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Multi-level, Multi-core Distributed Trace Synchronization

Masoume Jabbarifar
Masoume.jabbarifar@polymtl.ca

Supervisor: Michel Dagenais

DORSAL

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Outline

- Introduction
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- Results
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Streaming Data Challenges

- Synchronizing a live trace stream on the fly.
  - It is not practical to scan the data stream more than once
  - Buffering the data stream for a long period is problematic

Goal 1: *Online time synchronization of distributed traces has to be efficient in both time and memory*

Goal 2: *Prevent reading the whole data from the start point of tracing to the end of the current time*

Goal 3: *Online time synchronization has to be scalable and should not lose the accuracy over time*

Time Window based approaches

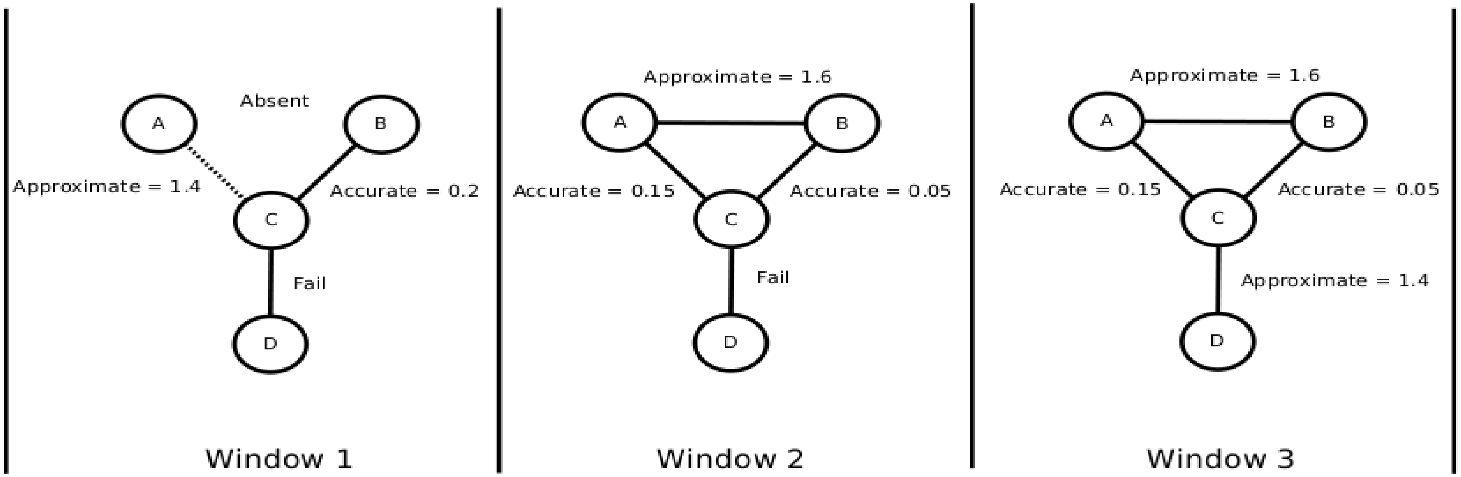
- Independent
- Replace
- Merge (10%, 50%, and 90%)
- Correlated

Independent Approach

- Analyze one time window at a time, independently
- Advantages:
  - No buffering or dependency on data from previous time windows.
  - Simpler and more efficient compared with the three other approaches
- Disadvantages:
  - It is not able to achieve a satisfactory accuracy, not only in each window, but also after a settling period.

Replacement Approach

- Using the useful results from convex-hulls of previous windows
- This approach insures accuracy improvement over time but the rate of improvement is slow



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For each link
    d = Accuracy(i–1) – Accuracy(i)
    if d > Threshold
        replace
    else
        drop current result
```

Merging Approach

- Merging the synchronization results of current window and previous window

$$Accuracy\ (i) = k * Accuracy\ (i-1) + (1-k) * a(i)$$

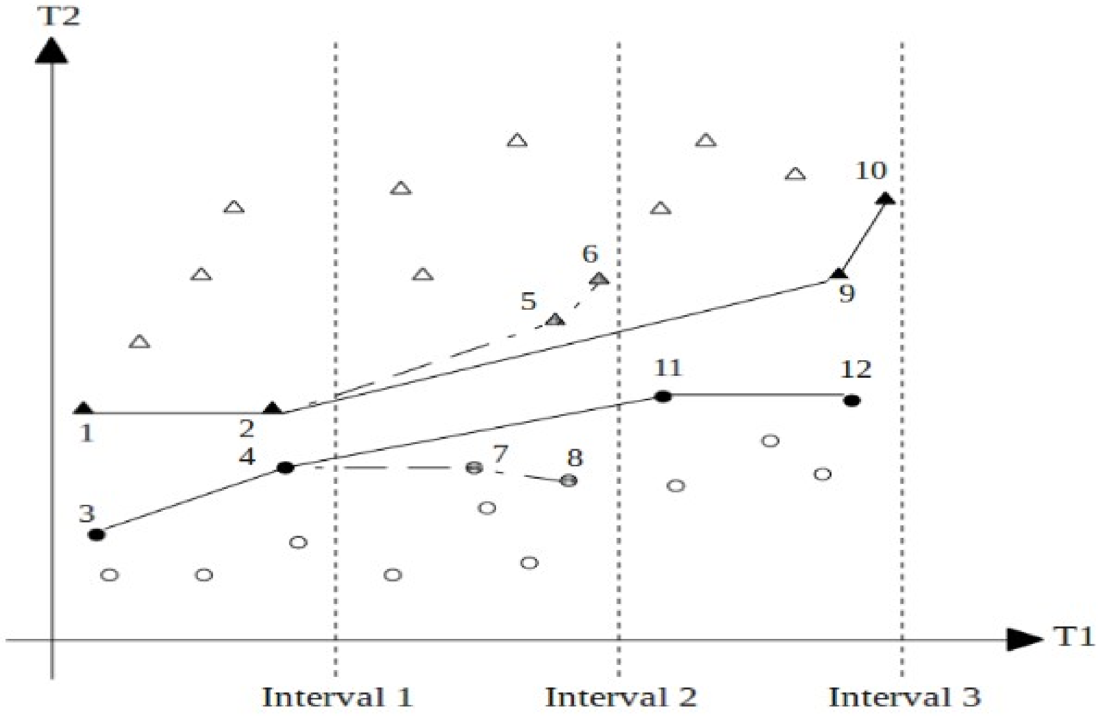
- *a(i): the output of the Convex-hull algorithm for window i*

- *k: the weighting factor*

- Different approaches can be defined based on *k* value:
  - Merge10 (K = 10)
  - Merge50 (K = 50)
  - Merge90 (K = 90)

Correlated Approach

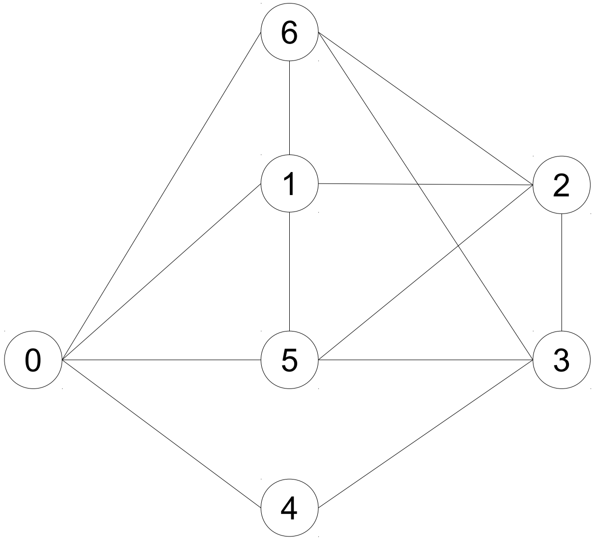
- Select the accurate packets in each window and transfer them to the next window



Correlated Sliding Window

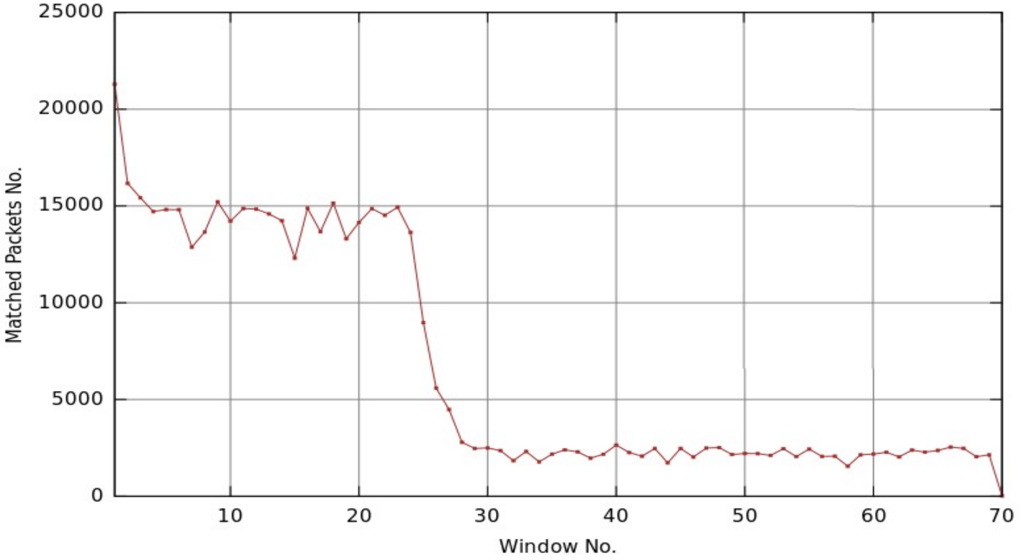
Cluster Setup

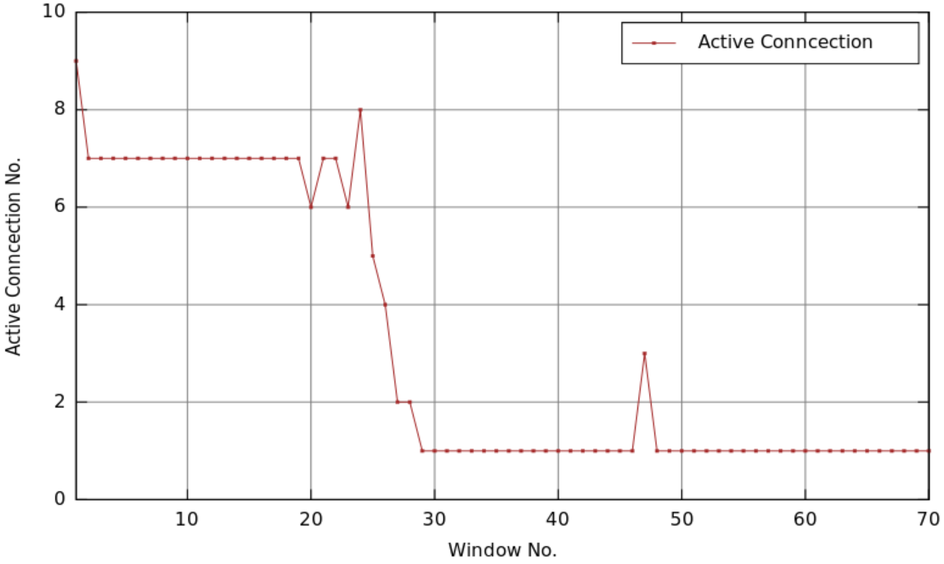
- Synchronisation of 7 nodes
- Each node is a Pentium III (4 CPUs) with 4 GB of RAM
- Window size is 3 seconds
- The nodes relationship graph:



Test Results (1)

- Total input and output events matched together to form a packet in each window

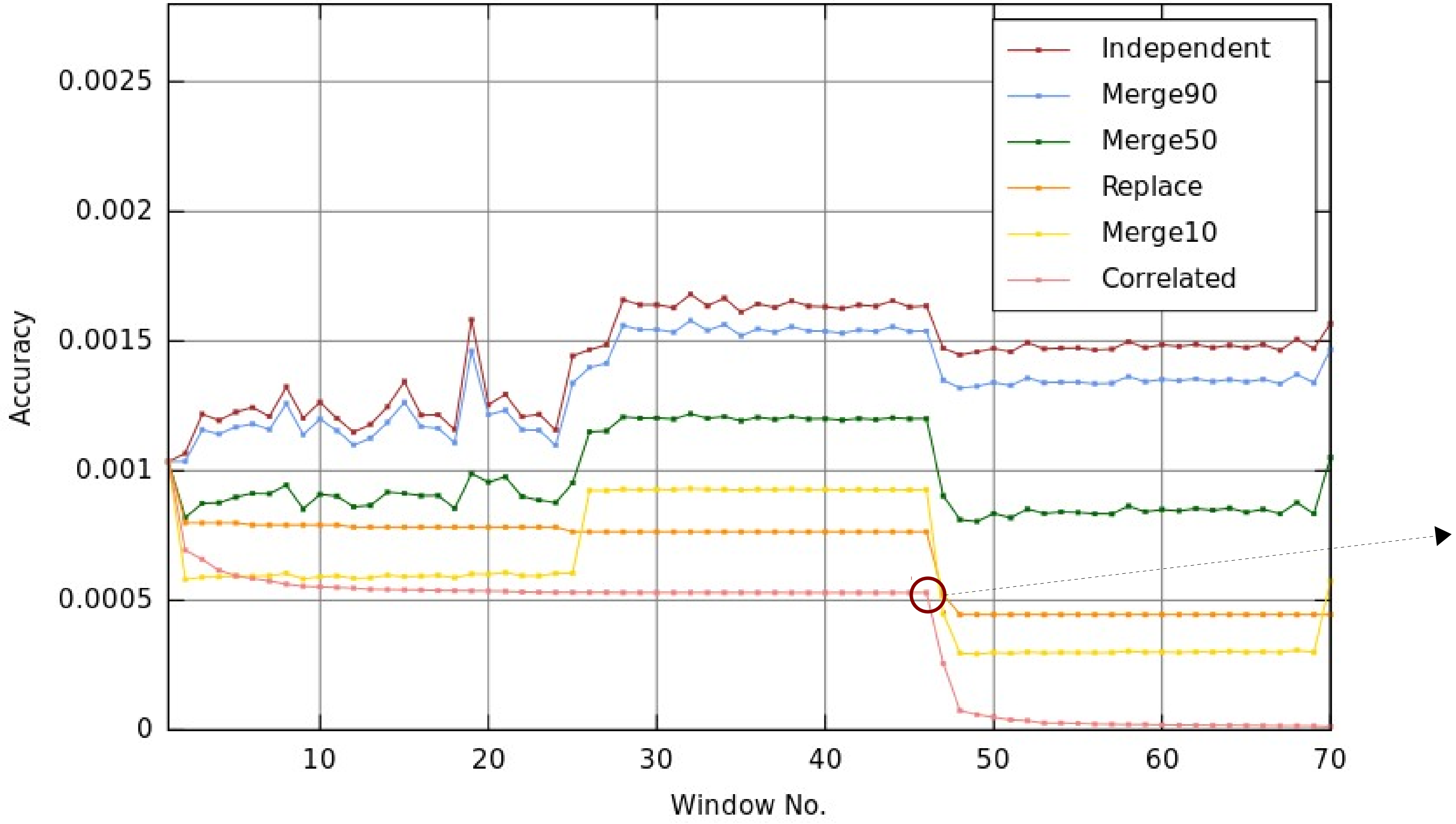




- The number of active connections in each window

Test Results (2)

- The best approach is correlated sliding window



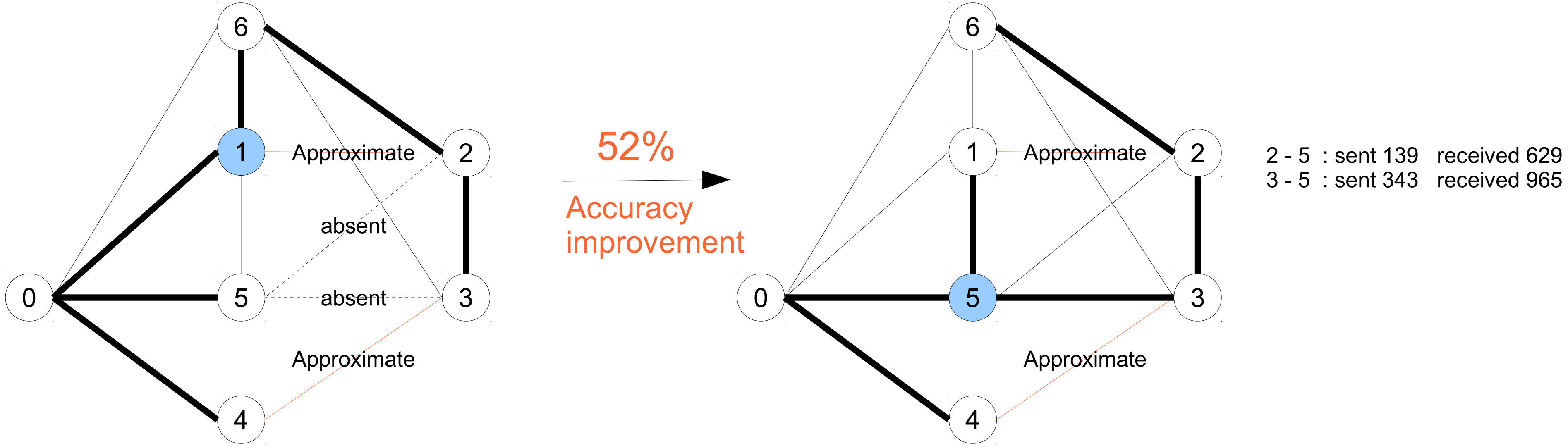
Why does accuracy change very rapidly?

Test Results (3)

- From window 1 to window 46, Node 1 is reference node
- From window 47 to window 70, Node 5 is reference node

System state before 47th Synchronization

System state in 47th Synchronization



52%

Accuracy improvement

2 - 5 : sent 139 received 629
3 - 5 : sent 343 received 965

(a)

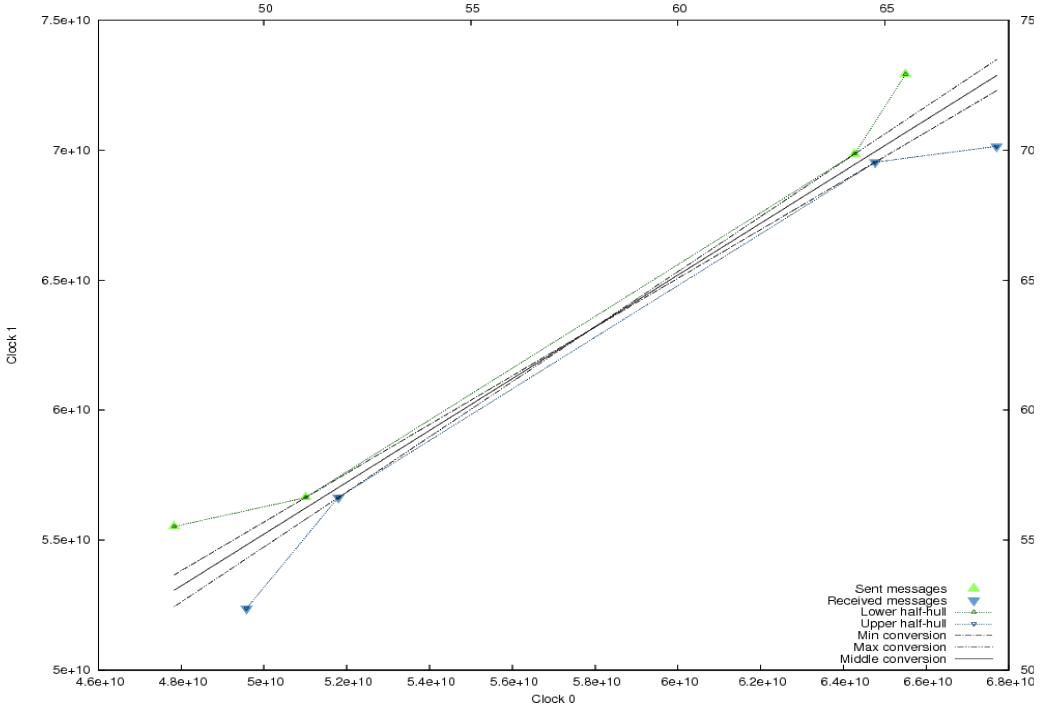
(b)

Question?

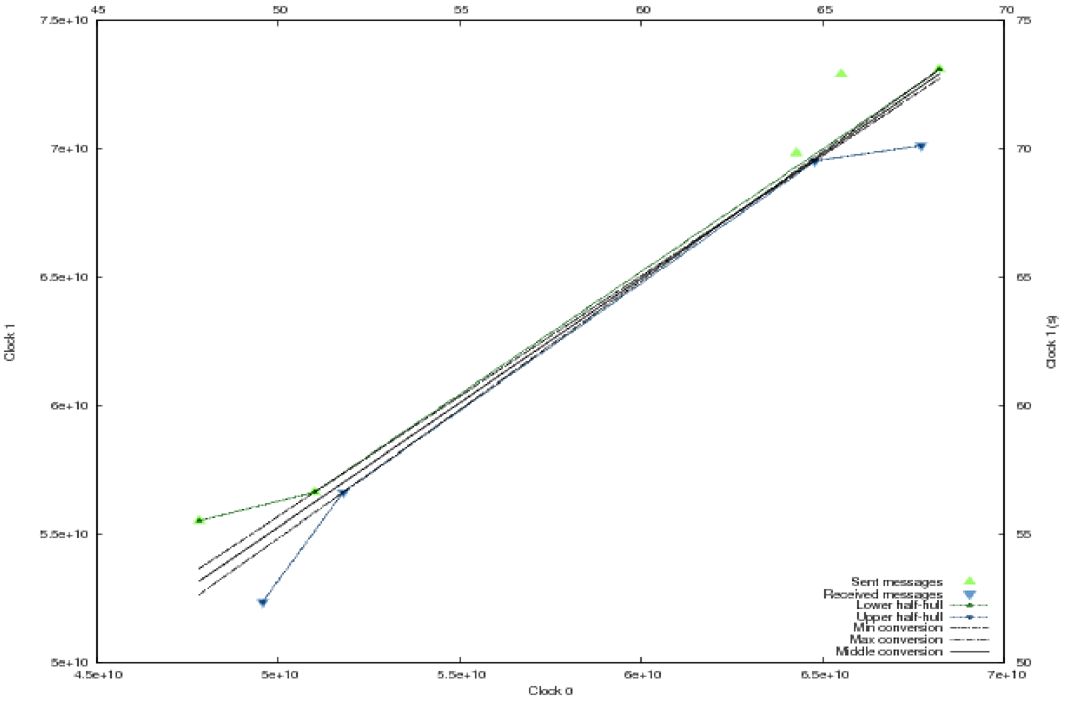
Is there any way to improve the correlated sliding window technique?

Incremental approach (1)

- The lowest distance to the middle line is the best accurate packet
- Accurate packets improve accuracy



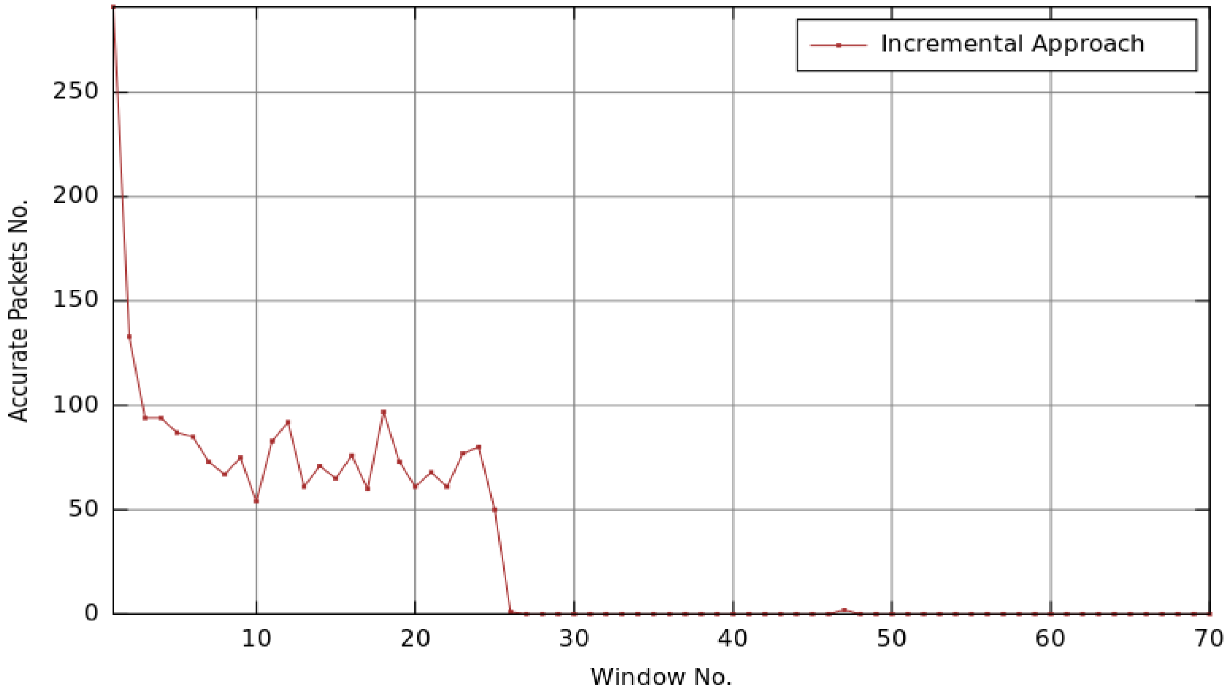
(a) Accuracy : 0.121842



(b) Accuracy : 0.067378

Incremental approach (2)

- There are many accurate packets between window 1 and 26 because there are many active connections
- If we recompute the synchronization each time an accurate packet is received, it increases the analysis time

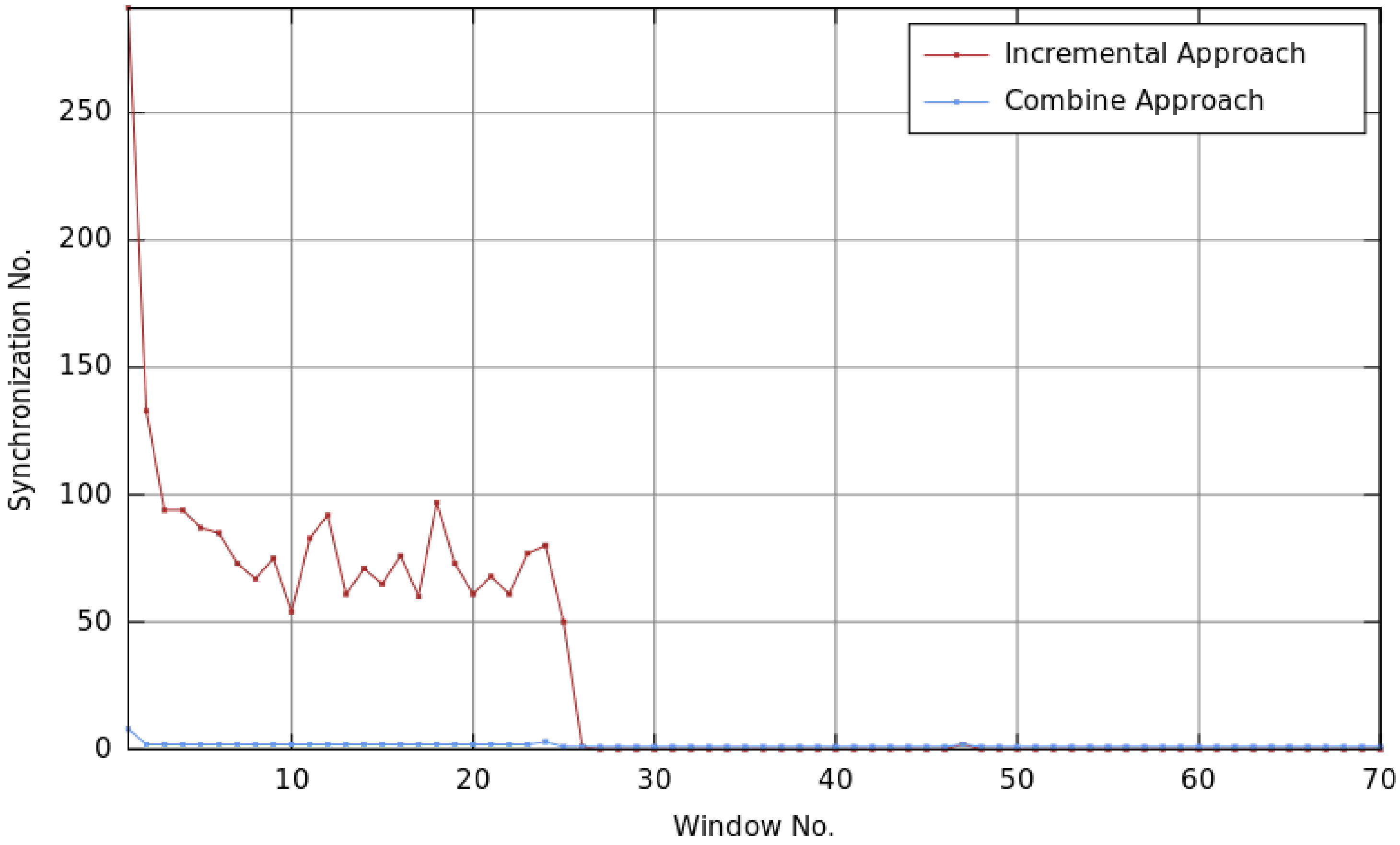


Incremental approach (3)

- Criteria to manage the accurate packets
  - Add window technique
  - Each link has <u>a chance</u> to activate time synchronization in each window
  - Synchronizing at the end of window if we were not triggered by an accurate packet
    - Sometimes a packet does not have minimum distance to the conversion functions but removes some packets on upper or lower hull (***interesting packet***)
    - Interesting packets improve accuracy a little
    - There is a trade off between the <u>*cost of synchronization*</u> and the accuracy increase we get with an interesting packet

Combined approach

- Combined approach has the same accuracy as correlated approach



Conclusion

- Live trace synchronization is ready for deployment.
- The combined approach offers an excellent compromise between performance and accuracy.

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