURPS (Functionality, Usability, Reliability, Performance and Supportability) [9], BABOK Guide (Requirement for Business, Stakeholder, Solution & Transition) [10], or MoSCoW (must-have, should-have, could-have, and won't-have, or will not have right now.).
Following is the outline of this paper: we begin with a literature review on dynamic pricing. Next, we will discuss the findings of our requirement analysis for dynamic pricing by following the requirement analysis schema laid out in the BABOK Guide and the resulting architecture proposal before concluding our work.

II. EXISTING WORK ON DYNAMIC PRICING

Since dynamic pricing encompasses a wide range of topics, many academics have explored it from different angles. In this section, we set out to systematically review this literature.

A. Background of Dynamic Pricing

In the 1970s, the airline industry brought back the practice of age-old tradition of dynamic pricing [11]. Since the introduction of digital technologies, dynamic pricing has emerged as a potential solution to simplify and streamline this labor-intensive process. In recent years, this pricing strategy has become increasingly common due to the surge pricing implemented by Uber and the retail pricing fluctuation performed by Amazon, Flipkart, and others [12]. Determining optimal selling prices of things and services in a system where pricing may simply and frequently be updated is the principle that underpins this idea. Dynamic pricing can be useful, but the process of fixing prices is challenging. It requires to understand the client's willingness to pay, projections of the future demand, and the ability to modify price strategies in order to maintain competitiveness [13].

B. Dynamic Pricing in Retail Ecommerce

In the context of e-commerce, digital sales give businesses with a wealth of data, including information regarding consumer behavior and their reactions to different price points [14]. Knowledge extraction from large e-commerce data sets and subsequent application of that knowledge to the system's parameters and components is essential to the success of dynamic pricing [15]. Kumari et al. [16] propose a real-time pricing system for e-commerce that optimizes sale prices based on demand, competition prices, and buyer characteristics. The system employs an algorithm that formulates pricing as an optimization problem and solves it using Linear Programming. Utilizing multiple successive optimization cycles, the system generates greater revenue than static pricing options. Elmaghraby et.al., [17] explore dynamic pricing scenarios for perishable products based on a combination of inventory size, product shelf life, customers (myopic vs. strategic), various products, replenishment vs. no replenishment, dependent vs. independent demand over time, etc.

C. Dynamic Pricing implementations

According to Lundstrom et al., data, automation, and AI are the primary forces behind the expansion of the online retail industry. According to the results of their survey, data-driven solutions allow businesses to keep tabs on hundreds of products and make educated choices. Kumari et al. [16] implement a real-time DP by decoupling the pricing calculation from the request paths reduces the time required to fulfill price requests. Smaller online shops have the capacity to stock thousands of items, cater to more than a million customers, and adjust prices as needed [18]. Chornous et. al. aim to investigate dynamic pricing modeling experience and the idea of using PLS regression to predict the impact of dynamic components on price. Modeling findings demonstrate that PLS regression, as opposed to linear regression, can discover hidden predictors among several collinear components [19]. Schlosser et.al. have a data driven approach towards dynamic pricing, they measure the effects of offer prices and particular market conditions on sales using logistic regression analyses. For a specific market circumstance, they consider up to 10 offer parameters (such as price, quality, ratings, feedback count, and shipping time) from each competition [20]. Using agent-based simulations, this study tries to evaluate retailers' responses to various price promotion strategies.

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Client behavior and retailer rivalry lead to intricate simulated dynamic exchanges. This study provides an initial evaluation of retailer pricing policies and their impacts using an agent-based model [21].

D. Outside E-Commerce examples

Magsino et.al., [22] apply dynamic pricing into the parking management. They examined five spatiotemporal and spatial parking pricing strategies based on value for money. Unused public cloud compute instances could be sold at substantial discounts. Li et.al describe a large-scale, repeating game between a cloud provider and many cloud users, where the users' goal is to minimize total cloud spending, while ensuring worst case revenue for the cloud providers [23].

III.REQUIREMENT ANALYSIS OF DYNAMIC PRICING

A. What is Requirement Analysis

A system can be defined as a set of two or more components that work together to achieve some common goal, function, or purpose [24]. A requirement is a state or set of abilities that a user needs in order to solve a problem or accomplish a goal, and it is also a state or set of abilities that a system or system component must meet or possess in order to adhere to a contract, standard, specification, or other formally imposed documents [25]. Requirements analysis focuses on the tasks that figure out what the new or changed product or project needs or how it should work [26][27]. Jumping right into "creating or programming software" is a common mistake. It is important to start by getting requirements, analyzing them, and managing them [28].

B. Types of Requirement Analysis

In this work, we study the four categories of requirements proposed by the BABOK® Guide [10] to analyze the requirements of Dynamic Pricing. 1. *Business requirements* are statements of goals, objectives, and outcomes that describe why a change has been initiated. 2. *Stakeholder requirements* describe the needs of stakeholders that must be met in order to achieve the business requirements. 3. *Solution requirements* describe the capabilities and qualities of a solution that meets the stakeholder requirements. Solution requirements can be divided into two sub-categories, (a) *functional requirements:* describe the capabilities that a solution must have in terms of the behavior and information that the solution will manage, and (b) *non-functional requirements* or quality of service requirements: describe conditions under which a solution must remain effective or qualities that a solution must have. 4. *Transition requirements* describe the capabilities that the solution must have and the conditions the solution must meet to facilitate transition from the current state to the future state such as data conversion, training, and business continuity. Considering that our focus is on generic use-cases, transition requirements are specific ones, these are outside the scope of this work.

C. Business Requirement

The primary business requirement for dynamic pricing is to maximize profit while balancing supply and demand [13][18]. To put it succinctly: maximize profit by setting prices in response to

1) Demand & supply for the product,
2) An individual customer willingness to pay at the offered price.
3) Product stage (including promotional, maturity, customer feedback, and ratings).

D. Stakeholder Requirement

Table 1. Stakeholders for a Dynamic Pricing System

Stakeholder	Identity & Role
Business analyst	Analysts determine whether a product is suitable for DP.
Customer & sponsor	Ecommerce owners.
Domain subject matter	Quants, Statisticians, help with DP model creation/selection.
End user	The Ecommerce Buyers.
Implementation SMEs or Supplier	Constitute Software Architect & Developers.
Operational support & Tester	IT operations team, e.g., DevOPs, SREs.
Regulator	FCA (UK), FTC (USA), CPA (India) have regulation on price disclination.

There are a total of 12 stakeholders identified by the BABOK® guide; we have listed all pertinent ones in table 1 and attempted to map out those stakeholders and the duties that go along with them in the context of e-commerce and dynamic pricing.

E. Solution Requirement – Functional Requirement

We analyze the current state of the art and determine below essential functional requirements.

1) Pricing Model: A pricing model should fulfill following requirement:

a) DP Factor Selection: The model must specify the market variables affecting the DP. Demand (Price elasticity demand), inventory size, product shelf life, competition prices, customers segment (myopic vs. strategic), replenishment vs. no replenishment, ratings, feedback count, and shipping time are some of these deciding variables for dynamic pricing [17][20].

b) Sales Probability Estimation: The model should predict the likelihood of a sale given a set of market characteristics [20].

2) Price Generation

a) The pricing system's primary objective is to calculate an offer price for the customer and provide it to them whenever a price request is received.

b) The objective is to maximize revenue, which is calculated by multiplying the number of units sold by their respective prices. An abstract mathematical formulation is proposed by Kumari and Babu Rao in their paper [20].

3) Data Collection: In order for Model to be accurate and Price generation to work, getting quality data is key. Some of the data collection activities needed are:

a) Recording of customer behavior, such as request, price offer, and did the sale occur at the price for future need.

b) Collection of competition prices through scraping competition websites.

F. Solution Requirement – Non-functional Requirement

When it comes to the success of an application, non-functional requirements, or NFRs, are just as important as functional requirements because they relate to the user experience that the system provides. Even if NFRs are not met, a system may continue to work, but it may fall short of what the business or its users expect. The NFRs serve as the basis for all design choices and serve as a road map for the whole development cycle. Literature cites reliability, scalability, performance, integration, configuration, multi-tenancy, security, configuration, multi-tenancy, auditing, and monitoring as the leading NFRs for contemporary applications [30]. When it comes to dynamic pricing, scalability is a crucial NFR for handling massive volumes of business (millions of clients and thousands of products). To facilitate real-time repricing, high performance is essential. Like any other cutting-edge system, dynamic pricing requires attention to non-functional requirements (FFRs) such as integration, security, configuration, etc.

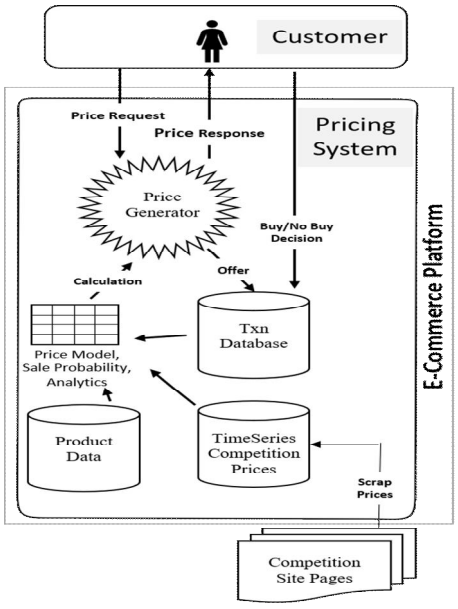


Fig. 2. Architectural blueprint for dynamic pricing

G. Architectural Blueprint

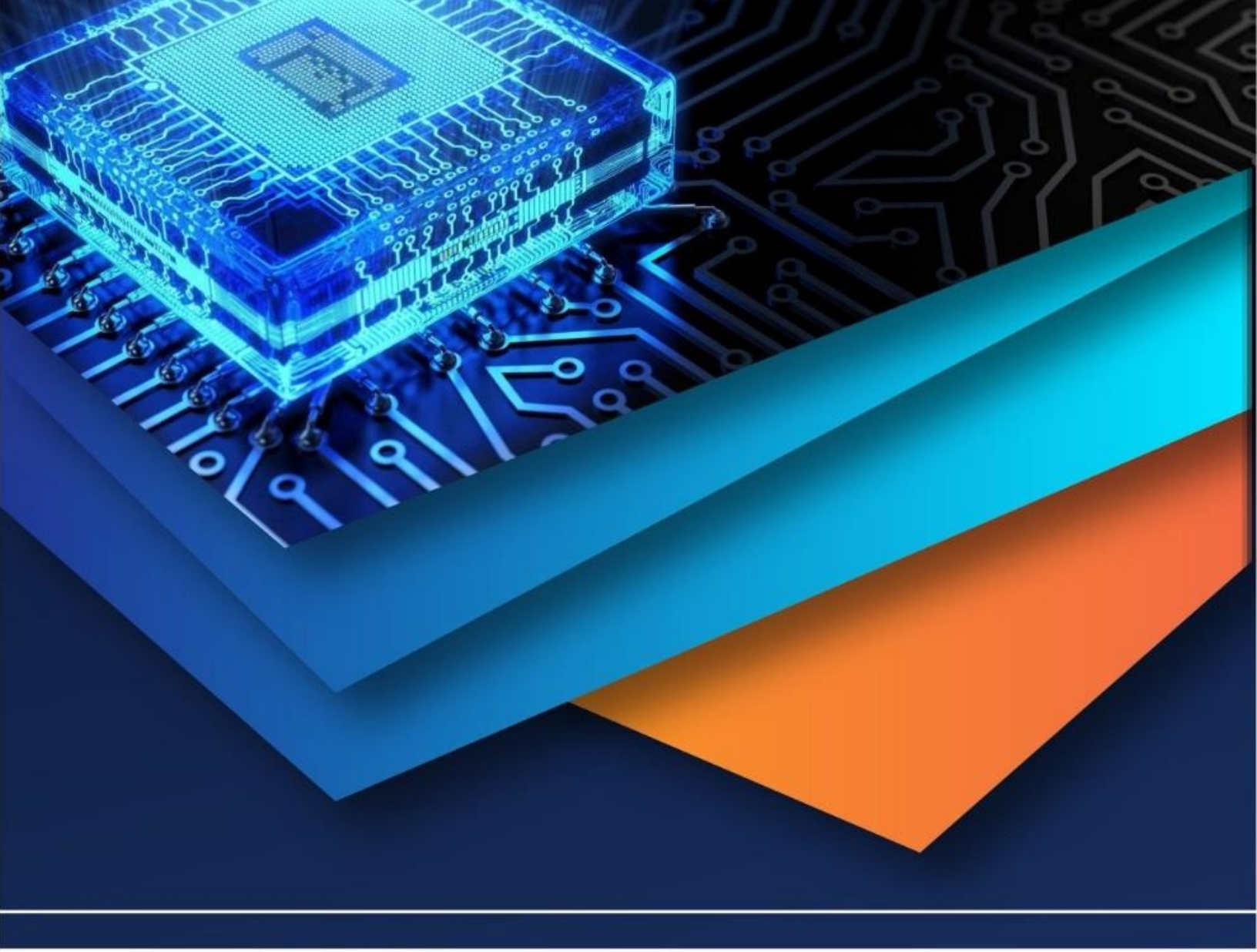
Fig. 2. depicts an architectural blueprint of a dynamic pricing system (part of an e-commerce platform) derived from the requirement analysis we performed. Price generators handle customer requests based on sale probability and other derived analytical parameters given by the pricing model. The pricing model obtains data from sources such as the transaction database and the competition price store. While Fig. 2 focuses on achieving functional requirements, non-functional requirements such as scalability and configuration are determined by the architecture chosen (such as monolith design vs microservices, on-prem vs cloud deployment). Some of these decisions are influenced by actual use-cases, and no one-size-fits-all solution exists.

IV. CONCLUSIONS

Dynamic pricing, a critical capability to have in today's competitive e-commerce market. The quality of software suffers when creators bypass the "requirement engineering" phase and get immediately into building the system. In this paper, we intend to provide implementers of dynamic pricing with a preliminary work on requirement analysis. Our main contribution has been to highlight the stakeholder, functional, and non-functional requirements for a generic e-commerce dynamic pricing system. The specified architectural blueprint can be used as a starting point for achieving the 'functional need'. Non-functional requirements, or NFRs, are crucial for the user experience and must be addressed with the appropriate technology, depending on the actual use case.

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