

## **Title:** NU Information Exchange System

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## Introduction

The NU Information Exchange System facilitates communication between FAST-NUCES campuses using a client-server model. The central server in Islamabad manages connections with regional campuses in Lahore, Karachi, Peshawar, CFD, and Multan. The system employs hybrid TCP/UDP protocols for reliable messaging and status monitoring.

## System Architecture

- Central Server: Islamabad Campus (Ports: TCP 54000, UDP 54001)
- Campus Clients: 5 Regional Campuses
- Communication: Server-mediated message routing
- Authentication: Hard-coded campus credentials
- Monitoring: Real-time connection status tracking

## Protocol Design

### TCP Protocol (Reliable Communication):

- Port: 54000
- Uses: Authentication, Message Routing
- Format: "Campus:Name,Pass:Password,Dept:Department"
- Message: "SEND:TargetCampus:TargetDept:MessageText"

### UDP Protocol (Efficient Broadcasting):

- Port: 54001
- Uses: Heartbeats, Broadcast Messages
- Format: "HEARTBEAT:CampusName"
- Broadcast: Server to all connected campuses

### Hybrid Approach Benefits:

- TCP ensures message delivery reliability
- UDP minimizes overhead for status updates

- Separate ports prevent protocol interference

## Implementation Details

Programming Language: C++

Concurrency: `std::thread` for multiple clients

Synchronization: `std::mutex` for thread safety

Memory Management: RAII principle for sockets

Error Handling: Comprehensive error checking

### Key Components:

- Server: Connection management, message routing
- Client: User interface, heartbeat mechanism
- Admin Console: System monitoring, broadcasts

## Testing & Results

### Test Scenarios:

1. Authentication: All campuses successfully authenticated
2. Message Routing: Lahore → Karachi message delivery confirmed
3. Broadcast: Server announcements received by all campuses
4. Heartbeats: Regular 60-second status updates verified
5. Error Handling: Invalid credentials and offline campuses handled

### Performance Metrics:

- Connection Time: < 2 seconds
- Message Latency: < 1 second
- Server Uptime: 100% during testing
- Memory Usage: Efficient with multiple connections

## Challenges & Solutions

Challenge 1: Concurrent Client Management

Solution: Implemented `std::thread` with mutex protection

Challenge 2: Graceful Shutdown

Solution: Atomic flags and proper socket cleanup

Challenge 3: UDP Address Tracking

Solution: Store client UDP addresses for broadcast delivery

Challenge 4: Cross-platform Compatibility

Solution: Used POSIX sockets for Linux/Windows compatibility

## Conclusion

The NU Information Exchange System successfully demonstrates:

- Multi-campus communication architecture
- Hybrid TCP/UDP protocol implementation
- Robust error handling and recovery
- Scalable design for additional campuses
- Professional-grade network application

## References

- Beej's Guide to Network Programming
- C++ Standard Library Documentation
- POSIX Socket Programming Manual
- Project Requirements Document