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How to profile roslaunch nodes

Description: This tutorial explains how to use profiling tools for roscpp (/roscpp) nodes (/Nodes) that you are launching with roslaunch (/roslaunch).

Keywords: roslaunch, gprof, valgrind, callgrind

Tutorial Level: INTERMEDIATE

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Here are some examples to to integrate with profiling a ROS node process.

1. gprof

gprof is a performance analysis tool for Unix processes. It uses a both instrumentation and sampling. An instrumentation code is automatically inserted into a program code during compilation time with `-pg` option (for gcc) and sampling data is save in `gmon.out` file, just before the program exits.

1. Add `-pg` option after `catkin_package()` in your `CMakeLists.txt` file

```
...
catkin_package()

### FOR PROFILING (need to set after catkin_package)
add_compile_options(-pg)
set(catkin_LIBRARIES ${catkin_LIBRARIES} -pg)
###

include_directories(${catkin_INCLUDE_DIRS})

add_executable(talker src/talker.cpp)
target_link_libraries(talker ${catkin_LIBRARIES})
...
```

2. Change your launch file(s) so that each ROS node outputs different output. (Otherwise, all ROS node outputs to same `gmon.out` file)

Add <`env`> tag just before the each <`node`> tag. The `GMON_OUT_PREFIX` environment variable specifies the output name for `gprof`, so it should be identical. For example, use ROS node name would be good idea.

```
  <env name="GMON_OUT_PREFIX" value="listener" />
  <node name="listener" pkg="examples" type="listener" output="screen" />

  <env name="GMON_OUT_PREFIX" value="talker" />
  <node name="talker" pkg="examples" type="talker" output="screen" />
```

In this example, the ROS node will output the profiling output data to you `~/.ros/` directory with file named `listener.[pid]` and `talker.[pid]`. Note that this is tricky and might be changed in the future release of `roslaunch`.

3. Start your ROS node with `roslaunch` command as usual, and exits with `C-c`

4. You can find your profiling output file under the `~/.ros` directory, for example `talker.21301` and `listener.21300`. To analyse, run

```
$ gprof devel/lib/examples/listener ~/.ros/listener.21300
```

and

```
$ gprof devel/lib/examples/talker ~/.ros/talker.21301
```

You'll get something like

```
Flat profile:

Each sample counts as 0.01 seconds.
 no time accumulated

  %   cumulative   self              self     total           
 time   seconds   seconds    calls  Ts/call  Ts/call  name    
  0.00      0.00     0.00      423     0.00     0.00  boost::detail::shared_count::~shared_count()
  0.00      0.00     0.00      222     0.00     0.00  boost::detail::sp_counted_base::release()
  0.00      0.00     0.00      222     0.00     0.00  boost::detail::atomic_exchange_and_add(int*, int)
  0.00      0.00     0.00      221     0.00     0.00  boost::detail::shared_count::shared_count(boost::detail::shared_c
ount const&)
  0.00      0.00     0.00      221     0.00     0.00  boost::detail::sp_counted_base::add_ref_copy()
  0.00      0.00     0.00      221     0.00     0.00  boost::detail::atomic_increment(int*)
  0.00      0.00     0.00      201     0.00     0.00  boost::detail::shared_count::shared_count()
  0.00      0.00     0.00      178     0.00     0.00  boost::detail::shared_count::swap(boost::detail::shared_count&)
  0.00      0.00     0.00      165     0.00     0.00  boost::function_base::empty() const
  0.00      0.00     0.00      154     0.00     0.00  boost::shared_ptr<std_msgs::String_<std::allocator<void> > >::~sh
ared_ptr()
  0.00      0.00     0.00      132     0.00     0.00  boost::shared_ptr<std_msgs::String_<std::allocator<void> > const 
>::~shared_ptr()
  0.00      0.00     0.00      132     0.00     0.00  std::remove_reference<std::map<std::__cxx11::basic_string<char, s
td::char_traits<char>, std::allocator<char> >, std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<
char> >, std::less<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > >, std::allocator<st
d::pair<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > const, std::__cxx11::basic_stri
ng<char, std::char_traits<char>, std::allocator<char> > > > >*&>::type&& std::move<std::map<std::__cxx11::basic_string<
char, std::char_traits<char>, std::allocator<char> >, std::__cxx11::basic_string<char, std::char_traits<char>, std::all
ocator<char> >, std::less<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > >, std::alloc
ator<std::pair<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > const, std::__cxx11::bas
ic_string<char, std::char_traits<char>, std::allocator<char> > > > >*&>(std::map<std::__cxx11::basic_string<char, std::
char_traits<char>, std::allocator<char> >, std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char
> >, std::less<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > >, std::allocator<std::p
air<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > const, std::__cxx11::basic_string<c
har, std::char_traits<char>, std::allocator<char> > > > >*&)

...
```

and

```
Flat profile:

Each sample counts as 0.01 seconds.
 no time accumulated

  %   cumulative   self              self     total           
 time   seconds   seconds    calls  Ts/call  Ts/call  name    
  0.00      0.00     0.00       99     0.00     0.00  boost::detail::shared_count::shared_count()
  0.00      0.00     0.00       78     0.00     0.00  boost::shared_ptr<ros::Publisher::Impl>::operator->() const
  0.00      0.00     0.00       78     0.00     0.00  bool std::operator==<char, std::char_traits<char>, std::allocator
<char> >(std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > const&, char const*)
  0.00      0.00     0.00       76     0.00     0.00  boost::detail::shared_count::~shared_count()
  0.00      0.00     0.00       69     0.00     0.00  std::remove_reference<unsigned char*&>::type&& std::move<unsigned
char*&>(unsigned char*&)
  0.00      0.00     0.00       57     0.00     0.00  void boost::checked_array_delete<unsigned char>(unsigned char*)
  0.00      0.00     0.00       57     0.00     0.00  boost::detail::sp_counted_base::~sp_counted_base()
  0.00      0.00     0.00       57     0.00     0.00  boost::detail::sp_counted_impl_pd<unsigned char*, boost::checked_
array_deleter<unsigned char> >::~sp_counted_impl_pd()
  0.00      0.00     0.00       57     0.00     0.00  boost::checked_array_deleter<unsigned char>::operator()(unsigned
char*) const
  0.00      0.00     0.00       53     0.00     0.00  ros::message_traits::MD5Sum<std_msgs::String_<std::allocator<void
> > >::value()
  0.00      0.00     0.00       52     0.00     0.00  ros::message_traits::MD5Sum<std_msgs::String_<std::allocator<void
> > >::value(std_msgs::String_<std::allocator<void> > const&)
  0.00      0.00     0.00       52     0.00     0.00  char const* ros::message_traits::md5sum<std_msgs::String_<std::al
locator<void> > >(std_msgs::String_<std::allocator<void> > const&)
  0.00      0.00     0.00       50     0.00     0.00  boost::shared_ptr<void const>::shared_ptr()
  0.00      0.00     0.00       50     0.00     0.00  std::_Rb_tree<std::__cxx11::basic_string<char, std::char_traits<c
har>, std::allocator<char> >, std::pair<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >
const, std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > >, std::_Select1st<std::pair<st
d::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > const, std::__cxx11::basic_string<char, s
td::char_traits<char>, std::allocator<char> > > >, std::less<std::__cxx11::basic_string<char, std::char_traits<char>, s
td::allocator<char> > >, std::allocator<std::pair<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocat
```

```
or<char> > const, std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > > > >::_M_get_Node_al
locator()

...
```

2. Callgrind + Kcachegrind

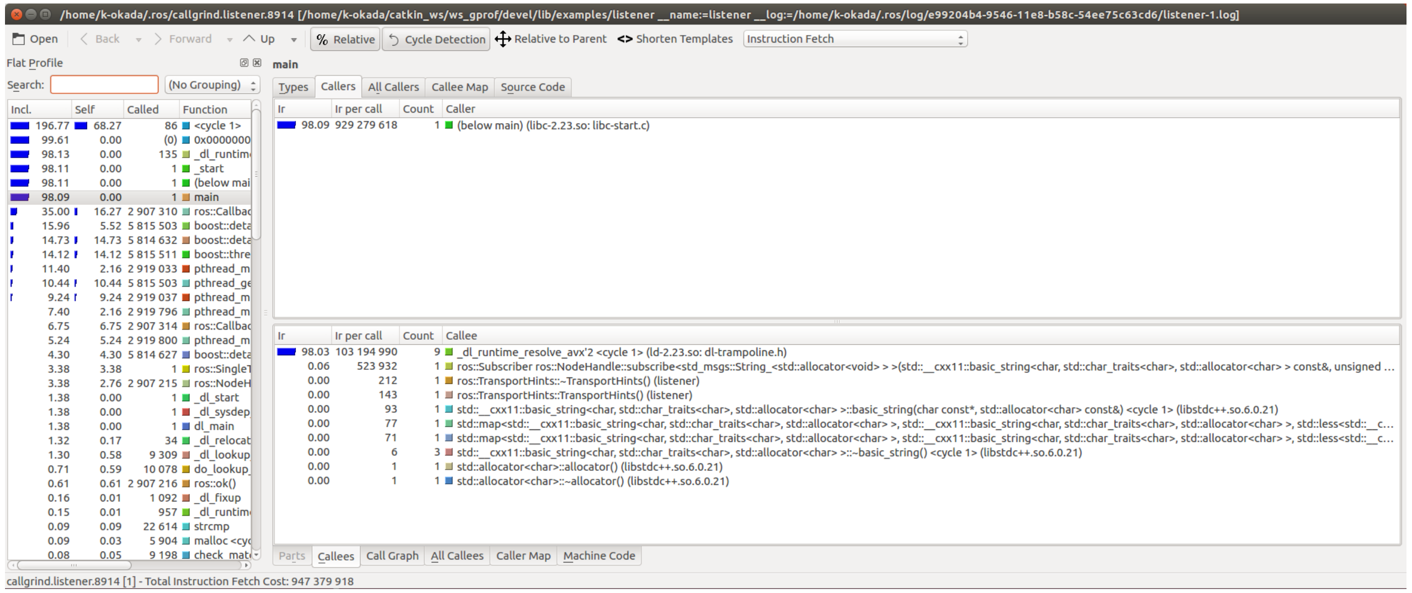
Callgrind is a profiling tool that records the call history among function in UNIX process.The profile data is written out to a file named `callgrind.out.[pid]` at a program termination. The data files generated by Callgrind can be loaded into Kcachegrind for browsing the performance results.

1. Update your launch file so that each ROS node outputs different profile data files.

```
  <node name="listener" pkg="examples" type="listener" output="screen"
        launch-prefix="valgrind --tool=callgrind --callgrind-out-file='callgrind.listener.%p' " />
  <node name="talker" pkg="examples" type="talker" output="screen"
        launch-prefix="valgrind --tool=callgrind --callgrind-out-file='callgrind.talker.%p'" />
```

2. Start your ROS node with `roslaunch` command, as usual. When you terminate the roslaunch process, you all get profile data under `~/.ros` directory.

3. Use Kcachegrind to visualize the profile data. For example `kcachegrind ~/.ros/callgrind.listener.8915` and `kcachegrind ~/.ros/callgrind.talker.8914` shows following images respectively.



```
/home/k-okada/.ros/callgrind.listener.8914 [/home/k-okada/catkin_ws/ws_gprof/devel/lib/examples/listener __name:=listener __log:=/home/k-okada/.ros/log/e99204b4-9546-11e8-b58c-54ee75c63cd6/listener-1.log]
```

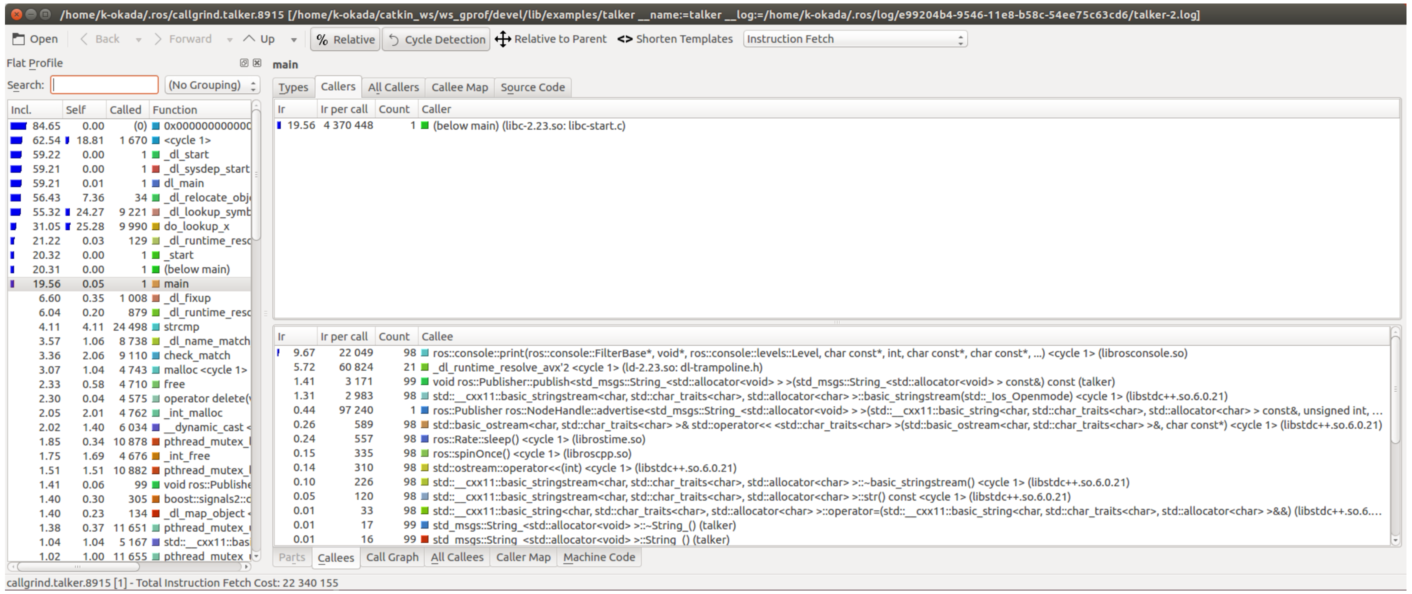
```
Incl.    Self      Called  Function
196.77   68.27         86  <cycle 1>
 99.61    0.00        (0)  0x0000000
 98.13    0.00        135  _dl_runtim
 98.11    0.00          1  _start
 98.11    0.00          1  (below mai
 98.09    0.00          1  main
 35.00   16.27  2 907 310  ros::Callbac
 15.96    5.52  5 815 503  boost::deta
 14.73   14.73  5 814 632  boost::deta
 14.12   14.12  5 815 511  boost::thre
 11.40    2.16  2 919 033  pthread_m
 10.44   10.44  5 815 503  pthread_ge
  9.24    9.24  2 919 037  pthread_m
  7.40    2.16  2 919 796  pthread_m
  6.75    6.75  2 907 314  ros::Callbac
  5.24    5.24  2 919 800  pthread_m
  4.30    4.30  5 814 627  boost::deta
  3.38    3.38          1  ros::SingleT
  3.38    2.76  2 907 215  ros::NodeH
  1.38    0.00          1  _dl_start
  1.38    0.00          1  _dl_sysdep
  1.38    0.00          1  dl_main
  1.32    0.17         34  _dl_relocat
  1.30    0.58      9 309  _dl_lookup
  0.71    0.59     10 078  do_lookup
  0.61    0.61  2 907 216  ros::ok()
  0.16    0.01      1 092  _dl_fixup
  0.15    0.01        957  _dl_runtim
  0.09    0.09     22 614  strcmp
  0.09    0.03      5 904  malloc <cyc
  0.08    0.05      9 198  check_matc
```

```
Ir     Ir per call  Count  Caller
98.09  929 279 618      1  (below main) (libc-2.23.so: libc-start.c)
```

```
Ir     Ir per call  Count  Callee
98.03  103 194 990      9  _dl_runtime_resolve_avx'2 <cycle 1> (ld-2.23.so: dl-trampoline.h)
 0.06      523 932      1  ros::Subscriber ros::NodeHandle::subscribe<std_msgs::String_<std::allocator<void> > >(std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > const&, unsigned …
 0.00          212      1  ros::TransportHints::~TransportHints() (listener)
 0.00          143      1  ros::TransportHints::TransportHints() (listener)
 0.00           93      1  std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >::basic_string(char const*, std::allocator<char> const&) <cycle 1> (libstdc++.so.6.0.21)
 0.00           77      1  std::map<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::less<std::__c…
 0.00           71      1  std::map<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::less<std::__c…
 0.00            6      3  std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >::~basic_string() <cycle 1> (libstdc++.so.6.0.21)
 0.00            1      1  std::allocator<char>::allocator() (libstdc++.so.6.0.21)
 0.00            1      1  std::allocator<char>::~allocator() (libstdc++.so.6.0.21)
```

```
callgrind.listener.8914 [1] - Total Instruction Fetch Cost: 947 379 918
```

(/roslaunch/Tutorials/Profiling%20roslaunch%20nodes?action=AttachFile&do=view&target=kcachegrind-listener.png)



```
/home/k-okada/.ros/callgrind.talker.8915 [/home/k-okada/catkin_ws/ws_gprof/devel/lib/examples/talker __name:=talker __log:=/home/k-okada/.ros/log/e99204b4-9546-11e8-b58c-54ee75c63cd6/talker-2.log]
```

```
Incl.  Self   Called  Function
84.65   0.00     (0)  0x000000000000
62.54  18.81   1 670  <cycle 1>
59.22   0.00       1  _dl_start
59.21   0.00       1  _dl_sysdep_start
59.21   0.01       1  dl_main
56.43   7.36      34  _dl_relocate_obj
55.32  24.27   9 221  _dl_lookup_symb
31.05  25.28   9 990  do_lookup_x
21.22   0.03     129  _dl_runtime_reso
20.32   0.00       1  _start
20.31   0.00       1  (below main)
19.56   0.05       1  main
 6.60   0.35   1 008  _dl_fixup
 6.04   0.20     879  _dl_runtime_reso
 4.11   4.11  24 498  strcmp
 3.57   1.06   8 738  _dl_name_match
 3.36   2.06   9 110  check_match
 3.07   1.04   4 743  malloc <cycle 1>
 2.33   0.58   4 710  free
 2.30   0.04   4 575  operator delete(
 2.05   2.01   4 762  _int_malloc
 2.02   1.40   6 034  __dynamic_cast <
 1.85   0.34  10 878  pthread_mutex_l
 1.75   1.69   4 676  _int_free
 1.51   1.51  10 882  pthread_mutex_l
 1.41   0.06      99  void ros::Publishe
 1.40   0.30     305  boost::signals2::c
 1.40   0.23     134  _dl_map_object <
 1.38   0.37  11 651  pthread_mutex_u
 1.04   1.04   5 167  std::__cxx11::basi
 1.02   1.00  11 655  pthread_mutex_u
```

```
Ir     Ir per call  Count  Caller
19.56  4 370 448        1  (below main) (libc-2.23.so: libc-start.c)
```

```
Ir    Ir per call  Count  Callee
9.67       22 049     98  ros::console::print(ros::console::FilterBase*, void*, ros::console::levels::Level, char const*, int, char const*, char const*, ...) <cycle 1> (librosconsole.so)
5.72       60 824     21  _dl_runtime_resolve_avx'2 <cycle 1> (ld-2.23.so: dl-trampoline.h)
1.41        3 171     99  void ros::Publisher::publish<std_msgs::String_<std::allocator<void> > >(std_msgs::String_<std::allocator<void> > const&) const (talker)
1.31        2 983     98  std::__cxx11::basic_stringstream<char, std::char_traits<char>, std::allocator<char> >::basic_stringstream(std::_Ios_Openmode) <cycle 1> (libstdc++.so.6.0.21)
0.44       97 240      1  ros::Publisher ros::NodeHandle::advertise<std_msgs::String_<std::allocator<void> > >(std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > const&, unsigned int, …
0.26          589     98  std::basic_ostream<char, std::char_traits<char> >& std::operator<< <std::char_traits<char> >(std::basic_ostream<char, std::char_traits<char> >&, char const*) <cycle 1> (libstdc++.so.6.0.21)
0.24          557     98  ros::Rate::sleep() <cycle 1> (librostime.so)
0.15          335     98  ros::spinOnce() <cycle 1> (libroscpp.so)
0.14          310     98  std::ostream::operator<<(int) <cycle 1> (libstdc++.so.6.0.21)
0.10          226     98  std::__cxx11::basic_stringstream<char, std::char_traits<char>, std::allocator<char> >::~basic_stringstream() <cycle 1> (libstdc++.so.6.0.21)
0.05          120     98  std::__cxx11::basic_stringstream<char, std::char_traits<char>, std::allocator<char> >::str() const <cycle 1> (libstdc++.so.6.0.21)
0.01           33     98  std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >::operator=(std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >&&) (libstdc++.so.6.…
0.01           17     99  std_msgs::String_<std::allocator<void> >::~String_() (talker)
0.01           16     99  std_msgs::String_<std::allocator<void> >::String_() (talker)
```

```
callgrind.talker.8915 [1] - Total Instruction Fetch Cost: 22 340 155
```

(/roslaunch/Tutorials/Profiling%20roslaunch%20nodes?action=AttachFile&do=view&target=kcachegrind-talker.png)