On Efficiency and Validity of Previous Homeplug MAC Performance Analysis

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MAC Modeling

- The Homeplug/1901 MAC similar to 802.11's DCF.
- 802.11's MAC extensively studied using Bianchi's model[1] and extensions.
- This has been extended to cover the Homeplug/1901[2].
- Deferral counter requires extra states in Markov Chain.

[1] Bianchi. *Performance analysis of the IEEE 802.11 distributed coordination function.* Selected Areas in Communications, IEEE Journal on 18.3 (2000): 535-547.

[2] Chung et al., *Performance analysis of HomePlug 1.0 MAC with CSMA/CA*, IEEE Journal on Selected Areas in Communications, vol. 24, no. 7, pp. 1411-1420, 2006.

- Solving the model is computationally expensive
  - 1 iteration loop that contains 2 more loops
  - Computationally expensive operations
- Aimed to simplify model to make it quicker to solve.
- Same assumptions as considered by Chung et al.
  - Infinite queue size and retry limit.
  - Exponential distributed interarrival of packets.
  - Ideal channel conditions.
  - Contention among homogeneous access categories.

Simplification

- We take a renewal reward approach[3][4].
  - We compute the waiting times at each backoff stage
  - Define the probability to fail at backoff stage i,
    - $p_{\mathrm{f}}^{(i)} = p \cdot p_{\mathrm{bo}}^{(i)} + p_{\mathrm{defer}}^{(i)}$..
  - Then compute average time in backoff to successfully transmit.
- We can precompute deferral probability and expected backoff times.
- Can also make exponential approx. to simplify further.

stations	Original Analysis	Simplified	Exponential	10000s Simulation
10	584.5 s	3.7 s	1.7 s	165.5 s
50	420.0 s	4.2 s	3.5 s	866.2 s

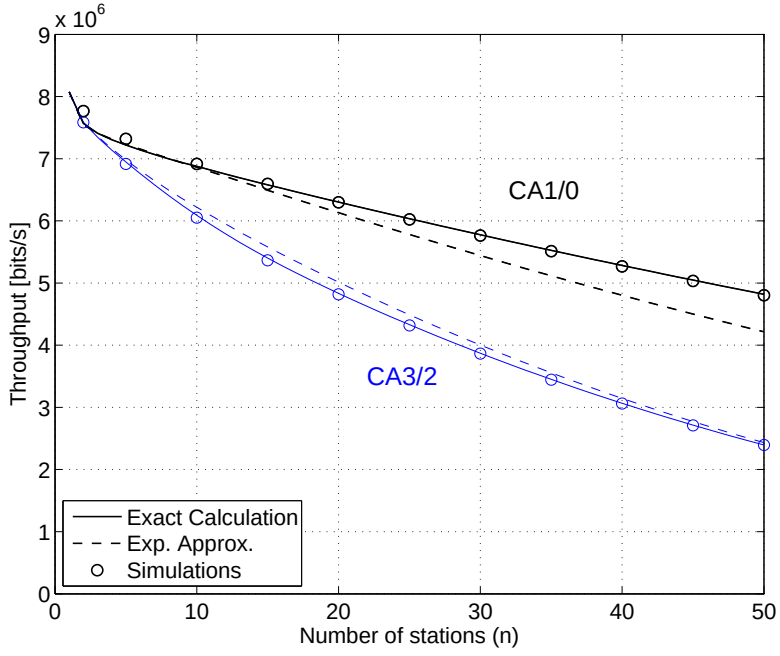
[3] Kumar et al., *New insights from a fixed point analysis of single cell IEEE 802.11 WLANs*, INFOCOM 2005.

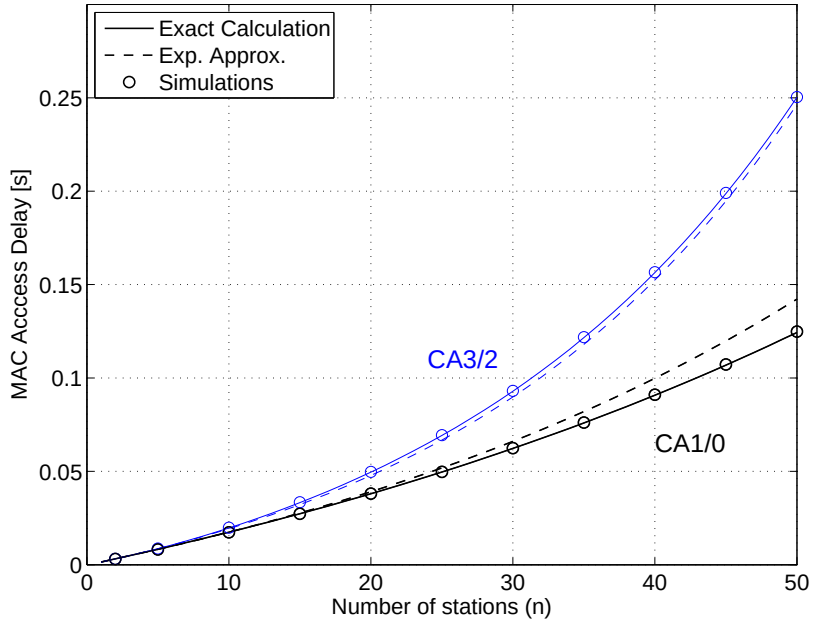
[4] Bianchi and Tinnirello, *Remarks on IEEE 802.11 DCF performance analysis*, IEEE Communication Letters, 2005.

Validation Problems

Saturated Conditions

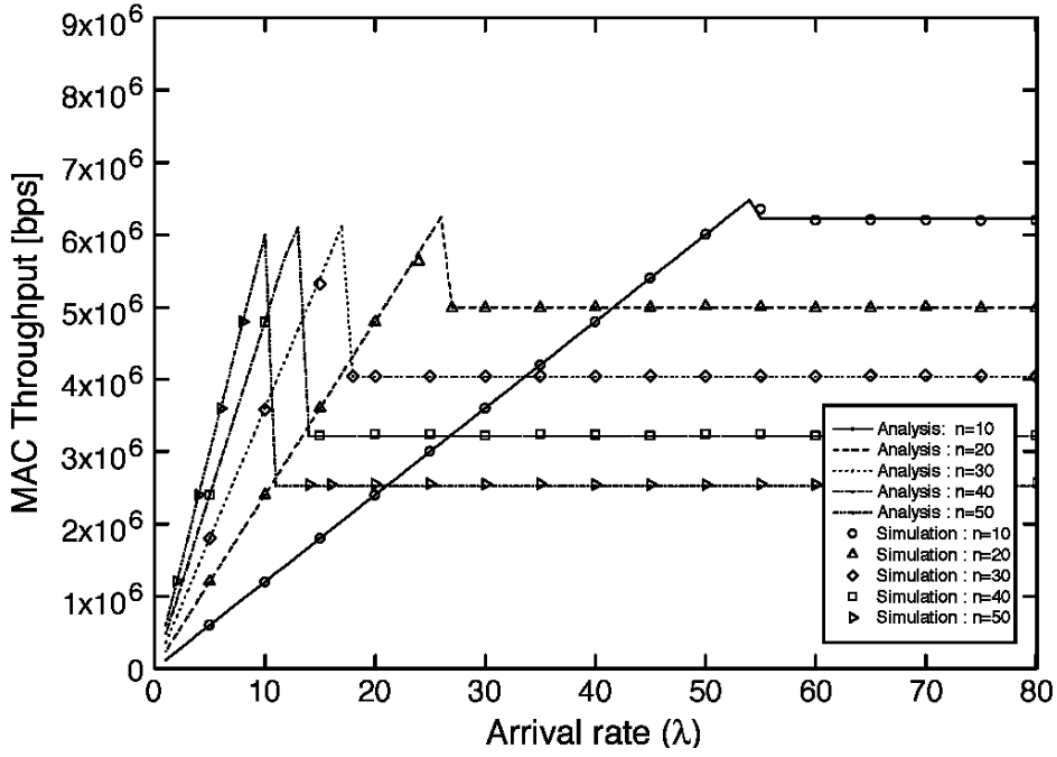
Same results as Chung. et al.





Unsaturated Conditions

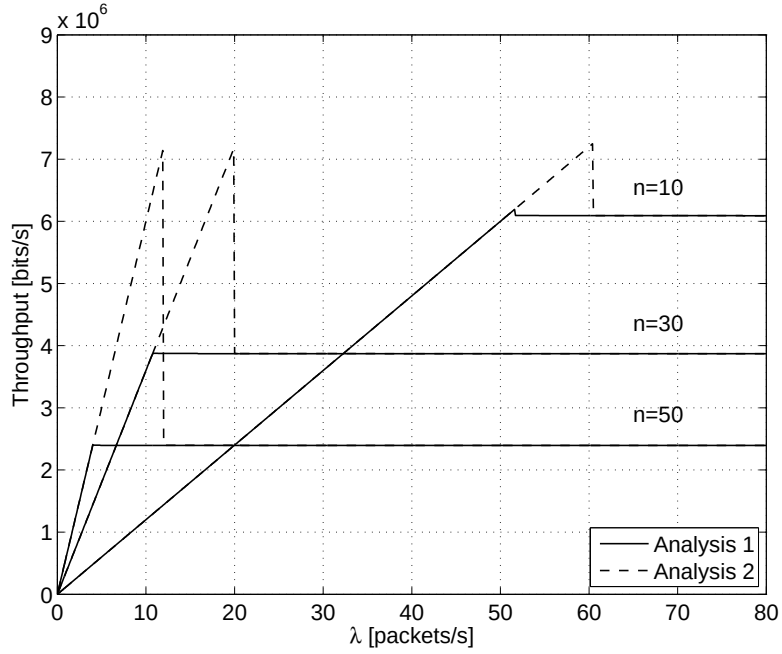
The results were not fitting but *prior to* saturation only



Explanation

Obtaining Two Solutions

Depending on the starting parameters:

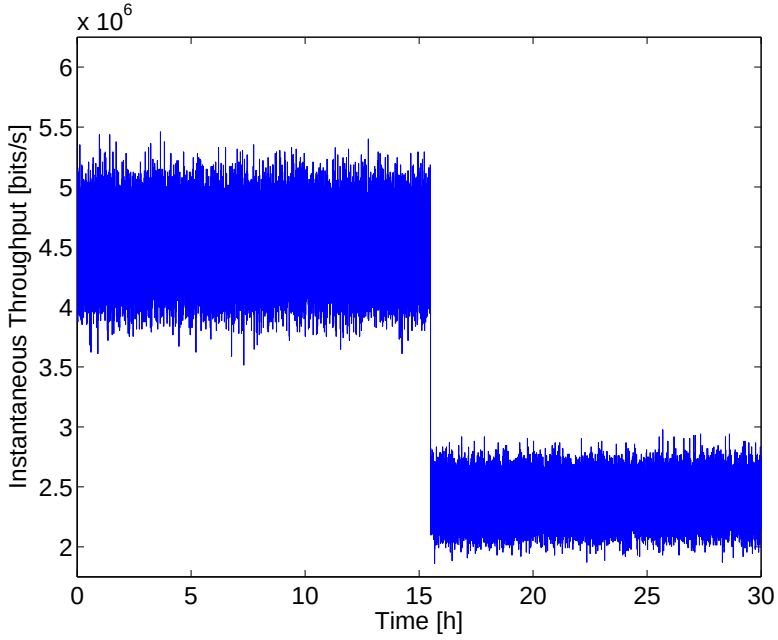


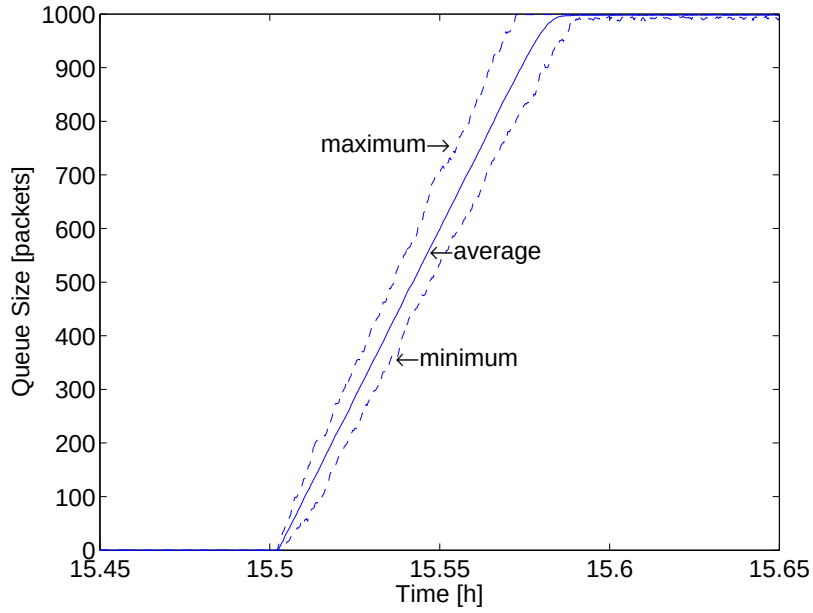
- Due to coupling of queue dynamics and channel access.
- Something similar in WiFi[5].

[5] Duffy, *Mean field Markov models of wireless local area networks*, Markov Processes and Related Fields, vol. 16, no. 2, pp. 295-328, 2010.

Temporal Evaluation

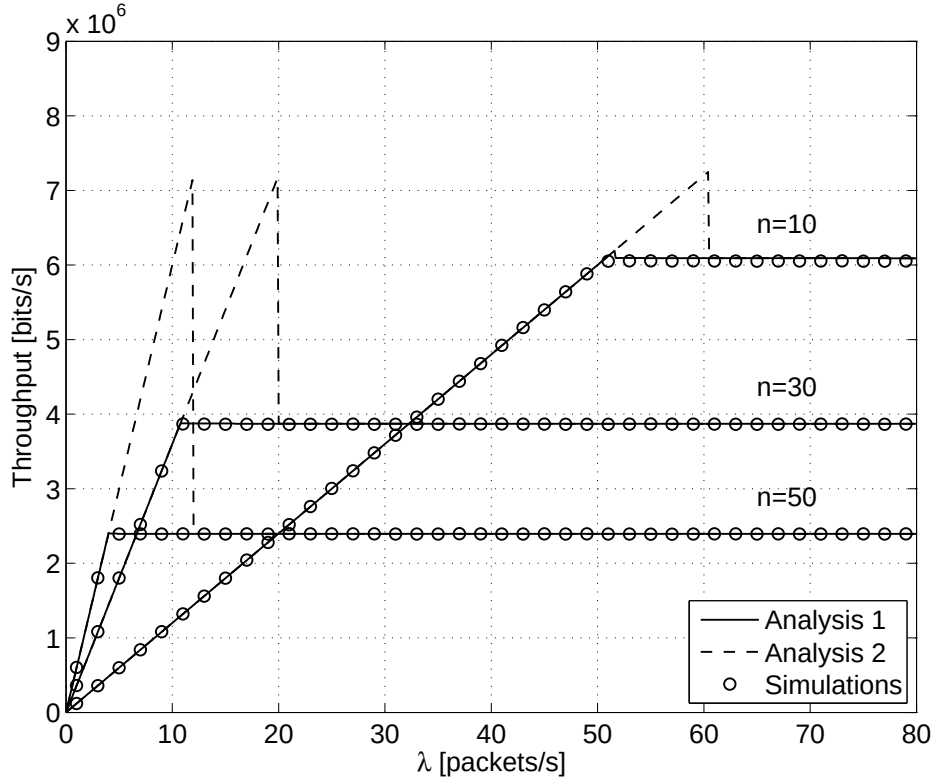
Evolution of throughput/Queue size (max, av, min):





Validation

Simulations (with pre-loaded queues) fit saturated solution:



Summary

- For large queues: long transitory phase before saturation.
- Shows up as extra fixed point in model.
- Can lead to misinterpretation of analysis and simulations.
- Model improvements for PLC at `http://arxiv.org/abs/1401.6803`.
- Actually present in Wi-Fi and other protocols too.
- Thinking about practical implications.