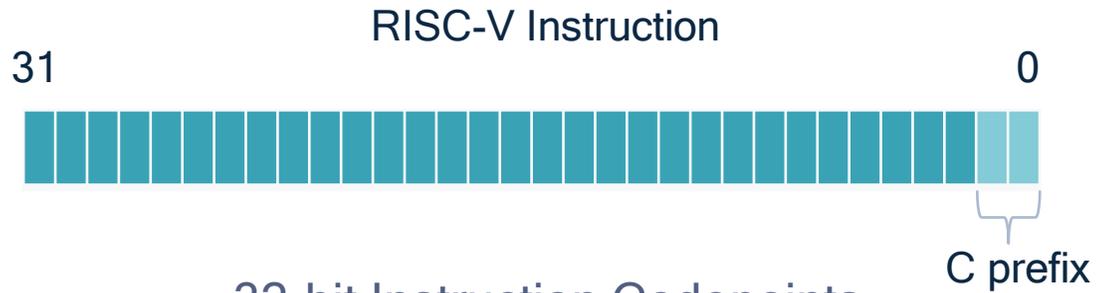


# A Case to Remove C from App Profiles

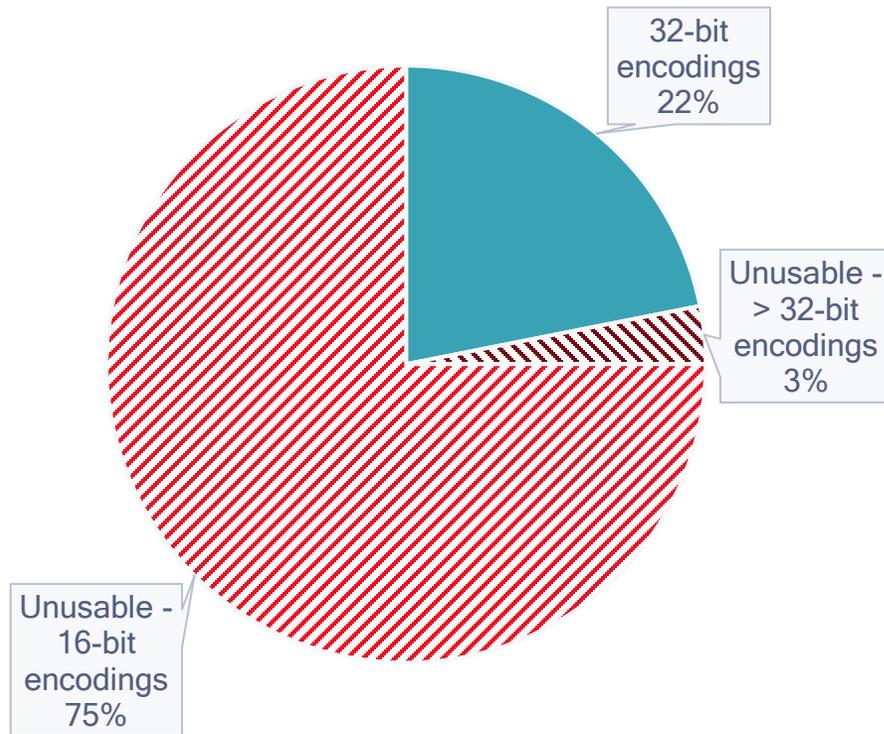
Derek Hower, James Ball, Conrado Blasco, Manu Gulati  
Qualcomm Technologies, Inc.



# C Extension - Compressed (16-bit) instruction encodings



32-bit Instruction Codepoints



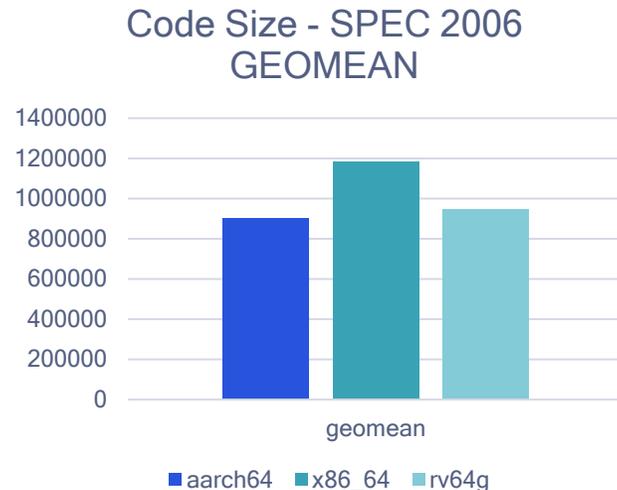
## Facts

- C defines compressed re-encodings of common 32-bit instructions
  - **No new instructions** - always 1:1 mapping between 16/32-bit
- 2 LSBs of instruction identify length
  - 3 of 4 values indicate 16-bit
  - 1 of 4 values indicate  $\geq$  32-bit
- C binaries are packed: **32-bit encodings can be unaligned**

# Problems with C in high performance designs

## Pushes RISC-V to large opcodes

- RISC-V is nearly out of 32-bit opcodes
- **Forced transition to > 32-bit opcodes will *degrade code size***
  - Eventually, *RV64 with 32-bit encodings will have better code size than RV64C + large encodings* as new instructions are added and used



## Substantial design complexity

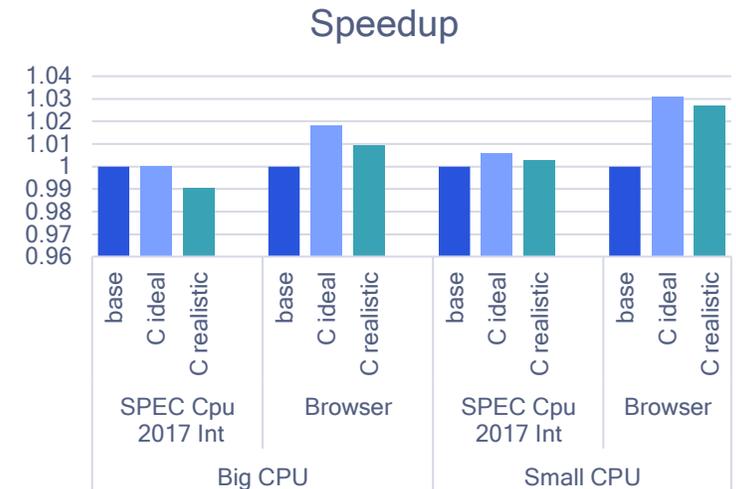
- Unaligned fetch is **challenging to design, verify**
  - Cache line, page crossing instructions
  - Increased wire delay/muxing
- Leads to designs that are:
  - **more expensive** (NRE)
  - **slower** (extra pipe stages)
  - **buggy** (see [Intel Jump Code Conditional](#))

“Under complex micro-architectural conditions involving branch instructions bytes that span multiple 64 byte boundaries (**cross cache line**), unpredictable system behavior may occur.”  
- Intel Xeon Erratum SKX102

Fix results in **0-8% slowdown**.

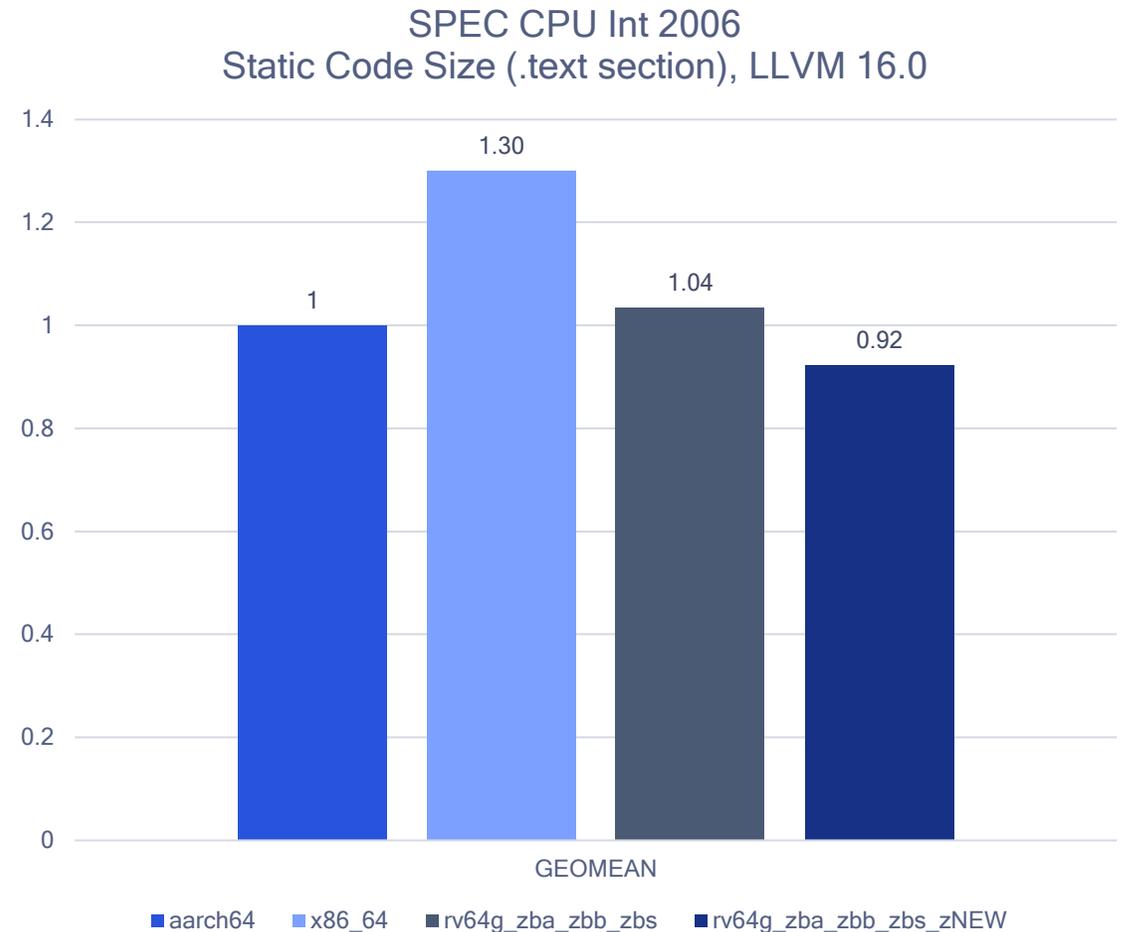
## Performance benefit is modest

- Best case: 2-3% speedup
- Often: slowdown (net negative when program fits in icache)

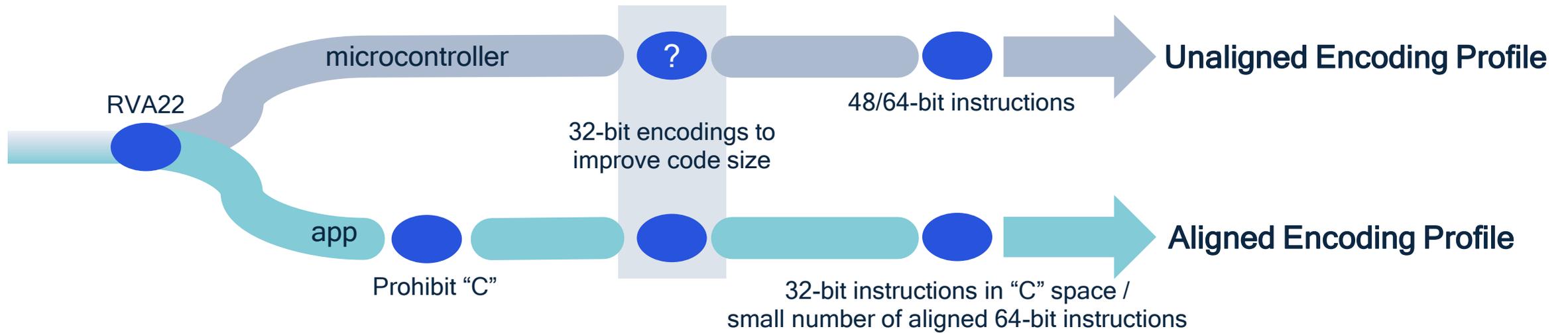


# C is not needed

- RV64G is already competitive on code size
- RV64G + 32-bit instructions for code size is *best in class*
  - More ld/st addressing modes
  - Ld/st pair
  - Conditional immediate branches
  - Move pair
- RV64GC has little performance benefit in beefy designs



# Diverging profiles



- Remove C from application profiles
- Once removed, the C opcode space can be reclaimed to keep code size down long term
- **It's not too late:** commercial distros have not picked a base
  - But, time is running short

# Thank you

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