# A Study of MIMO Host Location Optimization in Active Access-Point Configuration Algorithm for Elastic WLAN System

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***Abstract*—The *active AP configuration algorithm* has been proposed to optimize the configuration of the *elastic WLAN system* that dynamically changes the topology depending on traffic demands and environments. The *multiple-input multiple-output (MIMO)* is the technology to enhance the transmission capacity by adopting multiple antennas. It is common for *access-points (APs)* but is still rare for *hosts*. Thus, the location optimization for MIMO hosts in the field appears to be a contributing factor in improving the performance. In this paper, we study the *MIMO host location optimization* as an extension of the *active AP configuration algorithm*. The concurrent communications of multiple hosts with a single AP offer different throughput features from the single communication, which is considered. The effectiveness is verified through simulations and simple testbeds.**

## I. Introduction

The *wireless local-area network (WLAN)* has become prevailing around the world due to several advantages such as easy installations, low costs, and flexible coverages over the wired LAN. To enhance the performance of the WLAN while saving the energy consumption, in previous studies, the *active AP configuration algorithm* has been proposed to optimize the network configuration in the *elastic WLAN system* that dynamically changes the topology depending on traffic demands and network environments.

The *multiple-input multiple-output (MIMO)* technology has become popular in the WLAN. MIMO can increase the transmission capacity of a wireless link with multiple data streams between multiple antennas from *single-input-single-output (SISO)*. Unfortunately, MIMO is still rare for user *hosts*, although it is available for most *access-points (APs)*. As a result, the location optimization for MIMO hosts in the network field turns out to be another important factor to further improve the network performance.

In this paper, we study the *MIMO host location optimization* by repeatedly swapping locations of SISO hosts and MIMO hosts, as the extension of the *active AP configuration algorithm*. In [2], it has been observed that the concurrent communications of multiple hosts with a single AP offer different throughput features from the single communication [1]. This reason may originate from the unfairness among the links associated with the AP. It gives more opportunities to the links with the hosts in the same room as the AP than the hosts in the different rooms. The effectiveness of our proposal is verified through simulations and simple testbeds.

## II. Extension of MIMO Host Location Optimization

In this section, we present the extension of the MIMO host location optimization in the active AP configuration algorithm.

### A. Modification of Objective Function $E_2$

First, to consider the effect on concurrent communications, the estimated average throughput $TH_j$ for $j$th AP is modified:

$$TH_j = \frac{1}{\sum_{k \in H_j} \frac{r_{jk}}{s_{jk} \cdot f(|H_j|)}} \quad (1)$$

where $H_j$ is the set of hosts associated with $AP_j$. $r_{jk}$ is the number of host replicas to consider the transmission chance increase, where in the paper, it is 8 for the host in the same room, and 1 for other hosts. $s_{jk}$ is the throughput between $AP_j$ and $host_k$. $f(x)$ is the throughput reduction factor by:

$$f(x) = 1 - 0.1 * (x - 1)/4. \quad (2)$$

Then, the cost function $E_2$ is calculated by:

$$E_2 = \min_j \left[ TH_j \right]. \quad (3)$$

### B. MIMO Host Location Optimization

The following procedure describes the overview of the active AP configuration algorithm with the proposed extension of the MIMO host location optimization.

1) Calculate the throughput for each possible pair of an AP and a host using the *throughput estimation model* in [2].
2) Derive the initial solution with the number of active APs (=$E_1$) by the greedy algorithm, and calculate the minimum average host throughput for the bottleneck AP (=$E_2$) for the initial solution.
3) Jointly optimize $E_1$ and $E_2$ by the local search method.
4) Repeat the following steps in $L$ times for *MIMO host location optimization*:

a) Select one SISO host and one MIMO host randomly.
b) Calculate the new average host throughput by Eq. (1) and $E_2^{new}$ by Eq. (3) when the two hosts are swapped.
c) When the two hosts are associated with different APs, accept this swap if the following two conditions are satisfied:
   1) the new average host throughput $\geq G$.
   2) the sum of new average host throughputs $\geq$ previous one.
   3) $E_2^{new} \geq$ the previous $E_2$.
d) Otherwise, accept this swap if the new average host throughput $\geq$ the previous one.
e) Repeat the *MIMO host location optimization*, if locations of some *MIMO* hosts are changed.

5) Apply the throughput fairness criterion when the total expected bandwidth exceeds $B_a$ (available bandwidth).
6) Terminate the algorithm when either of the following conditions is satisfied:
   a) the minimum host throughput constraint is satisfied.
   b) all the APs in the network are activated.

## III. Evaluation

In this section, we evaluate the performance of the proposal in simulations and testbeds.

### A. Simulation Result

First, a network topology with 40 hosts and 7 DAPs in six rooms of $7m \times 6m$ or $3.5m \times 6m$ is considered for simulations. Figure 1 shows the topology with 20 MIMO hosts before and after applying the proposal with $G = 5Mbps$ and $B^a = \infty$. Table I shows simulation results using the *WIMNET simulator* [3] for different numbers of MIMO hosts. In any case, the proposal will improve the total throughput, but does not satisfy the minimum host throughput constraint. In concurrent communications, distant hosts suffer from low throughputs, which should be increased in future works.

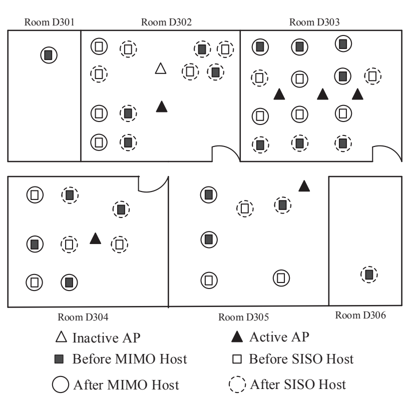


**Fig. 1:** Simulation network.

**TABLE I:** Simulation results.

| # of MIMO host | # of active APs | before optimization min. host through. (Mbps) | before optimization total through. (Mbps) | after optimization min. host through. (Mbps) | after optimization total through. (Mbps) |
|---|---|---|---|---|---|
| 4 | 6 | 1.99 | 242.48 | 2.05 | 250.93 |
| 8 | 6 | 2.11 | 255.99 | 2.26 | 274.49 |
| 12 | 6 | 2.13 | 260.98 | 2.61 | 315.49 |
| 16 | 6 | 2.37 | 273.69 | 2.91 | 338.02 |
| 20 | 6 | 2.45 | 288.21 | 3.13 | 372.78 |
| 24 | 6 | 2.72 | 330.04 | 3.38 | 419.35 |

### B. Testbed Experiment Result

Then, a small testbed with one AP and five hosts (one MIMO, four SISO) in three rooms is considered as a real network environment, as revealed in Figure 2. The size of room A is $3.5m \times 6m$ and room B or C is $7m \times 6m$. The MIMO host is initially located in either room. The throughput is measured before and after applying the proposal when the five hosts are concurrently communicating with the AP. Table II indicates that both measured and simulated throughputs have been improved by the proposal.

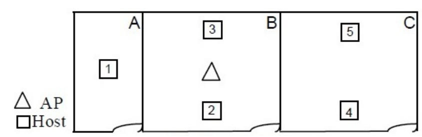


**Fig. 2:** Testbed network.

**TABLE II:** Testbed results.

| initial | | simulations | | | | |
|---|---|---|---|---|---|---|
| | | before optimization | | after optimization | | |
| MIMO host room | meas. through. (Mbps) | min. host through. (Mbps) | total through. (Mbps) | MIMO host room | min. host through. (Mbps) | total through. (Mbps) |
| A | 68.77 | 3.90 | 72.61 | B | 4.74 | 88.72 |
| B | 91.29 | 4.76 | 88.78 | B | 4.76 | 88.72 |
| C | 69.08 | 3.94 | 73.29 | B | 4.72 | 88.72 |

## IV. Conclusion

This paper presented the modification of the MIMO host location optimization considering concurrent communications between multiple hosts and a single AP. The effectiveness is verified through simulations and testbeds.

## Acknowledgments

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