

Traffic-Aware Channel Assignment in Wireless LANs

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1. Introduction

•Motivation

- WLAN densities and traffic are increasing
- Channel assignment significantly affects wireless performance
- Essential to develop automated channel assignments as topologies become more complex

•Open issues

- What is the best performance metric to optimize when allocating 802.11 channels in a WLAN?
- To what extent is the quality of channel assignments improved by incorporating observed traffic demands?

2. Related Work

•Campus/Enterprise WLANs

- RF Site Surveys, AP-centric approaches, client-centric approaches

•Chaotic networks

- Dynamic channel assignment with power control

•Multi-hop mesh networks

- Frequency hopping (SSCH) or multi-radio approaches

•Limitations of existing work

- Existing approaches minimize the number of mutually interfering APs or minimize a specified noise criterion. Which (if any) is the correct metric?
- Existing approaches do not incorporate traffic demands. Adapting to demands could provide better performance, similar to the benefits of traffic engineering in ISP networks.

3. Traffic-Agnostic Metrics

•Maximize channel separation of APs

- If $\text{Distance}(i,j) < \text{Interference_Range}$:
 $\text{Separation}(i,j) = \text{Min}(|\text{Chan}_i - \text{Chan}_j|, 5)$
- Else:
 $\text{Separation}(i,j) = 5$

•Minimize noise at all APs (AP Noise)

•Minimize noise at all clients (Client Noise)

•Minimize noise at APs & clients (Total Noise)

- Noise calculation: Friis free space model with loss factor of 3.5

•Maximize the throughput over all clients (Client Throughput)

- Assumes constant and symmetric traffic demands

4. Traffic-Aware Metrics

•Traffic-aware channel separation

$$\text{Maximize: } \sum_{i \in \text{AP}} \text{Demand}_i \sum_{\substack{j \in \text{AP}, \\ j \neq i}} \text{Separation}(i,j)$$

•Traffic-aware noise

- Scale the received signal strength (noise) from a node by its demand

•Traffic-aware client throughput

- Use a network simulator, or other flow throughput models, to analyze aggregate system throughput of a channel assignment given current traffic demands

5. Evaluation Methodology

•Dataset: Dartmouth College traces (Feb. 1, 2004)

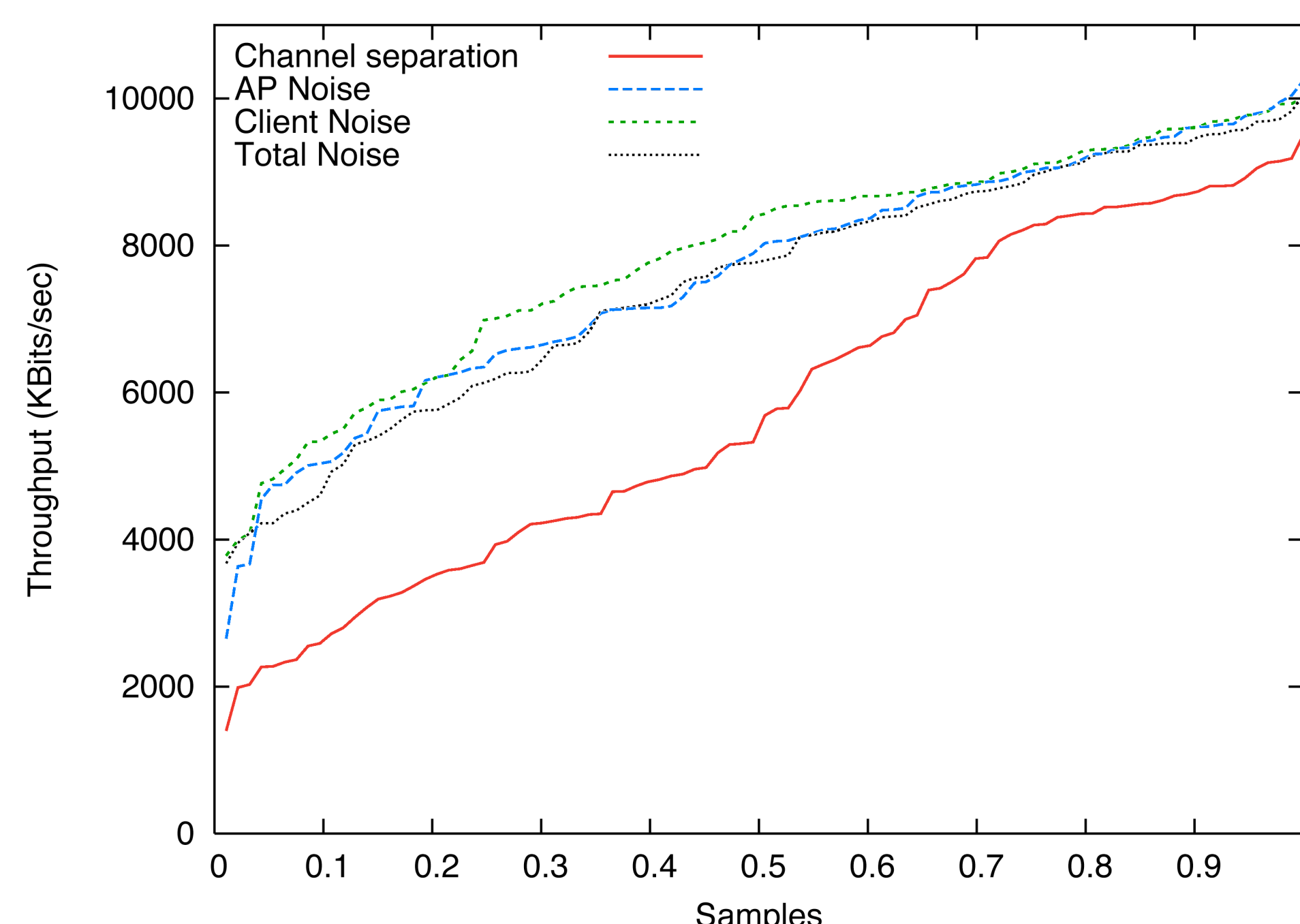
- 5 minute intervals, traces include SNMP statistics and number of active clients
- AP locations known; clients placed randomly within 30 meters of their AP
- CDF graphs in sections 6 and 7 focus on “ResBldg94”

•Simulation setup

- For each interval:
 - Use simulated annealing (30 iterations) to search the space of channel assignments for each metric and then analyze the resultant channel assignment with ns2.29
- Traffic demands scaled, per interval, to increase network utilization
- Focus on intervals with $\geq 50\%$ simultaneously active APs
- Constant-rate UDP traffic between clients and APs (aggregate system throughput used to quantify results)
- Utilizes an *oracle* to predict traffic demands

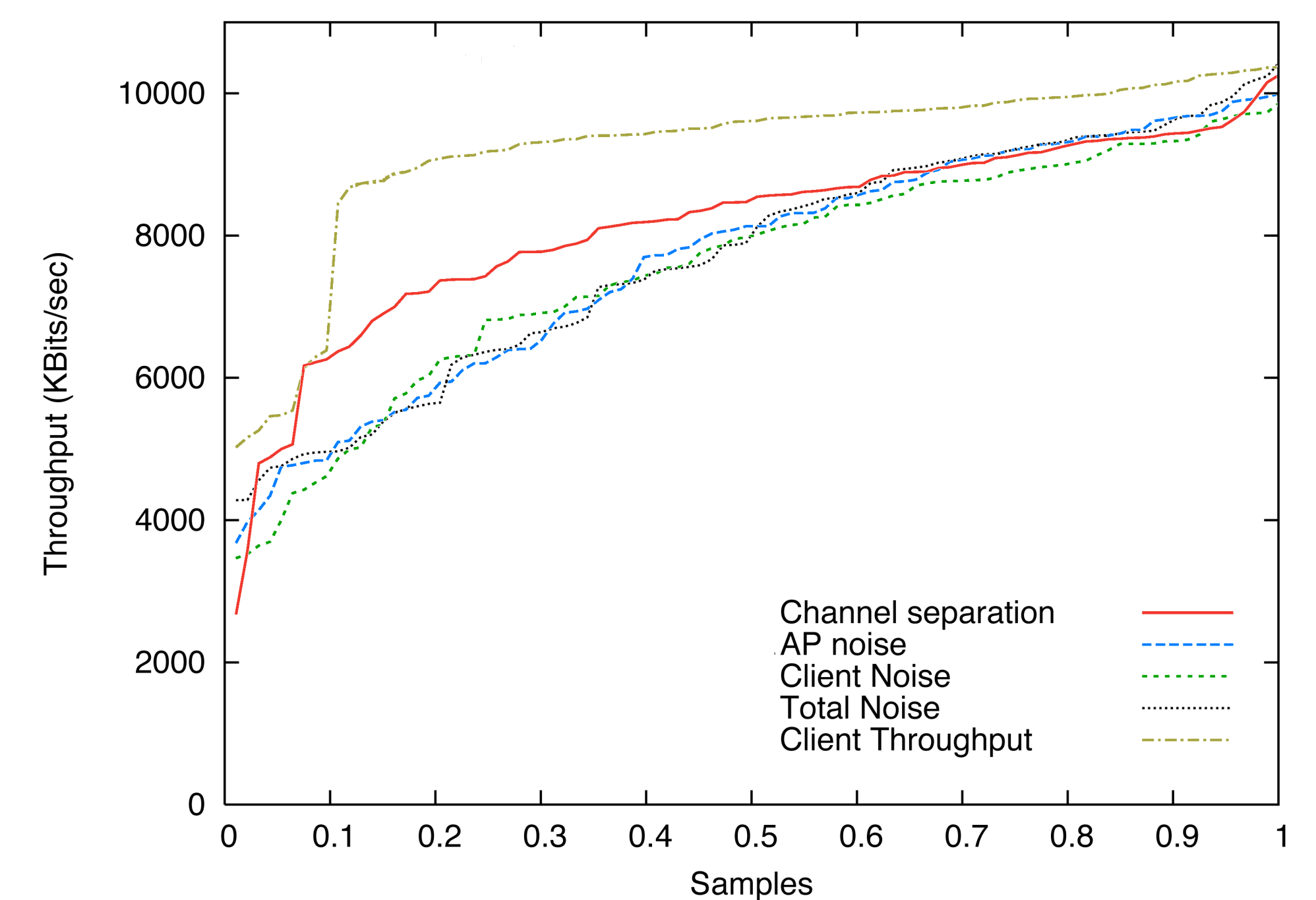
6. Conventional Metrics

•The correct metric can improve performance by up to 60% in the traffic-agnostic case



7. Traffic-Awareness

•Traffic-aware approaches can nearly double the median performance of conventional methods



8. Traffic-Awareness in Practice

•Traffic demand prediction algorithms (below) are necessary since the oracle is impractical

- Exponentially-Weighted Average of Demand (EWMA):

$$\text{APDem_Pred}(t) =$$

$$w \cdot \text{APDem_Actual}(t-1) + (1-w) \cdot \text{APDem_Pred}(t-1)$$

- Optimal for the previous interval (PREV)
- Optimal over the peak demand in the last N time windows (PEAK_N)

Algorithm	Relative Difference from Oracle
EWMA (w = 0.9)	9.6%
PREV	7.6%
PEAK_4	11.6%

•Traffic-aware channel assignment based on predicted demands seems promising

9. Conclusion and Future Work

•Contributions

- Identify the importance of optimization metrics for channel assignment
- Develop traffic-aware channel assignment

•Future Work

- Further explore prediction algorithms
- Take advantage of partially overlapping channels
- Develop a complete system and gain operational experience