

## ZETA ASSIGNMENT

### 4. Backend API Design - Rate Limiting for Banking Transactions

Zeta's payment platform processes thousands of transactions per second. You've been asked to implement rate limiting to prevent fraudulent users from spamming transactions while ensuring genuine users don't face unnecessary delays.

I have implemented and demonstrated two different approaches to rate limiting for Zeta's banking transactions:

- Sliding Window Algorithm - More precise control for strict enforcement
- Token Bucket Algorithm - Better for allowing controlled bursts of traffic

The implementation includes:

- Core rate limiting classes (rate\_limiter.py)
- A sample Flask API integration (banking\_api\_example.py)
- A load testing script (load\_test.py)
- Documentation with explanations (README.md)

Both implementations successfully limit each user to 5 requests per second (or 10 for premium users) and use efficient data structures for tracking request counts:

- The sliding window uses a deque to store timestamps, efficiently removing old requests
- The token bucket uses a simple (tokens, last\_refill\_time) tuple for memory efficiency

The test results demonstrate how each approach handles different user behavior patterns:

- Regular users with moderate transaction rates are rarely affected.
- Power users who occasionally burst transactions may experience some limiting
- Suspicious users attempting to spam transactions are effectively blocked

These rate limiting mechanisms effectively protect the banking platform from abuse while providing a good experience for legitimate users.

```
=== Testing Sliding Window Rate Limiter ===
[1745783745.601] Transaction 1 for user regular_user: PROCESSED
[1745783745.601] Transaction 1 for user power_user: PROCESSED
[1745783745.601] Transaction 1 for user suspicious_user: PROCESSED
[1745783745.634] Transaction 2 for user suspicious_user: PROCESSED
[1745783745.661] Transaction 3 for user suspicious_user: PROCESSED
[1745783745.740] Transaction 4 for user suspicious_user: PROCESSED
[1745783745.756] Transaction 2 for user power_user: PROCESSED
[1745783745.813] Transaction 5 for user suspicious_user: PROCESSED
[1745783745.824] Transaction 6 for user suspicious_user: BLOCKED (rate limit)
[1745783745.870] Transaction 2 for user regular_user: PROCESSED
[1745783745.871] Transaction 7 for user suspicious_user: BLOCKED (rate limit)
[1745783745.898] Transaction 8 for user suspicious_user: BLOCKED (rate limit)
[1745783745.953] Transaction 9 for user suspicious_user: BLOCKED (rate limit)
[1745783745.956] Transaction 10 for user suspicious_user: BLOCKED (rate limit)
[1745783745.981] Transaction 11 for user suspicious_user: BLOCKED (rate limit)
[1745783745.997] Transaction 3 for user power_user: PROCESSED
[1745783746.047] Transaction 12 for user suspicious_user: BLOCKED (rate limit)
[1745783746.074] Transaction 13 for user suspicious_user: BLOCKED (rate limit)
[1745783746.078] Transaction 3 for user regular_user: PROCESSED
[1745783746.138] Transaction 14 for user suspicious_user: BLOCKED (rate limit)
[1745783746.139] Transaction 15 for user suspicious_user: BLOCKED (rate limit)

User suspicious_user statistics:
  Successful transactions: 5
  Blocked transactions: 10
  Success rate: 33.3%
[1745783746.206] Transaction 4 for user power_user: PROCESSED
[1745783746.364] Transaction 4 for user regular_user: PROCESSED
[1745783746.442] Transaction 5 for user power_user: PROCESSED
[1745783746.631] Transaction 6 for user power_user: PROCESSED
[1745783746.636] Transaction 5 for user regular_user: PROCESSED
[1745783746.802] Transaction 7 for user power_user: PROCESSED
[1745783746.937] Transaction 6 for user regular_user: PROCESSED
[1745783746.991] Transaction 8 for user power_user: BLOCKED (rate limit)
[1745783747.149] Transaction 7 for user regular_user: PROCESSED
[1745783747.156] Transaction 9 for user power_user: PROCESSED
[1745783747.369] Transaction 10 for user power_user: PROCESSED

User power_user statistics:
  Successful transactions: 9
  Blocked transactions: 1
  Success rate: 90.0%
[1745783747.435] Transaction 8 for user regular_user: PROCESSED
[1745783747.720] Transaction 9 for user regular_user: PROCESSED
[1745783747.998] Transaction 10 for user regular_user: PROCESSED

User regular_user statistics:
  Successful transactions: 10
  Blocked transactions: 0
  Success rate: 100.0%
```

```
=== Testing Token Bucket Rate Limiter ===
[1745783750.003] Transaction 1 for user regular_user: PROCESSED
[1745783750.003] Transaction 1 for user power_user: PROCESSED
[1745783750.003] Transaction 1 for user suspicious_user: PROCESSED
[1745783750.042] Transaction 2 for user suspicious_user: PROCESSED
[1745783750.102] Transaction 3 for user suspicious_user: PROCESSED
[1745783750.190] Transaction 4 for user suspicious_user: PROCESSED
[1745783750.256] Transaction 2 for user power_user: PROCESSED
[1745783750.257] Transaction 5 for user suspicious_user: PROCESSED
[1745783750.257] Transaction 2 for user regular_user: PROCESSED
[1745783750.315] Transaction 6 for user suspicious_user: PROCESSED
[1745783750.321] Transaction 7 for user suspicious_user: BLOCKED (rate limit)
[1745783750.349] Transaction 8 for user suspicious_user: BLOCKED (rate limit)
[1745783750.383] Transaction 9 for user suspicious_user: BLOCKED (rate limit)
[1745783750.393] Transaction 10 for user suspicious_user: BLOCKED (rate limit)
[1745783750.421] Transaction 11 for user suspicious_user: PROCESSED
[1745783750.434] Transaction 12 for user suspicious_user: BLOCKED (rate limit)
[1745783750.467] Transaction 13 for user suspicious_user: BLOCKED (rate limit)
[1745783750.495] Transaction 3 for user power_user: PROCESSED
[1745783750.533] Transaction 3 for user regular_user: PROCESSED
[1745783750.533] Transaction 14 for user suspicious_user: BLOCKED (rate limit)
[1745783750.556] Transaction 15 for user suspicious_user: BLOCKED (rate limit)

User suspicious_user statistics:
  Successful transactions: 7
  Blocked transactions: 8
  Success rate: 46.7%
[1745783750.685] Transaction 4 for user power_user: PROCESSED
[1745783750.772] Transaction 4 for user regular_user: PROCESSED
[1745783750.862] Transaction 5 for user power_user: PROCESSED
[1745783751.069] Transaction 5 for user regular_user: PROCESSED
[1745783751.081] Transaction 6 for user power_user: PROCESSED
[1745783751.251] Transaction 7 for user power_user: PROCESSED
[1745783751.335] Transaction 6 for user regular_user: PROCESSED
[1745783751.475] Transaction 8 for user power_user: PROCESSED
[1745783751.556] Transaction 7 for user regular_user: PROCESSED
[1745783751.668] Transaction 9 for user power_user: PROCESSED
[1745783751.858] Transaction 8 for user regular_user: PROCESSED
[1745783751.882] Transaction 10 for user power_user: PROCESSED

User power_user statistics:
  Successful transactions: 10
  Blocked transactions: 0
  Success rate: 100.0%
[1745783752.119] Transaction 9 for user regular_user: PROCESSED
[1745783752.387] Transaction 10 for user regular_user: PROCESSED

User regular_user statistics:
  Successful transactions: 10
  Blocked transactions: 0
  Success rate: 100.0%
```

Both the images are the output of our code, for two different rate limiter algorithms