Secured and Robust Wireless Communication System for Low-Latency Applications

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Outline

- Introduction
- System Overview
- Performance Evaluation
- Demonstration
- Conclusions and Future Work

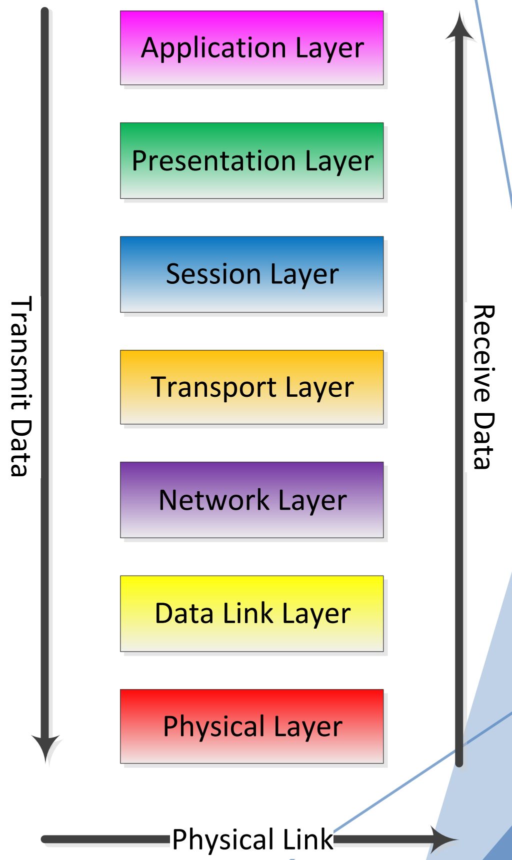
Introduction

- Wireless communication is a key **enabling technology** for ubiquitous computing:
  - Remote health monitoring
  - Connected autonomous vehicles
  - Mobile Phone Networks

- However, wireless communication is fraught with several **challenges**.
  - limited bandwidth
  - errors due to noise, interference and multipath fading
  - security vulnerabilities

Introduction

- **Physical layer modulation techniques** are used to enhance the transmission efficiency and robustness against channel impairments.
- In this work, we exploit these modulation techniques to introduce embedded **physical layer security** with reduced complexity and latency.
- Conventional (**higher layers**) cryptosystems can provide strong secrecy. However, they have several drawbacks.
  - Relatively high computational complexity
  - Reduces operation time of battery-powered devices
  - Relatively slow for high speed communications
  - Vulnerable to jamming (denial of service (DoS) attacks)



Introduction

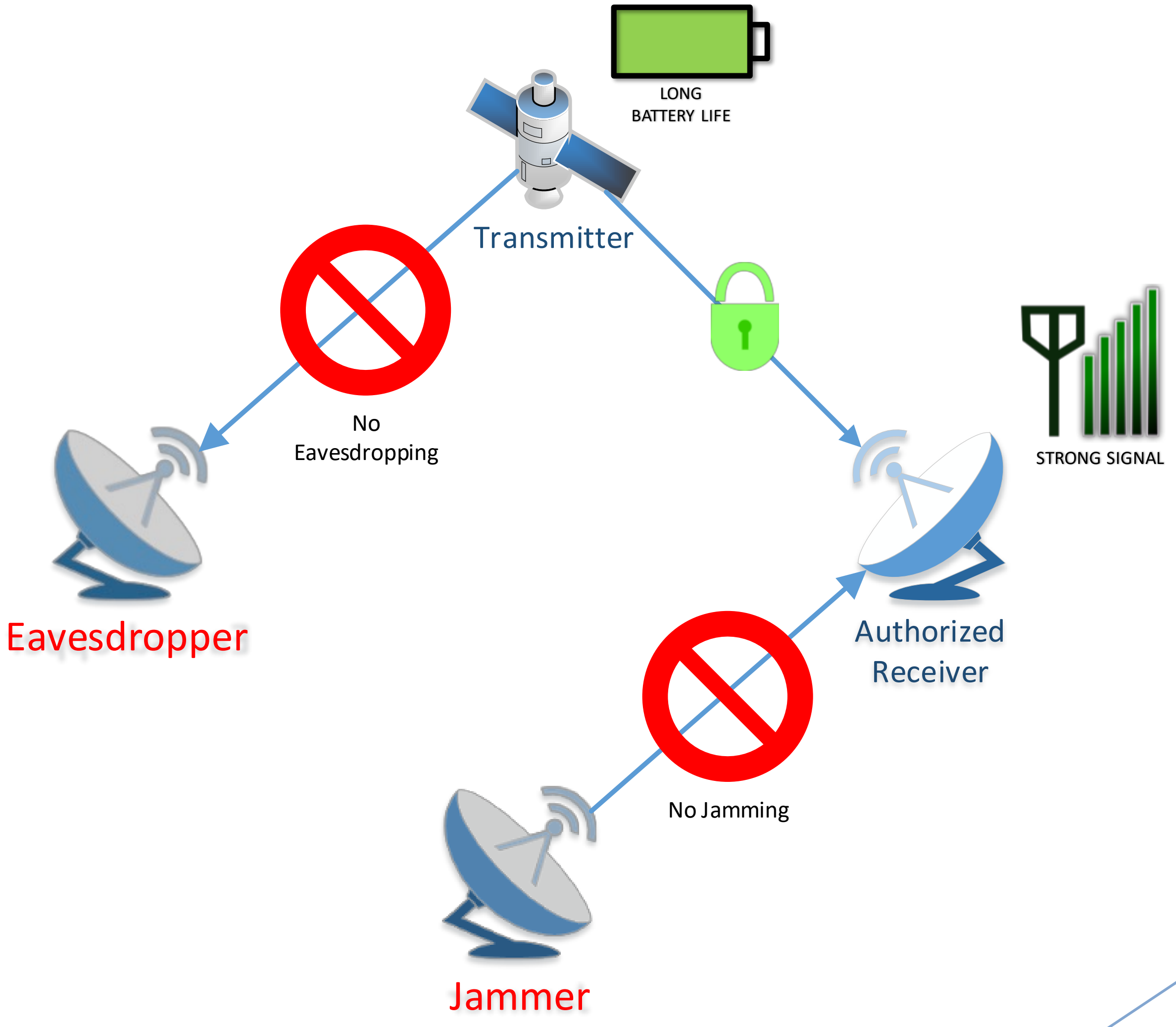
- Orthogonal frequency division multiplexing (**OFDM**) is a suitable solution for many challenges in wireless communications.
  - spectrally efficient modulation format.
  - efficient implementation.

- OFDM is a **major element** in most modern wireless communication standards such as WiFi, WiMAX and LTE.

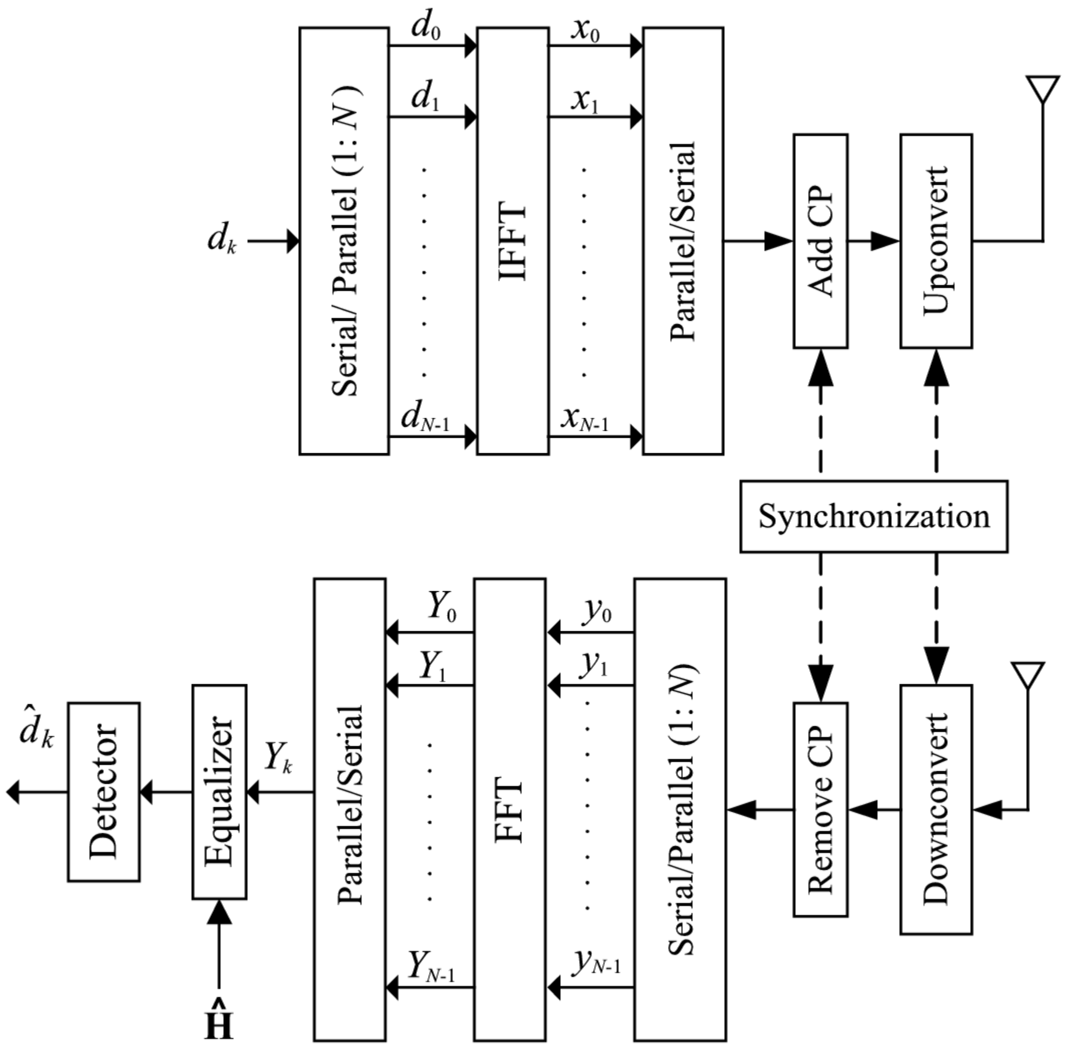
- We introduced time domain interleaving (**TDI**):
  - to improve **robustness** of OFDM systems in multipath fading channels
  - to provide **low complexity physical layer (PHY) security**

Patent Number:	US8645678 B2
Issue Date:	Feb 4, 2014

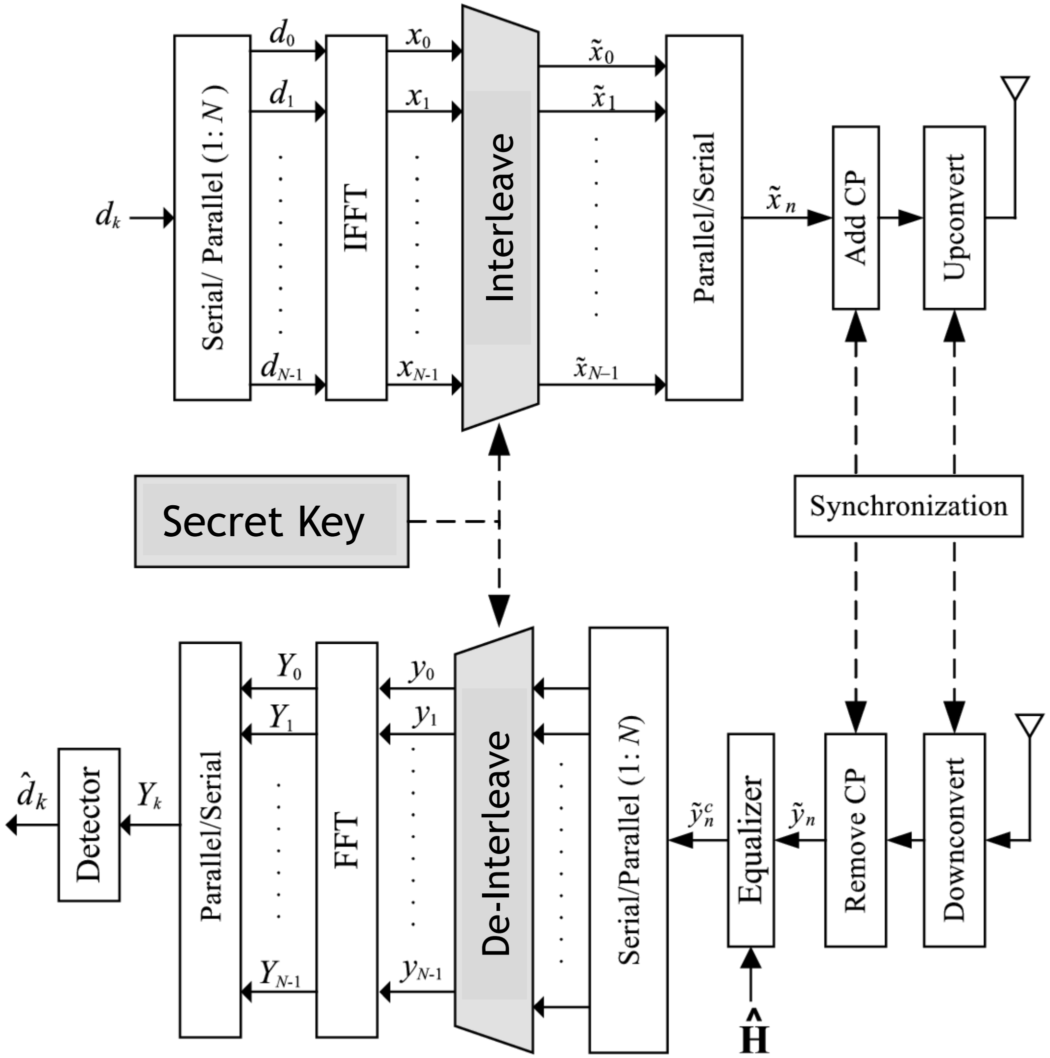
System Overview



System Overview



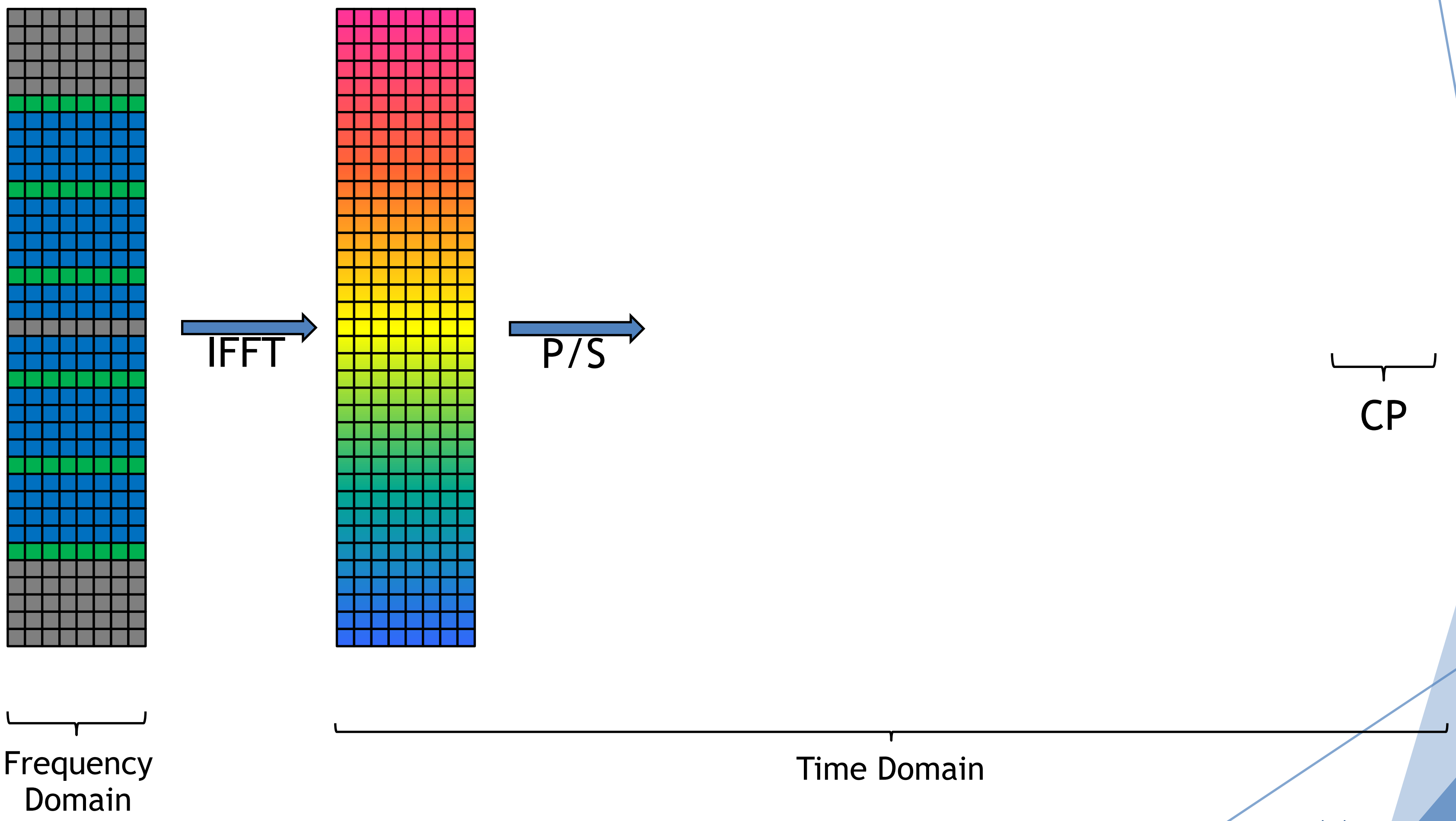
System Overview



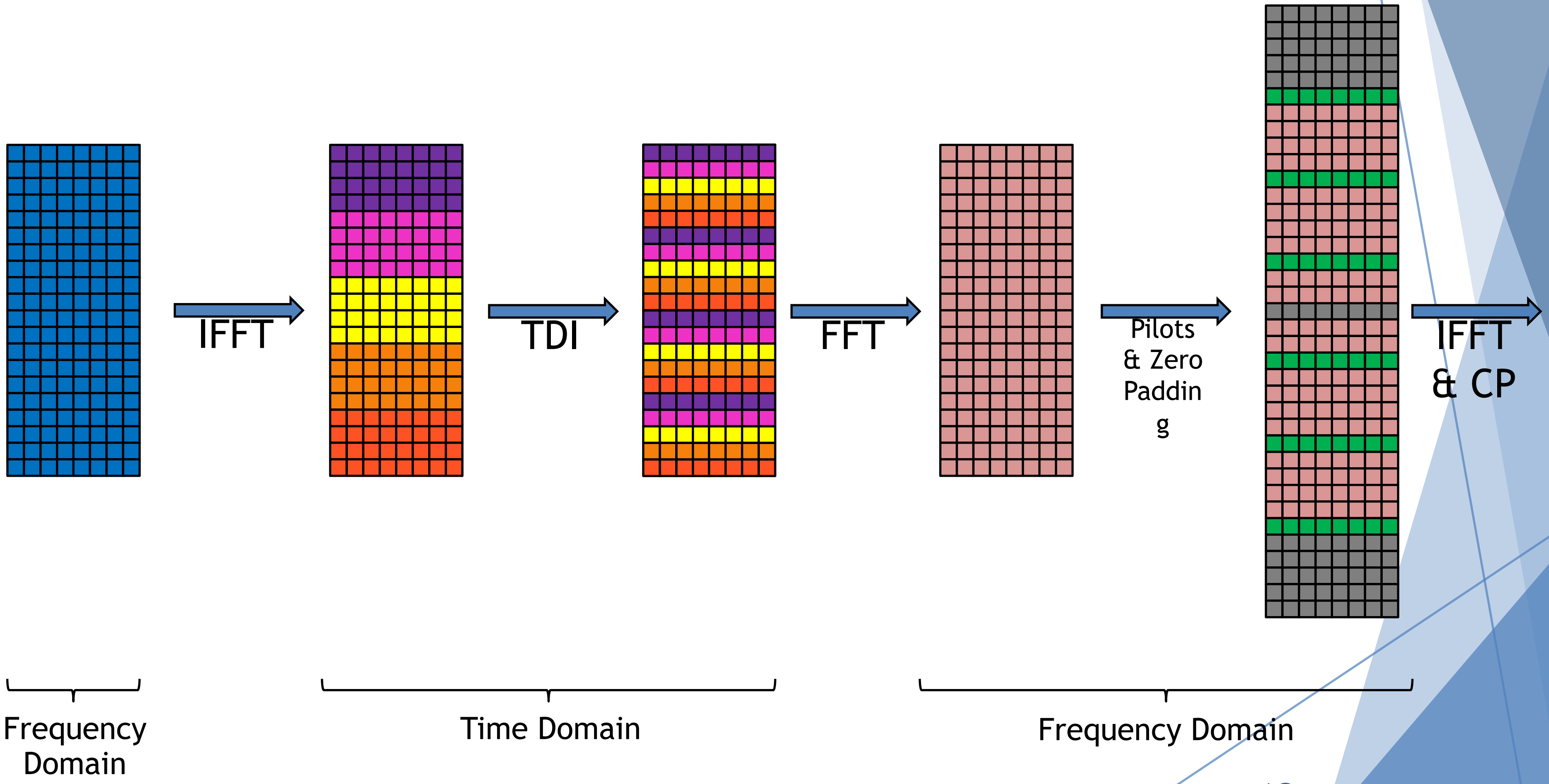
System Overview

Information symbols Pilot symbols Zero Padding

System Overview



System Overview



Performance Evaluation

- Interleaving can be performed within **one OFDM** frame (N subcarriers) or across **multiple OFDM** frames ($N \times N_d$ subcarriers).

- In the latter case, **buffering** of OFDM symbols is required which introduces additional **delay**.

- The **interleaver length or depth** (N_d) corresponds to the number of OFDM frames in an interleaving block.

- Hence, the larger the interleaver length is, the larger the **latency** will be.

Performance Evaluation

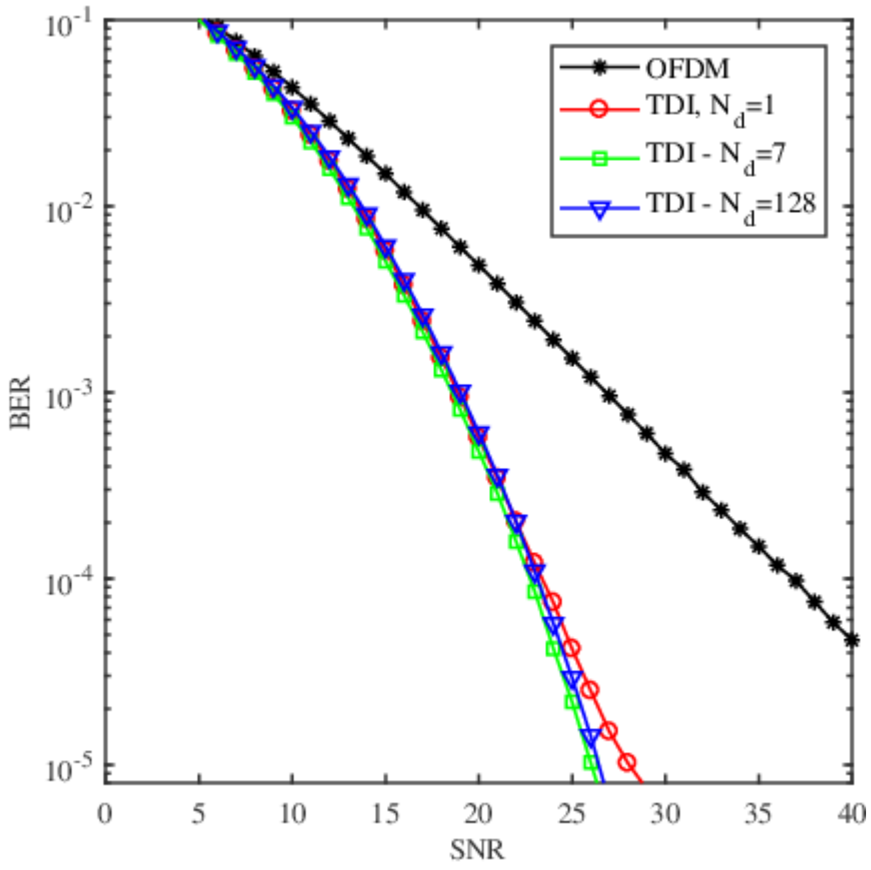
- The system security is proportional to $(N \times Nd)!$ where N is the number of subcarriers in the OFDM system and N_d is the number of OFDM frames involved in the interleaving process.

- The system is practically secured as long as $N \times Nd$ is large enough.

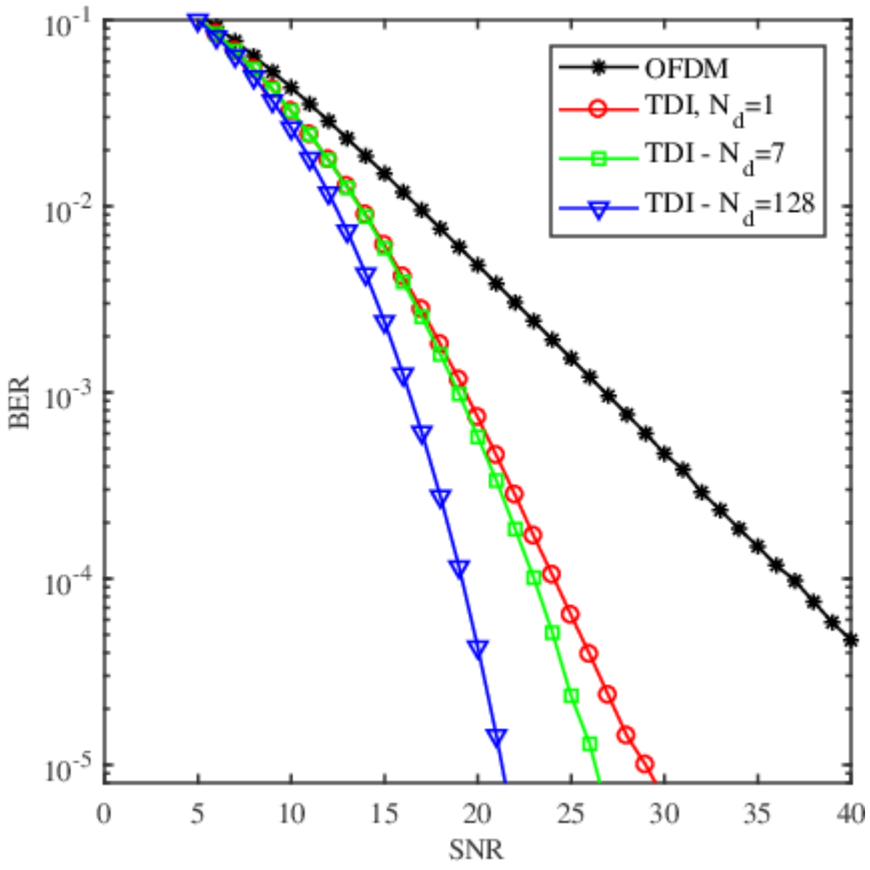
- For certain OFDM applications where $N \geq 256$, we can set $N_d = 1$ because breaking the system requires to perform $\boldsymbol{N}!$ **exhaustive-search trials**, which is **practically infeasible**.

- For an OFDM system with $N = 256$, the number of trails required to break the system given that $N_d = 1$ is huge as $256! > 2^{1683}$. Thus, it is computationally infeasible to break this system by the exhaustive search.

Performance Evaluation



low mobility



high mobility

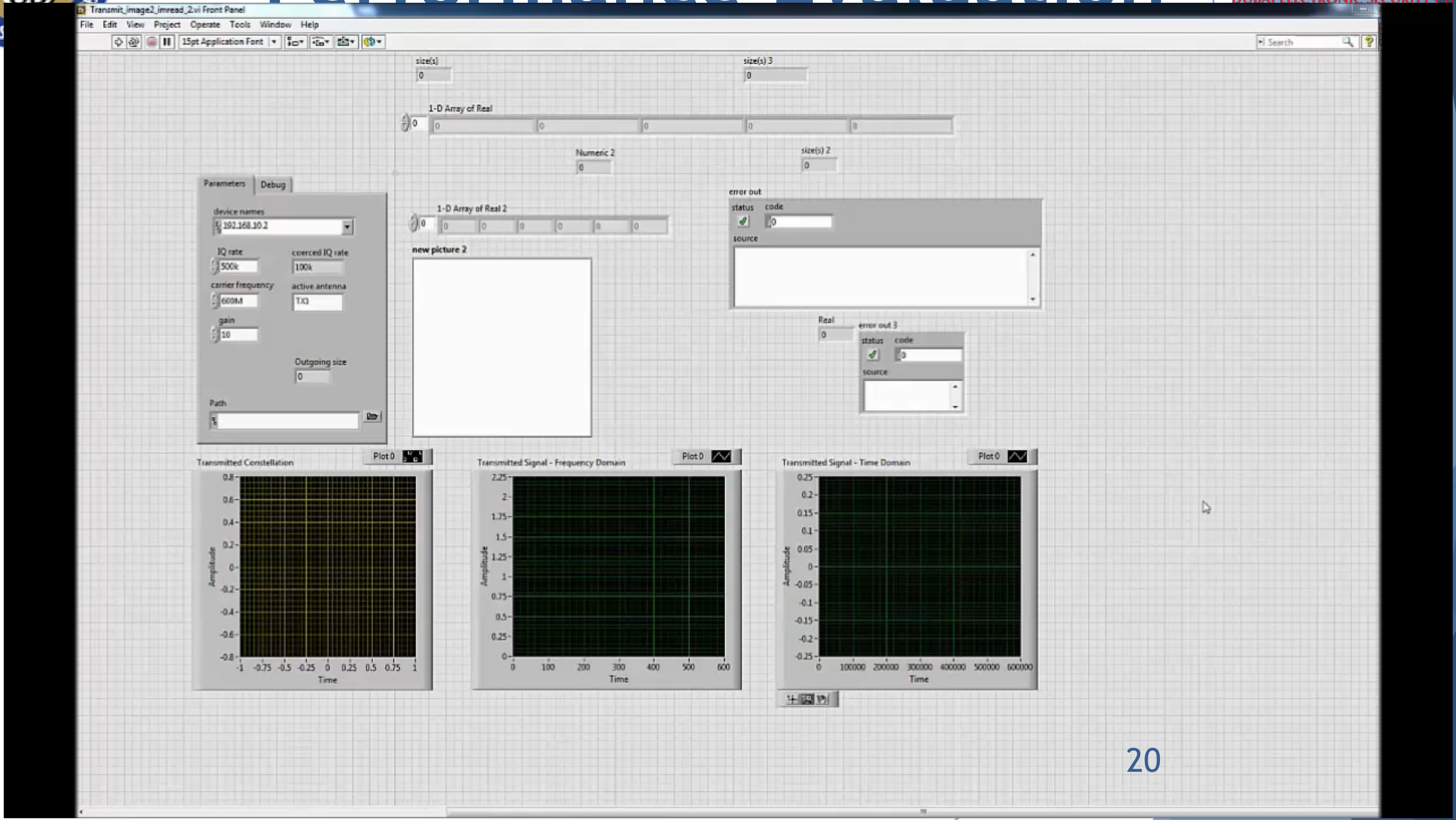
Performance Evaluation

- The obtained results show that:
  - TDI can substantially enhance the performance (**BER, Power, Signal Strength**) of OFDM systems without an increase in latency.
  - In **slow fading** channels, the interleaver length has no significant effect on the error performance.
  - In **fast fading** channels, the error performance can be further improved by using longer interleavers at the expense of increased latency.

Performance Evaluation

- The TDI system was implemented and tested using RF prototyping devices (Software Defined Radio - SDR).

Performance Evaluation



Conclusions

- A **physical layer security** solution based on **time domain interleaving** is developed for **OFDM** communication systems.
- The performance of the TDI system is studied using theoretical analysis, simulation and real experiments.
- The obtained results show that TDI can substantially enhance the error performance of OFDM systems without an increase in latency.
  - For low mobility applications, the interleaver length has no significant effect on the error performance;
  - For high mobility applications, the error performance can be further improved by using longer interleavers at the expense of increased latency.

Future Work

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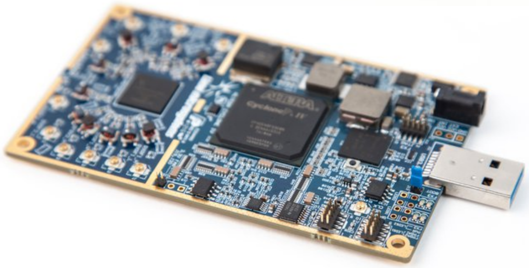

Relevant Publications

[1] H. Mukhtar, A. Al-Dweik, W. Mansoor, and H. Al Ahmad, “Reliability and Latency Trade-off in Time Domain Interleaving for OFDM Communication Systems,” in EUROMICRO/IEEE Workshop on Embedded and Cyber-Physical Systems (ECYPS), Mediterranean Conference on Embedded Computing (MECO), Budva, Montenegro, June 2018.

[2] H. Mukhtar, A. Al-Dweik, M. Masouridis and T. Stouraitis “Performance Evaluation of Time-Domain Interleaved OFDM Systems using Software Defined Radio Platforms,” International Conference on Electrical and Computing Technologies and Applications (ICECTA), Ras Al Khaimah, UAE, Nov. 2017.

[3] A. Al-Dweik, M. Mirahmadi, A. Shami, B. Sharif, R. Hamila, "Joint secured and robust technique for OFDM systems," in IEEE Int. Conf. Electron., Circuits, and Syst. (ICECS), Abu Dhabi, UAE, Dec. 2013, pp.865-868.

[4] M. Mirahmadi, A. Al-Dweik, A. Shami, "BER Reduction of OFDM Based Broadband Communication Systems over Multipath Channels with Impulsive Noise," IEEE Trans. Commun., vol. 61, no. 11, pp. 4602-4615, Nov. 2013.

Thank You!