Round-Robin Cellular Network: Performance Evaluation Through Discrete Event Simulation

UNIVERSITÀ DI PISA

Project Title: *Round-Robin Cellular Network*

Course: *Performance Evaluation of Computer Systems and Networks*

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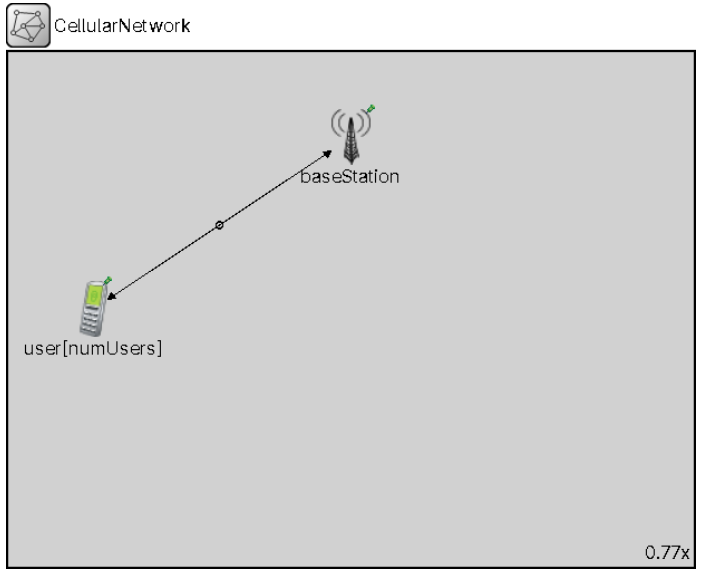
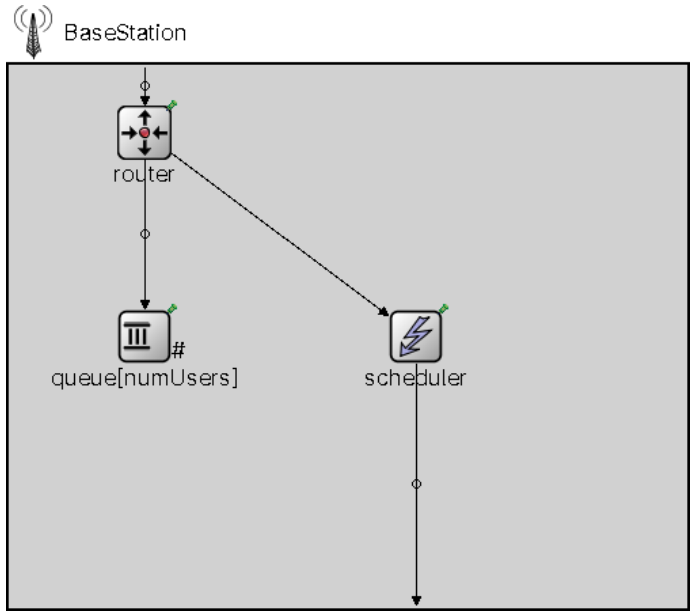
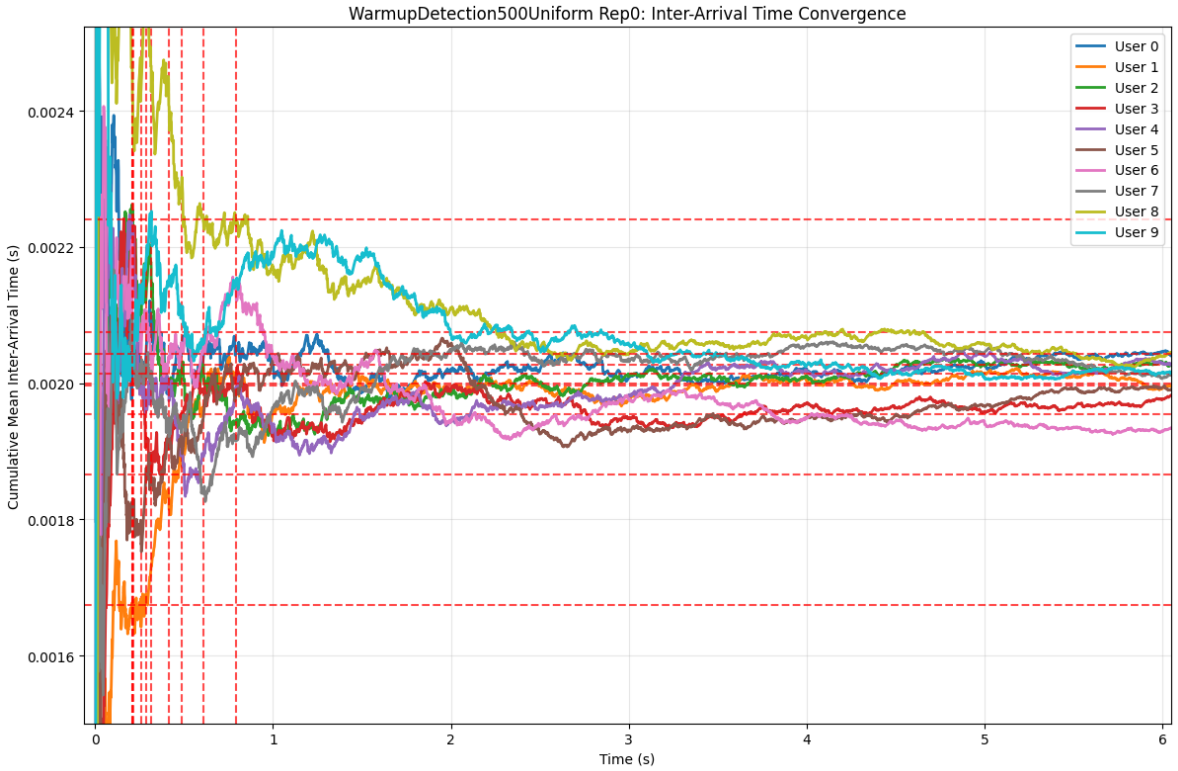




System Architecture

- *Cellular network with n=10 users*
- *25 Resource Blocks per frame, 1ms TTI*
- *CQI feedback mechanism (1-15 scale)*
- *Round-Robin scheduling policy*
- *FIFO queues per user*

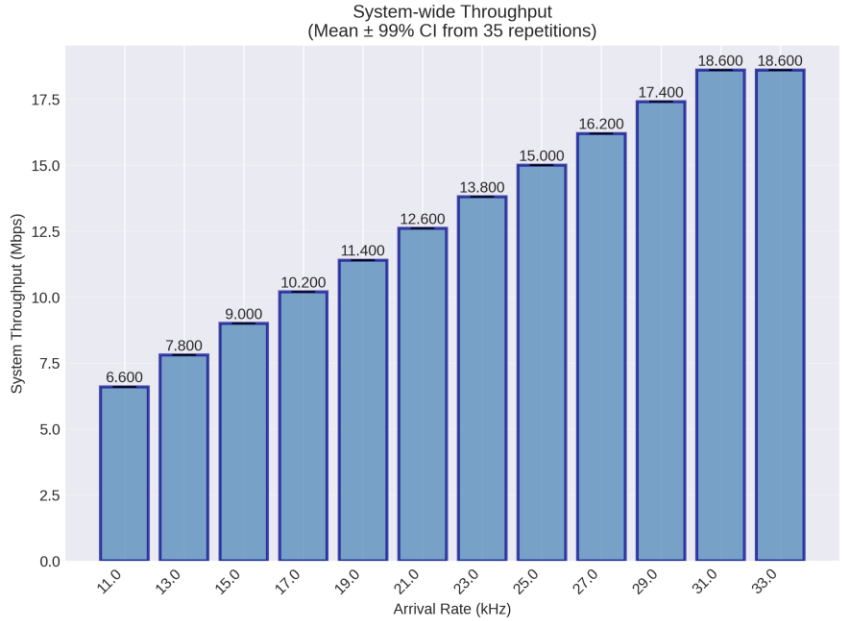
Warm-up Analysis

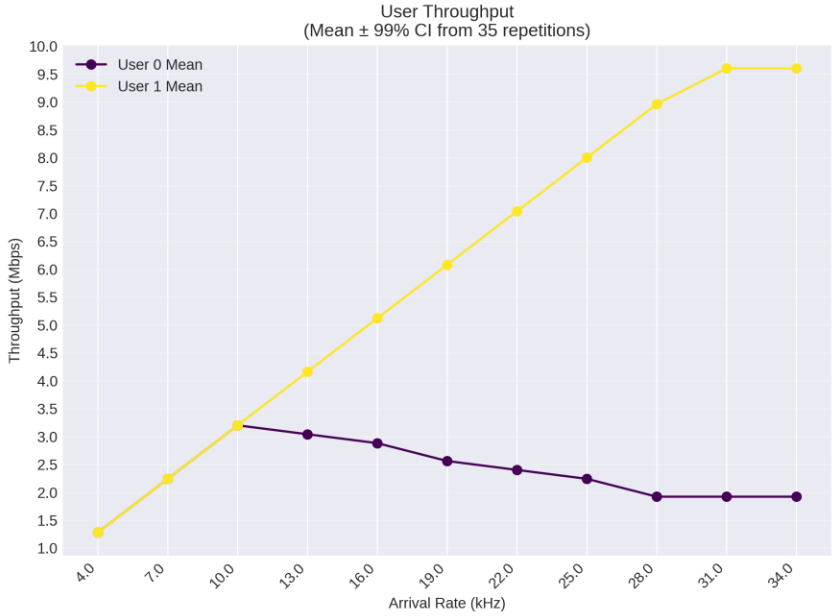


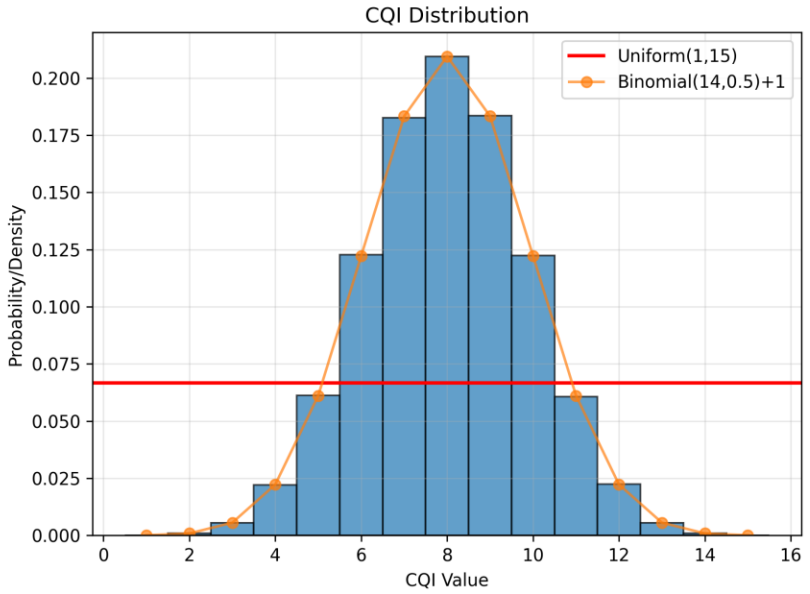
- **Challenge:** Eliminate transient effects for unbiased statistics
- **Method:** Cumulative mean analysis of inter-arrival times
- **Convergence criterion:** Coefficient of Variation < 2%
- **Result:** 5-second warm-up period (conservative choice)

Validation Methodology

- 5 validation tests with increasing complexity
- Theoretical calculations vs. simulation results
- Single user baseline (Test 1)
- Multi-user fairness verification (Tests 2 & 5)
- Statistical distribution validation (Tests 3 & 4)







Two Realistic Scenarios: Mobile vs. Stationary Users

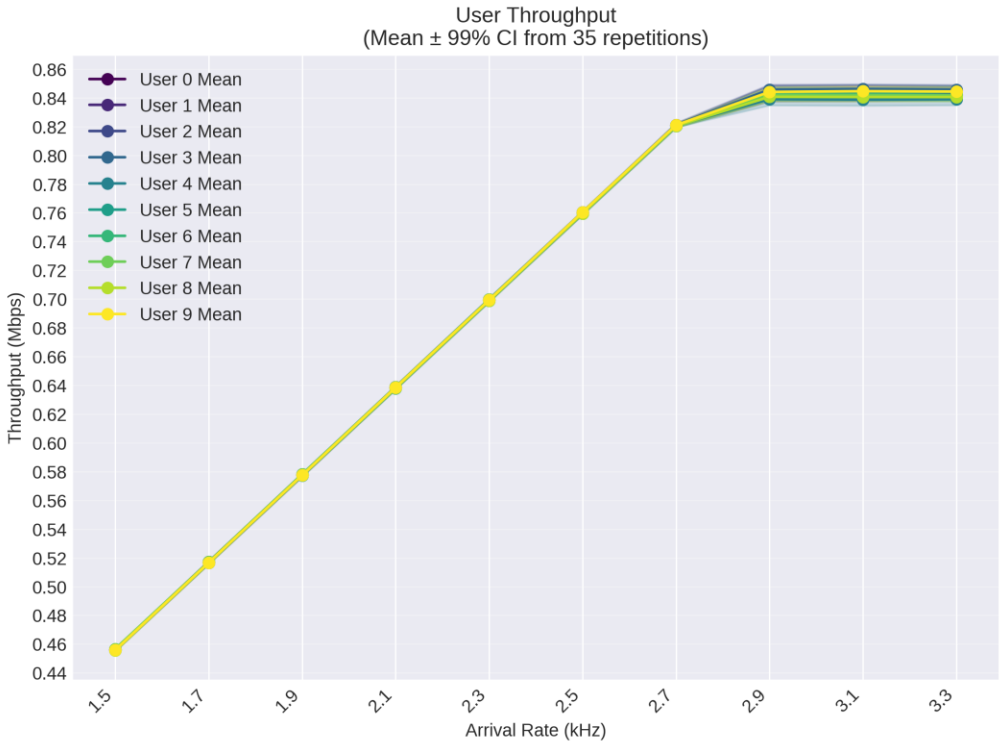
Scenario 1: *Uniform CQI - mobile users in urban environment*

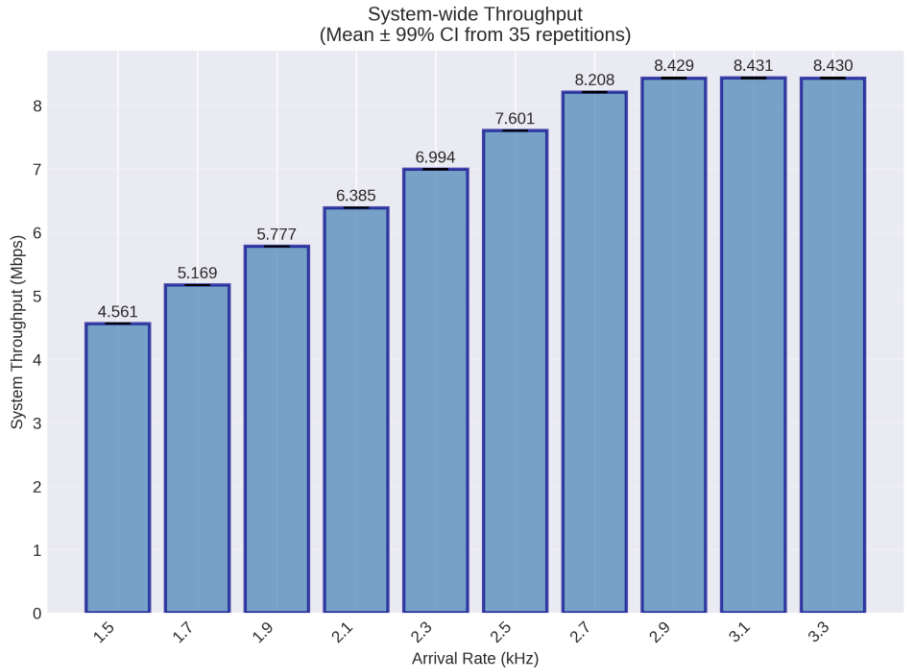
- *All users: CQI uniform [1,15]*
- *Models high mobility scenarios*

Scenario 2: *Binomial CQI - stationary users with location-based quality*

- *Group 1 (users 0-2): p=0.8 (near base station)*
- *Group 2 (users 3-6): p=0.5 (mid-cell)*
- *Group 3 (users 7-9): p=0.2 (cell edge)*

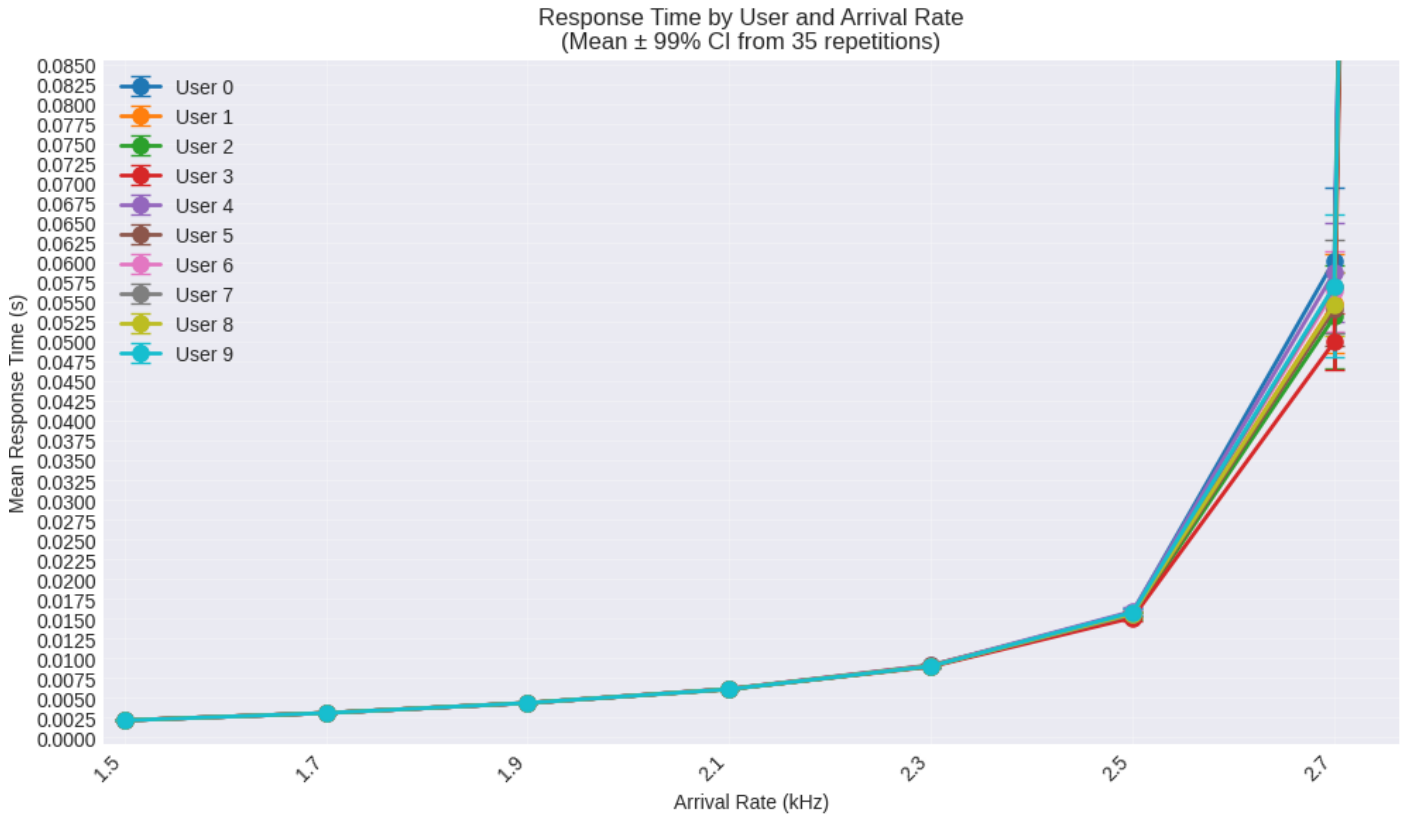
Uniform CQI Results: Perfect Fairness Under Homogeneous Conditions





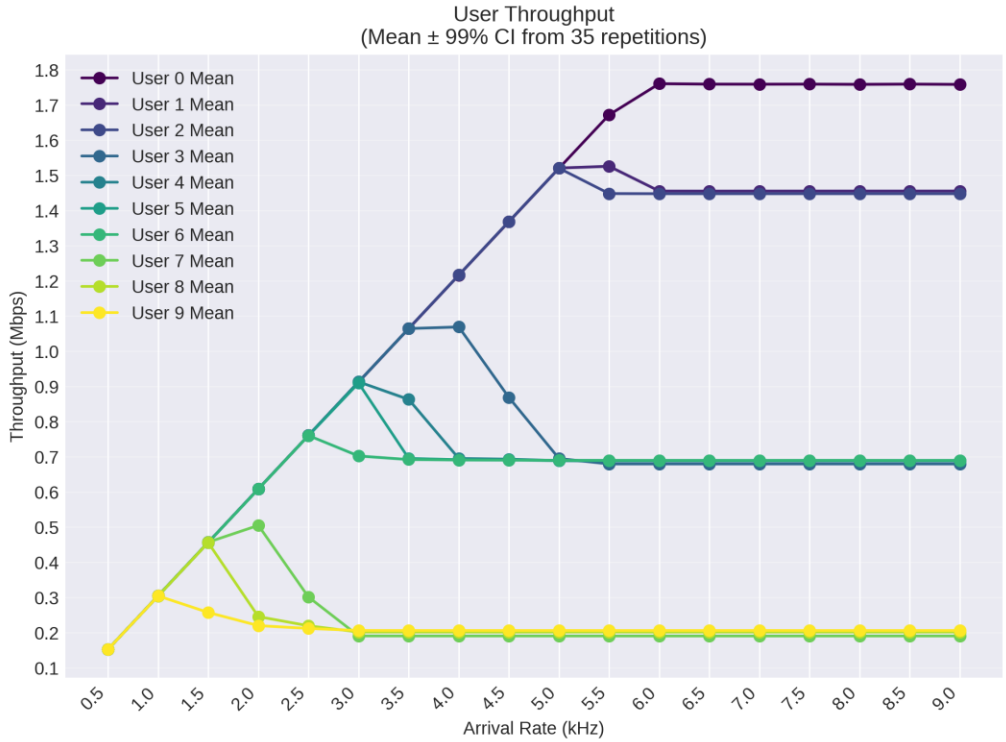
- System saturation at 8.428 Mbps ($\lambda \approx 2.9$ kHz/user)
- Perfect fairness: all users achieve ~0.84 Mbps at saturation
- Linear throughput growth in low-load region
- Statistical multiplexing gain from variable packet sizes

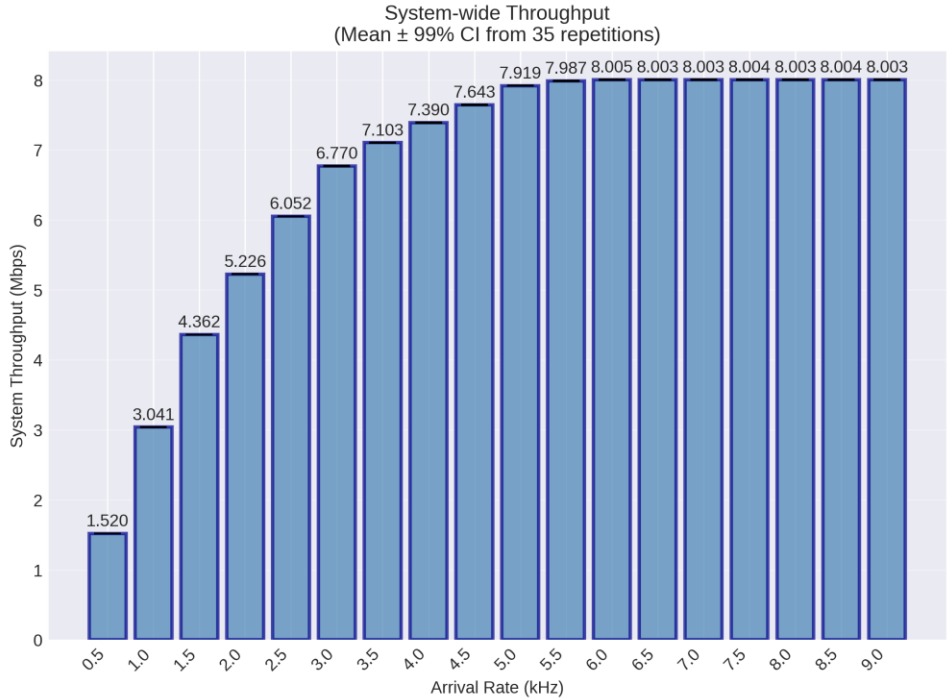
Response Time Behavior: From Milliseconds to Congestion



- Low load (< 2.0 kHz): Response time < 5ms
- Medium load (2.0-2.7 kHz): Gradual increase to 60ms
- Near saturation: Exponential growth to >1 second
- All users experience identical delay patterns

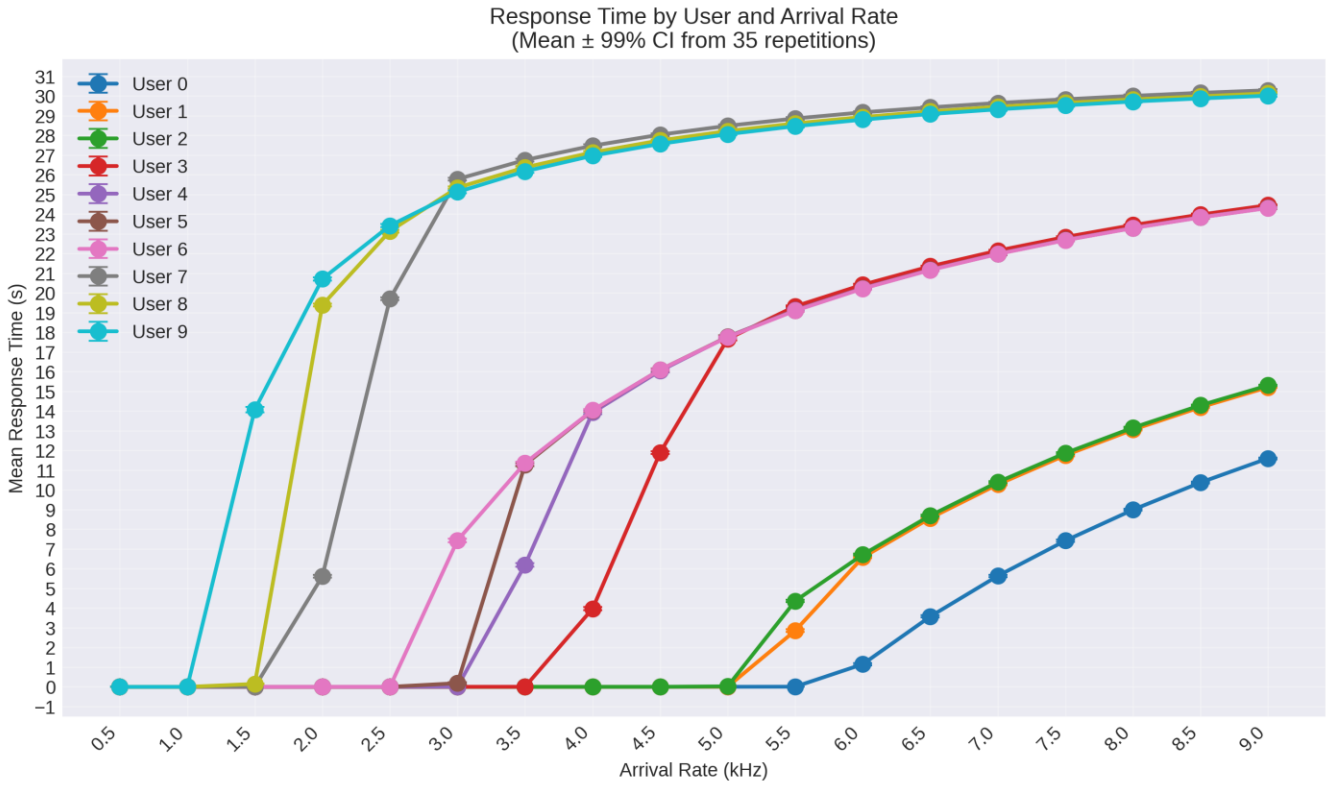
Binomial CQI Impact: When Location Matters





- Three distinct saturation points by user group:
  - Good channel (p=0.8): ~1.45 Mbps at 5-6 kHz
  - Medium channel (p=0.5): ~0.68 Mbps at 3-4 kHz
  - Poor channel (p=0.2): ~0.20 Mbps at 2-3 kHz
- User index bias within groups
- Resource "stealing" effect at high loads

Response Time Behavior



- ***Good-channel users:*** *Maintain low delays until 5 kHz*
- ***Medium-channel users:*** *Moderate delays starting at 3 kHz*
- ***Poor-channel users:*** *High delays even at moderate loads*

Round-Robin Performance: Fairness vs. Efficiency Trade-offs

- ***Fairness Achievement:*** *Perfect with homogeneous users, challenged with heterogeneous CQIs*
- ***Efficiency:*** *8.4 Mbps with uniform CQI, 8.0 Mbps with binomial (5% loss)*
- ***Critical Observations:***
  - *Statistical multiplexing improves efficiency*
  - *User ordering affects individual performance*
  - *Poor-channel users limit system capacity*
  - *Response time degrades rapidly near saturation*