STUDY OF TEMPLE UNIVERSITY WIMAX (TU-WIMAX) PERFORMANCE

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Project Objective

- Why WiMAX?
- Experimental methodology
- Present active measurement results from Temple University WiMAX-based network.
- Analyze and provide estimation of actual system
- Approach to predict link quality variations
- Conclusion

Why WiMAX?

- **WiMax**: Worldwide Interoperability for Microwave Access
- IEEE 802.16 std. for MAN
- Deliver wireless broadband access
- Offer service range up to 50 km
- Data rate: up to 100Mbps
- Applicable on large area public venues like airport & university
- Many applications for disaster recovery

  Recovery issues: Poor telecommunication infrastructures

  Communication link supports VoIP & video streaming

  Multimedia transmission
- Support sophisticated QoS capabilities (bandwidth, jitter, latency)

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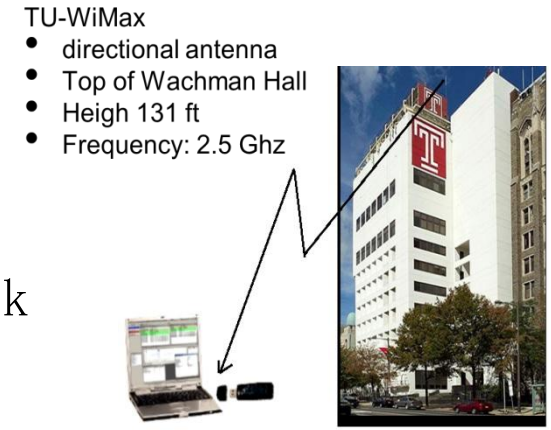
Experimental methodology

- Experiment both on campus and out off campus
- Driving around T.U.
  - Main lobe and sides lobe

- Active measurement from TU-WiMAX based network
- Focus on link performance
  - RSSI: Received Signal Strength Indicator (Kannon)
  - CINR: Carrier to Interference plus Noise Ratio (Kannon)
  - Bandwidth : bit rate measured in bits per sec. (Jperf)



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Results

- Antenna range:
  Main lobe: 4 km
  Sides lobe 2.57 km

- Excellent RSSI level when receiver close to BS

- Some areas close to BS experience shadowing Leading to low signal lev

- RSSI has a high correlation with distanc

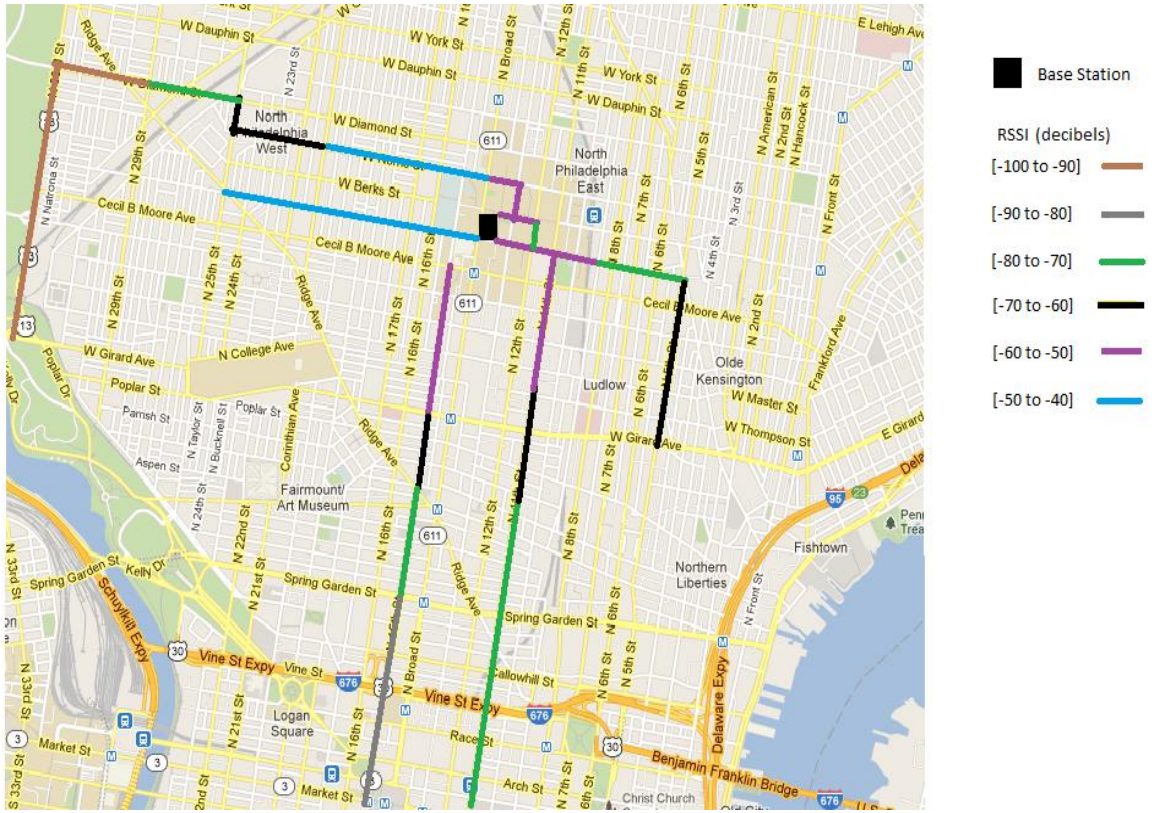

Fig. 1: signal strength map

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Results (Cont.)

- CINR quite good for distance with 4 km from the BS
- CINR has moderate Correlation with distance
- RSSI may be very good but interference could also Be very high
- Produce a low effective CINR

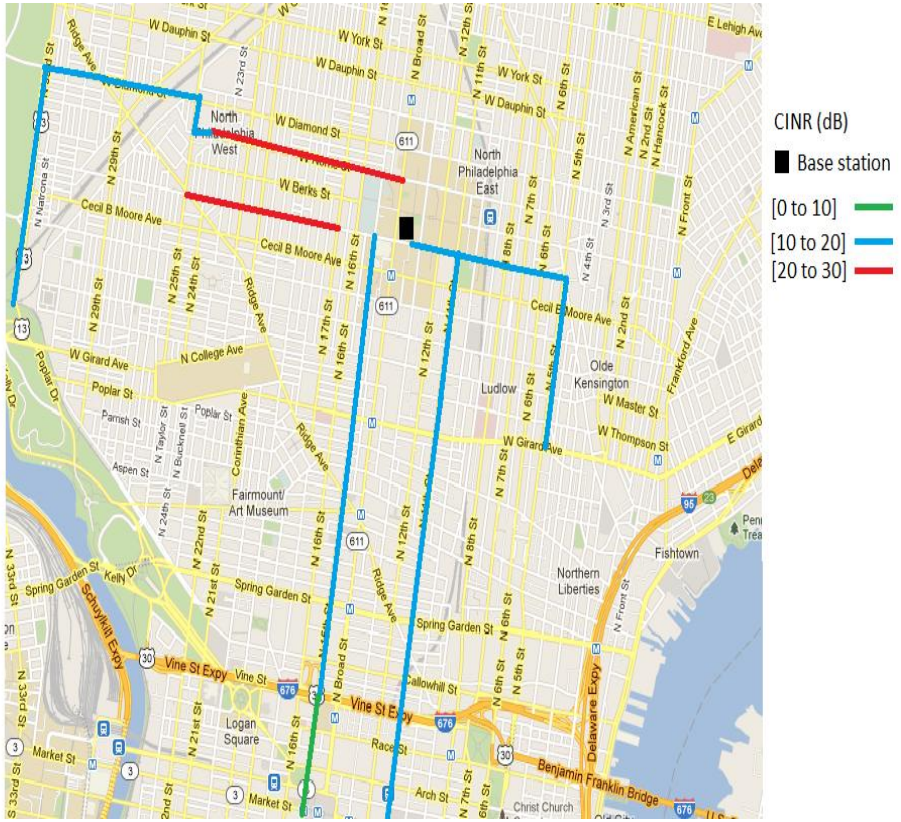

Fig. 2: Link quality map

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Results (Cont.)

Campus measurements

Avg. bandwidth:700 Kbps

Avg. RSSI: -69 dBm

Avg. CINR: 23 dB

- Better link quality when signal strength level increases.

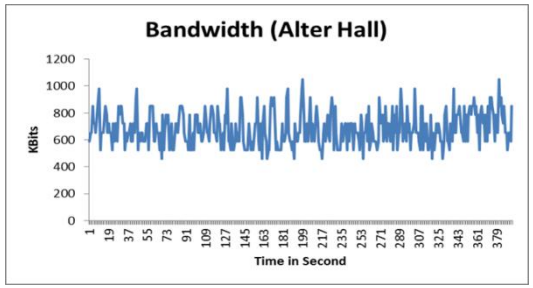
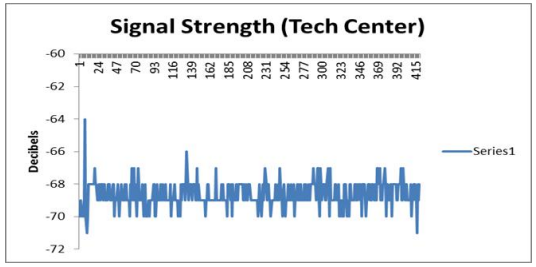
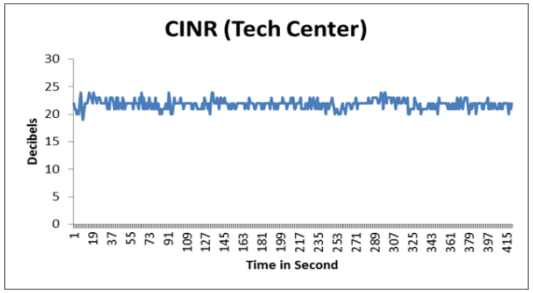


Fig. 3: Bandwidth variations over time



- Fig. 4: RSSI variation



- Fig. 5: CINR variation

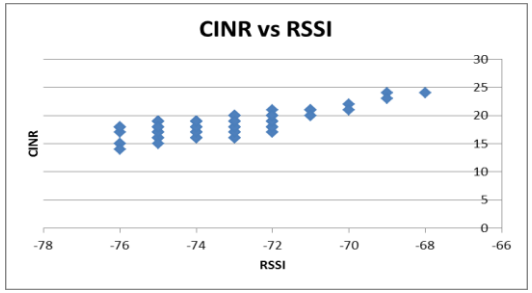


Fig. 6: Estimation of CINR versus signal strength

Performance analysis

- Factors affecting RSSI
  - Long distance: erratic and weak signal
  - Obstructions: Building (walls) tree, glass, weather

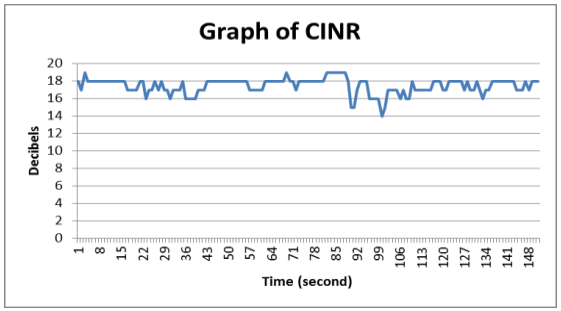
- RSSI alone cannot be utilized as communication link quality
- CINR not only takes RSSI into account, but also the amount of noise in the signal
- Signal to Noise Ratio is generally defi $SNR = 10*\log(\frac{\text{P-signal}}{\text{p-noise}})$

- CINR is subject of noise & interference

- CINR ultimately more relevant parameter for network performance

Prediction of link quality

- CINR measurements with correlation technique
- Short term prediction
- CINR takes into account RSSI, noise, interference & fading



- **Fig. 7: CINR evolution over time**

Autocorrelation

- Statistical method used for time series analysis
- Measure the correlation of two values in the same data set at different time steps
- Mathematical expression to find to evolution of a link
- Definition of autocorrelation between time s and t:

$$R(s,t) = \frac{\mathrm{E}[(X_t - \mu_t)(X_s - \mu_s)]}{\sigma_t \sigma_s},$$

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Correlation coefficient decreases each 17 sec

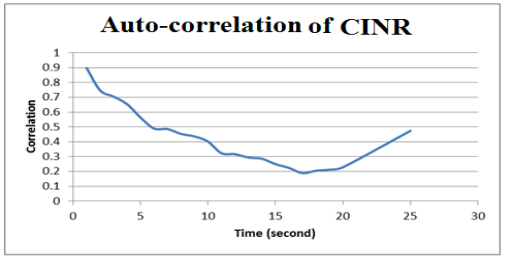

Fig. 9: Observed pattern of the evolution of CINR

Prediction of link quality based on observed pattern

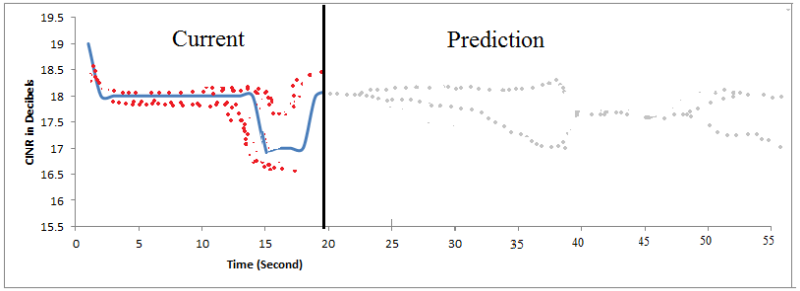

Fig. 10: Prediction of CINR based on autocorrelation pattern

Conclusion

- Empirical measurements of RSSI, CINR & bandwidth
- Average RSSI & CINR are -70 dBm and 20 dB respectively.
- Service range of TU-WiMAX is up to 4 km.
- High correlation RSSI vs Dist.
- Autocorrelation mechanism for future state of link variations

ANY QUESTIONS???