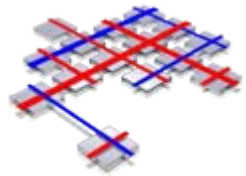
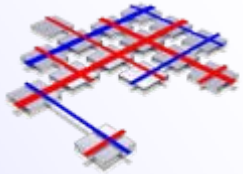
DMMP: A New Dynamic Mesh-based Overlay Multicast Protocol Framework

Jun Lei, Xiaoming Fu, Dieter Hogrefe

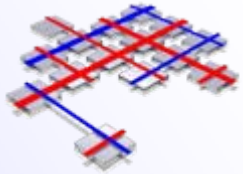
Telematics group
University of Göttingen, Germany





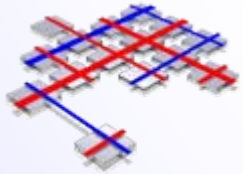
Outline

- Background and Motivations
- DMMP Framework Overview
- Further Analysis on DMMP Properties
  - Number of non-leaf nodes for tree construction
  - Tree depth
  - Resilience
- Discussions on Performance Metrics
- Conclusion and Future Work



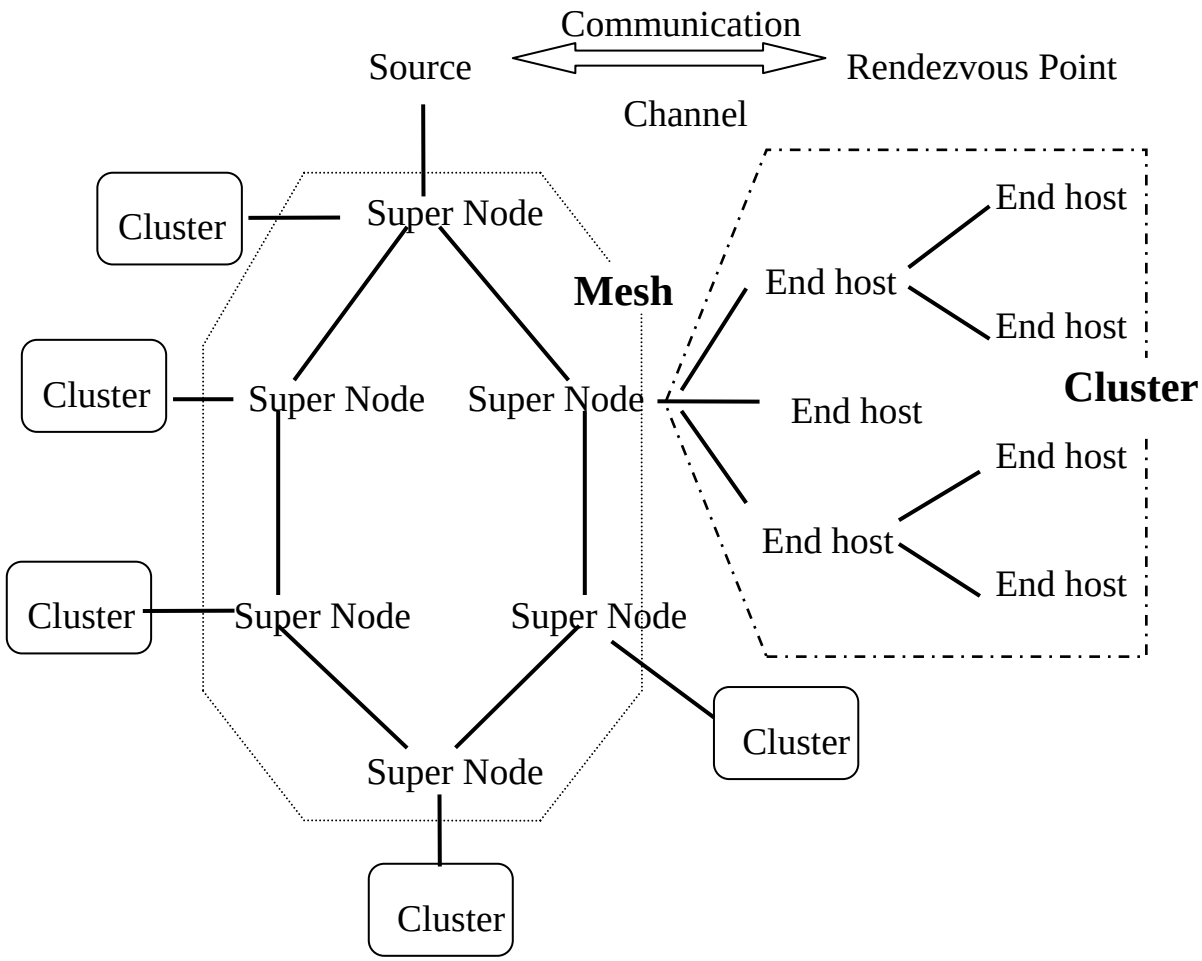
Background and Motivations

- Application level multicast solutions proposed to solve IP multicast issues
  - Application Layer Multicast (ALM)
  - Overlay Multicast (OM)
- Explosive growth of multimedia services
  - scalability of serving clients
  - reliability of media streaming applications
- DMMP properties
  - Supporting heterogeneous capacities
  - Considering e2e delay
  - Being relatively stable and resilient

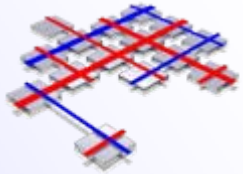


DMMP Framework Overview

- Two phases in DMMP framework construction
  - On-demand overlay core
  - Core-based clusters
- Overlay hierarchy construction
  - overlay mesh creation (super node selection)
  - local clusters formation
- A hybrid approach of ALM & OM

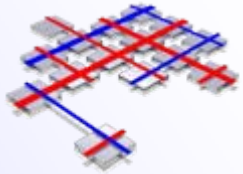


An example of DMMP overlay hierarchy



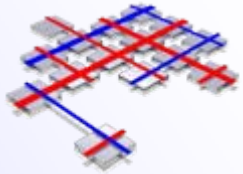
Further Analysis on DMMP Properties

- Required number of non-leaf nodes
- Tree depth
- Resilience properties



Required Non-leaf nodes

- Degree-constrained spanning tree
- Heterogeneous capacity
  - Assumption
    - m hosts participating in the cluster
    - α: percentage non-leaf nodes
    - out-degree for non-leaf node: n_i
  - Composing overlay multicast tree in the cluster
    - $\sum_{i=0}^{m} n_i \geq 2m$ and $n_i \geq 1$ => $(1-\alpha)\cdot m + \sum_{i=0}^{m\cdot\alpha} n_i \geq 2m$
    - Example: the distribution of n_i is arithmetical series (d=0.5)
      - $m\cdot\alpha^2 - (4\, n_1 - 5)\alpha - 4 \geq 0$
      - $\alpha \geq 0.06324$ if m=1000, n_1=2



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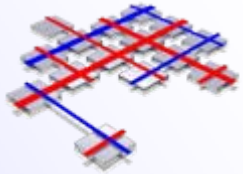
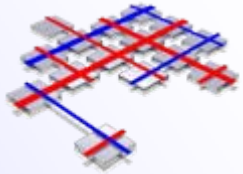


Analysis on Tree depth

- To reduce the overlay delay of multicast tree
  - Observing from the time-constraints of media streaming systems
  - Regarded as the multicast tree within each cluster as short as possible
- Best and worst case
  - Best case: all nodes with high out-degree occupy high level positions, $\log_{n-1}^{m(1-\alpha)}$
    - Example: attaching to the tree by accepting the best invitation
  - Worst case: leaf nodes placed at the high level, $[(1-\alpha)\cdot m/(n-2)]$
    - Example: attaching to the tree without invitation



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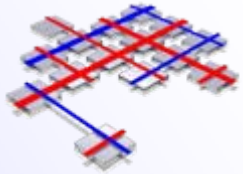
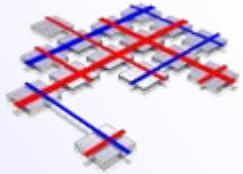


Resilience to dynamic changes

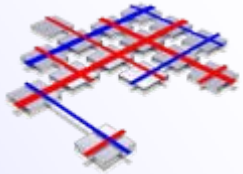
- QoS issues for media streaming services
  - Unstable network status
  - More susceptive in application level multicast approach
    - Transient nodes
    - Dynamic changes: nodes join/leave at will
- DMMP solutions
  - Failure detection: soft state (REFRESH & PROBE msgs)
  - Non-leaf node failures: proactive mechanism
    - periodically pushing high capacity nodes to high levels
    - Combination uptime with available bandwidth

$$C_i = b_i + \frac{b_i}{N} \cdot t_i, \quad 1 \le i \le N$$



Discussions on Performance Metrics

- Performance metrics
  - Stress
    - Number of identical copies of a packet carried by a physical link (or a node)
    - Average stress & maximum stress
  - Stretch
    - capability of corresponding super node
    - tree depth of the cluster
  - Overhead
    - mesh management overhead
    - cluster maintenance overhead



Investigation on Stress

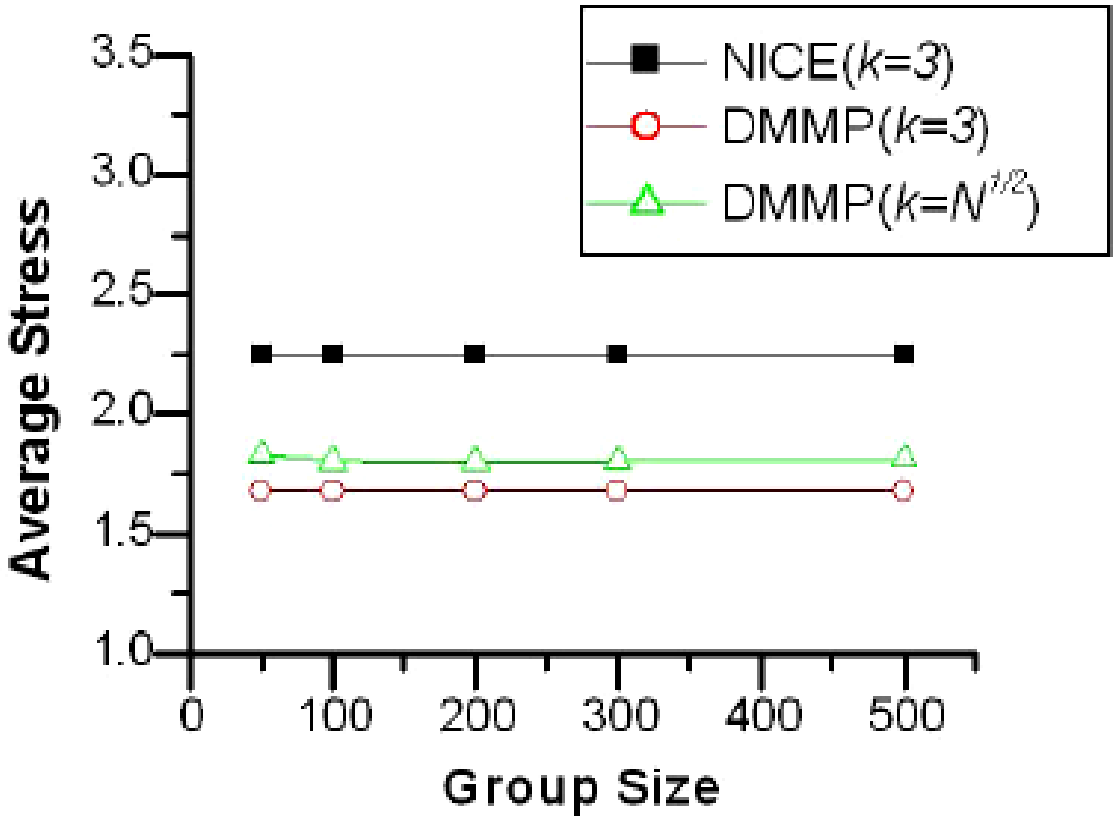
- Model
  - a very large number of end hosts uniformly distributed
  - DMMP-aware clusters having similar properties
- Discussions
  - The number of packet copies is determined by the number of downstream nodes ($\leq n_i$). The average stress would be:

$$\overline{\lambda} \leq \frac{\sum_{i=1}^{L} p_i + L[1 + \sum_{j=1}^{k\cdot\alpha}(n_j - 1)]}{N}$$

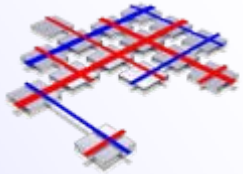
  - Based on $\sum_{j=0}^{k\cdot\alpha} n_j = 2k - k(1-\alpha)$ and we assume p = $k\cdot(1-\alpha)$,

$$\overline{\lambda} \leq 2 + \frac{1}{k} - \alpha,$$

  where p denotes the average out-degree of super nodes

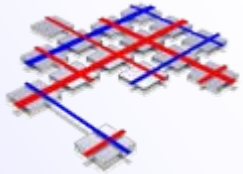


The comparison on the average stress



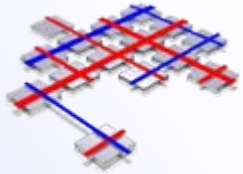
Conclusion and Future Work

- Conclusion
  - To overcome some efficiency and deployment issues with media streaming applications
  - Possible to construct DMMP-aware overlay hierarchy
  - Preliminary analysis shows low stress for large multicast groups
- Future work
  - Implementation of DMMP framework
  - Evaluation of its performance and scalability
  - Comparison with other approaches (e.g., NICE, Narada, OMNI)



Acknowledgement

- Ruediger Geib, Nicolai Leymann and Xiaodong Yang for their valuable input that helped improving this work.
- John Buford, Yuji-UG-Imai and Yangwoo Ko for helpful discussions in the SAMRG on exploiting super node selection.



Questions?