On Realism of Wireless Traffic Models
or "How Bad is CBR Anyway?"

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1 Introduction

- Realism deficit schpiel (adapted from MAE report).
- Mobility has been investigated and found to to have a drastic impact on a variety of metrics in wireless networks.
- Traffic patterns have not been investigated at all. There are three aspects that characterize traffic patterns:
  1. flow **topology**: how flows are mapped between nodes in the network
  2. flow **parameters**: duration, total bytes, total packets in a given flow
  3. flow **behavior**: the actual sequence of data exchanged between endpoints.
- Standard traffic model: random uniform topology, uniform fixed parameters, and CBR behavior.
- Clearly, this fails to match actual behavior in any but the most contrived scenarios.
  - Give some historical background for why CBR was chosen initially.
- There was previously no insight into what impact, if any, this has on the accuracy of metrics.
- This paper provides a comprehensive analysis of how the standard traffic model in common usage differs from a realistic usage—taken from actual traces in a large deployed wireless network.
- Summarize the major results.

2 Related Work

- Adapted from the discussion in the MAE report updated with any new relevant papers.

3 Methodology

- Discuss and describe the IETF60 data set and how it was collected.
- Simulation setup
  - qualnet: 802.11b + AODV
  - random node placement, no mobility
  - all traffic to external destination is sent to a single gateway node
- 24 hours of trace data split into 10-minute segments.
- Each segment serves as a simulation scenario and data from the scenario provides the basis for a set of simulations using a range of different traffic models.

3.1 The Traffic Models

- Flow topology variants:
  - **real**: mapping of wireless nodes and flow end-points from the trace data.
  - **uniform**: end points of each flow are randomly chosen from all of the wireless nodes.
  - **sink**: for each flow, one endpoint is internal and the other is external; the internal node is randomly chosen from all the wireless nodes.
- Flow parameter variants:
  - **actual**: each flow has the same start time, end time, total data sent, and number of packets as the corresponding flow in the IETF trace.
  - **average**: the average duration, total data sent, and number of packets sent across all trace flows is used for every simulated flow; flows start times are staggered across the duration of the simulation.
- Flow behavior variants:
  - **trace-based**: actual trace data is used to determine flow behavior.
  - **CBR**: each flow is modeled as a constant bit-rate stream of data, with packet size and inter-packet interval determined by the flow parameters.
  - **VBR**: similar to CBR, but each inter-packet interval time is randomly chosen from an exponential distribution instead of being fixed.
- The control traffic model uses:
  - real flow topology
  - actual flow parameters
  - trace-driven behavior
- Each alternate model is compared to this base model.
  - For each metric reported by the simulator, we compare the value reported by the control traffic model with the alternate traffic model.
  - If the pairs of control values and model values tend to lie around the diagonal line on a scatter plot, then the metrics is accurately represented by the alternate model.
  - Otherwise we conclude that the model tends to skew or misrepresent the metric somehow.
- Discussion of the metrics considered and why they were chosen.

4 Results

Application: Average Jitter The application model is everything here: the two trace-driven simulations (sink & uniform topologies) are both quite accurate, with just a few outliers. The CBR and CBR/Average application models on the other hand underestimate jitter by a huge margin.

Application: Bytes Sent vs. Bytes Received This appears to depend on a combination of application model and flow topology. None of the combinations of models I have run seems to accurately duplicate realistic behavior. It will be interesting to see what the results for VBR traffic are. The CBR/Average application models (what people typically use) are really way offfor both the uniform and sink topologies. The CBR model with a real flow topology is the most realistic, but still pretty far off of accurate.

Application: Total Bytes Received Apparently here the flow topology really matters, because the real topology with CBR application and realistic flow parameters is the only model that fared reasonably welleven then, there was a lot of room for improvement. Again, it will be very interesting to see the VBR results.

Layer	Proto	Metric	RC	RCA	ST	SC	SCA	UT	UC	UCA
Application		Average Jitter (s)	164.83	163.43	0.10	136.89	137.20	−0.82	105.46	135.00
Network	AODV	Total Hop Count For All Routes	14.53	12.95	8.36	16.92	32.26	55.61	82.99	110.95
Network	AODV	Number of RREQ Initiated	20.16	4.19	16.11	25.59	32.41	52.25	75.68	100.96
Network	AODV	Total Control Messages	16.71	18.37	13.40	19.41	33.85	47.31	68.92	96.04
Network	AODV	Number of Routes Selected	13.46	9.51	7.94	14.75	26.76	49.56	74.32	93.93
Physical	802.11	Signals received but with errors	8.69	23.71	6.49	15.46	39.44	21.34	36.23	53.65
Physical	802.11	Signals transmitted	8.22	23.46	6.46	15.03	38.29	21.72	36.20	51.62
Network	AODV	Total Number of RREQ/RREP/RERR Initiated	9.43	13.43	9.98	18.10	39.04	17.00	31.96	56.81
Application		Total Bytes Received	5.88	45.59	25.51	30.36	43.15	10.14	6.21	26.21
Application		Throughput at Receiver (bits/s)	5.88	45.59	25.51	30.36	43.15	10.14	6.21	26.21
Application		Average End-to-End Delay (s)	−5.88	−11.06	−15.98	−18.61	−23.73	−33.48	−31.70	−38.41
MAC	802.11DCF	Total RTS Packets Sent	6.82	21.50	6.74	17.28	41.79	13.19	26.41	40.24
Physical	802.11	Signals locked on by PHY	6.99	19.91	5.75	13.80	34.40	15.00	28.24	41.70
MAC	802.11DCF	Total RTS/CTS/ACK Packets Sent	6.30	21.18	6.35	16.70	40.29	11.66	24.01	35.84
MAC	802.11DCF	Total CTS Packets Sent	6.02	20.87	6.25	16.72	40.29	10.75	22.90	34.08
Application		Bytes Delivery Ratio	0.18	37.76	25.51	23.33	35.48	10.14	0.42	19.36
Application		Throughput Ratio	0.18	37.76	25.51	23.33	35.48	10.14	0.42	19.36
MAC	802.11DCF	Total ACK Packets Sent	5.53	20.40	5.96	15.94	37.95	9.72	20.67	29.67
Physical	802.11	Signals received and forwarded to MAC	5.93	17.32	5.35	13.11	31.68	10.89	23.13	34.25
Network	FIFO	Total Packets Dropped	11.08	13.01	6.15	6.43	−4.89	8.81	9.87	48.93
Network	AODV	Number of RERR Initiated	3.84	−5.33	8.39	10.78	11.39	11.49	19.42	24.67
Network	AODV	Number of Packets Dropped	−6.50	−16.74	−4.17	−11.16	−13.80	4.51	0.56	6.54
Network	AODV	Number of Link Breaks	4.44	−0.27	3.49	8.06	11.61	7.19	11.75	8.55
Transport	UDP	Packets to Application Layer	−2.79	−2.76	3.18	4.60	−5.13	−8.68	−7.32	−14.10
Application		Total Packets Received	−2.64	−2.43	3.43	4.86	−4.74	−8.44	−7.05	−13.94
Application		Throughput Difference (bits/s)	3.91	−6.74	−7.22	−2.77	−12.64	−2.94	−1.13	−4.03
Application		Total Bytes Lost	3.91	−6.74	−7.22	−2.77	−12.64	−2.94	−1.13	−4.03
Application		Total Bytes Sent	5.70	5.68	0.00	5.70	5.66	0.00	5.76	5.74
Application		Throughput at Sender (bits/s)	5.70	5.68	0.00	5.70	5.66	0.00	5.76	5.74
Network	AODV	Average Hop Count per Route	0.94	3.14	0.40	1.89	4.34	4.04	4.98	8.78
Application		Total Packets Sent	3.55	3.66	0.00	3.54	3.63	0.00	3.62	3.72
Transport	UDP	Packets from Application Layer	3.55	3.66	0.00	3.54	3.63	0.00	3.62	3.72
Physical	802.11	Energy consumption (in mWhr)	0.05	0.15	0.03	0.07	0.21	0.13	0.19	0.32

MAC/802.11DCF: Total RTS/CTS/ACK Packets Sent Here both flow topolgy and application model matter. The uniform flow topology does some serious damage to the realism of the results, but the real topology simulations with CBR and CBR/Average application models don't do that well either. The sink topology with trace-based flow behavior is the best here, indicating that the sink topology is good enough and that a more realistic individual flow behavior model is necessary.

Network/Routing: Total Packets Dropped Something really interesting happens here: the real and sink topologies behave very realistically, but all the uniform topology simulations drastically under-represent the number of dropped packets. The relationship between the realistic value and the values gotten from the uniform models are quite predictable, falling on a straight line on a log-log graph.

Network/AODV: Number of RREQs Initiated This is an odd one. The only combination of models that performs realistically is the real topology CBR/Average combination. The real topology CBR with realistic flow parameters predictably underestimates the number of RREQs initiated. All the other scenarios underestimate the it even more soall in log-log-linear ways.

5 Discussion

6 Conclusions