RESEARCH AND DEVELOPMENT TELECOMMUNICATIONS INSTITUTE

DESIGN AND IMPLEMENTATION OF SYNCHRONIZATION ALGORITHMS FOR DTMB

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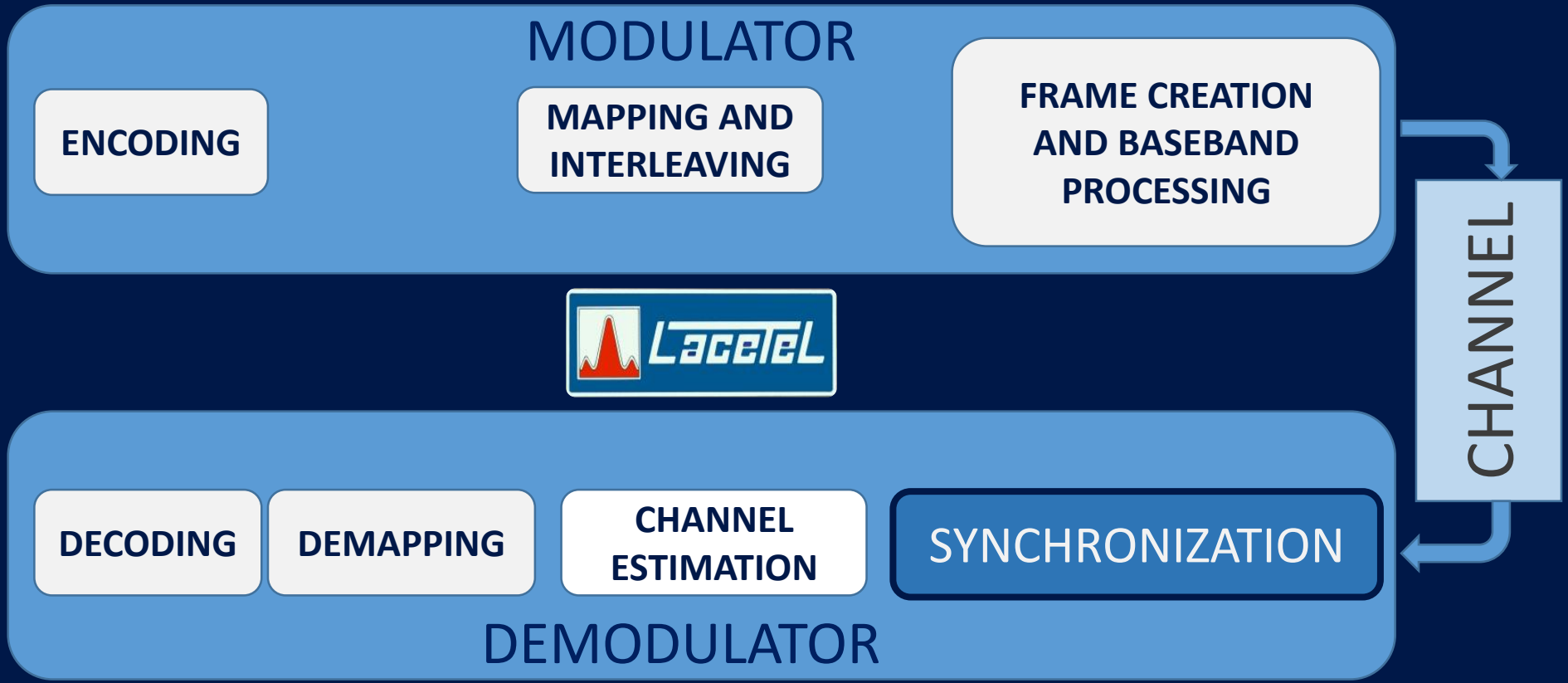
Havana, Cuba
November 2017


MODULATOR
ENCODING
MAPPING AND INTERLEAVING
FRAME CREATION AND BASEBAND PROCESSING
CHANNEL
DECODING
DEMAPPING
CHANNEL ESTIMATION
SYNCHRONIZATION
DEMODULATOR

Synchronization Errors

TRANSMITTER AND RECEIVER INNER ERRORS

- Frame Synchronization Delay.
- Oscillators Frequency Delay.
- Sampling Clocks Delay.

EFFECTS OVER COMMUNICATION CHANNEL

- Multipath.
- Doppler Effect.
- Noise.

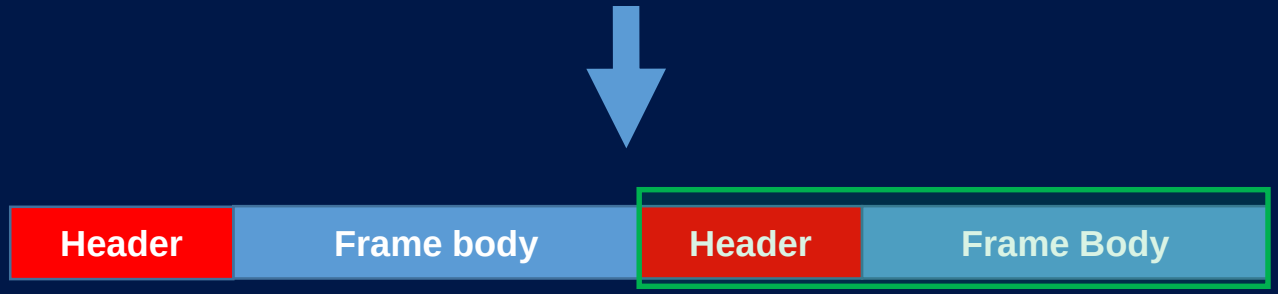
Synchronization Models

- FRAME SYNCHRONIZATION
- FREQUENCY SYNCHRONIZATION
- SYMBOL TIMING RECOVERY

Frame Synchronization

FRAME SYNCHRONIZATION DELAY

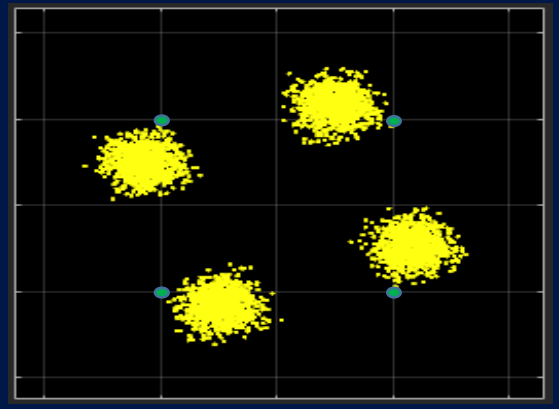
WRONG FRAME STRUCTURE



CORRECT FRAME STRUCTURE

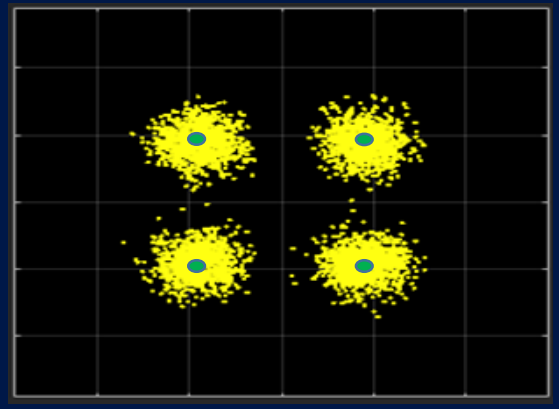
Frequency Synchronization

OSCILLATORS
FREQUENCY DELAY

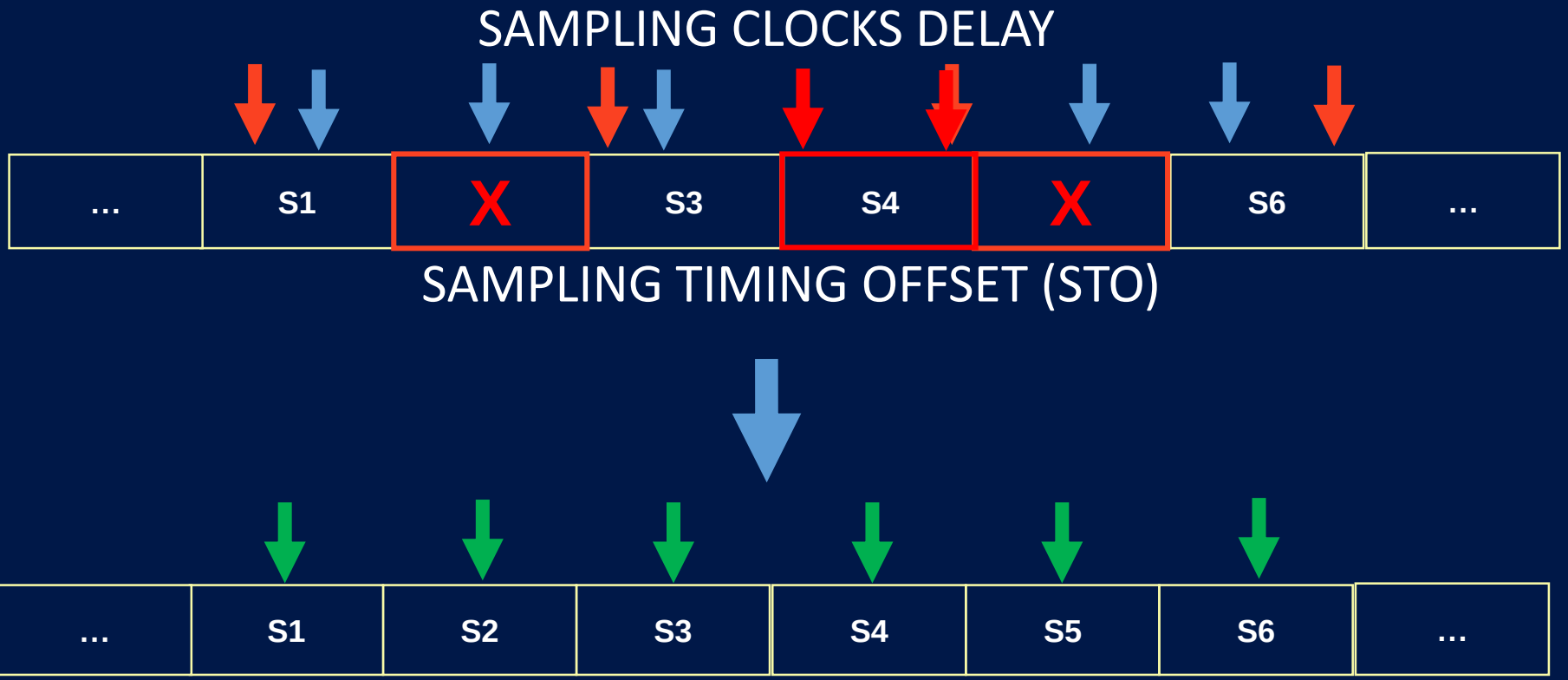


CARRIER FREQUENCY
OFFSET (CFO)

FREQUENCY
TRACKING



Symbol Timing Recovery



Proposed Implementations

FRAME SYNCHRONIZATION

COARSE FRAME SYNCHRONIZATION BY AUTOCORRELATION

COARSE FRAME SYNCHRONIZATION BY CORRELATION WITH LOCAL PN

FINE FRAME SYNCHRONIZATION BY CORRELATION WITH LOCAL PN

FREQUENCY SYNCHRONIZATION

FINE FREQUENCY SYNCHRONIZATION BY ALTERNATING PN AUTOCORRELATION

Proposed Implementations

FRAME SYNCHRONIZATION

- COARSE FRAME SYNCHRONIZATION BY AUTOCORRELATION
- COARSE FRAME SYNCHRONIZATION BY CORRELATION WITH LOCAL PN

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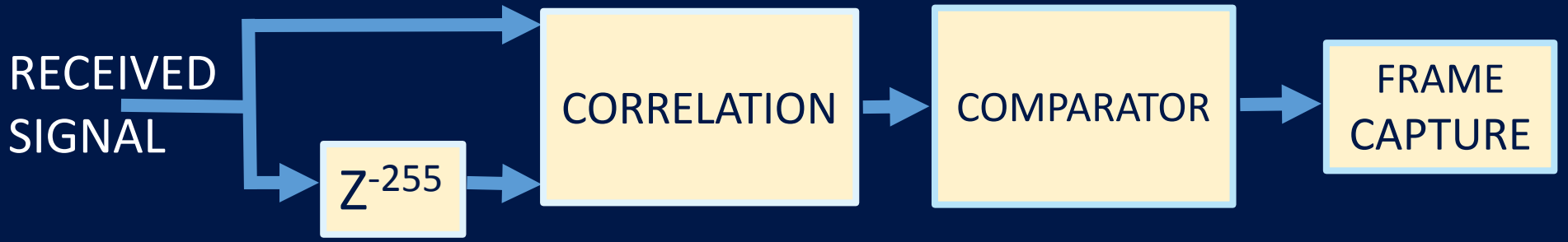
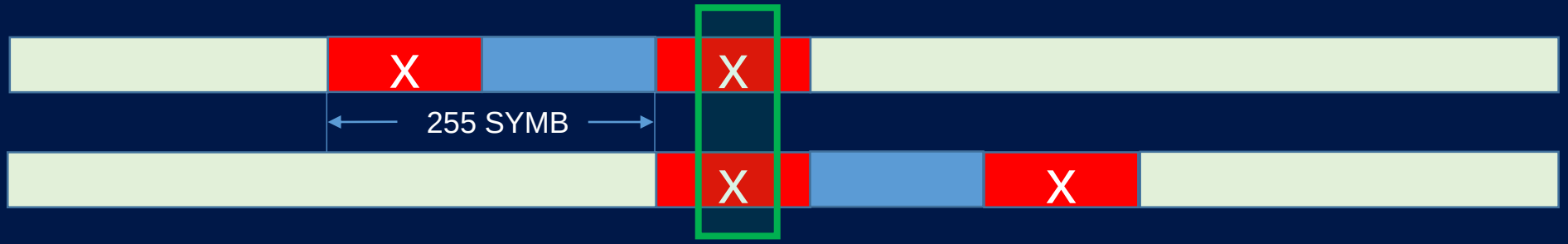
- FINE FRAME SYNCHRONIZATION BY CORRELATION WITH LOCAL PN

FREQUENCY SYNCHRONIZATION

- FINE FREQUENCY SYNCHRONIZATION BY ALTERNATING PN AUTOCORRELATION

Coarse Frame Synchronization By Autocorrelation





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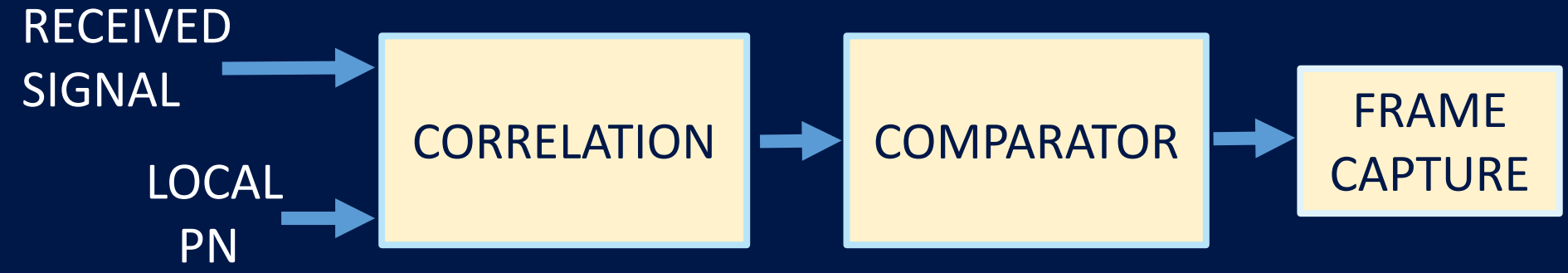
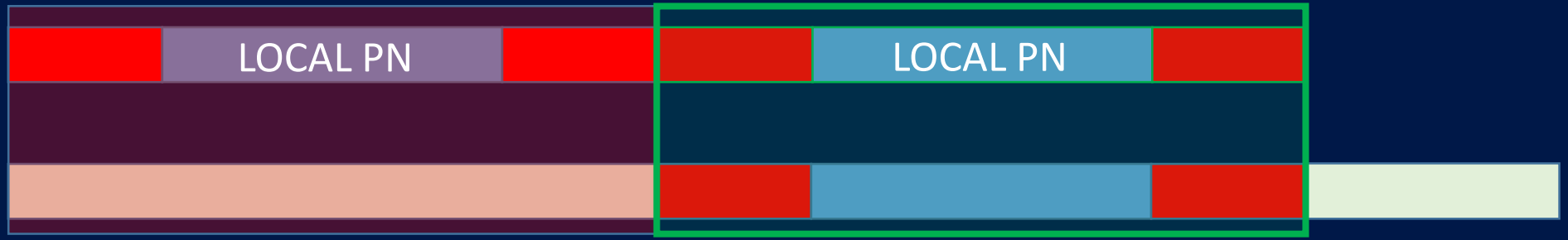
FREQUENCY SYNCHRONIZATION

FINE FREQUENCY SYNCHRONIZATION BY ALTERNATING PN AUTOCORRELATION

Coarse Frame Synchronization By Correlation With Local PN





Proposed Implementations

FRAME SYNCHRONIZATION

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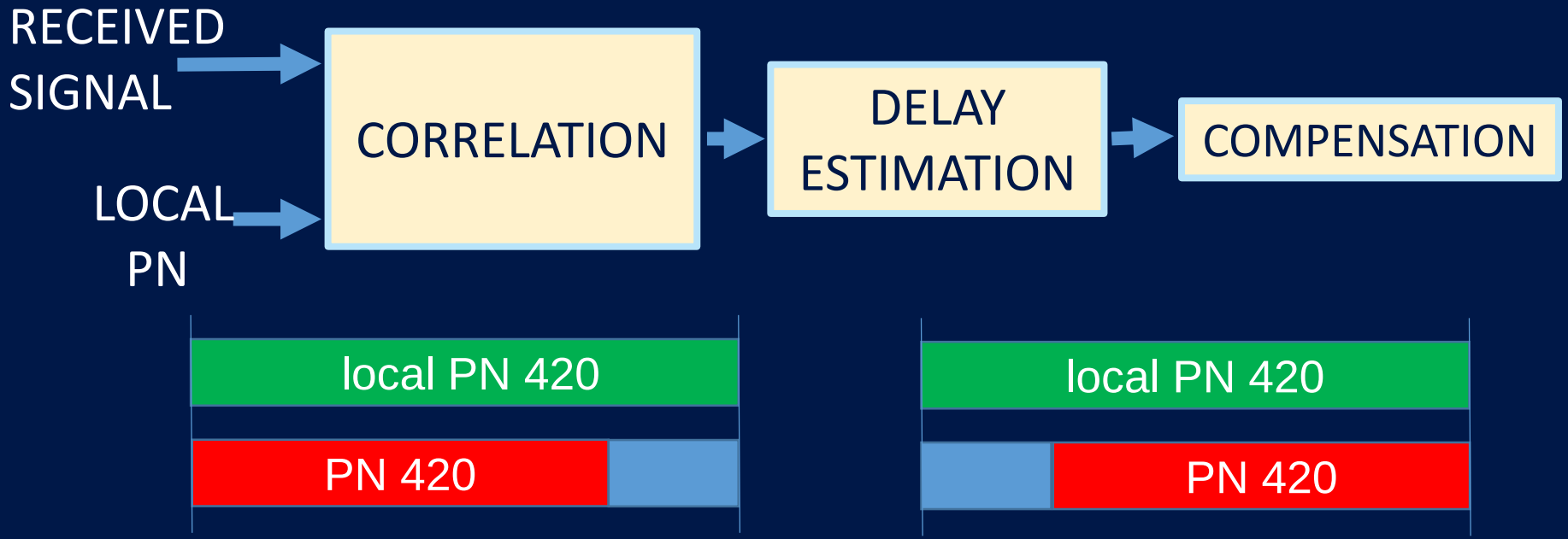
FINE FRAME SYNCHRONIZATION BY CORRELATION WITH LOCAL PN

FREQUENCY SYNCHRONIZATION

FINE FREQUENCY SYNCHRONIZATION BY ALTERNATING PN AUTOCORRELATION

Fine Frame Synchronization By Correlation With Local PN



Proposed Implementations

FRAME SYNCHRONIZATION

- COARSE FRAME SYNCHRONIZATION BY AUTOCORRELATION
- COARSE FRAME SYNCHRONIZATION BY CORRELATION WITH LOCAL PN

↓

- FINE FRAME SYNCHRONIZATION BY CORRELATION WITH LOCAL PN

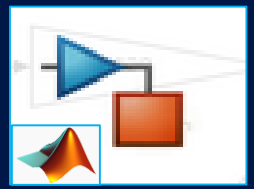
FREQUENCY SYNCHRONIZATION

- FINE FREQUENCY SYNCHRONIZATION BY ALTERNATING PN AUTOCORRELATION

Fine Frequency Synchronization By Alternating PN Autocorrelation

Validation Scheme

MODULATOR



SIMULINK/MATLAB

CHANNEL MODELS
- AWGN
- DOPPLER EFFECT
- MULTIPATH

SYNCHRONIZATION ERRORS
- FRAME DELAY
- CFO

FRAME SYNCHRONIZATION

FINE FRAME SYNCHRONIZATION

COARSE FRAME SYNCHRONIZATION BY AUTOCORRELATION

COARSE FRAME SYNCHRONIZATION BY CORRELATION WITH LOCAL PN

FINE FREQUENCY SYNCHRONIZATION

DEMODULATOR

Validation Scheme

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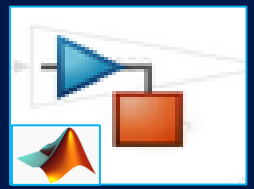

SIMULINK/MATLAB

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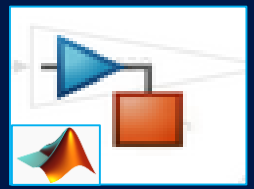

SIMULINK/MATLAB

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FRAME SYNCHRONIZATION

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COARSE FRAME SYNCHRONIZATION BY CORRELATION WITH LOCAL PN

FINE FREQUENCY SYNCHRONIZATION

DEMODULATOR

Validation

FRAME SYNCHRONIZATION:

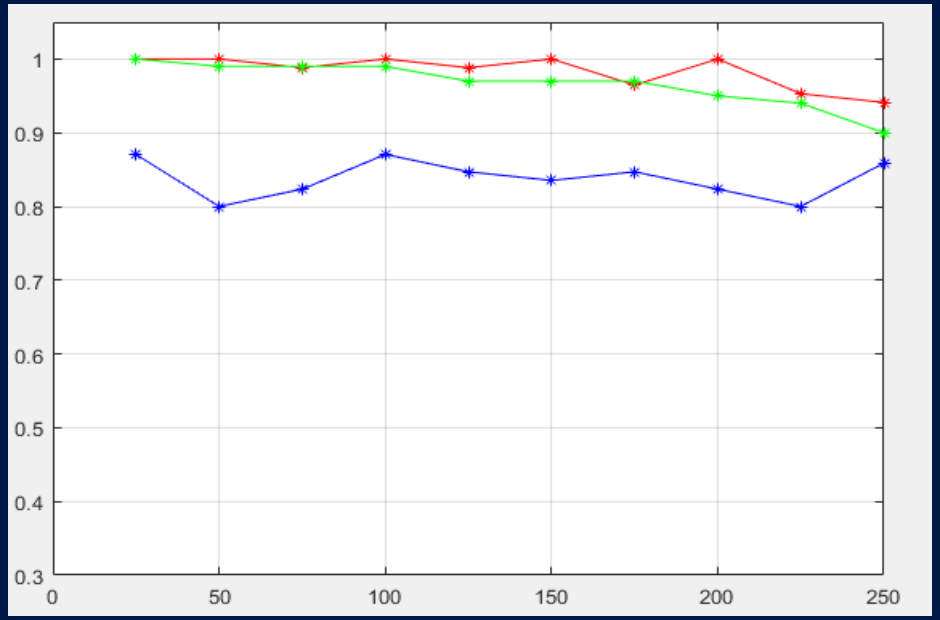
- CORRECT DETECTION RATE (CDR).

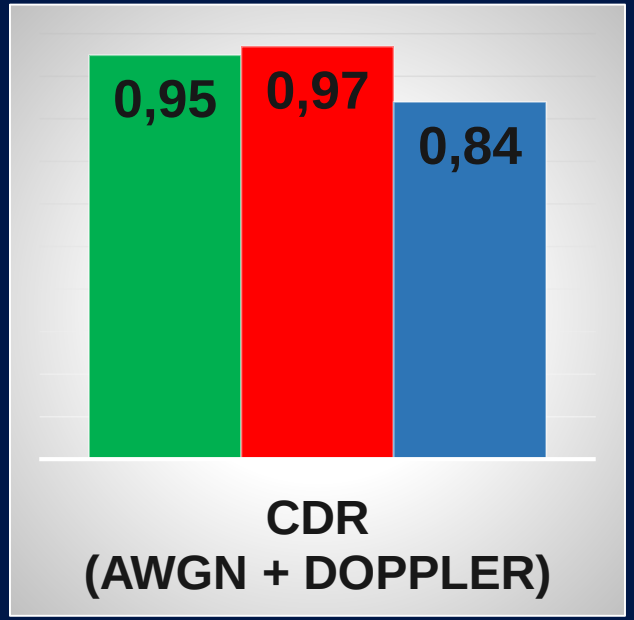
REFERENCE: “DTMB receiver: algorithm and design”, Lingwei Pei.

Correct Detection Rate (CDR)

REFERENCE AUTOCORRELATION CORRELATION WITH LOCAL PN

Correct Detection Rate (CDR)





REFERENCE

CORRELATION WITH LOCAL PN

AUTOCORRELATION

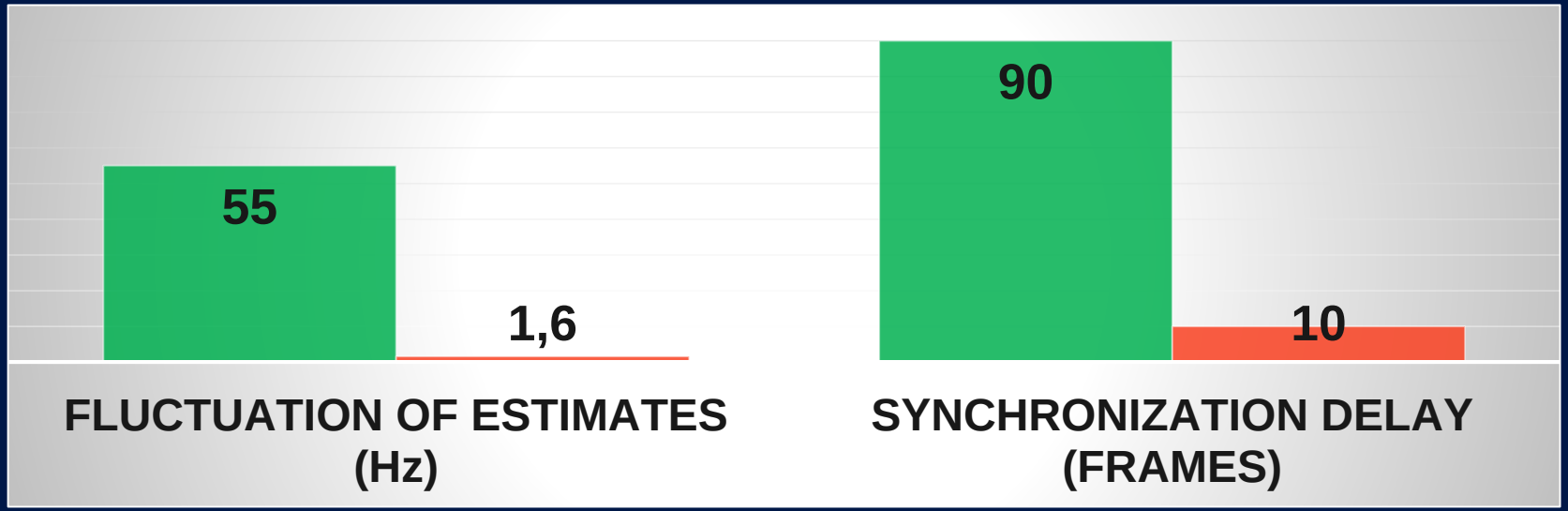
Validation

FREQUENCY SYNCHRONIZATION:

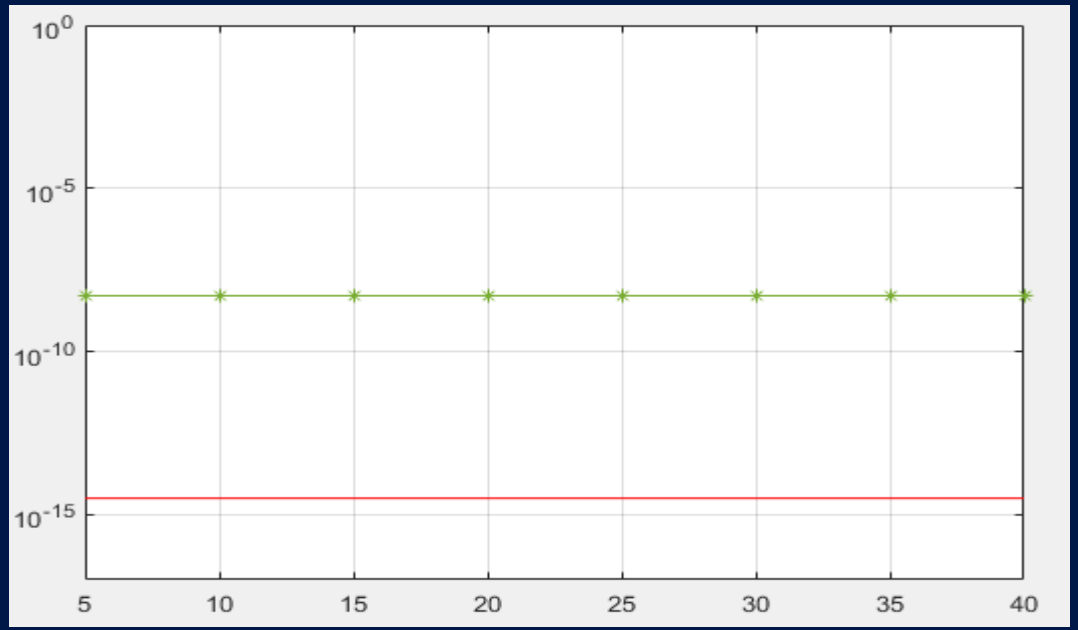
- SYNCHRONIZATION TIME AND ESTIMATION STABILITY.
- ESTIMATION VARIANCE.

REFERENCE: “A new frequency synchronization algorithm on TDS-OFDM systems”, Ling-Long Dai.

Synchronization Time and Estimation Stability



Estimation Variance



AWGN

TU-6 Multipath

Conclusions

- Two Frame Synchronization schemes were designed and implemented. The first is based on Autocorrelation function and the second is based on Correlation with a local PN.
- A Fine Frequency Synchronization scheme based on the alternating PN correlation was designed and implemented.
- The proposed implementations were validated on Simulink/MatLab.

Conclusions

- The Simulations proved the functionality of both Frame Synchronization schemes on AWGN and Doppler effect channels. The functionality of the Frequency Synchronization scheme on AWGN and multipath fading channels was proved too.
- Results are comparable with values that appears on the scientific literature.

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