Documentation for the Assignment

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# University of Iowa Parking Analysis Dashboard

## Project Overview

### Purpose:

This Power BI dashboard helps the **University of Iowa's Parking and Transportation Department** monitor, analyze, and optimize parking lot usage across campus. It provides **insights into:**

- Parking trends (entries, exits, duration)
- User behavior (access groups, patterns)
- Peak usage forecasting
- Academic events' impact on parking

This supports **data-driven decisions** for issuing new cards, managing access groups, and optimizing parking policies.

## Data Model & Relationships

### Core Tables:

| Table | Purpose | Key Fields |
|---|---|---|
| **CardTransaction** | Log of parking card transactions | CardNumber, EntranceDate, ExitDate, LotNumber |
| **CardAccessGroupAssignment** | Card to Access Group mappings | CardNumber, GroupNumber, Priority |
| **Calendar** | Date table for time intelligence | Date, Month, Year, DayOfWeek, IsWeekend |
| **AcademicCalendar** | Academic events (Semester Start, Breaks, Holidays) | Date, Event Type, Description |
| **DailyPeakUsage** | Pre-calculated daily peak usage per lot | Date, LotNumber, Daily Peak |
| **CardBridge** (Bridge Table) | Bridge for CardNumber relationships | CardNumber |

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**Relationships:**

**Active Relationship**:

- Calendar[Date] ➡️ CardTransaction[EntranceDate]

**Inactive Relationship**:

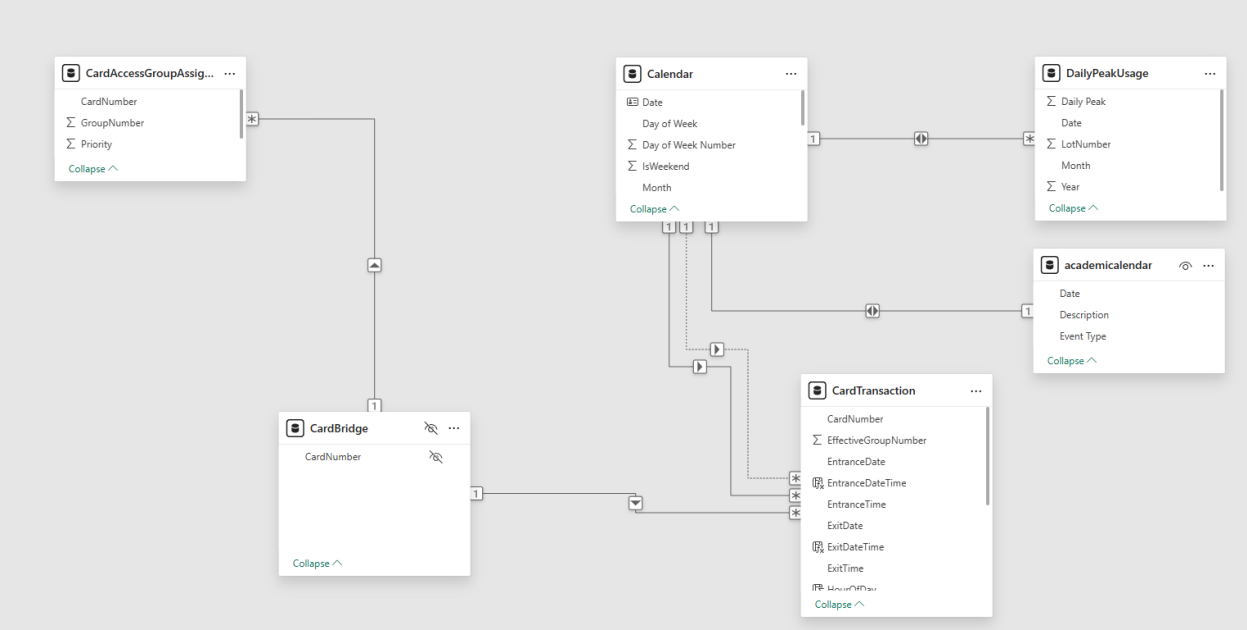
- Calendar[Date] ➡️ CardTransaction[ExitDate]

**Other Key Links**:

- CardTransaction[CardNumber] ➡️ CardBridge[CardNumber]
- CardAccessGroupAssignment[CardNumber] ➡️ CardBridge[CardNumber]
- Calendar[Date] ➡️ AcademicCalendar[Date]
- Calendar[Date] ➡️ DailyPeakUsage[Date]

**Why Bridge Table?**

The **CardBridge** enables handling **many-to-many** relationships (e.g., a card having multiple access groups).



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**Visualizations & Insights**

| Page | Key Visuals & Insights | Notes |
|---|---|---|
| **Dashboard Overview** | Purpose, key metrics, and academic calendar | Entry page with context & navigation |
| **Parking Access Insights** | Total active cards, total lots, access group breakdown, avg. transactions | Slicer for Year/Quarter/Month; Least/Top 10 Access Groups |
| **Usage by Lots** | Lot occupancy by hours, transactions by lot & group by day | Heatmap visuals |
| **Peak Entry/Exit Days** | Total Entries vs. Exits by Day of Week, Anomaly counts (No Entry/Exit, Overnight, Long Stay) | Daily usage patterns |
| **Parking During Academic Events** | Transactions during vs. non-events by month, academic event filtering | Event impact analysis |
| **Forecasted Peak Usage (2025)** | Forecasted monthly peak usage, seasonal trends | Line chart + annotations |

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**Forecasting (2025 Peak Usage)**

**Methodology:**

The forecasted peak parking usage for 2025 is generated using Python Prophet, a popular time-series forecasting model developed by Facebook.

- Why Prophet?
  Prophet is robust to:
    - Seasonal patterns (e.g., academic calendar effects)
    - Holiday effects (e.g., semester start/end, holidays)
    - Irregular data (missing values, sudden spikes)

**Forecast Setup in Power BI:**

- **Python Script Integration:**
    - Python code embedded directly into Power BI via the Python visual.
    - Historical parking usage data is passed to Prophet for modeling.
- **Forecast Variables:**
    - Date (monthly level granularity)
    - Peak Usage (simultaneous usage counts or peak transactions)
- **Forecast Output:**
    - Monthly peak usage predictions for 2025.
    - Seasonality is captured from academic events and trends in historical data.

**Forecast Highlights:**

- October 2025 Peak: ~131.2K forecasted peak usage.
- Dips in June/December: Likely due to semester breaks and holidays.
- Forecast Curve: Aligned with academic calendar impact.

**Forecast Visual:**

- Line Chart showing predicted peak usage per month.
- Tooltips and annotations highlight trends (e.g., "Peak in October").

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**Sample Forecasted Data**:

| | | | |
|---|---|---|---|
| Thursday, December 4, 2025 | 4500.51447311401 | 3837.50207470901 | 5204.42091099928 |
| Friday, December 5, 2025 | 4257.11007567798 | 3591.56183060942 | 4917.08868195293 |
| Saturday, December 6, 2025 | 2910.80240384779 | 2205.56935276725 | 3633.84775631469 |
| Sunday, December 7, 2025 | 2900.39244065083 | 2251.17927398113 | 3611.45560064266 |
| Monday, December 8, 2025 | 4340.31320631318 | 3608.46738320009 | 5066.17748796187 |
| Tuesday, December 9, 2025 | 4633.27948793047 | 3938.97192913596 | 5310.67157347932 |
| Wednesday, December 10, 2025 | 4624.23662503126 | 3890.89146589722 | 5355.60416574581 |
| Thursday, December 11, 2025 | 4492.48795610993 | 3802.77415556172 | 5203.36106383044 |
| Friday, December 12, 2025 | 4186.22674841888 | 3467.19616284414 | 4871.2552046182 |
| Saturday, December 13, 2025 | 2774.74165102437 | 2118.13194926989 | 3460.84666121522 |
| Sunday, December 14, 2025 | 2698.48036935446 | 1963.58044454769 | 3374.39867822012 |
| Monday, December 15, 2025 | 4073.56747449214 | 3318.03877933513 | 4772.65521930346 |
| Tuesday, December 16, 2025 | 4304.41073769634 | 3593.91135584249 | 4979.7056400742 |
| Wednesday, December 17, 2025 | 4237.60617553682 | 3508.8500212969 | 4893.38962660095 |
| Thursday, December 18, 2025 | 4054.0225813707 | 3340.79386555245 | 4664.22208910861 |
| Friday, December 19, 2025 | 3703.29251810036 | 3024.07713080748 | 4419.60383113036 |
| Saturday, December 20, 2025 | 2255.97991507261 | 1583.43238101198 | 2914.68107409993 |
| Sunday, December 21, 2025 | 2153.6099899122 | 1432.41713884617 | 2831.04046865619 |
| Monday, December 22, 2025 | 3513.15832259347 | 2787.94944684399 | 4202.32187271851 |
| Tuesday, December 23, 2025 | 3739.63425226911 | 3091.82989312123 | 4379.10046125692 |
| Wednesday, December 24, 2025 | 3679.96940686808 | 3063.38961069369 | 4348.90131045135 |
| Thursday, December 25, 2025 | 3515.09259266789 | 2815.5449403493 | 4190.68300850862 |
| Friday, December 26, 2025 | 3194.41828489739 | 2518.15023616125 | 3876.57182828281 |
| Saturday, December 27, 2025 | 1788.01893524444 | 1145.37264636017 | 2473.6506447507 |
| Sunday, December 28, 2025 | 1736.66669511143 | 1028.25389017817 | 2401.38321774699 |
| Monday, December 29, 2025 | 3156.34106797512 | 2460.14070823934 | 3807.62354038406 |
| Tuesday, December 30, 2025 | 3450.83716458547 | 2770.91033335597 | 4155.58901100787 |

**Key Measures & Calculations**

Sample **DAX Measures** used:

| **Measure** | **Purpose** |
|---|---|
| Peak Usage | Max simultaneous usage per lot/date |
| Simultaneous Usage | Count of users inside a lot at a point in time |
| Avg Transactions per Card | Average transactions per access group |
| No Entry Count / No Exit Count | Anomaly detection for incomplete transactions |
| % Transactions During Events | Percentage of transactions during academic events |
| Dynamic Average Transactions | Avg transactions by Day, Month, or Year (button-driven) |

These are just sample measures, I have used more than 25 measures.

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**Filters, Slicers & Interactivity**

- **Date Slicers**: Year, Quarter, Month for time-based filtering.
- **LotNumber Slicer**: Select individual or multiple lots.
- **GroupNumber Slicer**: Filter by Access Group.
- **Event Type Filter**: Academic event categories (Semester Start, Breaks, Holidays).
- **Toggle Buttons**:
    - Least 10 / Top 10 Access Groups.
    - Day/Month/Year views for transaction trends.

**Design & User Experience**

- **Color Theme**: University of Iowa branding (yellow & black).
- **Navigation**: Custom back/forward buttons, clear titles.
- **Annotations**: Info tooltips for context (e.g., forecast peak explanations).
- **Readable Fonts**: Large KPIs and clear category labels.

**Deployment & Optimization Notes**

**Data Size Management**:

- Dataset ~400MB; optimized by:
    - Aggregated DailyPeakUsage.
    - Pre-filtered Calendar table.
    - Removed unnecessary columns.

**Performance**:

- Star schema design for efficiency.
- Minimized inactive relationships (only ExitDate).
- Calculated columns for Time Intelligence.

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**Future Enhancements**

Ideas for the next iterations:

- **Weather Data Integration** for additional context.
- **Anomaly Alerts** via Power BI subscriptions.
- **User Segmentation**: Advanced clustering of cardholders by behavior.
- **Access Management Recommendations**: AI-based insights for access policies.