Long-Range Dependence in WiMAX traffic. A Preliminary Analysis

Cristina Stolojescu

"Politehnica" University of Timisoara, Romania and Telecom Bretagne, Brest, France

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Outline

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Subject

- studies of traffic: the actual Internet traffic is self-similar (fractal) or long-range dependent.
- goal: to analyze the downlink traffic in a WiMAX network in terms of long-range dependence (LRD).
- estimation of Hurst parameter using Rescaled Adjusted Range Method (R/S).
- estimate values for each downlink trace from the data base which correspond at the considered network.

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Long-range dependence(LRD)

- Long-range dependence - a key concept in analyzing the traffic in a telecommunications network.
- LRD = statistical measure for the speed of the autocorrelation function's decay for a time series.
- More intuitively it measures the length of the memory of a random process.
- A cause of LRD is the hidden periodicities which are present in the time series analyzed.

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Long-range dependence(LRD)

- The predominant way to quantify the LRD of a random process is the estimation of its Hurst parameter, H.
- A time series exhibits LRD if:

$$\mathbf{0.5<H<1} \tag{1}$$

- The LRD is stronger if the parameter H has a higher value.
- A value of H = 0.5 or smaller indicates the lack of LRD or the presence of SRD (short-range dependece).

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Estimation of Hurst parameter

- The Hurst parameter can not be calculated, **it can be only estimated**.
- various statistical techniques to estimate H:
  - estimators operating in the time domain:
    - absolute value method,
    - variance method,
    - rescaled adjusted range (R/S) method.
  - estimators operating in the frequency or wavelet domain:
    - periodogram,
    - Whittle estimator,
    - proposed by Abry-Veitch.

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Data base

- Historical data obtained by monitoring the traffic from 67 Base Stations (BS) composing a WiMAX network.
- Period of collection: eight weeks (March 17th - May 11th, 2008).
- Numerical values : the total number of packets from the downlink channel.

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SELFIS

- SELFIS = SELF-similarity analysIS.
- a java-based software tool for self-similarity and LRD analysis.
- developed by Thomas Karagiannis at University of California.
- R/S method to estimate the Hurst parameter.

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Evaluation of H

- First experiment: we calculated the value of R/S estimator for all the 67 time series, corresponding to all BSs.

BS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
H	0.693	0.628	0.658	0.682	0.691	0.676	0.606	0.665	0.665	0.643	0.657
BS	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
H	0.689	0.656	0.692	0.645	0.641	0.706	0.641	0.618	0.657	0.657	0.600
BS	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
H	0.723	0.706	0.717	0.679	0.740	0.656	0.665	0.619	0.637	0.719	0.653
BS	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
H	0.678	0.729	0.667	0.626	0.719	0.697	0.698	0.756	0.622	0.660	0.681
BS	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**
H	0.641	0.560	0.608	0.618	0.704	0.667	0.629	0.703	0.628	0.654	0.636
BS	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**
H	0.603	0.591	0.669	0.648	0.664	0.661	0.581	0.631	0.657	0.727	0.628

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Evaluation of H

- Next, we have chosen a certain BS (BS 61) and we have split the time series into weeks.

Week	BS61
1	0.649
2	0.568
3	0.525
4	0.638
5	0.580
6	0.489
7	0.472
8	0.532

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Evaluation of H

- Finally, we have split again the series, computing H for series containing daily values.

Days	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8
1	0.385	0.044	0.225	**0.599**	0.446	0.071	0.151	0.076
2	0.523	0.219	0.138	0.276	0.237	0.263	0.034	0.085
3	0.429	0.081	0.151	0.044	0.218	0.085	0.022	0.205
4	0.325	0.233	0.287	0.209	0.170	0.181	0.081	0.219
5	0.396	0.136	0.009	0.356	0.239	0.321	0.165	0.233
6	0.473	0.179	0.275	0.203	0.335	0.185	0.258	0.230
7	**0.891**	0.152	0.191	0.068	0.276	0.226	0.198	0.125

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Conclusions

- We have shown that WiMAX traffic exhibits LRD by estimating Hurst parameter.
- LRD depends on the duration of the time series.
- The entire series exhibits stronger LRD than each weekly series.
- The value of Hurst parameter for each of the seven daily series is smaller than the H value corresponding to the given weekly series.
- BS 61 has a good localization in the topology of the WiMAX network under study.

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Future work

- Apply the procedure to all the BSs which compose the considered network, indicating those with bad localization.
- Use other estimators of H parameter.
- Use other software environments.

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Thank you for your attention!

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