Campus Wireless Network Performance

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Project Topic and Summary

- Determine the network reliability of buildings commonly used by engineering students to study:
  - Siebel Center
  - Grainger Library
- Use the Iperf software to test for 3 different indicators of network reliability:
  - Bandwidth
  - Jitter
  - Packet Loss

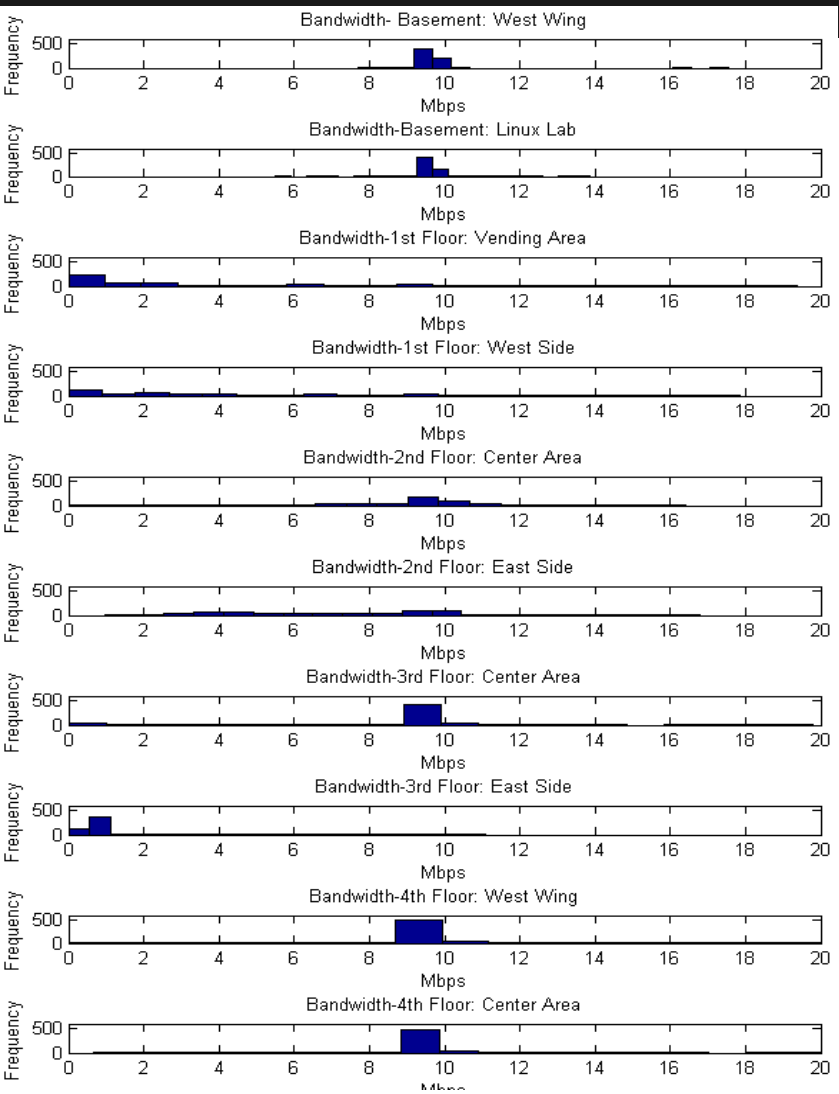
Data Collection Procedures

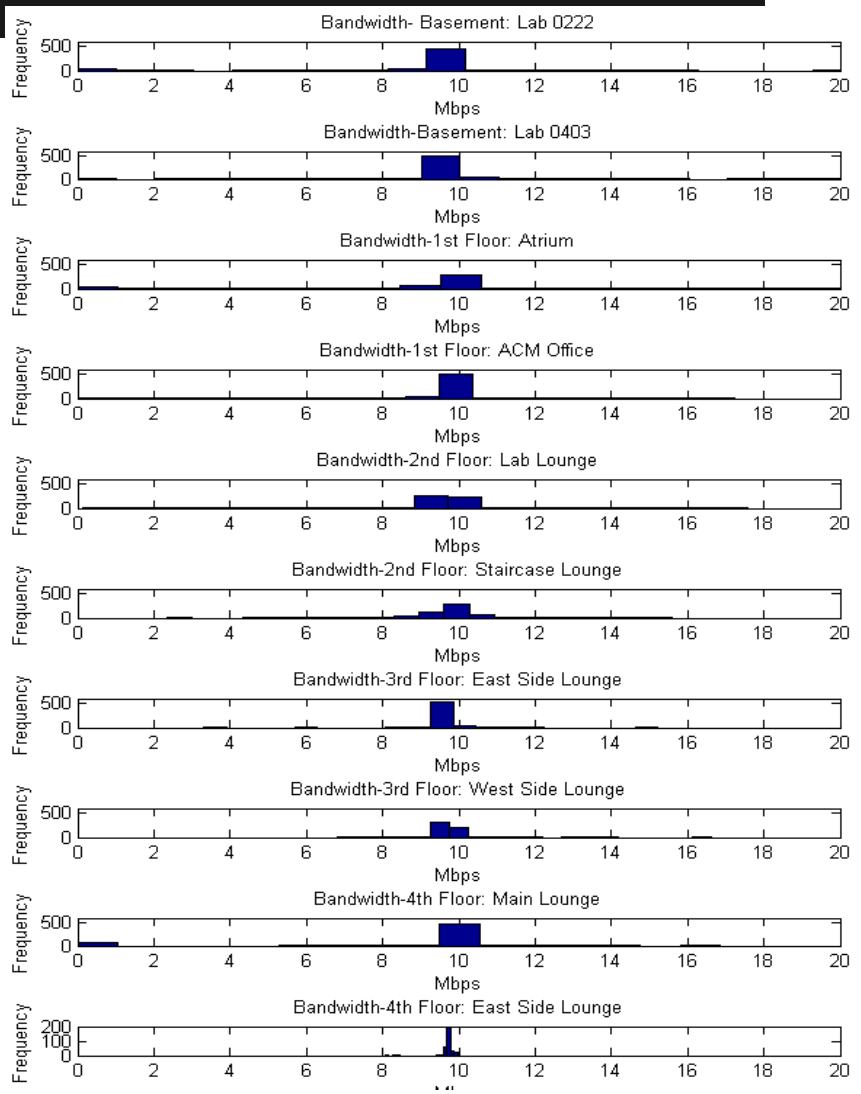
- Two spots per floor
- Collecting data when building network is under medium-heavy load
  - Data collection during early evening when many students are using the network
- Configure two laptops to run as client-server pair
- Client saturates wireless network connection between laptops with UDP packets
- Server records network performance data
- Run Iperf for 10 minutes
  - 600 data points @ 1s intervals

Data Analysis Approach

- Histograms
- Gaussian/Normal Distribution
- Various Statistics:
  - Median
  - Mean
  - Standard Deviation
  - Variance
  - Probability of Failure
- Mean Time To Failure
- Mean Failure Length
- Hazard Functions
- Likelihood Matrices and Decision Rules

Bandwidth Results





Bandwidth Results

- Failure defined as a Bandwidth of <= 2Mbps.

Grainger Library Data	Bandwidth (Mbps)					
Location	Mean	Median	Standard Deviation	Variance	Probablity of Failure (<=2 Mbps)	Mean Time to Failure
Basement: West Wing	9.6546	9.6465	0.4690	0.2200	0.0000	NaN
Basement: Linux Lab	9.6533	9.6465	0.4893	0.2394	0.0000	NaN
1st Floor: Vending Area	3.7100	2.0791	4.0630	16.5080	0.4908	5.8627
1st Floor: West Side	4.9373	3.9619	4.3360	18.8010	0.3545	6.2623
2nd Floor: Center Area	8.8824	9.5781	2.9646	8.7891	0.0468	26.7368
2nd Floor: East side	6.9599	6.9824	2.9459	8.6782	0.0134	55.5000
3rd Floor: Center Area	8.7873	9.6240	2.9494	8.6988	0.0819	69.8000
3rd Floor: East Side	1.3405	0.7002	2.0218	4.0876	0.8617	2.0833
4th Floor: West Wing	9.4547	9.6357	2.0122	4.0489	0.0234	101.0000
4th Floor: Center Area	9.4785	9.6357	1.7329	3.0030	0.0151	90.1667

Siebel Center Data	Bandwidth (Mbps)					
Location	Mean	Median	Standard Deviation	Variance	Probablity of Failure (<=2 Mbps)	Mean Time to Failure
Basement: Lab 0222	8.9533	9.6006	2.6898	7.2352	0.0702	70.8000
Basement: Lab 0403	9.5900	9.6699	1.5471	2.3936	0.0067	157.0000
1st Floor: Atrium	8.5293	9.6816	3.6606	13.3998	0.0973	13.6538
1st Floor: ACM Office	9.5556	9.7158	1.5016	2.2549	0.0167	60.1429
2nd Floor: Lab Lounge	9.4498	9.6982	1.6995	2.8883	0.0167	51.0000
2nd Floor: Staircase Lounge	9.6624	9.7041	1.0472	1.0965	0.0000	NaN
3rd Floor: East Side Lounge	9.7253	9.7275	0.4801	0.2304	0.0000	NaN
3rd Floor: West Side Lounge	9.7024	9.7383	0.6710	0.4502	0.0000	NaN
4th Floor: Main Lounge	8.4892	9.7158	3.3540	11.2490	0.1290	243.0000
4th Floor: East Side Lounge	9.7190	9.7275	0.1532	0.0235	0.0000	NaN

Bandwidth Results

	Grainger Likelihood Matrix-Packet Loss Hypotheses												
	0-2 Mbps	2-4 Mbps	4-6 Mbps	6-8 Mbps	8-10 Mbps	10-12 Mbps	12-14 Mbps	14-16 Mbps	16-18 Mbps	18-20 Mbps	20-22 Mbps	22-24 Mbps	24-26 Mbps
H1-Packet Loss< 20%	0.0646	0.0352	0.0390	0.0560	0.7016	0.0683	0.0225	0.0077	0.0037	0.0007	0.0004	0.0002	0.0000
H0-Packet Loss >= 20 %	0.5914	0.1473	0.0977	0.0758	0.0319	0.0262	0.0113	0.0092	0.0050	0.0035	0.0000	0.0000	0.0007

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H1-Packet Loss< 20%	0.0067	0.0071	0.0083	0.0225	0.8608	0.0744	0.0127	0.0044	0.0022	0.0005	0.0004	0.0000	0.0000
H0-Packet Loss >= 20 %	0.5385	0.0710	0.0888	0.0651	0.0473	0.0355	0.0473	0.0651	0.0178	0.0059	0.0178	0.0000	0.0000

	Grainger Likelihood Matrix-Jitter Hypotheses												
	0-2 Mbps	2-4 Mbps	4-6 Mbps	6-8 Mbps	8-10 Mbps	10-12 Mbps	12-14 Mbps	14-16 Mbps	16-18 Mbps	18-20 Mbps	20-22 Mbps	22-24 Mbps	24-26 Mbps
H1-Jitter< 5ms	0.0309	0.0520	0.0560	0.0693	0.6785	0.0714	0.0242	0.0101	0.0051	0.0017	0.0004	0.0002	0.0002
H0-Jitter >= 5ms	0.7992	0.0992	0.0407	0.0276	0.0220	0.0081	0.0033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

	Siebel Likelihood Matrix-Jitter Hypotheses												
	0-2 Mbps	2-4 Mbps	4-6 Mbps	6-8 Mbps	8-10 Mbps	10-12 Mbps	12-14 Mbps	14-16 Mbps	16-18 Mbps	18-20 Mbps	20-22 Mbps	22-24 Mbps	24-26 Mbps
H1-Jitter< 5ms	0.0051	0.0064	0.0087	0.0212	0.8597	0.0746	0.0138	0.0062	0.0027	0.0007	0.0009	0.0000	0.0000
H0-Jitter >= 5ms	0.5882	0.0941	0.0765	0.1059	0.0882	0.0294	0.0118	0.0059	0.0000	0.0000	0.0000	0.0000	0.0000

- Decision Rule:
  - Declare H1 true if Bandwidth >4Mbps
  - Declare H0 true if Bandwidth <=4Mbps
- For Grainger:
  - $P_{\text{False-Alarm Jitter}}=0.1016$, $P_{\text{Missed Detection Jitter}}= 0.0829$, $P_{\text{False-Alarm Packet Loss}}=.2613$, $P_{\text{Missed Detection Packet Loss}}=0.0998$
- For Siebel:
  - $P_{\text{False-Alarm Jitter}}=0.3176$, $P_{\text{Missed Detection Jitter}}=0.0114$, $P_{\text{False-Alarm Packet Loss}}=0.3905$, $P_{\text{Missed Detection Packet Loss}}= 0.0138$

Jitter: Grainger Results

Recap

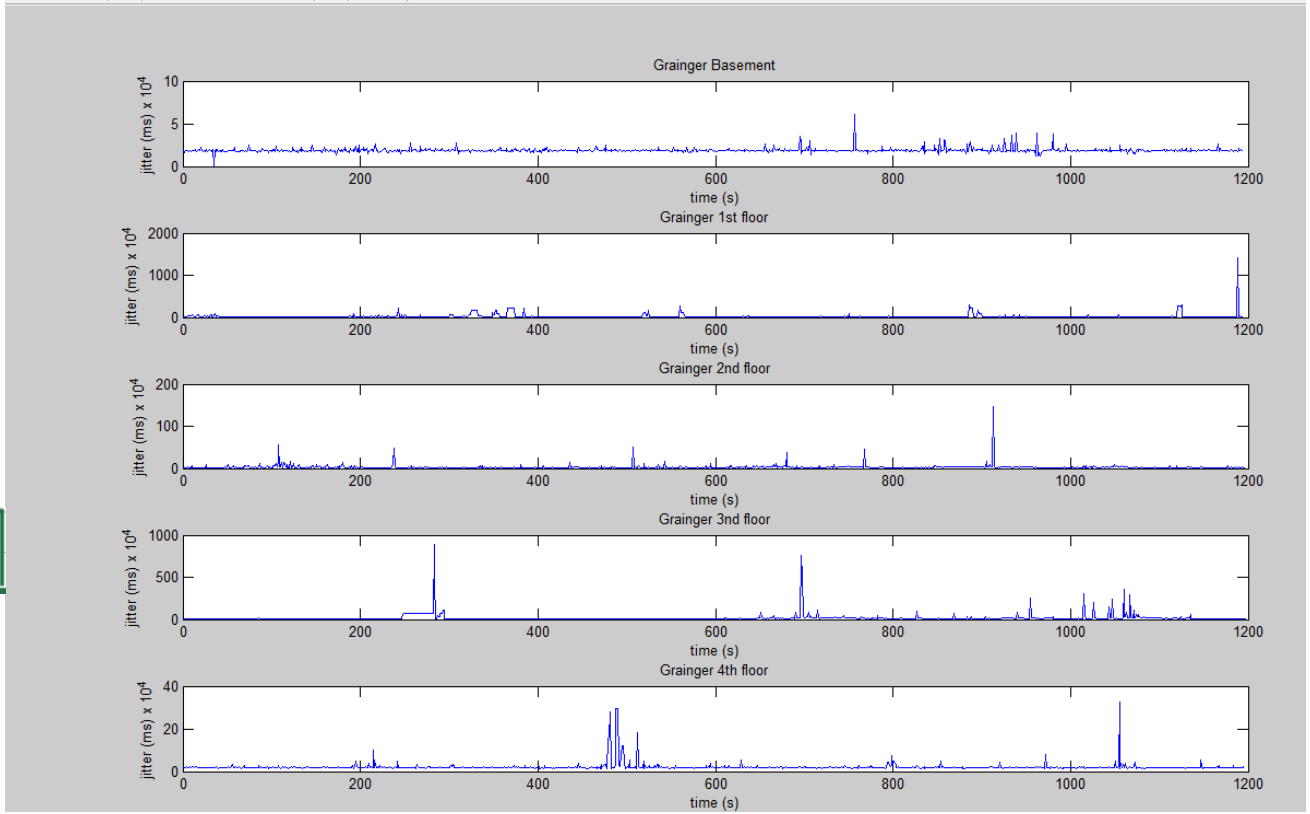
Analysis of Grainger Basement

	mean	median	std
0-1 west wing	1.8609	1.841	0.1671
0-2 linux lab	1.8936	1.835	0.3155

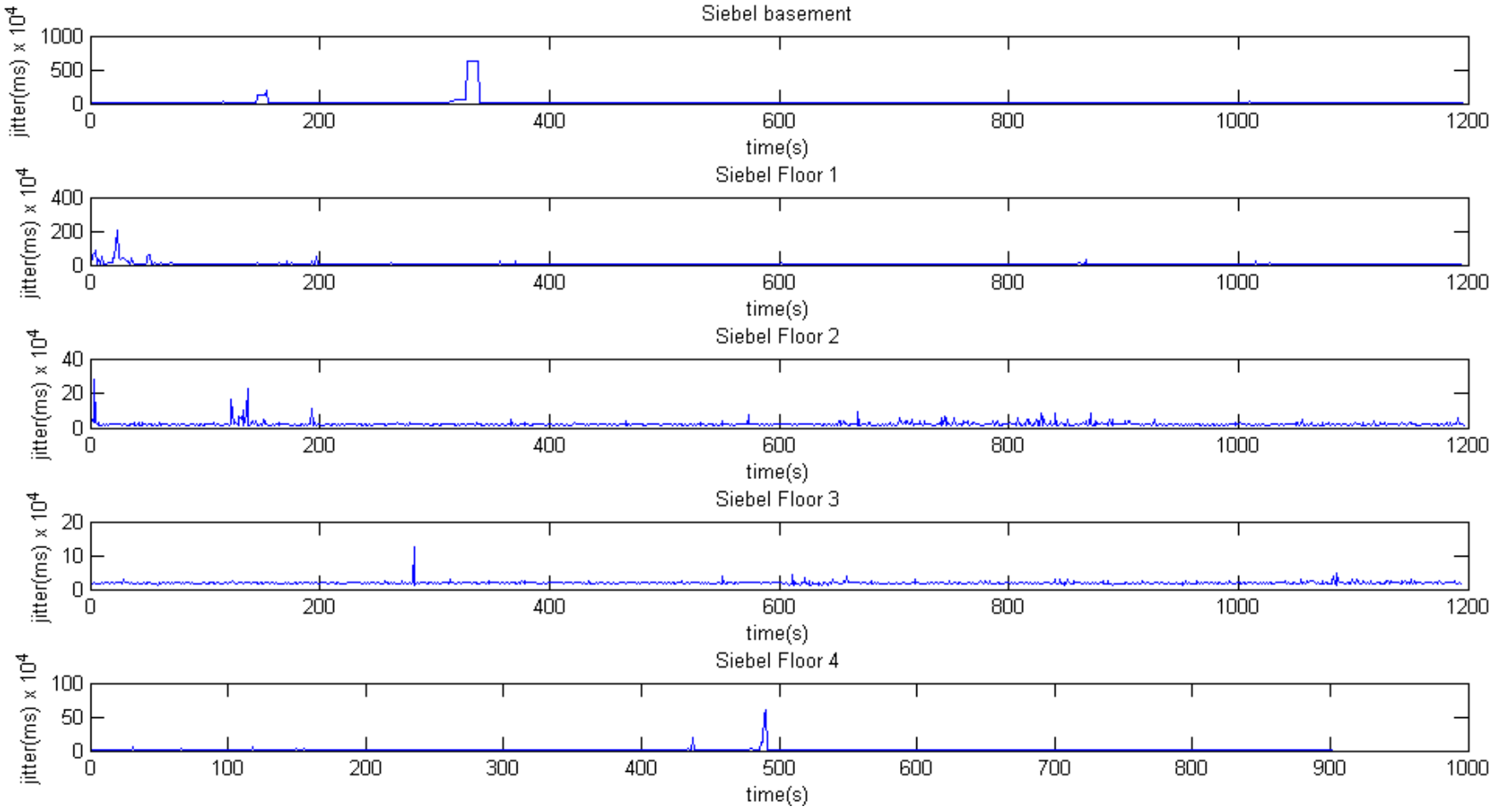
Compared to 4th Floor

	mean	median	std
4th floor	2.1269	1.84	2.0655

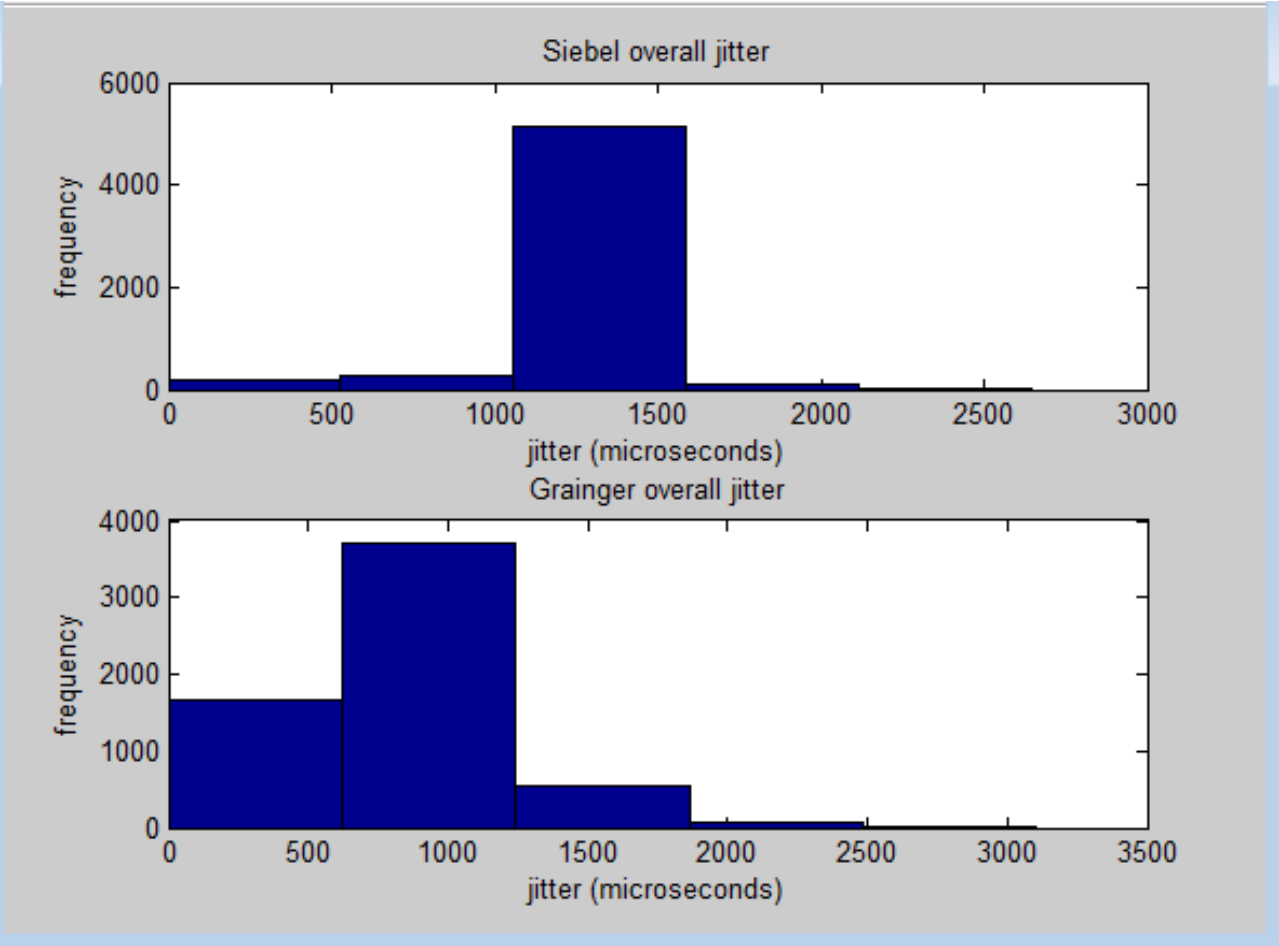
- 4th floor has varied jitter, with a much higher standard deviation.



Jitter: Siebel Results



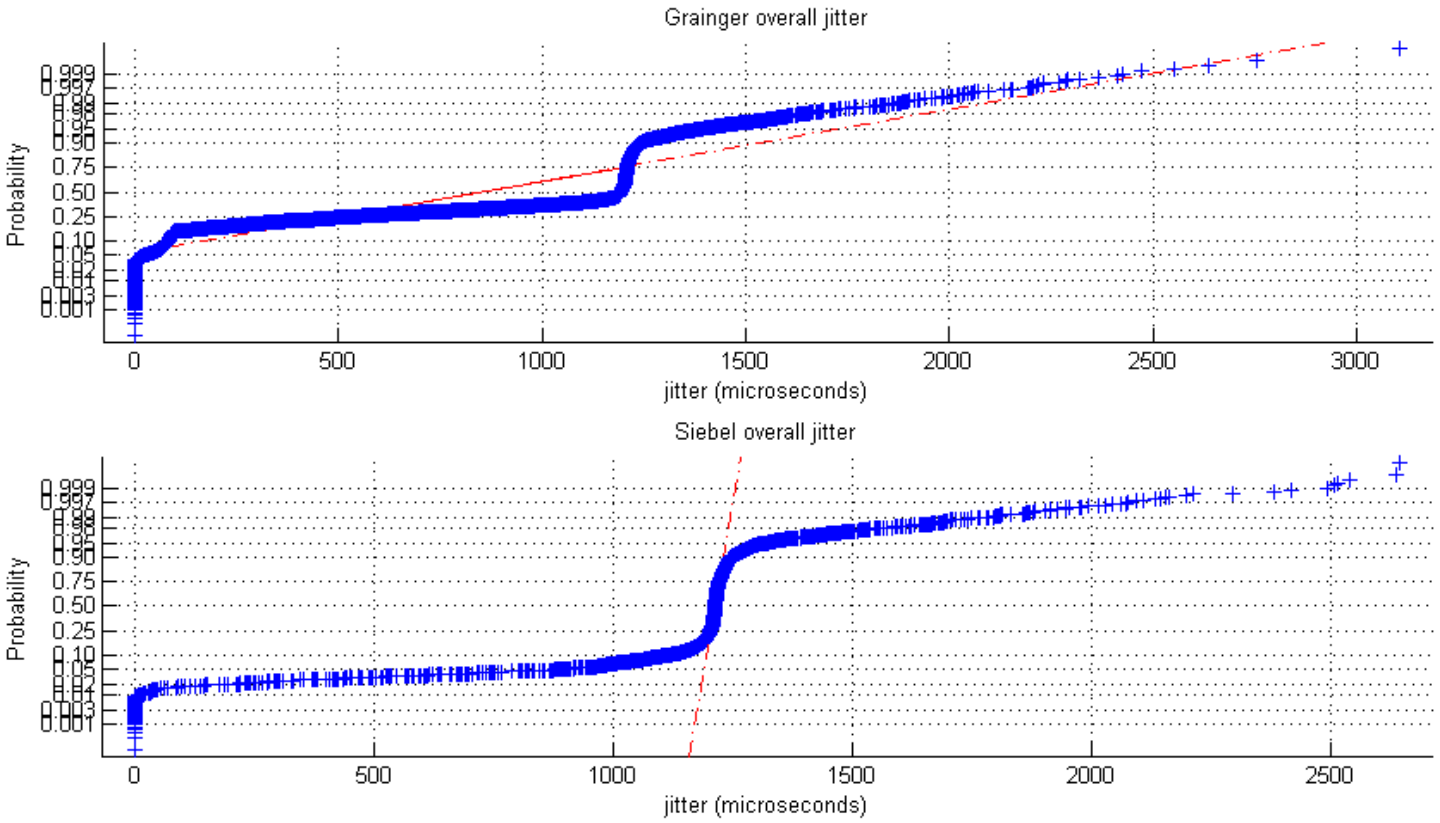
Jitter Results: Comparison



- From histograms, Siebel has a much more reliable jitter rate
- Grainger jitter is more sporadic and unpredictable

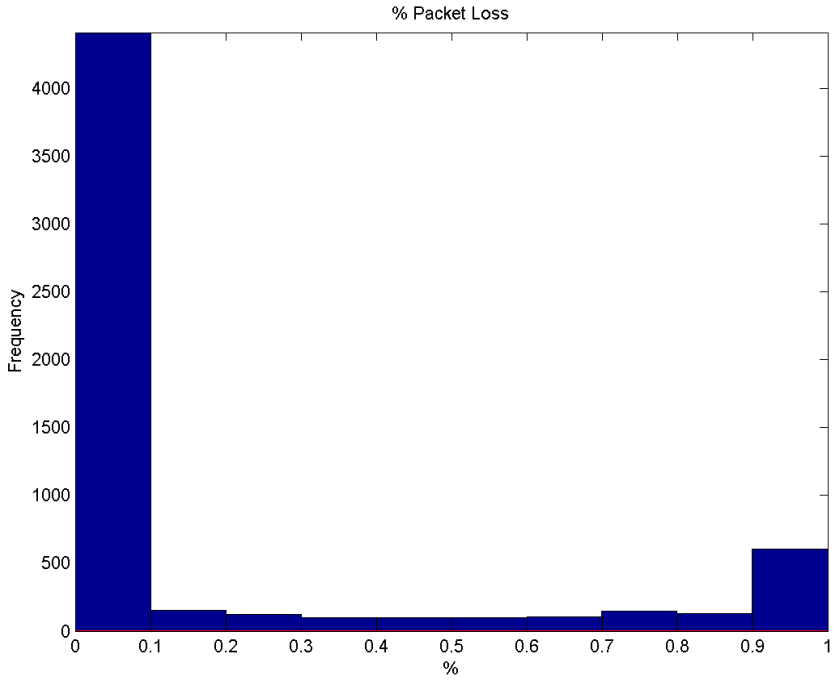
Jitter Results: Comparison

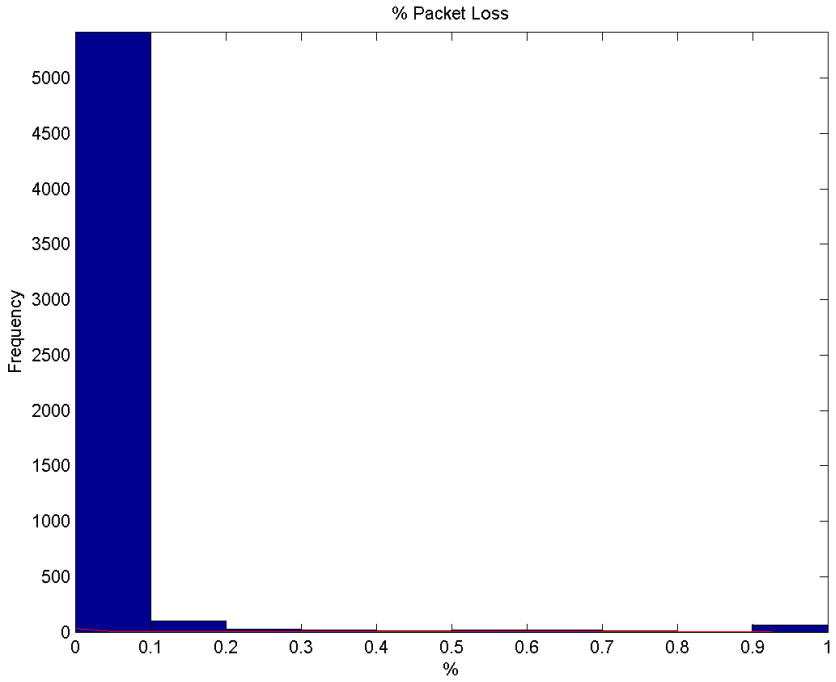
Normal Distribution



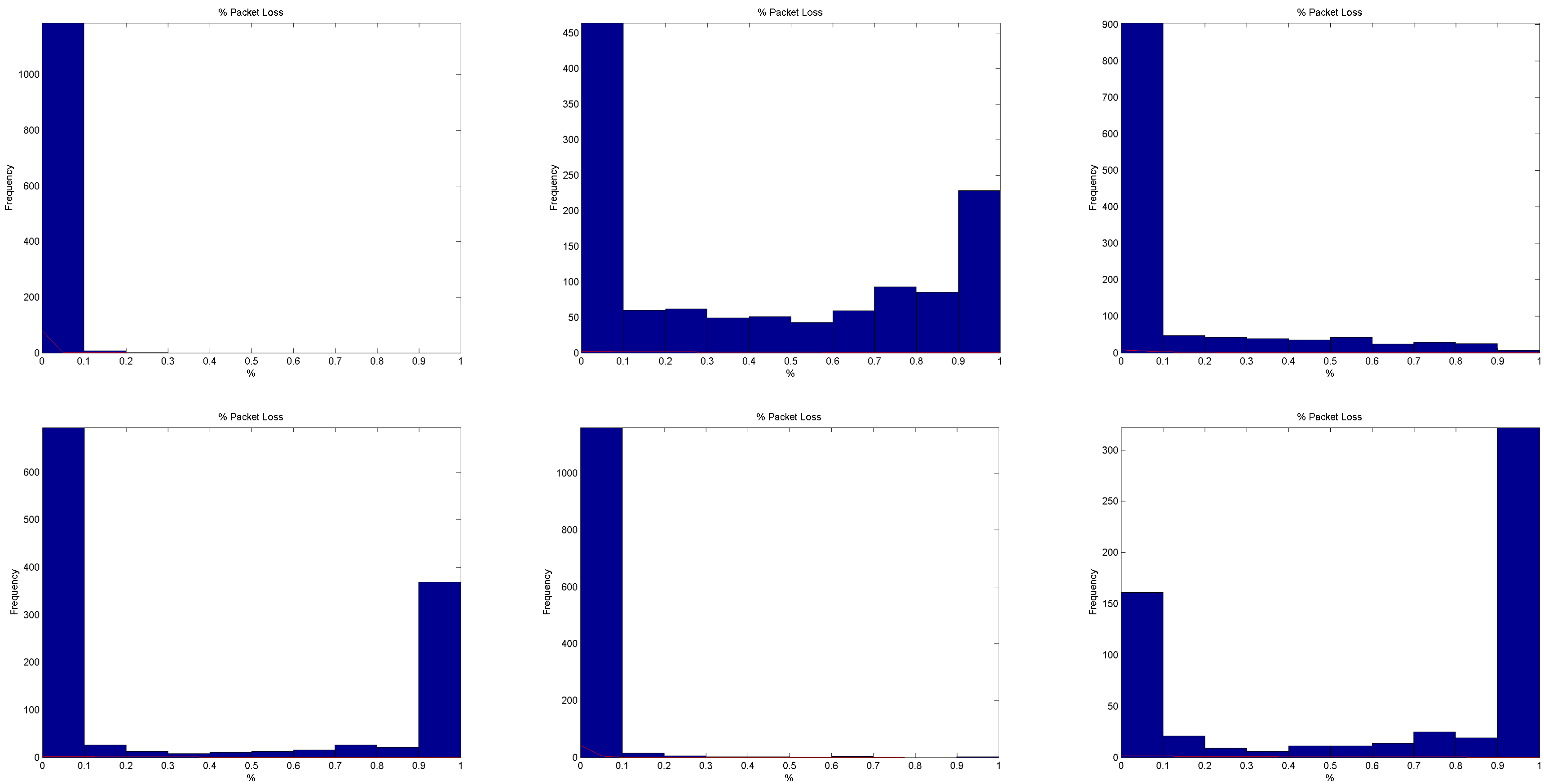
Packet Loss Results

- Packet loss analysis criteria:
  - % packet loss
  - MTTF & Mean length of failure
  - Hazard function
- Siebel (right) had much lower packet loss than Grainger (left), overall



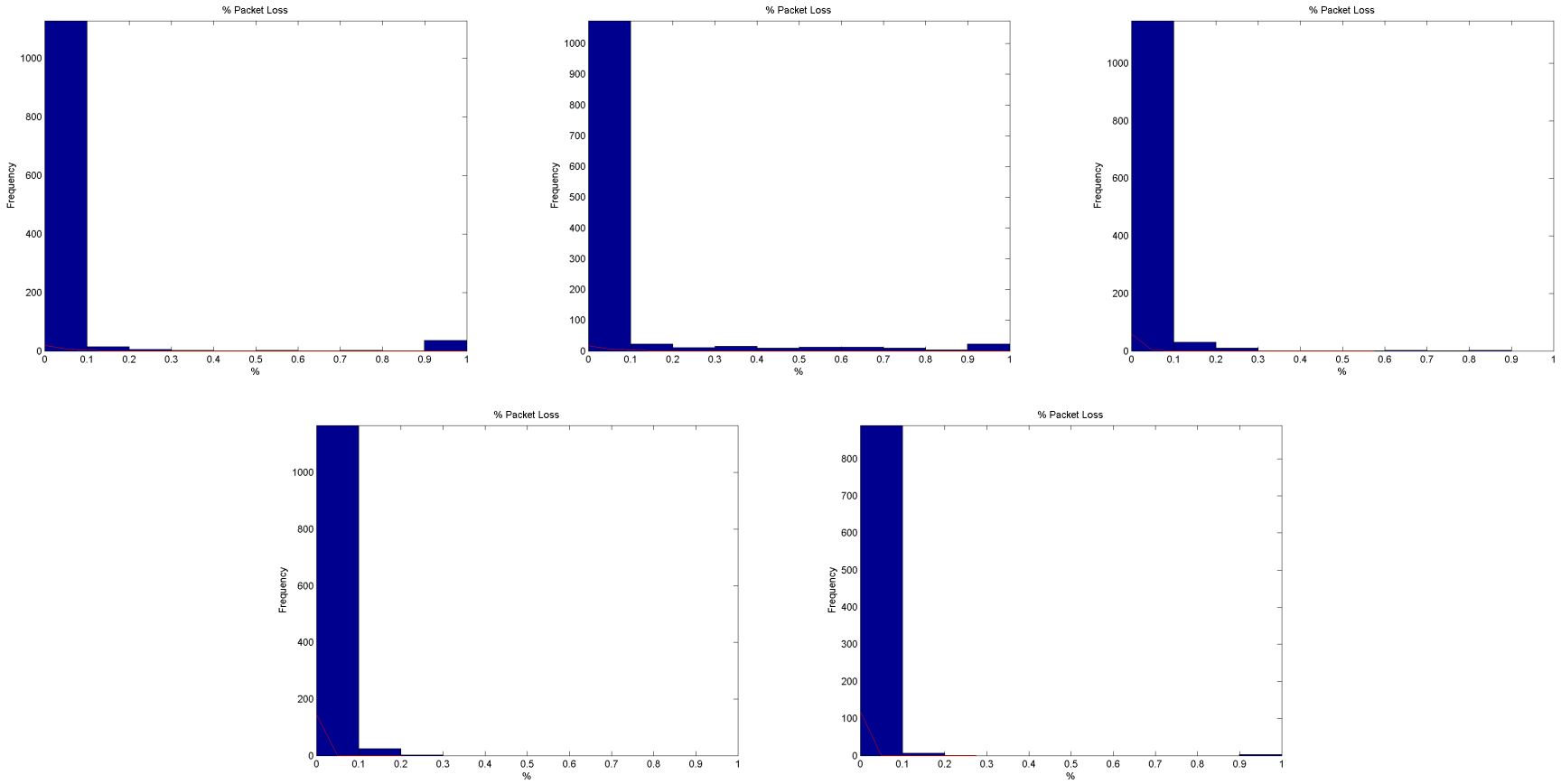


Percent Packet Loss - Grainger



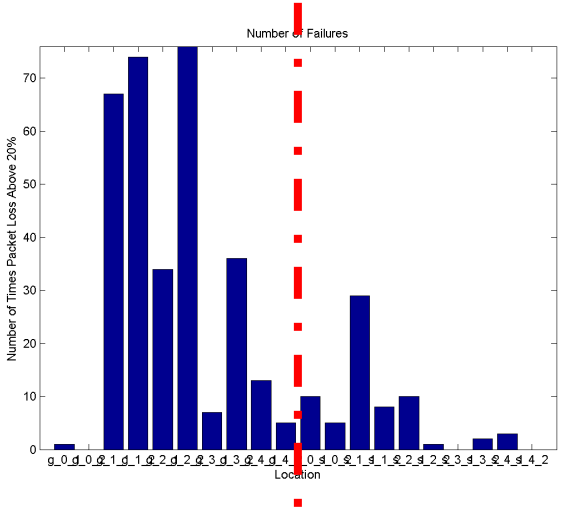
Top From Left: Basement, 1st Floor, 2nd Floor
Bottom From Left: 3rd Floor, 4th Floor, 3rd Floor East Wing

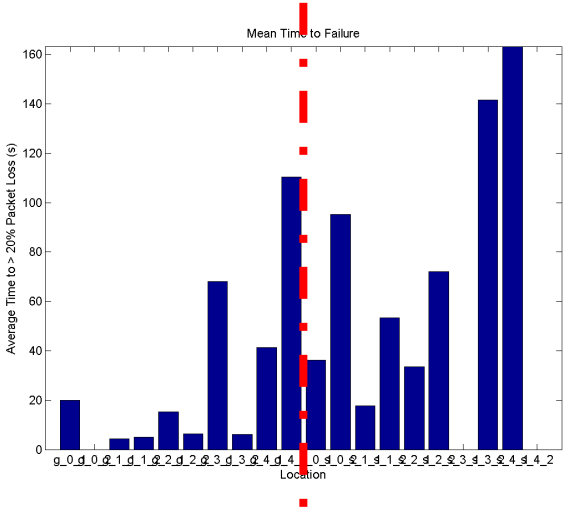
Percent Packet Loss - Siebel

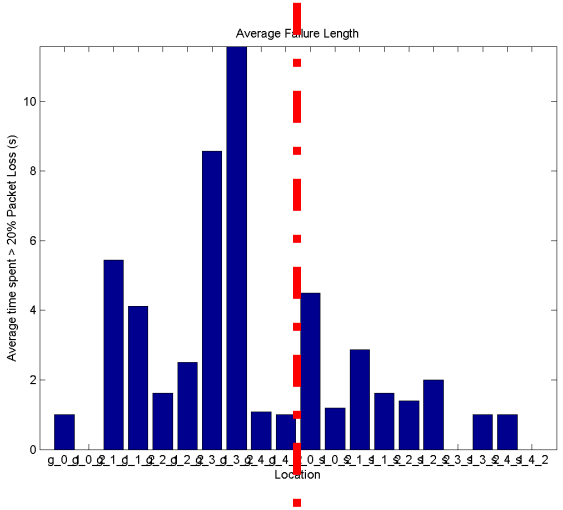


Top From Left: Basement, 1st Floor, 2nd Floor
Bottom From Left: 3rd Floor, 4th Floor

Number of Failures, MTTF, & Mean Failure Length



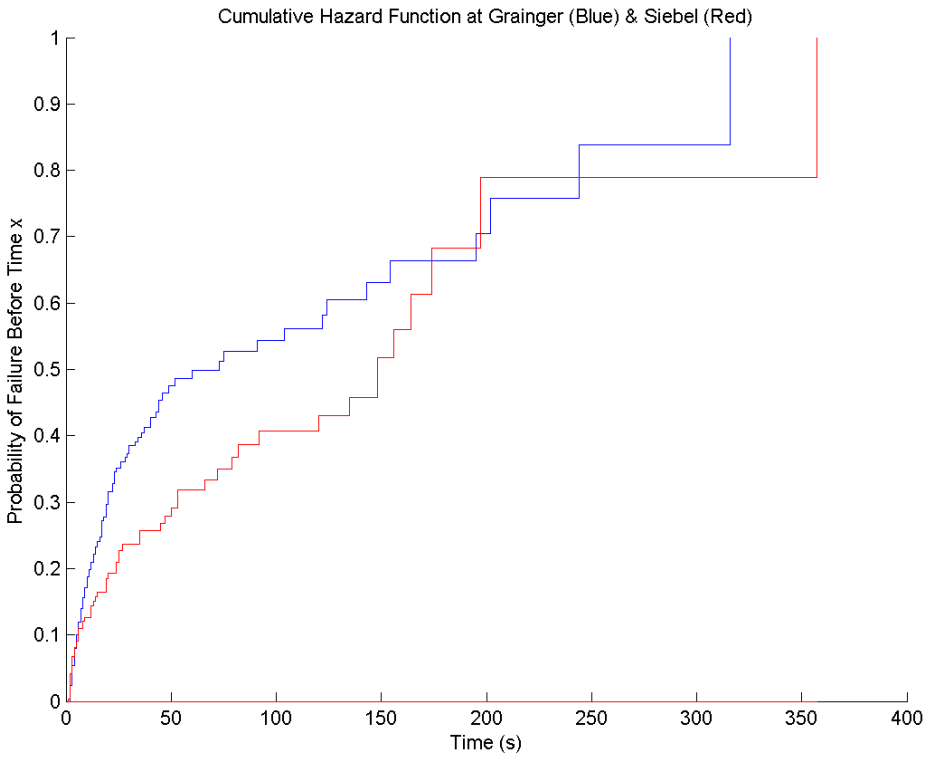




- In each of the above plots, Grainger data is left of the red line, Siebel on the right
- Failures defined as a contiguous set of samples with greater than 20% packet loss
- From the left: Number of failures (lower is better), MTTF (higher is better), Mean Failure Length (lower is better)
  - Note locations with no bar. These had no failures.

Hazard Functions

- Only metric with similar results
- Grainger in Blue, Siebel in Red
- Plot shows probability a failure will occur by time x
- As shown, Grainger packet failures tend to occur earlier than Siebel failures
- Graph is normalized to account for fewer overall Siebel failures



Conclusions and Key Insights

- Network performance varies widely based on location within a building
- 1st floor Grainger and 3rd floor Grainger have terrible network performance
  - The East wing of Grainger's 3rd floor actually had more seconds of >90% packet loss than <10%
- Despite it's overall better network performance, our laptops took longer to establish wireless connections at Siebel
- Jitter in Siebel is more reliable from our observations and analysis, Grainger wifi jitter is unpredictable
- Even though bandwidth is consistently higher in Siebel, it is more likely to have high bandwidth with high packet loss and jitter.

Suggestions

- Have groups decide on topics sooner
  - This year’s late planning for our final project led to difficulties planning times to meet and collect our data.

- Example presentations/reports so we know what expectations are (more number-crunching, more plots, etc.)