Introduction to Analysis with Paraver

For this mini-tutorial we will use one of the traces generated in the second laboratory session. Traces are composed of three files with the same name ended with extensions .prv (the tracefile itself), .pcf and .row (additional symbolic information for the numerically encoded records in the .prv file). A set of configuration files will be used, all of them available in the cfgs directory that you will copy from /scratch/nas/1/par0/sessions/cfgs.tar.gz.

Timelines: Navigation and Basic concepts

- Launch paraver (**wxparaver**, should be in the path if you have already sourced the environment.bash file). This will open the **Main Window**.
- **Load trace**: From the main menu, select "**File → Load Trace...**", and select one of the traces generated. Alternatively, traces can be located through the browser at the bottom of the **Main Window**. Double clicking on a .prv file will load it. For the purposes of this mini-tutorial, traces mainly contain two types of records: states and flags. These two records are used by Extrae to inject information in the trace.
- Once the file is loaded, click on the **New single timeline window** box (top left icon). A new timeline window appears showing the activity (state, encoded in color) of each thread (vertical axis) in the parallel program. The horizontal axis represents time, from left to right.
  - **Colors**: While moving the mouse over the window, a textual description of the meaning of each color is shown (at the bottom of the same window): light blue (idle), dark blue (running), red (synchronization), yellow (scheduling and for-join), … You can also see a table indicating the meaning of each color by clicking the right button in your mouse (anywhere inside the window) "**Right Button → Info Panel"**, then select the **Colors** tab. It is important to be aware that the meaning of each color is specific to each window. Thorough the tutorial you will see different timeline windows each of them displaying a different information with its own coloring table..
  - **Textual information:** Double click with the Left Button on any point in the window. It will list in textual form the actual value at the point selected and how long the time interval with that color is. The text display will be in the "**What/Where**" tab of the **Info Panel**. "**Right Button → Info Panel"**, can be used to hide the lower info panel.
  - **Zoom**: Click with the Left Button of the mouse to select the starting time of the zoomed view, drag the mouse over the area of interest, and release the mouse to select the end time of the zoomed view.
  - **Undo Zoom** and **Redo Zoom** commands are available on the Right Button menu. You can do and undo several levels of zooming.
  - The **Control**-**Zoom** option will let you select a subset of threads. This is useful when analyzing runs with many processes and you want to concentrate on a few of them. Hold down the "**Control**" or "**CTRL**" key on the keyboard, and using the mouse, identify a rectangular area by clicking on top left corner of the desired area with the left mouse button and dragging and releasing the button on the bottom right corner.
  - To measure time between any two points in the trace: Use the **Shift-Zoom** combination to activate the timing. The time and the interval between the two selected points of the trace is displayed in the **Timing** tab of the **Info Panel**.
  - **Flags**: Right-click on the window, and select the "**View → Event Flags**" checkbox. In this trace flags appear at the entry and exit points of the inserted user events and to signal the entry and exit points of different OpenMP activities. Flags are useful to differentiate different bursts in what may look like a simple burst. Selecting the visualization of a subset of flags (type and value) and giving them a specific semantic interpretation is possible through the **Main Window** (selecting the second icon in the Files & Windows properties panel); however this is not covered in this mini-tutorial.
- Configuration files are the simplest way to do the analysis of a trace. Next we will use some of them available in different sub-directories inside the cfgs main directory.
  - For example, configuration file **OMP_parallel_functions.cfg** (in cfgs/OpenMP) can be used to identify different parallel regions in the trace. To load it, from the main menu, select "**File → Load Configuration...**". Colors are used here to visualize different parallel regions (in our example only one). The textual information shows the name given by the compiler to the outlined routine that is called by each thread to execute the body of the parallel OpenMP construct. Different colors correspond to different parallel regions in the program.
  - In order to visualize the duration of these parallel bursts, load **OMP_parallel_functions_duration.cfg.** A gradient coloring scheme is used in this window: between light green representing a small duration and dark blue representing a long one**.** Moving the mouse over the window will show at the bottom of the timeline the range of durations represented by the color the mouse goes over. You can Right-click on the window, and select the "**Fit Semantic Scale → Fit Both**" to automatically adjust the gradient to the values in the window. Double click with the Left Button on any point in the window. It will list in

textual form the actual duration at the point selected (an vicinity if time scale too coarse). The text display will be in the "**What/Where**" tab of the **Info Panel**[1].
    - Open the **OMP_in_barrier.cfg** and **OMP_in_lock.cfg configuration** files to visualize the synchronization activity in this parallel execution. Observe the different states when accessing locks.
- Synchronize windows: In Paraver every timeline window represents a single metric or view for all selected threads and time span. It is possible to synchronize two timelines by making then display the exact same threads and time span. For doing so just right-click and select **Copy**, on the source (reference) window and then on the target window, right-click and select **"Paste Default Special"** (or separately "**Paste → Size**" and "**Paste → Time**"). Both windows will then be of the same size and represent different views (metrics) for the same part of the trace. If you put one above the other there is a one to one correspondence between points in vertical. The "**Paste Time**" lets you copy only the time scale from the first window to the target one. The "**Paste Semantic Scale**" lets you apply to the target window the same gradient coloring limits (semantic Minimum and Maximum) the source window had.

Profiles

The above analysis went directly to the detailed timeline, but a less detailed averaged statistic can often be sufficient to identify problems and gives a summarized view of the behavior of an application. Paraver provides one mechanism to obtain such profiles for the desired region of a trace. We call it the **2D Analyzer** as it is a very flexible mechanism to generate tables of summarized statistics. Let's use it:

- Load configuration file **OMP_profile.cfg**. A table pops up with one row per thread and one column per OpenMP state (Running, Synchronization, Scheduling and Fork/Join,…). Each cell value shows the absolute time spent by a thread in a specific state.
    - To see a different statistic change the **Statistic selector** in the Main Window. Interesting options at this time may be:
        - **%Time**: to show the percentage of the total time in a specific state.
        - **# Instances**: to count the number of times each state occurs.
        - **Average Duration**: to compute the average duration of each state.
    - All the above statistics are computed based on a single timeline window, which we call the "**Control Window**" and which can be popped up by clicking on the control window icon in the top left corner of the window. In this example, you will see that it is the initial timeline we opened at the beginning. The values of the control window determine to which column is a given statistic accumulated/accounted.
    - To apply the analysis to a subset of the trace, zoom on any of the timelines to the time region you are interested on. Right-click and select "**Copy**" on this window and right-click and select "**Paste → Time**" on the table. The analysis will be repeated just for the selected time interval.
- Load configuration file **OMP_critical_profile.cfg** to see the same statistics (total time, percent of time, number of instances or average duration) for the three phases of the critical section implementation.

Performance counters

Finally, a set of configuration files (in cfgs/Counters) is available to visualize information gathered through the hardware counters available in the architecture.

- Load configuration file **Instructions.cfg**. A timeline pops up showing the number of instructions executed while doing useful work in OpenMP. The number of instructions is shown in textual form at the bottom of the timeline.

[1] You can also change the color encoding by manually setting the **Semantic Maximum** and **Semantic Minimum** fields in the **Main Window** (they will appear when you select the second icon in the Files & Windows properties panel). Just keep in mind that values outside the specified range will be truncated in the function of time display and will be assigned a different color (orange) in the color display.