# 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.