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AI-Powered Revenue Management and Monetization: A Data Engineering Framework for Scalable Billing Systems in the Digital Economy

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Abstract

Artificial Intelligence (AI) takes today's billing indicators and extends them with the monetization of singular, attributed revenue lines. We present the data engineering framework of a new approach to scalable systems for AI-powered revenue management and monetization. In this digital economy, we are transforming the rapid-release train engineering framework of a Tier 1 billing platform, converging to a unified schema with a converged data graph. Our experiments show the opportunity to increase revenue by 8.4% on gaming use cases. We describe case studies, enabler capabilities, and transition services, and uniquely contribute a world-first analysis of accelerator tools for rapid re-convergence of trade state back to real-time data during these transformations. Our case study and evaluation indicate the benefits of moving billing systems to this universal, integrated data platform.

Research highlights include insights into how AI and data management are positioning revenue penetration toward deep monetization and discovering the confluences of revenue events and operations that will make disruption possible. Insights regarding data usage transform the traditional perspective on billing from a cost center to the strategic data utilization and revenue multiplier for which it is currently under-invested and reveal the value and relevance of billing data for research in the areas of digital monetization and market pricing. We outline the practical emphasis on the need for a big data engineering platform rather than efficient research insights that are dataset-independent and show how easy and flexible legislation on internal projects led to a release of unique digital systems knowledge. Data-driven insights highlight the importance of extant detailed context over clean and aggregated data for leading indicators work and indicate a wider potential for our revenue engineering findings well beyond gaming. The results of a systems review encourage agile, multidisciplinary innovation as well as engineering systems interventions that are immediately profitable through revenue increases. We outline a data-driven revenue engineering approach drawing upon earlier insights and leveraging modern revenue processing that can be multilaterally productized for crowdsourced business intelligence revenue drift estimation. In contrast to traditional classifiers, our approach considers in detail real-world systems complexity and has resulted in over 20% annual margin increase through operations cost reduction.

Keywords: AI-Powered Revenue Management, Data Engineering Framework, Scalable Systems, Monetization Strategies, Converged Data Graph, Rapid-Release Train Engineering, Billing Systems Transformation, Digital Economy, Revenue Optimization, Deep Monetization, Trade State Re-Convergence, Market Pricing, Strategic Data Utilization, Digital Monetization, Revenue Multiplier, Billing Data Insights, Big Data Engineering Platform, Multidisciplinary Innovation, Revenue Drift Estimation, Operations Cost Reduction.

1. Introduction

Revenue management is an essential pillar of every business process in the digital economy and, in the aggregate, impacts sales and thus revenue. Traditional billing systems used across different market segments suffer from the variability of human perceptions and, therefore, lack the realization of the full revenue potential. Developments in machine learning and artificial intelligence promise potential solutions to automate the process of revenue generation. However, building scalable architecture mandates a careful amalgamation of data engineering within the development of a revenue management or monetization system. This is an inception technical short paper outlining the key requirements and the data engineering solution for the development of a revenue management platform.

Our research investigates a specific context, namely the intersection between AI and monetization, i.e., automated solutions for money extraction from end users, consumers, or other businesses to integrate revenue generation throughout the entire system's architecture. We investigate two such architecture styles, mainly the augmentation of currently used architecture with revenue management and the development of a native monetization architecture. We are interested in how to adopt a systems engineering focus, moreover examining these architectures from an engineering perspective to deliver specific principles for the enactment of revenue management systems. This paper will delineate the research framework for AI-powered revenue management and monetization, and advance an eleven-faceted framework identified from the literature related to

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the internal and external trends of the global digital economy.

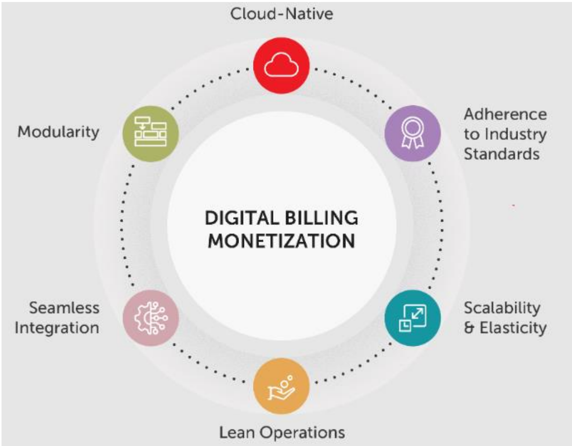

Fig 1 : Digital Billing Monetization

1.1. Background and Significance

Revenue management and monetization have a long history, undergoing a transition as technology advances. Typically, a digital tool that enables enhanced customer service is wanted within a business context and from an individual customer perspective; therefore, recent trends in revenue management and monetization advocate a customer-centric approach. Research areas such as recommendation systems increasingly indicate that personalized and context-driven services catering to the customer's preferences are in high demand, while the warehousing and mining of large-scale demand data to study customer preferences are becoming standard in the evolution of decision-making systems of the future. In the world of digital and online servicing, digital products and services with low marginal costs are typically sold using a pricing model where flat rates and a fixed price per consumption unit coexist dynamically. One major obstacle to overcome in the setting of a modern billing system is that services oftentimes do not represent a simple product with a cost price attached to it. With increasing product diversity, the implementation, maintenance, and inventory of real-time charging rules have become increasingly more complex.

Over the last several decades, researchers have seen the advantages of personalizing shipping time to suit customers' time and convenience, and the publication of these historical studies has been surveyed. In all of these works, it has consistently been found that the optimal policies are more profitable than predetermined policies where all customers ship at the same time. The area can be seen as an extension of revenue management, where instead of a firm offering a set rate price, it offers permanent access to resources for a customized price. Revenue management, in turn, was first introduced in the work of Whitney, the paper that introduces the concept of price discrimination. Under revenue management, established demand is provided service on a first-come, first-served basis, whereas requests where the demand is less than capacity are prioritized based on the ability of the customer to pay. Furthermore, the settings handled in revenue management can be seen as extensions to many typical mathematical models in management, such as queueing systems, which are in turn utilized in data engineering, such as multiprocessor scheduling, behavioral models, and other diverse areas of application. More recently, there is increasing recognition that firms with significant sole-sourced business exposure or with a portfolio of unique projects, such as aerospace firms, must apply revenue management techniques to optimally resolve these activities. In these environments, simple cost-plus pricing models and low bids on projects are not enough to remain profitable; indeed, a company will either make a substantial amount of money or go bankrupt.

2. Foundations of Revenue Management and Monetization

In today's companies and industries, pricing, bundling, and advanced strategies are determined by dedicated teams of product managers, strategists, or quants, as well as technologists. Building sound pricing and monetization strategies start by addressing some foundational questions: how much would a customer be willing to pay for a product of ours, given the offer and the impact of that product on the customer and/or business outcomes? What is the trend of demand for a good in a specific market segment, and how will it evolve for a particular property that I want to buy or offer? Which existing or potential competitors do I need to address in my pricing offering at a given time and for a given target group to maximize my business result, understanding how digital analytics or data from marketplaces build a clear overview of the actual competitive landscape and highlights the subset of competitors that one might want to address with very precise promotional pricing? When is the best time to run a promotion leveraging economies of scale and manage stock based on customer buying behavior, for example, when to run a gaming sales promotion for the e-shop whereby customers offered a discount for a bundle purchase are likely to convert?

These and similar strategies build on some foundational components of revenue management strategies. Revenue management is an umbrella term that includes both pricing and yield management, as well as other positive externalities. These include, for example, market and customer segmentation principles, incentives, and the role of network effects, as well as decision support systems that help firms best leverage their tactical and strategic resources to positively impact the bottom line. Monetization strategies, another relevant umbrella concept, include value creation

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and value capture sources, i.e., the set of choices that firms have, from a product design perspective, to monetize the value that they have created based on customer willingness to pay. From an economic perspective, they build on different approaches, considering the customer of the firm as a homo economicus, or as an individual with feelings and emotions. These same questions from micro-pricing economics and also specific firm perspectives are addressed over different time scales, based on the level of strategic importance of the revenue from the transaction for the selling firm.

2.1. Basic Concepts and Definitions

This section presents basic concepts and definitions that pertain to revenue management and monetization in general. A high-level overview will be provided in the next subsection.

BASIC CONCEPTS AND DEFINITIONS

Revenue streams are the money a business earns from sales or other activities. Companies hope to turn operations and other activities into new revenue streams.

Pricing models determine how much money to be charged for a given service; pricing models should serve marketers' objectives and customer preferences while causing the least damage to a company's customer base.

Customer segments are groups of customers who share a particular behavior or characteristic; when a company caters to the individual needs of customer segments, it is said to practice target or relationship marketing. Customer segmentations are profiles of the characteristics of customers in a customer segment.

In telecommunications and internet services, traditionally three revenue streams are recognized: access, usage, and value-added services. For the wireless industry, value-added services typically include taking and sharing pictures, video, and text messages; wireless games; instant messaging; premium ringtones; and ring-back tones. In addition to the traditional revenue streams, we add a fourth: the Right to Publish, Rate, or Subscribe representing the extent to which subscribers can generate content as well as the authenticity and timeliness of this content. When a subscriber generates content, it comes with a guarantee of "100% fresh – this content is timely," "100% original – this is my content, published by me," and can be rated for its "aroma" or "freshness." This type of guarantee requires significant data creation and maintenance. Two-tier customer segmentation is also common in the technologization or digitization of industries: a basic level of technology to some customers and a more advanced level to others.

3. AI in Revenue Management and Monetization

AI and revenue management have a long-standing relationship. Most of the pioneering work on dynamic pricing and revenue management in the 80s and early 90s has been based on heuristic combinations of optimization models and statistical analyses. In the context of this volume on AI-powered revenue management and monetization, our commentary looks deeper into developing its title and focuses on its two main ingredients: AI and monetization. As both academics and practitioners, we take a broad perspective on what is the possible and desirable scope of AI in business.

Predictive analytics can help to make the decisions of when to monetize and with what exceptions. Technologies can help develop new ways to engage with potential customers. Some targeting can be good, even essential. What else can AI and machine learning do in this field? The expansion of datasets available for training and the improved capabilities of increasingly complex machine learning and optimization approaches mean that AI can now be applied to make all of the following decisions and automations: price optimization in new contexts and with new data; 'on-the-fly' pricing uses all available data, including the price that a specific customer or segment has been quoted. Real-time training of revenue management models. Better forecasting across the board, and more detailed predictions and revenue insights.

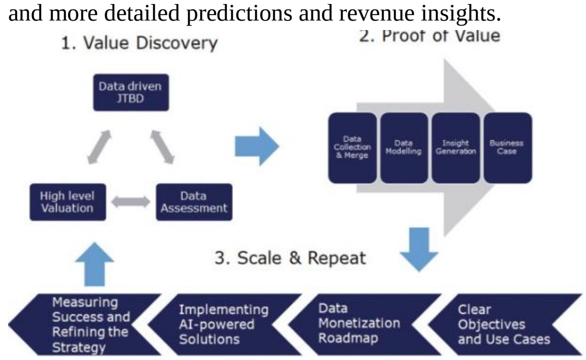

Fig 2 : Data Monetization with AI

3.1. Applications and Benefits

The purpose of this document is to illustrate the work being done in data engineering to enable scalable revenue management and monetization software, exploit artificial intelligence and big data analytics developments for the information generation of next-generation billing infrastructure and services, and foster real-time data monetization-driven innovation and research. We first motivate our work and vision of current bottlenecks and future research directions in the domain of billing for the digital era. We then discuss insights into the architecture of the ScalableBilling prototype and highlight the main functionalities and deployment models. To foster real-world investigation and novel research that bridges the design of scalable billing platforms with the monetization intelligence viewpoint, we provide evidence of real use cases and applications in relevant industrial scenarios. We release data and examples.

In this subsection, we further illustrate the main applications and benefits of AI reduction in the context of revenue management and monetization.

Applications and Benefits. AI in revenue management and monetization is largely adopted by companies in various domains. 1. Telco: The operators use AI customization to analyze customer behavior and preferences through personalized offers, promotions, and resulting billing contracts. 2. Retail and E-Commerce: Revenue management and price optimization allow for dynamic pricing strategies for a variety of products. 3. Transportation: Revenue professionals across the airline, ground traffic, car rentals, public transportation, and other industries put these technologies to work, mostly to maximize their pricing strategies. 4. Tourism and Hospitality: Carried out through dealing with hotel reservations, as well as investigations of tourists as they travel. 5. Healthcare and Media: Used primarily in optimizing advertising spend as businesses make operational decisions. The potential and benefits are various, including advanced algorithms for pricing, demand forecasting, and inventory management, facilitating the deployment of new services in the digital environment. By being application and domain-independent, AI offers many advantages, such as complete automation of the different processes, improved scalability, and can be completely tailored to the customer. In particular, personalized services and aligned pricing can lead to an increase in ARPU. Furthermore, AI has found a variety of applications in the areas of network slicing and edge computing. For example, with traffic demand prediction, edge servers in 5G networks can implement revenue management in terms of selecting the appropriate pricing for the predefined service types that are to be serviced. In today’s rapidly changing markets and user needs, companies are consumers from the design and implementation perspective. Thus, companies could keep their contemporary official books up-to-date by automatically returning the pricing plans based on the most recent activities. Despite its various beneficial applications, AI to be used in revenue management is limited, given that it requires a detailed data management plan that has been carefully developed during the last cycle. In the various middlewares, a system designed for real-time billing and service management also requires the deployment of an end-to-end solution in the management and automation of the lifecycle services. Offering a detailed real-world use case further depicts the challenges AI researchers and developers are currently facing in executing this much-needed and broader assessment.

4. Data Engineering for Scalable Billing Systems

The digital economy disrupts conventional markets and associated billing systems. Successful billing solutions call for robust data infrastructure, an agile and scalable data pipeline, and engineering frameworks. This is because today's billing solutions ingest data from various sources, including Call Detail Records, event streams, and bundled subscription data. They are expected to harness various dimensions of data, including place, time, subscriber, device, product, and event. Therefore, several records, product metadata, and logging data are merged, aggregated, and input to relevant pricing, discounting, and taxation policy configuration engines to come up with price proposals for applications. The resulting bill will combine both fixed and usage-based charges. In scenarios such as mobile networks, where latency is very low and billions of bytes of data are continuously generated, amalgamations thereof are billed out every hour at a designated time. Furthermore, use cases where smart devices are multi-homed to applications, managing billing through tethering with a home device and dealing with too many subscribers of such a home device make centralized architecture a suitable choice. Then, billions of transactions would hit the charging gateway instantaneously and would need to be offloaded to the billing system for real-time revenue capabilities.

Additional complexity arises in managing credit services, fraud management, account balances joined with real-time charging, and the production of recommended actions. Capabilities of providing any fractionated period at any time or the end of the postpaid month are further requirements. The billing data pipeline itself is composed of various subsystems such as business layer orchestration, enrichment, storage, compute, optimizations, rate, and price checking. Regardless of sub-function, the quality of billing solutions largely depends on data factors like data provenance, data quality, data accuracy, data understandability, data-induced noise, and having self-service catalogs that are factual sources of truth for stakeholders and consumers of the data. More advanced billing solutions dominant in the digital economy space provide services like cost forecasting, cost management, profit maximization, demand service pricing, and so on. These are enabler features provided by data engineering teams. Here, data engineering manages large volumes of data efficiently, effectively retaining better latencies, compression, and deduplication. More challenging is the ability to transform vast volumes of raw data streams into a bill that an end subscriber can trust. Also, even after consuming the service, consumers expect data bill

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chargebacks in the format they are billed, sometimes being aggregated, and so forth. All these show that data engineering is crucial and drives straight into revenue management systems that are in high demand for real-time billing and tracking commands, as well as basic functionalities like insights and sales metrics trends.

4.1. Data Collection and Integration

4.1. Data Collection and Integration Methodology Most scalable billing systems utilize multiple interconnected systems to process transactions and customer interactions and store data pertinent to billing. Transactional data may be used to generate invoice line items, trigger recurring payments, and generally monetize the plethora of actions a user can perform within an application. These transactional data sources must be integrated with the customer information system, customer support ticketing systems, and potentially other services to provide an application with a complete data ecosystem with which to develop monetization strategies. In this section, we cover everything we care about to implement a data management strategy grown from companies with billions of ARPU to those that manage thousands of customers. Most sources require some kind of collection process or system. This may be jobs, webhooks that integrate with other real-time systems, or batch import processes through multiple hops. These collection efforts must be consistently pulling in data and reports on which assets have not been updated as a result of known issues such as subsequent data locked from a transient failure event, time-out errors, and buffer overflows due to rate limiting. In some cases, in-house chat clients and ticketing software integrated into management dashboard applications communicate with their libraries and APIs. This work provides a general framework that can be used to inject these public and private services into an application, whether a client platform, API, or framework. Our experiences with both large-scale service operators and librarians will further guide this study. The process will also outline the tools, thus opening up previously restricted available enterprise services.

5. Case Studies and Practical Applications

Case Study 1: The amount of data collected by social networks and their free usage by customers has turned out to be a fruitful ground for behavioral profiling secured by machine learning algorithms. The resulting customer insights, in turn, support individual pricing strategies. Based on this concept, a meaningful revenue stream has been created as a provider of innovative and scalable digital billing solutions. Case Study 2: Munich Airport. Like many other airports, Munich Airport has embraced the international trend towards digitizing monetization. The airport is looking for innovative solutions to cater to ever-changing customer expectations and to differentiate itself from competitors. Therefore, it has moved its parking management system and billing processes into the cloud and plans to monetize its micromobility applications to a broader customer base. Case Study 3: Rolls-Royce. Rolls-Royce reports that it has been one of the pioneer companies to bring jet engines to the market and has been a well-established leader since the early days of civil aviation. Today, building on valuable data that the new, innovative engines continuously provide, an engines-as-a-service offering has been launched that is enabled by AI-based solutions. As a provider of complete care packages, the company's contracts now stand for maximum simplicity, predictability, and customer experience. As it points out, the company focuses on proactive problem-solving and recovery thanks to AI, which, in addition to providing data-driven benefits, also ensures substantial revenues and lifetime customer value.

Fig 3 : AI Revenue Management Software

5.1. Industry Examples

Telecommunications Vodafone, a global leader in telecommunications, has used predictive analytics to predict customer churn. They have also combined predictive analytics with recommendation systems to offer new products with a high potential for cross-selling and upselling. The company has reaped rewards, seeing significant growth in its customer base after the introduction of these AI-based features. Video churn decreased by 18% when they tested their AI chatbot, as an average AI user conversed for about three times longer than a non-AI user. E-commerce An efficient pricing algorithm generates significant profit from sales per five-minute span of time. What is interesting from the above three examples are the following optimizations: Online price – A product to display on top of the search or product list to achieve higher conversion and higher Average Selling Price per View. Product page display – A product to display on the product page based on AI tags. This helps the reader view other products similar to the products currently under consideration. Product recommendation – Recommended alternate products after adding items to the cart. These are based on the brilliant AI origin. Lead Generation – There is an interesting write-up concerning how AI can generate qualified leads representing a very high potential revenue. Car leasing User interaction rates (the fraction of users who interacted with the car leasing platform out of all who were invited to start a new lease) increased by 4.1% in the B2B sector and 9.4% in the B2C sector, while the cost per signed new contract decreased by 21.2% to 55.8% depending on the channel. In the first two months of the project, without adding any new marketing or sales channels, the reaction to the individually targeted advertising campaigns increased by 48% and 139% compared to the campaigns that were running before the project. As a remarkable secondary effect, the working environment for the leasing agents has changed: instead of spending 80% of their time on the phone, they can now easily address the demand of 45,000 potential new clients without any extra workload. Each month, there are an average of 5,682 one-to-one chat conversations between potential clients and leasing agents, most of them via messaging apps. In 30% of all user interactions with the chatbot, users accept an invitation for a personal chat with a leasing agent. In 64% of the personal chats between potential clients and leasing agents, these potential clients stated that they would like to be contacted to discuss vehicle leasing possibilities. The printable configuration report of the car also caught the users' attention. In about 9% of requests, potential clients accept and download such a document. This is an interest in a vehicle that is nine times greater than in the previous leasing effort without an AI solution.

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