*[1] "Estimation and Removal of Clock Skew from Network Delay Measurements"
Proc. IEEE Infocom'99 (New York, USA, March 1999).

S.B. Moon, P. Skelly, D. Towsley

*[2] "Clock synchronization algorithms for network measurements"
INFOCOM 2002.

L. Zhang, Z. Liu, C. Xia

* [3]"Estimation of clock offset from one-way delay measurment on asymmetric paths"

M. Tsuru, T. Takine, Y. Oie

*[4] "Needed services for network performance evaluation"

D.D. Luong, J. Biro

Presented by: Antonio Augusto Rocha (Guto)

Presentation format

- 4 papers to present
- Different format in this presentation
  - Not a full paper
  - Methods proposed, pointing the papers
- Overview:
  - Clock Terminology
  - Define the Clock´s problems
  - Explain the methods proposed to solve each problem
  - Traffic Generator
  - Experiments/results with TG
  - Conclusions and considerations

Clock Terminology

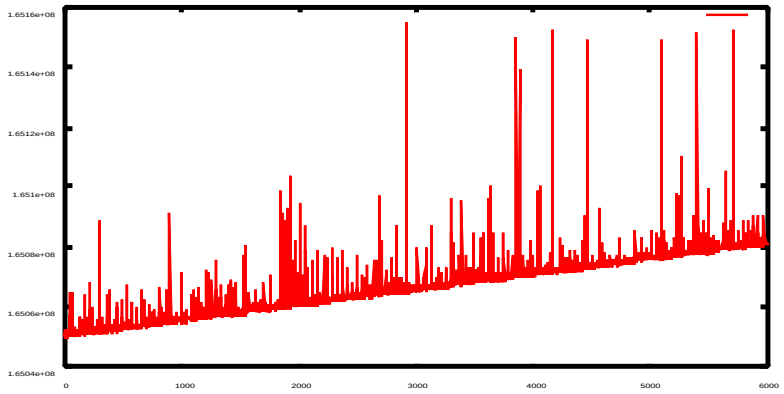
- C_x : represent the clock of machine X;
- Frequency: Growing rate of clock C_x;
- $C_x(t)$: Instant "t" in clock C_x;
- t_s and t_r : Instants "t" of sending and receiving a packet;
- Suposed Delay = $C_b(t_r) - C_a(t_s)$;

Problems

- With GPS that is valid;
- If NOT, the function D= $C_b(t_r)$ - $C_a(t_s)$ is NOT valid;
- Some problems must be considered:
  - The frequency of clocks (C'_a and C'_b) are not the same : SKEW
  - The difference between the clocks at intant "t" may be different of zero $C_b(t_s)$!= $C_a(t_s)$: Offset
  - The difference of clocks rate (frequency) may change, skew change: Drift
  - The clocks may be abruptly shifted (UPDATE): Shift
  - The O.S. break may cause noises in the results: Noise

Skew

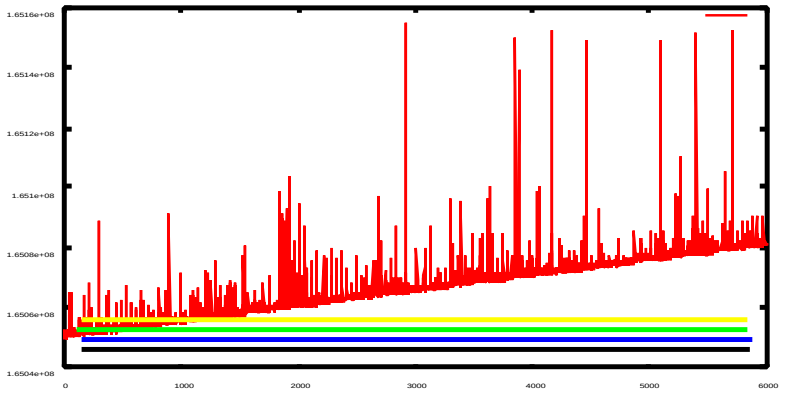
- The difference in the clocks frequency cause a tendencius growing in the trace.
  - Figure show this event, x-aix (# seq of pack) and y-aix(delay)



- Algorithms proposed in [1,2] try to solve this problem.
  - Find a line
  - All trace points cover this line
  - As close as possible from those poitns

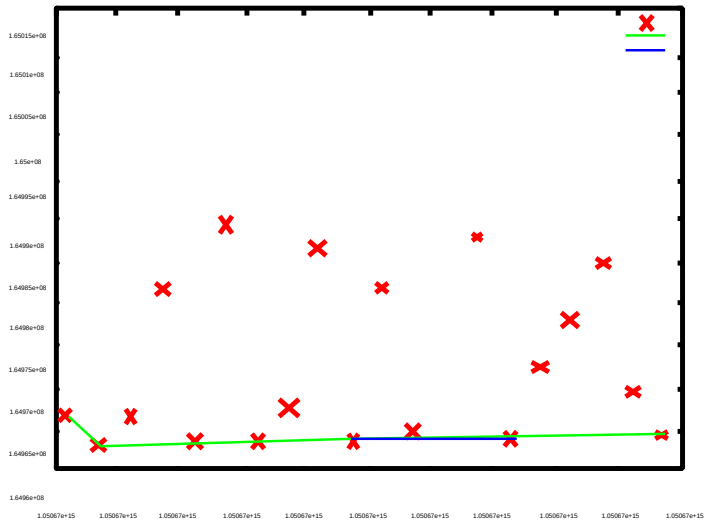
Skew (cont.)

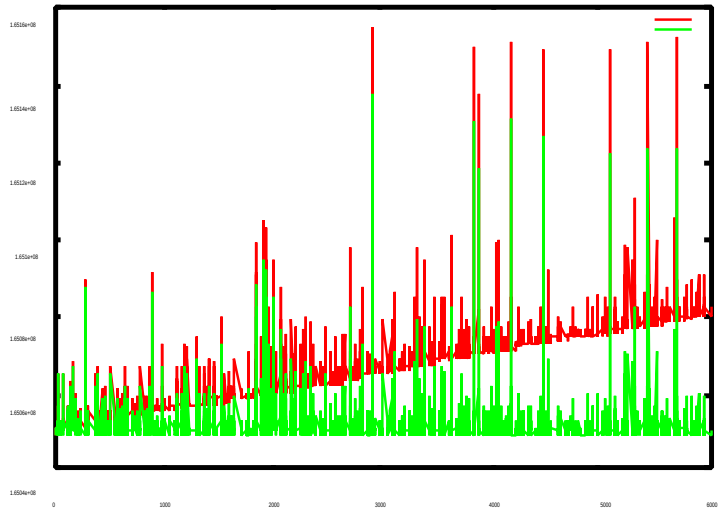
- [1] propose a algorithm, based on linear programming, to solve the problem
  - In this proposal, try to estimate parameters:
    - $\tilde{d}_i - (\hat{\alpha} - 1)\tilde{t}_i^s + \hat{\beta} \geq 0, \quad 1 \leq i \leq N$
  - Many possibilities.
  - the objective function minimizes the sum of the distance between the line and the data points.
    - $\min\{\sum_{i=1}^{N} \left(\tilde{d}_i - (\hat{\alpha} - 1)\tilde{t}_i^s + \hat{\beta}\right)\}$



Skew (cont.)

- [2] propose an algorithm to solve this problem based on computation of the convex hull.
  - Convex Hull (all points)
  - Estimate Points X, line cover X is used.



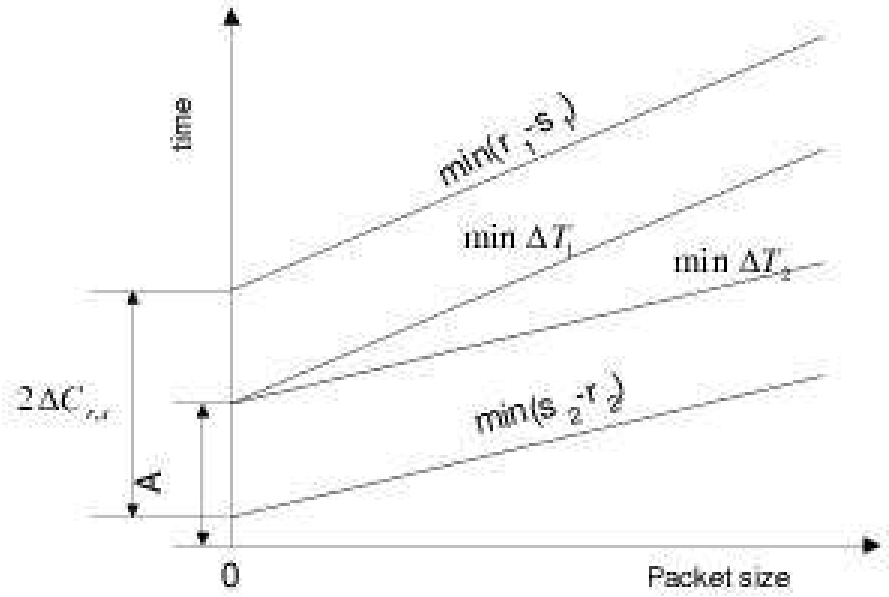


Offset

- The difference between the sender and the receiver clock introduce a fake value in the delay computation
- This value may be so different resulting in a "packet being send after received"
- [3,4] propose a method to solve this problems:
  - Exist other proposal, but they do NOT consider the possibility of asymmetric path.
    - Asymmetric path = different capacity of transmission along the path.

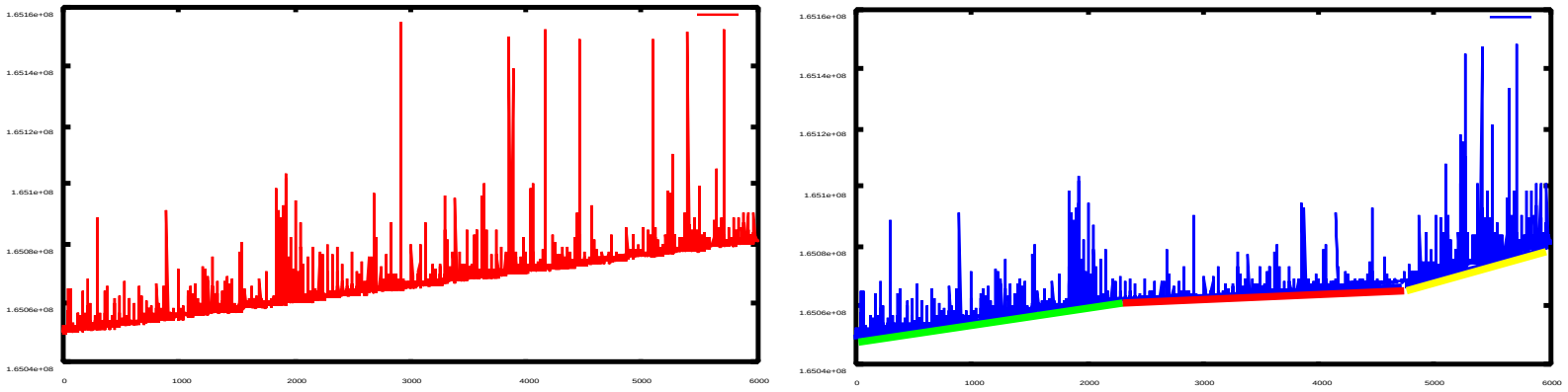
Offset (cont.)

- The algorithm variate the packet size of probes, in both directions, and take the minimal value (without SKEW) for each sample size.
- Identify a linear decrease.
- the diference of the points when both lines touch the y-aix, is considered twice the offset value.
  - This simulate a packet of size zero, or propagation time.



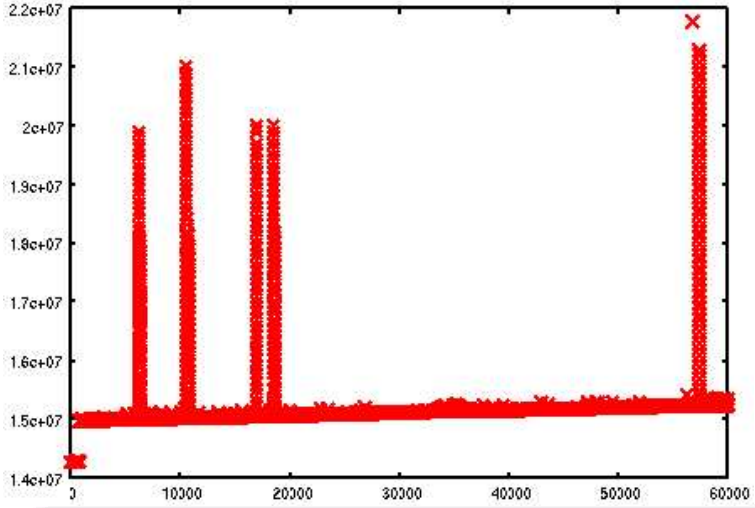
Drift

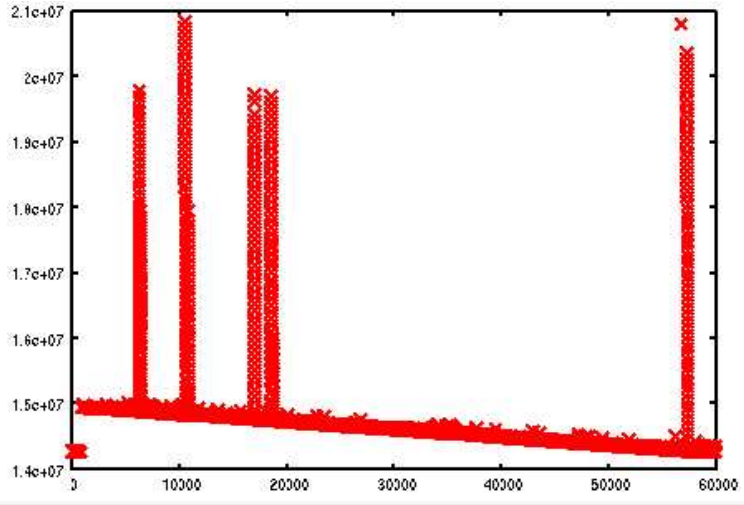
- Changes in the clock frequency
- It is possible SKEW change;
- Unvalidate the Skew estimation;
- NTP change the Drift of a clock:
  - First time the Clock is sincronized
  - Drift clocks are adjusted to keep sincronization



Shift

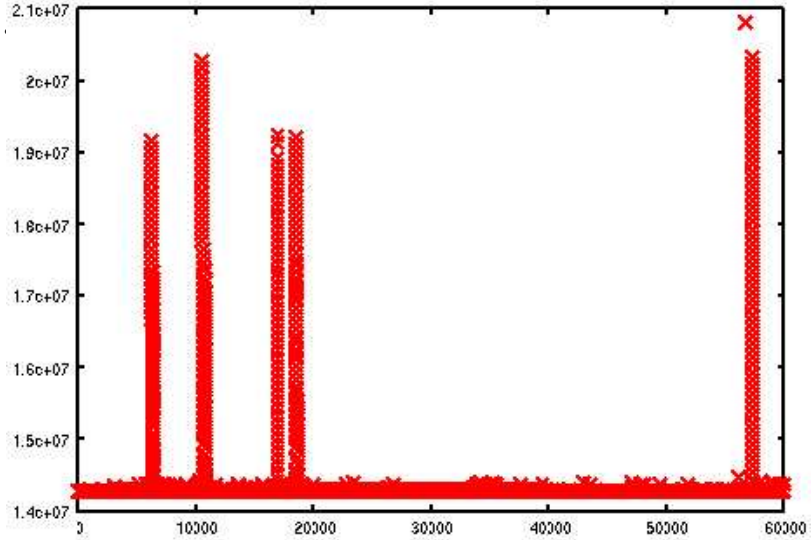
- Caused by a clock adjust in one of the two nodes;
- In the trace, an abrubt shift in the delays; Figure(A)
- It can cause a wrong skew estimation; Figure(B)
- [2] propose a way to estimate SKEW with Shifts in the trace.
  - Problems with this proposal;
  - Traffic Generetor has a solution implemented, we are comparing both;





Noise

- Not in any paper, and not in the literature
- We experimented this problems in ours traces
- Caused by a Operational Sistem break
- Consequence is noises in the trace,
  Figure shows the exemple;
- Option:
  - Ignore -> Could bring problems in the delay distribution estimation, it could be the responseble by the LONG TAIL of a distribution.
  - Remove -> The Traffic Generator is implementing a method to consider this noises (O.S. breaks).



Traffic Generator

- Tool to estimate end-to-end caracteristics
- One-way delay
- Implemented algorithms proposed by [2,3] (Skew and Offset)
- Methods proposed by us (Shift, Noise)

Estimating Delay Distribution

- Tool try to estimate the delay distribution
- Used in the Don's Class

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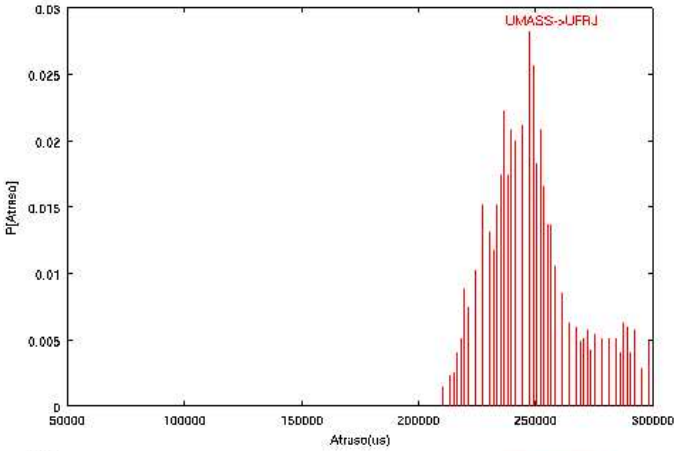

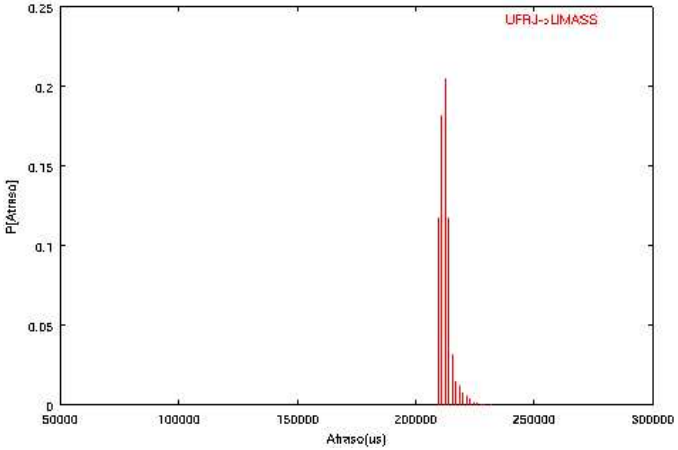

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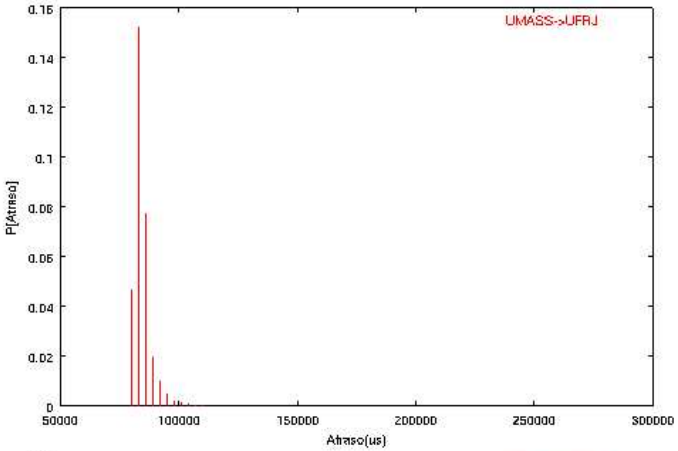

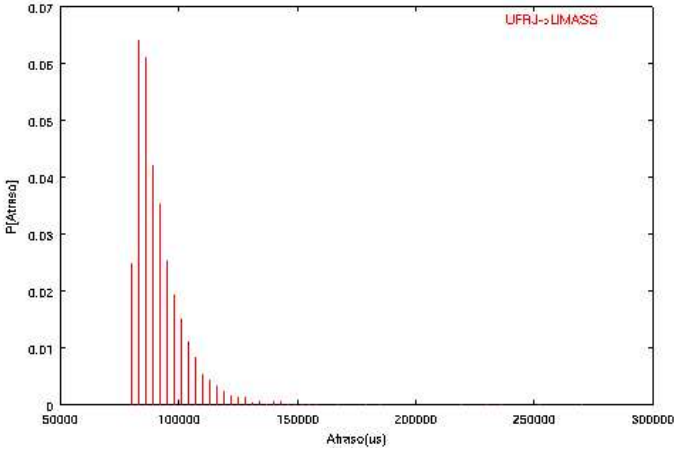

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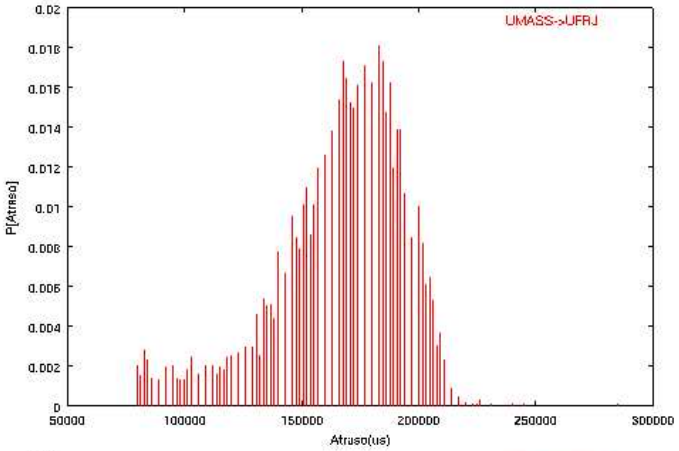

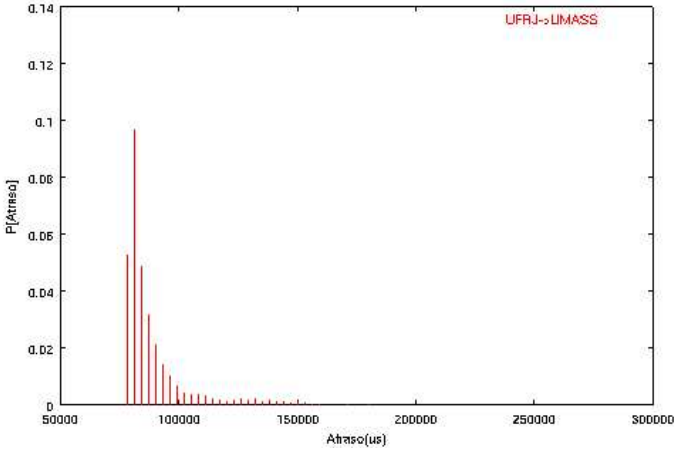

Conclusion and Considerations

- The methods proposed are good solution to estimate delay without Sinchronization equipaments
- Estimate the parameters in One-way is very important, the "round trip way" do NOT consider the differences between the ways.
- Traffic Generator is a unique tool for estimating end-to-end network caracteristics
- The tool has been usefull to:
  - Increase the quality of some multimidia application produced by the lab.
  - Create more realistics models to be simulated
  - Know the caracteristics of our National Research Network

END...

- Thanks!!!