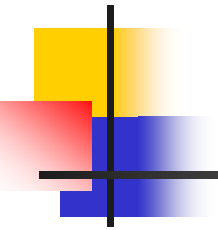
ZIGZAG : An Efficient Peer-to-Peer Scheme for Media Streaming

Presented by Chi-Hung Chao

INFOCOM 2003



Outline

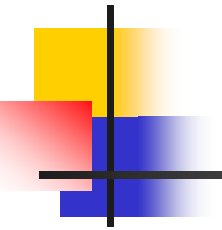
- Introduction
- Proposed Solution
- Performance Evaluation
- Conclusions

Introduction

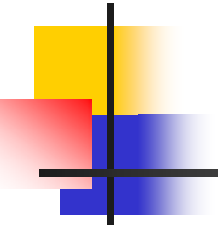
- Problem：

  Streaming live media from a single source to a large quantity of receivers on the Internet
- IP Multicast could be the best way to overcome this drawback，but……

Introduction

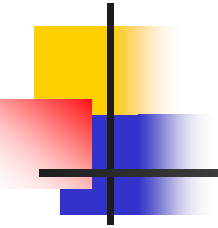


- Chaining
  - Building a delivery tree which is rooted at the source and including all receivers.
  - Receivers get the content from the source or from the other receivers.



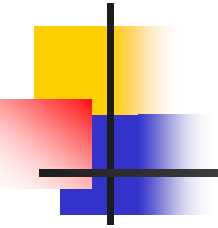
Introduction

- Important issues ：
  - End-to-end delay
    - Small tree height
    - Bounded node degree
  - Failure recovery
  - Control overhead at each receiver should be small



Introduction

- ZIGZAG：
  - Address all of the previous issues
    - Organizing receivers into a hierarchy of bounded-size cluster
    - Failure recovery can be done regionally with only impact on a constant number of existing receivers and no burden on the source.



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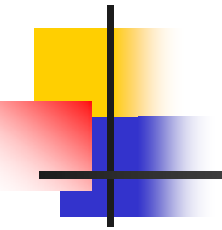


Proposed Solution

- Administrative Organization
- Multicast Tree
- Control Protocol
- Client Join
- Client Departure

Proposed Solution- Administrative Organization

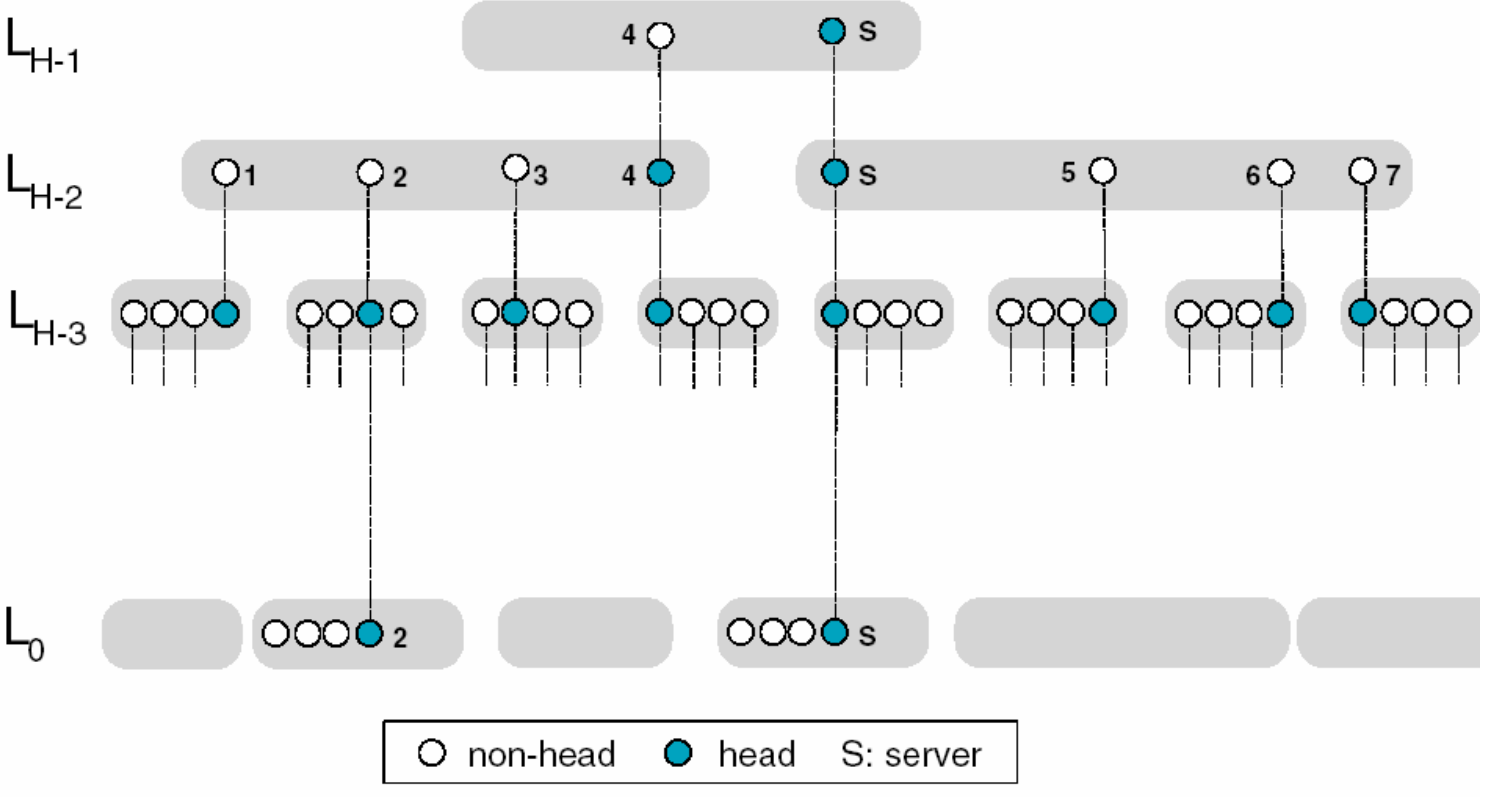
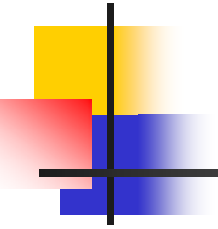


Fig. 1. Administrative organization of peers

Proposed Solution- Administrative Organization



- Layer 0 contains all peers
- Peers in layer j<H-1 are partitioned into clusters of sizes in [k,3k].Layer H-1 has only one cluster which has a size in [2,3k]
- Cluster head in layer j becomes a member of layer j+1 if j<H-1

Proposed Solution- Administrative Organization

- Subordinate
- Foreign head
- Foreign Subordinate
- Foreign cluster

Proposed Solution- Multicast Tree

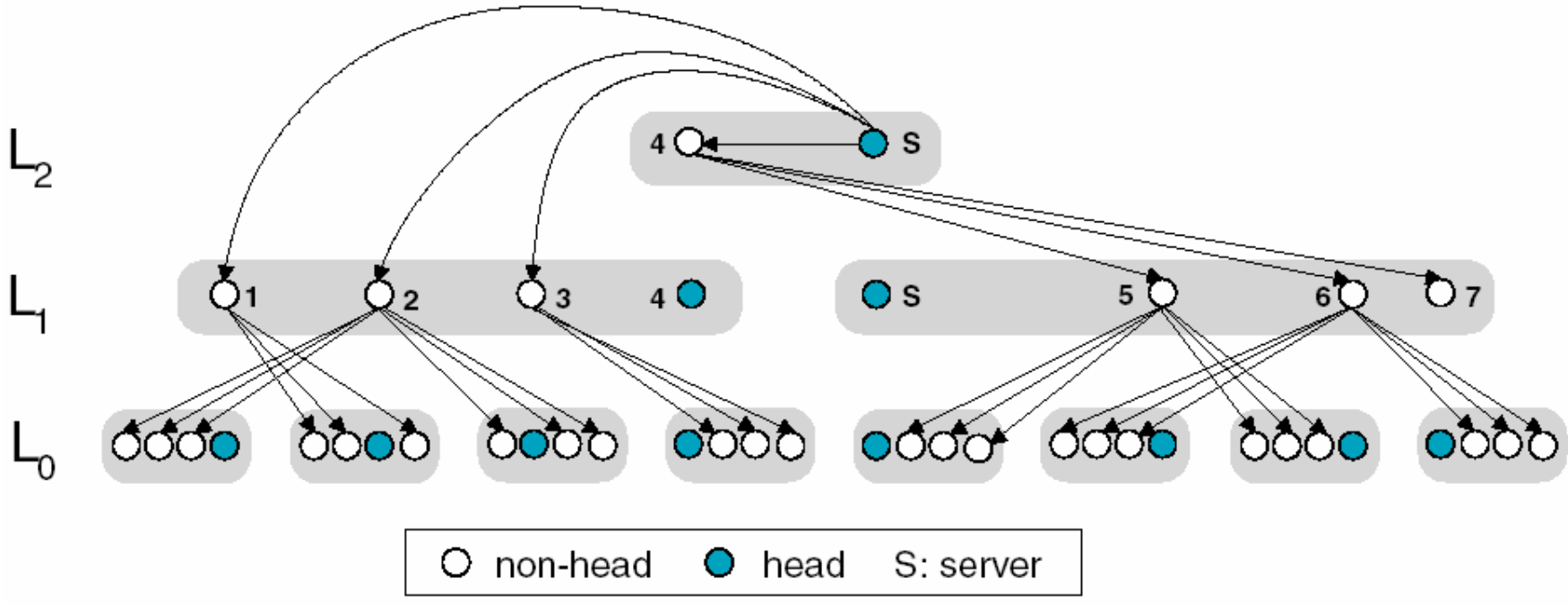
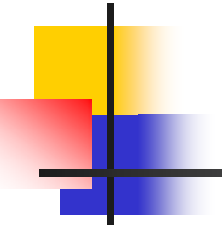


Fig. 2. The multicast tree of peers ($H = 3$, $k = 4$)

Proposed Solution- Multicast Tree



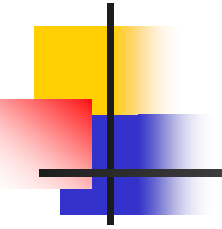
- A peer ,when not at its highest layer, cannot have any link to or from any other peer
- A peer ,when at its highest layer, can only link to its foreign subordinate. (besides server)
- Non-head members get the content directly from a foreign head

Proposed Solution- Multicast Tree

- Theorem 1 : The worst-case node degree of multicast tree is O(k^2)

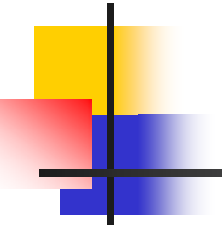
  Proof : A node has at most (3k-1) foreign cluster, thus having at most (3k-1)X(3k-1) foreign subordinates. Therefore the server degree is at most (3k-1)X(3k-1)+(3k-1)= $9k^2 - 3k$.Theorem 1 has been proved
- Theorem 2 : The height of the multicast tree is O($log_k N$)

Proposed Solution- Multicast Tree



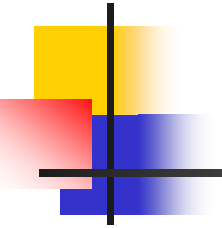
- A peer gets the content from a foreign head, but not its head, and can only forward the content to its foreign subordinate, but not its subordinate.
- Suppose the members of a cluster always get the content from their head. A node would have larger degree if it is closer to the source.

Proposed Solution- Multicast Tree



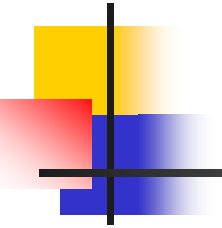
- Using a foreign head as the parent has another nice property.
  - When the parent peer fails, the head of its children is still working, thus helping reconnect the children to a new parent quickly and easily.

Proposed Solution- Control Protocol



- To maintain its position and connections in the multicast tree and the administrative organization, each node X periodically communicates with its clustermates, children and parent on the multicast tree.

Proposed Solution- Client Join



- Some functions in the algorithm
  - Reachable(X)
  - Addable(X)
  - D(X)
  - D(X,Y)

Proposed Solution- Client Join

1. If X is a leaf
2. Add P to the only cluster of X
3. Make P a new child of the parent of X
4. Else
5. If $Addable(X)$
6. Select a child Y:
   $Addable(Y)$ and $D(Y)+d(Y, P)$ is min
7. Forward the join request to Y
8. Else
9. Select a child Y:
   $Reachable(Y)$ and $D(Y)+d(Y, P)$ is min
10. Forward the join request to Y

Proposed Solution- Client Join

- Theorem：The join overhead is $\mathrm{O}(log_k N)$ in terms of number of nodes to contact.

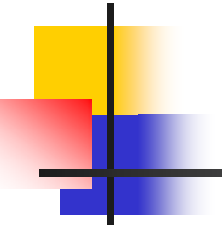
Proof：

height=O($log_k N$)

degree=O(k^2)

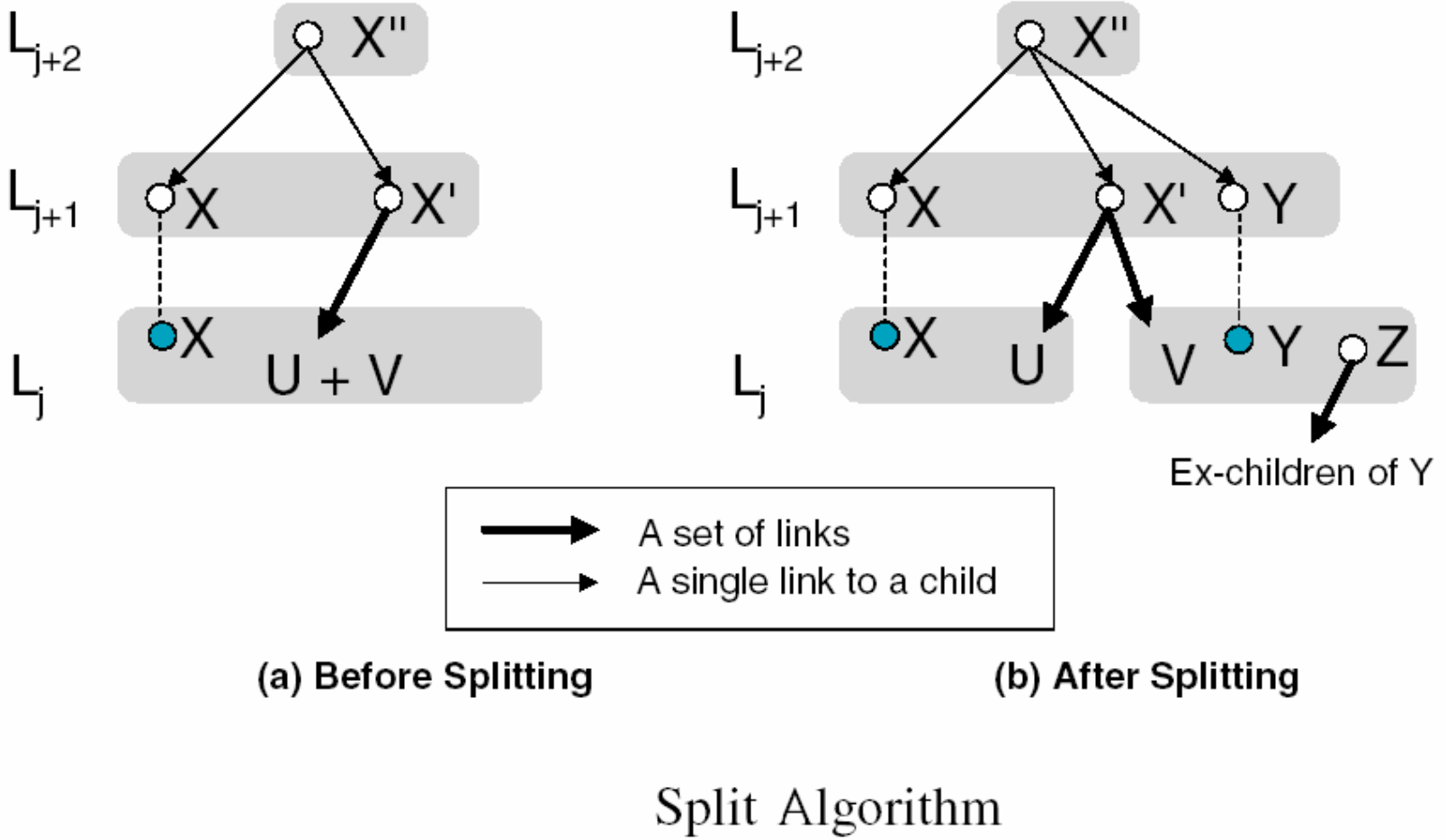
overhead=O(k^2 x$log_k N$)= $\mathrm{O}(log_k N)$

Proposed Solution- Client Join



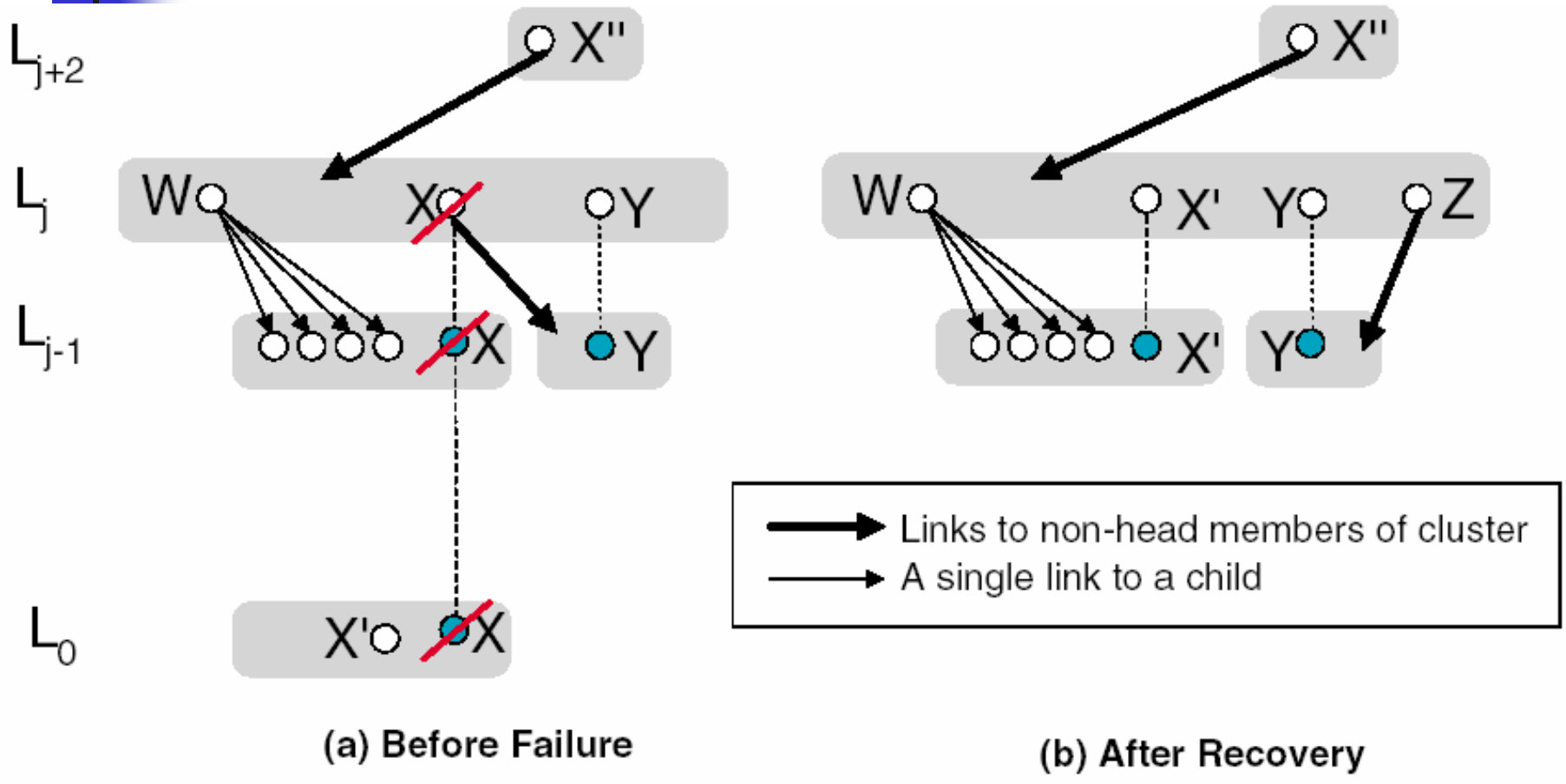
- If the new size of the joined cluster is over 3k, the cluster has to be split so that the newly created clusters must have sizes in [k,3k]

Proposed Solution- Client Join

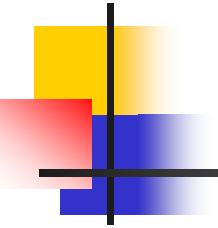


Split Algorithm

Proposed Solution- Client Departure



Outline



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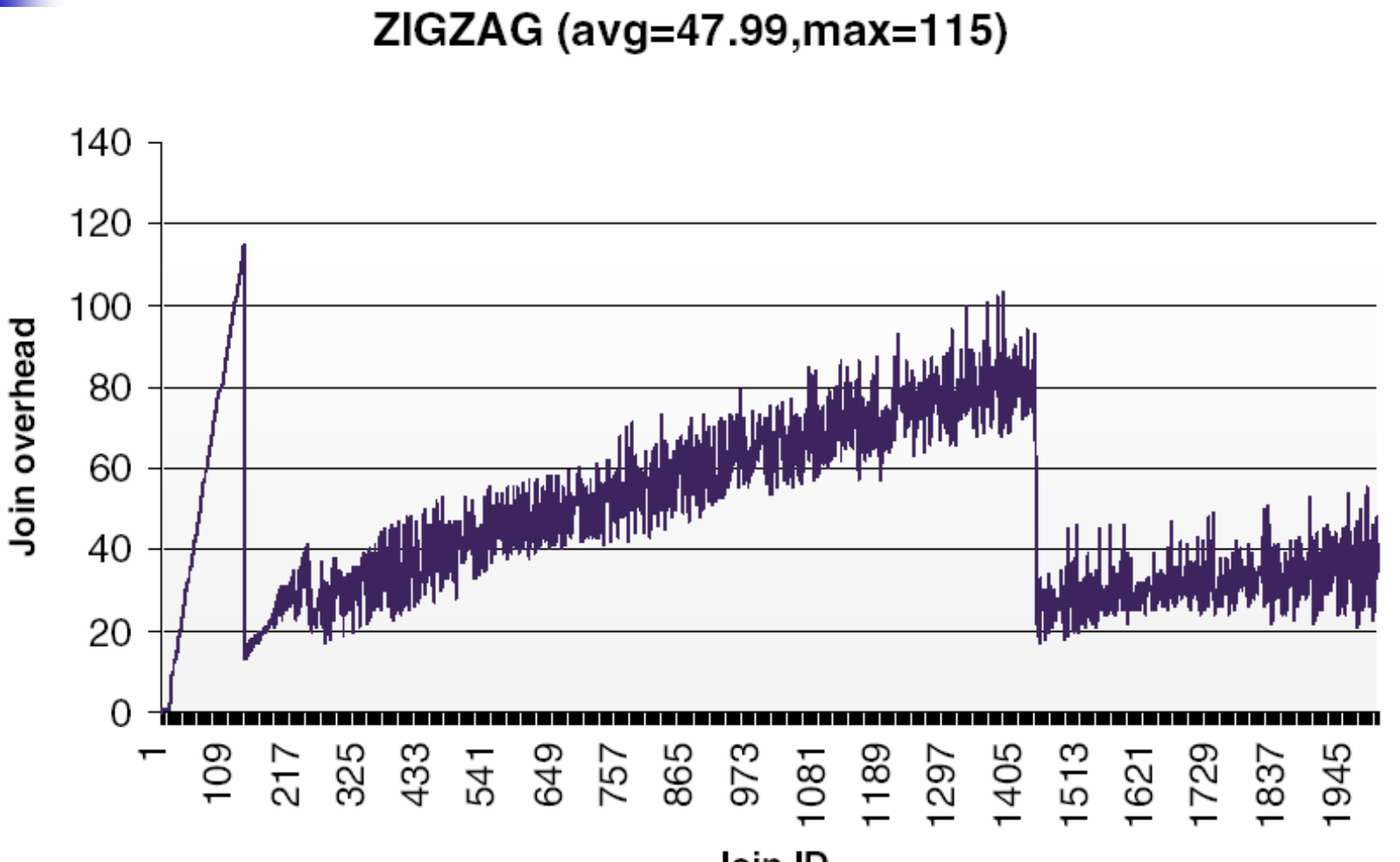
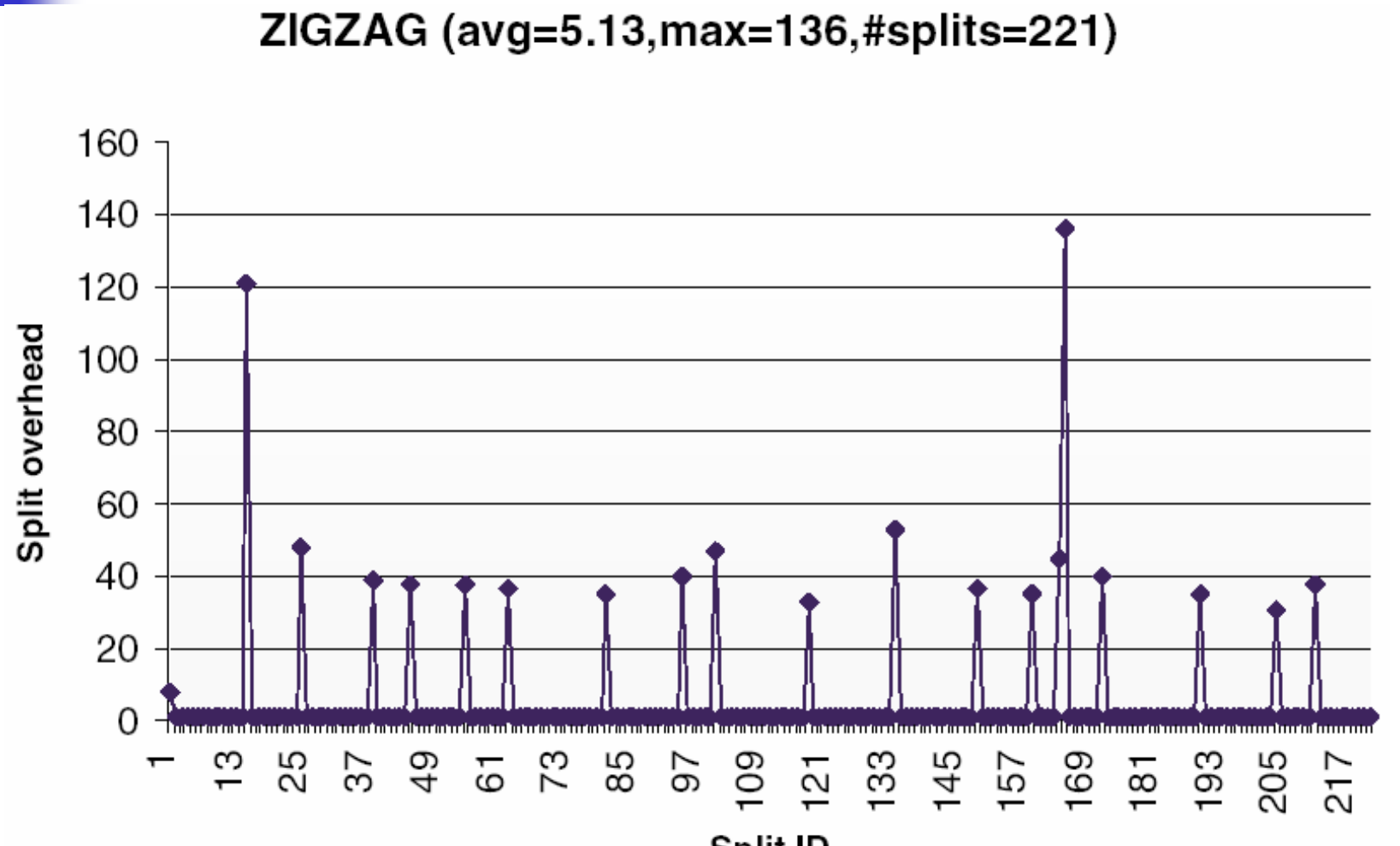
Performance Evaluation

- N=2000 ， k=5
- 3 scenarios
  - Failure free
  - Failure possible
  - Comparing ZIGZAG to NICE

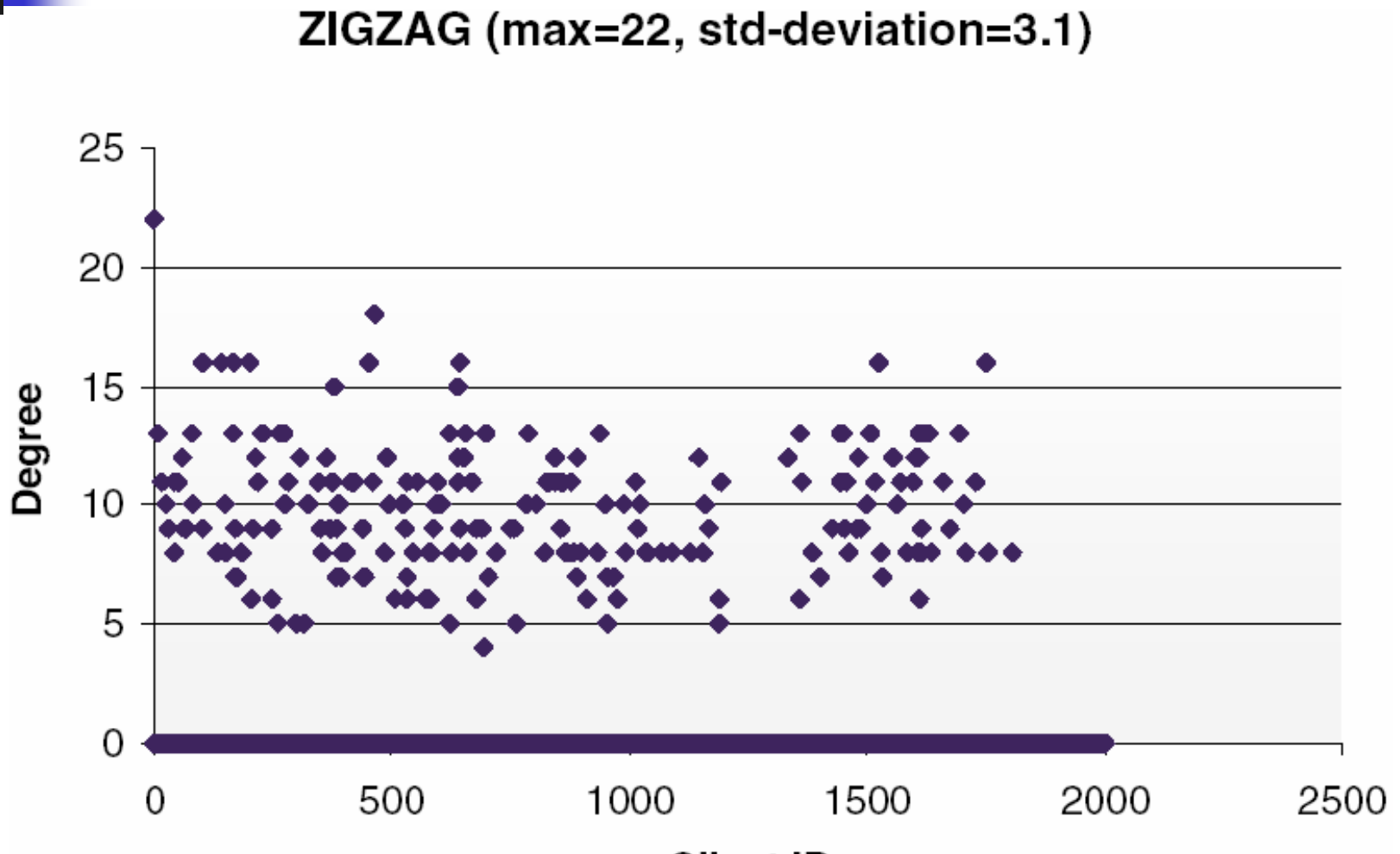
Performance Evaluation Failure Free



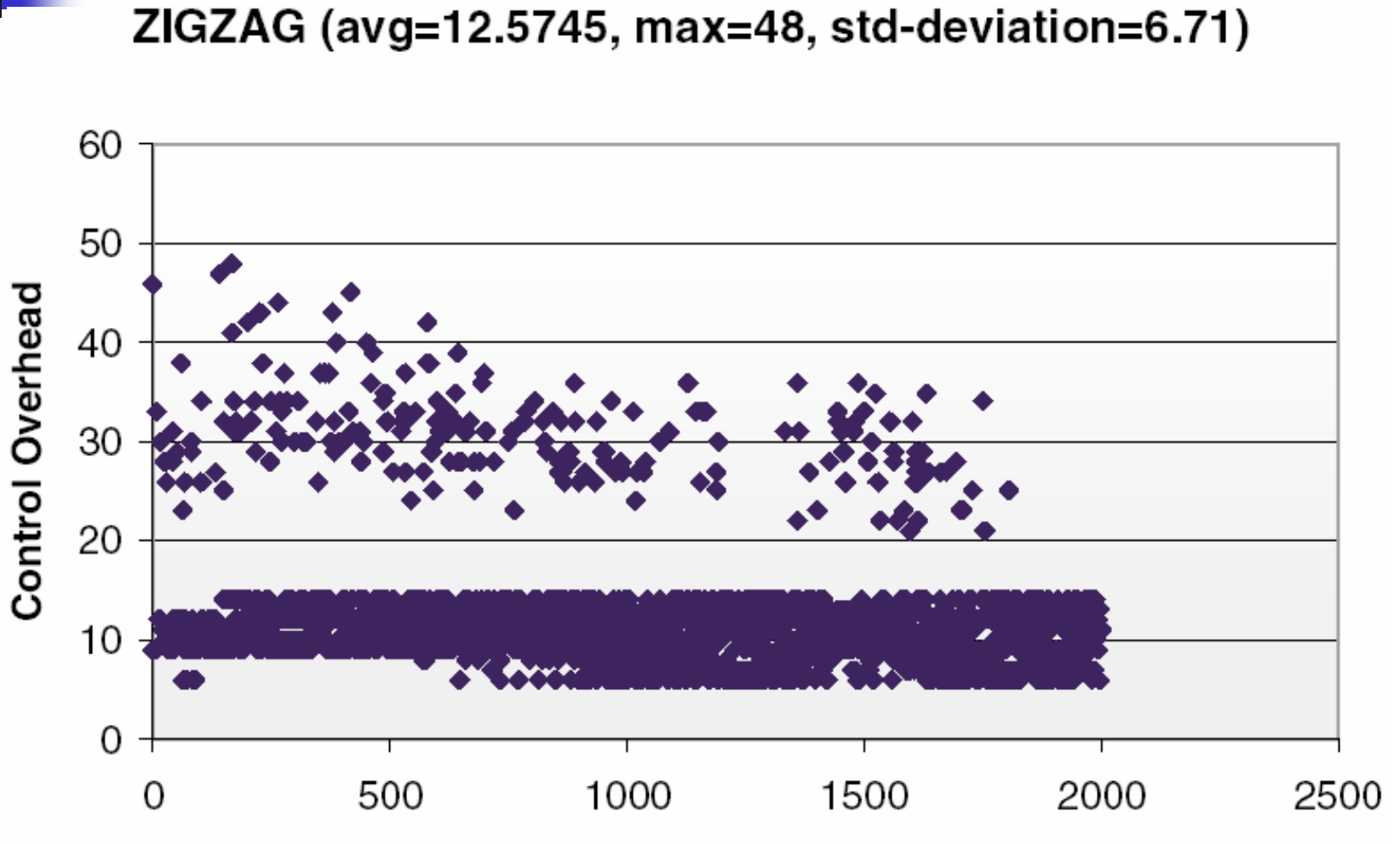
Performance Evaluation Failure Free



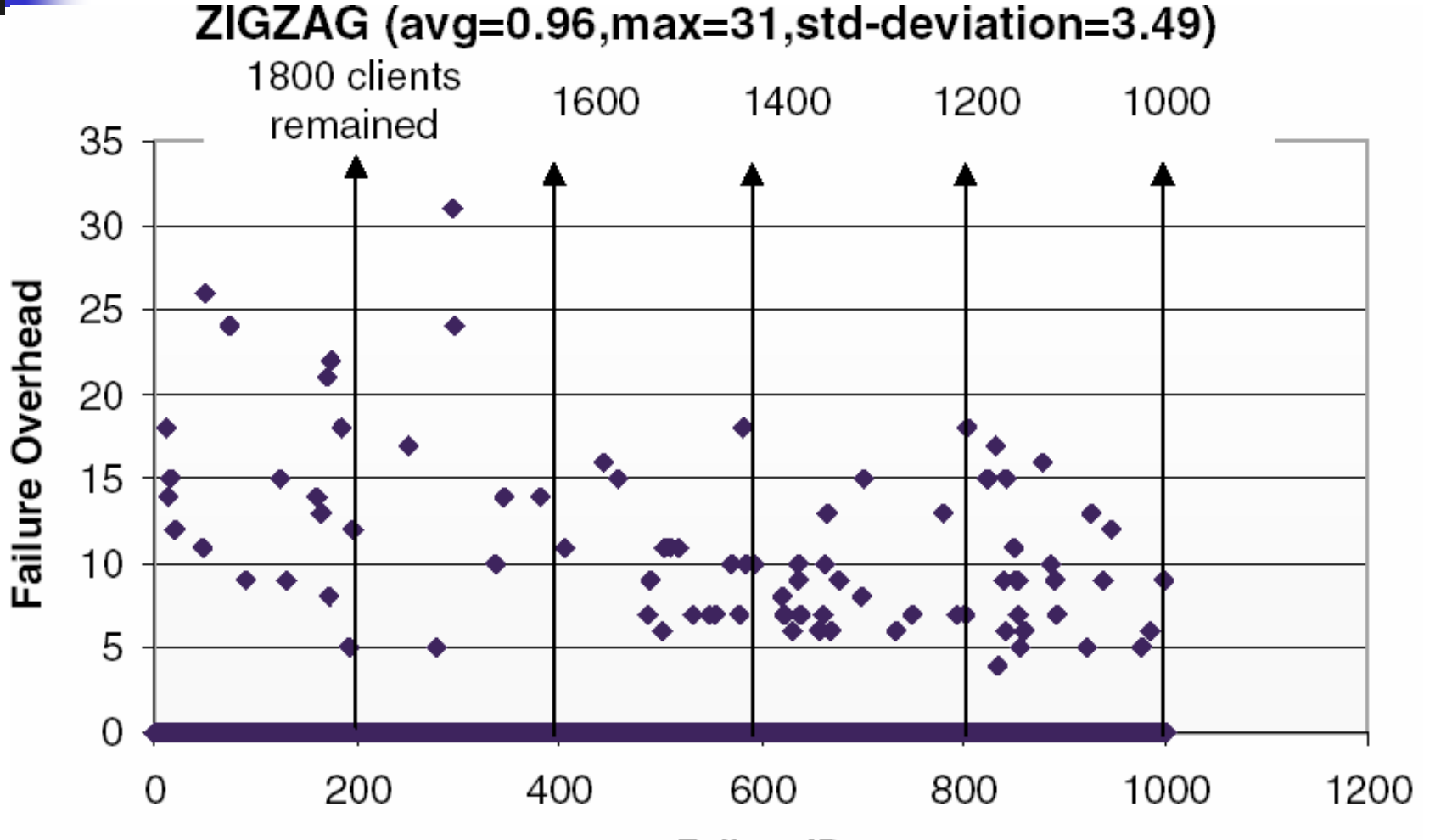
Performance Evaluation Failure Free



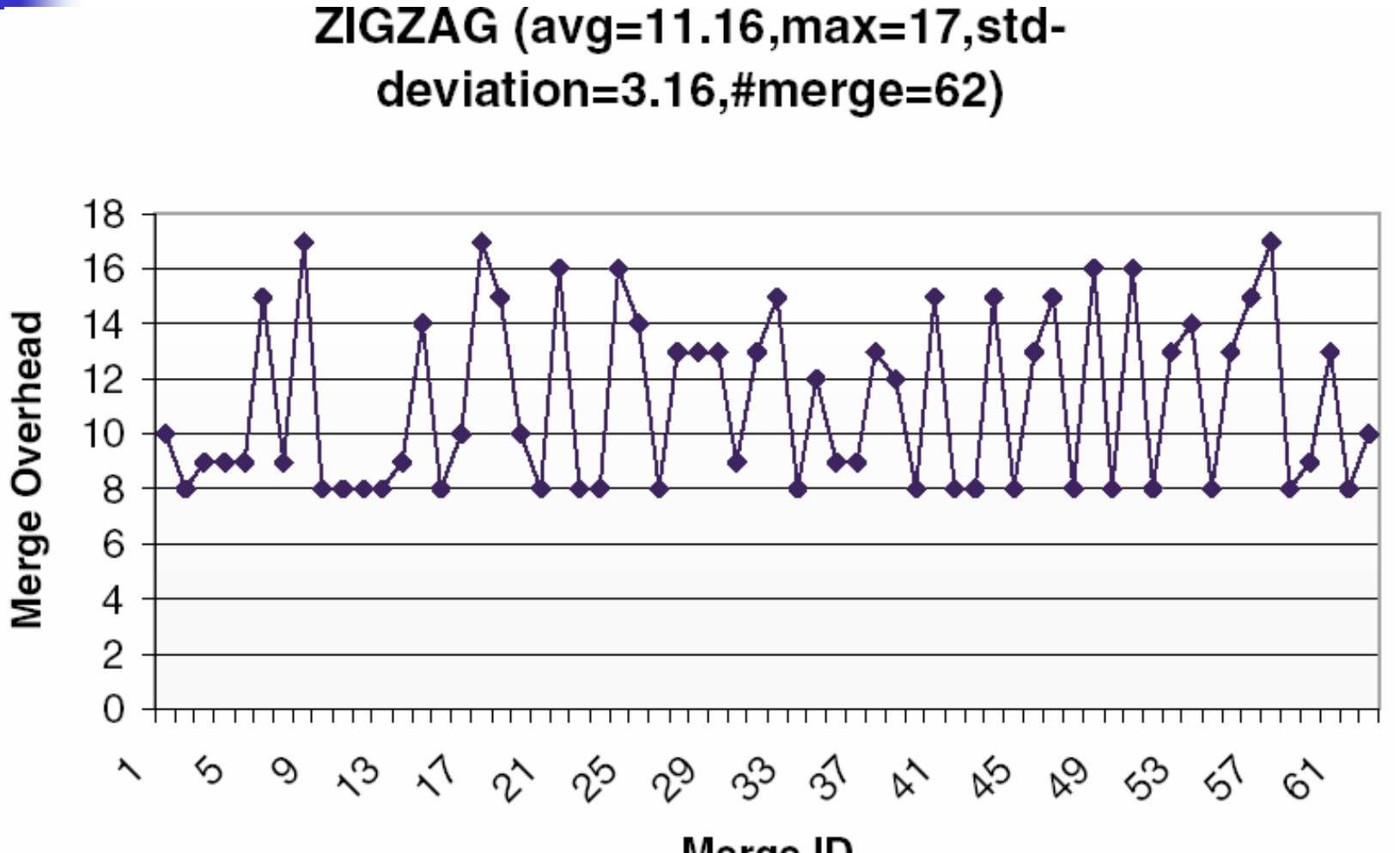
Performance Evaluation Failure Free



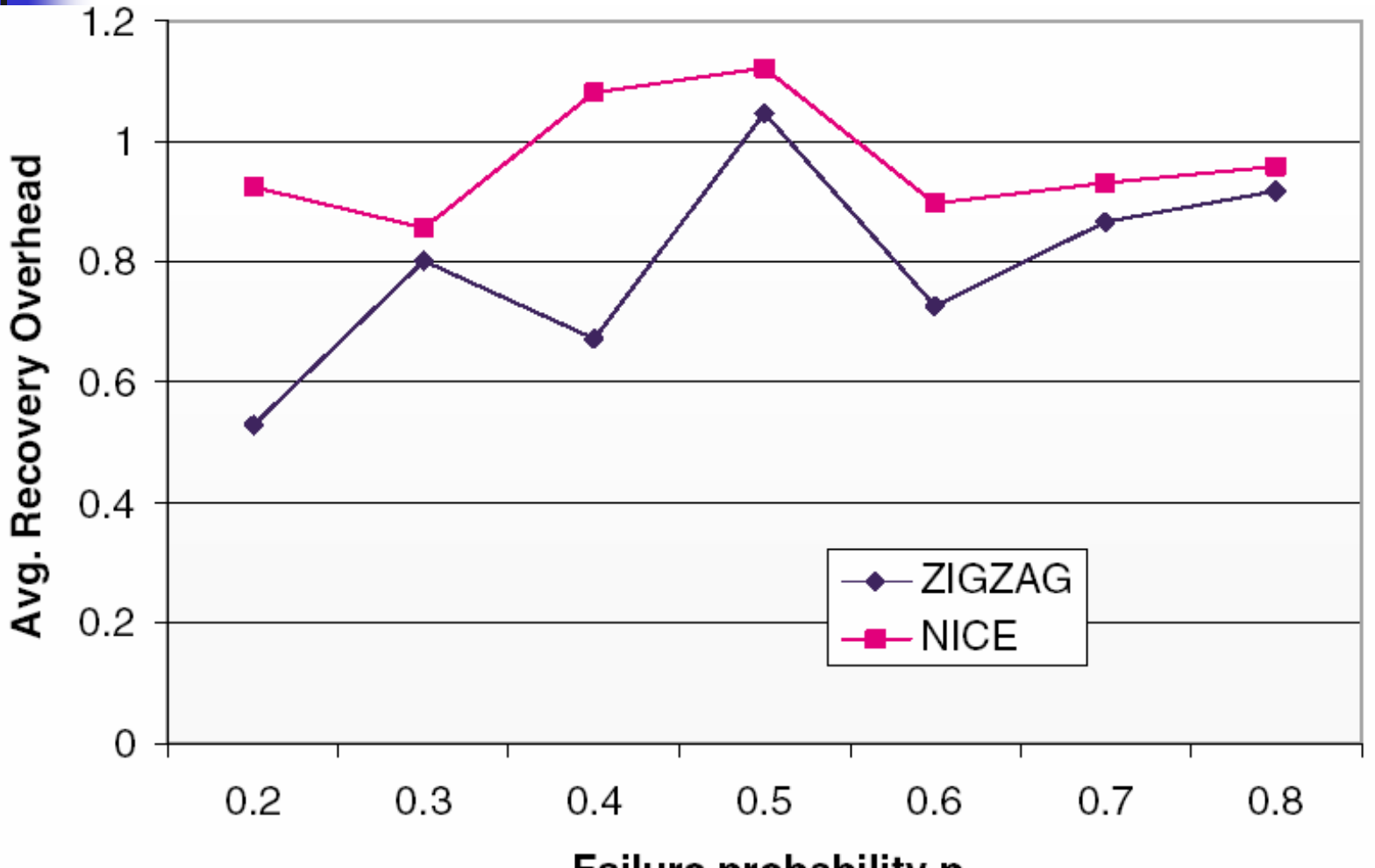
Performance Evaluation Failure Possible



Performance Evaluation Failure Possible



Performance Evaluation ZIGZAG vs NICE



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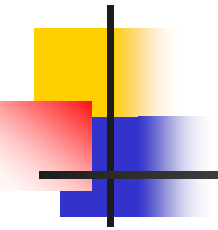

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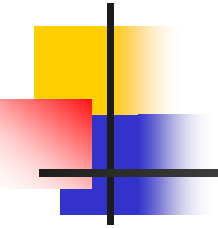

Conclusions

- The key in ZIGZAG's design is the use of a foreign head to forward the content.
- 4 properties
  - Short end-to-end delay
  - Low control overhead
  - Efficient join and failure recovery
  - Low maintenance overhead