`bencherl`: A scalability benchmark suite for Erlang/OTP

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Motivation

Frustrated Erlang programmer

I thought my Erlang program was **100% parallelizable**, but when I made it parallel and ran it on a machine with **N CPU cores**, I got a **speedup** that was **much lower than N**. Why?

bencherl

- Serves both as a tool to run and analyze benchmarks and as an enhanceable benchmark repository
- Focuses on scalability, rather than on throughput or latency
- Examines how the following factors influence the scalability of Erlang applications
  - Number of Erlang nodes
  - Number of CPU cores
  - Number of schedulers
  - Erlang/OTP release and flavor
  - Command-line arguments to `erl`
- Can be used to study the performance of any Erlang application, as well as for the Erlang/OTP itself

Definitions

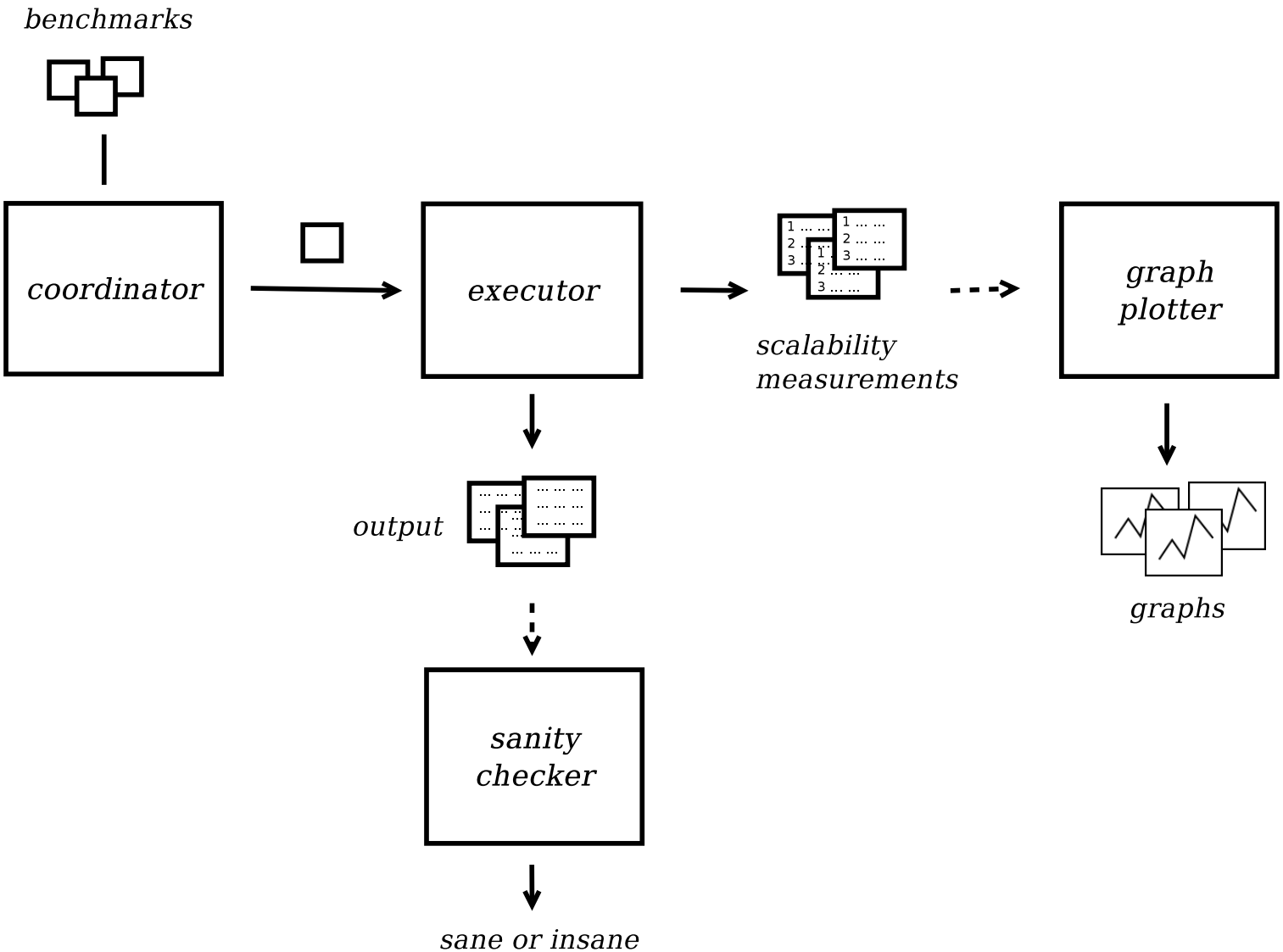
Application: The piece of software whose execution behaviour we intend to measure and analyze.

Benchmark: A specific use case of the application that includes setting up the environment, calling specific functions and using specific data.

Runtime environment: A specific combination of values for the scalability factors.

- E.g. 8 Erlang nodes on a machine with 64 CPU cores using 8 schedulers on each node and running Erlang/OTP R15B02 release with command-line arguments "+sbt db"

Architecture



Coordinator

The module that coordinates everything during a `bencherl` run.

- Determines the benchmarks that should be executed
- Determines the runtime environments, where each benchmark should be executed
- Sets up each runtime environment before a benchmark is executed in it
- Prepares instruction files for the executor
- Performs any benchmark-specific pre- and post-execution actions

Executor

The module that executes a particular benchmark in a particular runtime environment.

- Receives detailed instructions from the executor about what to do
- Starts any necessary Erlang slave nodes
- Executes the benchmark in a new process
- Stops the Erlang slave nodes it started
- Makes sure that the output that the benchmark produced during its execution is written in an output file
- Makes sure that the measurements that are collected during the execution of the benchmark are written in a measument file
  - Uses `erlang:now/0` and `timer:diff/2`

Sanity checker

The module that checks whether all executions of a particular benchmark produced the same output.

- Runs after a benchmark has executed in all desired runtime environments
- Examines the output that the benchmark produced in all runtime environments
- Decides whether the benchmark was successfully executed in all runtime environments
- Is based on the assumption that if a benchmark produces any output during its execution, then this output should be the same accross all runtime environments, where the benchmark was executed
  - Uses `diff`

Graph plotter

The module that plots scalability graps based on the collected measurements.

- Runs after a benchmark has executed in all desired runtime environments
- Processes the measurements that were collected during the execution of the benchmark
- Plots a set of scalability graphs
  - Uses `Gnuplot`

Scalability graphs

- Both time and speedup graphs
- Graphs that show how benchmarks scale when executed with specific erl version and command-line arguments and with different number of schedulers (nodes)
- Graphs that show how benchmarks scale when executed with specific erl version and with different number of schedulers (nodes) and runtime options
- Graphs that show how benchmarks scale when executed with specific erl runtime options and with different number of schedulers (nodes) and erl versions

Benchmarks

`bencherl` comes with an initial collection of benchmarks.

synthetic

- `bang`
- `big`
- `ehb`
- `ets_test`
- `genstress`
- `mbrot`
- `orbit_int`
- `parallel`
- `pcmark`
- `ran`
- `serialmsg`
- `timer_wheel`

real-world

- `dialyzer_bench`
- `scalaris_bench`

This collection can be enhanced in two simple steps.

Step 1: Add in `bencherl` everything that the benchmark needs for its execution.

- The sources of the Erlang application that it benchmarks
  - E.g. `dialyzer`
- Any scripts to run before or after its execution
  - E.g. a script that starts `scalaris`
- Any data that it needs for its execution
  - E.g. for `dialyzer_bench` the BEAM files
- Any specific configuration settings that it requires
  - E.g. a specific cookie that nodes should share

Step 2: Write the handler for the benchmark.

A benchmark handler is a standard Erlang module that exports two functions.

`bench_args`: a function that returns the different argument sets that should be used for running a specific version of the benchmark

```
bench_args(Vrsn, Conf) -> Args
  when
    Vrsn :: 'short' | 'intermediate' | 'long',
    Conf :: [{Key :: atom(), Val :: term()}, ...],
    Args :: [[term()]].
```

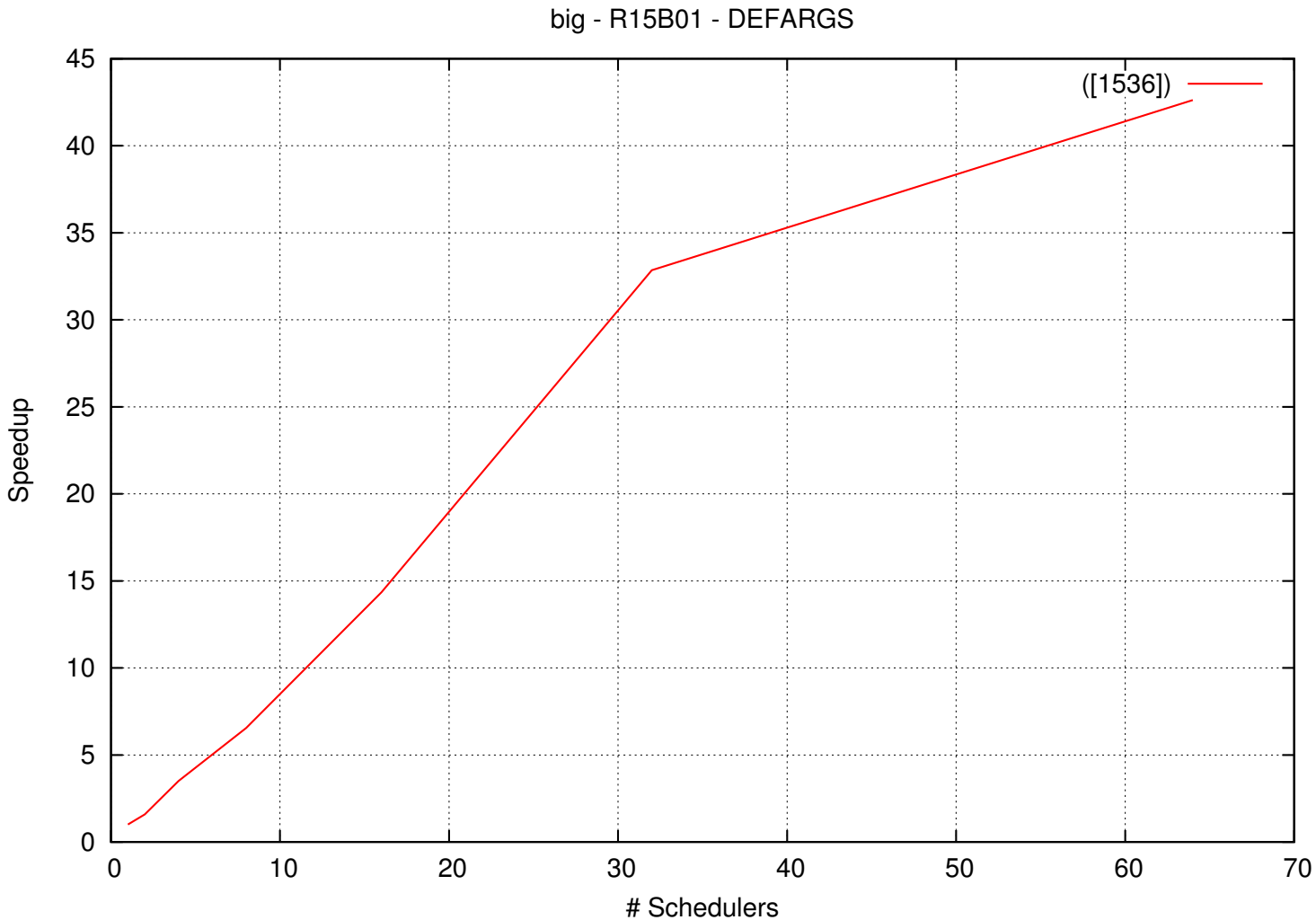
`run`: a function that runs the benchmark on specific Erlang nodes, with specific arguments and configuration settings

```
run(Args, Slaves, Conf) -> 'ok' | {'error', Reason}
  when
    Args   :: [term()],
    Slaves :: [node()],
    Conf   :: [{Key :: atom(), Val :: term()}, ...],
    Reason :: term().
```

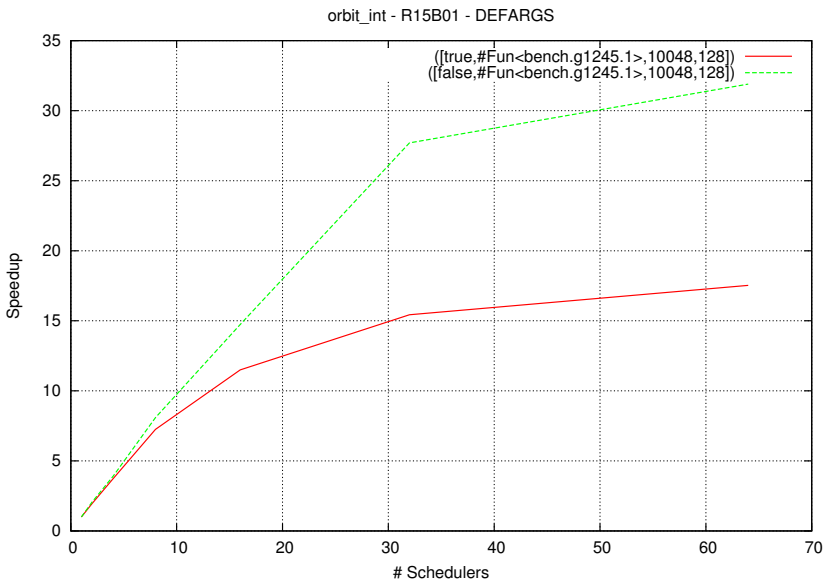
A benchmark handler example

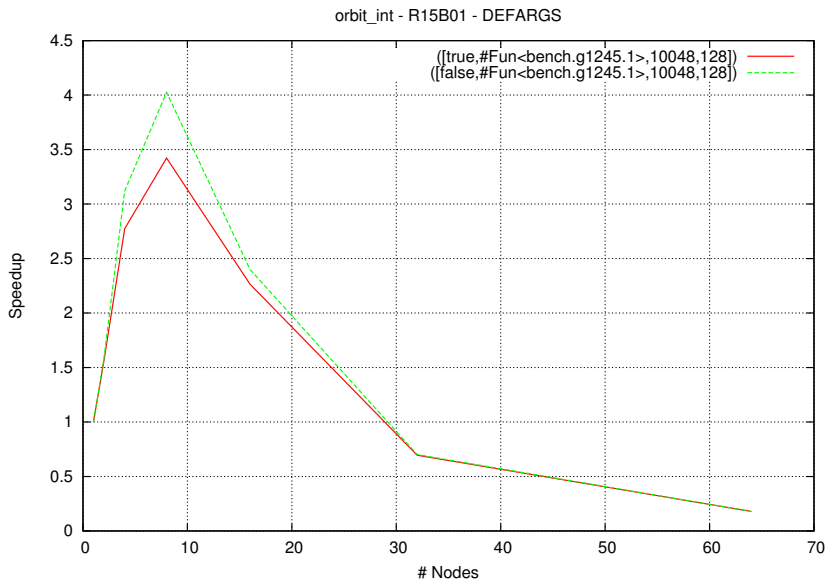
```
-module(scalaris_bench).

-include_lib("kernel/include/inet.hrl").

-export([bench_args/2, run/3]).

bench_args(Version, Conf) ->
    {_,Cores} = lists:keyfind(number_of_cores, 1, Conf),
    [F1, F2, F3] = case Version of
        short -> [1, 1, 0.5];
        intermediate -> [1, 8, 0.5];
        long -> [1, 16, 0.5]
    end,
    [[T,I,V] || T <- [F1 * Cores], I <- [F2 * Cores], V <- [trunc(F3 * Cores)]].

run([T,I,V|_], _, _) ->
    {ok, N} = inet:gethostname(),
    {ok, #hostent{h_name=H}}=inet:gethostbyname(N),
    Node = "firstnode@" ++ H,
    rpc:block_call(list_to_atom(Node), api_vm, add_nodes, [V]),
    io:format("~p~n", [rpc:block_call(list_to_atom(Node), bench, quorum_read, [T,I])]),
    ok.
```

Experience #1: Some benchmarks scale well.

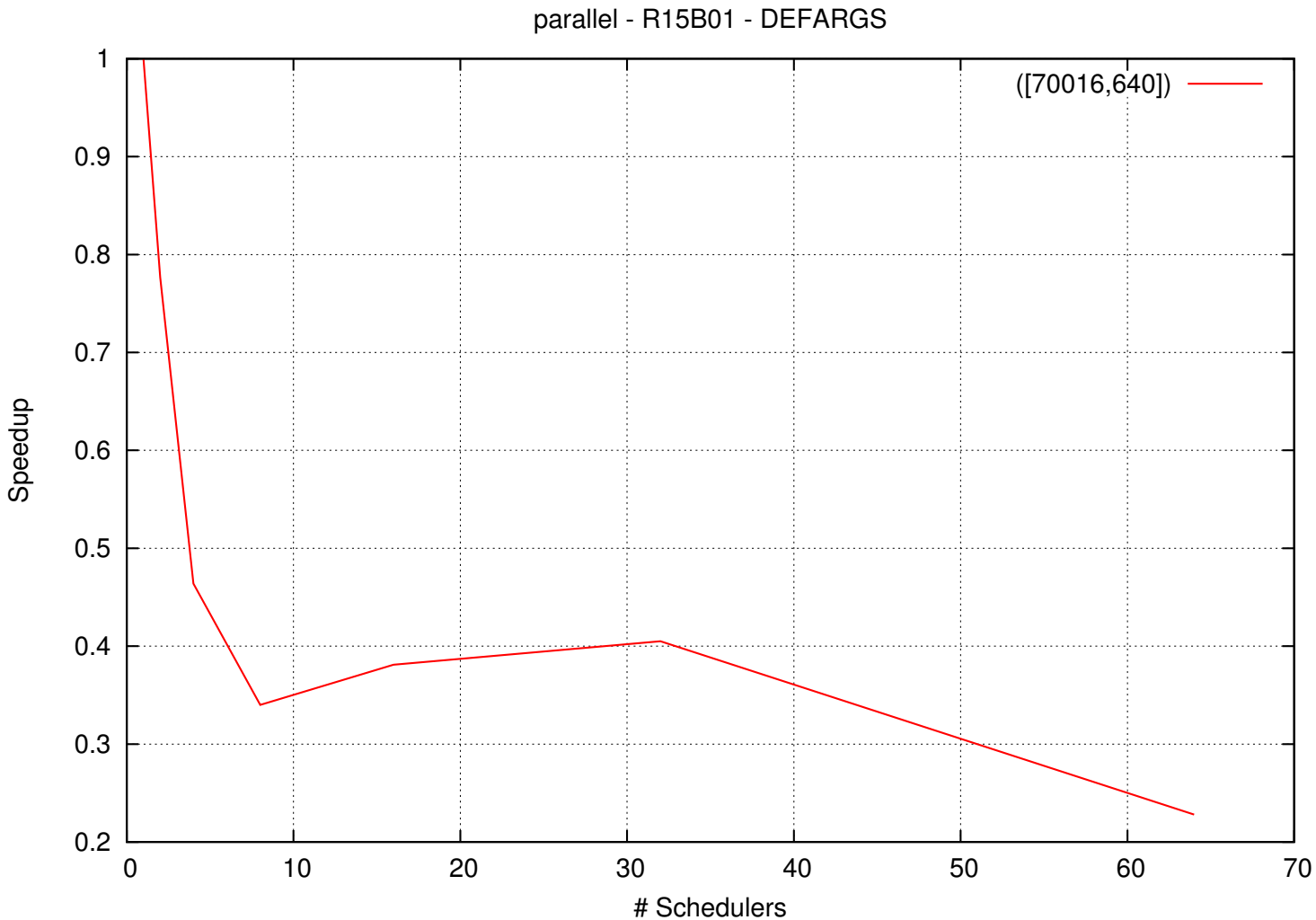


Experience #2: Some benchmarks scale do not scale as well on more than one nodes.

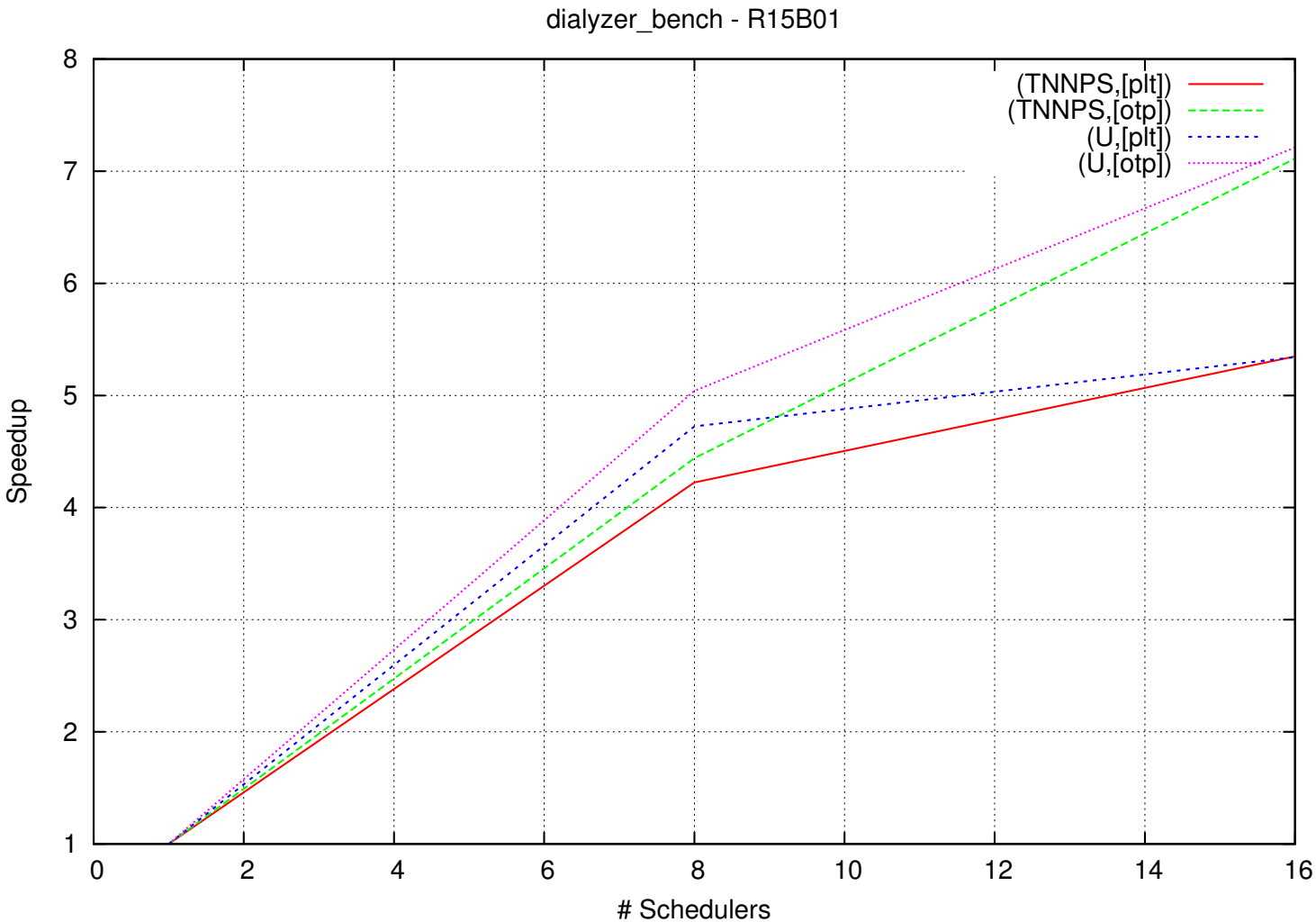




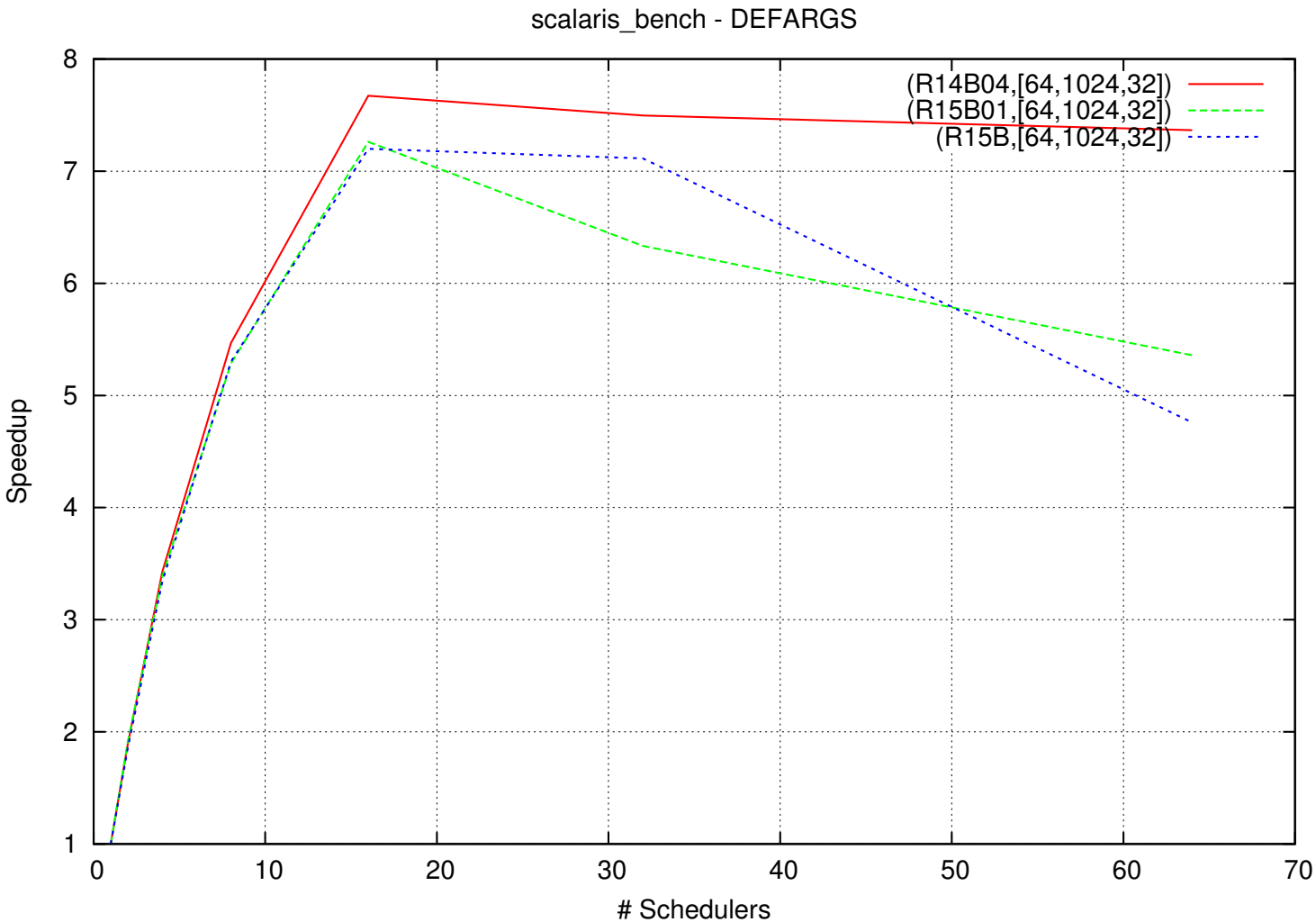
Experience #3: Some benchmarks do not scale.



Experience #4: Some benchmarks scale better with specific runtime options.



Experience #5: Some benchmarks scale better with specific Erlang/OTP releases.



Conclusions

- `bencherl` is a publicly available, scalability benchmark suite for Erlang/OTP
  - `http://release.softlab.ntua.gr/bencherl`
- Examines how nodes, cores, schedulers, Erlang/OTP versions and `erl` command-line options affect the scalability of Erlang applications
- Collects scalability measurements
- Plots scalability graphs

Future work

- `bencherl` currently collects only execution times
  - Collect more information during the execution of a benchmark (e.g. heap size)
- `bencherl` currently can only answer to the question "Does this application scale well for this scenario?"
  - Try to answer questions like "Why desn't this application scale well for this scenario?"
- `bencherl` could use `DTrace`

Thank you!