

# Solver in VeGen

The role of the solver in the VeGen framework was initially unclear to me. I discovered that the `optimizeBottomUp` function, which is invoked in the GSLP driver, is the core of the solver. The solver aims to create a good `VectorPackSet` for later code generation, using planning and heuristics. The construction of a `VectorPackSet` is simple, but the codegen method is complex. The only interaction between the solver and the `VectorPackSet` is the `tryAdd` method, which checks the compatibility of the `VectorPack` to be added and updates the `PackedValues`, `AllPacks`, and `ValueToPackMap`.

The main logic of the solver is implemented in another `optimizeBottomUp` function, which is overloaded with `Packer` and `SeedOperands` as parameters and returns a vector of `VectorPacks` to form a `VectorPackSet`. The solver is not a class, but a function named `optimizeBottomUp` in the solver file.

## 1 `optimizeBottomUp`

The function `optimizeBottomUp` is a solver that tries to find the best vectorization plan for a given set of seed operands. It takes four parameters:

- `Packs`: a reference to a vector of `VectorPack` pointers, which are data structures that represent a group of scalar instructions that can be packed into a single vector instruction. The function will append the optimal vector packs to this vector.
- `Pkr`: a pointer to a `Packer` object, which is a class that handles the packing of vector instructions. It also provides access to the LLVM context and the target machine information.
- `SeedOperands`: an array of `OperandPack` pointers, which are data structures that represent a group of scalar operands that can be packed into a single vector operand. These are the starting points for the vectorization process.
- `BlocksToIgnore`: blocks that should be skipped.

The function performs the following steps:

- It creates a `CandidatePackSet` object, which is a data structure that stores a set of candidate vector packs and a mapping from scalar instructions to vector packs that contain them.
- It resizes the `Inst2Packs` vector, which is a member of the `CandidatePackSet` object, to match the number of values in the `VectorPackContext`. This vector stores a list of vector packs for each scalar instruction.
- It iterates over the candidate vector packs and updates the `Inst2Packs` vector accordingly. For each vector pack, it gets the bitset of the elements that are packed, and for each set bit, it adds the vector pack to the corresponding list in the `Inst2Packs` vector.
- It creates a `Plan` object, which represents a vectorization plan. It takes the packer as a parameter and initializes the plan with the scalar cost, which is the total cost of executing the scalar instructions without vectorization.
- It calls the `improvePlan` function, which is defined in the same file as `optimizeBottomUp`, to find the optimal vectorization plan for the given seed operands and candidate vector packs. This function uses a greedy algorithm that tries to reduce the cost of the plan by adding or removing vector packs, while respecting the dependencies and constraints of the vectorization process.

- It insert the vector packs from the optimal plan to the Packs vector, which is the output parameter of the function.
- It calls the findDepCycle function, which is defined in the same file as optimizeBottomUp, to check if the vectorization plan introduces any dependence cycles that would prevent the correct execution of the program. If so, it prints an error message, clears the Packs vector, and returns the scalar cost as the result of the function.
- Otherwise, it returns the cost of the optimal vectorization plan as the result of the function.

## 2 improvePlan

### 2.1 Plan

A VPlan is a data structure used by VeGen, a vectorization framework for LLVM. A VPlan contains a reference to a Packer object, a floating-point number Cost, and a set of VectorPack objects. As the name suggests, a VectorPackSet is also a collection of VectorPack objects, but a VPlan is more concerned with the cost and the search algorithm.