Lateral Error Recovery for Application-Layer Multicast

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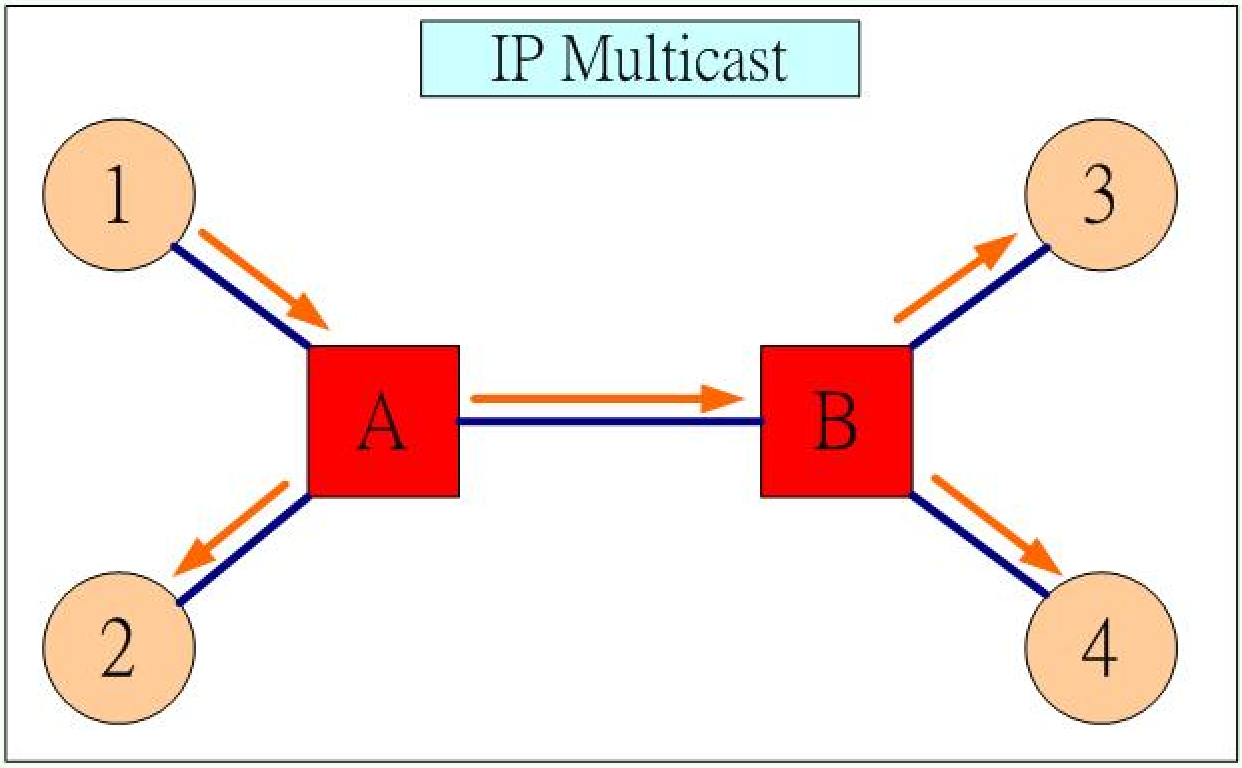
What is ALM?

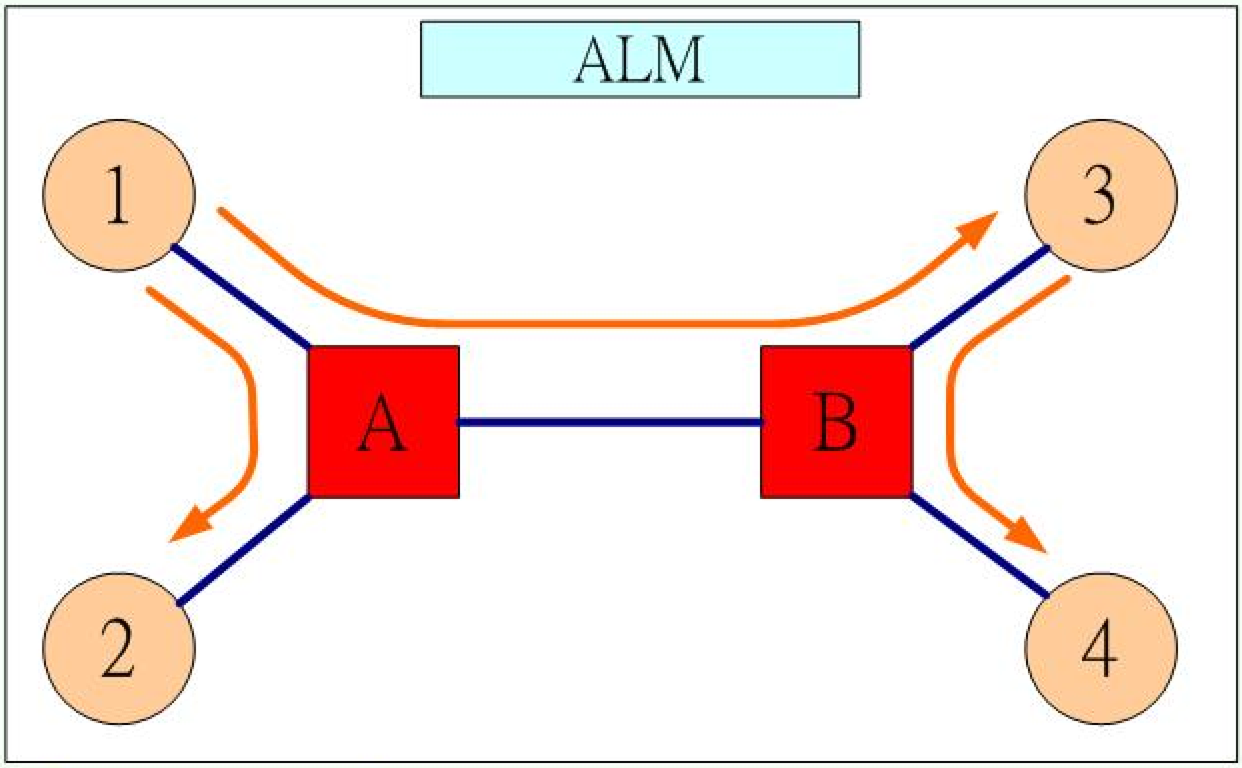
Multicast Applications:

File distribution, video conferencing, movie streaming, etc

Application-level Multicast (ALM):

- Promising technique to overcome the limitations in IP multicast for point-to-multipoint applications.
- Multicast functionality shifted from network layer to end-hosts.





Previous work:

- Focusing mainly on *connectivity* among the hosts.

Our Concern

Quality of Service (QoS):

Error recovery mechanism

Objective:

Deciding fast error recovery scheme without compromising the ALM tree performance (in terms of physical link stress and relative delay penalty, RDP)

Vertical recovery:

The error host requests retransmission from the parent or the ascendants (e.g. origin) of the error host. Two simple examples are studied:

Source Recovery - Retransmission performed with source only

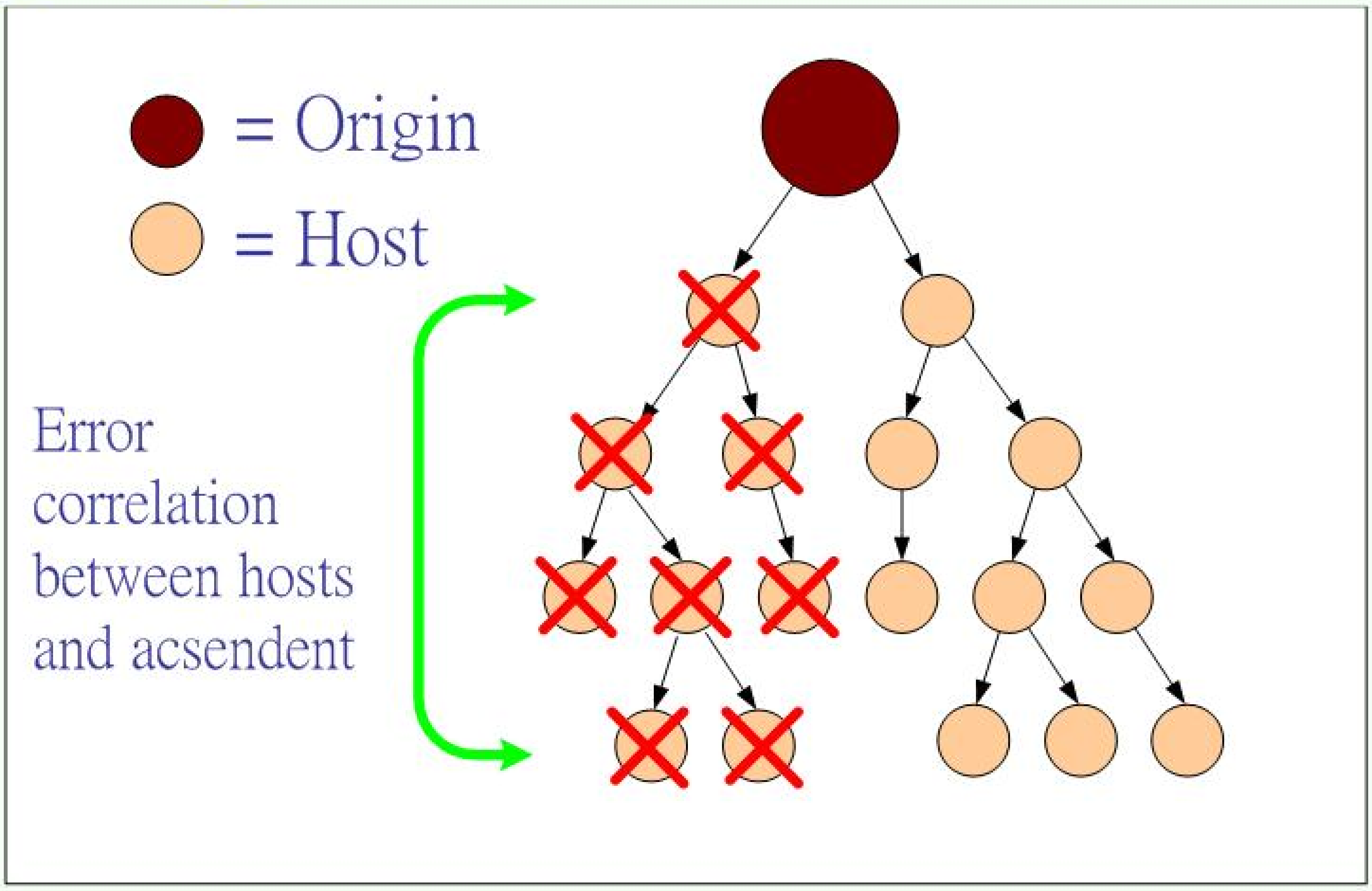
Parent Recovery - Error host repeatedly request the parent for retransmission

Weaknesses of vertical recovery:

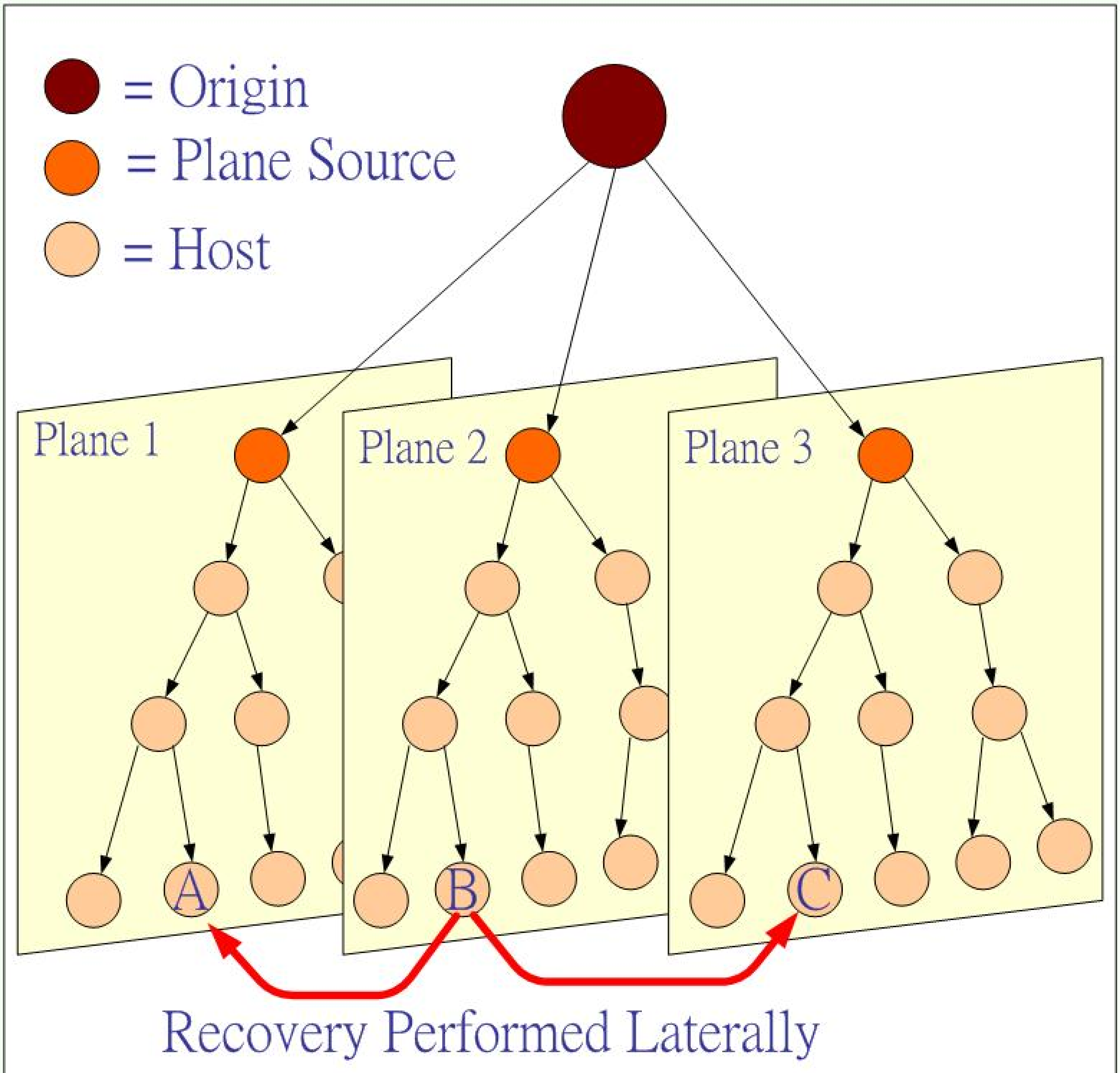
(1) Error correlation between host and the parent

(2) Implosion problem

(3) Outage due to host/link failure



Lateral Error Recovery (LER)



Lateral error recovery (LER):

- Randomly distribute hosts into a number of planes (w).
- Delivery tree is constructed independently for each of the planes.
- Identify the recovery neighbors (In the example host B identifies hosts A and C in the other planes as the recovery neighbors)
- Error retransmission performed laterally with the recovery neighbors
- The recovery neighbors identifying processes are performed before data delivery, no delay introduced upon discovery of error.

Strengths of LER:

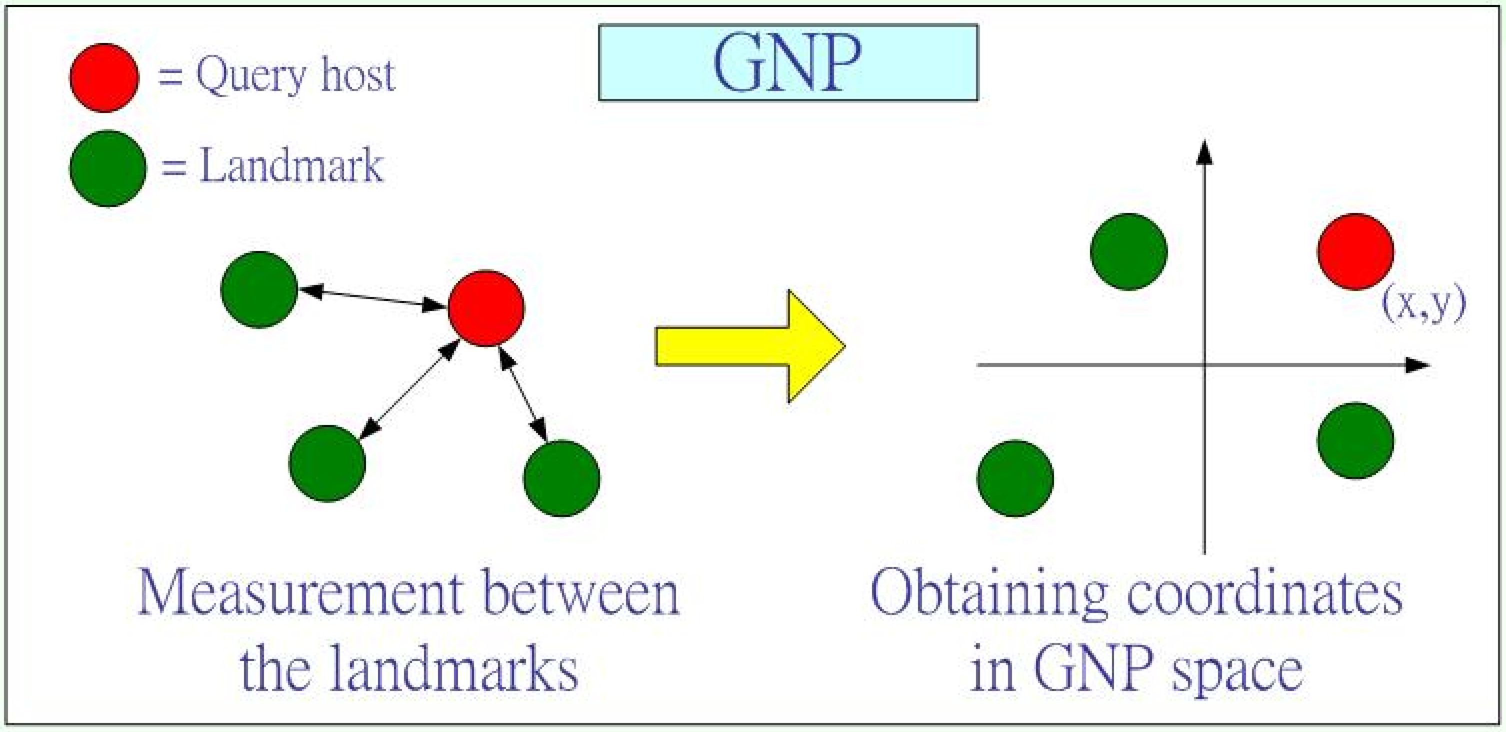
- Error correlation is reduced due to the random nature of dividing hosts into planes.
- Implosion problem is greatly relieved
- The error hosts can be pictured as temporarily attached to its recovery neighbors upon node/link failure

Issues:

1) How are the plane sources selected?
2) How to select ones recovery neighbors, and upon an error, which of them should be requested for retransmission?

1) Selection of Plane Sources

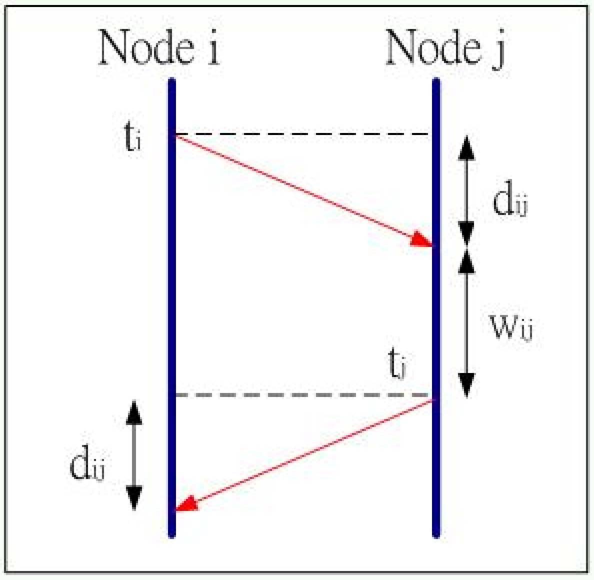
- Plane source served as the middle men between the origin and the plane hosts
- Selecting the host in each plane that are closest to the origin
-Using global network positioning (GNP) to obtain the coordinates of hosts in the GNP space
- Closest plane sources can be obtained by constructing Voronoi diagram by a distributed algorithm for each plane



2) Identification and Ordering of Recovery Neighbors

- Finding the close hosts in the other planes as the recovery neighbors
- The constructed Voronoi diagrams can be reused to obtain the recovery neighbors

- If the number of planes > 2, multiple number of recovery neighbors
- Order of attempts should be considered



The minimum turnaround time, R_{ij} for each recovery neighbor j of host i:

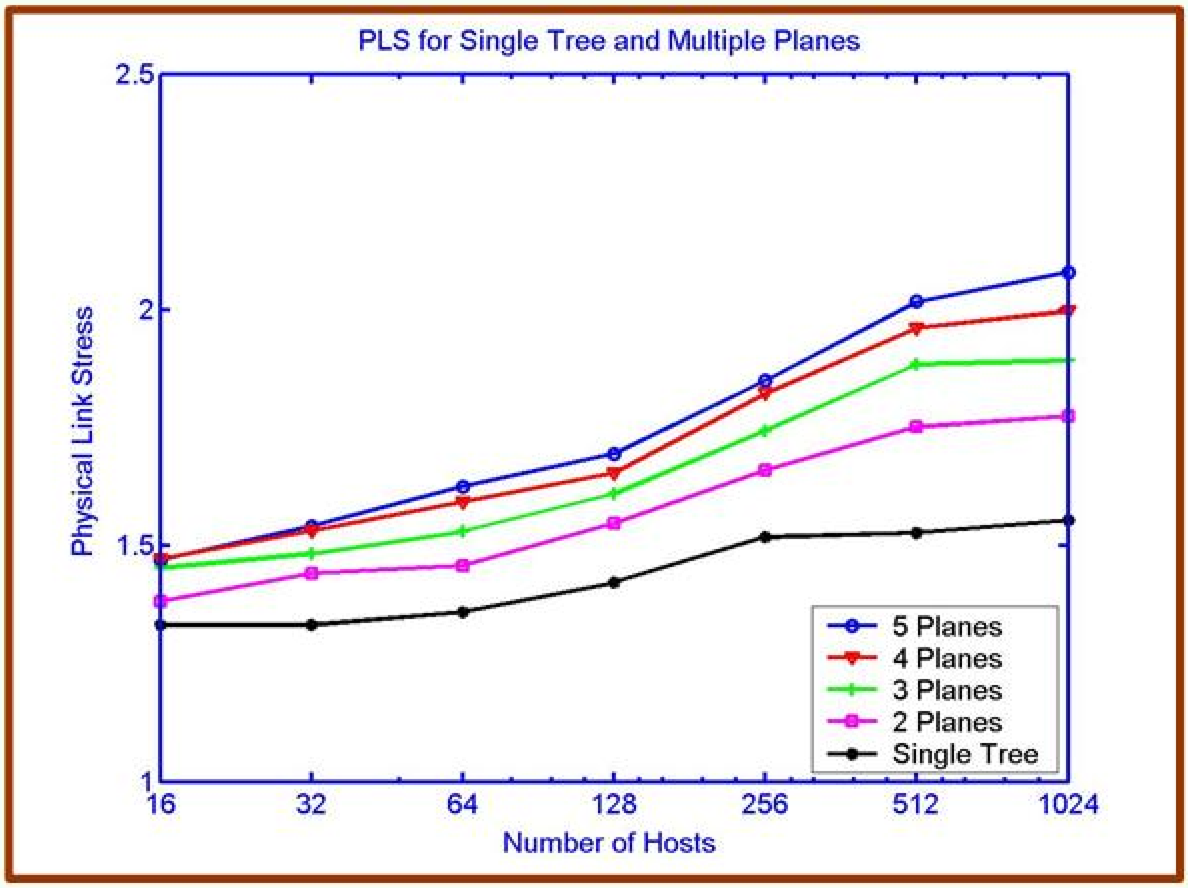
$$R_{ij} = 2d_{ij} + w_{ij}$$

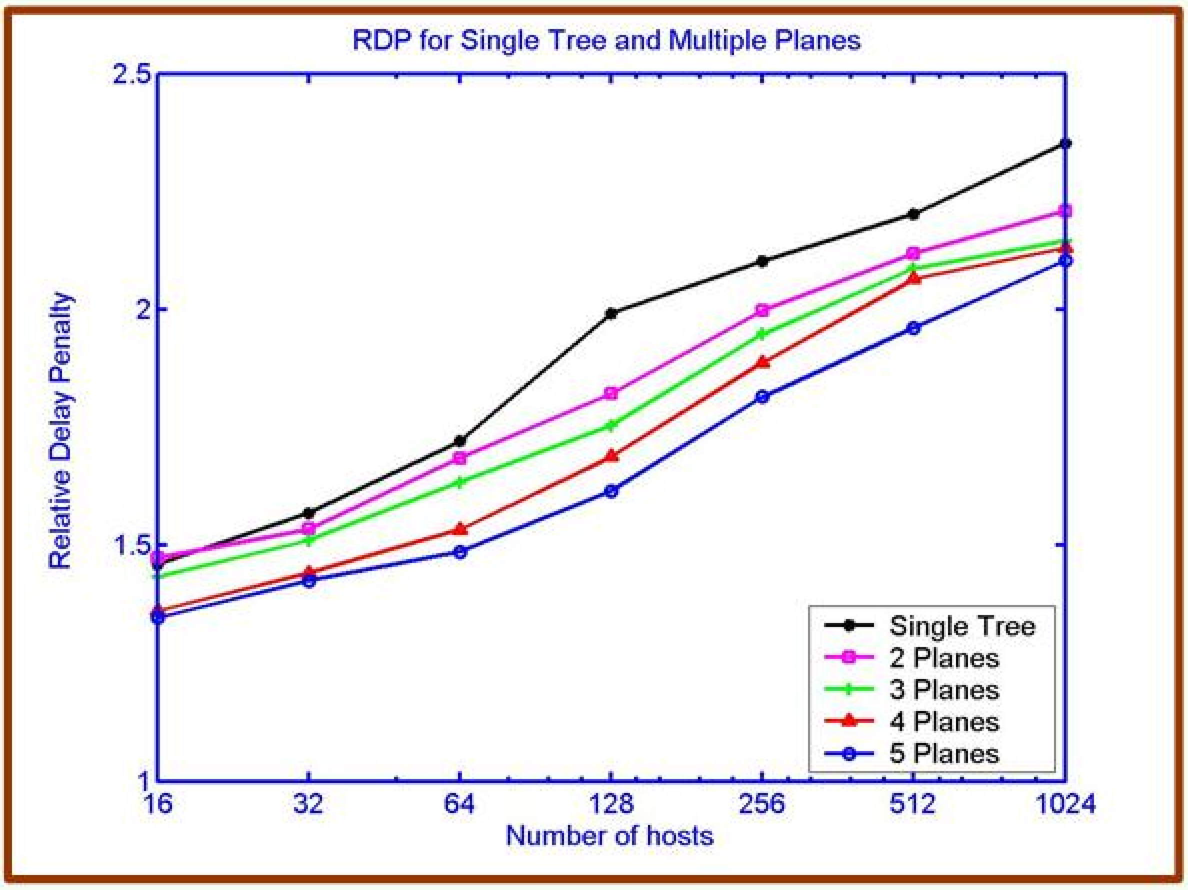
$$\text{where } w_{ij} = \max(0, t_j - t_i - d_{ij})$$

- Order of the attempts can be determined by sorting the value of R_{ij}
- Required parameters for calculating R_{ij} can be obtained by control messaging

Simulation Results

- Simulation performed by using an existing ALM scheme Delaunay Triangulation (DT) on Internet-like topologies
- The overhead of the system measured in terms of physical link stress (the average number of duplicated packets for each physical link).
- Our scheme reduce the relative delay penalty, RDP (the delay penalty comparing with IP multicast) due to reduction on tree depth.





- We compare our scheme with the two simple vertical recovery schemes. The performance is measured in terms of error rate in streaming application.