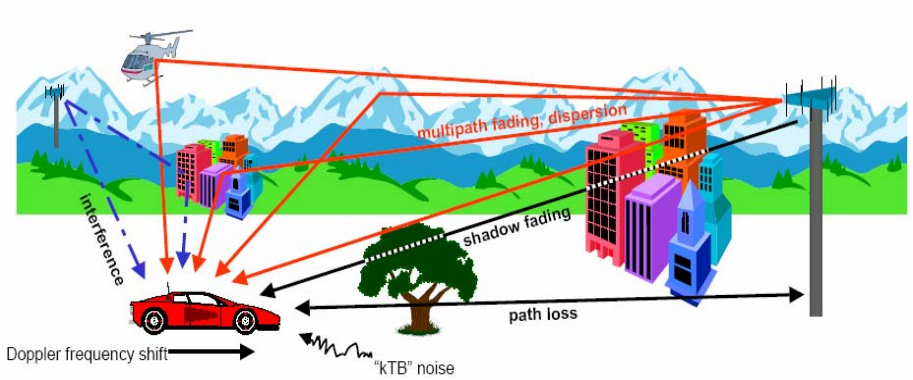
OFDM - Wavelet Domain Diversity for Wireless Image Transmission Using Hybrid OFDM Systems

Madhu Rangappagowda

Research Associate
University of Texas at Arlington
Mhr259.exchange@uta.edu

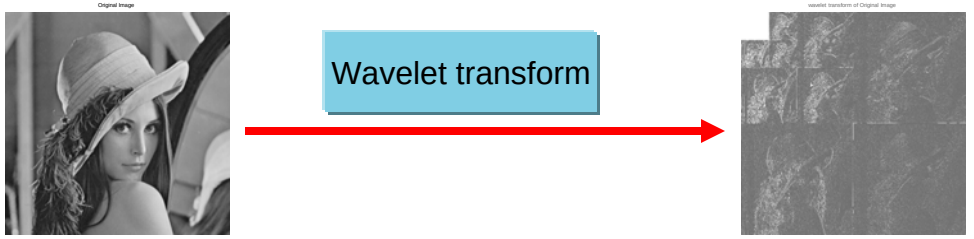
OFDM BASED WAVELET DOMAIN DIVERSITY

- A OFDM based wavelet domain diversity combining method to combat errors during image transmission on wireless channels is developed.
- For images represented in the wavelet domain, diversity is used to obtain multiple data streams corresponding to the transmitted image at the receiver.
- These individual image data streams are combined to form a composite image with higher perceptual quality.

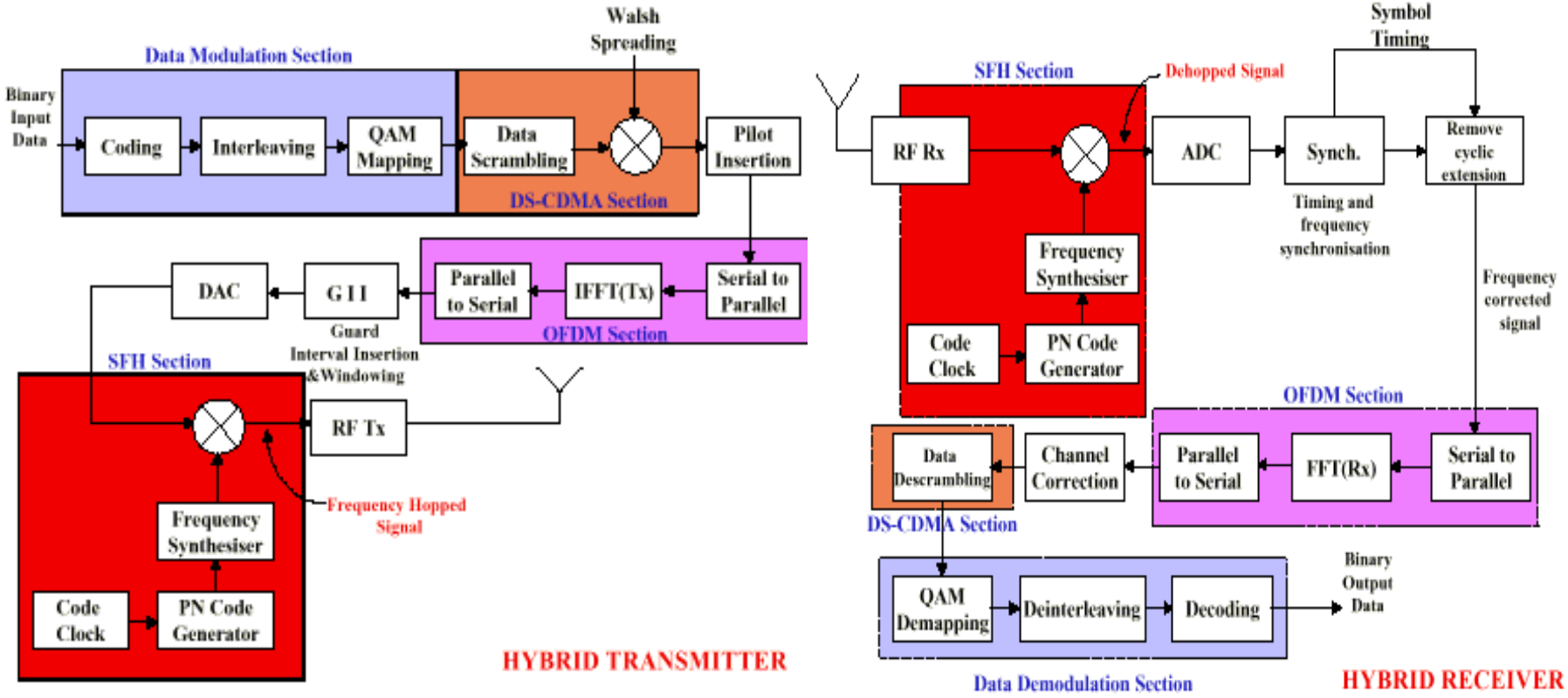


Diversity

- Diversity is a communication method used to improve wireless transmission that utilizes independent (or highly uncorrelated) communication signal paths to combat channel noise.
- Wavelet domain diversity is achieved by using the properties of the original image or its wavelet transform.



HYBRID OFDM SYSTEM

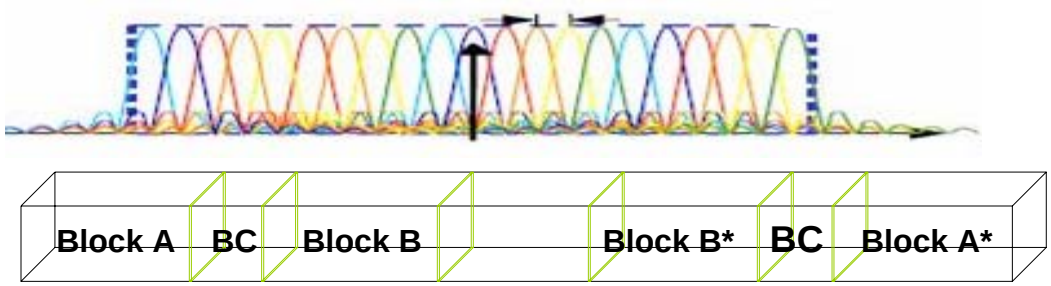


- OFDM system only supports one user.
- frequency selective fading does not permit very high data rates in DS-CDMA
- Near-far effect in uplink in CDMA
- CDMA-SFH solves near-far problem but only non-coherent modulation then
- Interference limited --- MAI limits the number of users that can be added to a CDMA system
- Synch problems at high chip rates

- OFDM/CDMA supports multiple users.
- Flat fading in OFDM sub-carriers
- SFH in Hybrid system solves this
- OFDM-FH hops on frame basis: allows coherent modulation
- Bandwidth limited --- allows any number of users by increasing the hops.
- Easier synch due to cyclic prefixes in OFDM

WAVELET - OFDM DIVERSITY MEHTODS AND PROCEDURE

- OFDM-based diversity is a novel approach that utilizes the sub-carrier orthogonality to send data blocks and combine them at the receiver.
- Our novel approach of using OFDM sub- carriers to attain diversity in wireless image transmission is more effective in combating the fading and other channel impairments due to its immunity to inter channel interference and inter symbol interference.
- Not only this method helps in improving the received image quality but also gives us the flexibility in high data rate transmission with multiple user access.



Block A → Bits modulated by sub – carrier set N1
Block B → Bits modulated by sub – carrier set N2

OFDM symbol

N TOTAL SUB-CARRIERS = N1 + N2 sub- carriers

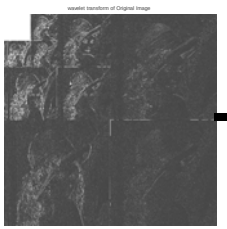
Bandwidth considerations

Multimedia requirements → >155Mbps
BW required → around 100-150MHz
Carrier frequency → 60 GHz frequency
Implies Rician fading and LOS communication – Rayleigh fading is simulated, though it can be extended to Rician easily.
Design required to incorporate large no. of users as opposed to robust design
Yields low BER

IMAGE DECOMPOSTION AND DATA PLACEMENT

CODER

WT



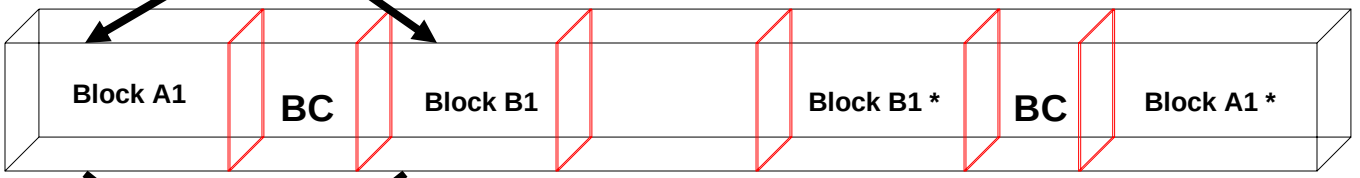
10 bit quantizer

Bit - interleaver

RS(78,64)

Uncompressed image

BC= Coherence Bandwidth



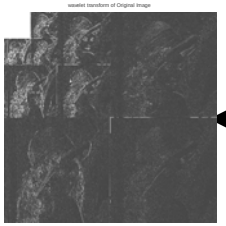
DE-CODER

RS decode(78,64)

Block An

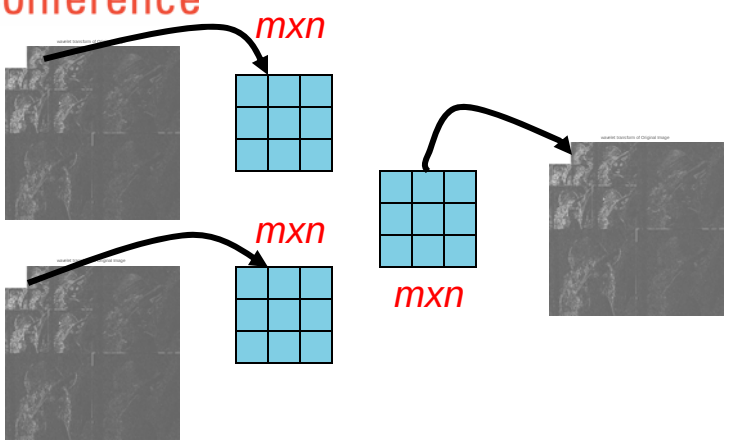
Block Bn

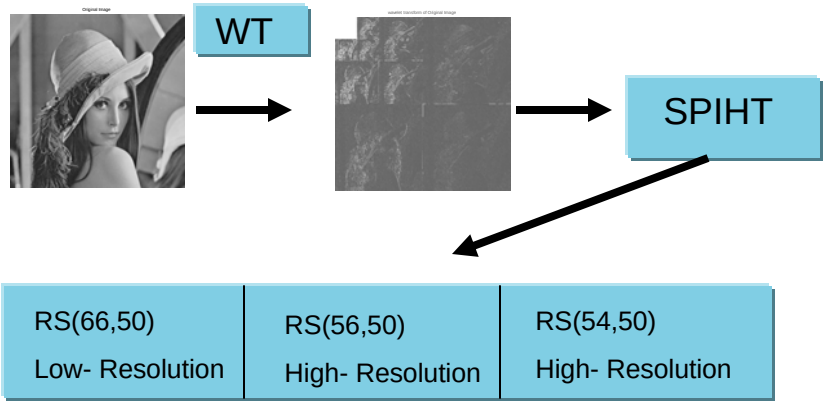
Diversity combination-Gathering data, its placement in transform coefficient block



IWT

DIVERSITY ALGORITHIMS AND PROCEDURES





Diversity algorithms for uncompressed images

Low-resolution sub-band

$$c_{Lc}(i,j) = \begin{cases} c_{L1}(i,j) & \text{if } c_{L1}(i,j) = c_{L2}(i,j) \\ med[\{c_{L1}(k,l)\},\{c_{L2}(k,l)\}] & \text{if } c_{L1}(i,j) \neq c_{L2}(i,j) \end{cases}$$

for

$$(k,l) \in \left(\left\{i - \frac{m-1}{2}, \cdots, i + \frac{m-1}{2}\right\}, \left\{j - \frac{n-1}{2}, \cdots, j + \frac{n-1}{2}\right\}\right)$$

High -resolution sub-band

$$c_{Hc}(i,j) = \begin{cases} c_{H1}(i,j) & \text{if } c_{H1}(i,j) = c_{H2}(i,j) \\ c_{H1}(i,j) & \text{if } |c_{H1}(i,j)| < |c_{H2}(i,j)| \\ c_{H2}(i,j) & \text{if } |c_{H2}(i,j)| < |c_{H1}(i,j)| \end{cases}$$

Diversity algorithms for compressed images

$$b_f(l) = \begin{cases} b_1(l) & \text{if } w_1(l) \leq w_2(l) \\ b_2(l) & \text{if } w_1(l) > w_2(l) \end{cases} \quad \text{for } l = 1, 2, \cdots$$

$$w_k(l) = h_L^k(l) + h_H^k(l)$$

$$h_L^k(l) = \sum_{\substack{(i,j) \in \text{low res.} \\ \text{subband}}} [d_k(i,j) + (c_{Lk}(i,j) - \mu_{Lk})^2]$$

$$h_H^k(l) = \sum_{\substack{(i,j) \in \text{detail} \\ \text{subbands}}} [t_k(i,j) + c_{Hk}(i,j)]$$

$$\mu_{Lk} = \frac{\sum_{\substack{(i,j) \in \text{low res.} \\ \text{subband}}} c_{Lk}(i,j)}{\text{no. of coefficients in low res. subband}}$$

$$d_k(i,j) = |c_{Lk}(i,j) - c_{Lk}(i,j+1)|$$

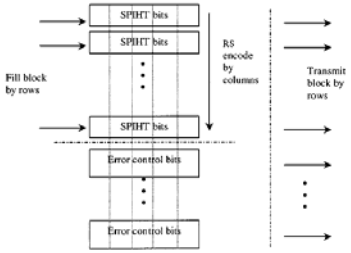
$$t_k(i,j) = \left| c_{Hk}(i,j) - \left(\sum_{m=0}^{1} \sum_{n=0}^{1} c_{Hk}(2i+m, 2j+n) \Big/ 4 \right) \right|$$

IMAGE DECOMPOSTION AND DATA PLACEMENT CONTD..

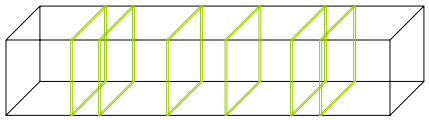
SPIHT

MD coding

UEP coding &
Interleaving &
Block formation



Packing the data to form OFDM symbol



CODER

Streaming data

Decoded Stream A

0111 11010 1010101010 10101 01010 0000 10101 0000 0011 1111 11101 01010 10101 1111

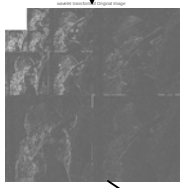
An

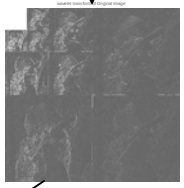
SPHIT decoder
MD decoder
Total size of block
An + Fn or Bn + Fn

Decoded Stream B

0111 11010 1010101010 10101 01010 0000 10101 0000 0011 1111 11101 01010 10101 1111

Bn



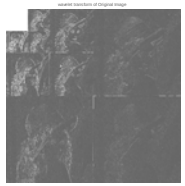


Diversity combination

DE-CODER

SPIHT

MD coding



IWT

Final Stream F

0111 11010 .....

Fn

FINDINGS ….

WITH OUT DIVERSITY

WITH DIVERSITY

image without diveristy, BER 0.005

image with diveristy, BER 0.005

image without diveristy, BER 0.015

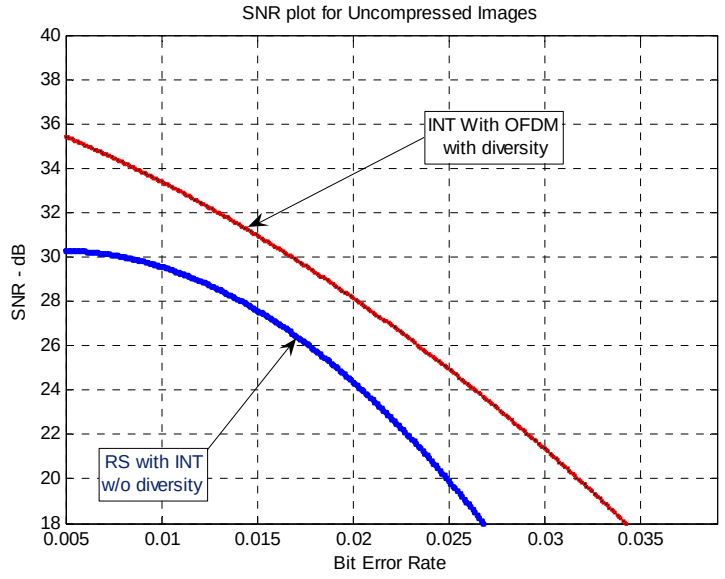
image with diveristy, BER 0.015

image without diveristy, BER 0.025

image with diveristy, BER 0.025

Uncompressed images

Transmission Method / BER	RS with INT w/o diversity	INT With OFDM with diversity
BER=0.005	30.728	35.326
BER=0.010	28.831	33.628
BER=0.015	27.005	30.83
BER=0.020	25.86	28.09
BER=0.025	19.269	25.001



FINDINGS CONTD …

WITH OUT DIVERSITY

WITH DIVERSITY

image reconstructed without diversity for BER = 0.010

image reconstructed with diversity for BER 0.010

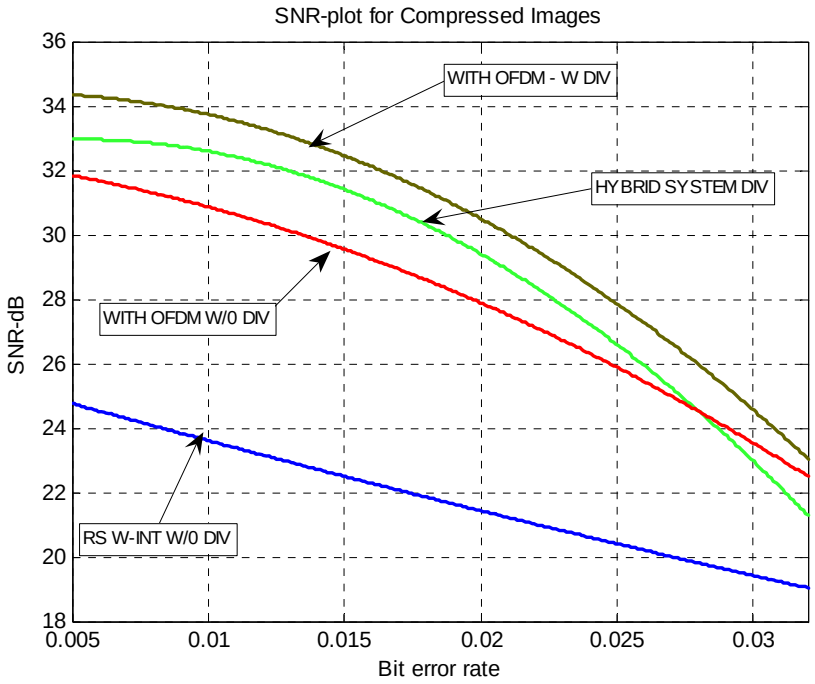
image reconstructed without diversity for BER = 0.020

image reconstructed with diversity for BER 0.020

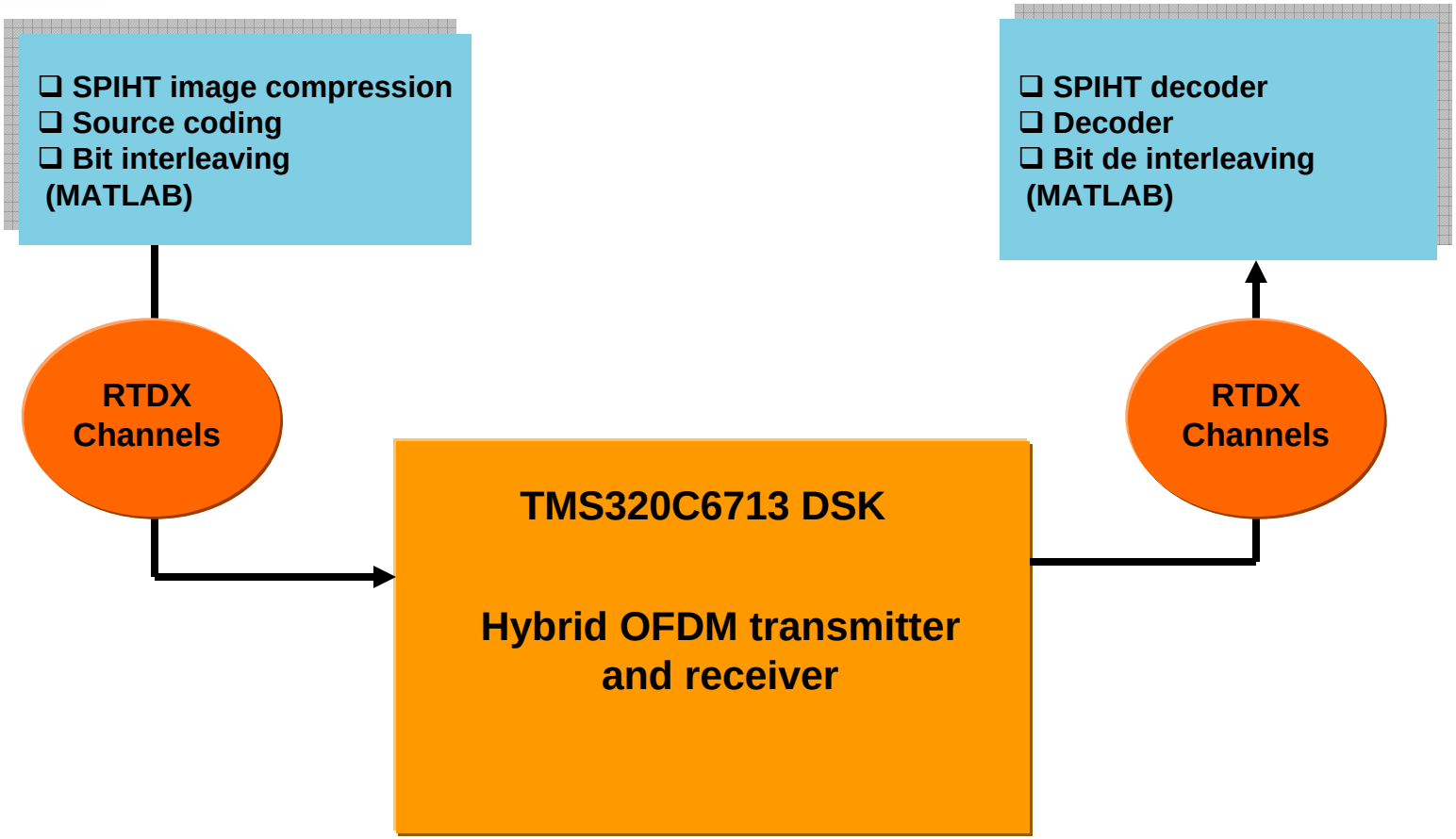
image reconstructed without diversity for BER = 0.025

image reconstructed with diversity for BER 0.025

compressed images



DSP IMPLEMENTATION



- Real time DSP implementation is done through RTDX protocols of TMS320c6713.
- Board used for the development is spectrum digital TMS320c6713 DSK.
- The DSK is communicated through USB interface, Program interface are done through code composer studio V 2.21.

CONCLUSION

- A new OFDM- WAVELET based diversity combination method is developed, which caters to the needs of multimedia communication.
- Requirement of high speed data rate with considerable Signal to Noise Ratio is achieved.
- Bandwidth requirements are specified and OFDM symbols are designed to meet those constraints.
- Wavelet domain based diversity is discussed thoroughly and also investigated in a new HYBRID OFDM system.
- Not only the diversity method was tested on HYBRID system , but also a significant advantage of the system is shown.

Future –work

Extending the work to video signals

Transmission of images through voice channels