Benchmarks of `redis-py`, `hiredis-py` and string creation

@mokaddem

March 5, 2018

Contents

Introduction

In the course of a software development, I needed a buffering medium which was able to fulfil these requirements:

- Capable of handling millions of request per second
- Data persistence
- Easy to use

Where Redis suits these.

My software being written in python, I evidently used one of the redis python client available; `redis-py` is the recommended one.

This report focuses only on throughput, so data size was fixed and was fitting my needs.
It contains benchmarks of `redis-py`, where we can see that it is particularly slow compared to the c-written `hiredis` library or `redis-benchmark`. It also presents some features and technics to boost performances, as well as comparing methods to rapidly create strings.

Chapter 1

Aggregated results

1.1 Summary

These tables and plots show a summary for each tested different configuration.

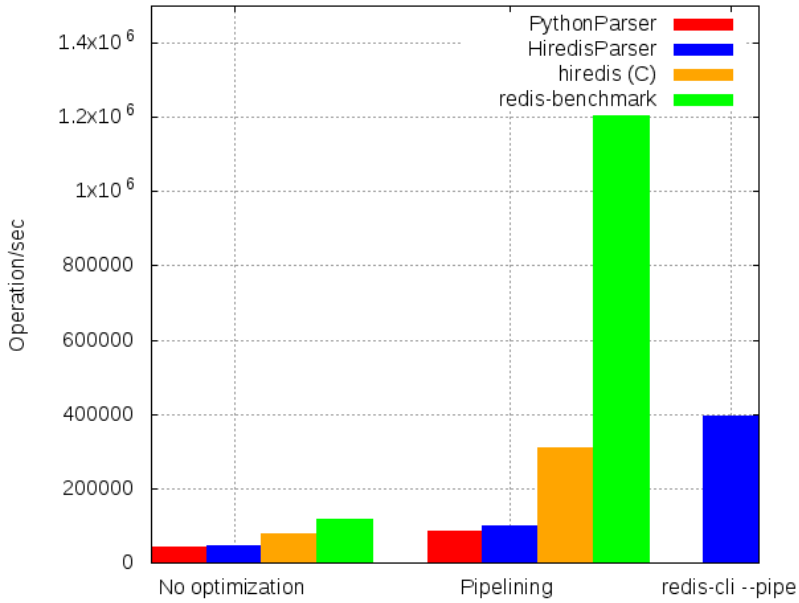
1.1.1 Pushing - `LPUSH`

	Tool/feature	Parser	Total time taken (s)			Operation/sec		
			worst	best	average	worst	best	average
2.2	Naive	PythonParser	2.86	2.20	2.37	34,942	45,464	42,158
	Naive	HiredisParser	2.20	2.09	2.17	45,388	47,745	46,150
	Naive	hiredis (C)[1]	1.33	1.23	1.25	75,363	81,365	79,977
2.3	Pipelining `-P 1000`	PythonParser	1.18	1.16	1.17	85,078	85,979	85,642
	Pipelining `-P 1000`	HiredisParser	1.01	0.96	0.98	98,863	104,368	101,535
	Pipelining `-P 1000`	hiredis (C)	0.35	0.31	0.32	281,466	320,858	308,386
2.5, 2.6.1	`redis-cli`, `format`	HiredisParser	0.28	0.23	0.25	358,529	437,094	394,046
2.6.2	`redis-cli`, `concatenation +`	HiredisParser	0.25	0.21	0.22	400,002	487,566	454,178
2.6.3	`redis-cli`, `substitution %`	HiredisParser	0.16	0.15	0.16	610,237	687,978	638,709
-	`redis-cli`, (no generation)	HiredisParser	0.08	0.07	0.07	1,287,382	1,523,811	1,400,926
	`redis-benchmark -c 1 -d 129`			-			-	117,508
	`redis-benchmark -c 1 -d 129 -P 1000`			-			-	1,204,819

1.1.2 Poping - `RPOP` or `LRANGE/LTRIM`

	Tool/feature	parser	Total time taken (s)			Operation/sec		
			worst	best	average	worst	best	average
2.2	Naive	PythonParser	2.68	2.11	2.27	37,301	47,323	44,021
	Naive	HiredisParser	1.96	1.85	1.91	51,050	53,950	52,383
	Naive	hiredis (C)	1.10	1.05	1.07	90,656	95,411	93,724
2.3	Pipelining	PythonParser	1.10	1.09	1.09	90,862	91,730	91,402
	Pipelining	HiredisParser	0.83	0.77	0.80	121,207	129,375	124,924
	Pipelining	hiredis (C)	0.15	0.13	0.14	659,078	751,359	720,310
2.4	`LRANGE` trick	PythonParser	0.34	0.32	0.33	292,466	311,161	304,744
	`LRANGE` trick	HiredisParser	0.08	0.07	0.07	1,207,644	1,511,085	1,416,695
	`LRANGE` trick	hiredis (C)	0.05	0.04	0.04	2,152,203	2,427,007	2,318,716
	`redis-benchmark -c 1 -d 129 (RPOP)`			-			-	116,822
	`redis-benchmark -c 1 -d 129 -P 1000 (RPOP)`			-			-	1,136,363
	`redis-benchmark -c 1 -d 129 (LRANGE_100)`			-			-	4,048,000

[1] Official C client



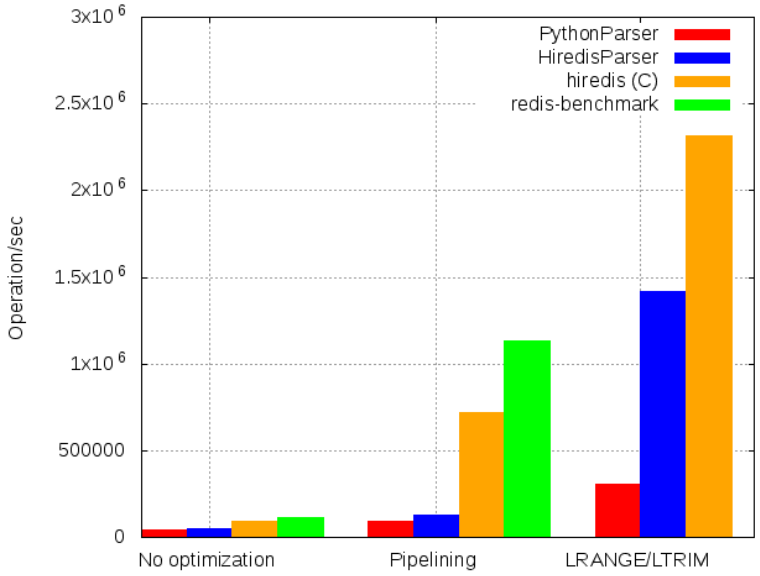
LPUSH:

With no optimization, python performs close to 60% of `hiredis (C)` performance:

$$\frac{\texttt{python perf}}{\texttt{hiredis (C) perf}} = \frac{46,150}{79,977} = 57.70\%$$

With pipelining, python performs close to only 30% of `hiredis (C)` performance:

$$\frac{\texttt{python perf}}{\texttt{hiredis (C) perf}} = \frac{101,535}{308,386} = 30.91\%$$



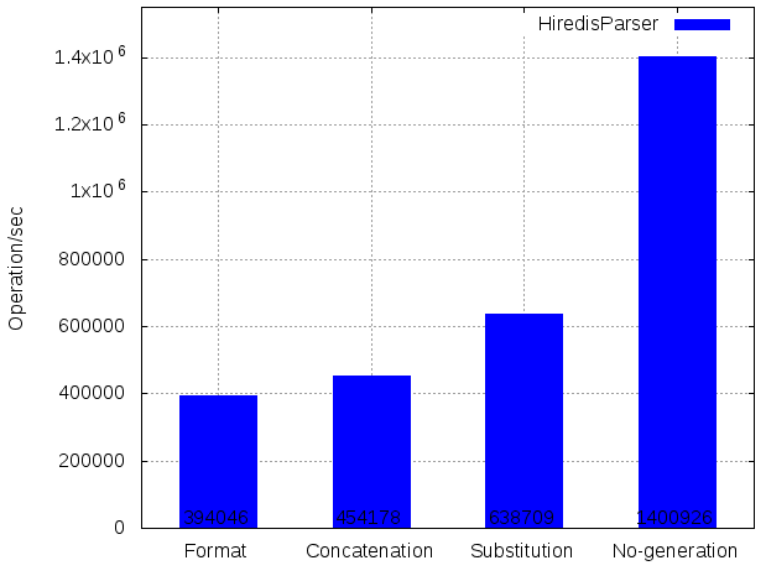
POP:

With no optimization, python performs close to 60% of `hiredis (C)` performance::

$$\frac{\texttt{python perf}}{\texttt{hiredis (C) perf}} = \frac{52,383}{93,724} = 55.89\%$$

With pipelining, python performs close to only 13% of `hiredis (C)` performance:

$$\frac{\texttt{python perf}}{\texttt{hiredis (C) perf}} = \frac{91,402}{720,310} = 12.69\%$$



String Generation:

Method	Cummulative gain
`format`	0%
`Concatenation`	15.26%
`Substitution`	40.63%

Chapter 2

Detailed implentations and tests

2.1 Benchmark parameters

All benchmarks have been performed using these parameters

- Usage of redis `unix_socket_path`
- Payload: size = 129 bytes

```
'{"origin": null, "channel": 0, "content": "redis@tshark_save:53619abd-a27c-432c-8f8d
    -1d059aab5f24", "size": 54, "redirect": true}'
```

- Operations:
  - 100000 `LPUSH`
  - Number of `POP` may differ if we use `RPOP` or `LRANGE/LTRIM`
- For each tests, we are using two different parsers for responses: PythonParser and HiredisParser[1]
- In order to simulate a working software poping and adding elements to a buffer, the logic of the benchmark is the folloging:

```
# push
# c =   total count     = 100,000
# d =   divisor         = 1,000
# c/d = iteration count = 100
for i in range(int(c/d)):
    for j in range(d):
        # push
    for j in range(d):
        # pop
```

- For each benchmark, the processing has been done 10 times, then averaged
- For each 100 $\left(\frac{100{,}000}{1{,}000}\right)$ iterations, we are pushing and poping 1,000 elements

[1] Hiredis is a C library that is available with Python bindings, `redis-py` will attempt to use the HiredisParser if you have the hiredis module installed and will fallback to the PythonParser otherwise.

2.2 Naive implementation

For each payloads to be buffered, we push them immediatly. Then, we retrieve them one at a time with a simple `POP` command.

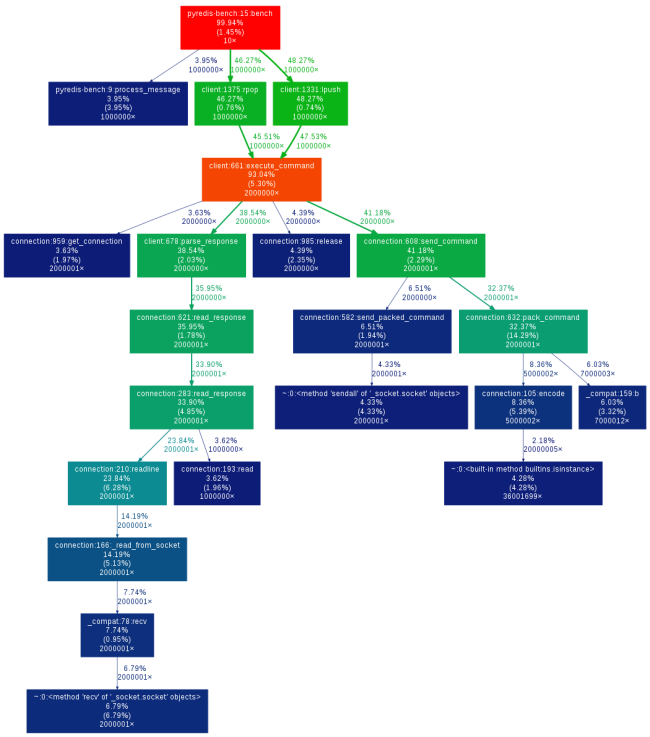
Source code

```
# push
t1=time.time()
for j in range(d):
    redis.lpush('k', payload)
    cpush+=1
time_push += time.time()-t1
# pop
t1=time.time()
for j in range(d):
    msg = redis.rpop('k')
    process_message(msg)
    cpop+=1
time_pop += time.time()-t1
```

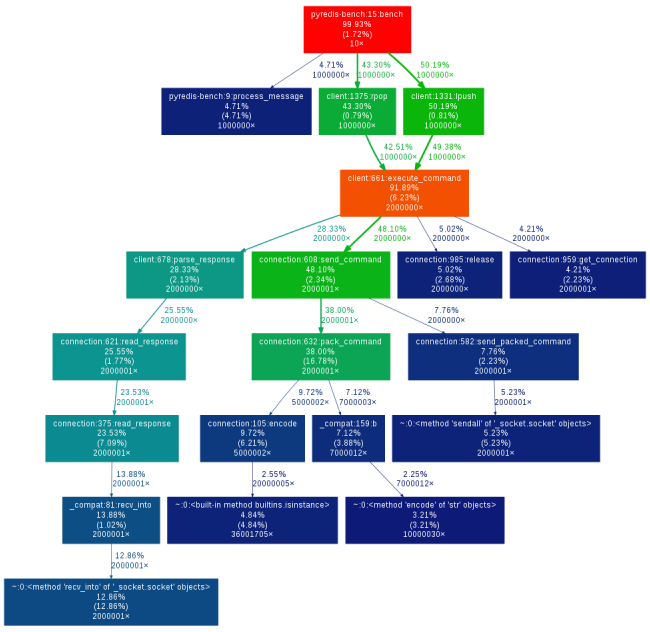
Profiling summary

Cumulative CPU %	PythonParser	HiredisParser
Processing	3.95%	4.71%
Receiving response	38.54%	28.33%
Sending command	41.18%	48.10%
Parser total gain: **19.24%**		

PythonParser



HiredisParser



2.3 Pipeline feature

Here, we use the redis pipeline[2] feature. For each payload to be buffered, we push them in a pipeline wich will execute pending command every 1000 pushing operation. Then, we retrieve them by sending the POP command in a pipeline which will also execute pending command every 1000 poping operation.

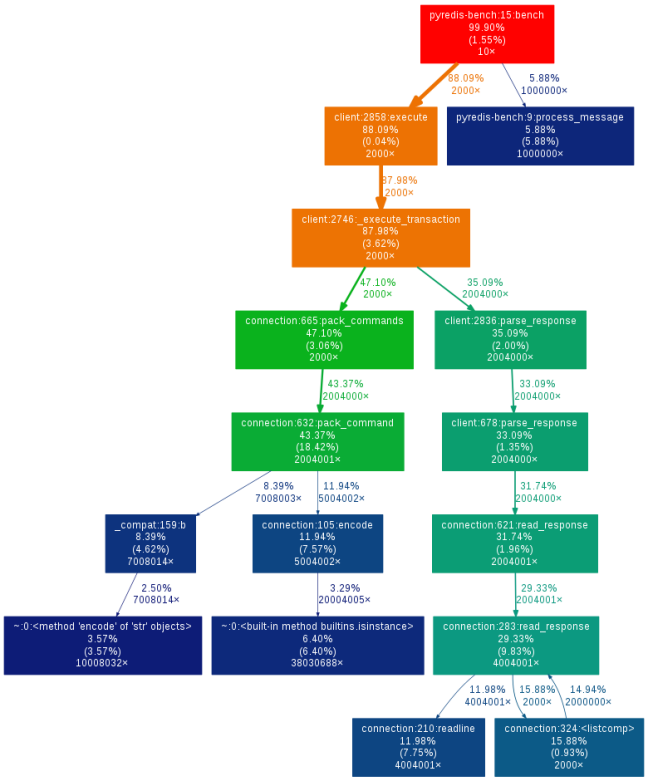
Source code

```
# push
t1=time.time()
for j in range(d):
    pipeline.lpush('k', payload)
    cpush+=1
pipeline.execute()
tpush += time.time()-t1
# pop
t1=time.time()
for j in range(d):
    pipeline.rpop('k')
resp = pipeline.execute()
for msg in resp:
    process_message(msg)
    cpop+=1
tpop += time.time()-t1
```

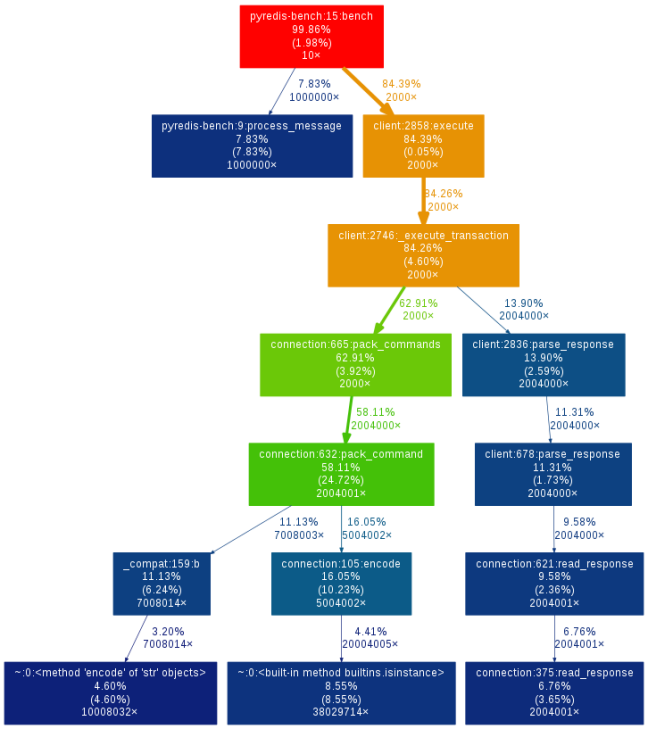
Profiling summary

Cumulative CPU %	PythonParser	HiredisParser
Processing	5.88%	7.83%
Receiving response	35.09%	13.90%
Sending command	47.10%	62.91%
Parser total gain:	**33.16%**	
Gain compare to 2.2:	**48.86%**	**66.24%**

PythonParser



HiredisParser



[2]Pipelining allows to send multiple commands to the server without waiting for the replies, and finally read the replies in a single step

2.4 Replacing `RPOP` by `LRANGE/LTRIM`

In this implementation, we are still using the redis pipeline feature for pushing data into the buffer, but we modify the poping behavior. Instead of sending one POP command at a time to the pipeline, we fetch a range (100 items) of buffered data with `LRANGE`, then we trim the buffer so that it mirror the effect of a `POP` command.

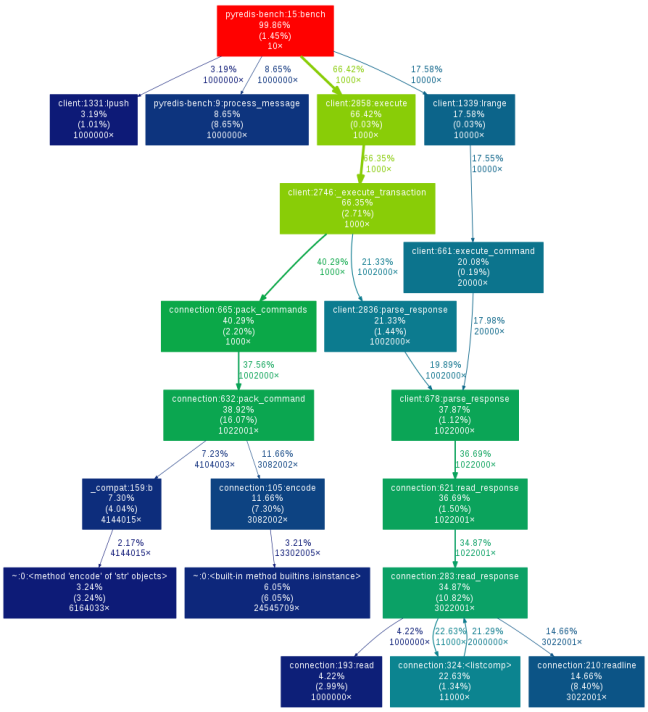
Source code

```
# lrange_count = 100
# push
t1=time.time()
for j in range(d):
    pipeline.lpush('k', payload)
    cpush+=1
pipeline.execute()
tpush += time.time()-t1
# pop
t1=time.time()
for j in range(int(d/lrange_count)+1):
    msg_list = redis.lrange('k', -
    lrange_count, -1)
    redis.ltrim('k', 0, -len(msg_list)-1)
    for msg in msg_list:
        process_message(msg)
        cpop+=1
tpop += time.time()-t1
```

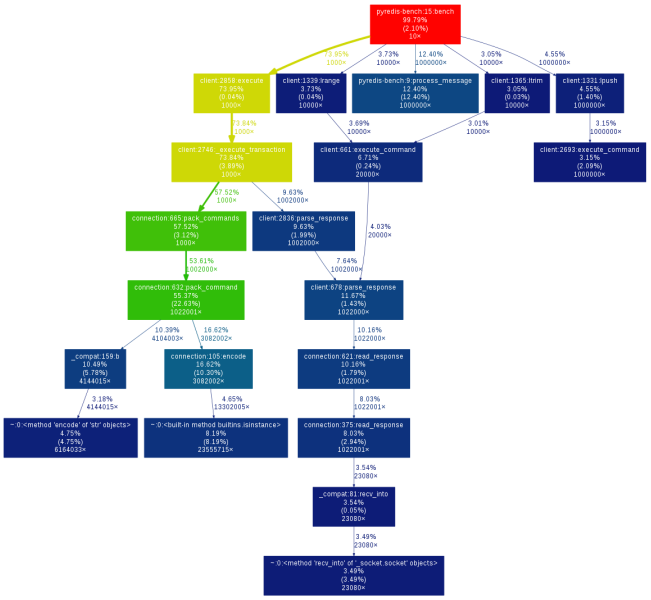
Profiling summary

Cumulative CPU %	PythonParser	HiredisParser
Processing	8.65%	12.40%
Receiving response	37.87%	11.67%
Sending command	40.29%	57.52%
Parser total gain:	**43.35%**	
Gain compare to 2.3:	**47.11%**	**58.37%**

PythonParser



HiredisParser



2.5 Using `redis-cli --pipe`

In this implementation, we are still using the redis pipeline feature and the `LRANGE/LTRIM` replacement of `POP`. However, we will use the `redis-cli` binary (provided by redis) with the `--pipe` options[3].

In order to use this binary, we have to generate the valid redis protocol from the wanted command. which will be writen to the STDIN of `redis-cli`.

Source code

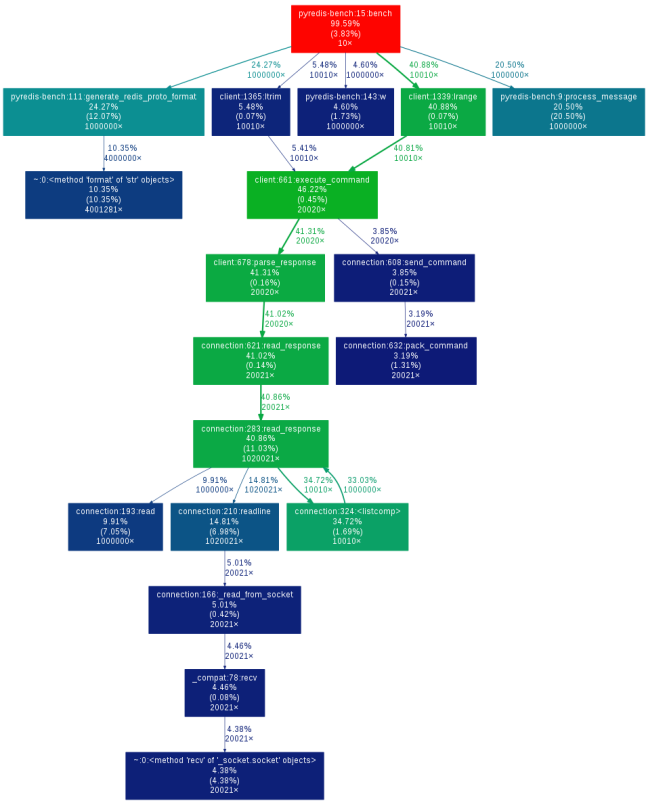
```
# push with redis-cli
t1=time.time()
for j in range(d):
    write_to_stdin(generate_redis_protocol('lpush', 'k', payload))
    cpush+=1
tpush += time.time()-t1
# pop with pipeline
t1=time.time()
for j in range(int(d/lrange_count)+1):
    msg_list = redis.lrange('k', -lrange_count, -1)
    redis.ltrim('k', 0, -len(msg_list)-1)
    for msg in msg_list:
        process_message(msg)
        cpop+=1
tpop += time.time()-t1
# flush and close stdin
# pop newly flushed items
```

Profiling summary

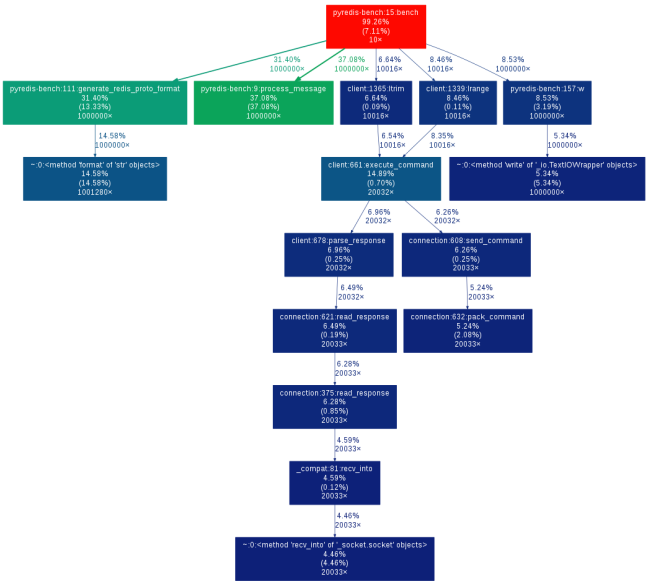
Cumulative CPU %	PythonParser	HiredisParser
Processing	20.50%	37.08%
Receiving response	41.51%	6.96%
Sending command[a]	8.45%[b]	14.79%[c]
Parser total gain:	**80.87%**	
Gain compare to 2.4:	**136.99%**	**199.03%**

[a] popping + mass insertion with `redis-cli`
[b] 3.85% + 4.6%
[c] 6.26% + 8.53%

PythonParser



HiredisParser



[3] `redis-cli --pipe` consists in writing new commands while you read replies at the same time, ignoring the round trip time for every command

2.6 Generating redis protocol

We saw in section 2.5 that we need to generate the redis protocol ourself. We will now see differents implentation of doing so, each one with drastically perfomance improvement.

For each algorythm, we use the same source code as in 2.5 with the `HiredisParser`.

2.6.1 Generating redis protocol with `string.Formatter`

```
def generate_redis_proto_format(cmd, key, value=''):
    cmd_split = cmd.split()
    if value == '':
        proto = '*{argNum}\r\n${argLen1}\r\n{arg1}\r\n${argLen2}\r\n{arg2}\r\n'.format(
                argNum=3 if value != '' else 2,
                argLen1=len(cmd), arg1=cmd,
                argLen2=len(key), arg2=key
                )
    else:
        proto = '*{argNum}\r\n${argLen1}\r\n{arg1}\r\n${argLen2}\r\n{arg2}\r\n${argLen3}\r\n{
    arg3}\r\n'.format(
                argNum=3 if value != '' else 2,
                argLen1=len(cmd), arg1=cmd,
                argLen2=len(key), arg2=key,
                argLen3=len(value), arg3=value)
    return proto
```

Profiling summary

It should be noted that the cumulative CPU time of `process_message` entirely depends on the function implentation. Still, it is given to starting point for comparision.

Cumulative CPU %	HiredisParser
`process_message`	37.08%
`generate_redis_protocol_format`	31.40%
Generation **loss**[4]	**46.87%**

2.6.2 Generating redis protocol with `String` + concatenation operator

```
def generate_redis_proto_concat(cmd, key, value=''):
    cmd_split = cmd.split()
    proto = '*'+(str(3) if value != '' else str(2))+'\r\n'
    proto += '$'+str(len(cmd))+'\r\n'+cmd+'\r\n'
    proto += '$'+str(len(key))+'\r\n'+key+'\r\n'
    if value != '':
        proto += '$'+str(len(value))+'\r\n'+value+'\r\n'
    return proto
```

Profiling summary

Cumulative CPU %	HiredisParser
`processing`	40.53%
`generate_redis_protocol_string`	26.34%
Gain compare to 2.6.1:	**9.30%**
Generation **loss**	**34.26%**

[4]Cost of generating the protocol compated to not generating it a all.

2.6.3 Generating redis protocol with `String` % substitution operator

```
def generate_redis_proto_subst(cmd, key, value=''):
    cmd_split = cmd.split()

    if value != '':
        proto = '*%s\r\n$%s\r\n%s\r\n$%s\r\n%s\r\n$%s\r\n%s\r\n' % ((str(3) if value != '' else str(2)), len(cmd), cmd, len(key), key, len(value), value)
    else:
        proto = '*%s\r\n$%s\r\n%s\r\n$%s\r\n%s\r\n' % ((str(3) if value != '' else str(2)), len(cmd), cmd, len(key), key)
    return proto
```

Profiling summary

Cumulative CPU %	HiredisParser
`processing`	43.62%
`generate_redis_protocol_subst`	19.92%
Gain compare to 2.6.2:	**7.62%**
Generation **loss**	**24.85%**

Conclusion

We saw that it is not recommended to use `redis-py` if we need pure throughput. Even so, some features like pipelining or using a different parser increase reasonably the performance, we are far from those achieved by `hiredis (C)`.

In anycase, using the HiredisParser increased performances up to 40% for our case. Don't forget: `redis-py` uses `HiredisParser` if it is installed, therefore:

```
pip install redis
pip install hiredis
```