Supplementary material

– Wi-Fi Channel Bonding: an All-Channel System and Experimental Study from Urban Hotspots to a Sold-Out Stadium –

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Abstract

This document compares the results presented in the paper "Wi-Fi Channel Bonding: an All-Channel System and Experimental Study from Urban Hotspots to a Sold-Out Stadium" against a new set of results obtained through trace-driven simulations with alternative IEEE 802.11ax inter frame durations (including SIFS, PIFS, and DIFS). We show that the insights presented in the abovementioned paper hold for slightly different inter frame durations, revealing the negligible impact of such durations in the estimation of mean throughput and other metrics of interest.

I. Original and new inter frame durations

In the paper "Wi-Fi Channel Bonding: an All-Channel System and Experimental Study from Urban Hotspots to a Sold-Out Stadium", we set inter frame durations rounded to multiples of $T_{\text{slot}} = 10\,\mu\text{s}$ rather than $9\,\mu\text{s}$ (IEEE 802.11's default value) to align the duration of an idle backoff slot with the sample duration of the WACA spectrum analyzer. Notice that these modifications on the durations are imposed by the sampling rate of the WACA platform. That is, we cannot achieve a smaller time resolution since the dataset provides 1 power sample every 10 µs. So, we opted to use the configuration that better resembles the standard-default inter frame durations. Accordingly, the findings presented in the paper were derived from performing trace-driven simulations with inter frame durations slightly different from the standard-based ones.

In this document, we graphically show that using similar inter frame durations (including DIFS $>$ PIFS) has a negligible impact as for the mean throughput and other metrics of interest. To do so, we have re-done all the trace-driven simulations of the collected experiments to show that the presented insights still hold when modifying the duration of the inter frame spaces. In particular, this document covers the differences between using the original durations against two alternative setups for the inter frame durations. The different setups are listed in Table I.

	Slot	**SIFS**	**PIFS**	**DIFS**
IEEE 802.11ax	9	16	25	34
Paper (original)	10	20	30	30
Alternative #1 (A1)	10	20	30	40
Alternative #2 (A2)	10	10	20	30

TABLE I: Combinations of the inter frame durations in µs.

Even though fine-grained accuracy is still constrained by the selection of the durations as multiples of $T_s = 10$ µs, we show that the differences when considering other inter frame durations (including DIFS $>$ PIFS) are negligible as for the gathered observations, but consistent with what could be expected from them (i.e., Alternative #1 offers less performance since the DIFS duration is now higher than the original, and Alternative #2 offers a better throughput performance since PIFS is now shorter than DIFS and so wider transmissions are now allowed).

II. Comparison of results

A. Contiguous vs. Non-Contiguous Aggregation

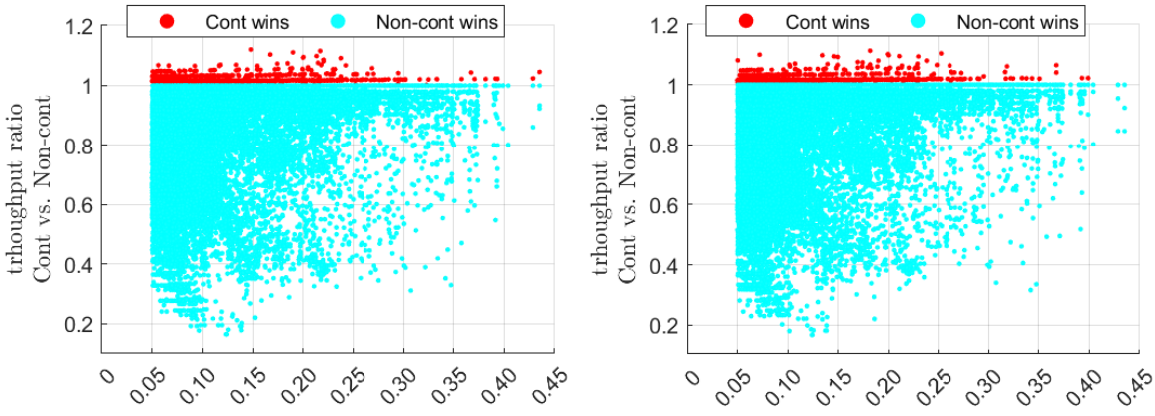
This experiment corresponds to §VI-A of the paper. Figure 1a and Figure 1b show the original and Alternative #1 inter frame durations, respectively.

B. Primary Channel Selection

This experiment corresponds to §VI-B of the paper. Figure 2a and Figure 2b show the original and Alternative #1 inter frame durations, respectively.

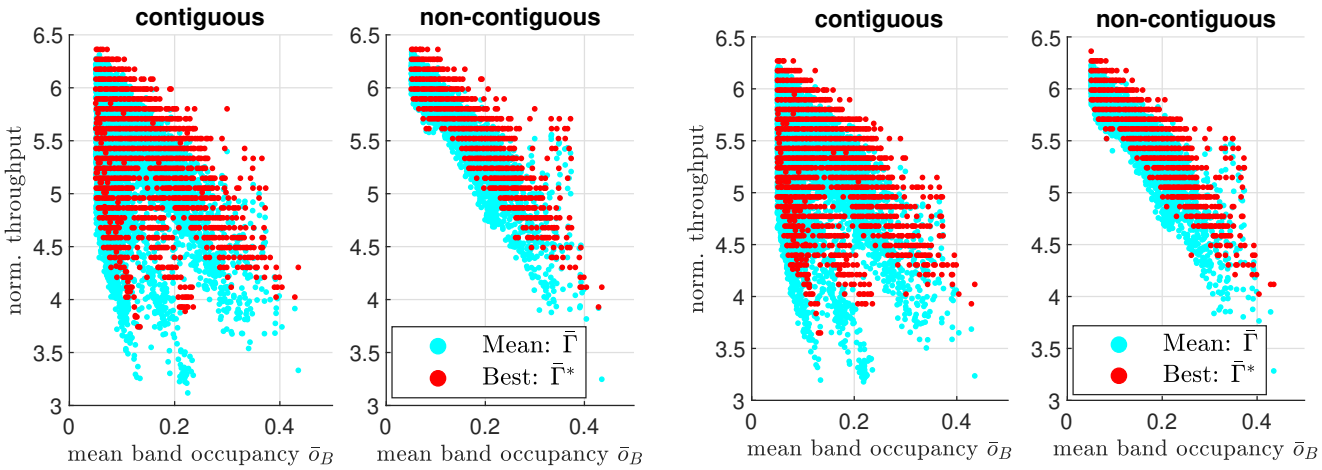
C. Inter-Channel Occupancy Correlation

This experiment corresponds to §VI-C of the paper. Figure 3a and Figure 3b show the original and Alternative #1 inter frame durations, respectively.



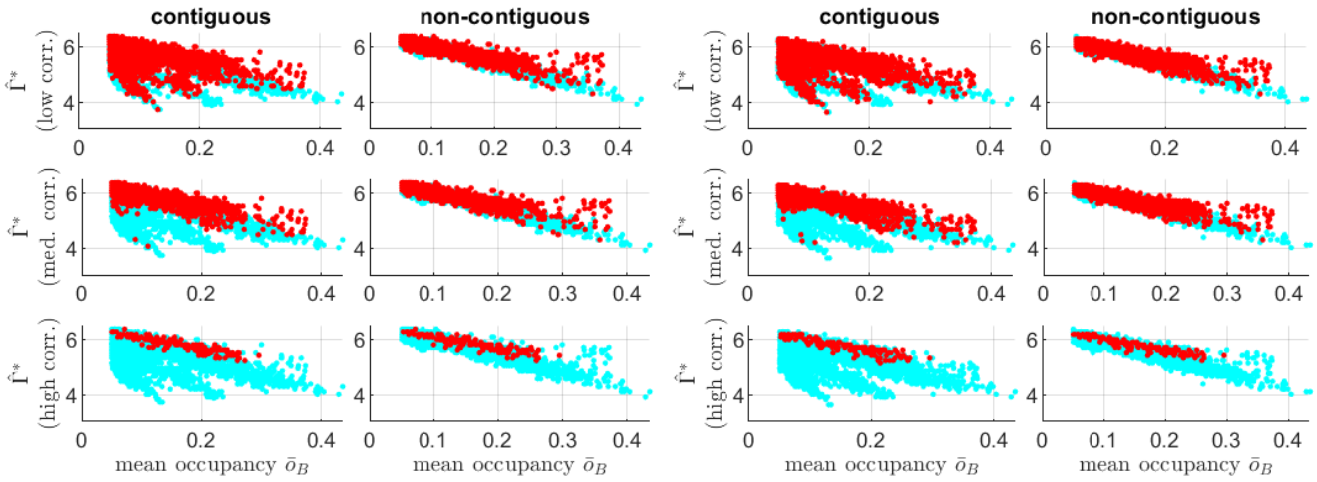
(a) Original. (b) Alternative #1.

Fig. 1: Throughput ratio of contiguous vs. non-contiguous.



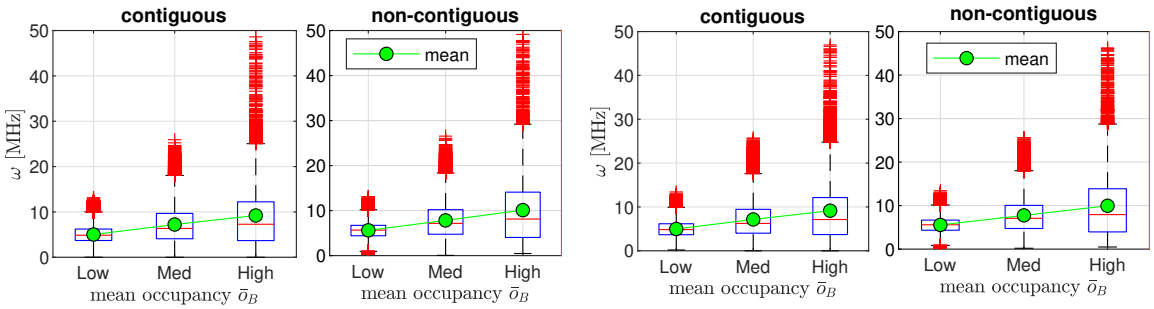
(a) Original. (b) Alternative #1.

Fig. 2: Normalized throughput of the best primary channel (*best*) and mean throughput for every primary channel (*mean*).



(a) Original. (b) Alternative #1.

Fig. 3: Evolution of the best-primary normalized throughput vs. correlation. We plot in blue all the epochs in all sub-figures and highlight in red only those that fall within the correlation range (low, medium, or high).



(a) Original. (b) Alternative #1.

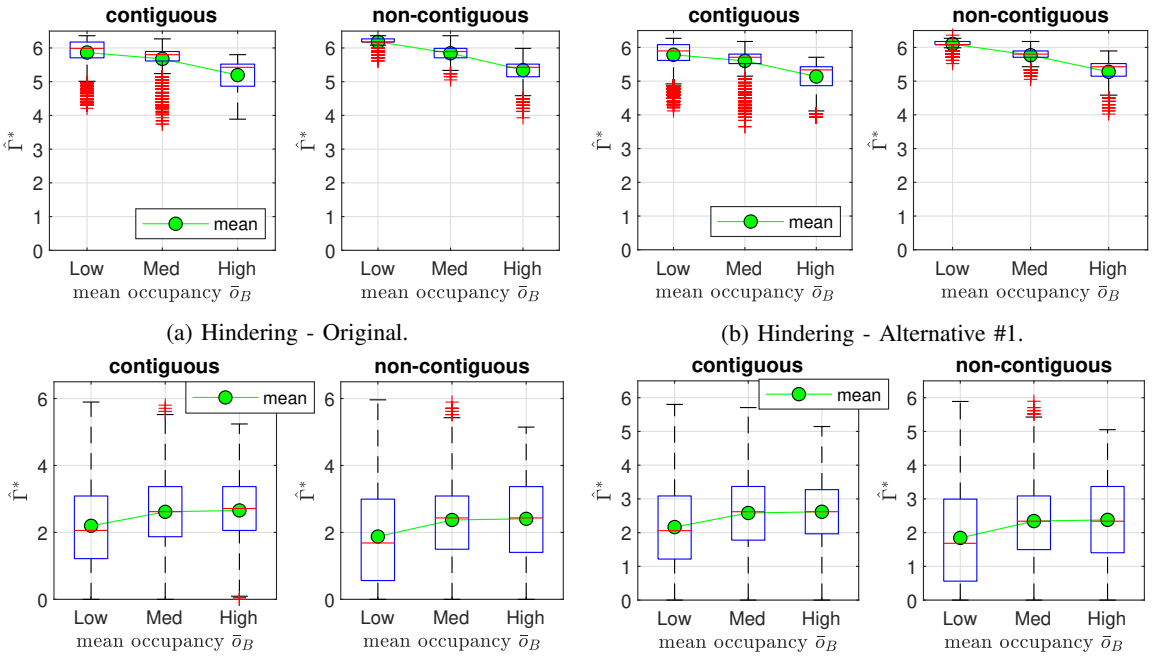
Fig. 4: Distribution of bandwidth and data rate lost for other BSS's for every primary channel.

D. How Much Are Others Hindered?

This experiment corresponds to §VII-A of the paper. Figure 4a and Figure 4b show the original and Alternative #1 inter frame durations, respectively.

E. The Hidden Cost of Hidden Nodes

This experiment corresponds to §VII-B of the paper. Figure 5a and Figure 5b show the original and Alternative #1 inter frame durations, respectively, for the *hindering* interaction model. Figure 5c and Figure 5d show the original and Alternative #1 inter frame durations, respectively, for the *hidden* interaction model.



(a) Hindering - Original. (b) Hindering - Alternative #1.

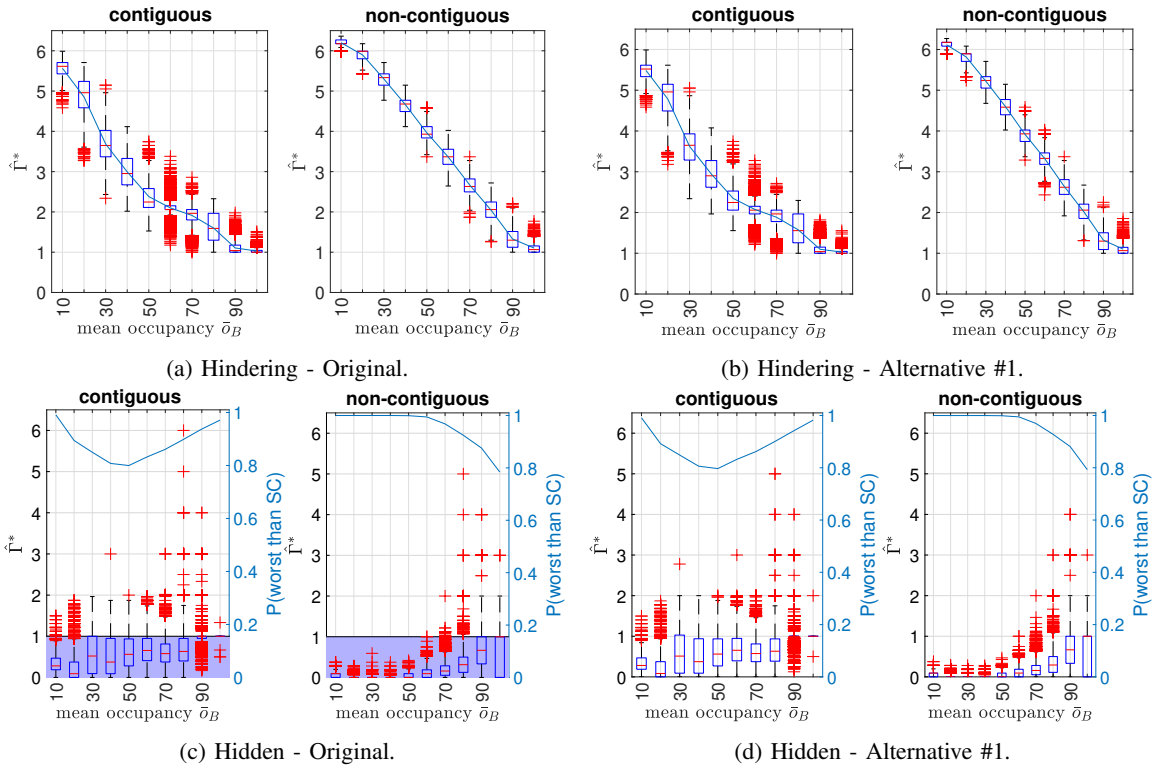
(c) Hidden - Original. (d) Hidden - Alternative #1.

Fig. 5: Distribution of the norm. best-primary-throughput.

F. A Sold-out Stadium

This experiment corresponds to §IX of the paper. Figure 6a and Figure 6b show the original and Alternative #1 inter frame durations, respectively, for the *hindering* interaction model. Figure 6c and Figure 6d show the original and Alternative #1 inter frame durations, respectively, for the *hidden* interaction model.

Finally, we show in Figure 7 the explicit throughput differences between the original inter frame values and the two alternative setups in Table I. While it is true that some epochs result in significant throughput differences (up to 70 Mbps), differences are normally negligible, with a mean value close to zero. Moreover, these difference, while small, are consistent with what could be expected from the two alternative configurations. Accordingly, and as shown in the different results comparisons in



(a) Hindering - Original.

(b) Hindering - Alternative #1.

(c) Hidden - Original.

(d) Hidden - Alternative #1.

Fig. 6: Futbol Club Barcelona stadium.

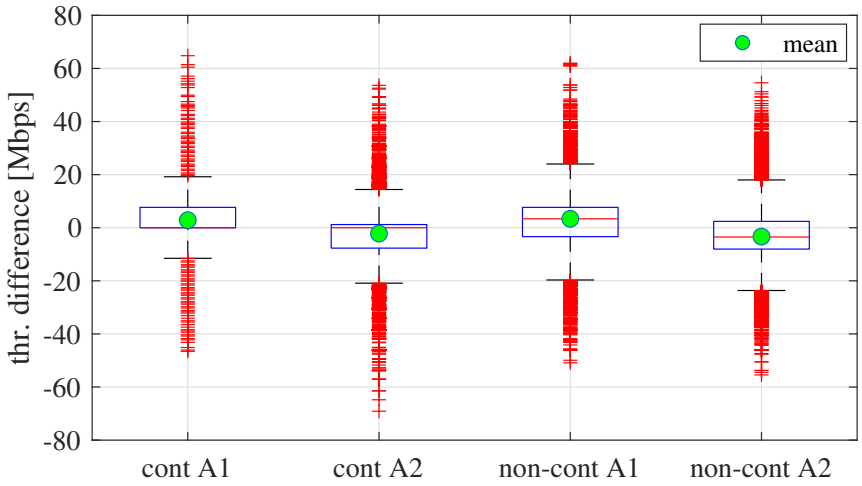


Fig. 7: Distribution of the throughput differences in the measurement campaign of the Camp Nou stadium.

this document, we confirm that the insights presented in the paper are still valid for slightly different inter frame durations, from which we derive that they would also hold for standard-default durations.