

CLAIMS:

1. A method for improving channel estimation for Orthogonal Frequency-Division Multiplexing (OFDM) signals in a Wi-Fi receiver, the method comprising:

receiving a preamble portion of a transmitted packet via a wireless channel, wherein the preamble portion includes a first long training field symbol, a first signal field symbol, a second signal field symbol and a second long training field symbol;

using the first long training field symbol to obtain a first channel estimation of the wireless channel;

decoding the first signal field symbol using the first channel estimation of the wireless channel to obtain a first binary pattern;

using the first binary pattern to reconstruct a first new signal field symbol;

dividing the first signal field symbol with the reconstructed first new signal field symbol to obtain a second channel estimation of the wireless channel;

decoding the second signal field symbol using the first channel estimation of the wireless channel to obtain a second binary pattern;

using the second binary pattern to reconstruct a new second signal field symbol;

dividing the second signal field symbol with the reconstructed new second signal field symbol to obtain a third channel estimation of the wireless channel;

using the second long training field symbol to obtain a fourth channel estimation of the wireless channel;

using the first and second channel estimations of the wireless channel to generate a first improved channel estimation of the wireless channel;

using the first, second and third channel estimations of the wireless channel to generate a second improved channel estimation of the wireless channel; and

determining if a difference between a legacy portion of the preamble and a high throughput portion of the preamble exceeds a threshold, wherein the legacy portion of the preamble includes the first and second signal field symbols and the first long training field symbol, and the high throughput portion includes the second long training field symbol,

whereby if the difference between the legacy portion and the high throughput portion does not exceed the threshold, using the fourth channel estimation of the wireless channel as a third improved channel estimation for the wireless channel.

2. The method according to claim 1 wherein before the using the obtained channel estimations of the wireless channel to generate the first improved channel estimation of the wireless channel, the method further comprises:

determining if a subcarrier amplitude of the first long training field symbol is equal to a subcarrier amplitude of the first signal field symbol; and

if it is determined that the subcarrier amplitude of the first long training field symbol is not equal to a subcarrier amplitude of the first signal field symbol, normalizing amplitudes of the subcarriers of the first signal field symbol and the first long training field symbol.

3. The method according to claim 1 wherein before the using the obtained channel estimations of the wireless channel to generate the third improved channel estimation of the wireless channel, the method further comprises:

determining if a subcarrier amplitude of the first long training field symbol, a subcarrier amplitude of the first signal field symbol and a subcarrier amplitude of the second signal field symbol are all equal to a subcarrier amplitude of the second long training field symbol; and

if it is determined that the subcarrier amplitude of the first long training field symbol, the subcarrier amplitude of the first signal field symbol and the subcarrier amplitude of the second signal field symbol are all not equal to the subcarrier amplitude of the second long

training field symbol, normalizing amplitudes of the subcarriers of the first and second signal field symbols and subcarriers of the first long training field symbol.

4. The method according to any one of claims 1 or 2 wherein the using the obtained channel estimations of the wireless channel to generate the first improved channel estimation for the wireless channel further comprises:

generating the first improved channel estimation of the wireless channel by weighting the obtained channel estimations, summing the weighted channel estimations and dividing the summed weighted channel estimations with a sum of the weights.

5. The method according to claim 1 wherein the using the obtained channel estimations of the wireless channel to generate the second improved channel estimation for the wireless channel further comprises:

generating the second improved channel estimation of the wireless channel by weighting the obtained channel estimations, summing the weighted channel estimations and dividing the summed weighted channel estimations with a sum of the weights.

6. The method according to any one of claims 1 or 3 wherein the using the obtained channel estimations of the wireless channel to generate the third improved channel estimation for the wireless channel further comprises:

generating the third improved channel estimation of the wireless channel by weighting the obtained channel estimations, summing the weighted channel estimations and dividing the summed weighted channel estimations with a sum of the weights.

7. The method according to any one of claims 1 or 2 further comprising:

using the first improved channel estimation of the wireless channel to decode a data portion of the transmitted packet.

8. The method according to any one of claims 1 or 3 further comprising:

using the second improved channel estimation of the wireless channel to decode a data portion of the transmitted packet.

9. The method according to claim 1 further comprising:

using the third improved channel estimation of the wireless channel to decode a data portion of the transmitted packet.

10. The method according to claim 1 wherein the using the first binary pattern to reconstruct

the first new signal field symbol comprises:

encoding the first binary pattern;

digitally modulating the encoded first binary pattern; and

adding pilot symbols to the digitally modulated first binary pattern to form the first new signal field symbol.

11. The method according to claim 1 wherein the using the second binary pattern to

reconstruct the second new signal field symbol comprises:

encoding the second binary pattern;

digitally modulating the encoded second binary pattern; and

adding pilot symbols to the digitally modulated second binary pattern to form the second new signal field symbol.

12. The method according to claim 1 wherein the determining if the difference between the legacy portion of the preamble and the high throughput portion of the preamble exceeds the threshold comprises determining:

$$\left[\frac{\text{sum}(\text{metric}_{I(n)})}{\text{sum}(\text{metric}_{Q(n)})} \right] > \text{threshold}$$

where:

$[\text{sum}(\text{metric}_{I(n)}) / \text{sum}(\text{metric}_{Q(n)})]$ is the difference between the legacy portion of the preamble and the high throughput portion of the preamble;

threshold is any value between 1 and 4 ;

$$\text{metric}_{I(n)} = |\text{real}(\text{ChEst}_{\text{legacy}(n)} \times \text{conjugate}(\text{ChEst}_{\text{htvht}(n)}))|;$$

$$\text{metric}_{Q(n)} = |\text{imag}(\text{ChEst}_{\text{legacy}(n)} \times \text{conjugate}(\text{ChEst}_{\text{htvht}(n)}))|;$$

where:

$$\text{ChEst}_{\text{legacy}(n)} =$$

$$((W1 \times \text{ChEst}_{1\text{LTF}(n)}) + (W2 \times \text{ChEst}_{1\text{Sig}(n)}) + (W3 \times \text{ChEst}_{2\text{Sig}(n)})) / (W1 + W2 + W3);$$

$$\text{ChEst}_{\text{htvht}(n)} = \text{ChEst}_{2\text{LTF}(n)};$$

$\text{ChEst}_{1\text{LTF}(n)}$ is the first channel estimation for the n^{th} subcarrier index for the first long training field symbol;

$\text{ChEst}_{1\text{Sig}(n)}$ is the second channel estimation for the n^{th} subcarrier index for the first signal symbol field;

$\text{ChEst}_{2\text{Sig}(n)}$ is the third channel estimation for the n^{th} subcarrier index for the second signal symbol field;

$\text{ChEst}_{2\text{LTF}(n)}$ is the fourth channel estimation for the n^{th} subcarrier index for the second long training field symbol;

n is the subcarrier index; and

$$W1 = 2, W2 = 1, W3 = 2, W4 = 1.$$

13. A system for improving channel estimation for Orthogonal Frequency-Division Multiplexing (OFDM) signals in a Wi-Fi receiver, the system comprising:

a processing unit; and

a non-transitory media readable by the processing unit, the media storing instructions that when executed by the processing unit, cause the processing unit to:

receive a preamble portion of a transmitted packet via a wireless channel, wherein the preamble portion includes a first long training field symbol, a first signal field symbol, a second signal field symbol and a second long training field symbol;

use the first long training field symbol to obtain a first channel estimation of the wireless channel;

decode the first signal field symbol using the first channel estimation of the wireless channel to obtain a first binary pattern;

use the first binary pattern to reconstruct a first new signal field symbol;

divide the first signal field symbol with the reconstructed first new signal field symbol to obtain a second channel estimation of the wireless channel;

decode the second signal field symbol using the first channel estimation of the wireless channel to obtain a second binary pattern;

use the second binary pattern to reconstruct a new second signal field symbol;

divide the second signal field symbol with the reconstructed new second signal field symbol to obtain a third channel estimation of the wireless channel;

use the second long training field symbol to obtain a fourth channel estimation of the wireless channel;

use the first and second channel estimations of the wireless channel to generate a first improved channel estimation of the wireless channel;

use the first, second and third channel estimations of the wireless channel to generate a second improved channel estimation of the wireless channel; and

determine if a difference between a legacy portion of the preamble and a high throughput portion of the preamble exceeds a threshold, wherein the legacy portion of the preamble includes the first and second signal field symbols and the first long training field symbol, and the high throughput portion includes the second long training field symbol,

whereby if the difference between the legacy portion and the high throughput portion does not exceed the threshold, use the fourth channel estimation of the wireless channel as a third improved channel estimation for the wireless channel.

14. The system according to claim 13 wherein before the using the obtained channel estimations of the wireless channel to generate the first improved channel estimation of the wireless channel, the system further comprises:

instructions for directing the processing unit to:

determine if a subcarrier amplitude of the first long training field symbol is equal to a subcarrier amplitude of the first signal field symbol; and

if it is determined that the subcarrier amplitude of the first long training field symbol is not equal to a subcarrier amplitude of the first signal field symbol, normalize amplitudes of the subcarriers of the first signal field symbol and the first long training field symbol.

15. The system according to claim 13 wherein before the instructions to use the obtained channel estimations of the wireless channel to generate the third improved channel estimation of the wireless channel, the system further comprises:

instructions for directing the processing unit to:

determine if a subcarrier amplitude of the first long training field symbol, a subcarrier amplitude of the first signal field symbol and a subcarrier amplitude of the second signal field symbol are all equal to a subcarrier amplitude of the second long training field symbol; and

if it is determined that the subcarrier amplitude of the first long training field symbol, the subcarrier amplitude of the first signal field symbol and the subcarrier amplitude of the second signal field symbol are all not equal to the subcarrier amplitude of the second long training field symbol, normalize amplitudes of the subcarriers of the first and second signal field symbols and subcarriers of the first long training field symbol.

16. The system according to any one of claims 13 or 14 wherein the instructions to use the obtained channel estimations of the wireless channel to generate the first improved channel estimation for the wireless channel further comprises:

instructions for directing the processing unit to:

generate the first improved channel estimation of the wireless channel by weighting the obtained channel estimations, summing the weighted channel estimations and dividing the summed weighted channel estimations with a sum of the weights.

17. The system according to claim 13 wherein the instructions to use the obtained channel estimations of the wireless channel to generate the second improved channel estimation for the wireless channel further comprises:

instructions for directing the processing unit to:

generate the second improved channel estimation of the wireless channel by weighting the obtained channel estimations, summing the weighted channel estimations and dividing the summed weighted channel estimations with a sum of the weights.

18. The system according to any one of claims 13 or 15 wherein the instructions to use the obtained channel estimations of the wireless channel to generate the third improved channel estimation for the wireless channel further comprises:

instructions for directing the processing unit to:

generate the third improved channel estimation of the wireless channel by weighting the obtained channel estimations, summing the weighted channel estimations and dividing the summed weighted channel estimations with a sum of the weights.

19. The system according to any one of claims 13 or 15 further comprising:

instructions for directing the processing unit to:

use the first improved channel estimation of the wireless channel to decode a data portion of the transmitted packet.

20. The system according to any one of claims 13 or 15 further comprising:

instructions for directing the processing unit to:

use the second improved channel estimation of the wireless channel to decode a data portion of the transmitted packet.

21. The system according to claim 13 further comprising:

instructions for directing the processing unit to:

use the third improved channel estimation of the wireless channel to decode a data portion of the transmitted packet.

22. The system according to claim 13 wherein the instructions to use the first binary pattern

to reconstruct the first new signal field symbol comprises:

instructions for directing the processing unit to:

encode the first binary pattern;
 digitally modulate the encoded first binary pattern; and
 add pilot symbols to the digitally modulated first binary pattern to form the first new signal field symbol.

23. The system according to claim 13 wherein the instructions to use the second binary pattern to reconstruct the second new signal field symbol comprises:

instructions for directing the processing unit to:

encode the second binary pattern;
 digitally modulate the encoded second binary pattern; and
 add pilot symbols to the digitally modulated second binary pattern to form the second new signal field symbol.

24. The system according to claim 13 wherein the instructions to determine if the difference between the legacy portion of the preamble and the high throughput portion of the preamble exceeds the threshold comprises determining:

$$\left[\frac{\text{sum}(\text{metric}_{I(n)})}{\text{sum}(\text{metric}_{Q(n)})} \right] > \text{threshold}$$

where:

$[\text{sum}(\text{metric}_{I(n)}) / \text{sum}(\text{metric}_{Q(n)})]$ is the difference between the legacy portion of the preamble and the high throughput portion of the preamble;

threshold is any value between 1 and 4 ;

$$\text{metric}_{I(n)} = |\text{real}(\text{ChEst}_{\text{legacy}(n)} \times \text{conjugate}(\text{ChEst}_{\text{htvht}(n)}))|;$$

$$\text{metric}_{Q(n)} = |\text{imag}(\text{ChEst}_{\text{legacy}(n)} \times \text{conjugate}(\text{ChEst}_{\text{htvht}(n)}))|;$$

where:

$$ChEst_{legacy(n)} = ((W1 \times ChEst_{1LTF(n)}) + (W2 \times ChEst_{1Sig(n)}) + (W3 \times ChEst_{2Sig(n)})) / (W1 + W2 + W3);$$

$$ChEst_{htvht(n)} = ChEst_{2LTF(n)};$$

$ChEst_{1LTF(n)}$ is the first channel estimation for the n^{th} subcarrier index for the first long training field symbol;

$ChEst_{1Sig(n)}$ is the second channel estimation for the n^{th} subcarrier index for the first signal symbol field;

$ChEst_{2Sig(n)}$ is the third channel estimation for the n^{th} subcarrier index for the second signal symbol field;

$ChEst_{2LTF(n)}$ is the fourth channel estimation for the n^{th} subcarrier index for the second long training field symbol;

n is the subcarrier index; and

$W1 = 2, W2 = 1, W3 = 2, W4 = 1$.