# *Programmable VLIW and SIMD architectures for DSP and Multimedia Applications*

**Deepu Talla**

# Overview

- Introduction/Motivation
- Methodology
- Tools
- Fallacies and Pitfalls
- Benchmarks
- Results
- Future work and Conclusions

# Introduction/Motivation

- VLIW processors exploit instruction parallelism while SIMD processors exploit data parallelism
- Over 90% of workloads in future expected to be multimedia and DSP oriented
- To my knowledge no quantitative work has been done in comparing commodity VLIW and SIMD processors
- **C6x** is a **VLIW** DSP processor and **Pentium II** with **MMX** is a **SIMD** processor

# Methodology

- Measure the execution times of benchmarks on C6x and Pentium II (MMX)
- Use execution time of Pentium II without MMX code as baseline
- Each benchmark will have three versions
  - Pentium II code without MMX
  - Pentium II code with MMX
  - C6x code

# Tools

- **C6x**
  - Stand-alone simulator for execution cycle count
  - Optimizing compiler, simulator and debugger
- **Pentium II**
  - Performance counters for execution statistics
  - Intel C/C++ compiler
  - Vtune for static code analysis

# Fallacies and Pitfalls

- **Two completely different processors are being evaluated; so how is an equivalent playground/environment being created?**
  - First of all the memory hierarchies of both processors are completely different -> Pentium II with two layers of caches and DRAM, C6x with small L1 and SRAM
  - To remove effects of memory latencies, data sets in both cases have been made to fit on chip (translates to fastest memory of each processor)
  - Each benchmark is run multiple times over the pre-loaded data set

# Fallacies and Pitfalls (continued..)

- **What is the importance of aggressive optimization of code ? (particularly for DSPs)**
  - Using ordinary C code is not the best step -> for a simple dot-product kernel C code is twice slower, and for the DCT it is an order of magnitude slower than optimized assembly
- **Compilers can generate MMX code**
  - Sure, but only for marketing people
  - It has been mentioned that compiler technology takes 5 to 10 years to catch up to an architecture

# Benchmarks - Kernels

- **Dot Product**
  - › Filtering, Matrix-Vector, Alpha Blending
- **Autocorrelation**
  - › Filtering applications
- **FIR (Finite Impulse Response) filter**

# Benchmarks - Applications

- **Audio-effects**
  - Echo effects, Signal mixing and Filtering
- **G.711 standard**
  - A-law to u-law and u-law to A-law
- **ADPCM**
  - 16-bit to 4-bit compression

# Creation of Benchmarks

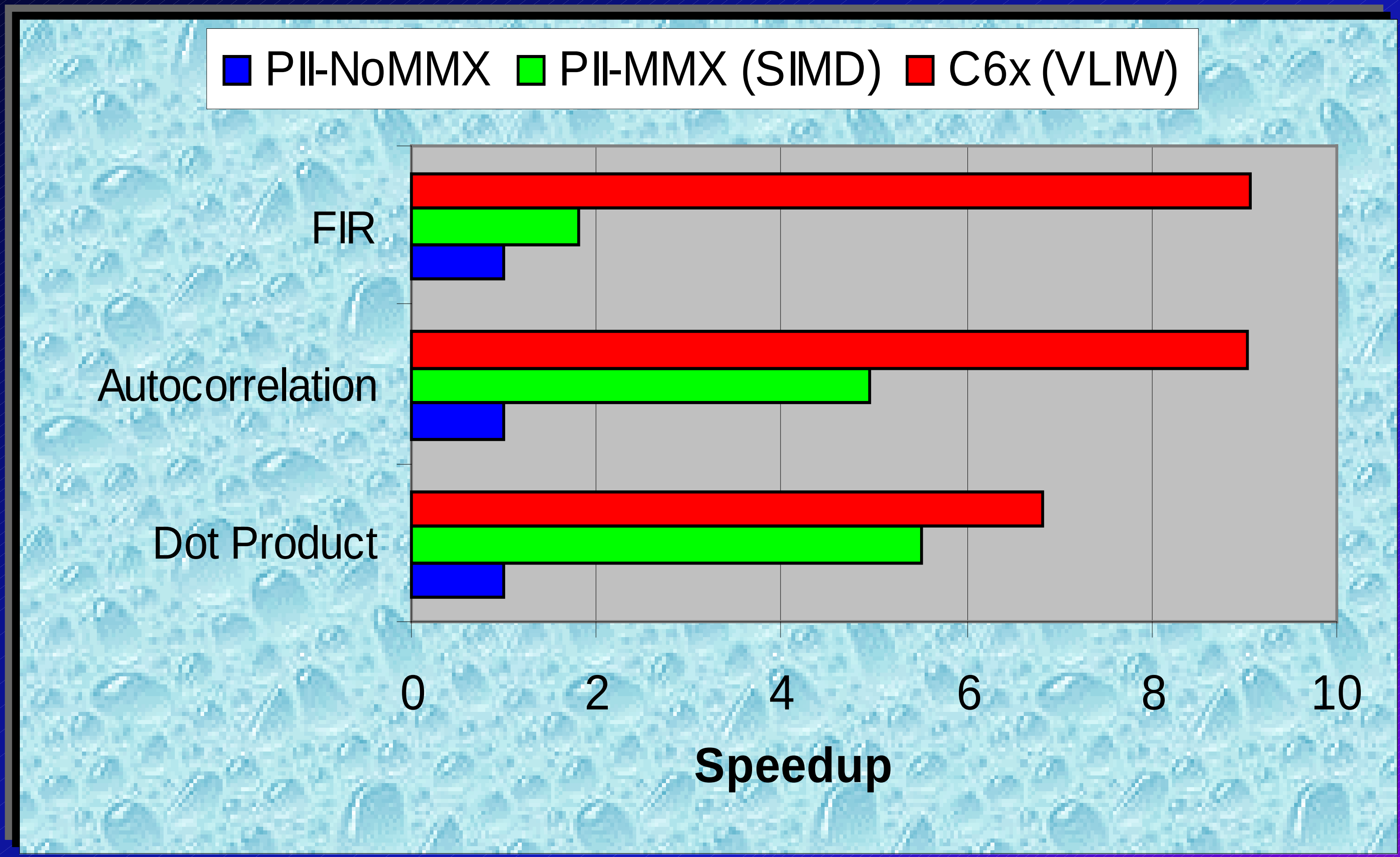
- **Dot Product and Autocorrelation**
  - › Hand-coded baseline and obtained MMX and VLIW code from libraries
- **FIR (Finite Impulse Response) filter**
  - › Hand-coded baseline and MMX code and VLIW code was obtained from libraries
  - › MMX code has been tweaked to get maximum performance (needs four copies of filter coefficients !)

# Creation of Benchmarks

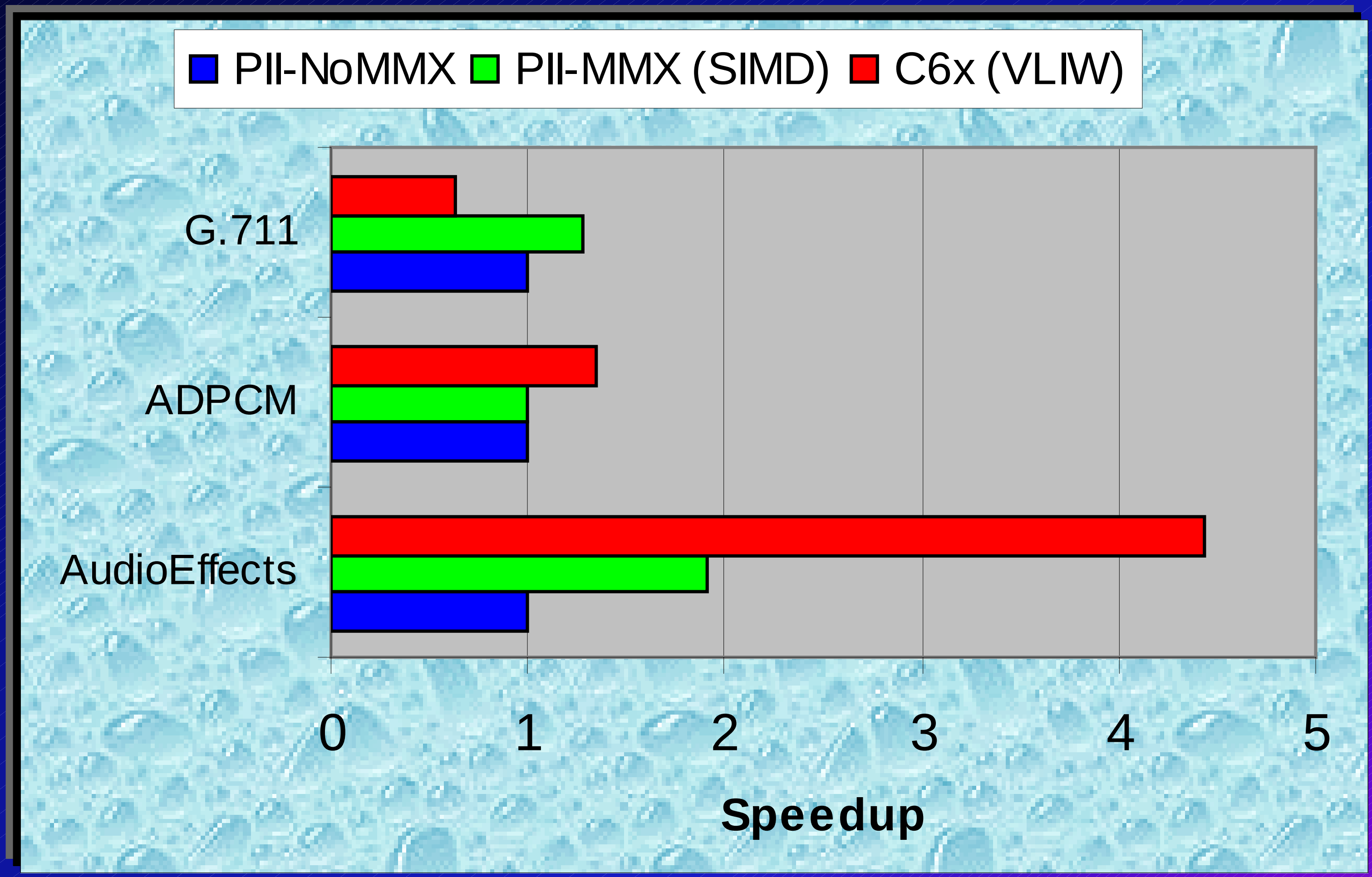
- **Audio-effects and G.711**
  - Hand-coded all versions of the benchmarks
- **ADPCM**
  - MMX could not be used here due to the fact that computation on each data sample involved result of computation on previous data sample

***All versions of benchmarks produce same results***

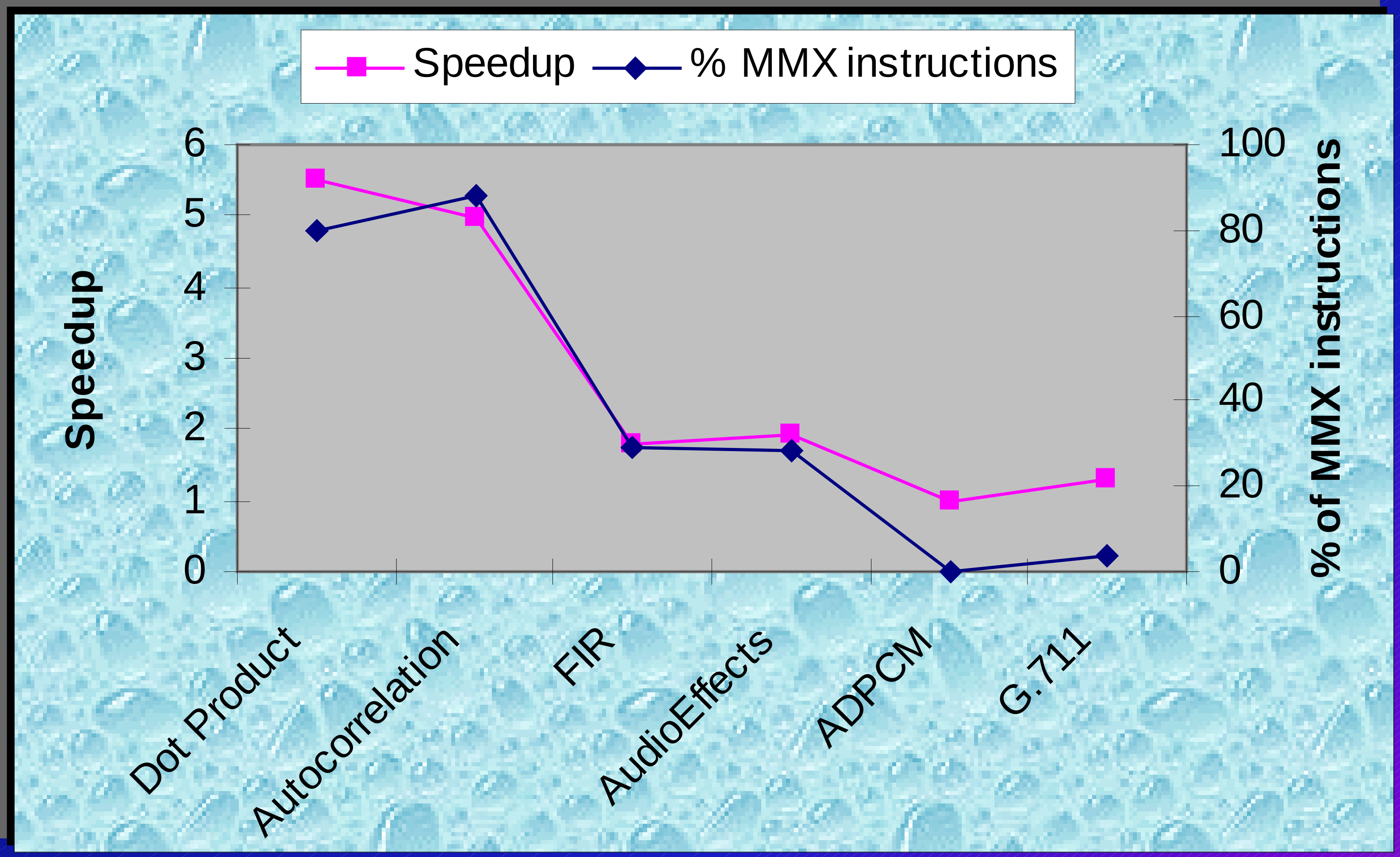
# Results - Kernels



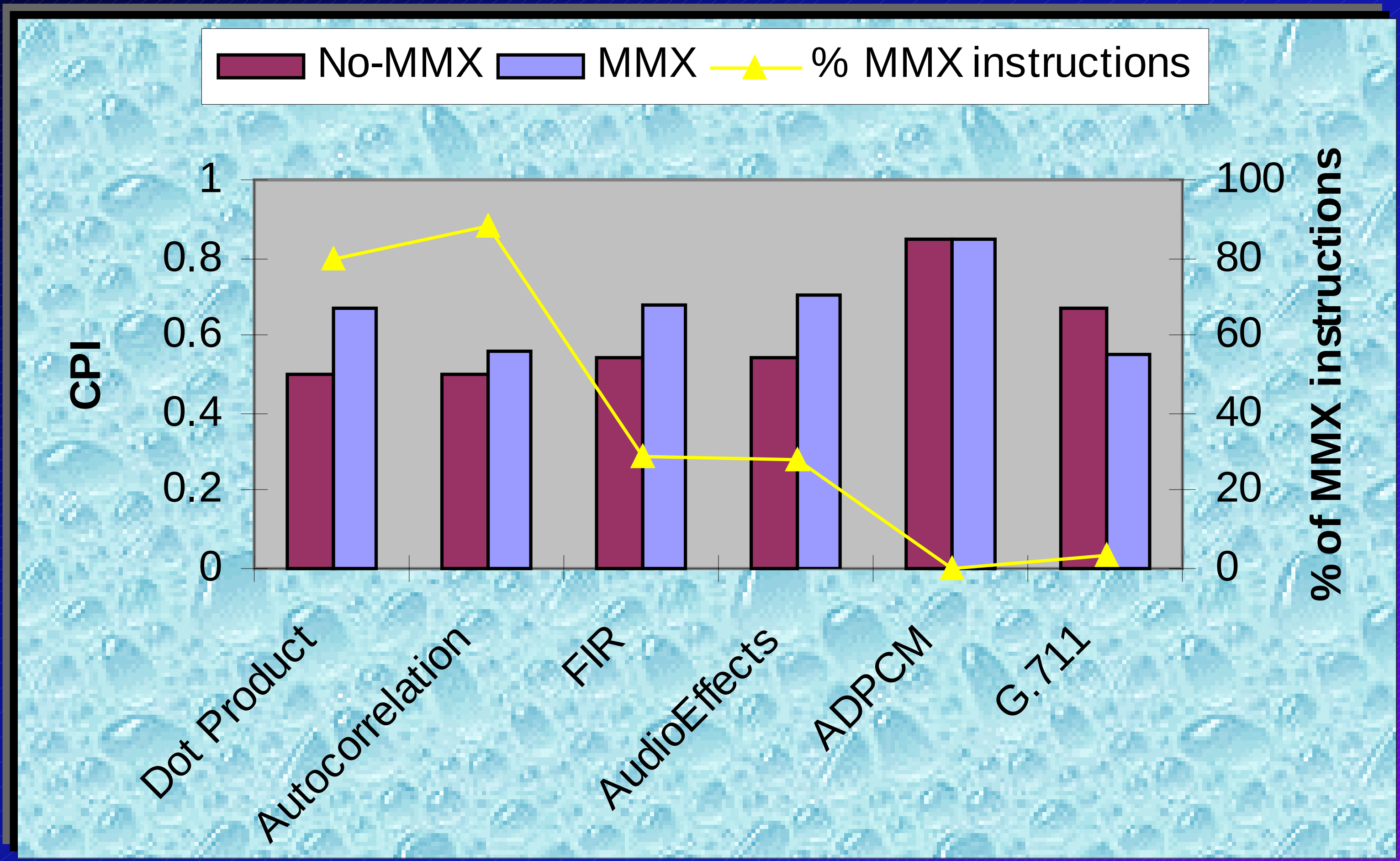
# Results - Applications



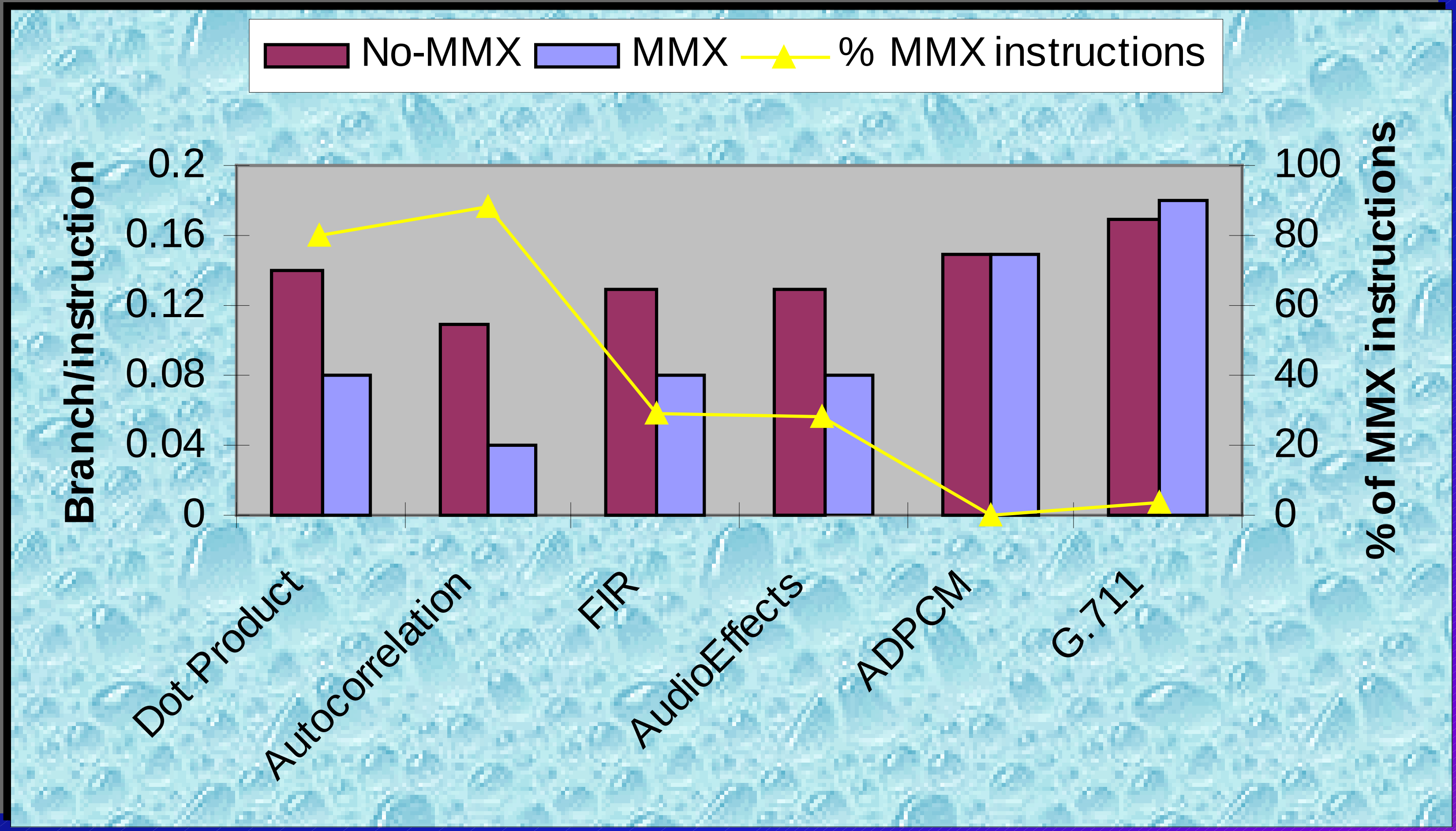
# % of MMX - Speedup



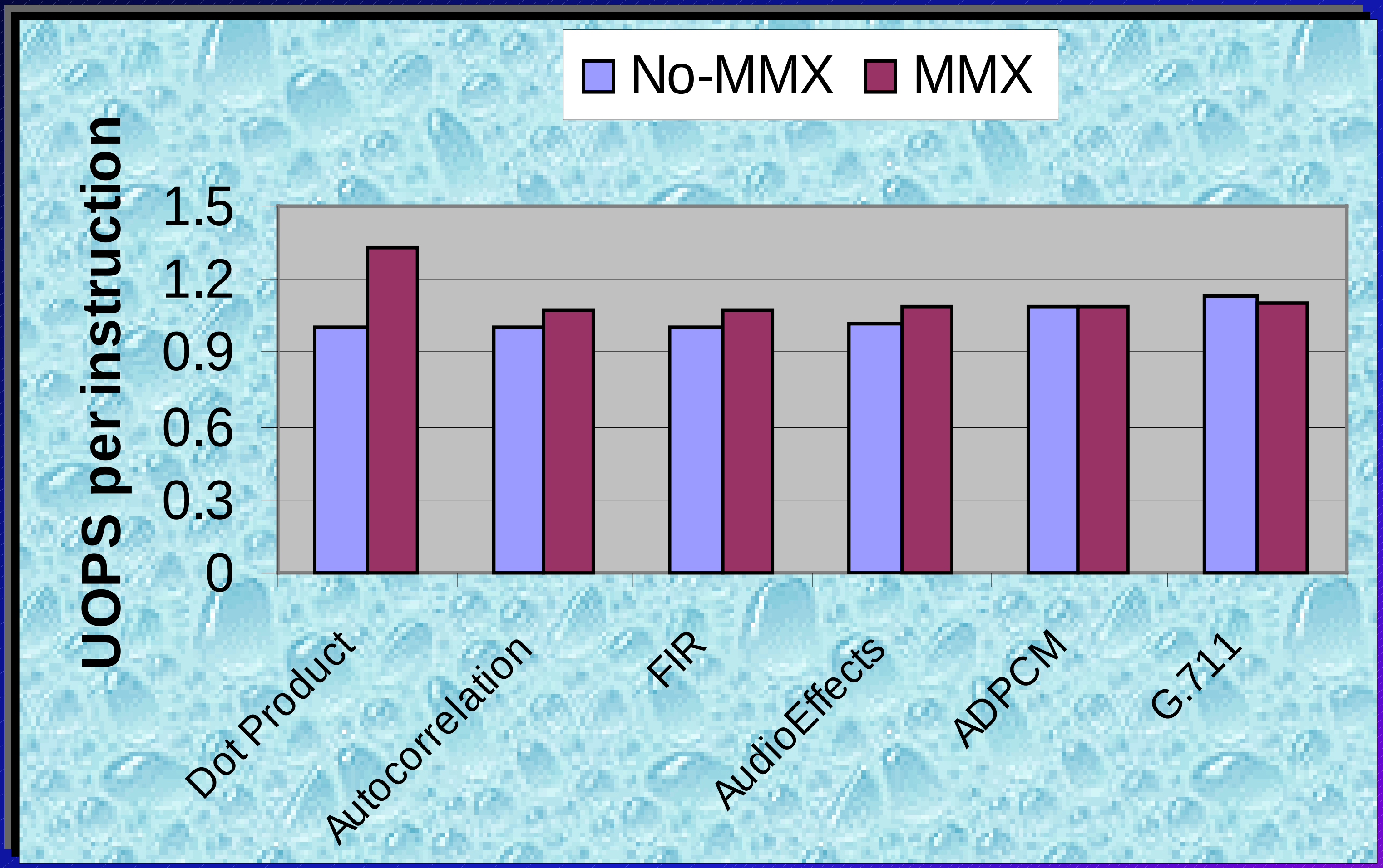
# Effect of MMX on Clock cycles per instruction



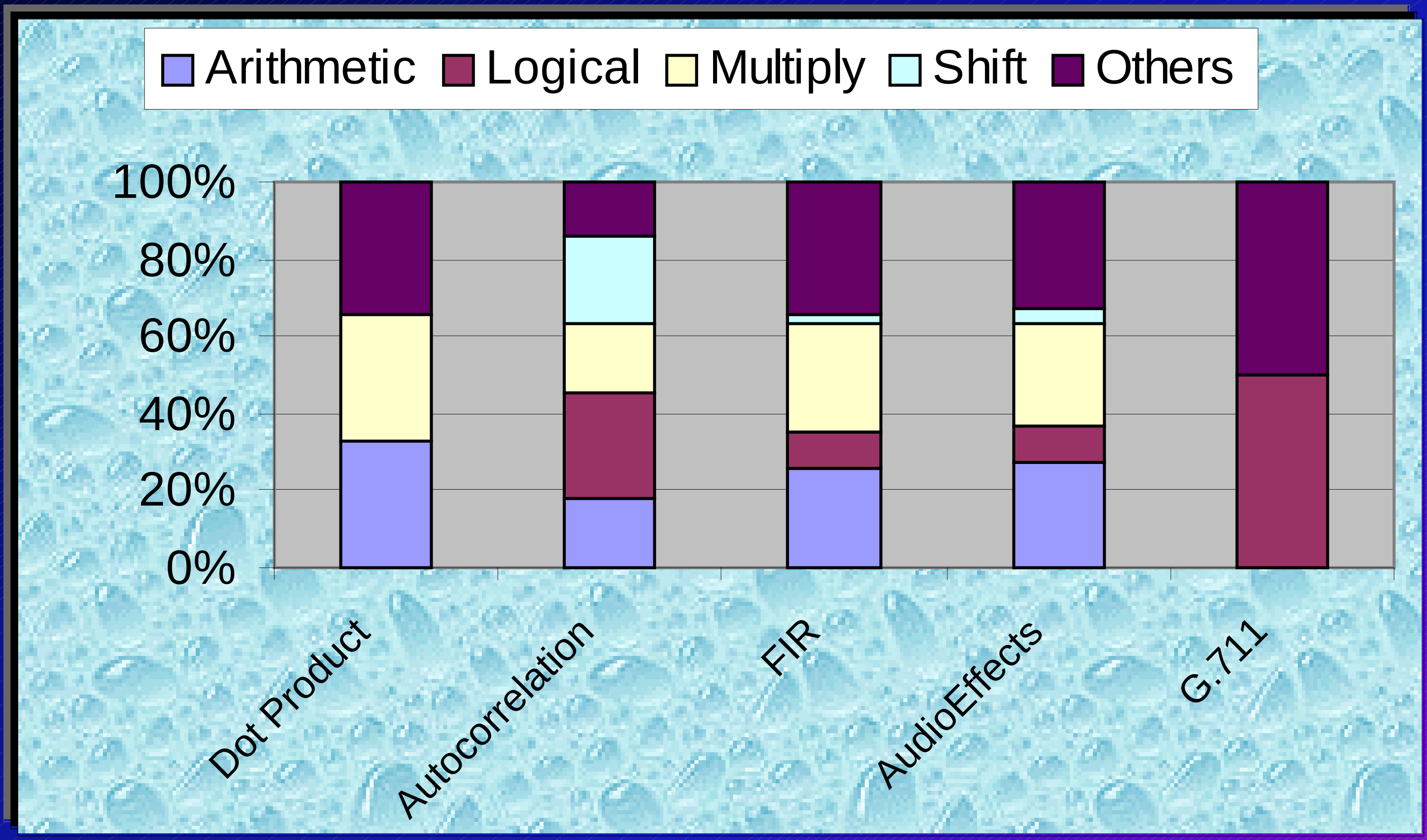
# Branch Characteristics



# Micro-ops per instruction



# Breakup of MMX instructions



# Future Work (by end of May)

- Create more applications
  - In fact applications like Doppler radar and ECG compression were tried, but C6x versions crashed -> need to significantly alter source code
- Evaluate the new floating-point streaming SIMD versus the C67x (waiting for a Pentium III processor to arrive in our lab!)
- Measure other statistics relevant to MMX technology (not related to this project per se, but for computer architects)

# Conclusions

- **Both SIMD and VLIW techniques provide significant performance improvement over baseline code**
- **Compilers are very crucial for efficient code development**
  - Benefit of C6x in applications is not fully achieved unless application is hand-coded (this involves month's of development time)
  - SIMD compilers are hardly existent, but hand-coding is comparatively easy (with intrinsics)