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 Distance\((i,j) < \text{Interference\_Range}\): Separation\((i,j) = \min(l \cdot \text{Chan}_i, \cdot \text{Chan}_j, 5)\)
  - Else: 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**
  
  \[
  \text{Maximize } \sum_{i \in \text{AP}} \text{Demand}_i \sum_{j \in \text{AP}} \text{Separation}_{i,j}
  \]

- **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)

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Relative Difference from Oracle</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWMA ((w = 0.9))</td>
<td>9.6%</td>
</tr>
<tr>
<td>PREV</td>
<td>7.6%</td>
</tr>
<tr>
<td>PEAK_4</td>
<td>11.6%</td>
</tr>
</tbody>
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- 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