Dynamic MultiPath Routing

Network Working Group Internet-Draft

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Motivation

- Internet Traffic is growing
  - New applications and services added constantly
- Network Throughput must be maximized
  - Multipath Routing could use more elasticity
    - Manage congestion effectively
    - Address fair allocation of resources
    - Preventing bottlenecks

Multipath Routing

- ECMP and MPTCP
  - Choice of paths independent of dynamic network conditions
  - ECMP
    - only equal cost paths
  - MPTCP
    - predetermined set of paths
    - not Pareto-Optimal

Dynamic Multipath Routing

- Dynamic Multipath Routing
  - New paths discovered dynamically
  - Improved Throughput
  - Congestion Management
  - Fairness amongst different source-destination pairs

Two Methods

- First Method: Congestion Control
  - Dynamic Re-Routing of Flows based on network conditions
- Second Method: Congestion Control with Fairness
  - Dynamic Re-routing of Flows based on network conditions
  - Fairness Enforcement
- Both Methods use
  - Additive Increase
  - Multiplicative Decrease
  - Combination of source routing and Link-State routing (OSPF)
  - Link-State Advertisements with queuing delay and queue occupancy

Method 1 (Congestion Control)

- Congestion Control
  - Based on congestion of a path's links
  - Expressed as variable b_i = [0,1]
- Flow on Path i at time t:
  - Multiplicative Decrease based on congestion
    - $x_i(t) = (1-b_i)*x_i(t-T)$ [T=cycle time]
  - Shortest Path based on link delay
  - If Shortest Path is new, add to path list
  - Additive Increase on shortest path [to achieve and maintain demand]
    - $x_i(t) = a + (1-b_i)*x_i(t-T)$

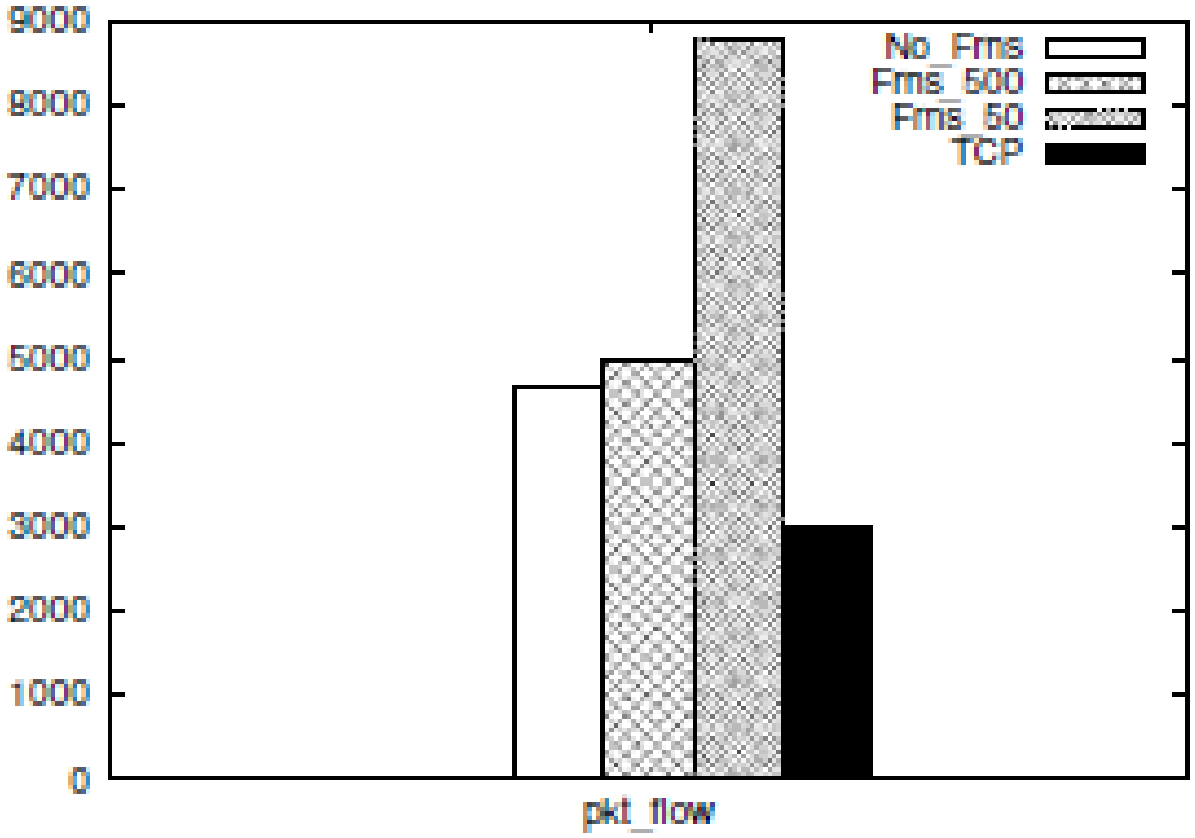
Method 2
(Congestion Control with Fairness)

- Congestion Control and Fairness Function
  - Expressed as function b_i = PBQ – PBF
  - PBQ as b_i in Method 1
  - PBF = 1 - $\frac{Total\ Flow}{\gamma * Demand}$ [γ = fairness coefficient]
- Flow on Path i at time t:
  - $x_i(t) = (1-b_i)*x_i(t-T)$
  - Shortest Path based on link delay
  - If Shortest Path is new, add to path list
  - Additive Increase on Shortest Path [to achieve and maintain demand]
    - $x_i(t) = a + (1-b_i)*x_i(t-T))$

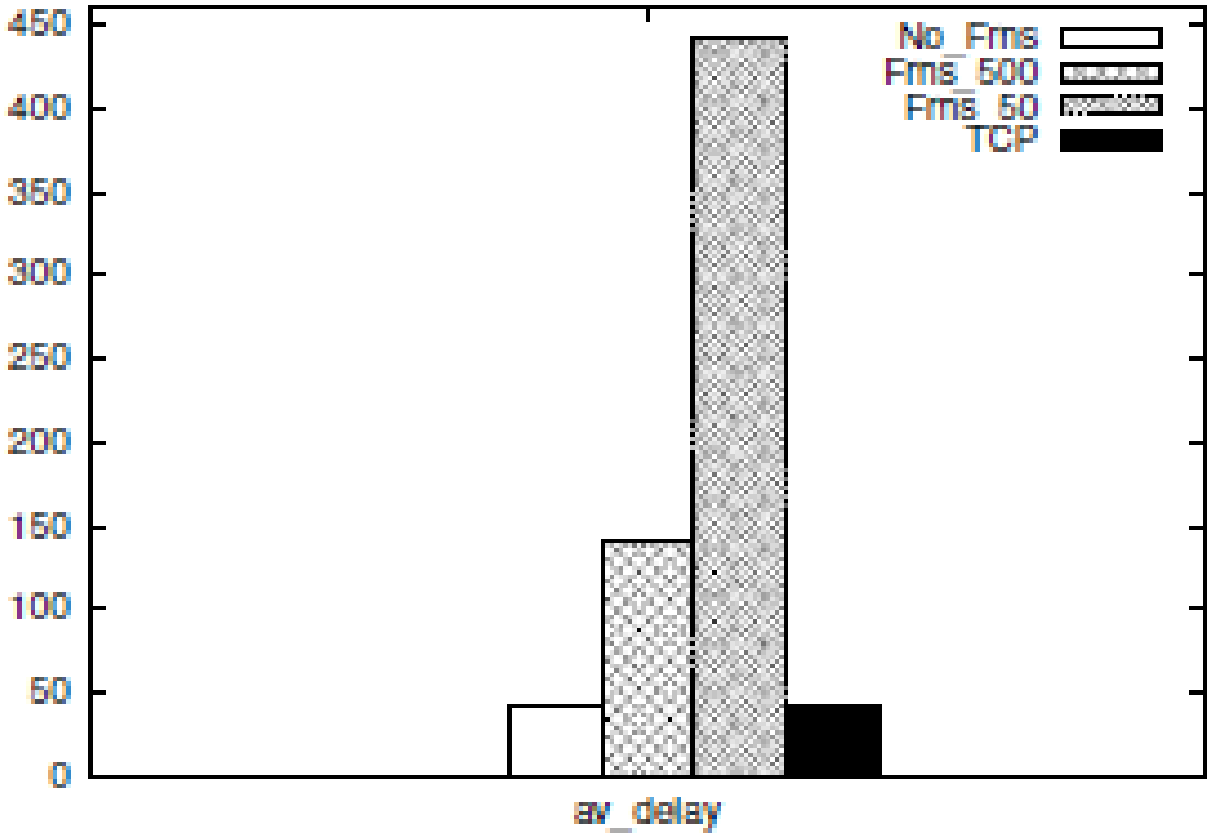
Implementation Details

- Both methods use factor b_i for flow control, but calculation is different
  - Method 1: b_i based on link queue occupancy
  - Method 2: b_i combination of method 1 and fairness factor
- Factor a is a unit of flow increase (integer)
- Source Routing using Nix-Vector Routing (NS-3)
- Shortest paths found using OSPF (NS-3) with some modifications
  - Link Cost = queuing delay
  - Queue occupancy of O/G link added to LSA
- Simulations:
  - multiple users starting at random times
  - background traffic

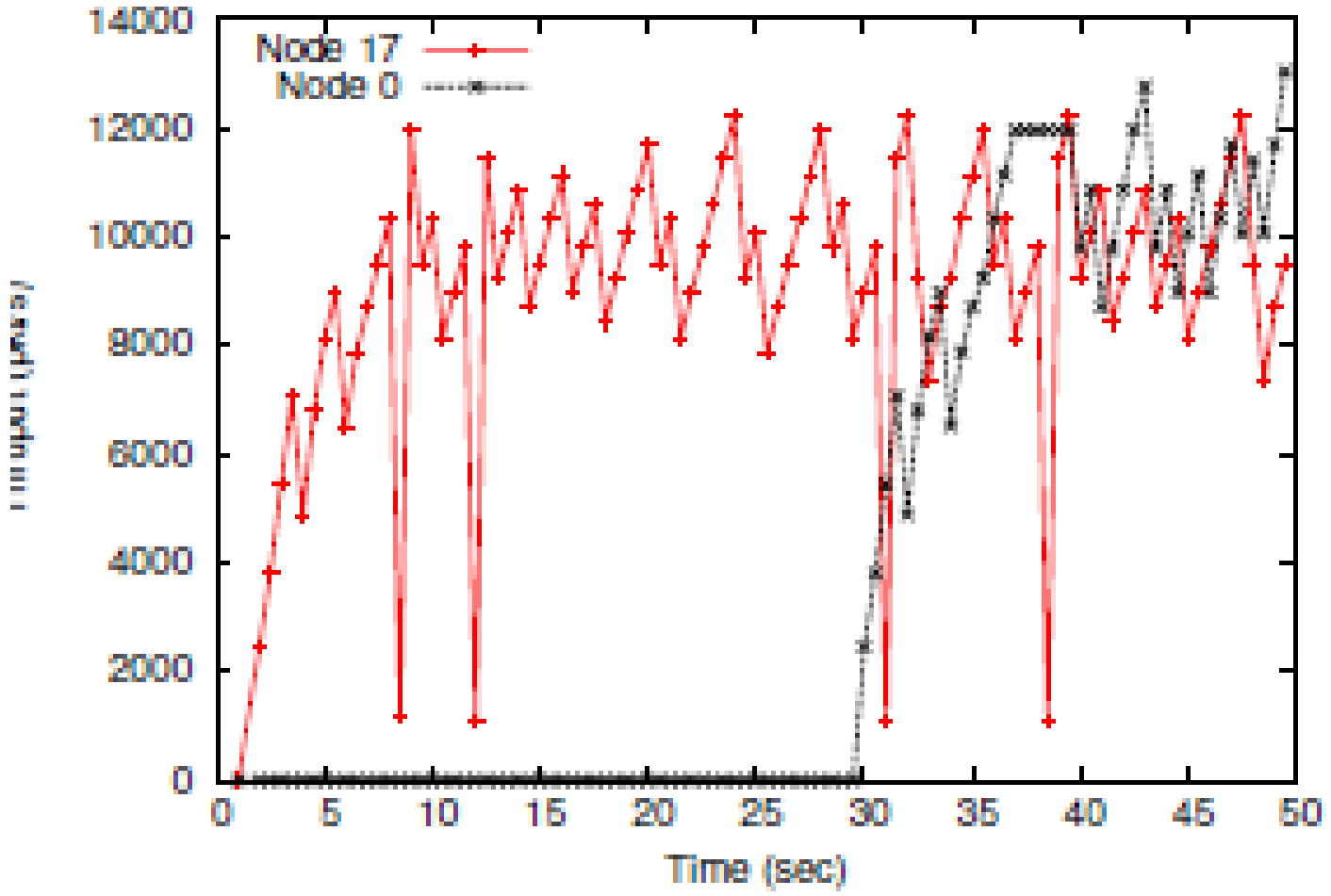
NS3 Simulations I



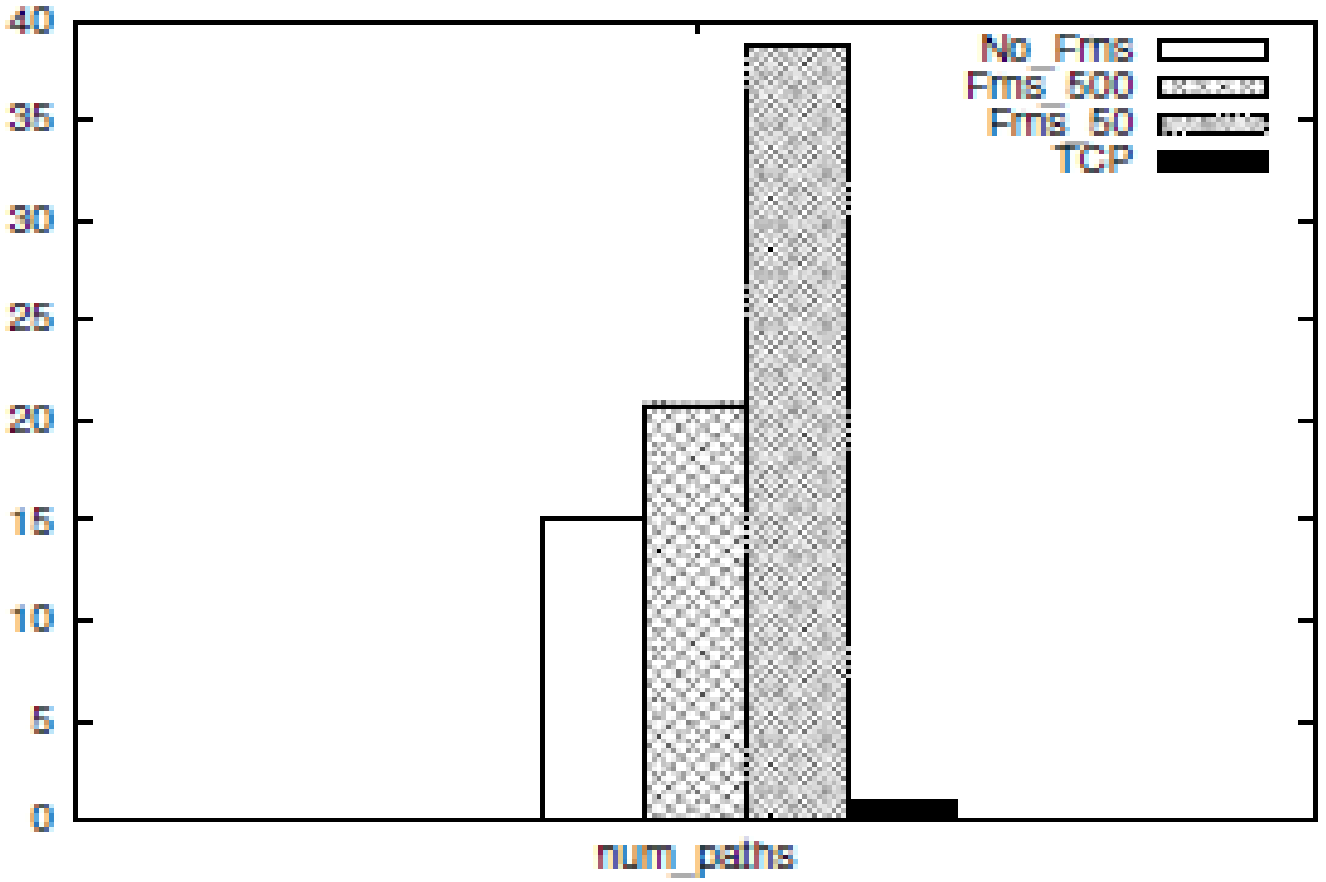
NS3 Simulations II



NS3 Simulations III



NS3 Simulations IV



Conclusion

- Improved Throughput
- Improved Fairness
- Further studies needed
  - Total Network Throughput
  - Reduce number of paths
  - Packet acknowledgement
  - Best method for Source Routing