INTRODUCTION

The telecommunications industry experiences a fast-paced evolution because data volumes increase exponentially while customers demand better services. Modern telecom networks handle daily data processing of terabytes that includes customer profiles together with service usage records and billing cycles and network performance metrics. According to Zahid et al. (2021) the industry needs robust scalable data architectures to support real-time decision-making and service quality maintenance in this environment. The lack of proper database structure creates risks for service providers through inaccurate billing and delayed customer support and missed strategic planning opportunities. Database systems need to unite operational data with analytical capabilities to solve these challenges. Lottu et al. (2024) show that integrating GIS with machine learning and user behavior analysis in telecom data warehouses leads to better churn reduction and network optimization. The research supports a design method which moves past basic relational tables to enable advanced analytical operations including geographic usage trend analysis and device-specific performance evaluation.

Geographic analytics is particularly important. Mededovic et al. (2019) used node centrality spatial modeling of usage patterns to identify high-demand zones which helped guide better network expansion and marketing strategies. Any telecom database design requires geolocation attributes such as city and region for both customers and usage events to meet this requirement. The data enables telecom operators to direct their infrastructure investments toward actual customer needs while making rapid adjustments to coverage gaps.

The growth of different device models and operating systems created substantial variations in network behavior. The research by Ezeh et al. (2022) demonstrates that particular device and operating system pairs show distinct energy usage and network behavior especially when base station distances change. Telecom providers can use device metadata and usage logs to detect service problems related to devices which enables them to create specific optimization plans through quality-of-service setting adjustments and OS-level support updates.

The system gains additional behavioral insights through customer feedback mechanisms which extend beyond basic usage metrics. The research by Suchanek and Bucicova (2025) demonstrates that post-interaction satisfaction scores effectively predict customer loyalty duration and churn probability while effective feedback systems allow for early intervention strategies. The database benefits from integrated performance reporting and service quality improvement loops through its embedded feedback collection system.

The proposed database system for a telecom provider receives its scope and objectives from these combined factors. The database requires management of customer entities together with service plans and usage records (calls, SMS, data sessions) and billing details and network infrastructure metadata. The design will reach its highest level through the integration of three advanced analytical modules which include customer location analytics and device-based usage analysis and a support feedback system. The comprehensive system design establishes operational support while creating a base for advanced business intelligence functions and strategic decisions through data analysis.

The following step involves creating an Entity–Relationship (ER) model which will accurately depict entities together with their attributes and keys and relationships and cardinalities. The ER model functions as the architectural blueprint for MySQL implementation to embed both standard and advanced analytical requirements structurally. After the ER diagram receives approval we will start defining the physical schema while enforcing referential integrity and creating sample queries to test the design.

CHAPTER ONE: SQL Query Writing and Analytical Implementation

The database design process together with database querying operations stood as the essential foundation for the telecommunications data management project. The practical database tool emerged from theoretical database structure development to serve business insights and decision-making needs. The SQL Query Writing phase started after the relational tables were successfully created and populated in MySQL. The phase presented multiple technical and conceptual obstacles which led to better understanding of the system through structural changes and syntax mistakes and repeated query optimizations.

The first task required establishing entity relationships which would represent vital operational aspects of telecom providers including customers and their plans and usage records and billing information and devices and support interactions and feedback. The SQL tables received their structure from the individual entities. The SQL environment hosted an entity-relationship diagram (ERD) that directed both database logical and physical design processes (Figure 1).

The development of the schema needed both a solid conceptual model and detailed attention to technical aspects such as data types and primary and foreign key relationships and normalization principles. The team dedicated special attention to match each entity and attribute with actual business operations which resulted in precise data modeling for customer transactions and service allocation and support feedback. The ERD functioned as a guide to prevent data structure inconsistencies and redundancy during the modeling process. The MySQL implementation demonstrated how abstract data design needs to be linked with SQL syntax functionality and storage optimization and query efficiency. The initial phase established the foundation which supported all subsequent querying and analysis activities while maintaining data reliability and semantic clarity throughout the project.During the creation of tables multiple issues emerged which forced the team to modify their structural design. The definition of UsageRecord and CustomerPlan tables required table deletion and recreation because of "UseageRecord" typographical mistakes and attribute name errors. The corrections proved essential to preserve foreign key relationships while preventing integrity errors from occurring. The population of data needed to be redone after making structural modifications to the database. The hands-on problem-solving experience strengthened my practical knowledge of SQL constraints and dependency enforcement and referential integrity.

After creating tables and loading data the project team began working on query development. The project had two main goals which were to prove SQL technical competence and to extract useful business intelligence from the available data. The queries served two purposes by extracting individual facts while also connecting related entities to reveal patterns about customer actions and revenue streams and service delivery quality.

The first query obtained fundamental customer data through a JOIN operation between the Customer, CustomerPlan and ServicePlan tables. The query delivered a unified view of customer identification together with subscription information which became the basis for advanced analytical operations. The design demonstrates the typical requirement in telecommunications operations to access integrated data between client and service modules. The second query processed customer subscription data by plan while generating revenue projections. The COUNT and SUM functions allowed the system to generate a summary of plan usage statistics and revenue potential. The analysis helps business departments match their marketing strategies with successful service plans.

The third query analyzed historical usage patterns through calculations of total data consumption and SMS and voice usage during a specified monthly period. The query achieved this result through date filtering and aggregation operations that grouped data by usage type. The query represents actual business requirements for identifying heavy users and evaluating plan adequacy for specific clients. The fourth query extracted billing information which included plan types together with billing dates and amounts and payment statuses. The query demonstrated how each customer engaged financially which helped with auditing and accounts receivable tracking. The query results enable users to detect payment patterns and delayed payments and evaluate plan profitability.

The development of advanced analytical SQL statements beyond these four fundamental queries led to increased business value. A specific query determined the most demanding customers by adding all usage types together before displaying results in descending order. The ranking system enables businesses to segment their customers and develop targeted loyalty programs. The advanced MySQL query demonstrated how to implement transaction control. The query used START TRANSACTION and UPDATE and COMMIT statements to demonstrate how a payment confirmation process works for unpaid bills. The practice demonstrates the critical nature of atomic operations particularly when working with financial modules. The implementation of controlled transactions maintains both consistency and reliability during complex multi-step data operations.

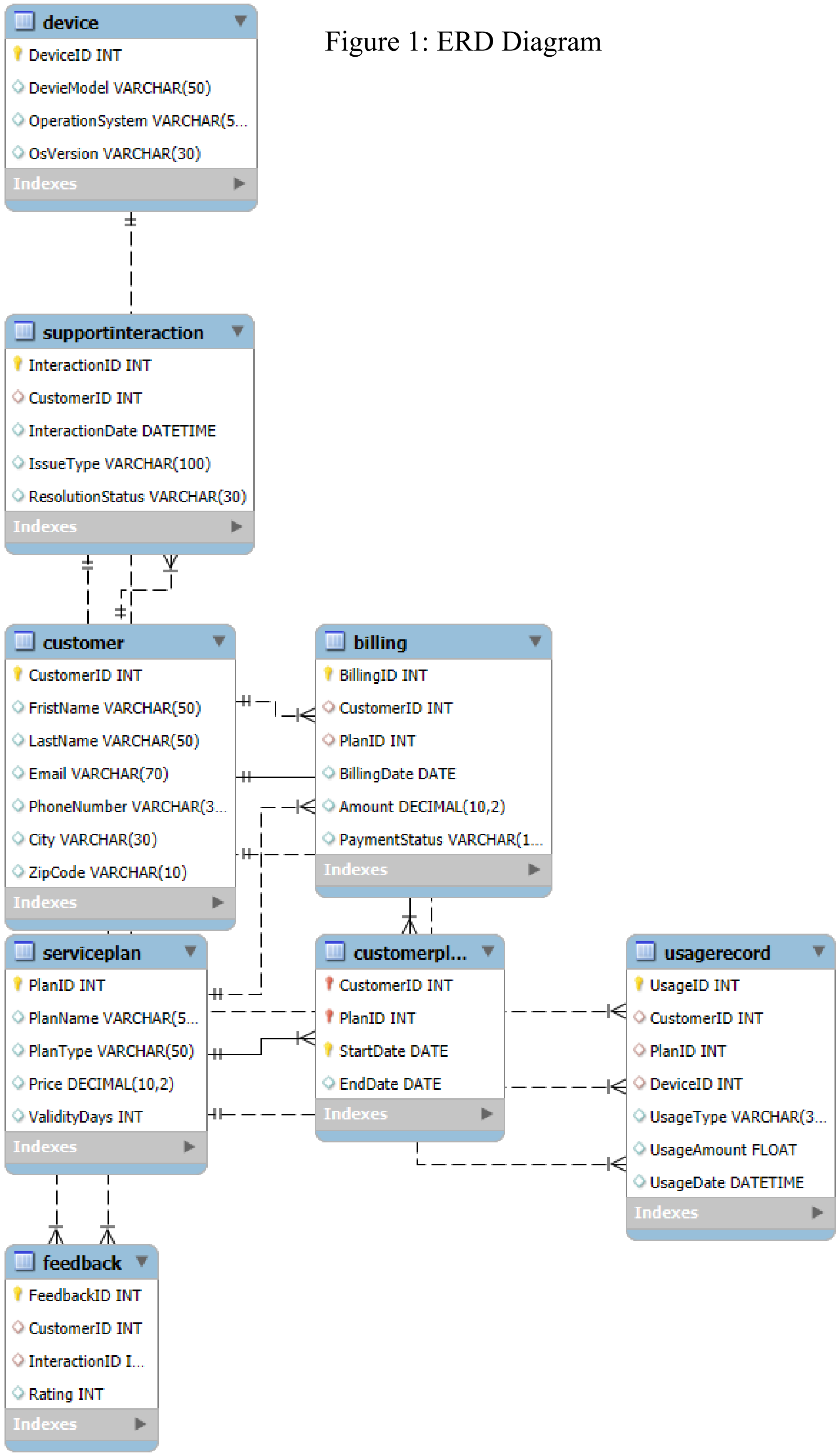
The analysis of customer satisfaction through support interaction feedback was conducted through multiple additional queries. The average feedback score per user was determined through a join operation between the Feedback, SupportInteraction and Customer tables. The system retrieved the most recent issue category from each customer to establish connections between satisfaction ratings and problem types. The analysis of multiple factors helps organizations understand their operational performance and client relationship health. The revenue analysis received additional geographical segmentation capabilities. The query that combined billing totals with customer city information showed how revenue distribution varied between different geographic areas. The analysis results guide organizations to make data-based decisions about network development and localized marketing strategies.

The query-writing phase confirmed the relational structure of the database while transforming static information into valuable analytics. Each query performed a unique strategic purpose by providing summaries of customer interactions and revenue hotspot identification as well as payment integrity checks and service satisfaction evaluations. The relational model allowed these connections through its efficient JOIN operations and consistent aggregation methods. The queries function correctly in MySQL and the implementation phase included sample data validation. The queries present a combination of operational reports and executive-level analytics which connect raw data to actionable intelligence. SQL functions beyond retrieval language status to become an essential organizational tool for evidence-based decision-making and strategic insight generation.

The database transforms into a dynamic forecasting and strategic planning tool when queries combine customer behavior data with billing performance information and network engagement metrics. The business can use high-usage customer analysis to discover suitable candidates for plan upgrades and loyalty initiatives. The analysis of billing delays together with customer feedback reveals service-related dissatisfaction that affects payment behaviors. The relational structure which was carefully planned for normalization and redundancy reduction enables the execution of complex multifaceted analyses.

The successful execution of these SQL queries also reflects the practical importance of combining data modeling with real-time analytics. The real-world enterprise systems benefit from accurate and insightful queries because they produce operational advantages in marketing personalization and resource allocation and financial monitoring. The integration of transactional control for sensitive operations like billing status updates maintains data integrity in multi-user environments that run concurrently. The process of query writing demonstrates the necessity of data extraction together with responsible management that follows business-critical standards. The SQL layer functions as an essential connection between backend storage systems and decision-making interfaces which span across different departments.

Figure 1: ERD Diagram



CHAPTER TWO: CAP Theorem Discussion in the Context of Telecommunications Data Systems

The CAP theorem functions as a basic principle for distributed computing to evaluate database system trade-offs. The theorem which Eric Brewer introduced in 2000 became a formalized concept through Gilbert and Lynch's work in 2002. The theorem proves that distributed database systems cannot provide simultaneous guarantees of Consistency, Availability and Partition Tolerance. System architects need to make purposeful decisions about which two properties to prioritize because the system requires different properties based on operational needs and failure scenarios.

The CAP theorem requires telecommunications providers to understand its principles for building reliable fault-tolerant data systems with high performance. The telecommunications infrastructure operates as a distributed system which covers multiple geographic areas to handle numerous concurrent transactions including real-time billing updates and service plan adjustments and call routing and customer authentication. The systems need to handle dynamic customer data changes and usage and payment status updates while maintaining continuous service operations and preserving data integrity (Patil et al., 2021).

The CAP theorem stands as a crucial factor in database architecture decisions because of its complexity. Mobile networks require real-time customer interaction handling through Availability and Partition Tolerance to maintain continuous service delivery during node failures or network partitions. The operations of billing reconciliation and fraud detection emphasize Consistency and Partition Tolerance for data correctness at the expense of temporary service unavailability (Qiu et al., 2020).

The CAP theorem provides practical guidance for designing essential database systems in telecom environments through its strategic implications. System designers must determine which service aspects (speed, reliability, or integrity) need to be prioritized in different situations when services expand and decentralize across worldwide infrastructure (Zhang et al., 2019). The definition of consistency in this context means that every read operation should return the most recent write. Real-time call authorization and billing functions of a telecommunications provider require this property to operate effectively. The system needs to update customer balances instantly after transactions or top-ups occur to prevent both unauthorized service use and incorrect service denials. The system achieves strong consistency through database node synchronization which minimizes the occurrence of conflicting records and incorrect service status. The pursuit of consistency leads to increased latency in distributed systems that operate across different geographic locations.

The system maintains operational responsiveness through availability features that continue to function even when some nodes experience downtime. Telecom services require high availability because system downtime causes service interruptions which result in revenue loss and customer dissatisfaction. The system provides uninterrupted access to data usage and SMS delivery and voice connectivity through high availability features. The application needs to maintain critical functionalities while responding to user queries during heavy loads or partial system failures. The billing subsystem failure should not interrupt call authorization services because they need to operate continuously to avoid complete service breakdown.

The system maintains operational functionality through Partition Tolerance when network partitions or communication breakdowns occur between nodes. Telecom environments heavily rely on distributed infrastructure which spans data centers and geographic regions so this characteristic becomes essential. The database maintains operational functionality when a portion of the network experiences temporary disconnection through partition tolerance. The system needs to maintain transaction handling and usage data logging capabilities during regional outages to synchronize data when connectivity returns.

Telecommunications providers must base their architectural choices on operational priorities because the CAP theorem shows that systems can only maintain two of the three properties simultaneously. The distributed nature of infrastructure makes Partition Tolerance an unavoidable requirement in many cases. The system must choose between Consistency and Availability because of this trade-off. The operational design of telecom systems focuses on Availability and Partition Tolerance because these features allow services to continue operating during failures even though the latest data becomes temporarily inaccessible. The system enables users to make calls and send messages during peak usage hours and minor partitions because this functionality takes priority over immediate billing record updates.

The mission-critical components including postpaid billing systems and regulatory audits and fraud detection systems require both Consistency and Partition Tolerance as their primary focus. The system components need to maintain data accuracy even though it means users will experience brief periods of unavailability. The system design includes strict consistency controls along with locking mechanisms and delayed response strategies to maintain data fidelity.

The design choices for this project's telecommunications database system were directly affected by CAP theorem requirements. The billing and usage data received referential integrity and relational constraints to support consistent updates through their structural design. The query structure together with modular table design provided high availability for support interactions and device metadata components which are less sensitive. The MySQL-based system implemented here does not achieve full cloud-native distribution yet its schema and logic were designed to accommodate future scalability needs.

The database design included failure prevention measures because developers needed to anticipate both network delay situations and partial data damage events. The database systems implement recovery strategies with error-handling routines to maintain service availability during synchronization delays and outages. The CAP theorem proved useful both as a theoretical model and as an operational framework to develop telecom-friendly data systems.

Telecom operations require strategic trade-offs between CAP theorem parameters according to their specific requirements. Telecom service reliability meets data accuracy standards when providers adjust availability and consistency based on the service importance level. The equilibrium between operational effectiveness and customer satisfaction and regulatory compliance stands as an essential requirement for fast-paced connected environments. Systems designed for telecommunications need to respond quickly to service demands because real-time operations like call routing and SMS delivery and mobile data transactions and billing updates require data protection. Telecom providers achieve system segmentation through CAP principle alignment by setting availability and partition tolerance for transactional services yet prioritizing consistency in financial and audit subsystems to maintain data integrity.

The application of CAP theorem principles in a refined manner creates systems that operate resiliently in operations. Distributed node services can maintain partial functionality during regional outages and system upgrades and network congestion which ensures essential services remain operational. The system implements delayed synchronization mechanisms with eventual consistency models to resolve data discrepancies while maintaining uninterrupted user operations. The adaptability of these systems functions as a fundamental element for delivering the expected level of mobile connectivity with seamless user experiences. Recognizing the trade-offs defined by CAP enables better technical design which brings IT infrastructure alignment to business priorities through the optimization of system responsiveness and trust and scalability in milliseconds and megabytes that affect customer satisfaction and corporate performance.

The SQL implementation scripts together with their corresponding ER diagram exist in a shared Google Drive folder. The access link to this folder appears in the Appendix section which concludes this assignment.

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Appendix

https://drive.google.com/file/d/1SEGyD8bbMA_eWSWvO30Ca9vmSG0IwrrN/view?usp=sharin
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