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# Implementation of an SDR platform using GPU and its Application to 2x2 MIMO WiMAX System

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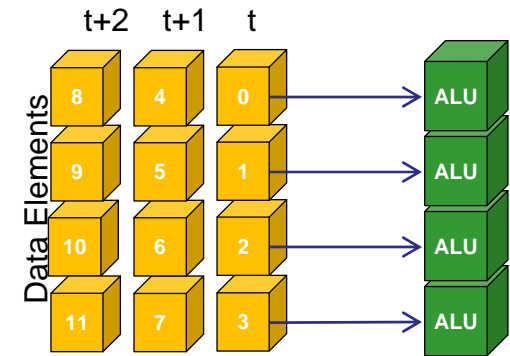


# 1. Introduction of GPU

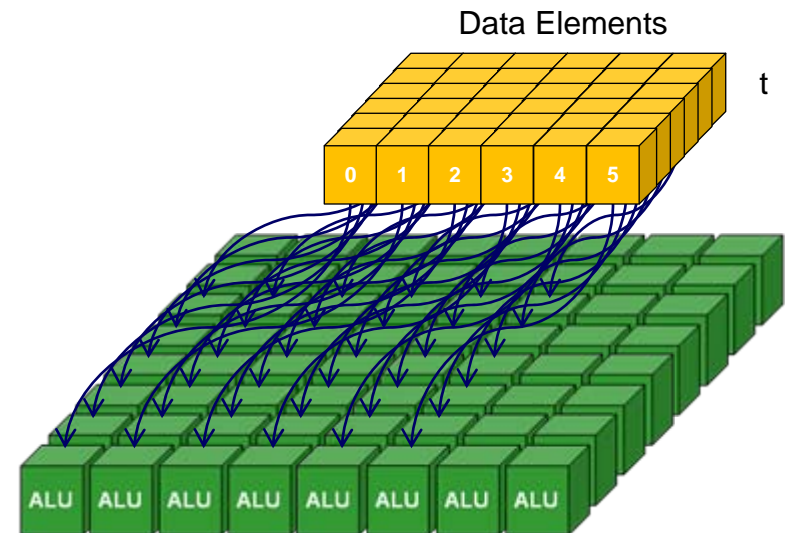


# Introduction of GPU - Structure of GPU

- In various kinds of the communication systems, the **signal processing operation speed** is the key issue.
- Propose a new scheme of the **Graphics Processing Unit (GPU)** for implementing the communication systems.
- GPU has a great number of ALU than Conventional DSP .
- Parallel computing power of GPU can accelerate the speed of signal processing which is needed in SDR.



< Conventional DSP Structure >



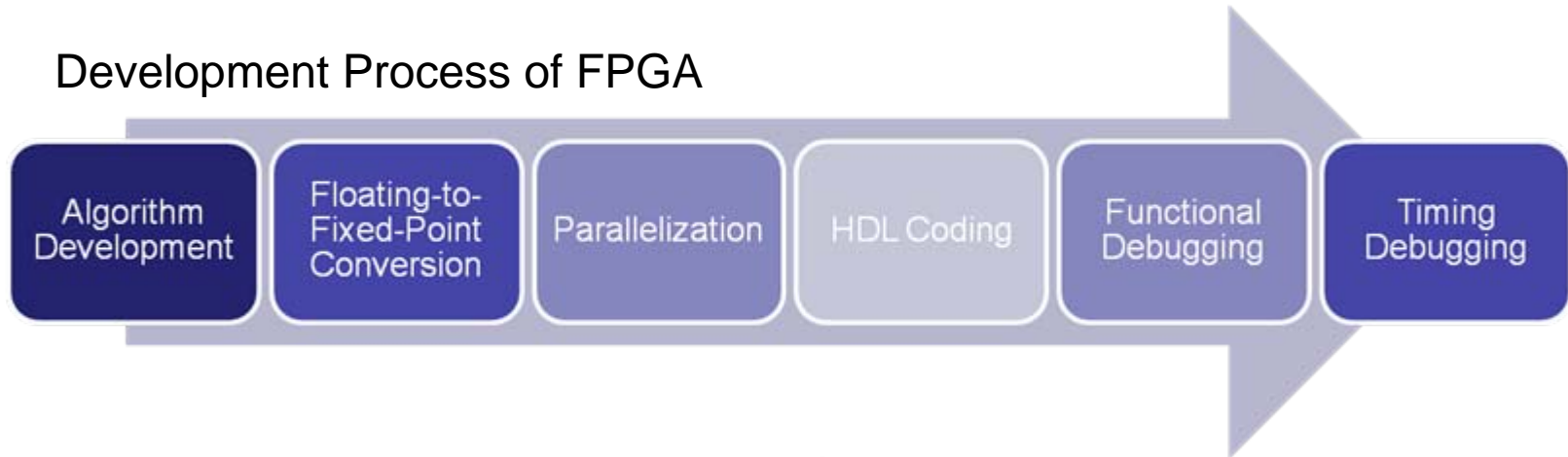
< GPU Structure >



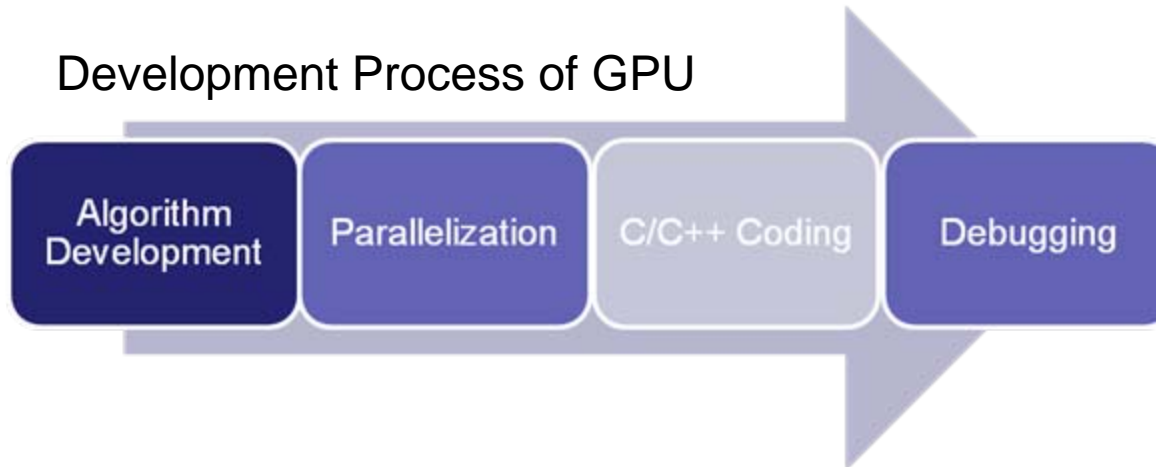
# Instruction of GPU – Advantage of GPU programming

- **FPGA suffers from relatively high price and extremely complicated procedures for development and debugging.**

## Development Process of FPGA

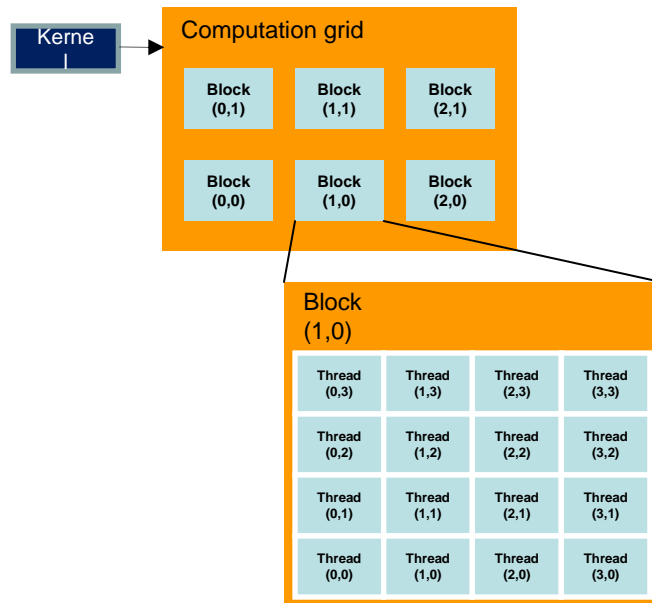


## Development Process of GPU

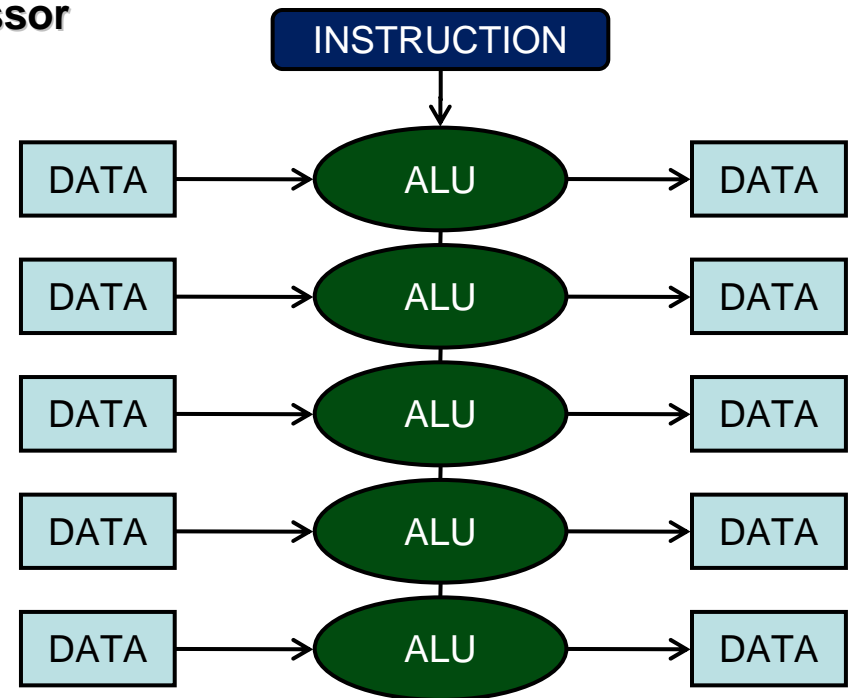


# Instruction of GPU – Structure of GPU

- Graphics Processing Unit ( GPU )
- Single Instruction Multiple Data( SIMD )
- The GPU is massively parallel processor
- Kernel
  - A function compiled for Device



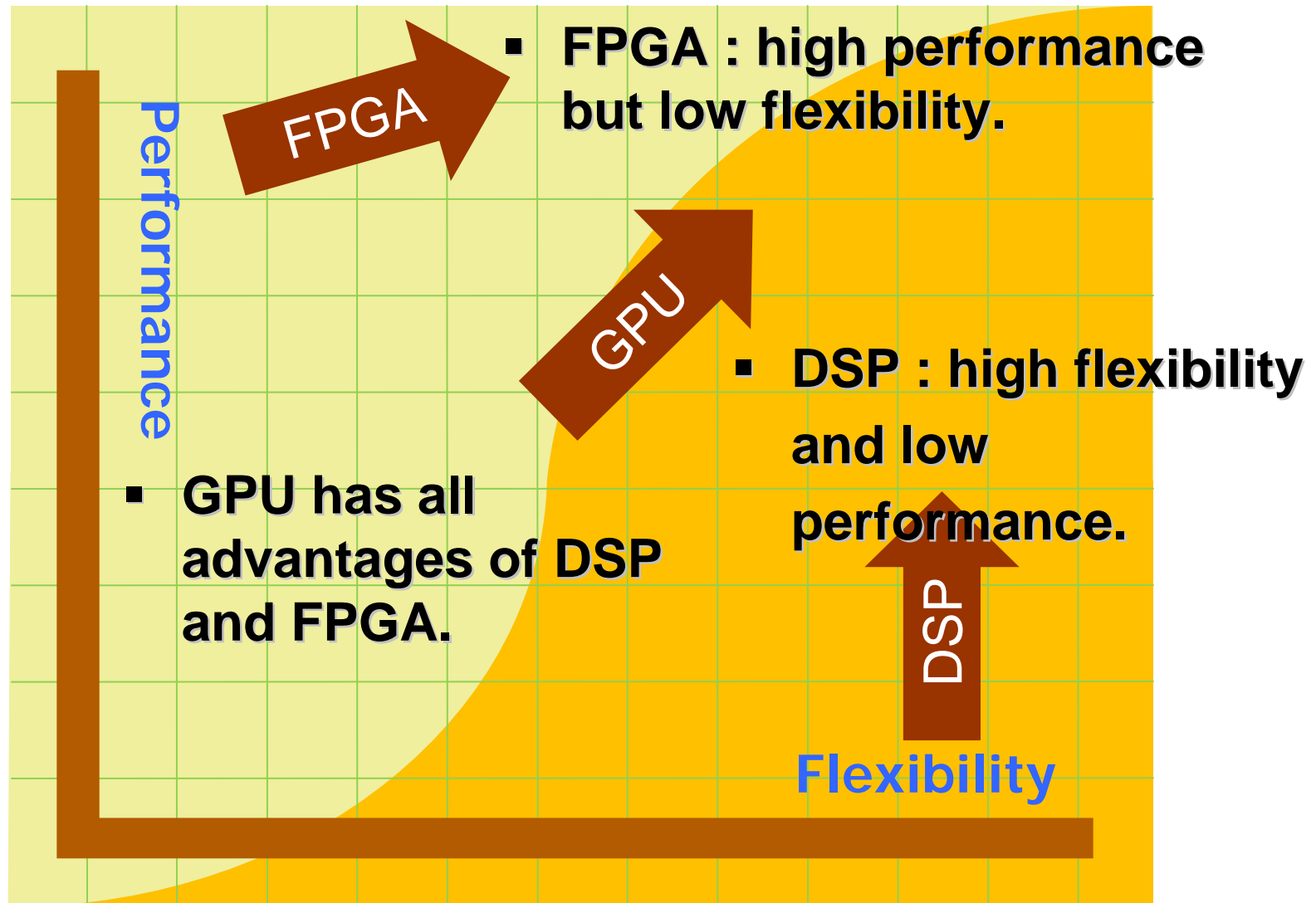
Structure of CUDA Memory



SIMD processor architecture



# Introduction of GPU – GPU vs DSP vs FPGA



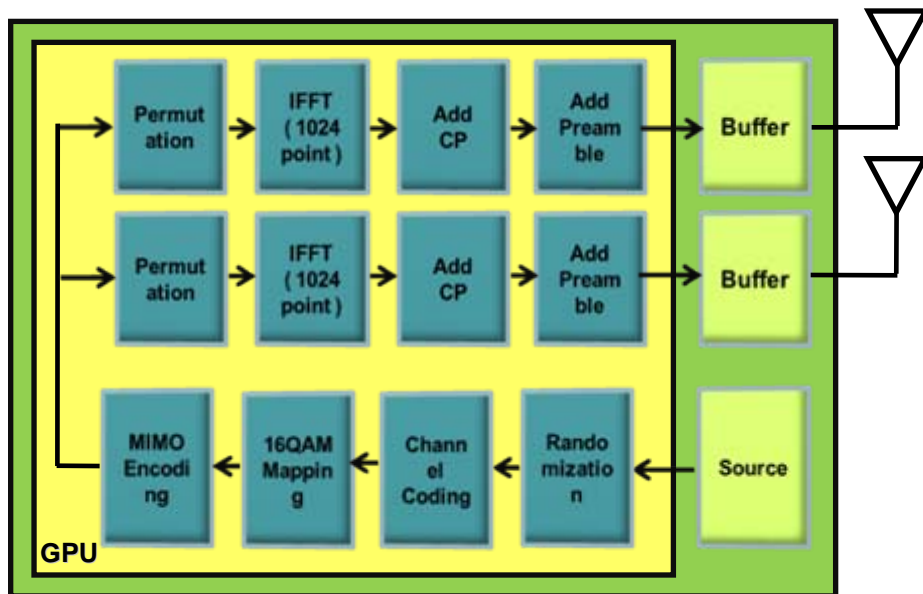
## 2. Proposed System



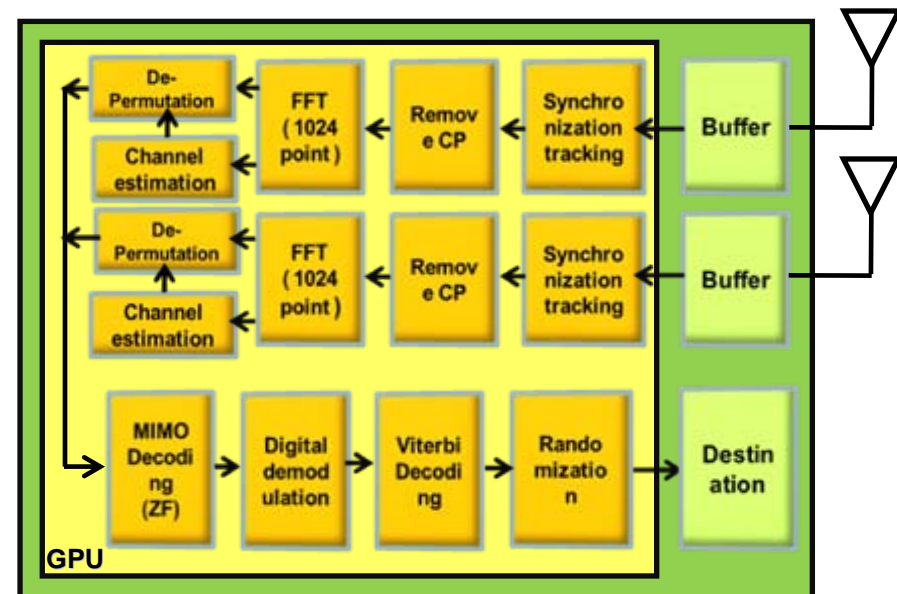


# Proposed System – 2x2 SM MIMO WiMAX system

- Block diagram of 2x2 SM MIMO WiMAX system
- The parallelization of signal processing algorithms appropriately for the SIMD architecture
  - To use GPU and CPU resources effectively



Transmitter

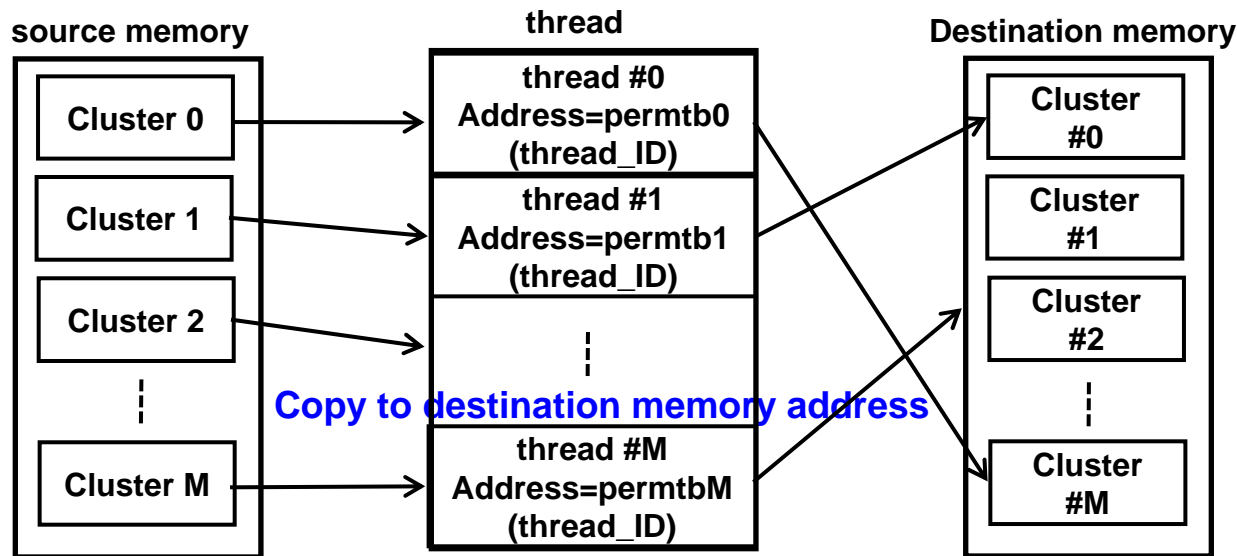


Receiver



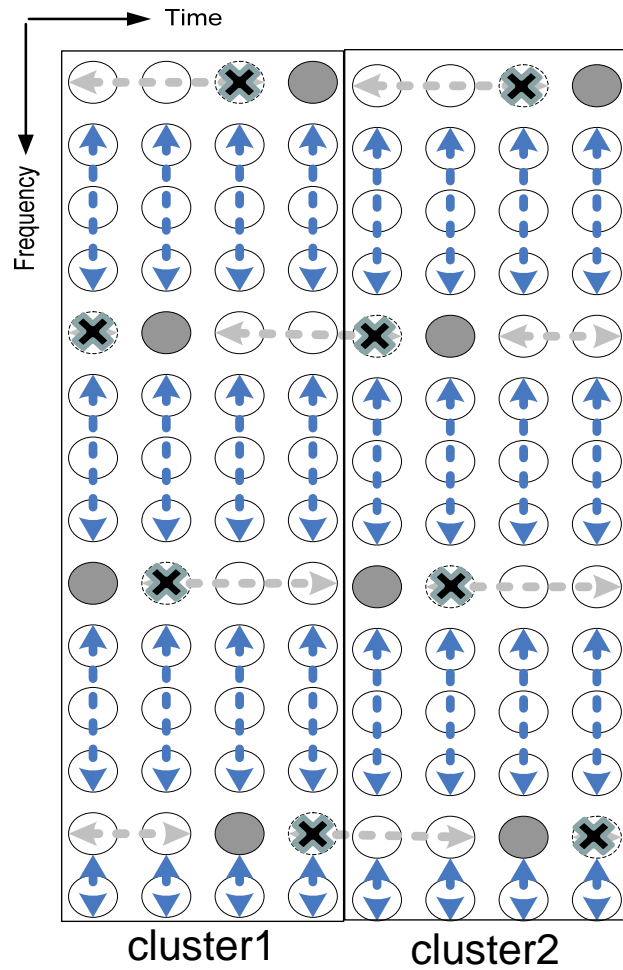
# Proposed System – Encoder Implementation

- Permutation component as an example of parallel technique
- Permutation is a procedure of re-ordering the clusters consisting of 14 neighboring sub-carriers using the predetermined permutation table.



Block diagram for permutation

# Proposed System – Decoder Implementation



Structure of WiMAX cluster

- **Channel Estimation component as an example of parallel technique**
- **4 pilot bits at each cluster are used for channel estimation associated with the surrounding data subcarriers.**
- **2D linear interpolation**
  - consisting of 2 steps

● : pilot  
○ : data  
✕ : Null

# **Proposed System** – *Decoder Implementation*

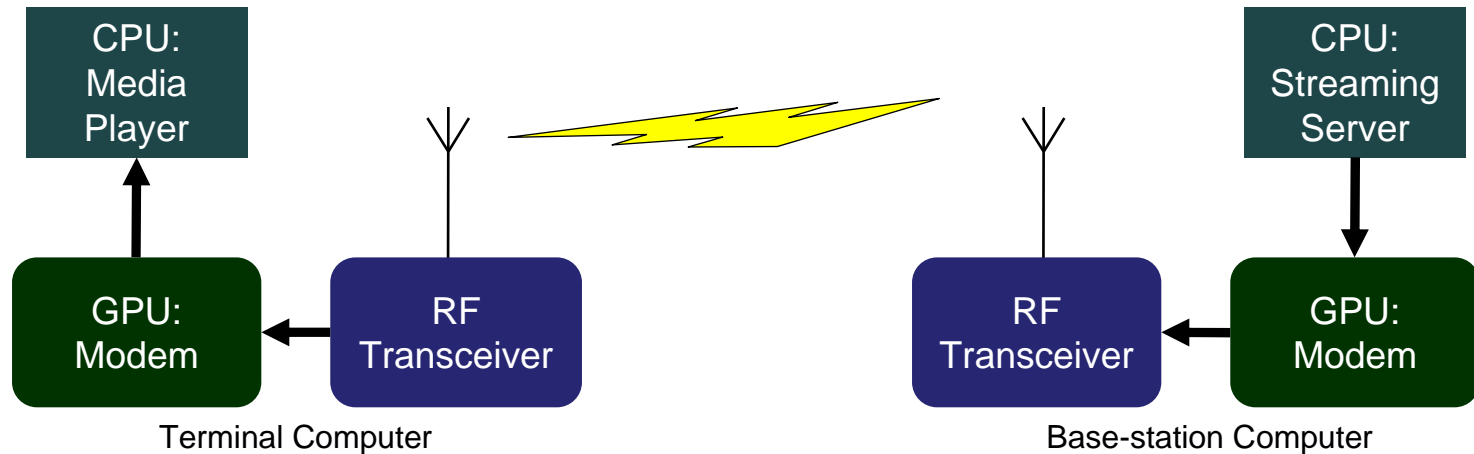
- **Need 2 pilots for interpolation, which means we used 2 clusters for the channel estimation.**
- **The first step**
  - A linear channel estimation is performed along the time axis.
  - The time needed for estimating for just 4 symbols only.
- **The second step**
  - Using the channel estimation obtained along the time axis, we perform the channel estimation along the frequency axis for the linear interpolation of data subcarriers.
- **Equivalent to the time needed for estimating for just 7 symbols only, regardless of the number of clusters.**



# **3. Performance Evaluation**



# Proposed System – Implemented System



- **GPU - Geforce GTX 260 provided by NVIDIA**
- **CPU - Intel(R) Core(TM) i5 750 2.67GHz**

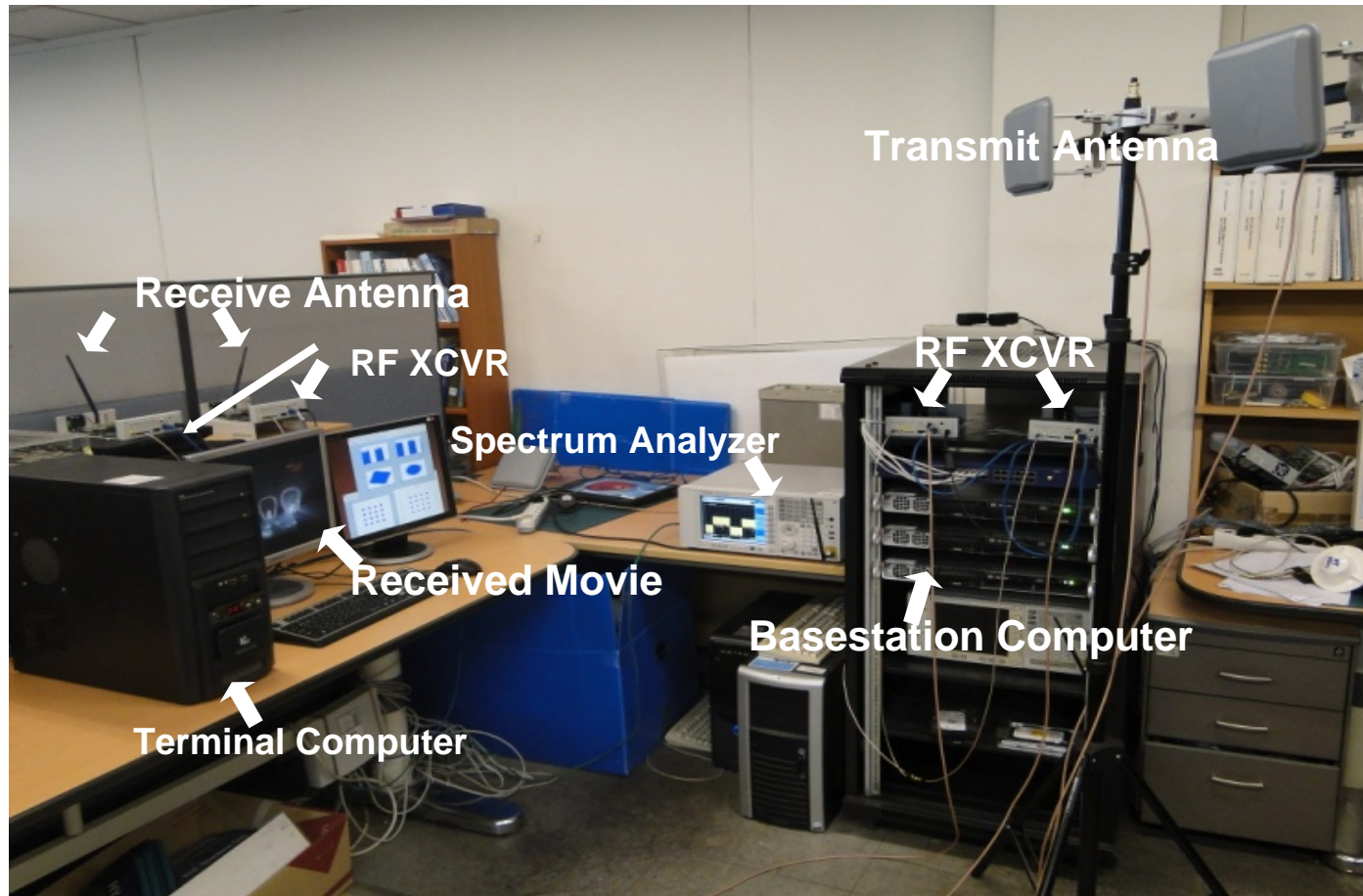
# Performance Analysis — System Parameter

- System Parameter

Modulation	16QAM
FFT Size	1024 points
Coding Rate	1/2
Channel	Fading Channel
Channel Estimation	2D Linear Interpolation
Frame Duration	5ms



# Proposed System – Implemented System



2x2 SM MIMO WiMAX system



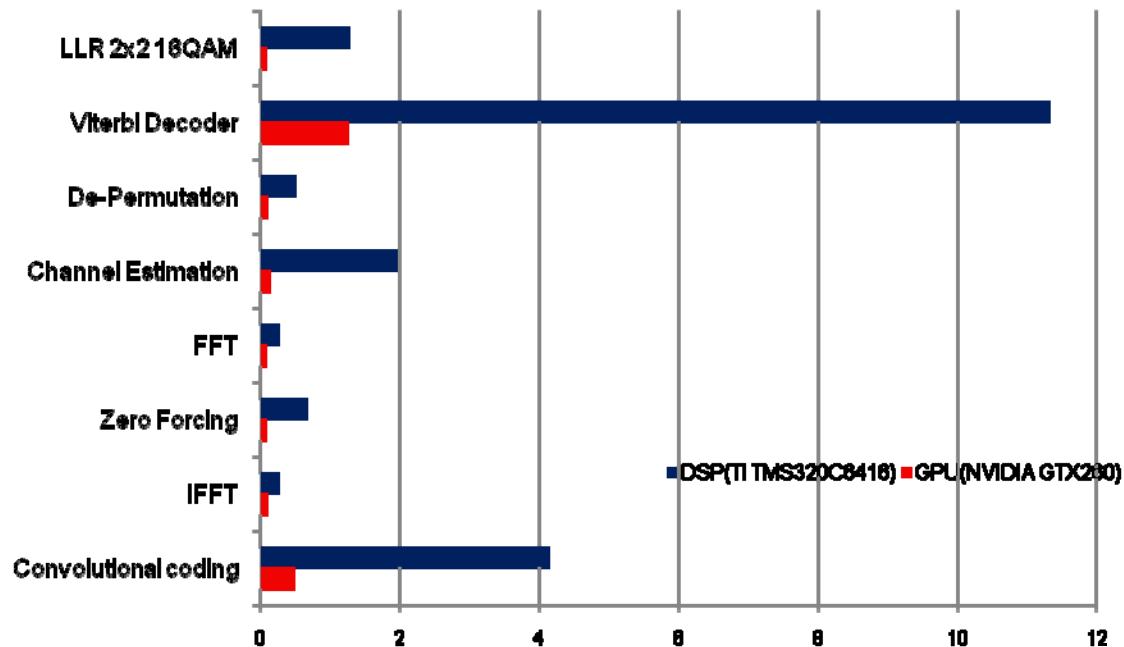
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# Performance Analysis – Computation Time

- Profiler provided by NVIDIA
- Computation time of GPU is 3-14 times less than DSP
  - Due to the difference in parallelization performance at each component.



Comparison of computation time: GPU vs DSP



# Performance Analysis – Computation Time

- Specifications of WiMAX : 1 frame = 5ms
- Enough for the real time processing.

	GPU Processing time	DSP Processing time
Downlink	754.976 $\mu$ s	6019.89 $\mu$ s
Uplink	2499.388 $\mu$ s	20148.2 $\mu$ s
Total time	3.254 ms	26.136 ms

Processing time for 1 frame: GPU vs DSP

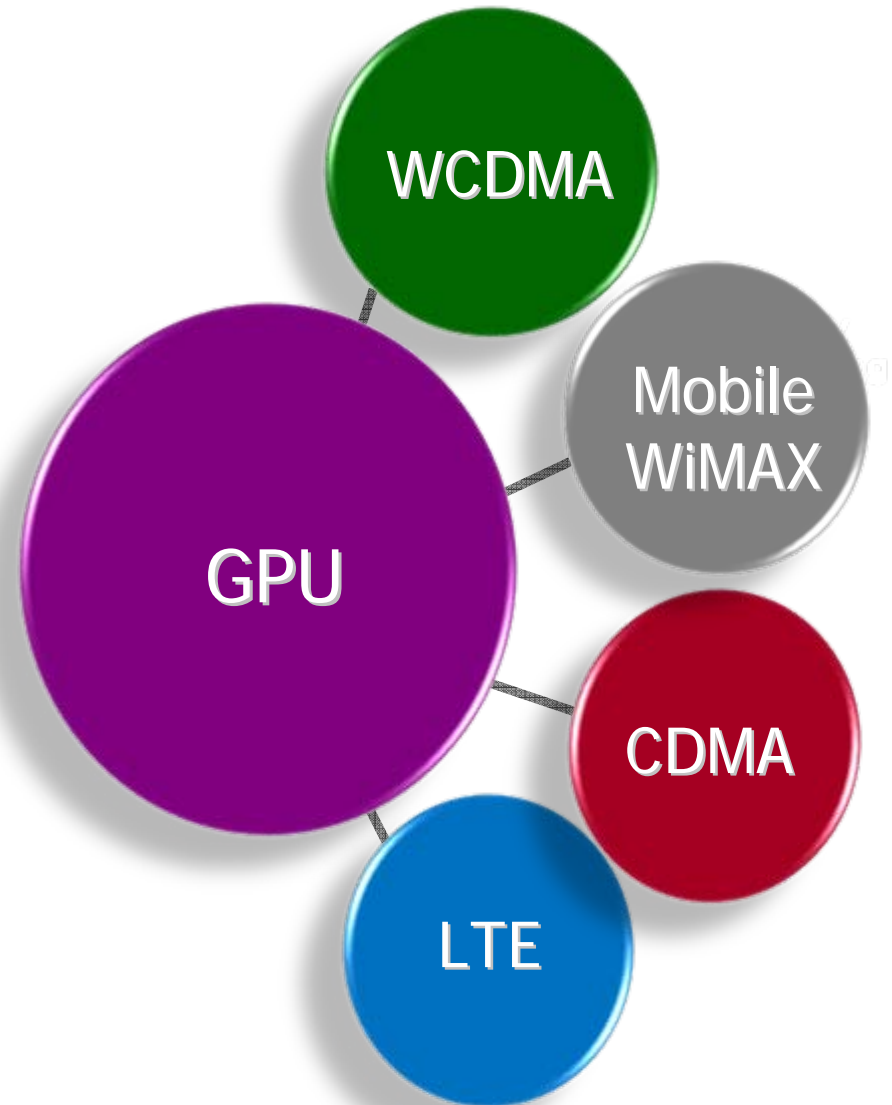


# 4. Conclusion



# Conclusion

- GPU can be a solution because of its powerful computation capacity
- Also with the GPU, wireless communication systems can be implemented effectively for SDR.
- GPU can operate all waveform effectively.



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# Q / A

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