



## A Rust interface for SCIP

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# How it started?

- Late 2022: Learning Rust in my free time.
- Rust is great, it would be amazing to use SCIP from Rust.
- `good_lp` issue to add support for SCIP.

# Why write a Rust interface for SCIP?

- No-overhead when binding to C.
- Memory safe and thread safe at compile time.
- No garbage collector.
- Great community and ecosystem.
- Great support for parallelism and concurrency.

# First Step: bindings

`scip_sys`: (unsafe) Rust bindings to SCIP's C API

- covers all of SCIP's C API
- can be hard to work with.

# Second Step - a Safe Wrapper

`russcip`: a safe and idiomatic Rust wrapper around `scip_sys`

## Philosophy

- Use Rust's type system to enforce safety and correctness.
- Hide complexity and boilerplate code.

# Current Features

- Easy access to SCIP through the bundled feature.
- Automatic memory management.
- Separate stages for model wrappers, avoiding many user errors at compile time. e.g. `focus_node()`
- Aim to reduce boilerplate code and improve usability.
- Simpler API for writing models (also through `good_lp`) and implementing callbacks.
- Unsafe access to SCIP's C API when needed through the `ffi` module.

# **russcip Guide**

# Modeling

maximize  $3x_1 + 2x_2$

subject to:

$$2x_1 + x_2 \leq 100 \quad (c_1)$$

$$x_1 + 2x_2 \leq 80 \quad (c_2)$$

$x_1, x_2 \geq 0$  and integer

```
// Create model
let mut model = Model::default().maximize();

// Add variables
let x1 = model.add(var().int(0..).obj(3.).name("x1"));
let x2 = model.add(var().int(0..).obj(2.).name("x2"));

// Add constraints
model.add(cons().name("c1").coef(&x1, 2.).coef(&x2, 1.).le(100.));
model.add(cons().name("c2").coef(&x1, 1.).coef(&x2, 2.).le(80.));
```



# Querying the solution

```
let solved_model = model.solve();

let status = solved_model.status();
println!("Solved with status {:?}", status);

let obj_val = solved_model.obj_val();
println!("Objective value: {}", obj_val);

let sol = solved_model.best_sol().unwrap();
let vars = solved_model.vars();

for var in vars {
    println!("{}", var.name(), sol.val(&var));
}
```

```
feasible solution found by trivial heuristic after 0.0 seconds, objective value 0.000000e+00
presolving:
(round 1, fast)      0 del vars, 0 del conss, 0 add conss, 3 chg bounds, 0 chg sides, 0 chg coeffs, 0
upgd conss, 0 impls, 0 clqs
(round 2, exhaustive) 0 del vars, 0 del conss, 0 add conss, 3 chg bounds, 0 chg sides, 0 chg coeffs, 2
upgd conss, 0 impls, 0 clqs
(0.0s) symmetry computation started: requiring (bin +, int +, cont +), (fixed: bin -, int -, cont
-)
(0.0s) no symmetry present (symcode time: 0.00)
presolving (3 rounds: 3 fast, 2 medium, 2 exhaustive):
  0 deleted vars, 0 deleted constraints, 0 added constraints, 3 tightened bounds, 0 added holes, 0
changed sides, 0 changed coefficients
  0 implications, 0 cliques
presolved problem has 2 variables (0 bin, 2 int, 0 impl, 0 cont) and 2 constraints
  2 constraints of type <varbound>
transformed objective value is always integral (scale: 1)
Presolving Time: 0.01
transformed 1/1 original solutions to the transformed problem space

time | node | left | LP iter|LP it/n|mem/heur|mdpt |vars |cons |rows |cuts |sepa|confs|strbr|
dualbound | primalbound | gap | compl.
p 0.0s| 1 | 0 | 0 | - | vbounds| 0 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
2.300000e+02 | 1.500000e+02 | 53.33%| unknown
* 0.0s| 1 | 0 | 2 | - | LP | 0 | 2 | 2 | 2 | 0 | 0 | 4 | 0 |
1.600000e+02 | 1.600000e+02 | 0.00%| unknown
0.0s| 1 | 0 | 2 | - | 596k | 0 | 2 | 2 | 2 | 0 | 0 | 4 | 0 |
1.600000e+02 | 1.600000e+02 | 0.00%| unknown

SCIP Status      : problem is solved [optimal solution found]
Solving Time (sec) : 0.02
Solving Nodes    : 1
Primal Bound     : +1.6000000000000000e+02 (3 solutions)
Dual Bound      : +1.6000000000000000e+02
Gap              : 0.00 %
Solved with status Optimal
Objective value: 160
t_x1 = 40
t_x2 = 20
```

# Setting Parameters

# Emphasis Modes

# Plugins

## Event Handlers

SCIP broadcasts many events during the solving process, callbacks can be registered to listen to these events.

### Example

event handler to print node data, [here](#).

# Primal Heuristics

Primal heuristics are used to find feasible solutions during the solving process.

## Example

Primal heuristic that rounds the current LP solution, [here](#).

# Branching Rules

Branching rules are used to select the next variable to branch on during the solving process (also enables custom branching).

## Example

Most infeasible branching rule, [here](#).

# Separators

Separators can add valid inequalities to the model to tighten the LP relaxation.

## Example

Clique separator for set partitioning problem, [here](#).



## Column Generation: Pricers

Column generation is a technique used to solve large-scale linear programming problems by solving a restricted master problem and generating new variables (columns) to add to the model.

### Example

Pricer for the Cutting Stock Problem, [here](#).

## Other SCIP features

SCIP supports many other callbacks, such as:

- Reader
- Presolvers
- Cut selection
- Relaxators

# **Future Work**

## Future Work: Simple Event Handlers

- Less boilerplate code for simple event handlers, by passing a closure and an event type.

```
let mut model = Model::default();  
// ... some variables and constraints  
model.set_callback(EventMask::NODE_FOCUSED, |model, event| {  
    let node_number = model.focus_node().number();  
    let node_depth = model.focus_node().depth();  
    println!("Solved node number: {}, at depth: {}", node_number,  
node_depth);  
});
```

# Future Work: Modeling

Enable more powerful modeling features for the many constraint types available in SCIP through a generic procedural macro.

```
model.add(c!( 2 * x + y <= 10)); // linear constraint
model.add(c!( x * y <= 10)); // nonlinear constraint
model.add(c!( e ^ y <= 10)); // exponential constraint
model.add(c!( log(y) <= 10)); // logarithmic constraint
model.add(c!( sqrt(x) <= 10)); // square root constraint

model.add(c!( y -> x <= 10)); // indicator constraint
model.add(c!( (x + y == 10) && (x >= 5) )); // AND constraint
model.add(c!( (x + y == 10) || (x >= 5) )); // OR constraint
```

## **Future Work: Parallel plugins**

Enable support for adding parallel plugins. They run on a separate thread and can only communicate with SCIP through an event handler and a message queue to modify the model.

Thank you for your attention!