Ultimate Technologies Inc. Take Home Challenge

By Cameron Hicks

Part 1 - Exploratory Data Analysis

Data Contents

The raw login data contained 93,142 login records with no visable duplicate timestamps. After aggregating logins into 15 minute time intervals, the resulting time series consisted of 9.788 unique intervals spanning approximately 16 weeks. There were no prolonged gaps or missing intervals observed.

Demand Patterns

Analysis of the aggregated time series reveals clear daily and weekly demand cycles. Average login activity is higher on weekends compared to weekdays, indicating increased overall usage during weekend periods.

Weekday and weekend login behavior also varies substantially by time of day indicating standard work hours have an impact on logins. On weekdays, elevated demand is observed during late-night hours (12:00am-1:00am), midday (10:00am-1:00pm, and evening hours (8:00pm-12:00am). On weekends, demand remains elevated for longer continuous periods, particularly from midnight through early morning (12:00am-6:00am) and from midday through late evening (12:00pm-12:00am).

Analysis of demand variability using interquartile ranges shows that periods of higher average login activity also exhibit greater variability indicating that peak demand hours are less predictable than off-peak periods.

Part 2 - Experiment and metrics design

Question:

The neighboring cities of Gotham and Metropolis have complementary circadian rhythms: on weekdays, Ultimate Gotham is most active at night, and Ultimate Metropolis is most active during the day. On weekends, there is reasonable activity in both cities. However, a toll bridge, with a two way toll, between the two cities causes driver partners to tend to be exclusive to each city. The Ultimate managers of city operations for the two cities have proposed an experiment to encourage driver partners to be available in both cities, by reimbursing all toll costs.

1. *What would you choose as the key measure of success of this experiment in encouraging driver partners to serve both cities, and why would you choose this metric?*
2. *Describe a practical experiment you would design to compare the effectiveness of the proposed change in relation to the key measure of success. Please provide details on:*
   a) how you will implement the experiment
   b) what statistical test(s) you will conduct to verify the significance of the observation

c) how you would interpret the results and provide recommendations to the city operations team along with any caveats.

Answer

1. The key metric to determine success of this experiment would be to measure Drivers Active in Both Cities. This metric would be measured by tracking the number of drivers who completed at least one pickup/dropoff in both Gotham and Metropolis during a shift. Success in this experiment would be to achieve a significant increase of drivers who are active in both cities during one shift proving that the toll reimbursement policy is effective in encouraging drivers to cross the city boundaries. However, there are two additional metrics that would be vital to track as part of this experiment to determine if this business plan meets the Ultimate managers needs. Profit - The experiment would need to track the total cost of the reimbursed tolls as well as the revenue generated from all of the rides. These two will determine the profitability of this business model. Rider wait times - tracked to determine if the new business model will increase or decrease rider wait times. These two additional metrics are vital to incorporate in the final report of this experiment because while the experiment may be a success in encouraging drivers to be active in both cities, if it reduces profitability or increases rider wait time it may ultimately have a negative effect and not be the result Ultimate managers are looking for.
2. Hypothesis - Can we increase the number of drivers who are active in both Gotham and Metropolis during a shift by reimbursing drivers toll costs?
   To test this hypothesis, I would conduct a randomized controlled trial. Firstly, I would separate all of the Ultimate drivers into groups. Depending on existing levels of data availability, I would group the drivers by their activity and driving levels (depending on the data this could be average number of hours worked per week, average number of rides completed per week, or possibly city preferred to drive in). Each group would then be randomly split in half with 50% receiving the toll reimbursement policy and the other 50% not receiving or being informed of the policy. If there is no data to separate into subgroups, the full driver roster would be randomly split into these two halves. Once split, data would be tracked for a minimum of 1 month. Specific metrics to be tracked (if possible):
   - Drivers Location upon beginning of shift - records city shift began in
   - Drivers location upon end of shift - records city shift ended in
   - Driver Toll Reimbursable - boolean indicating if the driver is eligible for Toll Reimbursement or not
   - Every pick up location during the shift - records city of each pick up
   - Every drop off location during the shift - records city of each drop off
   - Cross City Line to Pick Up - boolean indicating True if the driver had to cross city line from previous drop off to next pick up
   - Cross City Line to Drop Off - boolean indicating True if the driver had to cross city line from pick up to drop off
   - Trip Revenue - records the total revenue from each trip
   - Trip Toll - boolean indicating if there was a toll during the trip
   - Pick Up Toll - boolean indicating if there was a toll between previous drop off location and next pick up location
   - Total Toll Cost - records the total cost of the toll
   - Profit - records the total revenue minus the total toll cost

- Rider Wait Time - records how long the rider waited between requsting the ride and pick up
- Ride Length (Time) - records the duration of the ride
- Ride distance (Miles) - records the number of miles of the trip
- Pick Up Distance (Miles) - records the number of miles between the previous drop off location and next pick up location
- Active in Both Cities - boolean, True if any of these conditions are True: Drivers Location upon beginning of shift does not equal Drivers location upon end fo shift, Cross City Line to Pick Up is True, Cross City Line to Drop Off is True, Trip Toll is True, Pick Up Toll is True, Total Toll Cost does not equal 0.

Statistical tests - Once the experiment concludes or has been ongoing for at least a month I would conduct a two-proportion z-test to compare the proportion of drivers active in both cities between the treatment group and the control group. If we observe significantly more drivers in the treatment group that are active in both cities we can determine the experiment was a success in the target metric. However, to test the caveats, I would then perform two-sample t-tests on profit and average rider wait times to determine if there was a noticeable impact on either of those two metrics. Based on results from those tests, I would likely present one of four possible outcomes:

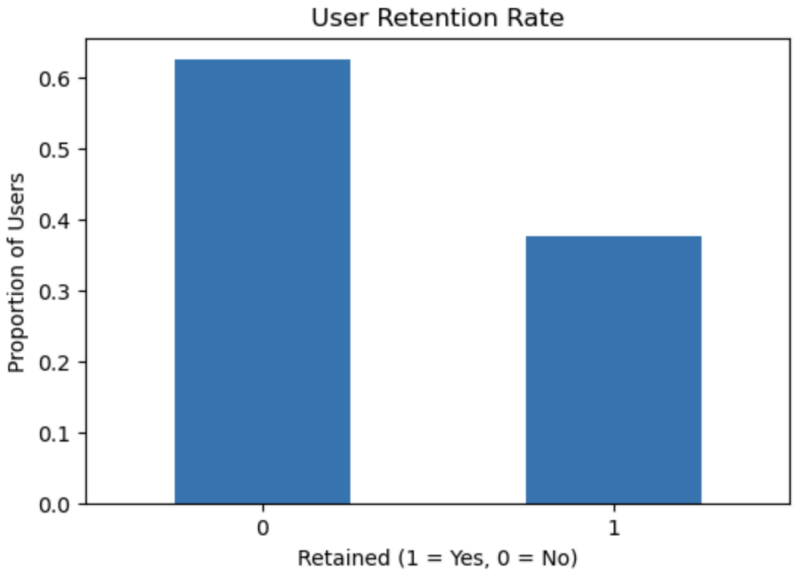
- **Outcome 1**: Significant increase in cross-city drivers with neutral or positive profit and rider experience impact. Recommendation: Roll out the policy company wide to further increase driver activity.
- **Outcome 2**: Significant increase in cross-city drivers with negative impact to profit. Recommendation: While the experiment was successful in increasing drivers active in both cities, the toll reimbursements are negatively impacting profits. Consider the implications of the draw backs before deciding to continue or expand the policy. If dual-city drivers are highly needed, consider continuing the program for highly active/high earning drivers only.
- **Outcome 3**: Significant increase in cross-city drivers with negative impact to rider wait times. Recommendation: While the experiment was successful in increasing drivers active in both cities, the rider wait times were increased by {x} amount. Rolling out the toll reimbursement policy to all drivers could have further negative effects on rider wait time potentially leaving the city with less demand with few to no drivers near by. Consider reducing the number of drivers eligible for the toll reimbursement policy to maintain a par of drivers available in each city, while keeping a par of drivers who are able to commute between cities as needed.
- **Outcome 4**: Decrease or no impact to cross-city drivers. Recommendation: The experiment showed no improved results of driver behavior becoming active in both cities. Roll back the toll reimbursement program and consider other encentives that could encourage drivers to cross city lines.

Caveats & Limitations - There are some caveats to consider prior to full adoption of the recommendation:

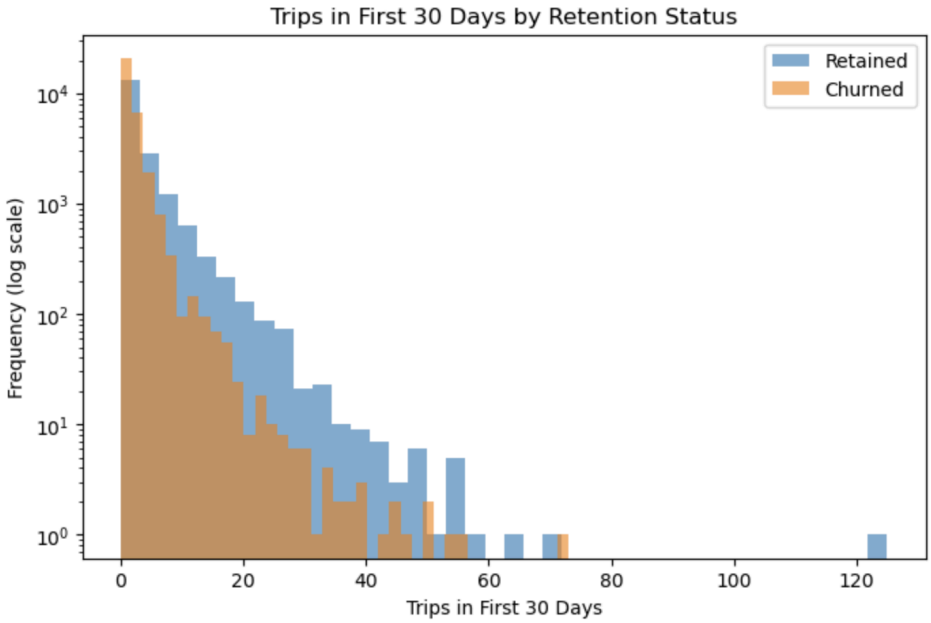
- Experiment Window - There could be seasonal effect on the outcomes that were not made apparent in this sort term experiment. Consider an extended roll out period to reduce surprises over long term.
- Major Events - If there is a major event likely to produce high demand in one of the cities, drivers could be disproportionatly distributed to one of the two cities, leaving customers without a nearby driver and a long wait time

Part 3

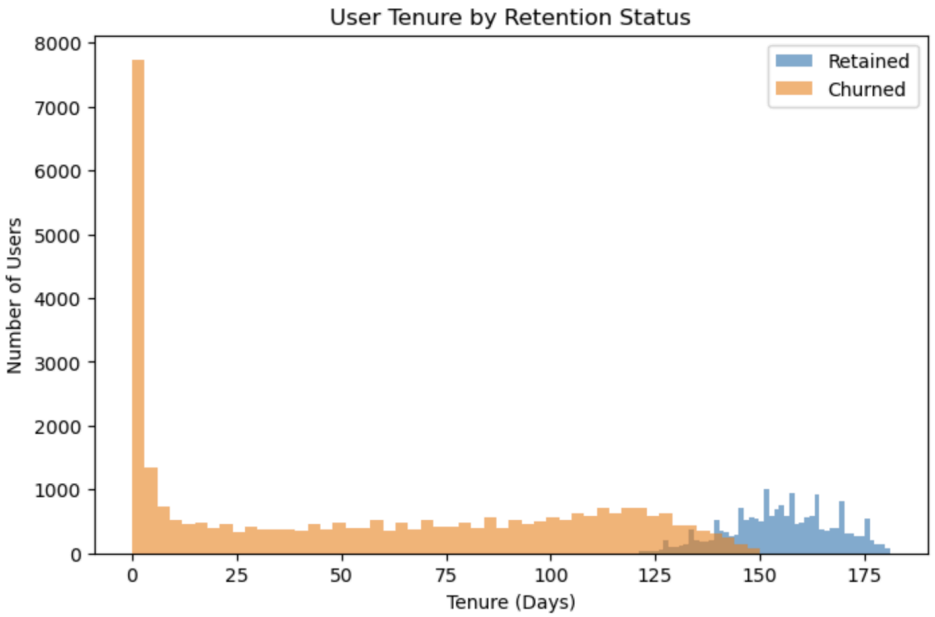
To analyze the Ultimate Technologies Ride Data Set I began by cleaning the data set, ensuring missing and duplicate values were handled properly, and converted the features to the correct data types. I then added the target feature for this analysis - Retained - which showed True if the rider had taken a ride within the previous 30 days. Approximately **37.6%** of riders were classified as “Retained”.



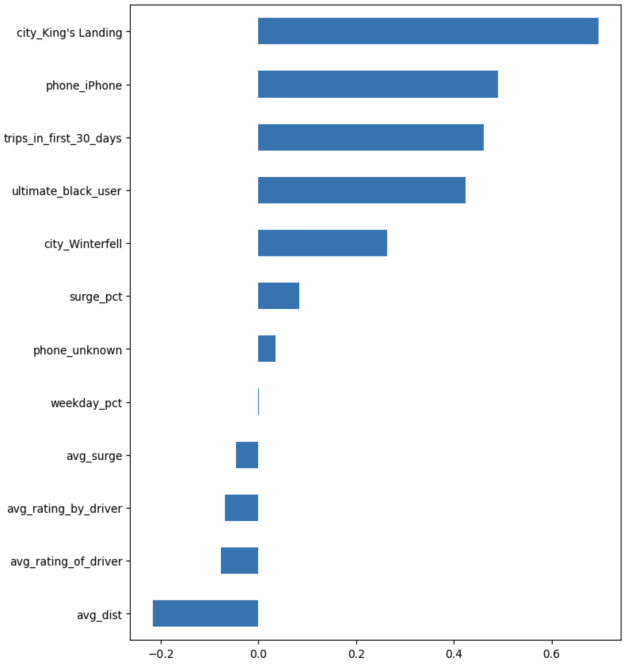
Exploratory data analysis showed that riders who were engaged and most active within the first 30 days of signing up were more likely to be retained.



Additionally riders who had longer tenures were also more likely to be retained. While this feature provides insight, it provides risk of overfitting a model and was subsequently dropped prior to modeling.



Logistic regression was chosen because it is well-suited for binary classification problems, provides interpretable results that directly explain drivers of user retention, and serves as a strong, transparent baseline model for understanding user behavior. This model identified several features with positive correlation to retention, among them are trips in the first 30 days, ultimate black user, surge percentage, and weekday percentage. Ultimate should focus on engaging new users within the first 30 days, and encouraging weekday trips to increase the chance of retaining those riders. Additionally, riders from King's Landing, and riders with iPhones show a higher retention probability than users from Winterfell and/or with Unknown phones. Ultimate can choose to focus on new riders from King's Landing and/or with iPhones to increase retention, or utilize this information to begin an additional project to discover how to increase retention of Winterfell/Unknown phone riders.

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city_King's Landing       0.696688
phone_iPhone              0.490086
trips_in_first_30_days    0.461963
ultimate_black_user       0.423624
city_Winterfell           0.262771
surge_pct                 0.083263
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```
phone_unknown             0.034599
weekday_pct               0.001488
avg_surge                -0.046084
avg_rating_by_driver     -0.068055
avg_rating_of_driver     -0.076852
avg_dist                 -0.217081
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