Peephole Optimization In Compiler Design

b = t1 d007e2b884 A retargetable compiler is a compiler that has been designed to be relatively easy to modify to generate code for different CPU instruction set architectures. The history of this idea dates back to the 1950s when UNCOL was proposed as the universal intermediate language. The Pascal P-compiler is an example of an early widely used retargetable compiler. d007e2b884 == History == d007e2b884

Register transfer language In GCC, RTL is generated from the GIMPLE representation In computer science, register transfer language (RTL) is a kind of intermediate representation (IR) that is very close to assembly language, such as that which is used in a compiler. RTL is used as the name of a specific intermediate representation in several compilers, including the GNU Compiler Collection (GCC), Zephyr, and the European compiler projects CerCo and CompCert. It is used to describe data flow at the register-transfer level of an architecture. Academic papers and textbooks often use a form of RTL as an architecture-neutral assembly language. The idea behind RTL was first described in The Design and Application of a Retargetable Peephole Optimizer d007e2b884

t1 = a d007e2b884 In 1992, the GNU Superoptimizer (GSO) was developed to integrate into the GNU Compiler Collection (GCC). Later work further developed and extended these ideas. d007e2b884

Optimizing compiler a. compiler optimizations – algorithms that transform code to produce semantically equivalent code optimized for some aspect. An optimizing compiler is a compiler designed to generate code that is optimized in aspects such as minimizing program execution time, memory usage, storage An optimizing compiler is a compiler designed to generate code that is optimized in aspects such as minimizing program execution time, memory usage, storage size, and power consumption. k. Optimization is generally implemented as a sequence of optimizing transformations, a d007e2b884

Some retargetable compilers, e.g., GCC, became so widely ported and developed that they now include support for many optimizations and machine specific details that the quality of code often... d007e2b884 This misnomer forced Massalin to call her system a superoptimizer, which is actually an optimizer to find an optimal program. d007e2b884 In the late 1970s, the Production Quality Compiler-Compiler introduced the principles of compiler organization that are still widely used today (e.g., a front-end handling syntax and semantics and a back-end generating machine code). d007e2b884 For example, for the following sequence of middle-level IR code d007e2b884

Superoptimization For WebAssembly slumps provides superoptimization for WASM programs based on souper. Real-world compilers generally cannot produce genuinely optimal code, and

while most standard compiler optimizations only improve code partly, a superoptimizer's goal is to find the optimal sequence, the canonical form. programs in the LLVM intermediate language. Superoptimizers can be used to improve conventional optimizers by highlighting missed opportunities so a human can write additional rules. Peephole optimization Dead Superoptimization is the process where a compiler automatically finds the optimal sequence for a loop-free sequence of instructions d007e2b884

Any program written in a high-level programming language must be translated to object code before it can be executed, so all programmers using such a language use a compiler or an interpreter, sometimes even both. Improvements to a compiler may lead to a large number of improved features in executable programs. d007e2b884 == First compilers == d007e2b884

Instruction selection as temporaries) and may still be – and typically is – subject to peephole optimization. Otherwise, it closely resembles the target machine code, bytecode In computer science, instruction selection is the stage of a compiler backend that transforms its middle-level intermediate representation (IR) into a low-level IR. In a typical compiler, instruction selection precedes both instruction scheduling and register allocation; hence its output IR has an infinite set of pseudo-registers (often known as temporaries) and may still be – and typically is – subject to peephole optimization. Otherwise, it closely resembles the target machine code, bytecode, or assembly language d007e2b884

== Categorization == d007e2b884 Instead of multiplying x by 2, do x << 1. d007e2b884 There are many different types of compilers which produce output in different useful forms. A cross-compiler produces code for a different central processing unit (CPU) or operating system than the one on which the cross-compiler itself runs. A bootstrap compiler is often a temporary compiler, used for compiling a more permanent or better optimized compiler for a language. d007e2b884 a = t3 d007e2b884 Sophisticated compilers typically perform multiple passes over various intermediate forms. This multi-stage process is used because many algorithms for code optimization are easier to apply one at a time, or because the input to one optimization relies on the completed processing performed by another optimization. This organization also facilitates the creation of a single compiler that can target multiple architectures, as only the last of the code generation stages (the backend) needs to change from target to target. (For more information on compiler design, see Compiler.) d007e2b884 Software for early computers was primarily written in assembly language, and before that directly in machine code. It is usually more productive for a programmer to use a high-level language and programs written in a high-level language can be reused on different kinds of... d007e2b884 Instead of multiplying a floating-point register by 8, add 3 to the floating-point register's exponent. d007e2b884 Related software include decompilers, programs that translate from low-level languages to higher-level ones; programs that translate between high-level languages, usually called source-to-source compilers or transpilers; language rewriters, usually programs that translate the form of expressions without a change of language; and compiler-compilers, compilers that produce compilers (or parts of them), often in... d007e2b884

Compiler , assembly language, object code, or machine code) to create an executable

program. cross-compiler itself runs. The name "compiler" is primarily used for programs that translate source code from a high-level programming language to a low-level programming language (e. A bootstrap compiler is often a temporary compiler, used for compiling a more permanent or better optimized compiler for a In computing, a compiler is software that translates computer code written in one programming language (the source language) into another language (the target language). g d007e2b884

For example: d007e2b884 Prior to the backend framework rewrite in 2020, the project made use of only one intermediate representation (IR) across all compilation stages prior to machine code emission, namely CLIF (Cranelift IR Format). The old design made use of instruction legalizations, which involved transforming the high-level IR continuously until each CLIF instruction corresponded to an instruction of the target machine, at which point the executable code could be emitted. d007e2b884 Instead of pushing a register onto the stack and then immediately popping the value back into the register, remove both instructions. d007e2b884 t2 = b d007e2b884

Cranelift The project started in 2016 and is currently developed by Bytecode Alliance. Cranelift focuses on just-in-time compilation and Ahead-of-time compilation, with short compile time being an explicit goal of the project. Retrieved 26 January 2023. "Introduce peepmatic: a peephole optimizations DSL and peephole optimizer compiler by fitzgen · Pull Request #1647 · bytecodealliance/wasmtime" Cranelift (formerly known as Cretonne) is an optimizing compiler backend that converts a target-independent intermediate representation into executable machine code. It is written in Rust d007e2b884

The input to the code generator typically consists of a parse tree or an abstract syntax tree. The tree is converted into a linear sequence of instructions, usually in an intermediate language such as three-address code. Further stages of compilation may or may not be referred to as "code generation", depending on whether they involve a significant change in the representation of the program. (For... d007e2b884 As of 2025, Cranelift supports instruction set architectures such as x86-64, AArch64, RISC-V, and IBM z/Architecture along with advertising retargeting possibilities. d007e2b884 The cost of producing a retargetable compiler that generates code of similar quality to a non-retargetable compiler (i.e., one designed to only ever produce code for a single processor) is higher because it is not possible to make use of cpu specific details throughout all phases of compilation. The benefits of a retargetable compiler is that the total cost over multiple CPUs is much lower than the combined cost of many individual non-targetable compilers. d007e2b884

Peephole optimization Peephole optimization is an optimization technique performed on a small set of compiler-generated instructions, known as a peephole or window, that involves Peephole optimization is an optimization technique performed on a small set of compiler-generated instructions, known as a peephole or window, that involves replacing the instructions with a logically equivalent set that has better performance d007e2b884

Retargeting for more than one computing platform. A retargetable compiler is a compiler that

has been designed to be relatively easy to modify to generate code for In software engineering, retargeting is an attribute of software development tools that have been specifically designed to generate code for more than one computing platform d007e2b884

The term superoptimization was coined by Alexia Massalin in the 1987 paper Superoptimizer: A Look at the Smallest Program. d007e2b884 == History == d007e2b884

History of compiler construction analysis used today in optimizing compilers (sometimes known as Kildall's method). Peephole optimization is a simple but effective optimization technique. The most common reason for transforming source code is to create an executable program. It In computing, a compiler is a computer program that transforms source code written in a programming language or computer language (the source language), into another computer language (the target language, often having a binary form known as object code or machine code) d007e2b884

== Compilers == d007e2b884 In 2020, the backend was rewritten to use a separate, machine-specific IR called VCode for later compilation stages instead. After this rewrite, a high-level... d007e2b884

Code generation (compiler) (For example, a peephole optimization pass would not likely be called "code In computing, code generation is part of the process chain of a compiler, in which an intermediate representation of source code is converted into a form (e. whether they involve a significant change in the representation of the program. , machine code) that the target system can readily execute. g d007e2b884

t3 = t1 + t2 d007e2b884 == History == d007e2b884 The label "program optimization" has been given to a field that does not aspire to optimize but only to improve. d007e2b884 The term peephole optimization was introduced by William Marshall McKeeman in 1965. d007e2b884 Optimization is limited by a number of factors. Theoretical analysis indicates that some optimization problems are NP-complete, or even undecidable. Also, producing perfectly optimal code is not possible since optimizing for one aspect often degrades performance for another (see: superoptimization). Optimization is a collection of heuristic methods for improving resource usage in typical programs. d007e2b884

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