



# How Good is RISC-V: Comparing Benchmark Results

Jeremy Bennett

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# Open Source Benchmarking

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# How to Benchmark

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Real open  
source code

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Benchmark  
speed & size

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One simple  
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Regularly  
updated

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SPEC CPU 2016 & 2017  
Application class cores





# How to Benchmark

Real open  
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SPEC CPU 2016 & 2017  
Application class cores



Emibench IoT 1.0 & 2.0  
Microcontroller cores



# Benchmarking Targets

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RISC-V
CV32E40Pv2 on Nexys A4 FPGA @ 15MHz
HiFive Unmatched @1.4GHz
MILK-V Pioneer @ 2.0GHz
BananaPi BPI_F3 @ 1.6GHz
QEMU User Mode

# Benchmarking Targets

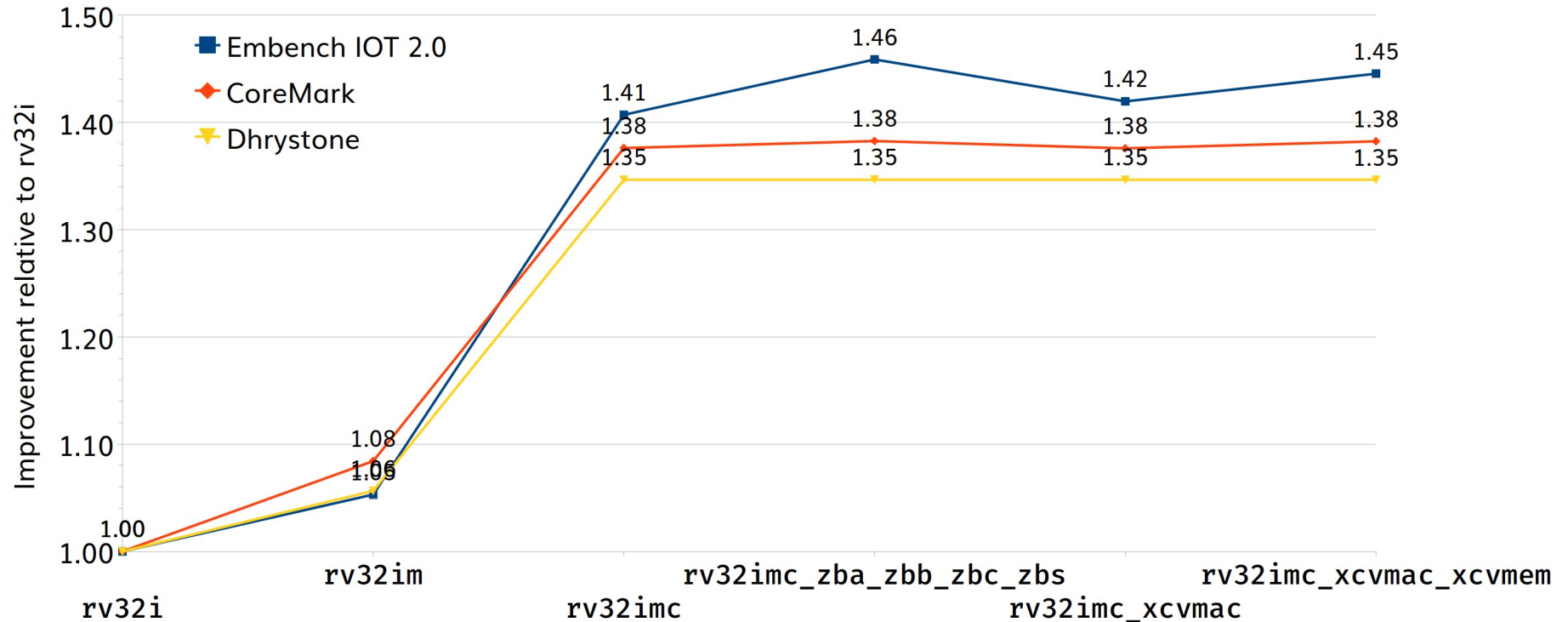
RISC-V	Arm
CV32E40Pv2 on Nexys A4 FPGA @ 15MHz	STM32F407 @ 16Mz
HiFive Unmatched @1.4GHz	Apple M1 @ 3.8MHz
MILK-V Pioneer @ 2.0GHz	QEMU User Mode
BananaPi BPI_F3 @ 1.6GHz	
QEMU User Mode	

# Benchmarking Targets

RISC-V	Arm	x86_64
CV32E40Pv2 on Nexys A4 FPGA @ 15MHz	STM32F407 @ 16Mz	AMD Threadripper 1950X @ 3.4GHz
HiFive Unmatched @1.4GHz	Apple M1 @ 3.8MHz	
MILK-V Pioneer @ 2.0GHz	QEMU User Mode	
BananaPi BPI_F3 @ 1.6GHz		
QEMU User Mode		

# Dhrystone & CoreMark

Code size improvement as add extensions to RISC-V





# Application Class Processors

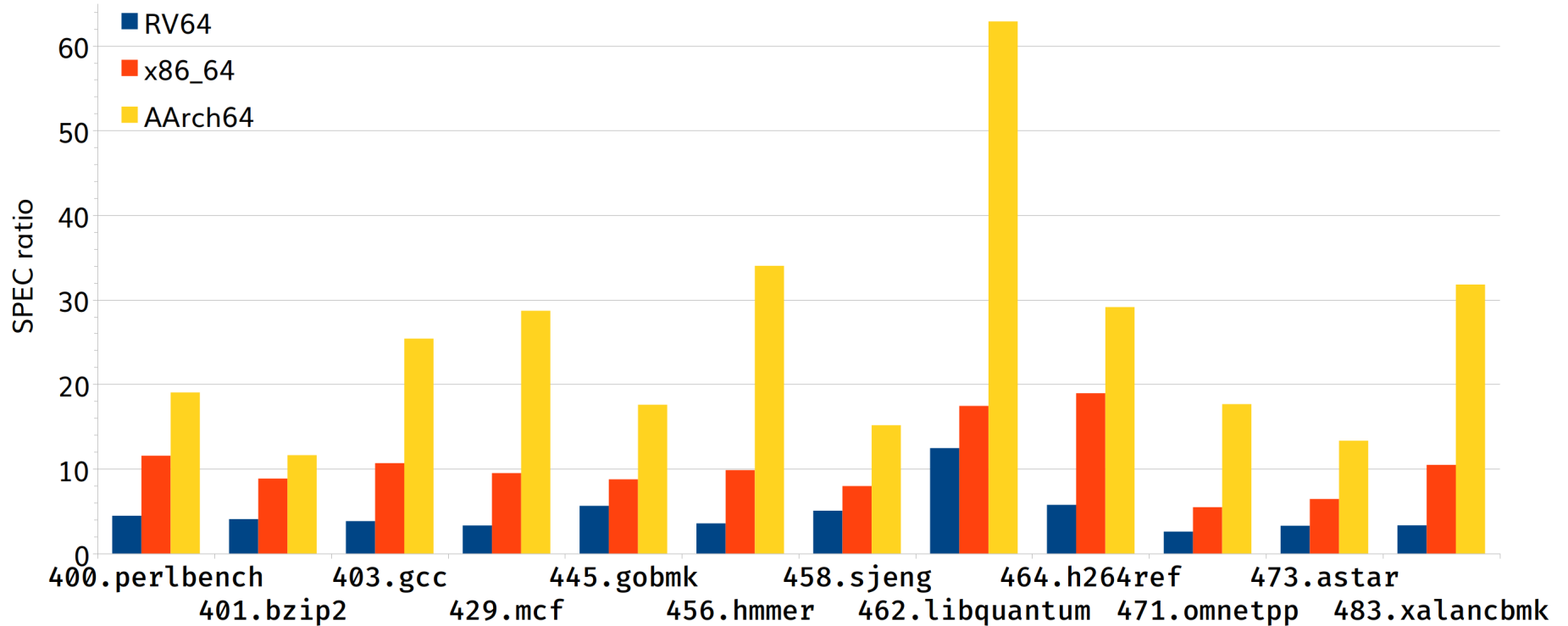
## SPEC CPU 2006 & 2017

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# Comparing Architectures (SPEC CPU 2006)

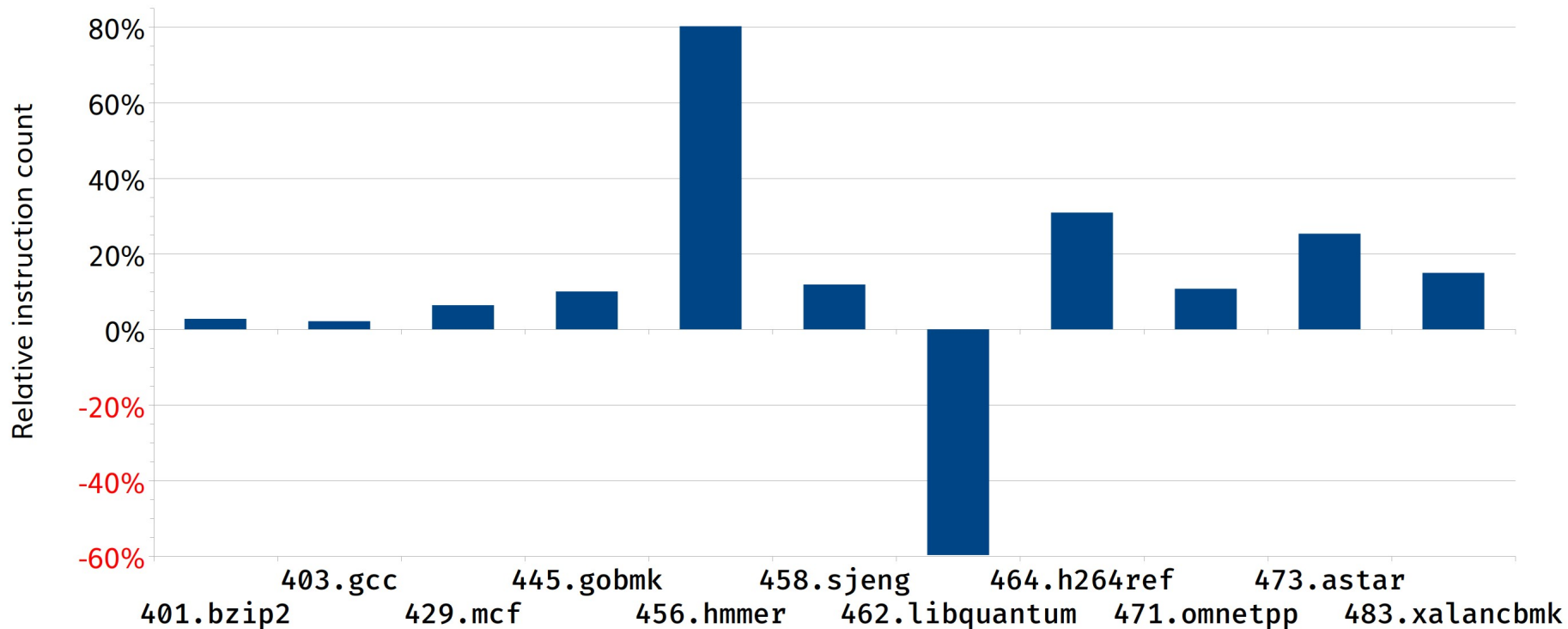
RV64 v x86\_64 v AArch64 (normalized to 1GHz)



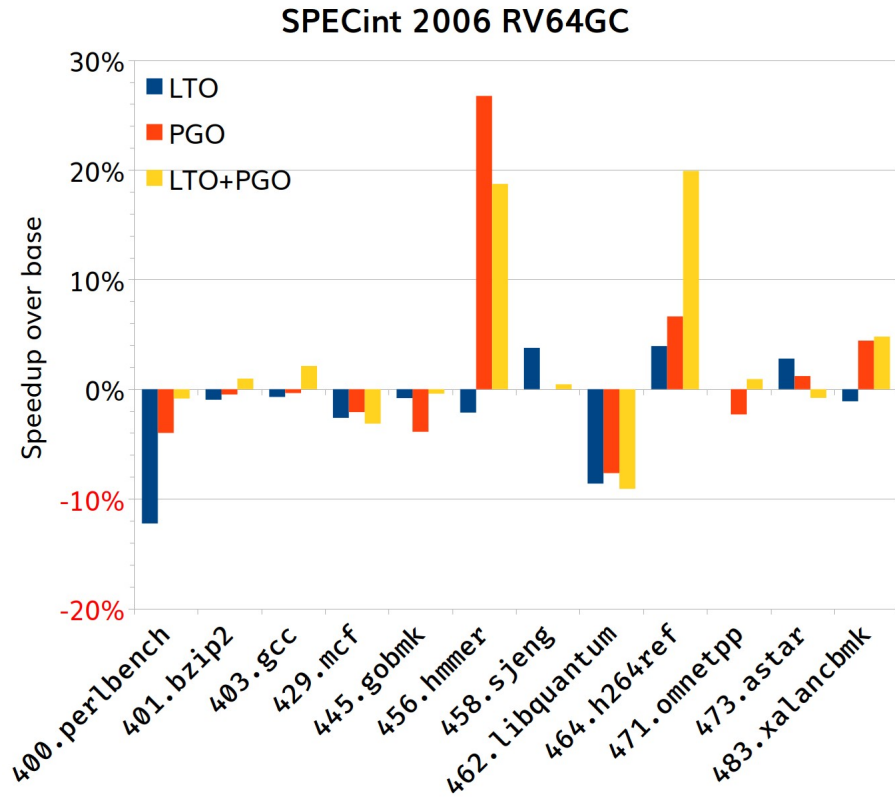


# GCC v LLVM

SPECint 2006 LLVM dynamic instruction count relative to GCC

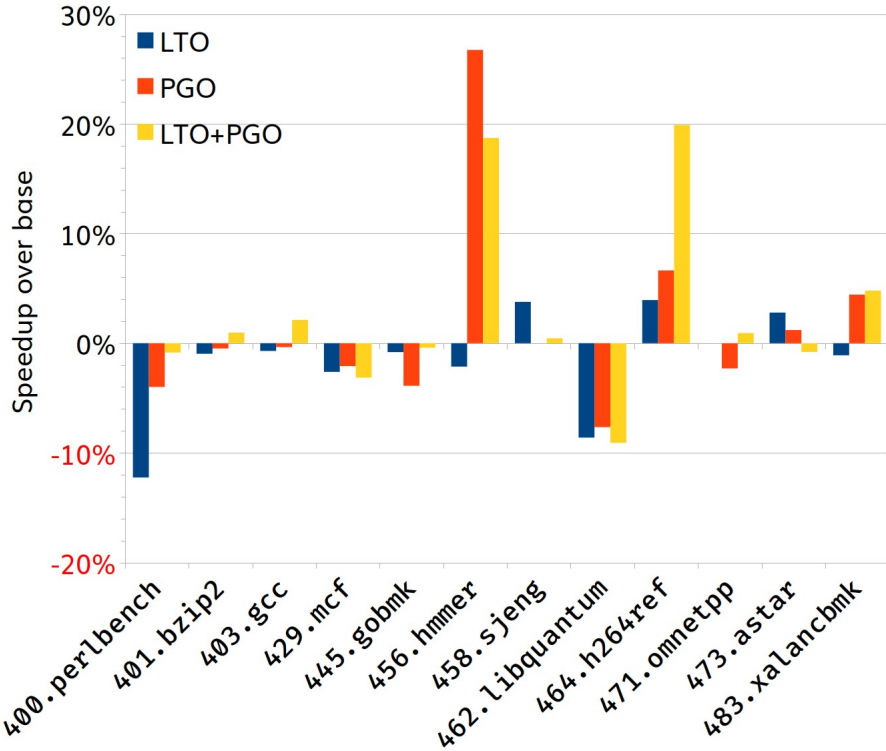


# Impact of LTO and PGO

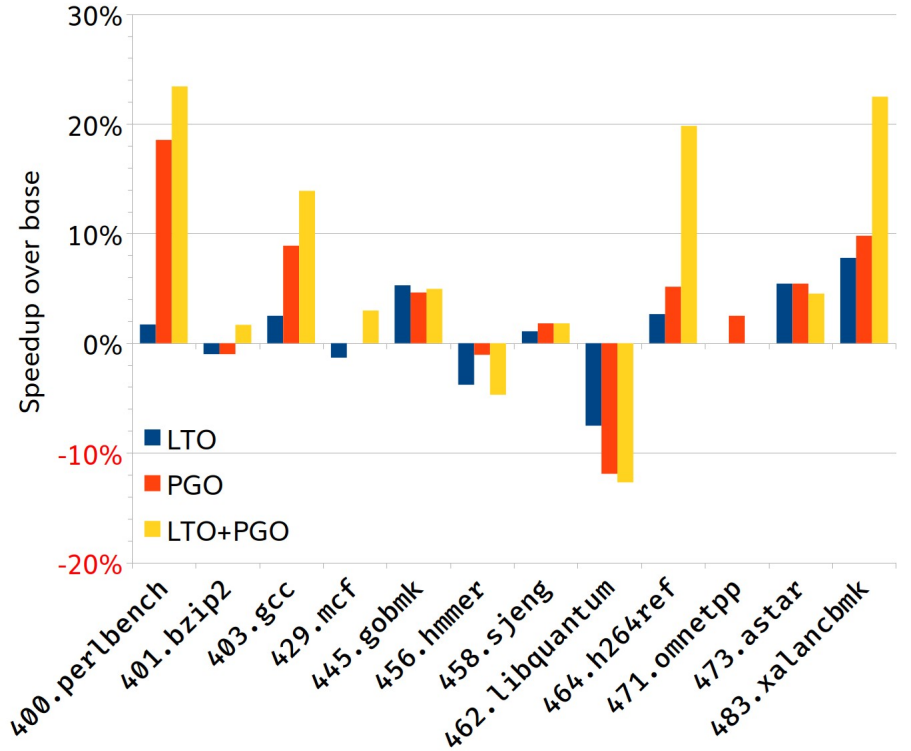


# Impact of LTO and PGO

SPECint 2006 RV64GC

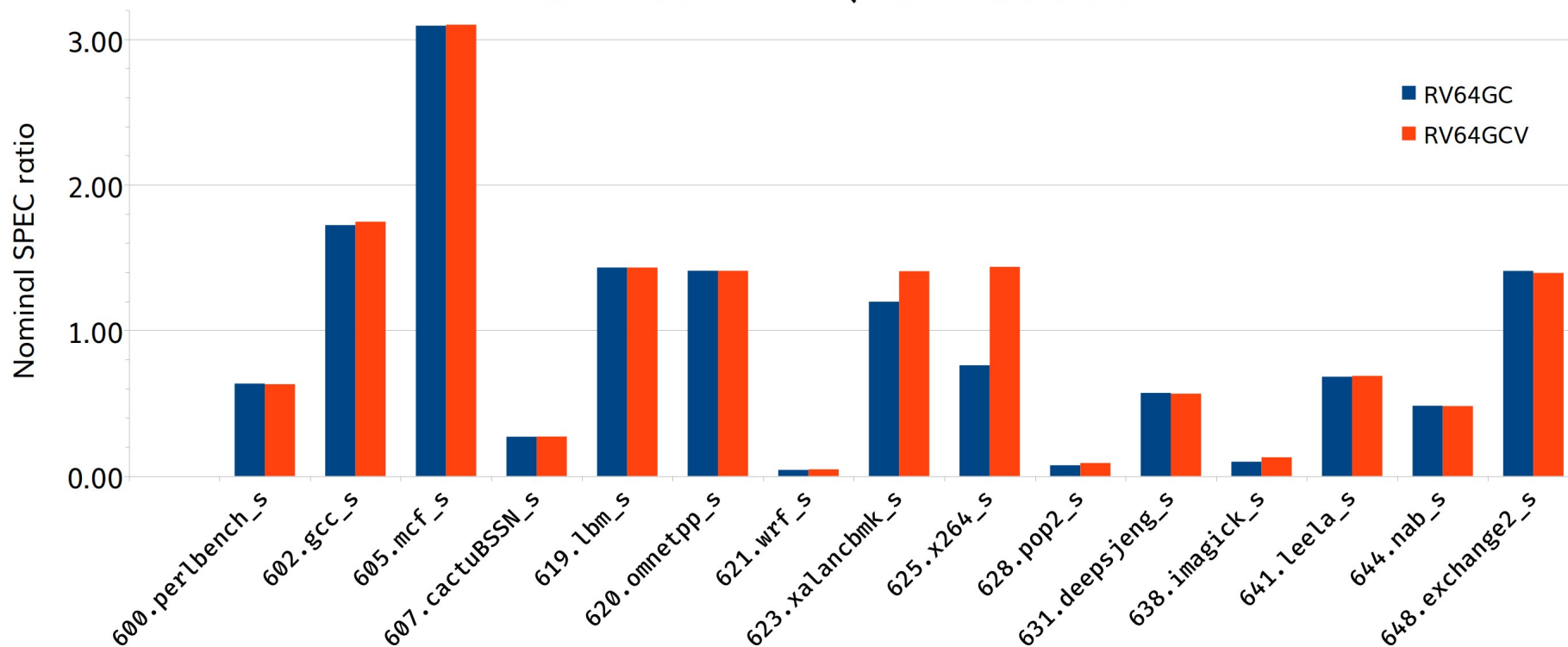


SPECint 2006 x86\_64



# RISC-V Vector (RVV)

SPECint 2017 based on QEMU instruction counts





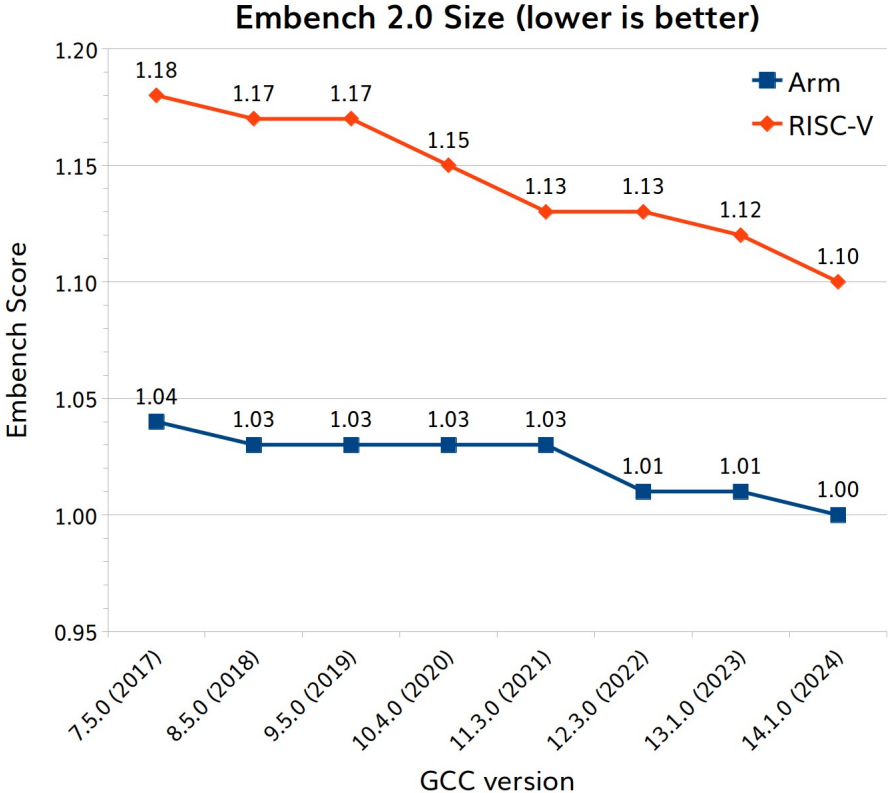
# Microcontrollers

## Embench IoT 1.0 and 2.0

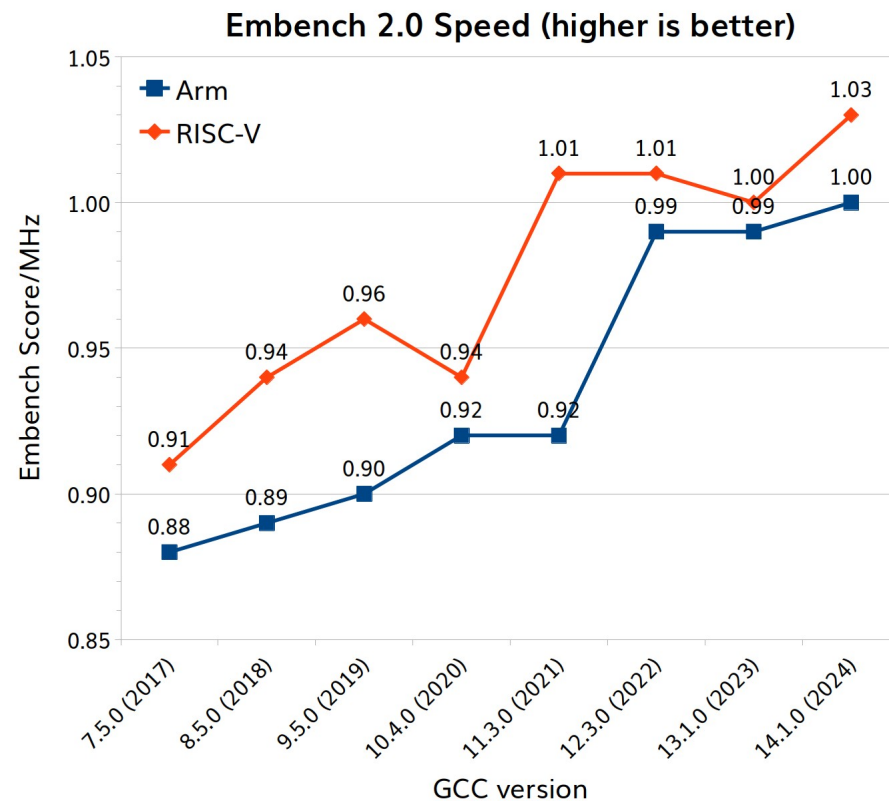
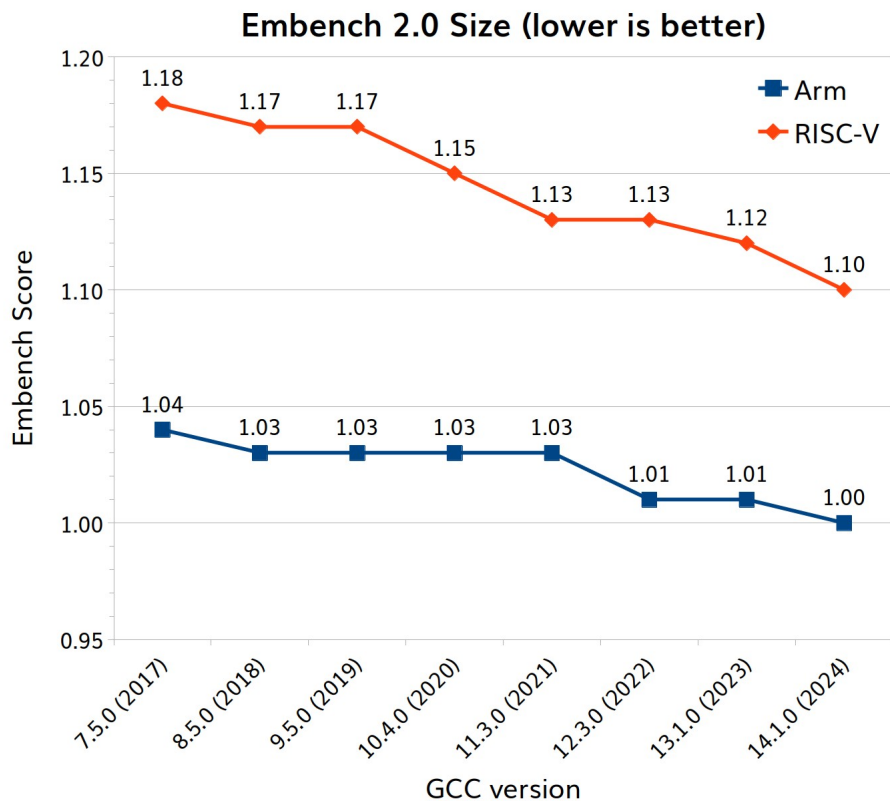
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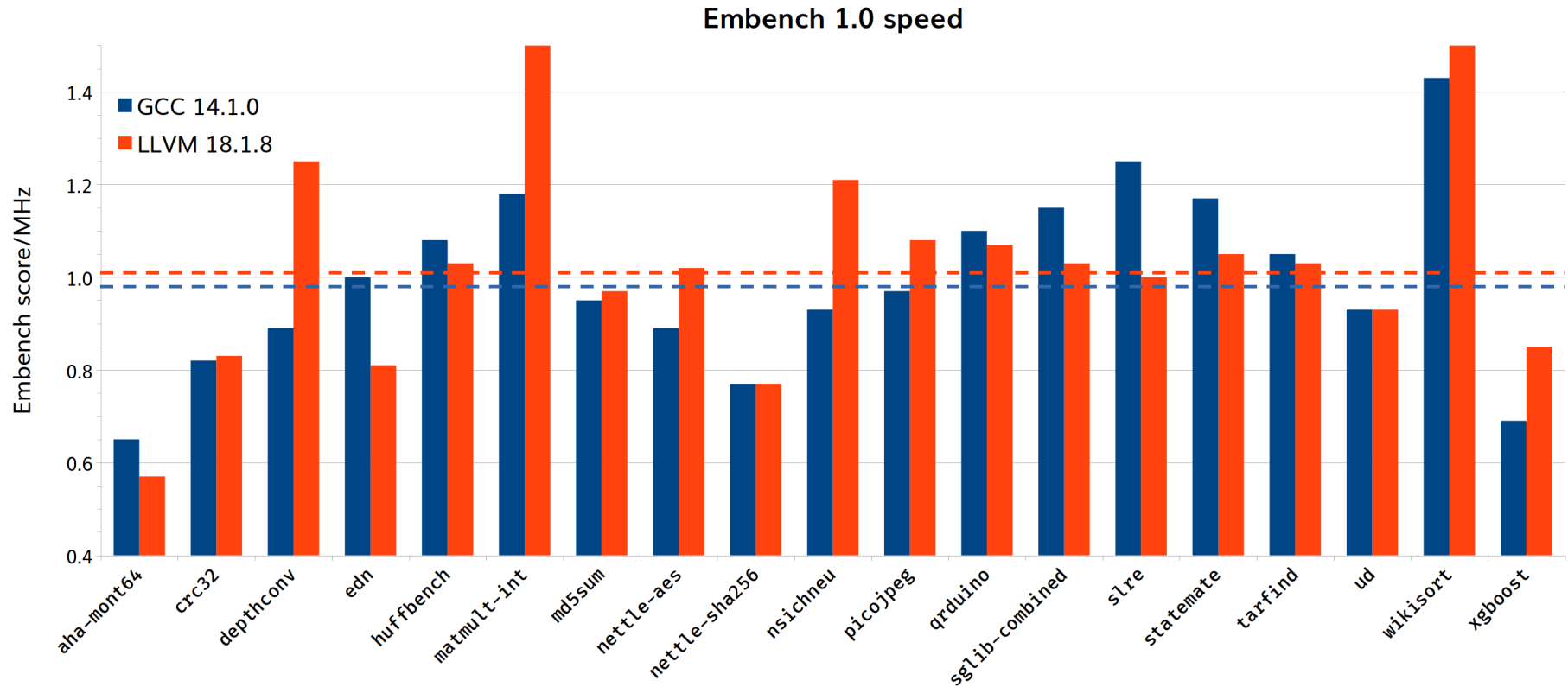
# Compilers over Time (GCC)



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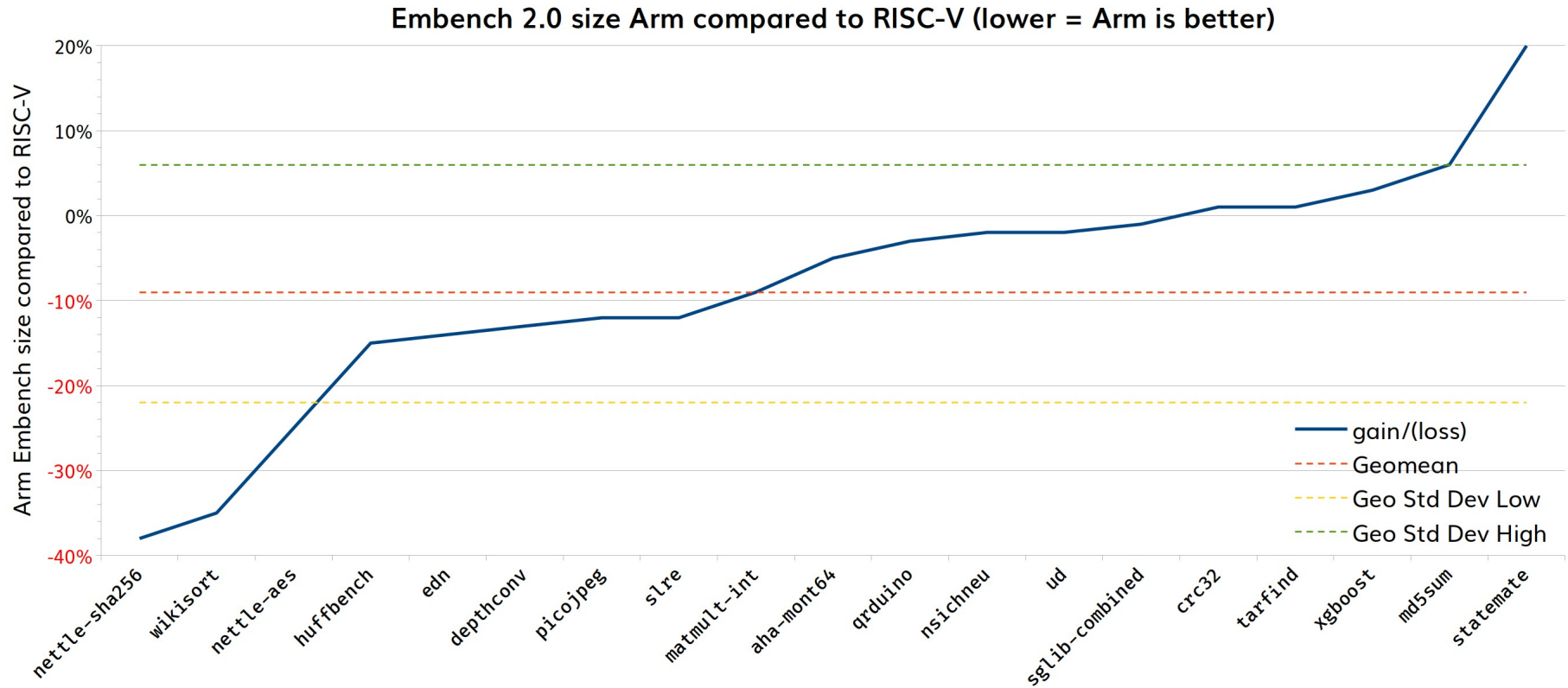


# Comparing Compilers

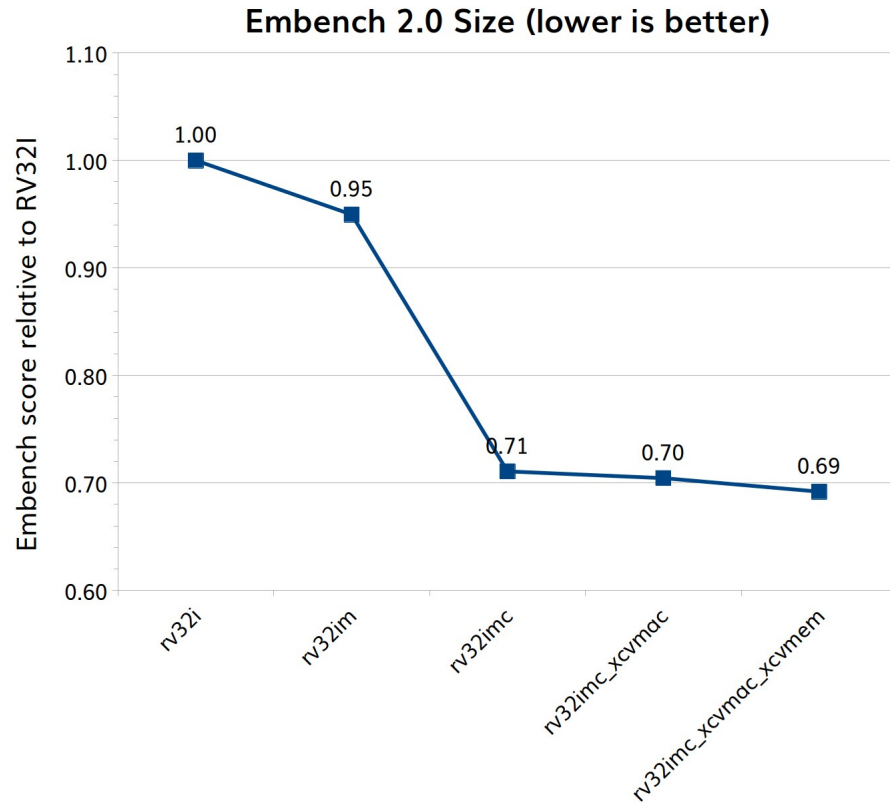




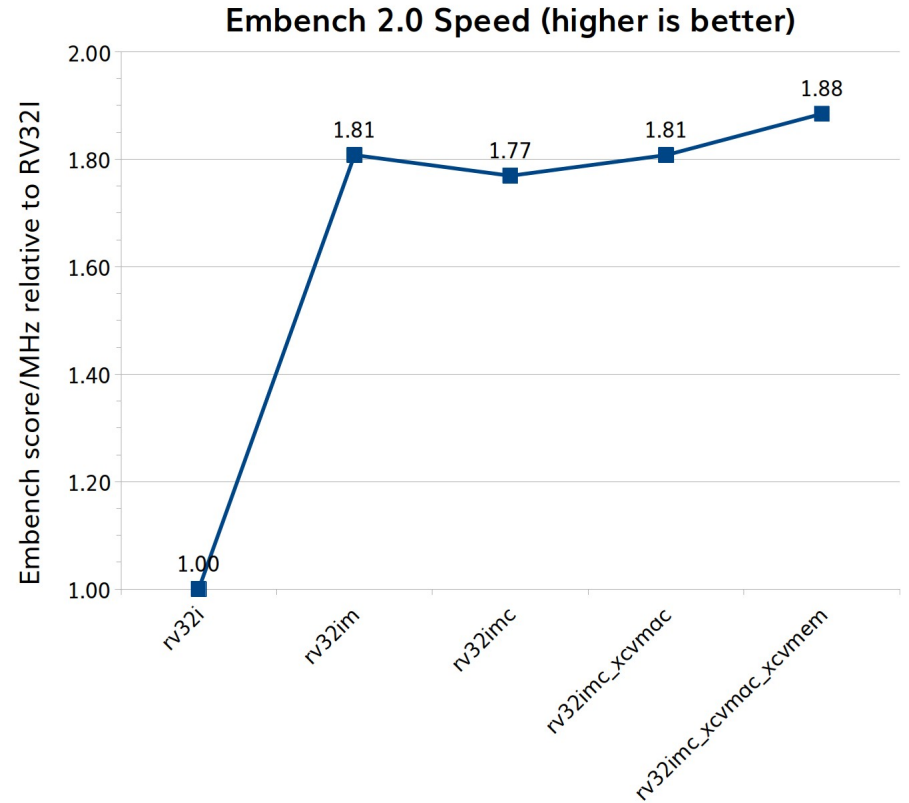
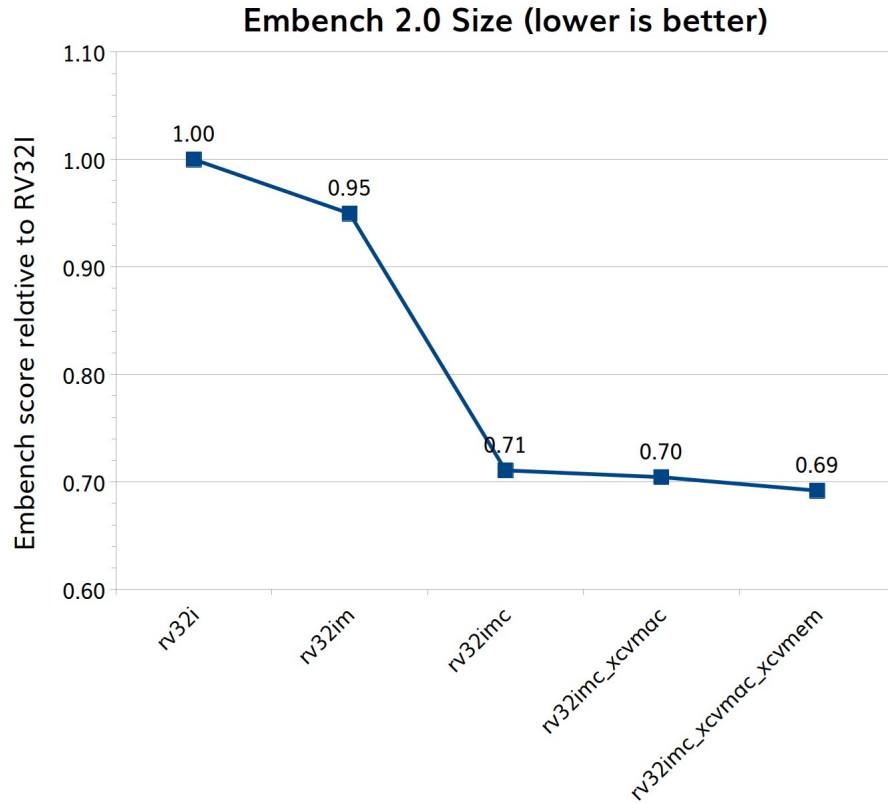
# Comparing Architectures



# Impact of ISA Extensions



# Impact of ISA Extensions





# The Compiler Community

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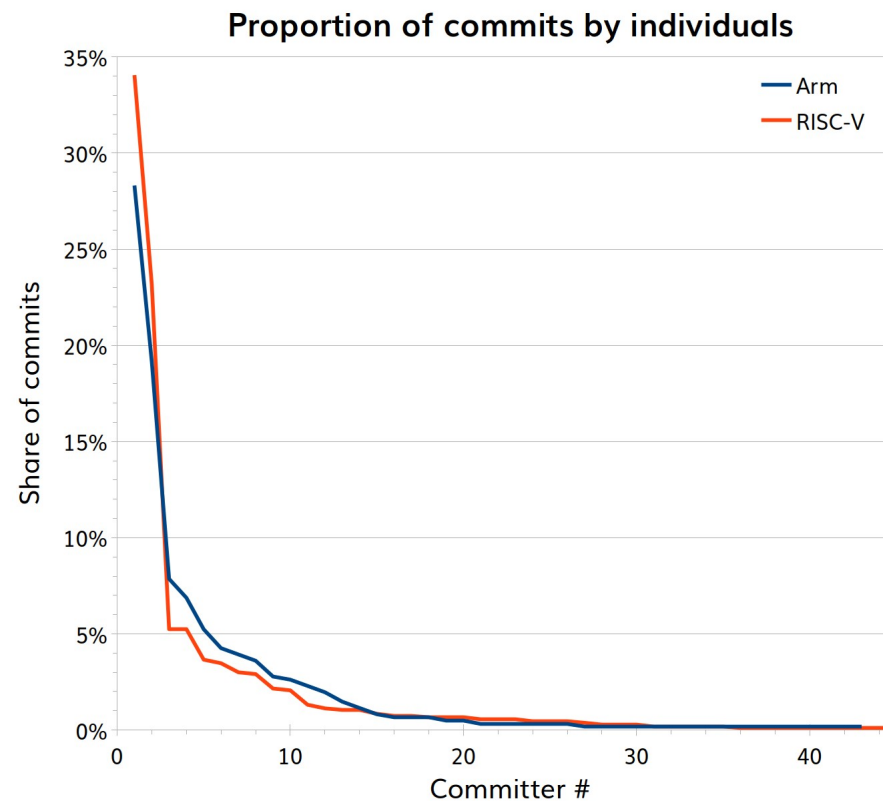


# Community Statistics

Metric	RISC-V	Arm
# commits	1,058	611
# committers	45	43
Most commits	363	173
# committers to reach 90%	15	13
# companies committing	16	12

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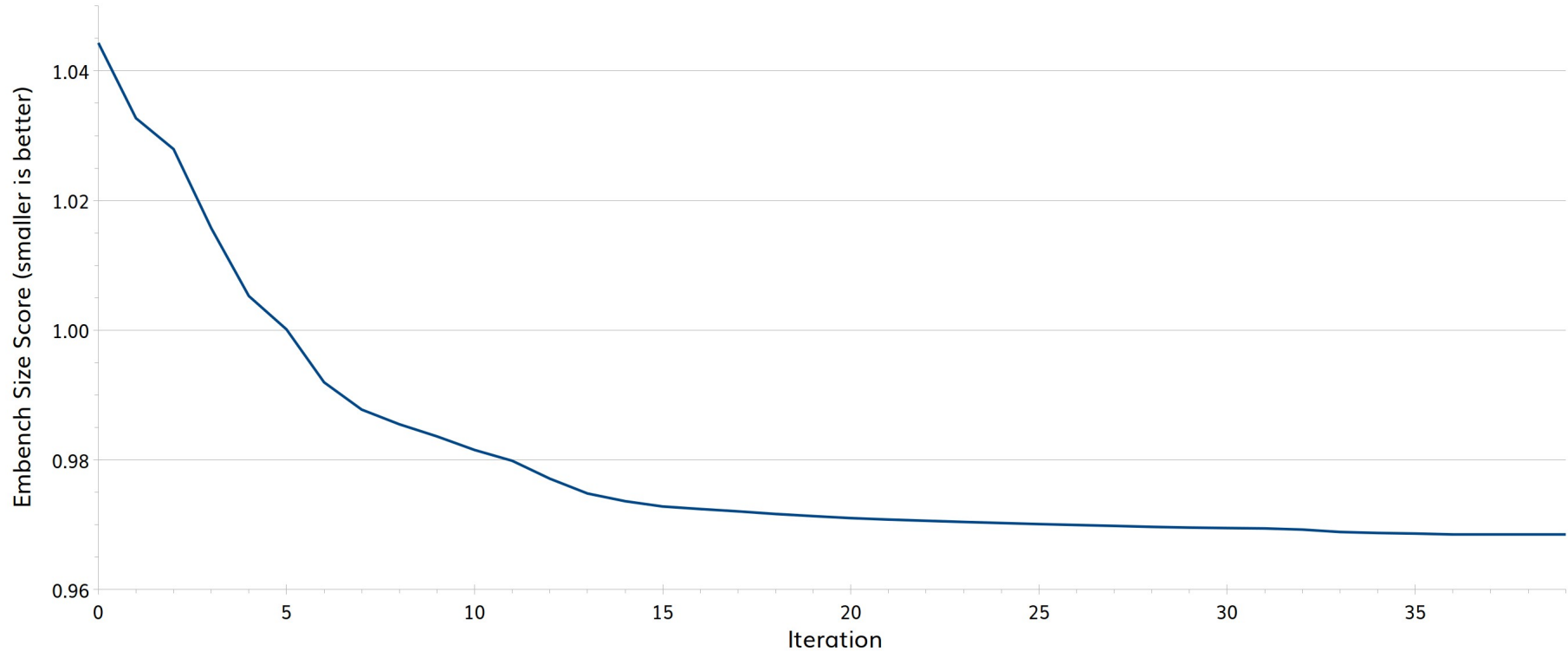
# Using Benchmarks: Improving the Compiler

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# Iterative and Combined Elimination

CV32E40Pv2 ISA extensions and iterative elimination





# Acknowledgements

Dave Patterson and the Embench community



The Open Hardware Foundation



The GCC and LLVM communities



The Embecosm team





# Thank You

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