

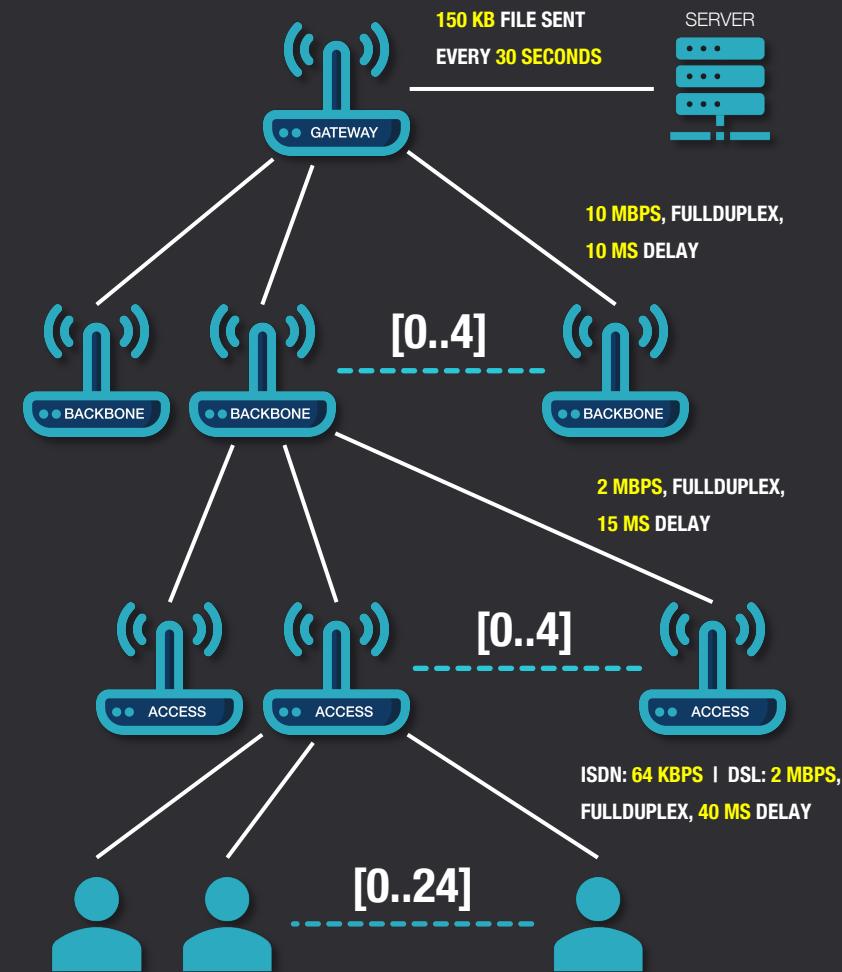
PROBLEM STATEMENT

- CONSULT OPERATOR RUNNING A SMALL INTERNET PROTOCOL NETWORK
 - USES INTEGRATED SERVICES DIGITAL NETWORK (**ISDN**)
- OBJECTIVE
 - OFFER VOICE OVER IP (**VoIP**) SERVICE
 - UPGRADE ALL ISDN DIAL UP NODES TO DIGITAL SUBSCRIBER LINE (**DSL**)
- PERFORMANCE EVALUATION
 - AVERAGE BIT RATE
 - PACKET LOSS RATE



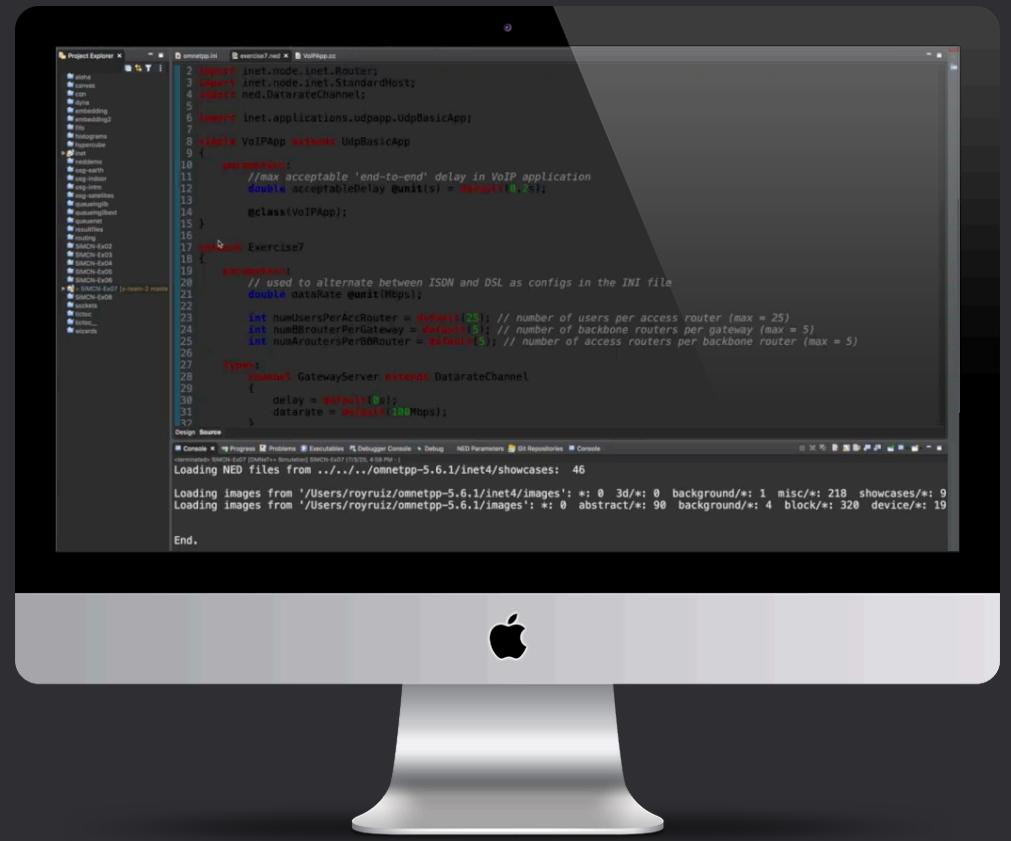
NETWORK DESCRIPTION

- CURRENT NETWORK TOPOLOGY
- ENVISIONED SERVICES
 - UPGRADE LINKS (**ISDN** → **DSL**)
 - ENABLE VOICE CALL (**VoIP**)
 - NO SERVICE DEGRADATION BELOW **1% PACKET LOSS RATE**



IMPLEMENTATION

- PARAMETER SELECTION
 - TCP SETTINGS
 - **TcpNewReno**
 - CONGESTION WINDOW
 - **mss = 1000**
 - **advertisedWindow = 100000**
 - **windowScalingSupport = true**
 - OUTPUT PORT BUFFER
 - MAXIMUM CAPACITY OF **40 IP PACKETS**
 - **startTime = uniform (1s, 30s)**
 - **VoIP VIA UDP SETTINGS**
 - PACKET RATE of **50 pps**
 - **acceptableDelay = 200 ms**
 - IMPLEMENT **VoIPApp** CLASS
 - USE **UdpBasicApp** MEMBER FUNCTIONS
 - CALCULATE **AVERAGE PACKET LOSS**
 - **startTime = exponential (0.001s)**



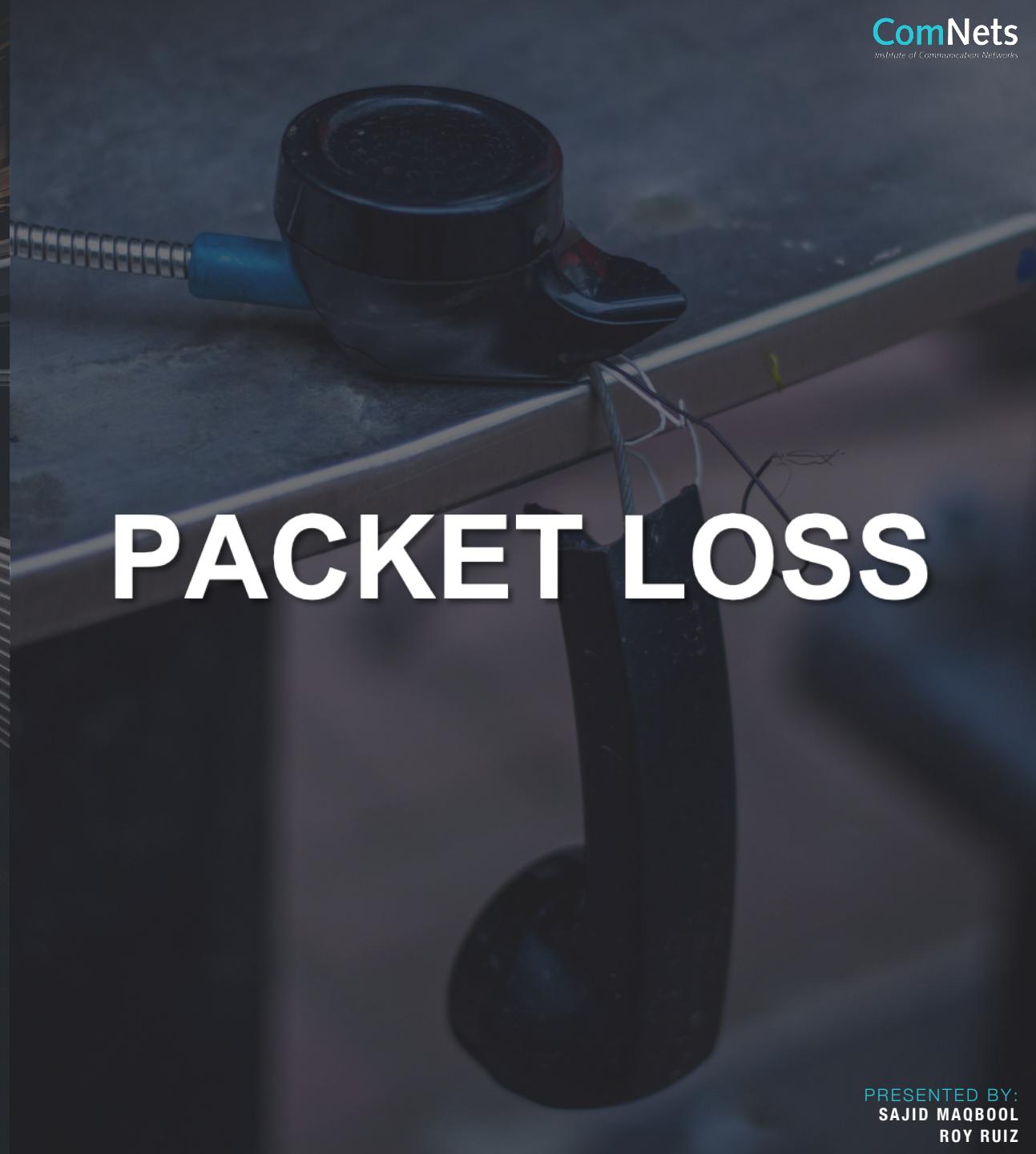
IMPLEMENTATION

- MULTIPLE SCENARIOS TO EVALUATE PERFORMANCE
 - USED EDGE CASES (BEST & WORST)
 - STEADY-STATE ACHIEVED AFTER ~50 SECONDS
 - SIMULATED ACROSS 3, 10, 30 RUNS

| VOICE CALL | YES VoIP | | NO VoIP | | | | | |
|---------------------|----------|------|---------|----|------|------|----|------|
| WEB SURFING | DSL | ISDN | DSL | | | ISDN | | |
| Simulation Time (s) | 1K | 1K | 500 | 1K | 2.5K | 500 | 1K | 2.5K |
| VIA GATEWAY | ✓ | ✓ | | ✓ | | | ✓ | |
| VIA BACKBONE | ✓ | ✓ | | ✓ | | | ✓ | |
| VIA ACCESS | ✓ | ✓ | | ✓ | | | ✓ | |
| ACC + BB (MIXED) | ✓ | ✓ | | - | | | - | |



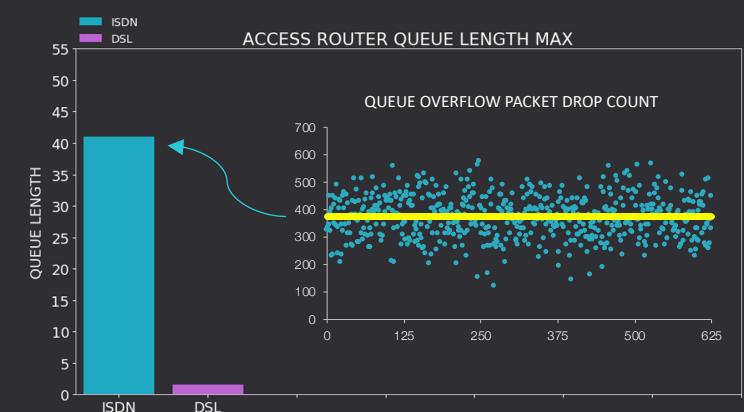
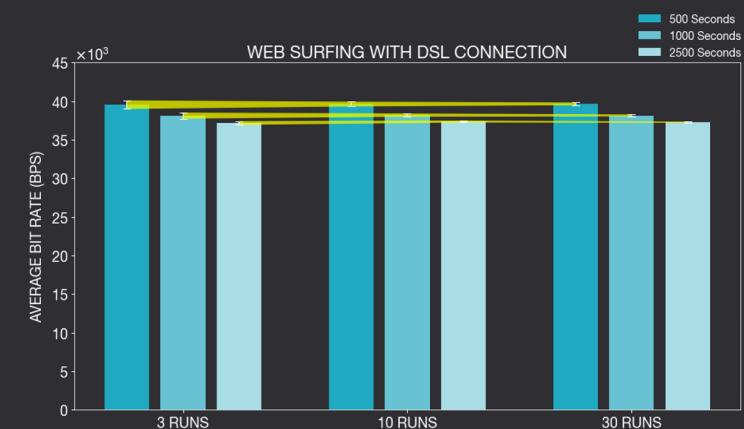
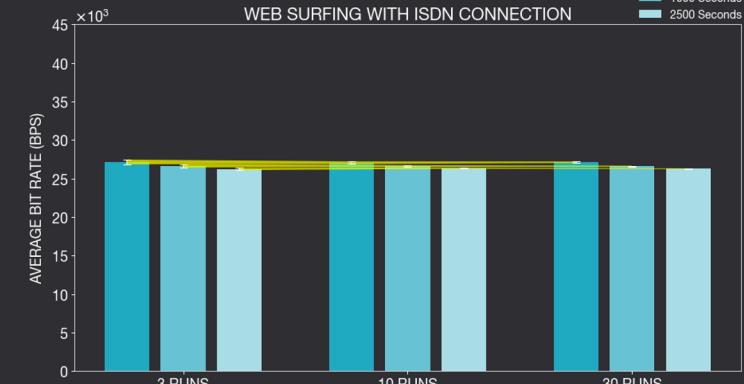
BIT RATE



PACKET LOSS

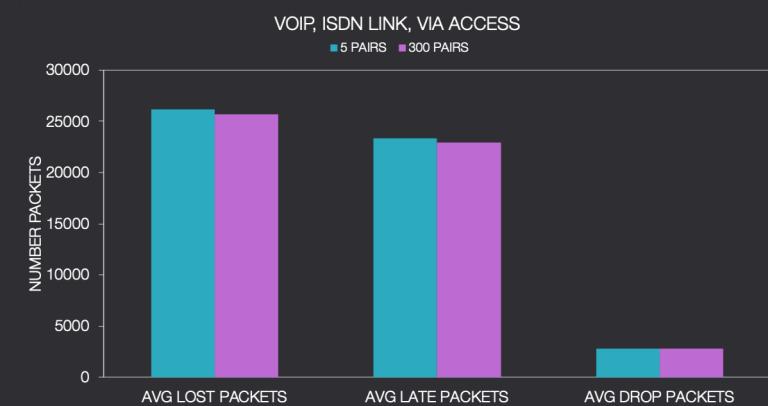
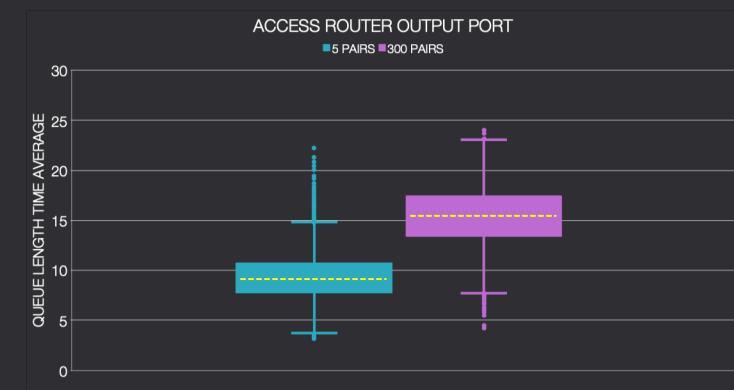
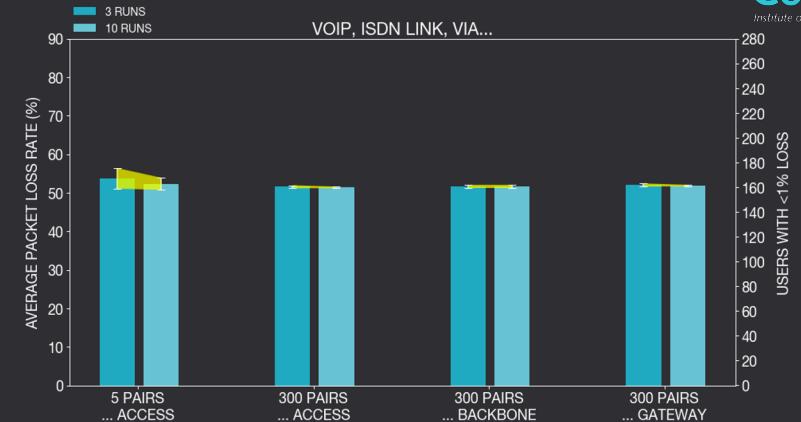
SIMULATION RESULTS

- AVERAGE BITRATE WHILE WEB SURFING PER USER
 - ISDN: ~26.7 Kbps
 - DSL: ~38.4 Kbps
- ELIMINATION OF TRANSIENT EFFECTS
- EFFECT OF CONGESTION WINDOW
- OBSERVED QUEUE LENGTHS
- QUEUE OVERFLOW PACKET DROP COUNT



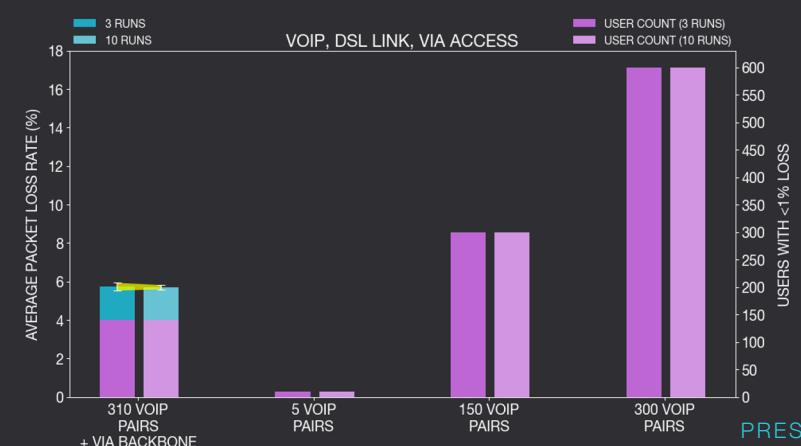
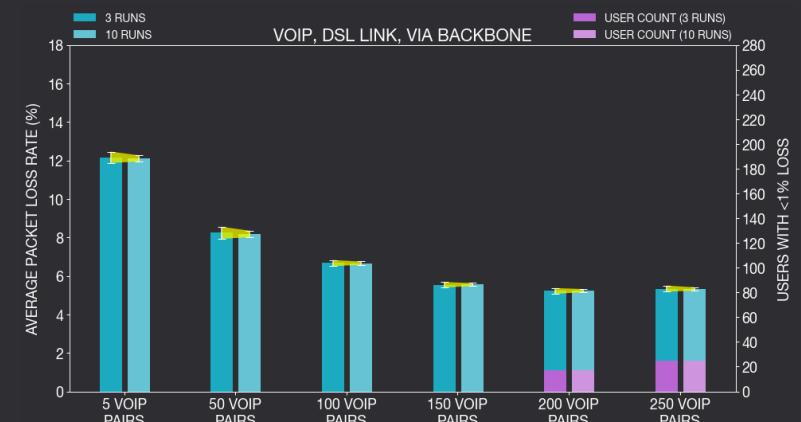
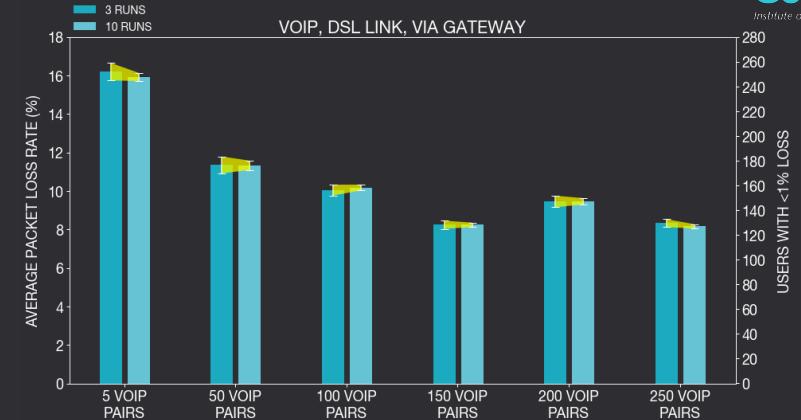
SIMULATION RESULTS

- WORST CASE PACKET LOSS RATE IN CURRENT NETWORK
 - VoIP + ISDN: **51.8%**
- NO TREND OBSERVED
 - **queueLength timeAvg >> acceptableDelay**
 - **TOTAL LATE PACKETS >> TOTAL DROP PACKETS**



SIMULATION RESULTS

- WORST CASE PACKET LOSS RATE IN UPGRADED NETWORK
 - VoIP + DSL: **15.9%**
- TREND OBSERVED
 - PACKET LOSS RATE DECREASED AS NUMBER OF **VoIP PAIRS** INCREASED
 - SOME USERS EXPERIENCED NO DEGRADATION (**<1% AVERAGE PACKET LOSS**)



SIMULATION RESULTS

- VIA GATEWAY (WORST CASE)
 - DELAY EXPERIENCED
- MIXED SCENARIO (BEST CASE)
 - CONSIDERABLY LOW **AVERAGE PACKET LOSS RATE**
 - CONSIDERABLY HIGH NUMBER OF USERS EXPERIENCED NO DEGRADATION (**<1% AVERAGE PACKET LOSS**)

| | VOICE CALL | CASE | VoIP | | CASE |
|-------------------------|------------|------|-----------------------|------|----------|
| | | | DSL | ISDN | |
| VIA GATEWAY | BEST | | 8.2% [1.1, 18.7] | | WORST |
| | WORST | | 15.9% [13.9, 18.5] | | |
| | USERS <1% | | 0 | | |
| VIA BACKBONE | BEST | | 5.3%* [0.6, 15.8] | | MEDIocre |
| | WORST | | 12.1% [9.8, 14.2] | | |
| | USERS <1% | | 25 | | |
| VIA ACCESS | SPECIAL | | 0% | | BEST |
| | USERS <1% | | 625 | | |
| VIA ACC + BB (MIXED) | BEST | | 5.7%** [0.0, 14.8] | | - |
| | USERS <1% | | 140 | | |

* BASED ON 250 VoIP PAIRS DATA

** BASED ON 310 VoIP PAIRS DATA

CONCLUSION & REMARKS

- BOTH OBJECTIVES INVESTIGATED THOROUGHLY
 - MULTIPLE SCENARIOS WITH EDGE CASES PERFORMED
- OUR RECOMMENDATION IS TO...
 - UPGRADE TO DIGITAL SUBSCRIBER LINE (**DSL**)
 - VOICE SERVICE DEGRADATION UNAVOIDABLE BEYOND ACCESS ROUTER LEVEL
- FUTURE WORK BEYOND EXERCISE
 - EVALUATE THE EFFECT OF CONGESTION WINDOW AND BUFFER CAPACITY TO MAXIMIZE PERFORMANCE
 - TRADEOFF BETWEEN **TCP** AND **VoIP**



THANK YOU