Instagram Data Warehouse Implementation Report

1. Assignment Overview

The design and deployment of the Instagram Data Warehouse leverage Databricks and Delta Lake for ETL tasks and analytics functions. The data acquisition process includes structured extraction from various sources, transformations into a star schema structure, and loading for analytical querying and business intelligence insights.

2. Data Sources

The dataset originates from simulated Instagram interactions and engagement data, including user activities such as likes, comments, and follows. The raw data analysis consists of millions of records presenting information about user profiles, photos, engagement metrics, and social interactions.

Dataset Overview

The Instagram data warehouse collects and structures user interaction data to analyze engagement trends and performance. The dataset includes:

- **Users Data**: Profile details, account creation date, and activity logs.
- **Photos Data**: Image metadata, upload timestamps, and associated tags.
- **Engagement Data**: Like, comment, and follow actions.

Potential Use Cases

1. **User Engagement Analysis**
    - Identify the most active users and their engagement levels.
    - Track social influence by analyzing followers and interactions.
2. **Content Performance Benchmarking**
    - Measure the most liked and commented photos over time.
    - Determine content trends based on tags and interactions.
3. **Influencer Identification**
    - Discover users with the highest engagement scores.
    - Analyze relationships between engagement and follower growth.
4. **Predictive Engagement Modeling**
    - Utilize machine learning to predict trending content.
    - Forecast user behavior based on historical activity.
5. **Advertising and Monetization Insights**
    - Analyze user engagement with sponsored content.
    - Optimize advertisement targeting based on interaction patterns.

Dataset Files

The following datasets were used:

Dataset File Name	Description
users.csv	Contains user profile details, including usernames, creation dates, and activity logs.
photos.csv	Metadata about uploaded photos, including URLs, timestamps, and associated tags.
likes.csv	Records of user interactions in the form of likes.
comments.csv	Contains user comments and associated timestamps.
follows.csv	Tracks users follow actions and relationships.
tags.csv	Stores hashtags and labels associated with photos.

A full data dictionary is provided in the README file accompanying this report.

3. Normalized Database

The normalized database contains multiple tables linked by foreign keys to maintain referential integrity and optimize storage. The primary relationships between tables are as follows:

- **Users Table**: Stores user profiles and activity logs.
- **Photos Table**: Stores metadata about uploaded content.
- **Likes, Comments, and Follows Tables**: Track engagement actions.
- **Tags Table**: Links hashtags to photos.

4. ETL Process Implementation

ETL Steps:

1. **Extract:** Data is loaded from CSV files in Azure Blob Storage.
2. **Transform:** Data is cleaned, formatted, and structured into a normalized schema.
3. **Load:** Normalized data is inserted into staging tables and later transformed into dimensional tables and fact tables.

ETL Challenges and Solutions:

- **Handling Missing Data:** Null values are either imputed or removed.
- **Data Deduplication:** Ensures unique records for each user and interaction.
- **Surrogate Keys:** Implemented in dimension tables for consistency.
- **Slowly Changing Dimensions (SCD Type 2):** Tracks historical changes in user and photo data.

ETL Execution Logs:

Screenshots and logs of successful execution are included in the README file.

5. Data Warehouse Design: Star Schema

Dimension Tables:

Table Name	Description
dim_users	Stores user attributes such as username, account creation date, and engagement metrics.
dim_photos	Contains metadata about uploaded photos, including URLs and timestamps.
dim_tags	Stores hashtag and label associations for content.
dim_interaction_type	Defines different types of engagement (likes, comments, follows).

Fact Tables:

Table Name	Description
fact_interactions	Stores all user engagement data, including likes, comments, and follows.

Star Schema Design

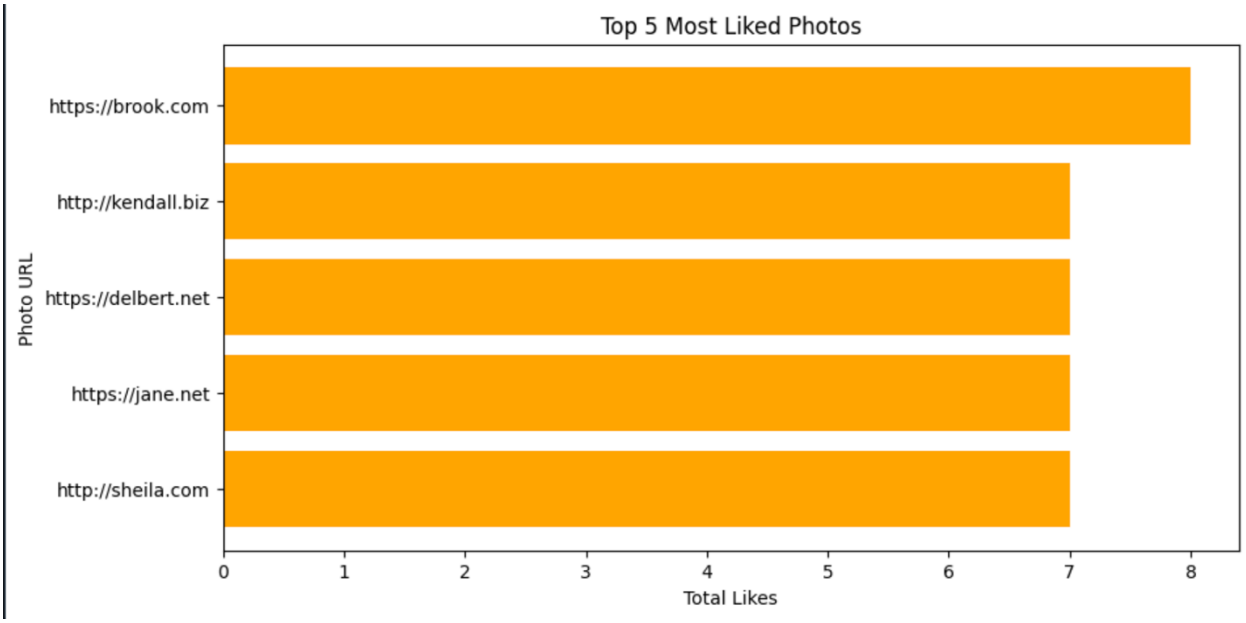
The fact table **fact_interactions** is linked to multiple dimension tables to enable efficient querying and reporting. The structure is optimized for aggregating engagement metrics.

6. Analytical Queryig and Business Insights

Query 1: Identify Top 5 Most Liked Photos

Business Insight: Helps identify content trends and popular posts.

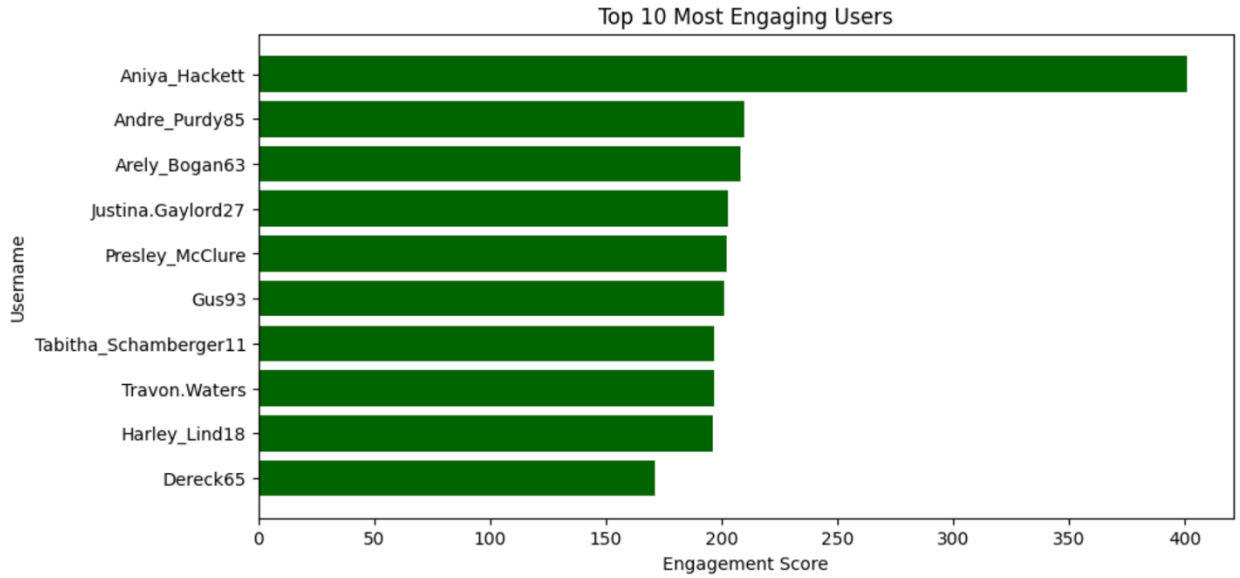
```
SELECT p.photo_url, u.username AS uploaded_by, COUNT(f.interaction_type_sk) AS total_likes
FROM fact_interactions f
JOIN dim_photos p ON f.photo_sk = p.sk_id
JOIN dim_users u ON p.user_id = u.user_id
WHERE f.interaction_type_sk = (SELECT interaction_type_sk FROM dim_interaction_type WHERE
interaction_type = 'like')
GROUP BY p.photo_url, u.username
ORDER BY total_likes DESC
LIMIT 5;
```



Query 2: Identify Top 10 Most Engaging Users

Business Insight: Determines users with the highest interaction levels.

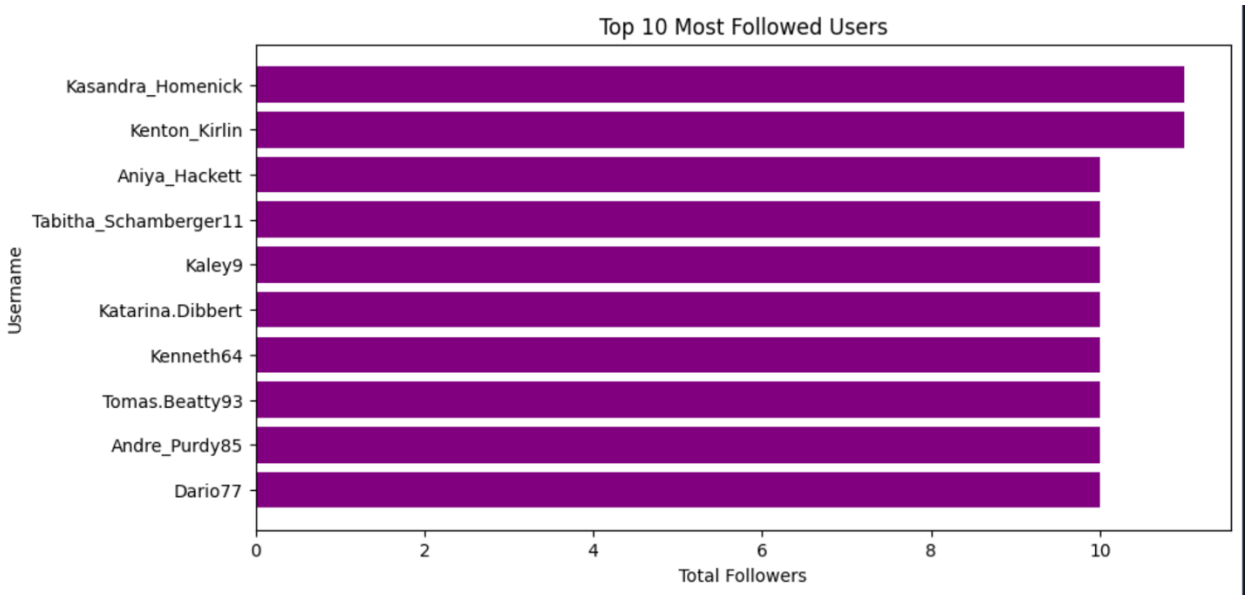
```
SELECT ua.username, ua.total_interactions, ue.received_interactions,
(ua.total_interactions + COALESCE(ue.received_interactions, 0)) AS engagement_score
FROM (
    SELECT u.username, COUNT(f.user_sk) AS total_interactions
    FROM fact_interactions f
    JOIN dim_users u ON f.user_sk = u.sk_id
    GROUP BY u.username
) ua
LEFT JOIN (
    SELECT u.username, COUNT(f.followed_user_sk) AS received_interactions
    FROM fact_interactions f
    JOIN dim_users u ON f.followed_user_sk = u.sk_id
    WHERE f.followed_user_sk IS NOT NULL
    GROUP BY u.username
) ue
ON ua.username = ue.username
ORDER BY engagement_score DESC
LIMIT 10;
```



Query 3: Identify Top 10 Most Followed Users

Business Insight: Highlights social influencers based on follower count.

```
SELECT u.username, COUNT(f.followed_user_sk) AS total_followers
FROM fact_interactions f
JOIN dim_users u ON f.followed_user_sk = u.sk_id
WHERE f.interaction_type_sk = 3
GROUP BY u.username
ORDER BY total_followers DESC
LIMIT 10;
```



7. Conclusion and Future Improvements

This ETL pipeline effectively processes Instagram engagement data, enabling scalable analytics and business insights. The implementation follows best practices, including normalized staging, star schema modeling, and optimized querying.

Future Enhancements:

1. **AI-Driven Insights:** Implement sentiment analysis on comments.
2. **Real-Time Analytics:** Introduce Apache Kafka for streaming data processing.
3. **Enhanced Visualization:** Build interactive dashboards with Power BI or Tableau.
4. **Predictive Modeling:** Use machine learning to forecast engagement trends.

The Instagram Data Warehouse provides a scalable, high-performance analytical solution that can be further enhanced for deeper insights into user behavior and social interactions.