Simulation Details and Results

***Abstract*—I thought this might be an easier format to digest, since I can include easy figure references, etc.**

I. Analytical Results

First, I'll include the current symptotics equations I used to get the analytical results included in the graphs.

A. Contention Factor

All of these simulations are using TDMA. For the line networks, the TDMA setup is three repeating slots, with nodes scheduled in the same repeating fashion from 1 to N so that when a node transmits, it does not interfere with either of its neighbors. In fact, no other node within two hops of the transmitting node is transmitting during the same slot, so no hidden terminal problem exists either. I am calling this a contention factor of $CF = 3$. For the manhattan grid networks, nodes are scheduled in the five slot repeating pattern from the WiNet draft paper (and others). It also removes any collisions of any kind. I use $CF = 5$ here. (This might be different from the setup in the paper that includes a "$+1$" which I think I am just including here so the result should be the same.)

B. Channel Rate

W is the available channel rate between each two nodes that can be achieved when that node reaches its scheduled slot. In this slot, it transmits at the full rate to one neighbor of its choice. Queues are FIFO, so the selection of neighbor is based on what the next packet's destination is, i.e., the next hop in the path of that flow. Currently, all packets are 1500 Bytes because those were the largest IP packets allowed without making any modifications. To avoid dead air, each slot has a time length of $Packet_Size/W$ so that exactly one packet is sent (if available from the queue) in each slot.

C. Transit Factor

For a line network, I am using the result in the WiNet draft:

$$TF_{line} = \frac{(N-1)^2}{2(N-2)} \tag{1}$$

As we have determined, I am using

$$TF_{grid} = \sqrt{N} \tag{2}$$

for the Manhattan grid network's transit factor.

D. Symptotic Equations - Before and After Multi-hop

1) Old - No Multihop: The first round of results were not including any multi hop relay effects. I used the following equations, which I solved for numerically using Matlab. Generally:

$$W - CF * (TF + 1) * QRF(SS_{req}) = 0 \tag{3}$$

Here, for $QRF(SS_{req})$, the SS_{req} give the number of images, Req_{images}. That, along with the image size, I_{size}, gives the total number of bits, $B = Req_{images} * I_{size}$. The required rate from the QRF function, R, is then, simply $R = B/T$, where T is the timeliness requirement.

Then, specifically, for the line network, the scalability is the solution for N in:

$$W - CF * (\frac{(N-1)^2}{2(N-2)} + 1) * \frac{B}{T} = 0 \tag{4}$$

and for the grid:

$$W - CF * (\sqrt{N} + 1) * \frac{B}{T} = 0 \tag{5}$$

I'll note that the "$+1$" in these equations is to account for the traffic originating at the node in question.

2) New - With Multihop: Here, as Ertugrul worked out, we should include the time for the delay required to "prime the packet pipeline."

$$QRF(SS_{req}) = \frac{B + (k-1) * P}{T} \tag{6}$$

So, the line network equation becomes:

$$W - CF * (\frac{(N-1)^2}{2(N-2)} + 1) * \frac{B + (k-1) * P}{T} = 0 \tag{7}$$

where k should be the average path length. Here, I think the accurate value for k should be the actual average path length for the specific bottleneck node, which would be the center node. I calculated that to be $\frac{N-1}{4} + \frac{1}{2}$. So the full equation would be:

$$W - CF * (\frac{(N-1)^2}{2(N-2)} + 1) * \frac{B + (\frac{N-1}{4} - \frac{1}{2}) * P}{T} = 0 \tag{8}$$

Then for the grid:

$$W - CF * (\sqrt{N} + 1) * \frac{B + (k-1) * P}{T} = 0 \tag{9}$$

$$W - CF * (\sqrt{N} + 1) * \frac{B + (\frac{2}{3} * \sqrt{N} - 1) * P}{T} = 0 \tag{10}$$

I think to be complete, the average path length here should be recalculated to be the average path length of the center node specifically, but I started with the result already known for the entire network.

II. Current Results

A. Line Network

Figure 1 is the one that I shared via email the other night. I am keeping this one as the absolute packet difference on the right for now because the small differences for small scalability numbers, e.g., on the near and right sides of the figures, dominate the figure when it is normalized (because the number of expected nodes is so small to begin with). Details of this scenario are $W = 2Mbps$, $I_{size} = 50KB$, $Req_{images} = \{1, ..., 6\}$.

When I include the multi hop consideration in this scenario, the analytical results I get are significantly different. This is shown in Figure 2 with the difference showing the absolute value. Here, we actually miss by much more.

B. Grid Network

Now, here's where things get a little tricky. The initial results that do not include any multi hop consideration are off by around 150 packets at the worst, which turns out to be around 30%. These results are in Figure 3.

When I include the multi hop consideration in this scenario from the equation above, which simply uses the average path length over the entire network, the results actually improve to become quite close. Here, I switched to a percentage difference in the right-most figure because it was the easiest to see in this case. This set of results is in Figure 4. You can't see actual numbers here, but the worst is around 30% for some of the trials, which is actually also an absolute difference of about 30 nodes at the maximum. The largest scalability values are the closest here, though. At Sum Sim = 0.5 and a timeliness of 50, the results are almost a perfect match.

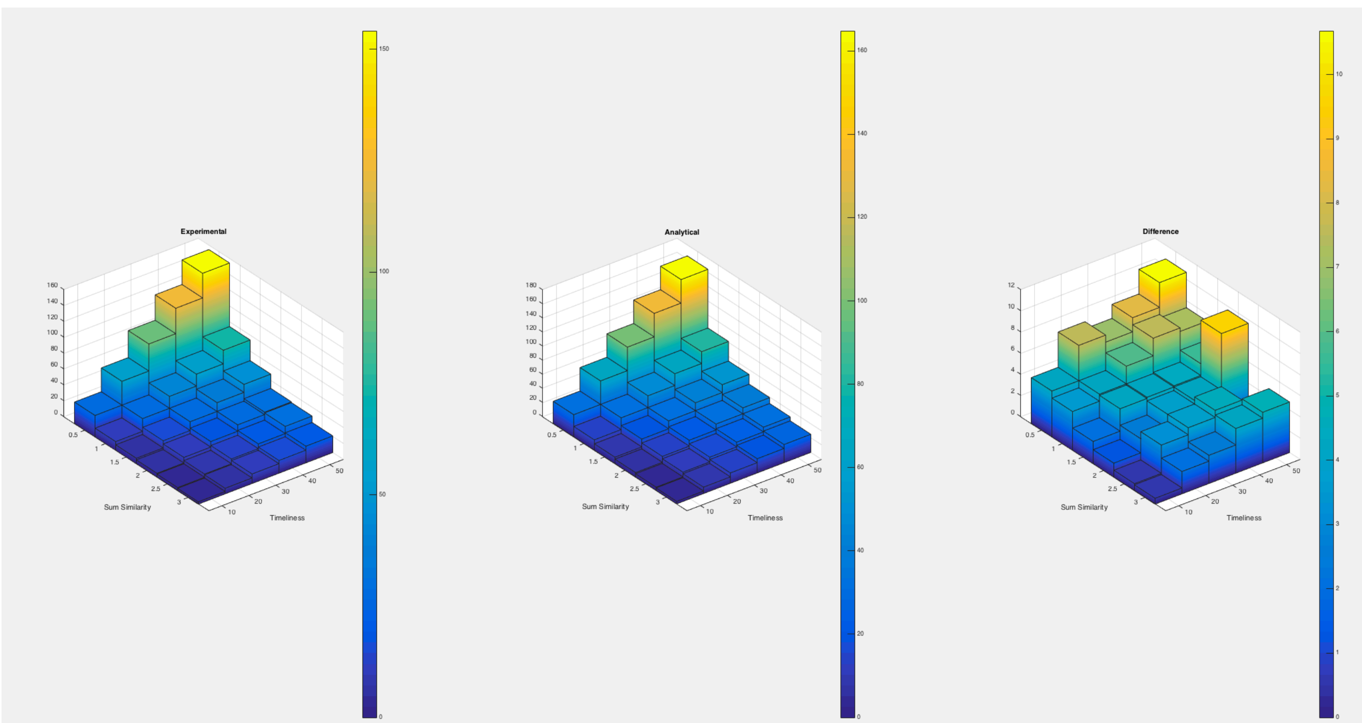

Fig. 1. Line Network - No Multihop Consideration - [Experimental, Analytical, Difference(Num packets)]

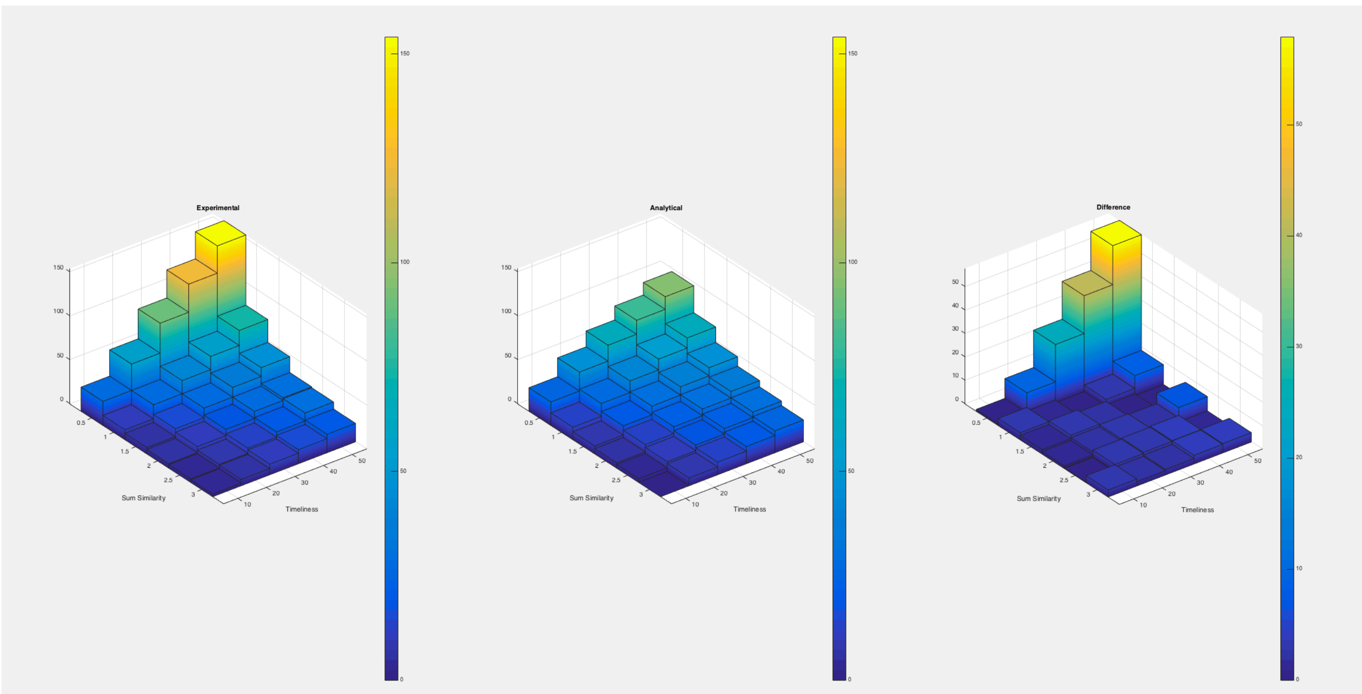

Fig. 2. Line Network - Including Multihop Consideration - [Experimental, Analytical, Difference(Num packets)]

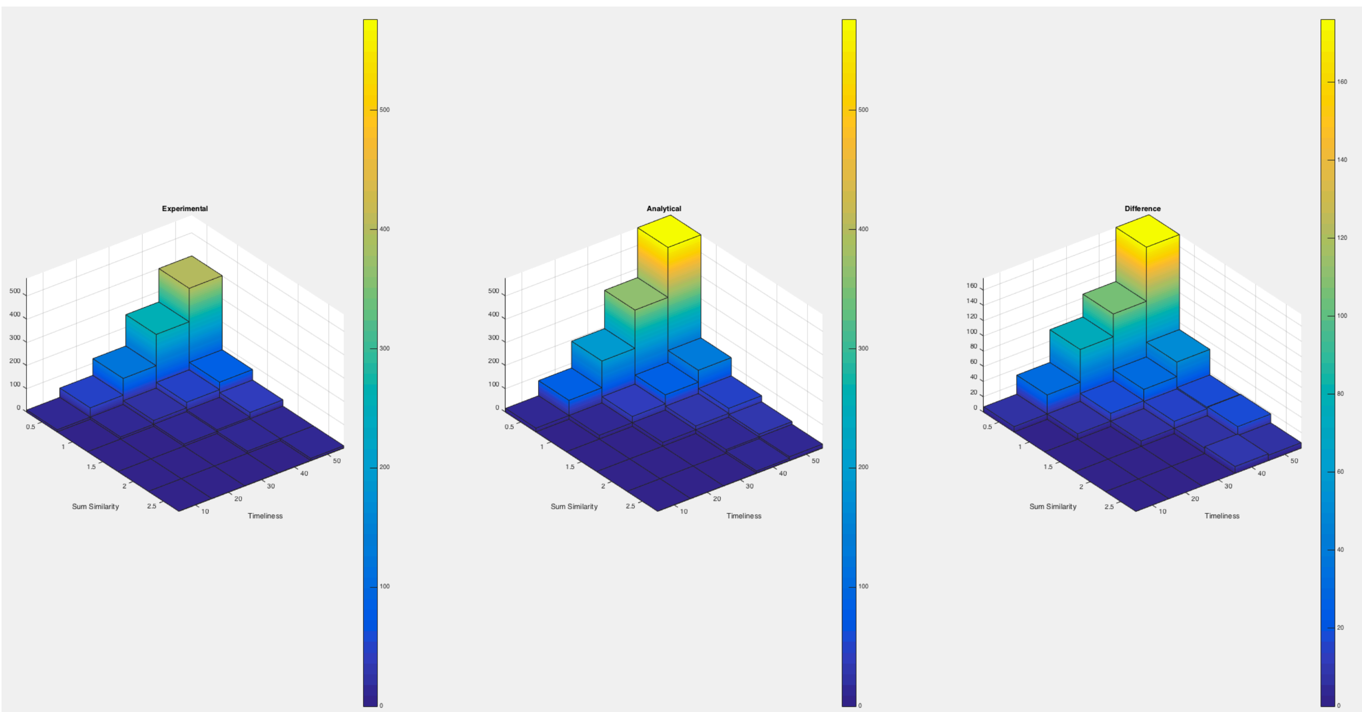

Fig. 3. Grid Network - No Multihop Consideration - [Experimental, Analytical, Difference(Num packets)]

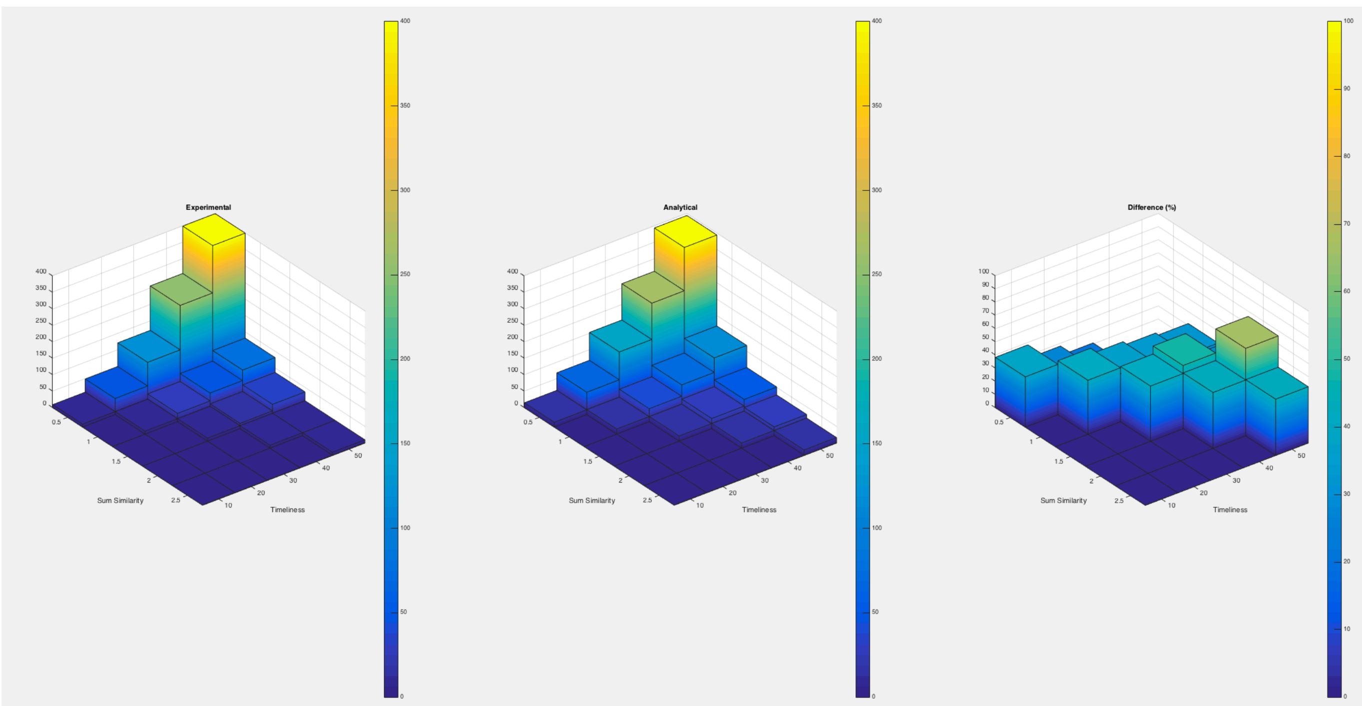

Fig. 4. Grid Network - Including Multihop Consideration - [Experimental, Analytical, Difference(%)]