Distributed Dynamic Channel Selection in Chaotic Wireless Networks

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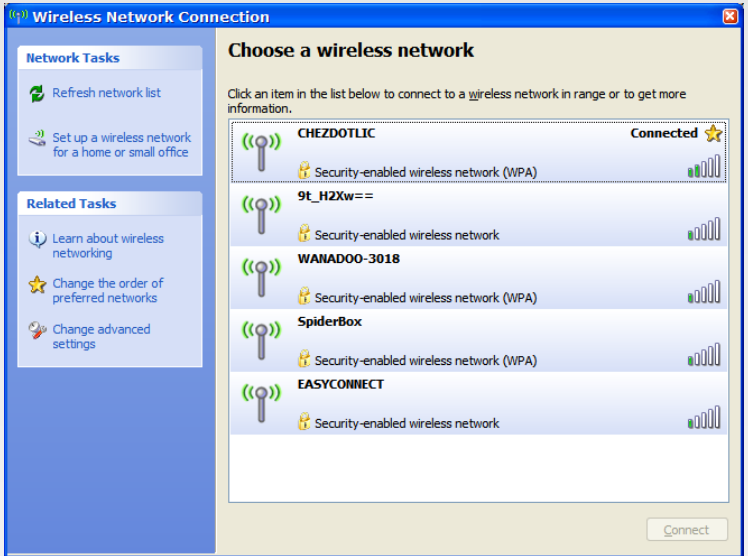
Overview

- Wireless networking problem:
  Channel Allocation
- A proposed solution:
  Dynamic Channel Selection
- Proposed algorithm explained.
- Simulations using OPNET
- Conclusions

Problem:

- Wireless networking is popular
  - Many users in contention for a finite amount of bandwidth per channel
  - Most users do not properly configure their devices to maximize throughput
  - Even if they do, the situation can change at any time
- Wireless Channel Selection Issues Include:
  - High density of APs
  - Unpredictable, Dynamic load



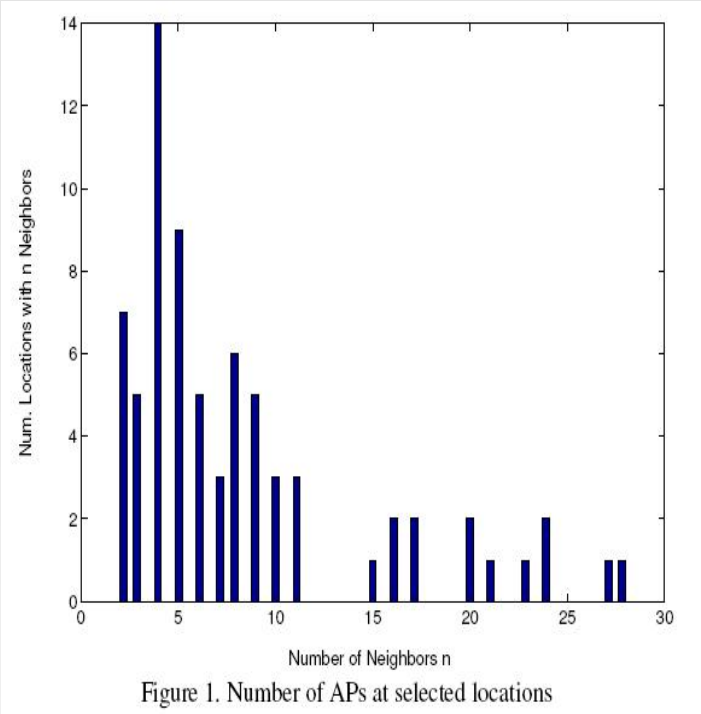


Figure 1. Number of APs at selected locations

Solution:

- Dynamically select channel based on current load conditions
- Problems:
  - What devices should calculate load in an unmanaged space?
  - How should load be calculated?
  - How often should load be calculated?
  - What is the best way to switch channels on the fly?

Algorithm Overview

- Monitoring Component
  - Monitor load on current channel
- Evaluation Component
  - Compare current channel load against a threshold
  - Trigger switch if this channel is no good
  - Change threshold accordingly
- Channel Switching Component
  - Set up the hardware for new channel

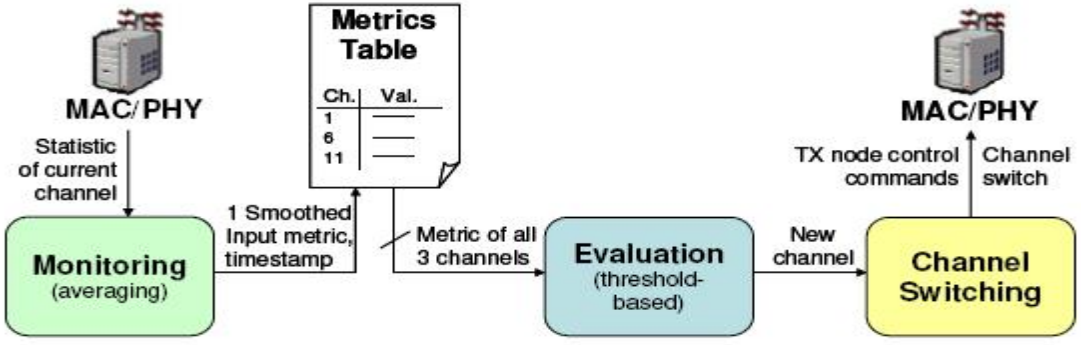


Figure 3. Function modules and data flow

Algorithm

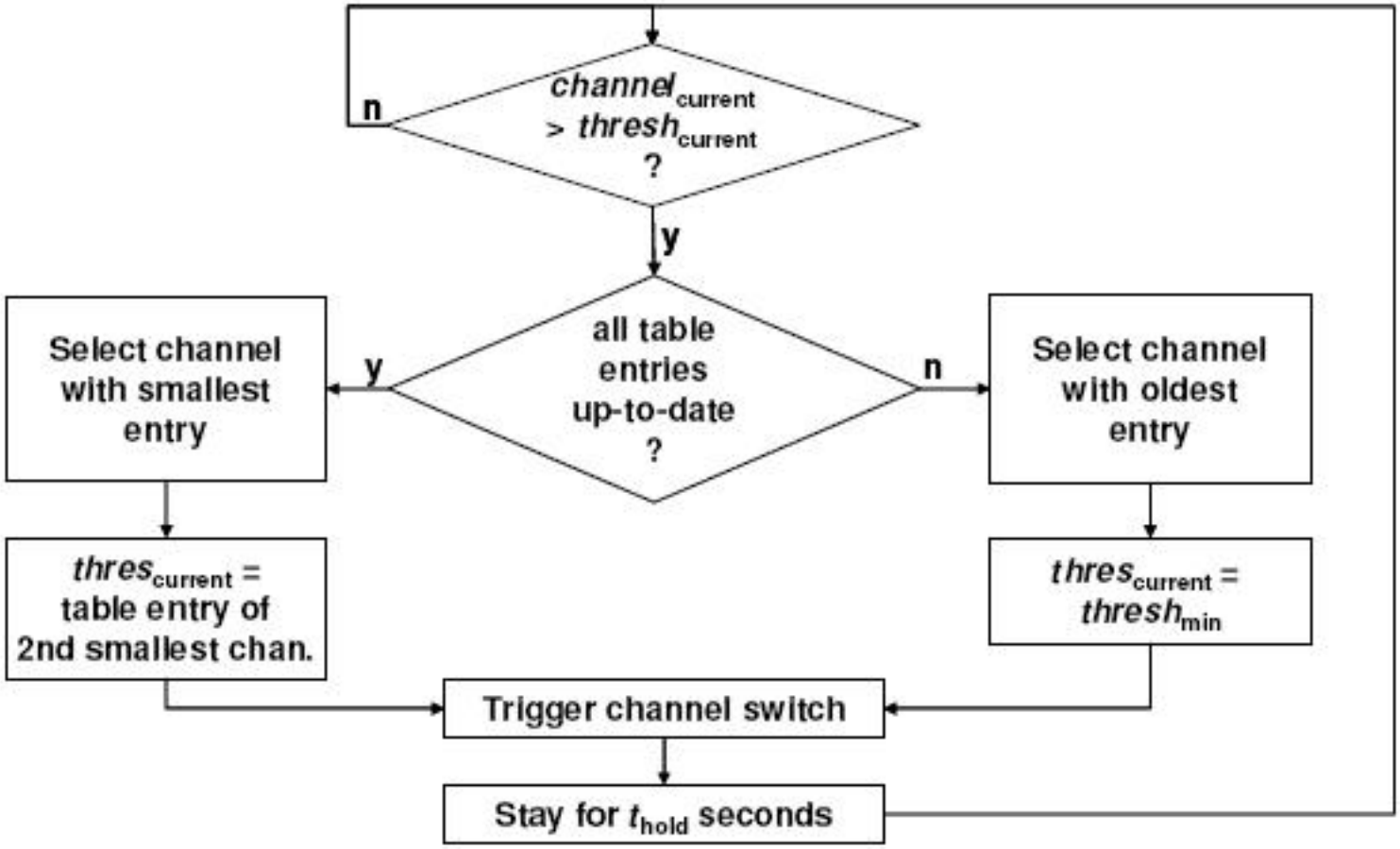


Figure 4. Flow chart algorithm for evaluation function

Channel Switching Coordination

- No Coordination
  - The AP simply switches channels, expecting the client to loose connectivity and reconnect
- AP-Client Coordination
  - The AP tells the client what channel to switch to and when (SWITCH message)
  - This is supported by 802.11k
- AP-AP Coordination
  - The AP tells other APs what channel it plans to switch to to avoid congestion (HOLD message)

Where To Calculate Network Load

- Because this is an unmanaged, decentralized system:
  - Devices are not distributed across the space evenly
  - No one device can be guaranteed to hear all other devices
  - No one device can be trusted to calculate fairly for all devices
  - All devices must calculate load for their particular space and situation

Which metric?

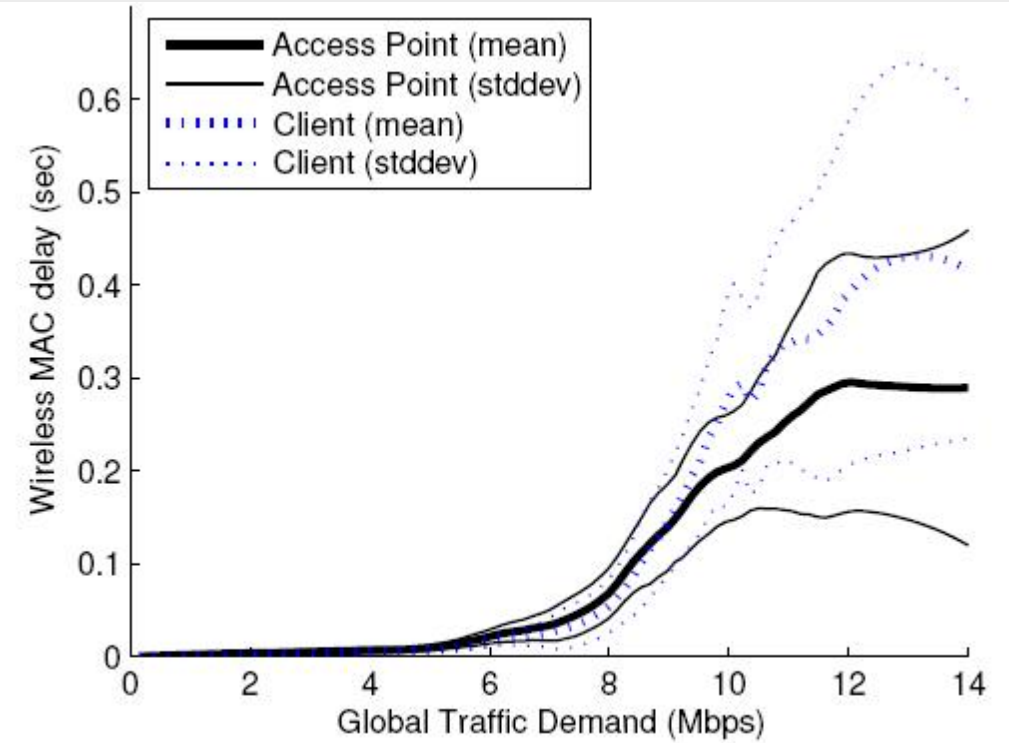


Figure 5. MAC delay versus traffic load

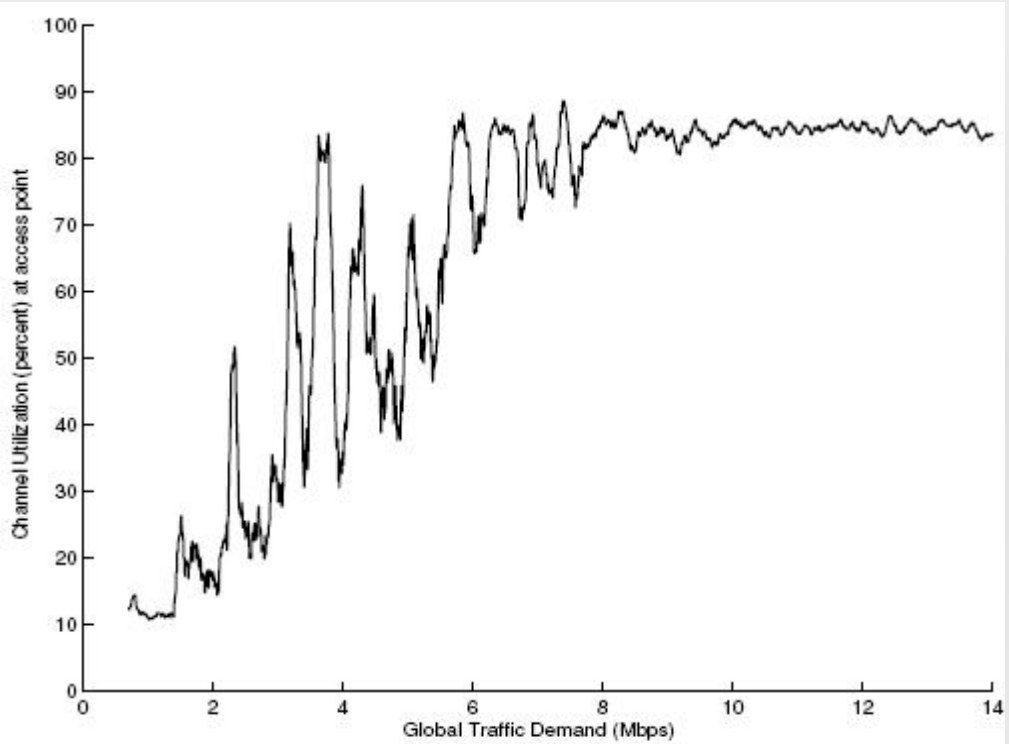


Figure 6. Channel Utilization versus traffic load

Calculating Network Load

- Dynamic nature of traffic
  - Dynamic number of clients
  - Dynamic bandwidth demand
- Channel Utilization
  - Many spikes – can cause false triggers
- Transmit Queue Length
  - Easy to measure
  - Highly variable – many false triggers
- MAC/Packet Delay
  - Transmit queue and channel contention time measured
  - Most attractive – very steady readings

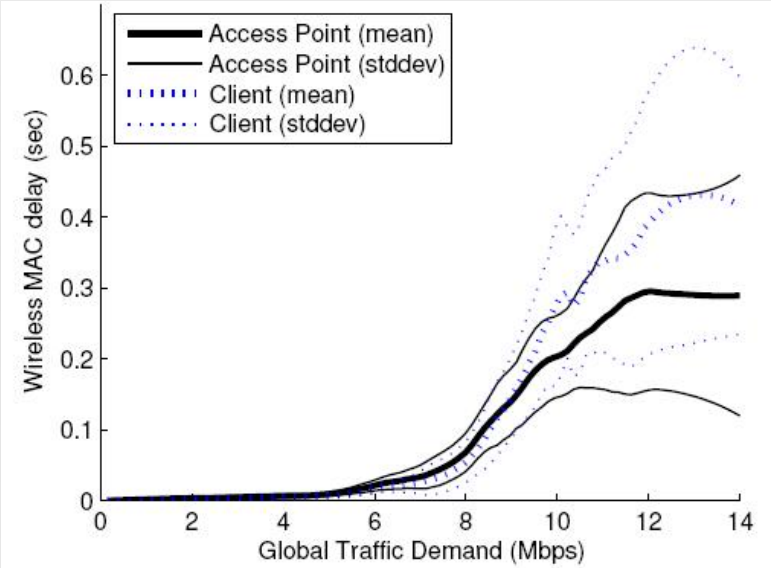


Figure 5. MAC delay versus traffic load

OPNET Simulation

- Utilizes both SWITCH for AP-Client coordination and HOLD for AP-AP coordination
- Comparison:
  - All APs and clients on a single channel
  - All APs and clients on non-overlapping channels
  - APs set to dynamically configure channel and coordinate with clients and other APs

Simulation Result

- Single channel performance was poor – as expected
- Manually configured on non-overlapping channels provided the most throughput – as expected
- Dynamic configuration provided about 5% less throughput than the manually configured non-overlapping channel setup

Simulation Result

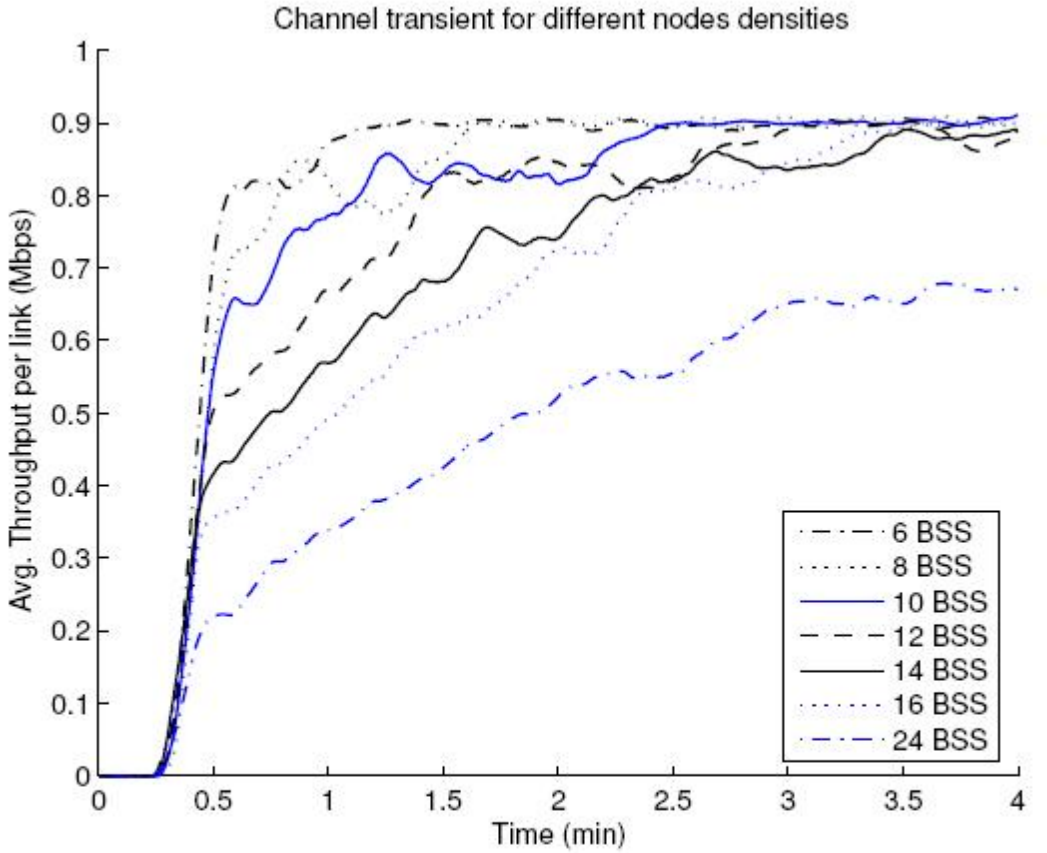


Figure 7. Average throughput as a function of increasing node density

Tuning the Algorithm: Coordination

- Removing Client-AP coordination – for legacy clients – reduces performance around the channel switch by a constant factor based on rescan/reconnect time
  - Remove the SWITCH capability
  - About 7% delay was gained and 2% throughput was lost
- Removing AP-AP coordination – the HOLD capability – reduces the global throughput by about 3%

Tuning the Algorithm: Parameters

- Load Average
  - The load is calculated using a moving average to negate small changes
  - Shrinking the averaging interval
    - Causes the system to converge on the maximum global throughput quickly
    - Causes excessive channel switching
  - Increasing the averaging interval
    - Slower convergence
    - Less time wasted switching channels
- Same is true of the channel hold time t_HOLD

Tuning the Algorithm: Parameters (contin)

- thres_min
  - The threshold for channel switching
  - Set to about 50% of channel capacity
  - Higher values increase convergence time
  - Lower causes increased number of channel switches

Tuning the Algorithm: Parameters (contin)

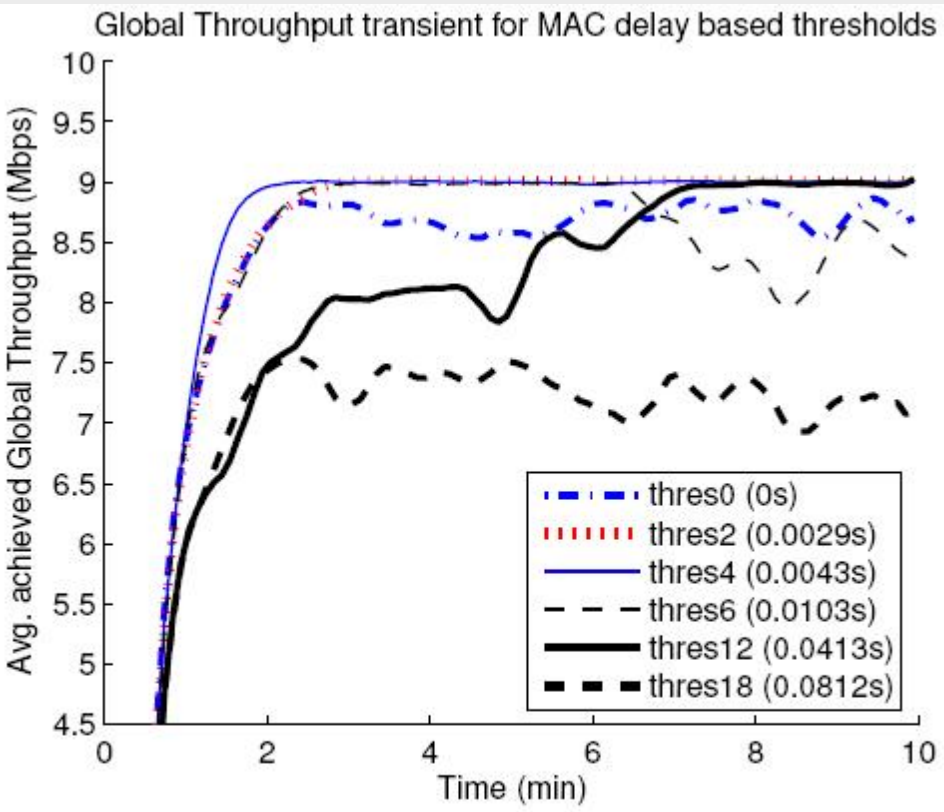


Figure 12. Throughput for varying MAC delay thresholds

Conclusions

- A decentralized algorithm that works.
- Delay based metrics are suitable.
- 95% throughput compared to manual config.
- Handles varying usage.

Works Cited

- Article:
  - Distributed Dynamic Channel Selection in Chaotic Wireless Networks

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Questions?