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Part 1: OMP Functions

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Abstract

This report describes the performance analysis of `Talbot Suite` by means of TAU (Tuning and Analysis Utilities). `Talbot Suite` is a parallel software collection developed by the authors for the numerical inversion of Laplace Transform on recent advanced architectures. `Talbot Suite` deals with both single and multi-point inversion problems and collects *Open MP* functions for shared memory machines and *MPI* functions for distributed memory one. It integrates a first version of a hybrid implementation too. This report presents only performance measurements of the OMP functions on a specific architecture: a Blade Server.

1 Introduction

`Talbot Suite` [1] is part of Parallel Inverse Laplace Transform Package[1], a set of sequential and parallel software based on different numerical methods for inverting Laplace Transform (LT) on high performance architectures. We note that at our knowledge, there are not parallel software for LT inversion (for more details, see [1]).

`Talbot Suite`'s algorithms are based on two versions of the Talbot's method in order to deal with single and multi-point inversion problems. The original version has been proposed by Talbot [4], and it produces approximations for $f(t)$ when numerical values of its LT function:

$$F(s) = \int_0^\infty f(t)e^{-st}dt, \quad Re(s) > \sigma_0, \tag{1}$$

are available for all complex value s. σ_0 is the *abscissa of convergence* and it is defined so that the integral converges uniformly if $Re(s) > \sigma_0$. Generally, the numerical inversion of (1) consists in computing an approximation $\widetilde{f(t)}$ to $f(t)$ from a finite values of $F(s)$, starting from the Riemann's Inversion Formula on the Bromwich contour $B = \{s \in \mathbb{C} : Re(s) = \sigma \wedge Im(s) \in \Re\}$:

$$f(t) = \frac{1}{2\pi i} \int_B F(s)e^{st}ds. \tag{2}$$

---

[1]`PILTPack` is a work in progress project involving research studies and experiences of the authors. `PILTPack` collects different suites, each one is based on different method for the numerical inversion of Laplace Transform. In this report we discuss only about `Talbot Suite`.

In particular, Talbot's method belongs to the class of inversion methods based on the integration of (2) along a special contour. The underlying idea is to apply the composite trapezoidal rule in order to approximate (2) by a sum (of Chebyshev-Clenshaw kind) as follows:

$$f(t) \approx \widetilde{f(t)} = \lambda\, e^{\sigma t} \frac{1}{N} \left(\frac{\nu}{2} e^{\lambda t} F(\sigma + \lambda) + \sum_{j=1}^{N-1} (x_j \cos \phi_j - y_j \sin \phi_j) \right) = \lambda\, e^{\sigma t} \frac{T_N(t)}{N} \qquad (3)$$

where λ, σ, ν, are the Talbot's *geometrical parameters*, N is the number of nodes in the quadrature rule (the *accuracy parameter*), depending on t and on the singularities of $F(s)$, whereas $\phi_j = \lambda t \nu \pi j / N$, x_j, y_j depend on j, on t, on geometrical parameters and on values of F along the contour. For more details on theoretical aspects we address to [4].

In `Talbot Suite` designing two versions of Talbot's method have been employed as well as different parallel programming models have been used for the implementation. Tuning and performances analysis of `Talbot Suite`'s functions have been carried out with several tests to put in evidence (and then correct) performance problems (bottleneck, poor performance, load imbalance) on recent advanced architectures. Performance analysis has been performed using TAU[2]. Since TAU is able to track performance data of programs written in different (parallel) programming models in execution on several computing environments, it has been a suitable framework for examining our suite.

For the sake of brevity, in this report only the TAU results about OMP functions of `Talbot Suite` are shown. In [2] performance measurements about MPI functions are shown.

2 Talbot Suite

2.1 Purpose

Talbot's algorithm was implemented in FORTRAN 77 by one of the authors [5]. The main steps of the algorithm are the evaluation of the methodo parameters $(\lambda, \sigma, \nu, N)$ and the evaluation of the inverse LT on a set of t values. They are performed, one after the other, by two routines named as `TAPAR` and `TSUM` respectively of the Algorithm 682 in CALGO software collection. A sketch of Talbot's algorithm is shown in **Algorithm 0**.

Algorithm 0: Talbot algorithm

Input: LT function $F(s)$, t, error tolerance, singularities of $F(s)$
Output: $\widetilde{f(t)}$

1: Compute the method parameters λ, σ, ν, N (`TAPAR`).
2: Compute the Talbot-Clenshaw sum and $\widetilde{f(t)}$ (`TSUM`).

`Talbot Suite` deals with both single and multi-point inversion problems (that occurs in solution of partial or ordinary differential equation). For multi-point inversion a different version of the

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[2]TAU (Tuning and Analysis Utilities) Performance System [8, 9, 10] is a robust, flexible, portable and integrated framework and toolkit for performance instrumentation, measurement, analysis and visualization of large-scale parallel computer system and application. TAU project is a product that gathers the researchers effort at University of Oregon, at the Research Centre Juelich and Los Alamos National Laboratory.

Talbot's method was implemented, the so-called *Modified* Talbot method. The *Modified* algorithm approximates the inverse LT function $f(t)$ at several values of t in the interval supplied using a fixed set of parameters, estimated at an optimal $t^\star$. In [6] the root mean square error is proved to be minimum provided that parameters are chosen for $t^\star$ equal to the midpoint of the interval enclosing the interval supplied.

The *Classical* and the *Modified* Talbot's method led respectively to two different strategies of parallelism:

- *Modified* Talbot: a coarse grain parallelism is realized by means of a distribution of the t values subsets (*data partitioning*) among the available processes;

- *Classical* Talbot: a fine grain parallelism is realized introducing the parallel Goertzel-Reinsh algorithm (as described in [7]) for evaluating a single Clenshaw sum (*task parallelism*).

In this way, the functions of `Talbot Suite` are organized in two branches, one is based on the *Classical* algorithm and the second on the *Modified* one. A sketch of the two parallel algorithms is shown in **Algorithm 2** and **Algorithm 1** respectively. Since the two proposed parallel strategies may be combined together, we implemented in `Talbot Suite` a hybrid parallel algorithm depicted in **Algorithm 3**.

Algorithm 1: Coarse grain parallelism

Input: LT function $F(s)$, `NTval`=number of t values, $\mathbb{T} = \{t_1, \ldots, t_{\texttt{NTval}}\}$, error tolerance, singularities of F, midpoint $t^\star$ of $\mathbb{T}$, number of processes np

Output: $\widetilde{f(t)}, \ \forall t \in \mathbb{T}$

1: compute λ, σ, ν, N for $t = t^\star$;

for *each process i : $i = 0, 1, \ldots, np - 1$* **do**
    2.1: compute $\texttt{NTval}_{\mathrm{loc}}(i)$, the local number of t values;
    2.2: define $\mathbb{T}_i$, the local set of t values;
    2.3: for *each value $t \in \mathbb{T}_i$* **do**
        compute $\widetilde{f(t)}$;
    end
end

Algorithm 2: Fine grain parallelism

Input: LT function $F(s)$, t, error tolerance, singularities of F, number of processes np

Output: $\widetilde{f(t)}$

1: compute $\widetilde{\lambda, \sigma, \nu}$, N;
2: compute $\widetilde{f(t)}$ in parallel.

`Talbot Suite` aims at recent advanced architectures, thus we provided versions of the two algorithms described above for both shared and distributed memory machines. We used *Open MP*

Algorithm 3: Two-level hybrid parallelism

Input: LT function $F(s)$, `NTval`=number of t values, $\mathbb{T} = \{t_1, \ldots, t_{\texttt{NTval}}\}$, error tolerance, singularities of F, midpoint $t^\star$ of $\mathbb{T}$, number of processes np

Output: $\widetilde{f(t)}$, $\forall t \in \mathbb{T}$

1: compute λ, σ, ν, N for $t = t^\star$;

for *each process i : $i = 0, 1, \ldots, np - 1$* **do**

    2.1: compute $\texttt{NTval}_{\text{loc}}(i)$, the local number of the t values;

    2.2: define the local set of t values $\mathbb{T}_i$;

    2.3: for *each value $t \in \mathbb{T}_i$* **do**

        compute $\widetilde{f(t)}$ in parallel;

    end

end

---

[12] for the shared memory machines and *MPI* for the distributed memory one. Furthermore, the two level hybrid parallel version uses MPI for the *coarse-grain parallelism* (data partitioning) and OMP for the *fine-grain parallelism* (parallel summation). For more details see [1]. In this report we analyse only pure OMP functions.

Functions organization of `Talbot Suite`, according to our conventions defined for `PILTPack`, is the following:

- `user_level`: one single driver function for single or multi points inversion;

- `skill_level`: two computational functions, the former for computation of the parameters method-based and the second for the numerical evaluation of the inverse LT.

We remark that each driver function includes the corresponding two skill-level functions. In this way, skill user can manage directly the two computational functions according to own goals.

2.2   Suite Organization and Conventions Assumed

To define a standard notation, we adopted a common name style for the `Talbot Suite`'s functions[3]. The driver functions have been named as follows:

$$\texttt{VERSION\_Method strategy}$$

where:

- `VERSION` is one among `MPI` (pure MPI), `OMP` (pure OMP), `HYB` (hybrid);

- `Method` is `Talbot`;

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[3]This name style has been adopted also in the other suites of `PILTPack`.

- **strategy** is either 1 for **Algorithm 1** (functions implementing the *coarse grain parallelism*) or 2 for **Algorithm 2** (functions implementing the *fine grain parallelism*) or 3 for **Algorithm 3** (functions implementing hybrid strategy).

For instance, `OMP_Talbot2` refers to the Open MP parallel version (`OMP`) of the *Classical* Talbot's method with the *fine grain parallelism* (with the parallelism performed in the summation process). A sketch of the organization of `Talbot Suite`'s functions is shown in Figure 1.
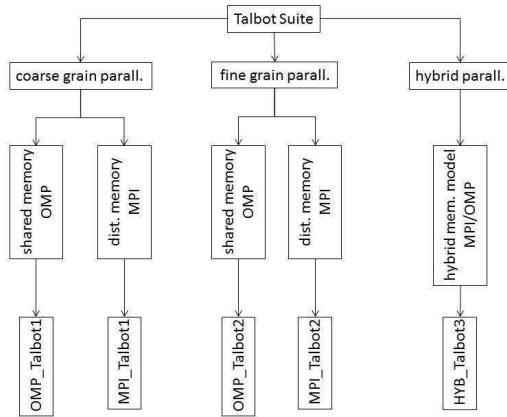
Figure 1: *Organization of* `Talbot Suite`*'s functions.*

Driver functions prototypes have been defined so that arguments common to all versions and algorithms are listed first - input parameters, then output ones - followed by arguments related to the specific method and version. For instance, we have:

```
int VERSION_Talbot_strategy(double complex (*LTpt)(double complex s),
                double sigma0,unsigned int NTval,double *Tval,double tol,
                double *NUMft,int *IFAIL,unsigned int NSING,double complex *SING,
                unsigned int *MULT,algorithm parameters,version parameters);
```

where:

- `LTpt (I)`: pointer to a Laplace Transform;

- `sigma0 (I)`: abscissa of convergence;

- `NTval (I)`: number of points where inversion is required;

- `Tval (I)`: pointer to values where inversion is required;

- `tol (I)`: error threshold;

5

- `NUMft (O)`: pointer to inverse Laplace Transform;

- `IFAIL (O)`: pointer to error flags;

- `NSINGS (I)`: number of singularities of function LTpt;

- `SING (I)`: pointer to singularities;

- `MULT (I)`: pointer to singularities multiplicities.

At skill level, the function evaluating the method parameters is sequential, and it is used both from **Algorithm 1** and **Algorithm 2**. It is named:

<div align="center">

`TAPAR`

</div>

Whereas, we adopted a common name-style for the functions that evaluate the inverse LT as follows[4]:

<div align="center">

`VERSION_TSUMxx`

</div>

where:

- `VERSION` is one among `MPI` (pure MPI), `OMP` (pure OMP), `HYB` (hybrid);

- `xx` is either `1` for **Algorithm 1** (for functions implementing the *coarse grain parallelism*) or `2` **Algorithm 2** (for functions implementing the *fine grain parallelism*) or `12` for the hybrid strategy.

For instance, `OMP_TSUM1` is the computational function for the parallel implementation of Goertzel-Reinsch algorithm using `OMP` and "1" denotes the *coarse grain parallelism*.

3 Test Cases

Several Laplace transforms $F(s)$, with known inverse functions $f(t)$, have been selected to test `Talbot Suite`. In this report we selected one test function [11]:

$$F_{24} = \frac{1}{(s^2 + 9)^2}, \quad f_{24} = t sin(3t)/6, \tag{4}$$

with complex singularities. In this case, the number of terms in the Clenshaw sum may becomes very large. The function name implementing F_{24} in (4) is `F24`. Two intervals in which t is sampled, have been chosen: $T_1 = [10, 50]$ and $T_2 = [1000, 3000]$; they refer to small and large values of t, in order to imply an increasing number of addends in the final sum. For both intervals T_1 and T_2, we

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[4]We are on going to define a common name-style like:

<div align="center">

`Method_parameters`

</div>

for the functions that carry out parameters method-based. For instance, in `Talbot Suite` there will be `Talbot_parameters` instead of `TAPAR`.

analysed two problems: the first test requires the inversion of LT in a few values (`NTval=10`) and the second test in a greater number of t (`NTval=100`). In such a way we reproduced the following situations for a better comparison between the two parallel strategies:

- `NTval=10`, much less values of t than addends in summations;

- `NTval=100`, much more values of t than addends in summations.
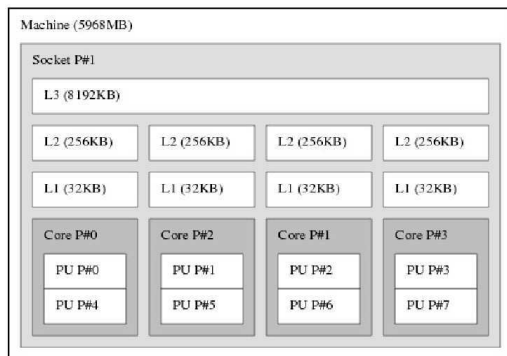
Figure 2: *Blade scheme*

All the experiments have been carried out on a HP Blade Server installed at Università di Napoli "Parthenope". It consists of 4 blades each one equipped with an Intel Quad-Core Xeon E5540 2.53 GHz processor and the Hyper-Threading Technology. Each blade has 6 GB of RAM and three levels of cache memory: 8 MB L3 cache memory shared among cores and 256KB L2 and 32KB L1 cache memory per core. Blades are connected via a 1 Gigabit Ethernet network. In Figure 2 a sketch of one of the blade is reported.

4 Performance Analysis with TAU Tools

In order to analyse performance behaviours of `Talbot Suite`'s functions by means of TAU tools, we had to insert additional instructions into the source code. This process is named *instrumentation*. We used the automatic instrumentation of the source code by means of PDT[5] framework as well as the *manual* instrumentation [8, 10] in order to customize the profiling (e.g. for analysing OMP sections). Furthermore, we enabled the *callpath* profile[6] setting the following TAU environmental variables:

- `TAU_CALLPATH = 1` (enabling callpath);

In the callpath profile, TAU displays for each test the following metrics:

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[5]Program Database Toolkit (PDT) is a framework for analysing source code included in TAU distribution.

[6]*Callpath profile* table tracks time spent in function paths rather than time spent in each function as shown in a table like *flat profile*. We point out that a flat profile can be constructed from a path profile, but not vice versa.

- `%Time` - percentage of the "total" time spent in this function and its children;

- `Exclusive msec` - cumulative, exclusive time (milliseconds) summed over all the invocations of the functions. Exclusive time refers to the total time spent in the function minus any time spent in other profiled functions called from it;

- `Inclusive msec` - time spent from the entry point to the exit, summed over all the function invocations;

- `#Call` - number of function invocations;

- `#Subrs` - number of invocated functions (multiple invocations are accounted);

- `Inclusive usec/call` - inclusive time for call (microseconds);

Last column of the callpath profile is `Name` showing the analysed function name. Moreover, since we enabled the *callpath* in TAU profiling, the `Name` column displays also the symbol "a() => b()" describing the time spent (exclusive/inclusive) in routine "b()" when it is called by routine "a()".

Before analysing the OMP functions of `Talbot Suite`, we profiled a prototype written in C language of the **Algorithm 0** proposed in [5]. In this report we named it as `SEQ_Talbot`. In Figure 3 we can see the call tree graph of `SEQ_Talbot` driver[7]: driver program calls sequentially `TAPAR` and `TSUM`. So, according to the current call tree depth we set `TAU_CALLPATH_DEPTH = 4`[8]. The colour of functions box depends on the exclusive execution time distribution of single function. Legend colour is shown in Figure 3.(a), so blue box specifies that function spends a small fraction of the overall time, the red one, conversely is employed for functions that spent a large fraction of the overall time.

(a)

(b)
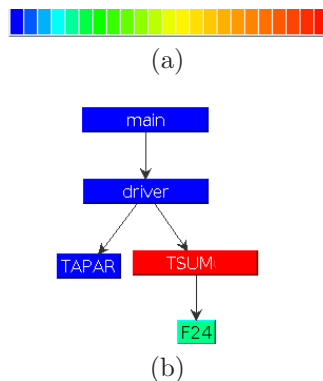
Figure 3: *Call Graph of* `SEQ_Talbot` *(b), legend colour of increasing (exclusive) execution time (a).*

Box colours in the Call graph of Figure 3 show a general case of the execution time distribution when running `SEQ_Talbot`. We can note that `TAPAR`, the function for the computation of

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[7]In the current report we used the name `driver` for all driver functions of `Talbot Suite`.

[8]When callpath profile is enabled, default value of `TAU_CALLPATH_DEPTH` is 2. We note that the *callpath* of *depth* 1 is a flat profile.

parameters method-based, has a low computational time with respect to `TSUM`, the function implementing Clenshaw algorithm. As special cases, we executed two profiling tests on this driver, with `NTval = 1`: $t = 10$, in order to have few addends in Clenshaw summation and $t = 3000$ in order to have many addends in Clenshaw summation. We set error tolerance to $1e - 12$ for the two test cases.

In the following, in the list-points named **test 01** and **test 02**, we report the Callpath profile tables produced by TAU on the two tests. Furthermore, for both tests a graph of the inclusive execution time distribution is reported, in Figure 4 and 5 respectively.

test 01: `SEQ_Talbot` with *Input Data*: Test Function n. 24, `NTval = 1`, $t = 10$.

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
              msec   total msec                         usec/call
---------------------------------------------------------------------------------
100.0        0.105        0.404          1           1        404 main
 74.0        0.094        0.299          1           2        299 driver
 74.0        0.094        0.299          1           2        299 main => driver
 37.4        0.094        0.151          1          59        151 TSUM
 37.4        0.094        0.151          1          59        151 main => driver => TSUM
 14.1        0.057        0.057         59           0          1 F24
 14.1        0.057        0.057         59           0          1 driver => TSUM => F24
 13.4        0.054        0.054          1           0         54 TAPAR
 13.4        0.054        0.054          1           0         54 main => driver => TAPAR
```
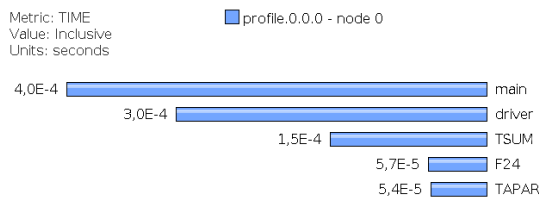

(a)
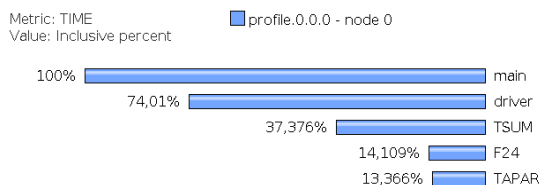
(b)

Figure 4: `SEQ_Talbot` on **test 01**: *inclusive time measured with TAU (a), values shown as percents (b).*

test 02: `SEQ_Talbot` with *Input Data*: Test Function n. 24, `NTval = 1`, $t = 3000$.

```
NODE 0;CONTEXT 0;THREAD 0:
```

9

```
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs   Inclusive Name
           msec       total msec                         usec/call
--------------------------------------------------------------------------------
100.0      0.031          212           1           1     212147 main
100.0      0.107          212           1           2     212116 driver
100.0      0.107          212           1           2     212116 main => driver
 99.9      178            211           1      645087     211956 TSUM
 99.9      178            211           1      645087     211956 main => driver => TSUM
 15.6       33             33      645087           0          0 F24
 15.6       33             33      645087           0          0 main => driver => TSUM => F24
  0.0      0.053          0.053          1           0         53 TAPAR
  0.0      0.053          0.053          1           0         53 main => driver => TAPAR
```
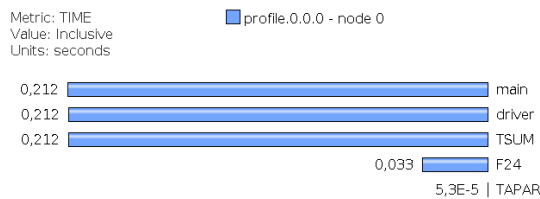

(a)
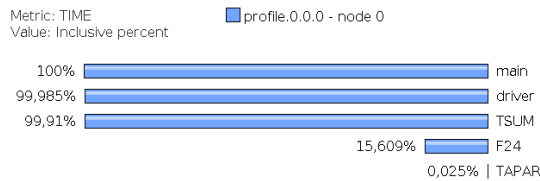
(b)

Figure 5: `SEQ_Talbot` on **test 02**: *inclusive time measured with TAU (a), values shown as percents (b).*

In **test 01**, corresponding to small value of t ($t = 10$), only $N = 59$ addends are required for the numerical evaluation of inverse function, instead in **test 02** corresponding to a large value of t ($t = 3000$), $N = 645087$ addends are required. These tests point out that the function `TSUM` is the most time consuming process, indeed `TSUM` takes the 74% and the 99% of total time in **test 01** and in **test 02** respectively, thus we parallelized this step only implementing the parallel Goertzel-Reinsch algorithm for a Talbot-Clenshaw sum[7]. On the other hand, when we deal with the parallel solution of the multi-point inversion problem, we meet another computational issue: the strongly variation of the number of addends in Clenshaw summation leads to load imbalance using an uniform partitiong of the t set among processes. For this reason, we suggest to use the *Modified* method of `Talbot Suite` when the LT has to be inverted on several values of t.

4.1 Talbot Suite's OMP Functions

In this section we describe some profiling tests run on `Talbot Suite`'s OMP functions. Details on performance measurements carried out with TAU tools are described in subsection 4.1.1 for `OMP_Talbot1` and in subsection 4.1.2 for `OMP_Talbot2` respectively. We performed for both driver functions the following execution tests:

TEST 1 `OMP_Talbotx` with *Input Data*: Test Function n. 24, `NTval = 10`, `T1` interval.

TEST 2 `OMP_Talbotx` with *Input Data*: Test Function n. 24, `NTval = 100`, `T1` interval.

TEST 3 `OMP_Talbotx` with *Input Data*: Test Function n. 24, `NTval = 10`, `T2` interval.

TEST 4 `OMP_Talbotx` with *Input Data*: Test Function n. 24, `NTval = 100`, `T2` interval.

TEST 1 and **TEST 3** concern the multi-point inversion of LT on few values of t, (`NTval = 10`), and require a small or large number of addens in the Clenshaw summation respectively, whereas **TEST 2** and **TEST 4** concern the multi-point inversion of LT on a greater number of t (`NTval = 100`), and require small or large number of addens in Clenshaw summation respectively. In details for each test the total number of addens, $\mathbf{N} = \sum_{i}^{Ntval} N_i$ is shown in the following table:

	OMP_Talbot1 N	OMP_Talbot2 N
TEST 1	1480	1442
TEST 2	14800	14488
TEST 3	545997	2434700
TEST 4	18199900	23330900

The number of addens in **TEST 3** for `OMP_Talbot2` and in **TEST 4** for both driver functions leads to the *throttling*[9] of the function `F24` in TAU profiling. In order to avoid this, we set the TAU environmental variable, `TAU_THROTTLE_NUMCALLS`, in **TEST 3** to 2.500.000 and in **TEST 4** to 20.000.000 and 25.000.000 for `OMP_Talbot1` and `OMP_Talbot2` respectively.

For each test we analysed performances with the callpath profile tables and the graph of the inclusive execution time running the code with 1, 4 and 8 number of threads. We note that *thread comparison window* of TAU[10] is displayed in the graph of the inclusive execution time, where we can observe a comparative analysis based on individual threads of execution. When the number of threads is greater than one, the *thread comparison window* shows the (inclusive) execution time for each thread in each function and the time percentage with respect to thread 0.

---

[9]In order to reduce profiling overhead, TAU does not profile (*throttles*) functions with short execution time and a large number of calls. Default values are less than 10 microseconds per call inclusive time, and 100000 per number of calls.

[10]The graphical analysis in TAU is supported by `ParaProf` (Parallel Analysis Profile) included in the TAU distribution.

4.1.1 OMP Talbot1

`OMP_Talbot1` driver function is the OMP implementation of **Algorithm 1**. It calls the two computational functions `TAPAR` and `OMP_TSUM1`. Figure 6 depicts a general case of the execution time distribution when running `OMP_Talbot1` on one thread. So, we set `TAU_CALLPATH_DEPTH = 5` according to call tree depth of the function. `OMP_SEC` is the OMP section in `OMP_TSUM1`, implementing multi-threading parallel version of the main **for** loop in **Algorithm 1**. Since we instrumented manually the source code of `OMP_TSUM1` inserting the time measurements of `OMP_SEC` for each thread, TAU profiler tools used a special timer [14] [11] showing in `Name` column of the profiling tables (excepted for the master) the call to `.TAU application`.

(a)

(b)
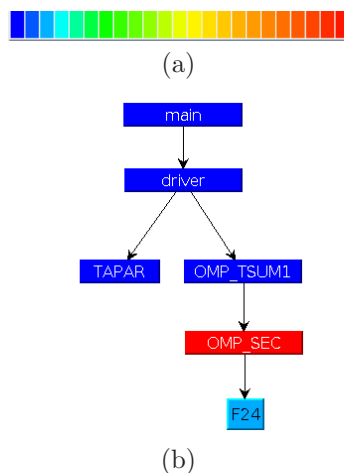
Figure 6: *Call Graph of* `OMP_Talbot1` *(b), legend colour of increasing (exclusive) execution time (a).*

In the following, we reported the performance analysis of `OMP_Talbot1` in the four tests described above, by means callpath profile and the corresponding *thread comparison window*. We can summarize that our analysis has shown that the OMP implementation of the **Algorithm 1** provides a considerable reduction of the execution time of the driver functions `OMP_Talbot1`. In particular, **TEST 2** and **TEST 4** exhibit a balanced computational load among the threads as well as a reduction of the execution time with respect to number of threads (increasing speedup). Similar results have been observed on **TEST 3**, whereas on **TEST 1** we observe a slight load imbalance produced by the very low computational cost of the test.

You can find the details about the results about `OMP_Talbot1` on a specific test searching the point list **TESTx - N. of Threads=y**, where **x**= $1, \ldots, 4$ and **y**=1,4,8.

TEST 1 `OMP_Talbot1` with *Input Data*: Test Function n. 24, `NTval` $= 10$, `T1` interval.

---

[11] `.TAU application` is a timer creates at the start of thread execution which is then stopped at the end of program execution.

– TEST 1 – N. of Threads=1 (see Figure 7)

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec    total msec                          usec/call
---------------------------------------------------------------------------------
100.0       0.03            1          1           1         1532 main
 98.0      0.093            1          1           2         1502 driver
 98.0      0.093            1          1           2         1502 main => driver
 88.4       0.06            1          1           1         1355 OMP_TSUM1
 88.4       0.06            1          1           1         1355 main => driver => OMP_TSUM1
 84.5      0.756            1          1        1480         1295 OMP_SEC
 84.5      0.756            1          1        1480         1295 driver => OMP_TSUM1 => OMP_SEC
 35.2      0.539        0.539       1480           0            0 F24
 35.2      0.539        0.539       1480           0            0 OMP_TSUM1 => OMP_SEC => F24
  3.5      0.054        0.054          1           0           54 TAPAR
  3.5      0.054        0.054          1           0           54 main => driver => TAPAR
```

Metric: TIME
Value: Inclusive
Units: seconds
☐ profile.0.0.0 - node 0

0,002	main
0,002	driver
0,001	OMP_TSUM1
0,001	OMP_SEC
5,4E-4	F24
5,4E-5	TAPAR

(a)

Metric: TIME
Value: Inclusive percent
☐ profile.0.0.0 - node 0

100%	main
98,042%	driver
88,446%	OMP_TSUM1
84,53%	OMP_SEC
35,183%	F24
3,525%	TAPAR
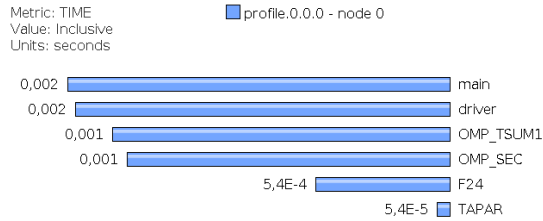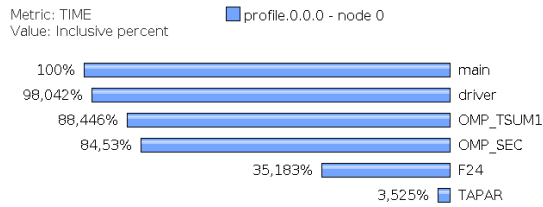
(b)

Figure 7: `OMP_Talbot1` on **TEST 1 - N. of Threads 1**: *Inclusive Time measured with TAU (a), values shown as percents (b).*

– TEST 1 – N. of Threads=4 (see Figure 8)

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec    total msec                          usec/call
---------------------------------------------------------------------------------
100.0       0.03           73          1           1        73350 main
100.0      0.092           73          1           2        73320 driver
```

```
100.0        0.092          73          1          2        73320 main => driver
 99.8          42          73          1          1        73175 OMP_TSUM1
 99.8          42          73          1          1        73175 main => driver => OMP_TSUM1
 41.2          20          30          1        444        30244 OMP_SEC
 41.2          20          30          1        444        30244 driver => OMP_TSUM1 => OMP_SEC
 13.0           9           9        444          0           22 F24
 13.0           9           9        444          0           22 OMP_TSUM1 => OMP_SEC => F24
  0.1       0.053       0.053          1          0           53 TAPAR
  0.1       0.053       0.053          1          0           53 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0       0.002          39          1          1        39963 .TAU application
100.0          39          39          1        444        39961 .TAU application => OMP_SEC
100.0          39          39          1        444        39961 OMP_SEC
  0.7       0.283       0.283        444          0            1 .TAU application => OMP_SEC => F24
  0.7       0.283       0.283        444          0            1 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0       0.002          29          1          1        29633 .TAU application
100.0          20          29          1        296        29631 .TAU application => OMP_SEC
100.0          20          29          1        296        29631 OMP_SEC
 31.9           9           9        296          0           32 .TAU application => OMP_SEC => F24
 31.9           9           9        296          0           32 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0       0.001       0.304          1          1          304 .TAU application
 99.7       0.164       0.303          1        296          303 .TAU application => OMP_SEC
 99.7       0.164       0.303          1        296          303 OMP_SEC
 45.7       0.139       0.139        296          0            0 .TAU application => OMP_SEC => F24
 45.7       0.139       0.139        296          0            0 F24

FUNCTION SUMMARY (total):
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
 69.9         322         400         16       5920        25035 OMP_SEC
 51.2        0.12         293          4          4        73350 main
 51.2       0.368         293          4          8        73320 driver
 51.2       0.368         293          4          8        73320 main => driver
 51.1         171         292          4          4        73175 OMP_TSUM1
 51.1         171         292          4          4        73175 main => driver => OMP_TSUM1
 48.8        0.02         279         12         12        23300 .TAU application
 48.8         240         279         12       4144        23298 .TAU application => OMP_SEC
```

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```
 21.1              82             120              4            1776        30244 driver => OMP_TSUM1 => OMP_SEC
 13.6              77              77           5920               0           13 F24
  6.9              39              39           4144               0           10 .TAU application => OMP_SEC => F24
  6.7              38              38           1776               0           22 OMP_TSUM1 => OMP_SEC => F24
  0.0           0.212           0.212              4               0           53 TAPAR
  0.0           0.212           0.212              4               0           53 main => driver => TAPAR

FUNCTION SUMMARY (mean):
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
--------------------------------------------------------------------------------
 69.9             20              25              1             370        25035 OMP_SEC
 51.2         0.0075              18           0.25            0.25        73350 main
 51.2          0.023              18           0.25             0.5        73320 driver
 51.2          0.023              18           0.25             0.5        73320 main => driver
 51.1             10              18           0.25            0.25        73175 OMP_TSUM1
 51.1             10              18           0.25            0.25        73175 main => driver => OMP_TSUM1
 48.8        0.00125              17           0.75            0.75        23300 .TAU application
 48.8             15              17           0.75             259        23298 .TAU application => OMP_SEC
 21.1              5               7           0.25             111        30244 driver => OMP_TSUM1 => OMP_SEC
 13.6              4               4            370               0           13 F24
  6.9              2               2            259               0           10 .TAU application => OMP_SEC => F24
  6.7              2               2            111               0           22 OMP_TSUM1 => OMP_SEC => F24
  0.0         0.0132          0.0132           0.25               0           53 TAPAR
  0.0         0.0132          0.0132           0.25               0           53 main => driver => TAPAR
```
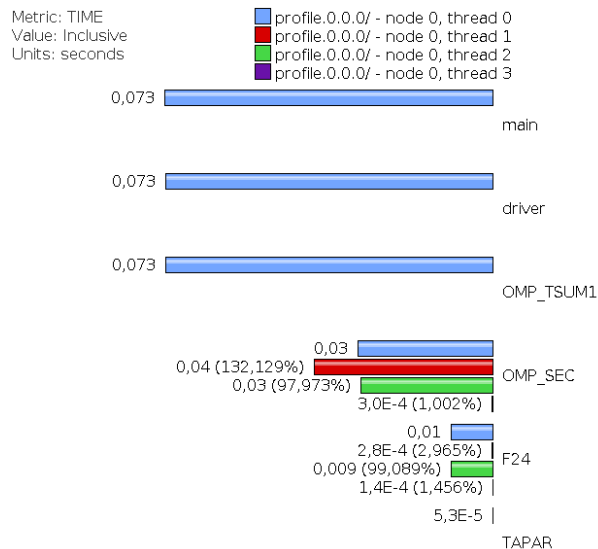

Figure 8: `OMP_Talbot1` on **TEST 1 - N. of Threads 4**: *Inclusive Time measured with TAU.*

– **TEST 1 – N. of Threads=8** (see Figure 9)

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```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        0.029          165           1           1     165564 main
100.0        0.092          165           1           2     165535 driver
100.0        0.092          165           1           2     165535 main => driver
 99.9          125          165           1           1     165389 OMP_TSUM1
 99.9          125          165           1           1     165389 main => driver => OMP_TSUM1
 24.3           40           40           1         296      40233 OMP_SEC
 24.3           40           40           1         296      40233 driver => OMP_TSUM1 => OMP_SEC
  0.1        0.204        0.204         296           0          1 F24
  0.1        0.204        0.204         296           0          1 OMP_TSUM1 => OMP_SEC => F24
  0.0        0.054        0.054           1           0         54 TAPAR
  0.0        0.054        0.054           1           0         54 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        0.002           39           1           1      39810 .TAU application
100.0           39           39           1         296      39808 .TAU application => OMP_SEC
100.0           39           39           1         296      39808 OMP_SEC
  1.3        0.508        0.508         296           0          2 .TAU application => OMP_SEC => F24
  1.3        0.508        0.508         296           0          2 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        0.006           39           1           1      39706 .TAU application
100.0           39           39           1         148      39700 .TAU application => OMP_SEC
100.0           39           39           1         148      39700 OMP_SEC
  0.3        0.119        0.119         148           0          1 .TAU application => OMP_SEC => F24
  0.3        0.119        0.119         148           0          1 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        0.002           20           1           1      20172 .TAU application
100.0           19           20           1         148      20170 .TAU application => OMP_SEC
100.0           19           20           1         148      20170 OMP_SEC
  1.6        0.318        0.318         148           0          2 .TAU application => OMP_SEC => F24
  1.6        0.318        0.318         148           0          2 F24

NODE 0;CONTEXT 0;THREAD 4:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        0.001           39           1           1      39584 .TAU application
```

```
100.0           39           39           1          148       39583 .TAU application => OMP_SEC
100.0           39           39           1          148       39583 OMP_SEC
  0.4        0.153        0.153         148            0           1 .TAU application => OMP_SEC => F24
  0.4        0.153        0.153         148            0           1 F24
```

NODE 0;CONTEXT 0;THREAD 5:
```
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
--------------------------------------------------------------------------------
100.0        0.001           39           1            1       39563 .TAU application
100.0           39           39           1          148       39562 .TAU application => OMP_SEC
100.0           39           39           1          148       39562 OMP_SEC
  0.4         0.17         0.17         148            0           1 .TAU application => OMP_SEC => F24
  0.4         0.17         0.17         148            0           1 F24
```

NODE 0;CONTEXT 0;THREAD 6:
```
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
--------------------------------------------------------------------------------
100.0            0           39           1            1       39963 .TAU application
100.0           39           39           1          148       39963 .TAU application => OMP_SEC
100.0           39           39           1          148       39963 OMP_SEC
  0.5        0.186        0.186         148            0           1 .TAU application => OMP_SEC => F24
  0.5        0.186        0.186         148            0           1 F24
```

NODE 0;CONTEXT 0;THREAD 7:
```
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
--------------------------------------------------------------------------------
100.0        0.001           39           1            1       39937 .TAU application
100.0           39           39           1          148       39936 .TAU application => OMP_SEC
100.0           39           39           1          148       39936 OMP_SEC
  0.5          0.2          0.2         148            0           1 .TAU application => OMP_SEC => F24
  0.5          0.2          0.2         148            0           1 F24
```

FUNCTION SUMMARY (total):
```
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
--------------------------------------------------------------------------------
 70.5        2,376        2,391          64        11840       37369 OMP_SEC
 61.0        0.104        2,069          56           56       36962 .TAU application
 61.0        2,056        2,069          56         9472       36960 .TAU application => OMP_SEC
 39.0        0.232        1,324           8            8      165564 main
 39.0        0.736        1,324           8           16      165535 driver
 39.0        0.736        1,324           8           16      165535 main => driver
 39.0        1,001        1,323           8            8      165389 OMP_TSUM1
 39.0        1,001        1,323           8            8      165389 main => driver => OMP_TSUM1
  9.5          320          321           8         2368       40233 driver => OMP_TSUM1 => OMP_SEC
  0.4           14           14       11840            0           1 F24
  0.4           13           13        9472            0           1 .TAU application => OMP_SEC => F24
  0.0            1            1        2368            0           1 OMP_TSUM1 => OMP_SEC => F24
  0.0        0.432        0.432           8            0          54 TAPAR
```

```
   0.0        0.432        0.432         8           0          54 main => driver => TAPAR

   FUNCTION SUMMARY (mean):
   ---------------------------------------------------------------------------------------
   %Time   Exclusive   Inclusive       #Call      #Subrs   Inclusive Name
             msec    total msec                           usec/call
   ---------------------------------------------------------------------------------------
   70.5          37           37           1         185       37369 OMP_SEC
   61.0     0.00162           32       0.875       0.875       36962 .TAU application
   61.0          32           32       0.875         148       36960 .TAU application => OMP_SEC
   39.0     0.00363           20       0.125       0.125      165564 main
   39.0      0.0115           20       0.125        0.25      165535 driver
   39.0      0.0115           20       0.125        0.25      165535 main => driver
   39.0          15           20       0.125       0.125      165389 OMP_TSUM1
   39.0          15           20       0.125       0.125      165389 main => driver => OMP_TSUM1
    9.5           5            5       0.125          37       40233 driver => OMP_TSUM1 => OMP_SEC
    0.4       0.232        0.232         185           0           1 F24
    0.4       0.207        0.207         148           0           1 .TAU application => OMP_SEC => F24
    0.0      0.0255       0.0255          37           0           1 OMP_TSUM1 => OMP_SEC => F24
    0.0     0.00675      0.00675       0.125           0          54 TAPAR
    0.0     0.00675      0.00675       0.125           0          54 main => driver => TAPAR
```

TEST 2 OMP_Talbot1 with *Input Data*: Test Function n. 24, NTval $= 100$, T1 interval.

  – **TEST 2 – N. of Threads=1** (see Figure 10)

```
   NODE 0;CONTEXT 0;THREAD 0:
   ---------------------------------------------------------------------------------------
   %Time   Exclusive   Inclusive       #Call      #Subrs   Inclusive Name
             msec    total msec                           usec/call
   ---------------------------------------------------------------------------------------
   100.0       0.031           12           1           1       12312 main
    99.7       0.092           12           1           2       12281 driver
    99.7       0.092           12           1           2       12281 main => driver
    98.5       0.052           12           1           1       12133 OMP_TSUM1
    98.5       0.052           12           1           1       12133 main => driver => OMP_TSUM1
    98.1           6           12           1       14800       12081 OMP_SEC
    98.1           6           12           1       14800       12081 driver => OMP_TSUM1 => OMP_SEC
    42.2           5            5       14800           0           0 F24
    42.2           5            5       14800           0           0 OMP_TSUM1 => OMP_SEC => F24
     0.5       0.056        0.056           1           0          56 TAPAR
     0.5       0.056        0.056           1           0          56 main => driver => TAPAR
```

  – **TEST 2 – N. of Threads=4** (see Figure 11)

```
   NODE 0;CONTEXT 0;THREAD 0:
   ---------------------------------------------------------------------------------------
   %Time   Exclusive   Inclusive       #Call      #Subrs   Inclusive Name
             msec    total msec                           usec/call
   ---------------------------------------------------------------------------------------
   100.0       0.031           33           1           1       33899 main
    99.9       0.096           33           1           2       33868 driver
    99.9       0.096           33           1           2       33868 main => driver
```
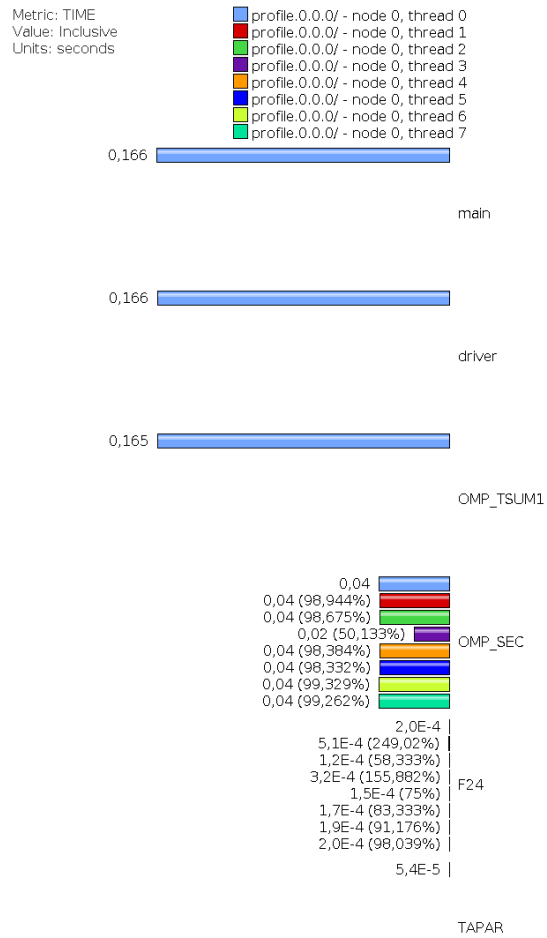
Figure 9: `OMP_Talbot1` on **TEST 1 - N. of Threads 8**: *Inclusive Time measured with TAU.*

```
99.5          26          33          1          1     33719 OMP_TSUM1
99.5          26          33          1          1     33719 main => driver => OMP_TSUM1
20.7           4           7          1       3700      7027 OMP_SEC
20.7           4           7          1       3700      7027 driver => OMP_TSUM1 => OMP_SEC
 6.0           2           2       3700          0         1 F24
 6.0           2           2       3700          0         1 OMP_TSUM1 => OMP_SEC => F24
 0.2       0.053       0.053          1          0        53 TAPAR
 0.2       0.053       0.053          1          0        53 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
-------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
```

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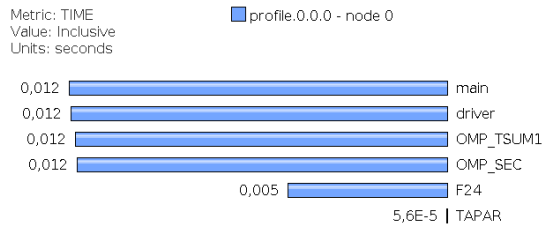
(a)
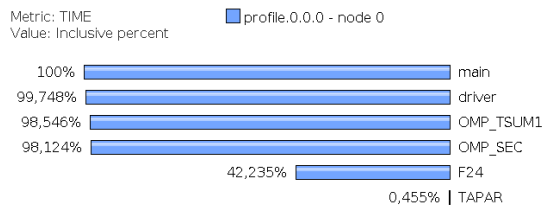
(b)

Figure 10: `OMP_Talbot1` on **TEST 2 - N. of Threads 1**: *Inclusive Time measured with TAU (a), values shown as percents (b).*

```
            msec    total msec                        usec/call
-----------------------------------------------------------------------------------
100.0      0.002          6           1           1        6587 .TAU application
100.0         3           6           1        3700        6585 .TAU application => OMP_SEC
100.0         3           6           1        3700        6585 OMP_SEC
 48.1         3           3        3700           0           1 .TAU application => OMP_SEC => F24
 48.1         3           3        3700           0           1 F24


NODE 0;CONTEXT 0;THREAD 2:
-----------------------------------------------------------------------------------
%Time   Exclusive   Inclusive      #Call      #Subrs  Inclusive Name
            msec    total msec                        usec/call
-----------------------------------------------------------------------------------
100.0      0.005          6           1           1        6642 .TAU application
 99.9         3           6           1        3700        6637 .TAU application => OMP_SEC
 99.9         3           6           1        3700        6637 OMP_SEC
 48.3         3           3        3700           0           1 .TAU application => OMP_SEC => F24
 48.3         3           3        3700           0           1 F24


NODE 0;CONTEXT 0;THREAD 3:
-----------------------------------------------------------------------------------
%Time   Exclusive   Inclusive      #Call      #Subrs  Inclusive Name
            msec    total msec                        usec/call
-----------------------------------------------------------------------------------
100.0      0.002          6           1           1        6856 .TAU application
100.0         4           6           1        3700        6854 .TAU application => OMP_SEC
100.0         4           6           1        3700        6854 OMP_SEC
 30.7         2           2        3700           0           1 .TAU application => OMP_SEC => F24
 30.7         2           2        3700           0           1 F24
```

```
FUNCTION SUMMARY (total):
-------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
-------------------------------------------------------------------------------
 62.8       0.124          135           4           4      33899 main
 62.7       0.384          135           4           8      33868 driver
 62.7       0.384          135           4           8      33868 main => driver
 62.5         106          134           4           4      33719 OMP_TSUM1
 62.5         106          134           4           4      33719 main => driver => OMP_TSUM1
 50.2          66          108          16       59200       6776 OMP_SEC
 37.2       0.036           80          12          12       6695 .TAU application
 37.2          46           80          12       44400       6692 .TAU application => OMP_SEC
 19.5          42           42       59200           0          1 F24
 15.7          33           33       44400           0          1 .TAU application => OMP_SEC => F24
 13.0          19           28           4       14800       7027 driver => OMP_TSUM1 => OMP_SEC
  3.8           8            8       14800           0          1 OMP_TSUM1 => OMP_SEC => F24
  0.1       0.212        0.212           4           0         53 TAPAR
  0.1       0.212        0.212           4           0         53 main => driver => TAPAR

FUNCTION SUMMARY (mean):
-------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
-------------------------------------------------------------------------------
 62.8     0.00775            8        0.25        0.25      33899 main
 62.7       0.024            8        0.25         0.5      33868 driver
 62.7       0.024            8        0.25         0.5      33868 main => driver
 62.5           6            8        0.25        0.25      33719 OMP_TSUM1
 62.5           6            8        0.25        0.25      33719 main => driver => OMP_TSUM1
 50.2           4            6           1        3700       6776 OMP_SEC
 37.2     0.00225            5        0.75        0.75       6695 .TAU application
 37.2           2            5        0.75        2775       6692 .TAU application => OMP_SEC
 19.5           2            2        3700           0          1 F24
 15.7           2            2        2775           0          1 .TAU application => OMP_SEC => F24
 13.0           1            1        0.25         925       7027 driver => OMP_TSUM1 => OMP_SEC
  3.8       0.511        0.511         925           0          1 OMP_TSUM1 => OMP_SEC => F24
  0.1      0.0132       0.0132        0.25           0         53 TAPAR
  0.1      0.0132       0.0132        0.25           0         53 main => driver => TAPAR
```

    – TEST 2 – N. of Threads=8 (see Figure 4.1.1)

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0       0.033            1           1           1       1296 main
 97.5       0.093            1           1          20       1263 driver
 97.5       0.093            1           1          20       1263 main => driver
 84.7       0.621            1          10         366        110 OMP_TSUM2
 84.7       0.621            1          10         366        110 main => driver => OMP_TSUM2
 36.8       0.477        0.477         366           0          1 F24
 36.8       0.477        0.477         366           0          1 main => driver => OMP_TSUM2 => F24
```
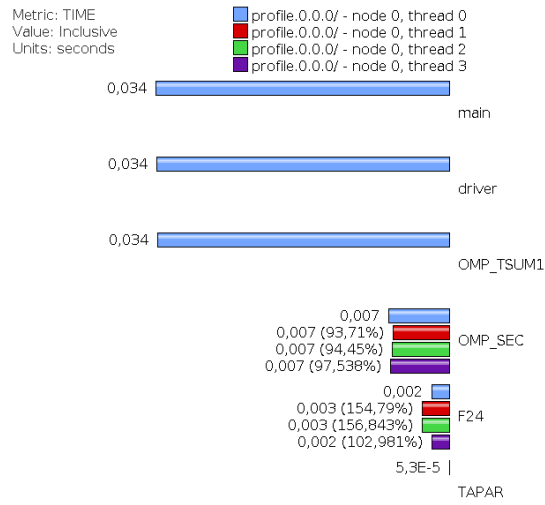
Figure 11: `OMP_Talbot1` on **TEST 2 - N. of Threads 4**: *Inclusive Time measured with TAU.*

```
        5.6         0.072         0.072          10             0           7 TAPAR
        5.6         0.072         0.072          10             0           7 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call       #Subrs  Inclusive Name
              msec   total msec                             usec/call
---------------------------------------------------------------------------------------
100.0        0.441        0.664           1          360         664 .TAU application
 33.6        0.223        0.223         360            0           1 .TAU application => F24
 33.6        0.223        0.223         360            0           1 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call       #Subrs  Inclusive Name
              msec   total msec                             usec/call
---------------------------------------------------------------------------------------
100.0        0.337        0.577           1          359         577 .TAU application
 41.6         0.24         0.24         359            0           1 .TAU application => F24
 41.6         0.24         0.24         359            0           1 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call       #Subrs  Inclusive Name
              msec   total msec                             usec/call
---------------------------------------------------------------------------------------
100.0        0.494         0.73           1          357         730 .TAU application
 32.3        0.236        0.236         357            0           1 .TAU application => F24
 32.3        0.236        0.236         357            0           1 F24

FUNCTION SUMMARY (total):
```

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```
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                           usec/call
--------------------------------------------------------------------------------
 60.3           1            1           3        1076        657 .TAU application
 39.7       0.033            1           1           1       1296 main
 38.7       0.093            1           1          20       1263 driver
 38.7       0.093            1           1          20       1263 main => driver
 36.0           1            1        1442           0          1 F24
 33.6       0.621            1          10         366        110 OMP_TSUM2
 33.6       0.621            1          10         366        110 main => driver => OMP_TSUM2
 21.4       0.699        0.699        1076           0          1 .TAU application => F24
 14.6       0.477        0.477         366           0          1 main => driver => OMP_TSUM2 => F24
  2.2       0.072        0.072          10           0          7 TAPAR
  2.2       0.072        0.072          10           0          7 main => driver => TAPAR

FUNCTION SUMMARY (mean):
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                           usec/call
--------------------------------------------------------------------------------
 60.3       0.318        0.493        0.75         269        657 .TAU application
 39.7     0.00825        0.324        0.25        0.25       1296 main
 38.7      0.0232        0.316        0.25           5       1263 driver
 38.7      0.0232        0.316        0.25           5       1263 main => driver
 36.0       0.294        0.294       360.5           0          1 F24
 33.6       0.155        0.275         2.5        91.5        110 OMP_TSUM2
 33.6       0.155        0.275         2.5        91.5        110 main => driver => OMP_TSUM2
 21.4       0.175        0.175         269           0          1 .TAU application => F24
 14.6       0.119        0.119        91.5           0          1 main => driver => OMP_TSUM2 => F24
  2.2       0.018        0.018         2.5           0          7 TAPAR
  2.2       0.018        0.018         2.5           0          7 main => driver => TAPAR
```

TEST 3 OMP_Talbot1 with *Input Data*: Test Function n. 24, NTval = 10, T2 interval.

  – TEST 3 – N. of Threads=1 (see Figure 13)

```
NODE 0;CONTEXT 0;THREAD 0:
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                           usec/call
--------------------------------------------------------------------------------
100.0        0.03          951           1           1     951507 main
100.0       0.091          951           1           2     951477 driver
100.0       0.091          951           1           2     951477 main => driver
100.0       0.055          951           1           1     951331 OMP_TSUM1
100.0       0.055          951           1           1     951331 main => driver => OMP_TSUM1
100.0         541          951           1 1.81999E+06     951276 OMP_SEC
100.0         541          951           1 1.81999E+06     951276 driver => OMP_TSUM1 => OMP_SEC
 43.1         410          410 1.81999E+06           0          0 F24
 43.1         410          410 1.81999E+06           0          0 OMP_TSUM1 => OMP_SEC => F24
  0.0       0.055        0.055           1           0         55 TAPAR
  0.0       0.055        0.055           1           0         55 main => driver => TAPAR
```

  – TEST 3 – N. of Threads=4 (see Figure 14)

Figure 12: `OMP_Talbot1` on **TEST 2 - N. of Threads 8**: *Inclusive Time measured with TAU.*

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec   total msec                           usec/call
---------------------------------------------------------------------------------
100.0       0.031          454          1           1   454242 main
100.0       0.082          454          1           2   454211 driver
100.0       0.082          454          1           2   454211 main => driver
100.0       0.232          454          1           1   454071 OMP_TSUM1
100.0       0.232          454          1           1   454071 main => driver => OMP_TSUM1
 99.9         254          453          1      545997   453839 OMP_SEC
 99.9         254          453          1      545997   453839 main => driver => OMP_TSUM1 => OMP_SEC
 44.0         199          199     545997           0        0 F24
 44.0         199          199     545997           0        0 driver => OMP_TSUM1 => OMP_SEC => F24
  0.0       0.058        0.058          1           0       58 TAPAR
  0.0       0.058        0.058          1           0       58 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec   total msec                           usec/call
---------------------------------------------------------------------------------
100.0       0.002          453          1           1   453390 .TAU application
```

24

Metric: TIME
Value: Inclusive
Units: seconds
☐ profile.0.0.0 - node 0

0,459 ▮ main
0,459 ▮ driver
0,459 ▮ OMP_TSUM1
0,459 ▮ OMP_SEC
0,036 ▮ F24 [THROTTLED]
5,4E-5 | TAPAR

(a)

Metric: TIME
Value: Inclusive percent
☐ profile.0.0.0 - node 0

100% ▮ main
99,997% ▮ driver
99,982% ▮ OMP_TSUM1
99,976% ▮ OMP_SEC
43,103% ▮ F24
0,006% | TAPAR

(b)

Figure 13: `OMP_Talbot1` on **TEST 3 - N. of Threads 1**: *Inclusive Time measured with TAU (a), values shown as percents (b).*

```
100.0          250          453           1       545997      453388 .TAU application => OMP_SEC
100.0          250          453           1       545997      453388 OMP_SEC
 44.7          202          202      545997            0           0 .TAU application => OMP_SEC => F24
 44.7          202          202      545997            0           0 F24


NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------------
%Time     Exclusive     Inclusive        #Call      #Subrs  Inclusive Name
              msec    total msec                              usec/call
---------------------------------------------------------------------------------------
100.0         0.002          453            1            1      453540 .TAU application
100.0           295          453            1       363998      453538 .TAU application => OMP_SEC
100.0           295          453            1       363998      453538 OMP_SEC
 34.8           157          157       363998            0           0 .TAU application => OMP_SEC => F24
 34.8           157          157       363998            0           0 F24


NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------------
%Time     Exclusive     Inclusive        #Call      #Subrs  Inclusive Name
              msec    total msec                              usec/call
---------------------------------------------------------------------------------------
100.0         0.001          453            1            1      453540 .TAU application
100.0           297          453            1       363998      453539 .TAU application => OMP_SEC
100.0           297          453            1       363998      453539 OMP_SEC
 34.4           155          155       363998            0           0 .TAU application => OMP_SEC => F24
 34.4           155          155       363998            0           0 F24


FUNCTION SUMMARY (total):
---------------------------------------------------------------------------------------
%Time     Exclusive     Inclusive        #Call      #Subrs  Inclusive Name
```

25

```
               msec    total msec                            usec/call
   -----------------------------------------------------------------------------------
   100.0        1,098         1,814             4 1.81999E+06        453576 OMP_SEC
    75.0        0.005         1,360             3          3         453490 .TAU application
    75.0          844         1,360             3 1.27399E+06        453488 .TAU application => OMP_SEC
    39.5          715           715 1.81999E+06          0              0 F24
    28.4          516           516 1.27399E+06          0              0 .TAU application => OMP_SEC => F24
    25.0        0.031           454             1          1         454242 main
    25.0        0.082           454             1          2         454211 driver
    25.0        0.082           454             1          2         454211 main => driver
    25.0        0.232           454             1          1         454071 OMP_TSUM1
    25.0        0.232           454             1          1         454071 main => driver => OMP_TSUM1
    25.0          254           453             1     545997         453839 main => driver => OMP_TSUM1 => OMP_SEC
    11.0          199           199        545997          0              0 driver => OMP_TSUM1 => OMP_SEC => F24
     0.0        0.058         0.058             1          0             58 TAPAR
     0.0        0.058         0.058             1          0             58 main => driver => TAPAR

   FUNCTION SUMMARY (mean):
   -----------------------------------------------------------------------------------
   %Time     Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
                 msec   total msec                           usec/call
   -----------------------------------------------------------------------------------
   100.0          274           453             1     454998         453576 OMP_SEC
    75.0      0.00125           340          0.75       0.75         453490 .TAU application
    75.0          211           340          0.75     318498         453488 .TAU application => OMP_SEC
    39.5          178           178        454998          0              0 F24
    28.4          129           129        318498          0              0 .TAU application => OMP_SEC => F24
    25.0      0.00775           113          0.25       0.25         454242 main
    25.0       0.0205           113          0.25        0.5         454211 driver
    25.0       0.0205           113          0.25        0.5         454211 main => driver
    25.0        0.058           113          0.25       0.25         454071 OMP_TSUM1
    25.0        0.058           113          0.25       0.25         454071 main => driver => OMP_TSUM1
    25.0           63           113          0.25     136499         453839 main => driver => OMP_TSUM1 => OMP_SEC
    11.0           49            49        136499          0              0 driver => OMP_TSUM1 => OMP_SEC => F24
     0.0       0.0145        0.0145          0.25          0             58 TAPAR
     0.0       0.0145        0.0145          0.25          0             58 main => driver => TAPAR
```
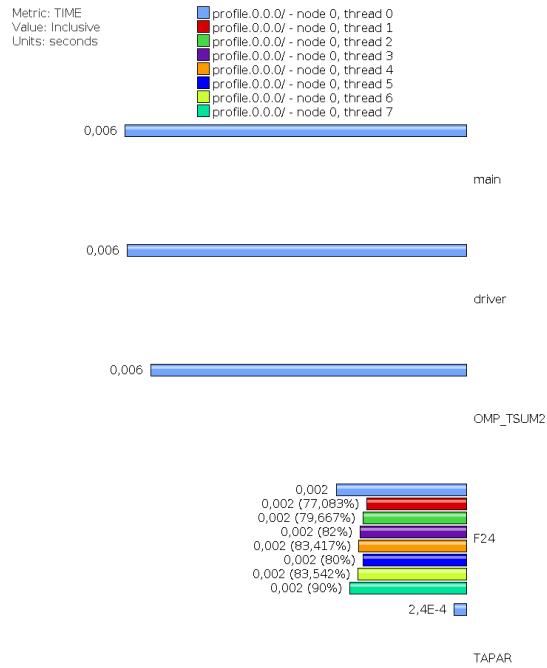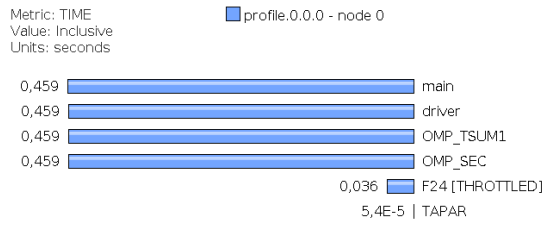
  – **TEST 3 – N. of Threads=8** (see Figure 15)

```
   NODE 0;CONTEXT 0;THREAD 0:
   -----------------------------------------------------------------------------------
   %Time     Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
                 msec   total msec                           usec/call
   -----------------------------------------------------------------------------------
   100.0        0.031           454             1          1         454242 main
   100.0        0.082           454             1          2         454211 driver
   100.0        0.082           454             1          2         454211 main => driver
   100.0        0.232           454             1          1         454071 OMP_TSUM1
   100.0        0.232           454             1          1         454071 main => driver => OMP_TSUM1
    99.9          254           453             1     545997         453839 OMP_SEC
    99.9          254           453             1     545997         453839 main => driver => OMP_TSUM1 => OMP_SEC
    44.0          199           199        545997          0              0 F24
    44.0          199           199        545997          0              0 driver => OMP_TSUM1 => OMP_SEC => F24
     0.0        0.058         0.058             1          0             58 TAPAR
     0.0        0.058         0.058             1          0             58 main => driver => TAPAR
```

Figure 14: `OMP_Talbot1` on **TEST 3 - N. of Threads 4**: *Inclusive Time measured with TAU.*

```
NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
             msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0        0.002          453          1           1     453390 .TAU application
100.0          250          453          1      545997     453388 .TAU application => OMP_SEC
100.0          250          453          1      545997     453388 OMP_SEC
 44.7          202          202     545997           0          0 .TAU application => OMP_SEC => F24
 44.7          202          202     545997           0          0 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
             msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0        0.002          453          1           1     453540 .TAU application
100.0          295          453          1      363998     453538 .TAU application => OMP_SEC
100.0          295          453          1      363998     453538 OMP_SEC
 34.8          157          157     363998           0          0 .TAU application => OMP_SEC => F24
 34.8          157          157     363998           0          0 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
             msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0        0.001          453          1           1     453540 .TAU application
100.0          297          453          1      363998     453539 .TAU application => OMP_SEC
100.0          297          453          1      363998     453539 OMP_SEC
```

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```
34.4          155          155       363998             0           0 .TAU application => OMP_SEC => F24
34.4          155          155       363998             0           0 F24

FUNCTION SUMMARY (total):
-----------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
              msec   total msec                         usec/call
-----------------------------------------------------------------------------------------
100.0        1,098        1,814          4 1.81999E+06     453576 OMP_SEC
 75.0        0.005        1,360          3           3     453490 .TAU application
 75.0          844        1,360          3 1.27399E+06     453488 .TAU application => OMP_SEC
 39.5          715          715 1.81999E+06         0          0 F24
 28.4          516          516 1.27399E+06         0          0 .TAU application => OMP_SEC => F24
 25.0        0.031          454          1           1     454242 main
 25.0        0.082          454          1           2     454211 driver
 25.0        0.082          454          1           2     454211 main => driver
 25.0        0.232          454          1           1     454071 OMP_TSUM1
 25.0        0.232          454          1           1     454071 main => driver => OMP_TSUM1
 25.0          254          453          1      545997     453839 main => driver => OMP_TSUM1 => OMP_SEC
 11.0          199          199     545997           0          0 driver => OMP_TSUM1 => OMP_SEC => F24
  0.0        0.058        0.058          1           0         58 TAPAR
  0.0        0.058        0.058          1           0         58 main => driver => TAPAR

FUNCTION SUMMARY (mean):
-----------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
              msec   total msec                         usec/call
-----------------------------------------------------------------------------------------
100.0          274          453          1      454998     453576 OMP_SEC
 75.0      0.00125          340       0.75        0.75     453490 .TAU application
 75.0          211          340       0.75      318498     453488 .TAU application => OMP_SEC
 39.5          178          178     454998           0          0 F24
 28.4          129          129     318498           0          0 .TAU application => OMP_SEC => F24
 25.0      0.00775          113       0.25        0.25     454242 main
 25.0       0.0205          113       0.25         0.5     454211 driver
 25.0       0.0205          113       0.25         0.5     454211 main => driver
 25.0        0.058          113       0.25        0.25     454071 OMP_TSUM1
 25.0        0.058          113       0.25        0.25     454071 main => driver => OMP_TSUM1
 25.0           63          113       0.25      136499     453839 main => driver => OMP_TSUM1 => OMP_SEC
 11.0           49           49     136499           0          0 driver => OMP_TSUM1 => OMP_SEC => F24
  0.0       0.0145       0.0145       0.25           0         58 TAPAR
  0.0       0.0145       0.0145       0.25           0         58 main => driver => TAPAR
```

TEST 4 OMP_Talbot1 with *Input Data*: Test Function n. 24, NTval = 100, T2 interval.

    – TEST 4 – N. of Threads=1 (see Figure 16)

```
NODE 0;CONTEXT 0;THREAD 0:
-----------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
              msec   total msec                         usec/call
-----------------------------------------------------------------------------------------
100.0        0.032        8,728          1           1    8728895 main
100.0        0.093        8,728          1           2    8728863 driver
100.0        0.093        8,728          1           2    8728863 main => driver
```

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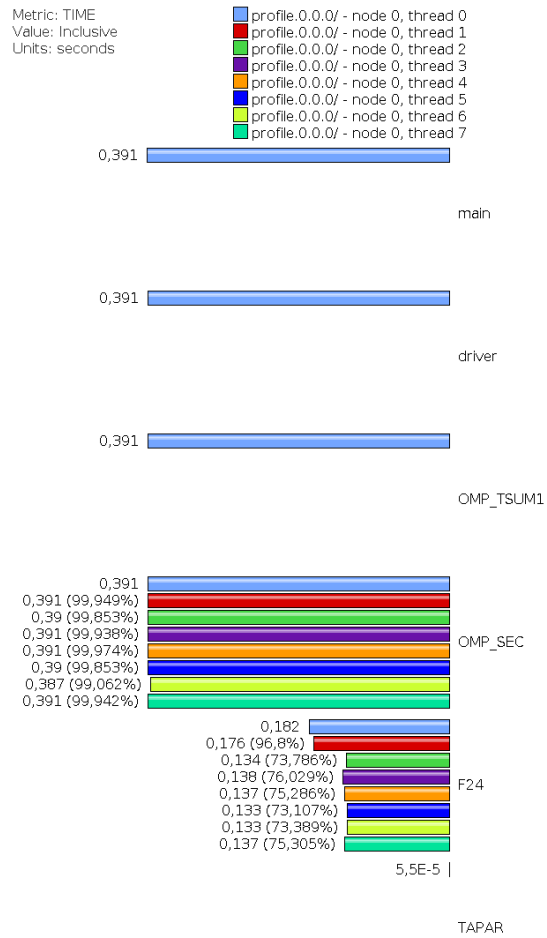
Figure 15: `OMP‗Talbot1` on **TEST 3 - N. of Threads 8**: *Inclusive Time measured with TAU.*

```
100.0      0.051      8,728           1           1    8728715 OMP_TSUM1
100.0      0.051      8,728           1           1    8728715 main => driver => OMP_TSUM1
100.0      5,007      8,728           1 1.81999E+07   8728664 OMP_SEC
100.0      5,007      8,728           1 1.81999E+07   8728664 main => driver => OMP_TSUM1 => OMP_SEC
 42.6      3,720      3,720 1.81999E+07           0         0 F24
 42.6      3,720      3,720 1.81999E+07           0         0 driver => OMP_TSUM1 => OMP_SEC => F24
  0.0      0.055      0.055           1           0        55 TAPAR
  0.0      0.055      0.055           1           0        55 main => driver => TAPAR
```
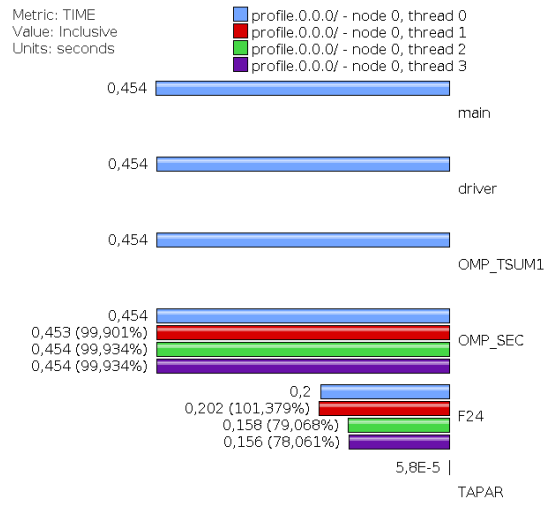
– **TEST 4 – N. of Threads=4** (see Figure 17)

```
NODE 0;CONTEXT 0;THREAD 0:
```

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Metric: TIME
Value: Inclusive
Units: seconds

☐ profile.0.0.0 - node 0

8,729	main
8,729	driver
8,729	OMP_TSUM1
8,729	OMP_SEC
3,721	F24
5,5E-5	TAPAR

(a)

Metric: TIME
Value: Inclusive percent

☐ profile.0.0.0 - node 0

100%	main
100%	driver
99,998%	OMP_TSUM1
99,997%	OMP_SEC
42,628%	F24
6,3E-4%	TAPAR
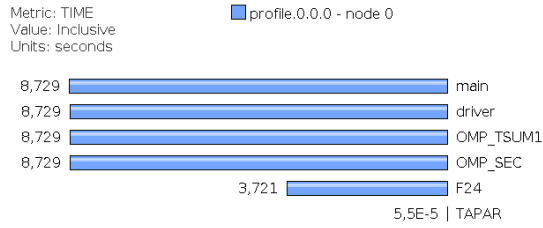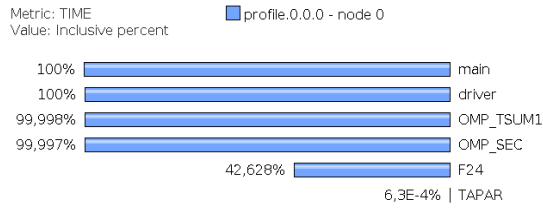
(b)

Figure 16: `OMP_Talbot1` on **TEST 4 - N. of Threads 1**: *Inclusive Time measured with TAU (a), values shown as percents (b).*

```
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec   total msec                          usec/call
--------------------------------------------------------------------------------
100.0       0.033        3,518          1          1    3518673 main
100.0       0.091        3,518          1          2    3518640 driver
100.0       0.091        3,518          1          2    3518640 main => driver
100.0       0.361        3,518          1          1    3518493 OMP_TSUM1
100.0       0.361        3,518          1          1    3518493 main => driver => OMP_TSUM1
100.0       2,029        3,518          1 4.54998E+06  3518132 OMP_SEC
100.0       2,029        3,518          1 4.54998E+06  3518132 main => driver => OMP_TSUM1 => OMP_SEC
 42.3       1,488        1,488 4.54998E+06          0          0 F24
 42.3       1,488        1,488 4.54998E+06          0          0 driver => OMP_TSUM1 => OMP_SEC => F24
  0.0       0.056        0.056          1          0         56 TAPAR
  0.0       0.056        0.056          1          0         56 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec   total msec                          usec/call
--------------------------------------------------------------------------------
100.0       0.001        3,517          1          1    3517962 .TAU application
100.0       1,963        3,517          1 4.54998E+06  3517961 .TAU application => OMP_SEC
100.0       1,963        3,517          1 4.54998E+06  3517961 OMP_SEC
 44.2       1,554        1,554 4.54998E+06          0          0 .TAU application => OMP_SEC => F24
 44.2       1,554        1,554 4.54998E+06          0          0 F24

NODE 0;CONTEXT 0;THREAD 2:
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
```

```
              msec    total msec                              usec/call
------------------------------------------------------------------------------------
100.0         0.001        3,518             1            1   3518024 .TAU application
100.0         2,013        3,518             1 4.54998E+06   3518023 .TAU application => OMP_SEC
100.0         2,013        3,518             1 4.54998E+06   3518023 OMP_SEC
 42.8         1,504        1,504 4.54998E+06            0         0 .TAU application => OMP_SEC => F24
 42.8         1,504        1,504 4.54998E+06            0         0 F24

NODE 0;CONTEXT 0;THREAD 3:
------------------------------------------------------------------------------------
%Time     Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec    total msec                              usec/call
------------------------------------------------------------------------------------
100.0         0.001        3,517             1            1   3517882 .TAU application
100.0         1,977        3,517             1 4.54998E+06   3517881 .TAU application => OMP_SEC
100.0         1,977        3,517             1 4.54998E+06   3517881 OMP_SEC
 43.8         1,540        1,540 4.54998E+06            0         0 .TAU application => OMP_SEC => F24
 43.8         1,540        1,540 4.54998E+06            0         0 F24

FUNCTION SUMMARY (total):
------------------------------------------------------------------------------------
%Time     Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec    total msec                              usec/call
------------------------------------------------------------------------------------
100.0         7,984       14,071             4 1.81999E+07   3517999 OMP_SEC
 75.0         0.003       10,553             3            3   3517956 .TAU application
 75.0         5,954       10,553             3 1.36499E+07   3517955 .TAU application => OMP_SEC
 43.3         6,087        6,087 1.81999E+07            0         0 F24
 32.7         4,599        4,599 1.36499E+07            0         0 .TAU application => OMP_SEC => F24
 25.0         0.033        3,518             1            1   3518673 main
 25.0         0.091        3,518             1            2   3518640 driver
 25.0         0.091        3,518             1            2   3518640 main => driver
 25.0         0.361        3,518             1            1   3518493 OMP_TSUM1
 25.0         0.361        3,518             1            1   3518493 main => driver => OMP_TSUM1
 25.0         2,029        3,518             1 4.54998E+06   3518132 main => driver => OMP_TSUM1 => OMP_SEC
 10.6         1,488        1,488 4.54998E+06            0         0 driver => OMP_TSUM1 => OMP_SEC => F24
  0.0         0.056        0.056             1            0        56 TAPAR
  0.0         0.056        0.056             1            0        56 main => driver => TAPAR

FUNCTION SUMMARY (mean):
------------------------------------------------------------------------------------
%Time     Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec    total msec                              usec/call
------------------------------------------------------------------------------------
100.0         1,996        3,517             1 4.54998E+06   3517999 OMP_SEC
 75.0       0.00075        2,638          0.75         0.75   3517956 .TAU application
 75.0         1,488        2,638          0.75 3.41248E+06   3517955 .TAU application => OMP_SEC
 43.3         1,521        1,521 4.54998E+06            0         0 F24
 32.7         1,149        1,149 3.41248E+06            0         0 .TAU application => OMP_SEC => F24
 25.0       0.00825          879          0.25         0.25   3518673 main
 25.0        0.0227          879          0.25          0.5   3518640 driver
 25.0        0.0227          879          0.25          0.5   3518640 main => driver
 25.0        0.0902          879          0.25         0.25   3518493 OMP_TSUM1
 25.0        0.0902          879          0.25         0.25   3518493 main => driver => OMP_TSUM1
 25.0           507          879          0.25 1.13749E+06   3518132 main => driver => OMP_TSUM1 => OMP_SEC
 10.6           372          372 1.13749E+06            0         0 driver => OMP_TSUM1 => OMP_SEC => F24
```

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```
0.0          0.014          0.014          0.25             0          56 TAPAR
0.0          0.014          0.014          0.25             0          56 main => driver => TAPAR
```



```
Metric: TIME        ▩ profile.0.0.0/ - node 0, thread 0
Value: Inclusive    ▩ profile.0.0.0/ - node 0, thread 1
Units: seconds      ▩ profile.0.0.0/ - node 0, thread 2
                    ▩ profile.0.0.0/ - node 0, thread 3

3,519                                                              main

3,519                                                              driver

3,518                                                              OMP_TSUM1

3,518                                                              OMP_SEC
3,518 (99,995%)
3,518 (99,997%)
3,518 (99,993%)

            1,488                                                  F24
1,555 (104,454%)
1,505 (101,086%)
1,54 (103,463%)
                    5,6E-5                                         TAPAR
```

Figure 17: `OMP_Talbot1` on **TEST 4 - N. of Threads 4**: *Inclusive Time measured with TAU.*

– **TEST 4 – N. of Threads=8** (see Figure 18)

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------------
%Time   Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec    total msec                         usec/call
---------------------------------------------------------------------------------------
100.0        0.033        3,518          1          1  3518673 main
100.0        0.091        3,518          1          2  3518640 driver
100.0        0.091        3,518          1          2  3518640 main => driver
100.0        0.361        3,518          1          1  3518493 OMP_TSUM1
100.0        0.361        3,518          1          1  3518493 main => driver => OMP_TSUM1
100.0        2,029        3,518          1 4.54998E+06  3518132 OMP_SEC
100.0        2,029        3,518          1 4.54998E+06  3518132 main => driver => OMP_TSUM1 => OMP_SEC
 42.3        1,488        1,488 4.54998E+06          0        0 F24
 42.3        1,488        1,488 4.54998E+06          0        0 driver => OMP_TSUM1 => OMP_SEC => F24
  0.0        0.056        0.056          1          0       56 TAPAR
  0.0        0.056        0.056          1          0       56 main => driver => TAPAR


NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------------
%Time   Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec    total msec                         usec/call
---------------------------------------------------------------------------------------
100.0        0.001        3,517          1          1  3517962 .TAU application
100.0        1,963        3,517          1 4.54998E+06  3517961 .TAU application => OMP_SEC
100.0        1,963        3,517          1 4.54998E+06  3517961 OMP_SEC
```

```
44.2        1,554         1,554 4.54998E+06              0           0 .TAU application => OMP_SEC => F24
44.2        1,554         1,554 4.54998E+06              0           0 F24


NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        0.001         3,518           1           1    3518024 .TAU application
100.0        2,013         3,518           1 4.54998E+06    3518023 .TAU application => OMP_SEC
100.0        2,013         3,518           1 4.54998E+06    3518023 OMP_SEC
 42.8        1,504         1,504 4.54998E+06              0           0 .TAU application => OMP_SEC => F24
 42.8        1,504         1,504 4.54998E+06              0           0 F24


NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        0.001         3,517           1           1    3517882 .TAU application
100.0        1,977         3,517           1 4.54998E+06    3517881 .TAU application => OMP_SEC
100.0        1,977         3,517           1 4.54998E+06    3517881 OMP_SEC
 43.8        1,540         1,540 4.54998E+06              0           0 .TAU application => OMP_SEC => F24
 43.8        1,540         1,540 4.54998E+06              0           0 F24


FUNCTION SUMMARY (total):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        7,984        14,071           4 1.81999E+07    3517999 OMP_SEC
 75.0        0.003        10,553           3           3    3517956 .TAU application
 75.0        5,954        10,553           3 1.36499E+07    3517955 .TAU application => OMP_SEC
 43.3        6,087         6,087 1.81999E+07              0           0 F24
 32.7        4,599         4,599 1.36499E+07              0           0 .TAU application => OMP_SEC => F24
 25.0        0.033         3,518           1           1    3518673 main
 25.0        0.091         3,518           1           2    3518640 driver
 25.0        0.091         3,518           1           2    3518640 main => driver
 25.0        0.361         3,518           1           1    3518493 OMP_TSUM1
 25.0        0.361         3,518           1           1    3518493 main => driver => OMP_TSUM1
 25.0        2,029         3,518           1 4.54998E+06    3518132 main => driver => OMP_TSUM1 => OMP_SEC
 10.6        1,488         1,488 4.54998E+06              0           0 driver => OMP_TSUM1 => OMP_SEC => F24
  0.0        0.056         0.056           1           0          56 TAPAR
  0.0        0.056         0.056           1           0          56 main => driver => TAPAR


FUNCTION SUMMARY (mean):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        1,996         3,517           1 4.54998E+06    3517999 OMP_SEC
 75.0      0.00075         2,638        0.75        0.75    3517956 .TAU application
 75.0        1,488         2,638        0.75 3.41248E+06    3517955 .TAU application => OMP_SEC
 43.3        1,521         1,521 4.54998E+06              0           0 F24
 32.7        1,149         1,149 3.41248E+06              0           0 .TAU application => OMP_SEC => F24
 25.0      0.00825           879        0.25        0.25    3518673 main
```

```
25.0        0.0227         879         0.25          0.5      3518640 driver
25.0        0.0227         879         0.25          0.5      3518640 main => driver
25.0        0.0902         879         0.25          0.25     3518493 OMP_TSUM1
25.0        0.0902         879         0.25          0.25     3518493 main => driver => OMP_TSUM1
25.0        507            879         0.25   1.13749E+06     3518132 main => driver => OMP_TSUM1 => OMP_SEC
10.6        372            372  1.13749E+06          0              0 driver => OMP_TSUM1 => OMP_SEC => F24
 0.0        0.014          0.014       0.25          0              56 TAPAR
 0.0        0.014          0.014       0.25          0              56 main => driver => TAPAR
```
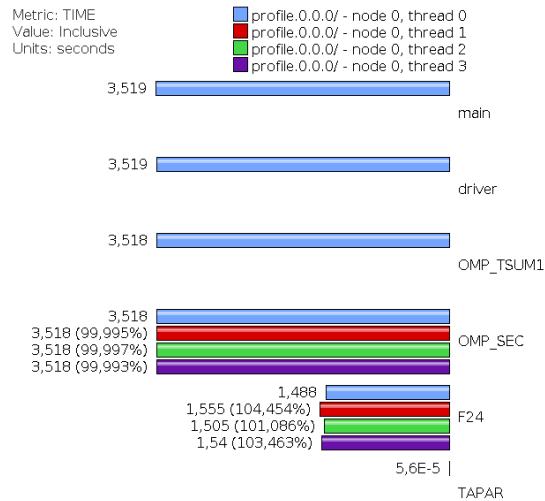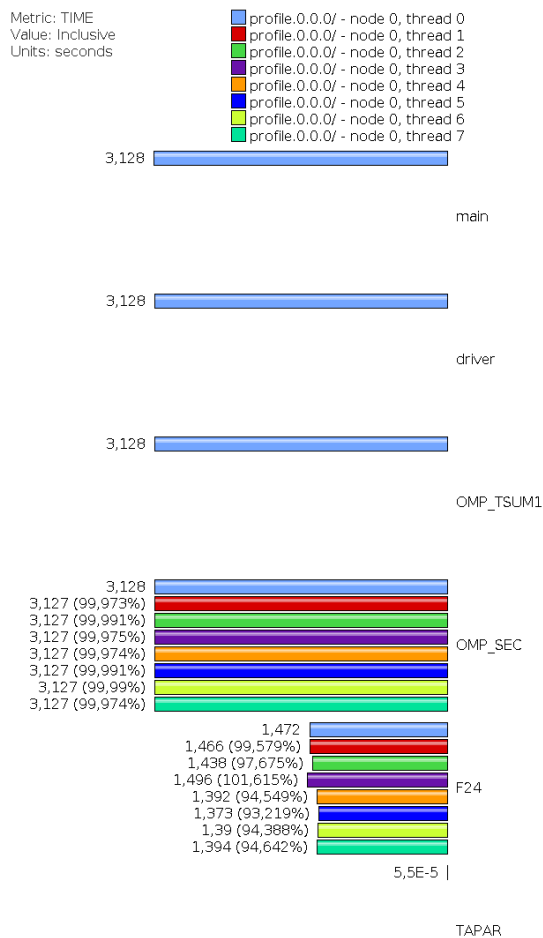

Figure 18: `OMP_Talbot1` on **TEST 4 - N. of Threads 8**: *Inclusive Time measured with TAU.*

4.1.2   OMP_ Talbot2

OMP_Talbot2 driver function is the OMP implementation of **Algorithm 2**. It calls the two computational functions TAPAR and OMP_TSUM2. Figure 19 depicts a general case of the execution time distribution when running OMP_Talbot2 on one thread. So, we set TAU_CALLPATH_DEPTH = 5 according to call tree depth of the function. OMP_SEC is the OMP section in OMP_TSUM2, implementing multi-threading parallel version of the step **2 Algorithm 2**. Since we instrumented manually the source code of OMP_TSUM2 inserting the time measurements of OMP_SEC for each thread, TAU profiler tools used a special timer[12] showing in Name column of the profiling tables (excepted for the master) the call to .TAU application.

(a)

(b)
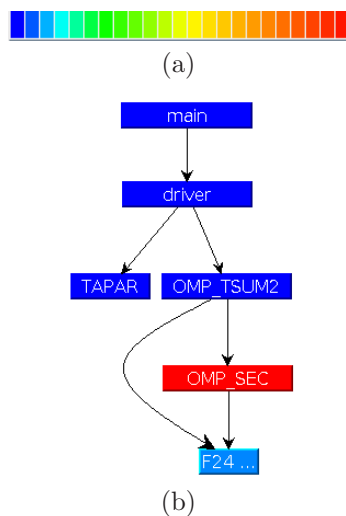
Figure 19: *Call Graph of* OMP_TSUM2 *(b), legend colour of increasing (exclusive) execution time (a).*

In the following, we reported the performance analysis of OMP_Talbot2 in the four tests described above, by means callpath profile and the corresponding *thread comparison window*. We can summarize that our analysis has shown that the OMP implementation of the **Algorithm 2** provides a considerable reduction of the execution time of the driver functions OMP_Talbot2. In particular, **TEST 2** and **TEST 4** exhibit a balanced computational load among the threads as well as a reduction of the execution time with respect to number of threads (increasing speedup). Similar results have been observed on **TEST 3**, whereas on **TEST 1** we observe a slight load imbalance produced by the very low computational cost of the test.

You can find the details about the results about OMP_Talbot2 on a specific test searching the point list **TESTx - N. of Threads=y**, where **x**= $1, \ldots, 4$ and **y**=1,4,8.

TEST 1 OMP_Talbot2 with *Input Data*: Test Function n. 24, NTval = 10, T1 interval.

---

[12].TAU application is a timer creates at the start of thread execution which is then stopped at the end of program execution.
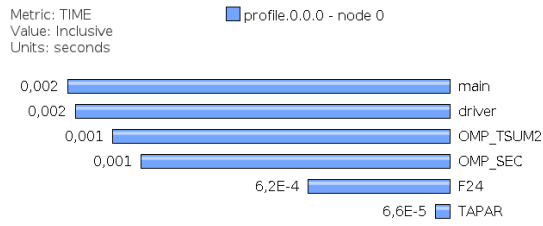
(a)
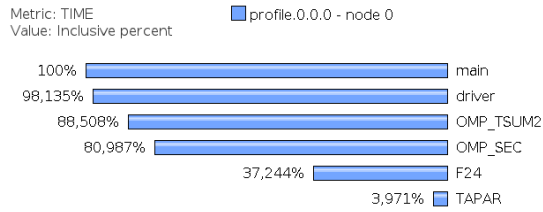
(b)

Figure 20: `OMP_Talbot2` on **TEST 1 - N. of Threads 1**: *Inclusive Time measured with TAU (a), values shown as percents (b).*

– **TEST 1 – N. of Threads=1** (see Figure 20)

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                            usec/call
---------------------------------------------------------------------------------------
100.0        0.031            1           1           1       1662 main
 98.1        0.094            1           1          20       1631 driver
 98.1        0.094            1           1          20       1631 main => driver
 88.5        0.093            1          10          20        147 OMP_TSUM2
 88.5        0.093            1          10          20        147 main => driver => OMP_TSUM2
 81.0        0.759            1          10        1432        135 OMP_SEC
 81.0        0.759            1          10        1432        135 driver => OMP_TSUM2 => OMP_SEC
 37.2        0.619        0.619        1442           0          0 F24
 35.3        0.587        0.587        1432           0          0 OMP_TSUM2 => OMP_SEC => F24
  4.0        0.066        0.066          10           0          7 TAPAR
  4.0        0.066        0.066          10           0          7 main => driver => TAPAR
  1.9        0.032        0.032          10           0          3 driver => OMP_TSUM2 => F24
```

– **TEST 1 – N. of Threads=4**

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                            usec/call
---------------------------------------------------------------------------------------
```

36

```
100.0      0.029        28            1            1      28969 main
 99.9      0.092        28            1           20      28940 driver
 99.9      0.092        28            1           20      28940 main => driver
 99.3        18         28           10           20       2878 OMP_TSUM2
 99.3        18         28           10           20       2878 main => driver => OMP_TSUM2
 37.0         1         10           10          356       1072 OMP_SEC
 37.0         1         10           10          356       1072 driver => OMP_TSUM2 => OMP_SEC
 33.5         9          9          366            0         27 F24
 33.4         9          9          356            0         27 OMP_TSUM2 => OMP_SEC => F24
  0.2      0.069      0.069          10            0          7 TAPAR
  0.2      0.069      0.069          10            0          7 main => driver => TAPAR
  0.1      0.032      0.032          10            0          3 driver => OMP_TSUM2 => F24

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0      0.099        10            1           10      10256 .TAU application
 99.0         9         10           10          360       1016 .TAU application => OMP_SEC
 99.0         9         10           10          360       1016 OMP_SEC
  4.7      0.485      0.485         360            0          1 .TAU application => OMP_SEC => F24
  4.7      0.485      0.485         360            0          1 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0      0.101      0.667           1           10        667 .TAU application
 84.9      0.29       0.566          10          359         57 .TAU application => OMP_SEC
 84.9      0.29       0.566          10          359         57 OMP_SEC
 41.4      0.276      0.276         359            0          1 .TAU application => OMP_SEC => F24
 41.4      0.276      0.276         359            0          1 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0      0.099      0.759           1           10        759 .TAU application
 87.0      0.413      0.66           10          357         66 .TAU application => OMP_SEC
 87.0      0.413      0.66           10          357         66 OMP_SEC
 32.5      0.247      0.247         357            0          1 .TAU application => OMP_SEC => F24
 32.5      0.247      0.247         357            0          1 F24

FUNCTION SUMMARY (total):
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
 71.3      0.116       115            4            4      28969 main
 71.2      0.368       115            4           80      28940 driver
 71.2      0.368       115            4           80      28940 main => driver
 70.8        72        115           40           80       2878 OMP_TSUM2
 70.8        72        115           40           80       2878 main => driver => OMP_TSUM2
```

```
54.4          45          88          160        5728         553 OMP_SEC
28.7           1          46           12         120        3894 .TAU application
28.0          41          45          120        4304         379 .TAU application => OMP_SEC
26.4           4          42           40        1424        1072 driver => OMP_TSUM2 => OMP_SEC
26.3          42          42         5768           0           7 F24
23.8          38          38         1424           0          27 OMP_TSUM2 => OMP_SEC => F24
 2.5           4           4         4304           0           1 .TAU application => OMP_SEC => F24
 0.2       0.276       0.276           40           0           7 TAPAR
 0.2       0.276       0.276           40           0           7 main => driver => TAPAR
 0.1       0.128       0.128           40           0           3 driver => OMP_TSUM2 => F24

FUNCTION SUMMARY (mean):
-------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
-------------------------------------------------------------------------------
 71.3      0.00725            7        0.25        0.25      28969 main
 71.2        0.023            7        0.25           5      28940 driver
 71.2        0.023            7        0.25           5      28940 main => driver
 70.8            4            7         2.5           5       2878 OMP_TSUM2
 70.8            4            7         2.5           5       2878 main => driver => OMP_TSUM2
 54.4            2            5          10         358        553 OMP_SEC
 28.7       0.0747            2        0.75         7.5       3894 .TAU application
 28.0            2            2         7.5         269        379 .TAU application => OMP_SEC
 26.4        0.263            2         2.5          89       1072 driver => OMP_TSUM2 => OMP_SEC
 26.3            2            2       360.5           0          7 F24
 23.8            2            2          89           0         27 OMP_TSUM2 => OMP_SEC => F24
  2.5        0.252        0.252         269           0          1 .TAU application => OMP_SEC => F24
  0.2       0.0173       0.0173         2.5           0          7 TAPAR
  0.2       0.0173       0.0173         2.5           0          7 main => driver => TAPAR
  0.1        0.008        0.008         2.5           0          3 driver => OMP_TSUM2 => F24
```
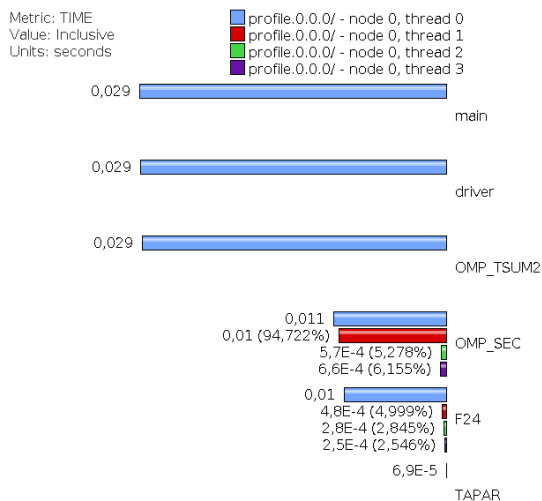

Figure 21: OMP_Talbot2 on **TEST 1 - N. of Threads 4**: *Inclusive Time measured with TAU.*

– TEST 1 – N. of Threads=8

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec   total msec                           usec/call
---------------------------------------------------------------------------------
100.0         0.03        1,003          1           1  1003435 main
100.0        0.093        1,003          1          20  1003405 driver
100.0        0.093        1,003          1          20  1003405 main => driver
100.0          692        1,003         10          20   100324 OMP_TSUM2
100.0          692        1,003         10          20   100324 main => driver => OMP_TSUM2
 30.9          310          310         10         176    31024 OMP_SEC
 30.9          310          310         10         176    31024 driver => OMP_TSUM2 => OMP_SEC
  0.0        0.261        0.261        186           0        1 F24
  0.0        0.226        0.226        176           0        1 OMP_TSUM2 => OMP_SEC => F24
  0.0        0.069        0.069         10           0        7 TAPAR
  0.0        0.069        0.069         10           0        7 main => driver => TAPAR
  0.0        0.035        0.035         10           0        4 driver => OMP_TSUM2 => F24

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec   total msec                           usec/call
---------------------------------------------------------------------------------
100.0          549          859          1          10   859415 .TAU application
 36.0          309          309         10         183    30966 .TAU application => OMP_SEC
 36.0          309          309         10         183    30966 OMP_SEC
  0.0        0.142        0.142        183           0        1 .TAU application => OMP_SEC => F24
  0.0        0.142        0.142        183           0        1 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec   total msec                           usec/call
---------------------------------------------------------------------------------
100.0          519          879          1          10   879357 .TAU application
 40.9          359          359         10         183    35939 .TAU application => OMP_SEC
 40.9          359          359         10         183    35939 OMP_SEC
  0.0        0.119        0.119        183           0        1 .TAU application => OMP_SEC => F24
  0.0        0.119        0.119        183           0        1 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
            msec   total msec                           usec/call
---------------------------------------------------------------------------------
100.0          559          869          1          10   869957 .TAU application
 35.6          309          309         10         181    31000 .TAU application => OMP_SEC
 35.6          309          309         10         181    31000 OMP_SEC
  0.0        0.109        0.109        181           0        1 .TAU application => OMP_SEC => F24
  0.0        0.109        0.109        181           0        1 F24

NODE 0;CONTEXT 0;THREAD 4:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
```

```
              msec   total msec                          usec/call
         ------------------------------------------------------------------------------
100.0      549           859            1        10      859346 .TAU application
 36.0      309           309           10       180       30958 .TAU application => OMP_SEC
 36.0      309           309           10       180       30958 OMP_SEC
  0.0      0.159         0.159         180        0           1 .TAU application => OMP_SEC => F24
  0.0      0.159         0.159         180        0           1 F24

NODE 0;CONTEXT 0;THREAD 5:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0      579           819            1        10      819989 .TAU application
 29.3      240           240           10       177       24012 .TAU application => OMP_SEC
 29.3      240           240           10       177       24012 OMP_SEC
  0.0      0.109         0.109         177        0           1 .TAU application => OMP_SEC => F24
  0.0      0.109         0.109         177        0           1 F24

NODE 0;CONTEXT 0;THREAD 6:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0      529           839            1        10      839965 .TAU application
 36.9      309           309           10       176       30999 .TAU application => OMP_SEC
 36.9      309           309           10       176       30999 OMP_SEC
  0.0      0.101         0.101         176        0           1 .TAU application => OMP_SEC => F24
  0.0      0.101         0.101         176        0           1 F24

NODE 0;CONTEXT 0;THREAD 7:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0      549           859            1        10      859427 .TAU application
 36.0      309           309           10       176       30967 .TAU application => OMP_SEC
 36.0      309           309           10       176       30967 OMP_SEC
  0.0      0.209         0.209         176        0           1 .TAU application => OMP_SEC => F24
  0.0      0.209         0.209         176        0           1 F24

FUNCTION SUMMARY (total):
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
 85.6   30,712        47,899           56       560      855351 .TAU application
 35.2   19,659        19,669          640     11456       30733 OMP_SEC
 30.7   17,179        17,187          560     10048       30692 .TAU application => OMP_SEC
 14.4      0.24        8,027            8         8     1003435 main
 14.4      0.744       8,027            8       160     1003405 driver
 14.4      0.744       8,027            8       160     1003405 main => driver
 14.4    5,543         8,025           80       160      100324 OMP_TSUM2
 14.4    5,543         8,025           80       160      100324 main => driver => OMP_TSUM2
  4.4    2,480         2,481           80      1408       31024 driver => OMP_TSUM2 => OMP_SEC
  0.0       9             9         11536        0           1 F24
```

```
     0.0            7             7       10048            0         1 .TAU application => OMP_SEC => F24
     0.0            1             1        1408            0         1 OMP_TSUM2 => OMP_SEC => F24
     0.0        0.552         0.552          80            0         7 TAPAR
     0.0        0.552         0.552          80            0         7 main => driver => TAPAR
     0.0         0.28          0.28          80            0         4 driver => OMP_TSUM2 => F24

FUNCTION SUMMARY (mean):
-------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call     #Subrs  Inclusive Name
              msec   total msec                         usec/call
-------------------------------------------------------------------------------------
 85.6          479           748       0.875       8.75    855351 .TAU application
 35.2          307           307          10        179     30733 OMP_SEC
 30.7          268           268        8.75        157     30692 .TAU application => OMP_SEC
 14.4      0.00375           125       0.125      0.125   1003435 main
 14.4       0.0116           125       0.125        2.5   1003405 driver
 14.4       0.0116           125       0.125        2.5   1003405 main => driver
 14.4           86           125        1.25        2.5    100324 OMP_TSUM2
 14.4           86           125        1.25        2.5    100324 main => driver => OMP_TSUM2
  4.4           38            38        1.25         22     31024 driver => OMP_TSUM2 => OMP_SEC
  0.0        0.151         0.151      180.25          0         1 F24
  0.0        0.118         0.118         157          0         1 .TAU application => OMP_SEC => F24
  0.0       0.0283        0.0283          22          0         1 OMP_TSUM2 => OMP_SEC => F24
  0.0      0.00863       0.00863        1.25          0         7 TAPAR
  0.0      0.00863       0.00863        1.25          0         7 main => driver => TAPAR
  0.0      0.00438       0.00438        1.25          0         4 driver => OMP_TSUM2 => F24
```

TEST 2 OMP_Talbot2 with *Input Data*: Test Function n. 24, NTval = 100, T1 interval.

  – **TEST 2 – N. of Threads=1** (see Figure 23)

```
NODE 0;CONTEXT 0;THREAD 0:
-------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive      #Call     #Subrs  Inclusive Name
              msec   total msec                         usec/call
-------------------------------------------------------------------------------------
100.0        0.033            14           1          1     14047 main
 99.8        0.135            14           1        200     14014 driver
 99.8        0.135            14           1        200     14014 main => driver
 97.6        0.277            13         100        200       137 OMP_TSUM2
 97.6        0.277            13         100        200       137 main => driver => OMP_TSUM2
 95.1            7            13         100      14388       134 OMP_SEC
 95.1            7            13         100      14388       134 driver => OMP_TSUM2 => OMP_SEC
 43.5            6             6       14488          0         0 F24
 42.9            6             6       14388          0         0 OMP_TSUM2 => OMP_SEC => F24
  1.2        0.173         0.173         100          0         2 TAPAR
  1.2        0.173         0.173         100          0         2 main => driver => TAPAR
  0.5        0.075         0.075         100          0         1 driver => OMP_TSUM2 => F24
```

  – **TEST 2 – N. of Threads=4**(see Figure 24)

```
NODE 0;CONTEXT 0;THREAD 0:
-------------------------------------------------------------------------------------
```
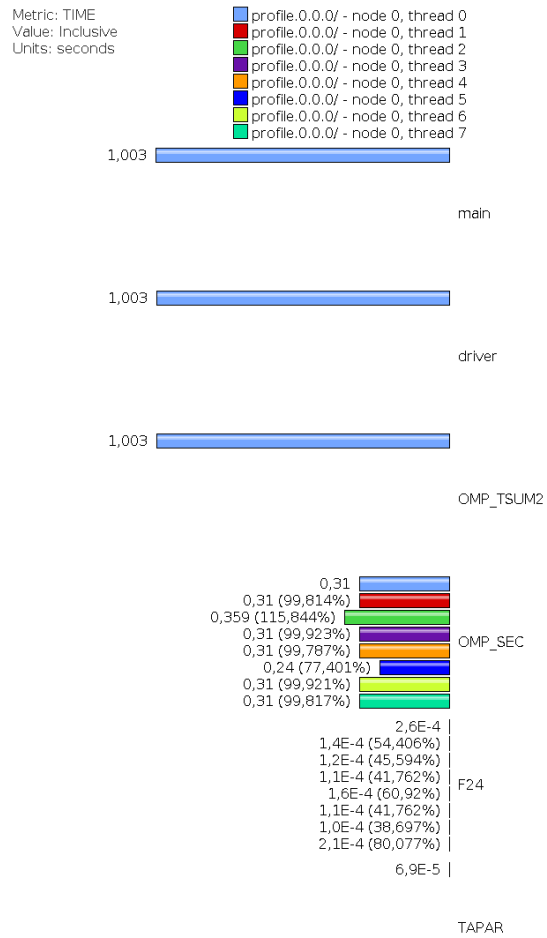
Figure 22: `OMP_Talbot2` on **TEST 1 - N. of Threads 8**: *Inclusive Time measured with TAU.*

```
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------
100.0        0.033           19           1           1      19159 main
 99.8        0.138           19           1         200      19126 driver
 99.8        0.138           19           1         200      19126 main => driver
 98.1          11            18         100         200        188 OMP_TSUM2
 98.1          11            18         100         200        188 main => driver => OMP_TSUM2
 38.6           5             7         100        3562         74 OMP_SEC
 38.6           5             7         100        3562         74 driver => OMP_TSUM2 => OMP_SEC
 11.5           2             2        3662           0          1 F24
 11.1           2             2        3562           0          1 OMP_TSUM2 => OMP_SEC => F24
```

(a)

(b)

Figure 23: `OMP_Talbot2` on **TEST 2 - N. of Threads 1**: *Inclusive Time measured with TAU (a), values shown as percents (b).*

```
     1.0           0.187        0.187         100           0          2 TAPAR
     1.0           0.187        0.187         100           0          2 main => driver => TAPAR
     0.4           0.086        0.086         100           0          1 driver => OMP_TSUM2 => F24

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec    total msec                            usec/call
---------------------------------------------------------------------------------
100.0        0.574            7           1         100       7375 .TAU application
 92.2            3            6         100        3634         68 .TAU application => OMP_SEC
 92.2            3            6         100        3634         68 OMP_SEC
 41.4            3            3        3634           0          1 .TAU application => OMP_SEC => F24
 41.4            3            3        3634           0          1 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec    total msec                            usec/call
---------------------------------------------------------------------------------
100.0        0.576            7           1         100       7341 .TAU application
 92.2            3            6         100        3610         68 .TAU application => OMP_SEC
 92.2            3            6         100        3610         68 OMP_SEC
 42.5            3            3        3610           0          1 .TAU application => OMP_SEC => F24
 42.5            3            3        3610           0          1 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec    total msec                            usec/call
```

43

```
--------------------------------------------------------------------------------
100.0         0.588            7            1          100        7414 .TAU application
 92.1            4             6          100         3582          68  .TAU application => OMP_SEC
 92.1            4             6          100         3582          68 OMP_SEC
 27.4            2             2         3582            0           1  .TAU application => OMP_SEC => F24
 27.4            2             2         3582            0           1 F24

FUNCTION SUMMARY (total):
--------------------------------------------------------------------------------
%Time     Exclusive      Inclusive        #Call      #Subrs   Inclusive Name
             msec       total msec                             usec/call
--------------------------------------------------------------------------------
 67.3           69           111         1600        57552          69 OMP_SEC
 53.6            6            88           12         1200        7377 .TAU application
 49.4           48            81         1200        43304          68  .TAU application => OMP_SEC
 46.4        0.132            76            4            4       19159 main
 46.3        0.552            76            4          800       19126 driver
 46.3        0.552            76            4          800       19126 main => driver
 45.5           45            75          400          800         188 OMP_TSUM2
 45.5           45            75          400          800         188 main => driver => OMP_TSUM2
 25.2           41            41        57952            0           1 F24
 19.9           32            32        43304            0           1  .TAU application => OMP_SEC => F24
 17.9           21            29          400        14248          74 driver => OMP_TSUM2 => OMP_SEC
  5.1            8             8        14248            0           1 OMP_TSUM2 => OMP_SEC => F24
  0.5        0.748         0.748          400            0           2 TAPAR
  0.5        0.748         0.748          400            0           2 main => driver => TAPAR
  0.2        0.344         0.344          400            0           1 driver => OMP_TSUM2 => F24

FUNCTION SUMMARY (mean):
--------------------------------------------------------------------------------
%Time     Exclusive      Inclusive        #Call      #Subrs   Inclusive Name
             msec       total msec                             usec/call
--------------------------------------------------------------------------------
 67.3            4             6          100         3597          69 OMP_SEC
 53.6        0.434            5          0.75           75        7377 .TAU application
 49.4            3             5           75       2706.5          68  .TAU application => OMP_SEC
 46.4      0.00825            4          0.25         0.25       19159 main
 46.3       0.0345            4          0.25           50       19126 driver
 46.3       0.0345            4          0.25           50       19126 main => driver
 45.5            2             4           25           50         188 OMP_TSUM2
 45.5            2             4           25           50         188 main => driver => OMP_TSUM2
 25.2            2             2         3622            0           1 F24
 19.9            2             2       2706.5            0           1  .TAU application => OMP_SEC => F24
 17.9            1             1           25        890.5          74 driver => OMP_TSUM2 => OMP_SEC
  5.1        0.529         0.529        890.5            0           1 OMP_TSUM2 => OMP_SEC => F24
  0.5       0.0467        0.0467           25            0           2 TAPAR
  0.5       0.0467        0.0467           25            0           2 main => driver => TAPAR
  0.2       0.0215        0.0215           25            0           1 driver => OMP_TSUM2 => F24
```
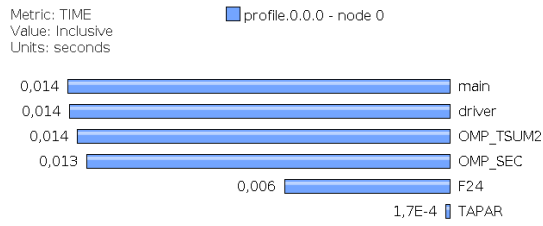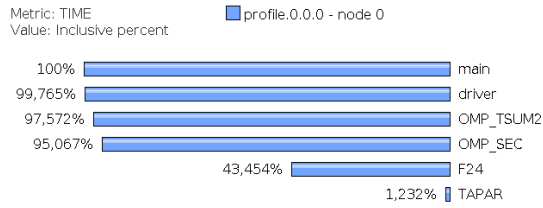
– **TEST 2** – **N. of Threads=8** (see Figure 25)

```
NODE 0;CONTEXT 0;THREAD 0:
--------------------------------------------------------------------------------
%Time     Exclusive      Inclusive        #Call      #Subrs   Inclusive Name
             msec       total msec                             usec/call
```

Figure 24: `OMP_Talbot2` on **TEST 2 - N. of Threads 4**: *Inclusive Time measured with TAU.*

```
--------------------------------------------------------------------------------
100.0        0.032        9,145            1           1     9145215 main
100.0        0.137        9,145            1         200     9145183 driver
100.0        0.137        9,145            1         200     9145183 main => driver
100.0        6,093        9,144          100         200       91449 OMP_TSUM2
100.0        6,093        9,144          100         200       91449 main => driver => OMP_TSUM2
 33.4        3,031        3,051          100        1754       30516 OMP_SEC
 33.4        3,031        3,051          100        1754       30516 driver => OMP_TSUM2 => OMP_SEC
  0.2           20           20         1854           0          11 F24
  0.2           20           20         1754           0          12 OMP_TSUM2 => OMP_SEC => F24
  0.0        0.146        0.146          100           0           1 TAPAR
  0.0        0.146        0.146          100           0           1 main => driver => TAPAR
  0.0        0.052        0.052          100           0           1 driver => OMP_TSUM2 => F24

NODE 0;CONTEXT 0;THREAD 1:
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
--------------------------------------------------------------------------------
100.0        5,958        8,989            1         100     8989801 .TAU application
 33.7        3,030        3,031          100        1843       30315 .TAU application => OMP_SEC
 33.7        3,030        3,031          100        1843       30315 OMP_SEC
  0.0        0.996        0.996         1843           0           1 .TAU application => OMP_SEC => F24
  0.0        0.996        0.996         1843           0           1 F24

NODE 0;CONTEXT 0;THREAD 2:
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
--------------------------------------------------------------------------------
100.0        5,958        8,989            1         100     8989778 .TAU application
```

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```
    33.7      3,030      3,031       100      1829     30314 .TAU application => OMP_SEC
    33.7      3,030      3,031       100      1829     30314 OMP_SEC
     0.0          1          1      1829         0         1 .TAU application => OMP_SEC => F24
     0.0          1          1      1829         0         1 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
   100.0      5,959      8,959         1          100     8959976 .TAU application
    33.5      2,999      3,000       100      1816       30004 .TAU application => OMP_SEC
    33.5      2,999      3,000       100      1816       30004 OMP_SEC
     0.0      0.802      0.802      1816         0         0 .TAU application => OMP_SEC => F24
     0.0      0.802      0.802      1816         0         0 F24

NODE 0;CONTEXT 0;THREAD 4:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
   100.0      5,949      8,999         1          100     8999963 .TAU application
    33.9      3,049      3,050       100      1808       30504 .TAU application => OMP_SEC
    33.9      3,049      3,050       100      1808       30504 OMP_SEC
     0.0      0.829      0.829      1808         0         0 .TAU application => OMP_SEC => F24
     0.0      0.829      0.829      1808         0         0 F24

NODE 0;CONTEXT 0;THREAD 5:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
   100.0      5,959      8,989         1          100     8989743 .TAU application
    33.7      3,029      3,030       100      1791       30301 .TAU application => OMP_SEC
    33.7      3,029      3,030       100      1791       30301 OMP_SEC
     0.0       0.82       0.82      1791         0         0 .TAU application => OMP_SEC => F24
     0.0       0.82       0.82      1791         0         0 F24

NODE 0;CONTEXT 0;THREAD 6:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
   100.0      5,959      8,979         1          100     8979968 .TAU application
    33.6      3,019      3,020       100      1781       30204 .TAU application => OMP_SEC
    33.6      3,019      3,020       100      1781       30204 OMP_SEC
     0.0      0.797      0.797      1781         0         0 .TAU application => OMP_SEC => F24
     0.0      0.797      0.797      1781         0         0 F24

NODE 0;CONTEXT 0;THREAD 7:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
   100.0      5,958      9,009         1          100     9009576 .TAU application
    33.9      3,030      3,051       100      1766       30512 .TAU application => OMP_SEC
```
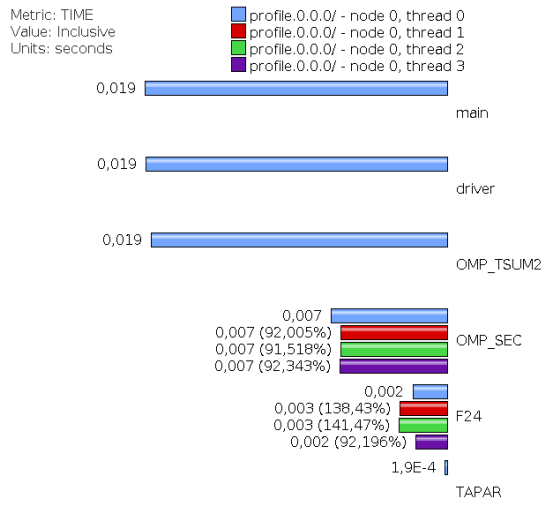
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```
  33.9         3,030        3,051         100       1766       30512 OMP_SEC
   0.2            20           20        1766          0          12 .TAU application => OMP_SEC => F24
   0.2            20           20        1766          0          12 F24

FUNCTION SUMMARY (total):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                           usec/call
---------------------------------------------------------------------------------------
  87.3    5:33.627     8:23.350          56        5600    8988401 .TAU application
  33.7    3:13.766     3:14.135        6400      115104      30334 OMP_SEC
  29.4    2:49.516     2:49.722        5600      101072      30308 .TAU application => OMP_SEC
  12.7       0.256     1:13.161           8           8    9145215 main
  12.7           1     1:13.161           8        1600    9145183 driver
  12.7           1     1:13.161           8        1600    9145183 main => driver
  12.7      48,745     1:13.159         800        1600      91449 OMP_TSUM2
  12.7      48,745     1:13.159         800        1600      91449 main => driver => OMP_TSUM2
   4.2      24,249       24,412         800       14032      30516 driver => OMP_TSUM2 => OMP_SEC
   0.1         369          369      115904           0          3 F24
   0.0         206          206      101072           0          2 .TAU application => OMP_SEC => F24
   0.0         163          163       14032           0         12 OMP_TSUM2 => OMP_SEC => F24
   0.0           1            1         800           0          1 TAPAR
   0.0           1            1         800           0          1 main => driver => TAPAR
   0.0       0.416        0.416         800           0          1 driver => OMP_TSUM2 => F24

FUNCTION SUMMARY (mean):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                           usec/call
---------------------------------------------------------------------------------------
  87.3       5,212        7,864       0.875        87.5    8988401 .TAU application
  33.7       3,027        3,033         100      1798.5      30334 OMP_SEC
  29.4       2,648        2,651        87.5     1579.25      30308 .TAU application => OMP_SEC
  12.7       0.004        1,143       0.125       0.125    9145215 main
  12.7      0.0171        1,143       0.125          25    9145183 driver
  12.7      0.0171        1,143       0.125          25    9145183 main => driver
  12.7         761        1,143        12.5          25      91449 OMP_TSUM2
  12.7         761        1,143        12.5          25      91449 main => driver => OMP_TSUM2
   4.2         378          381        12.5      219.25      30516 driver => OMP_TSUM2 => OMP_SEC
   0.1           5            5        1811           0          3 F24
   0.0           3            3     1579.25           0          2 .TAU application => OMP_SEC => F24
   0.0           2            2      219.25           0         12 OMP_TSUM2 => OMP_SEC => F24
   0.0      0.0182       0.0182        12.5           0          1 TAPAR
   0.0      0.0182       0.0182        12.5           0          1 main => driver => TAPAR
   0.0      0.0065       0.0065        12.5           0          1 driver => OMP_TSUM2 => F24
```

TEST 3 OMP_Talbot2 with *Input Data*: Test Function n. 24, NTval = 10, T2 interval.

   – **TEST 3 – N. of Threads=1** (see Figure 26)

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                           usec/call
---------------------------------------------------------------------------------------
```
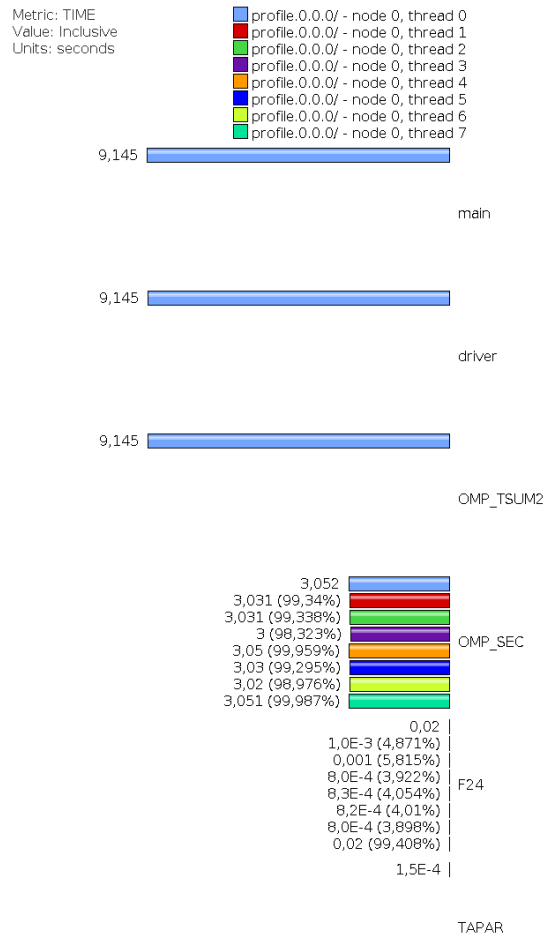
Figure 25: `OMP_Talbot2` on **TEST 2 - N. of Threads 8**: *Inclusive Time measured with TAU.*

```
100.0        0.031       1,280            1            1     1280222 main
100.0        0.094       1,280            1           20     1280191 driver
100.0        0.094       1,280            1           20     1280191 main => driver
100.0         738        1,280           10    2.4347E+06    128003 OMP_TSUM2
100.0         738        1,280           10    2.4347E+06    128003 main => driver => OMP_TSUM2
 42.3         541          541    2.4347E+06            0          0 F24
 42.3         541          541    2.4347E+06            0          0 main => driver => OMP_TSUM2 => F24
  0.0        0.067        0.067           10            0          7 TAPAR
  0.0        0.067        0.067           10            0          7 main => driver => TAPAR
```

– **TEST 3 – N. of Threads=4** (see Figure 27)

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```
1,28    ████████████████████████  main
1,28    ████████████████████████  driver
1,28    █████████████████████████ OMP_TSUM2
0,541   ██████  F24
6,7E-5 | TAPAR
```

(a)

```
100%     ████████████████████████  main
99,998%  ████████████████████████  driver
99,985%  █████████████████████████ OMP_TSUM2
42,268%  ██████  F24
0,005% | TAPAR
```

(b)

Figure 26: `OMP_Talbot2` on **TEST 3 - N. of Threads 1**: *Inclusive Time measured with TAU (a), values shown as percents (b).*

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0       0.032          546           1           1     546713 main
100.0       0.094          546           1          20     546681 driver
100.0       0.094          546           1          20     546681 main => driver
100.0         308          546          10      608678      54651 OMP_TSUM2
100.0         308          546          10      608678      54651 main => driver => OMP_TSUM2
 43.5         237          237      608678           0          0 F24
 43.5         237          237      608678           0          0 main => driver => OMP_TSUM2 => F24
  0.0       0.081        0.081          10           0          8 TAPAR
  0.0       0.081        0.081          10           0          8 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0         306          541           1      608675     541809 .TAU application
 43.4         234          234      608675           0          0 .TAU application => F24
 43.4         234          234      608675           0          0 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0         309          542           1      608673     542327 .TAU application
 42.9         232          232      608673           0          0 .TAU application => F24
 42.9         232          232      608673           0          0 F24
```
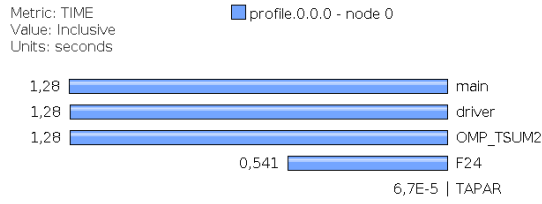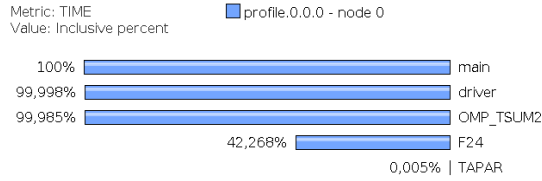
49

```
NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                            usec/call
---------------------------------------------------------------------------------------
100.0          311          545           1      608670     545847 .TAU application
 42.9          233          233      608670           0          0 .TAU application => F24
 42.9          233          233      608670           0          0 F24

FUNCTION SUMMARY (total):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                            usec/call
---------------------------------------------------------------------------------------
 74.9          928        1,629           3 1.82602E+06     543328 .TAU application
 43.2          939          939    2.4347E+06         0          0 F24
 32.2          701          701 1.82602E+06           0          0 .TAU application => F24
 25.1        0.032          546           1           1     546713 main
 25.1        0.094          546           1          20     546681 driver
 25.1        0.094          546           1          20     546681 main => driver
 25.1          308          546          10      608678      54651 OMP_TSUM2
 25.1          308          546          10      608678      54651 main => driver => OMP_TSUM2
 10.9          237          237      608678           0          0 main => driver => OMP_TSUM2 => F24
  0.0        0.081        0.081          10           0          8 TAPAR
  0.0        0.081        0.081          10           0          8 main => driver => TAPAR

FUNCTION SUMMARY (mean):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                            usec/call
---------------------------------------------------------------------------------------
 74.9          232          407        0.75      456504     543328 .TAU application
 43.2          234          234      608674           0          0 F24
 32.2          175          175      456504           0          0 .TAU application => F24
 25.1        0.008          136        0.25        0.25     546713 main
 25.1       0.0235          136        0.25           5     546681 driver
 25.1       0.0235          136        0.25           5     546681 main => driver
 25.1           77          136         2.5      152170      54651 OMP_TSUM2
 25.1           77          136         2.5      152170      54651 main => driver => OMP_TSUM2
 10.9           59           59      152170           0          0 main => driver => OMP_TSUM2 => F24
  0.0       0.0203       0.0203         2.5           0          8 TAPAR
  0.0       0.0203       0.0203         2.5           0          8 main => driver => TAPAR
```

– **TEST 3** – **N. of Threads=8** (see Figure 28)

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                            usec/call
---------------------------------------------------------------------------------------
100.0        0.032          439           1           1     439506 main
100.0        0.096          439           1          20     439474 driver
100.0        0.096          439           1          20     439474 main => driver
100.0          227          439          10      304342      43930 OMP_TSUM2
```
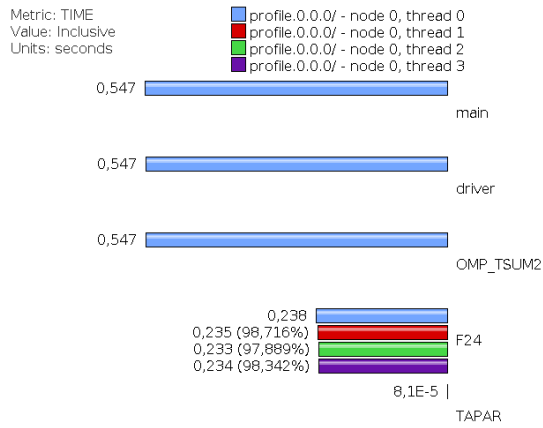
Figure 27: OMP_Talbot2 on **TEST 3 - N. of Threads 4**: *Inclusive Time measured with TAU.*

```
100.0          227           439           10        304342        43930 main => driver => OMP_TSUM2
 48.1          211           211       304342             0            1 F24
 48.1          211           211       304342             0            1 main => driver => OMP_TSUM2 => F24
  0.0        0.076         0.076           10             0            8 TAPAR
  0.0        0.076         0.076           10             0            8 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------------
%Time     Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                            usec/call
---------------------------------------------------------------------------------------
100.0          219           436            1        304340       436721 .TAU application
 49.7          217           217       304340             0            1 .TAU application => F24
 49.7          217           217       304340             0            1 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------------
%Time     Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                            usec/call
---------------------------------------------------------------------------------------
100.0          217           437            1        304339       437774 .TAU application
 50.3          220           220       304339             0            1 .TAU application => F24
 50.3          220           220       304339             0            1 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------------
%Time     Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                            usec/call
---------------------------------------------------------------------------------------
100.0          226           436            1        304338       436015 .TAU application
 48.0          209           209       304338             0            1 .TAU application => F24
 48.0          209           209       304338             0            1 F24

NODE 0;CONTEXT 0;THREAD 4:
```

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```
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
             msec   total msec                            usec/call
--------------------------------------------------------------------------------
100.0          224          438           1      304336     438015 .TAU application
 48.7          213          213      304336           0          1 .TAU application => F24
 48.7          213          213      304336           0          1 F24

NODE 0;CONTEXT 0;THREAD 5:
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
             msec   total msec                            usec/call
--------------------------------------------------------------------------------
100.0          219          437           1      304335     437949 .TAU application
 50.0          218          218      304335           0          1 .TAU application => F24
 50.0          218          218      304335           0          1 F24

NODE 0;CONTEXT 0;THREAD 6:
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
             msec   total msec                            usec/call
--------------------------------------------------------------------------------
100.0          226          436           1      304334     436705 .TAU application
 48.2          210          210      304334           0          1 .TAU application => F24
 48.2          210          210      304334           0          1 F24

NODE 0;CONTEXT 0;THREAD 7:
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
             msec   total msec                            usec/call
--------------------------------------------------------------------------------
100.0          221          438           1      304332     438439 .TAU application
 49.5          217          217      304332           0          1 .TAU application => F24
 49.5          217          217      304332           0          1 F24

FUNCTION SUMMARY (total):
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
             msec   total msec                            usec/call
--------------------------------------------------------------------------------
 87.4        1,555        3,061           7 2.13035E+06     437374 .TAU application
 49.1        1,717        1,717  2.4347E+06           0          1 F24
 43.0        1,506        1,506 2.13035E+06           0          1 .TAU application => F24
 12.6        0.032          439           1           1     439506 main
 12.6        0.096          439           1          20     439474 driver
 12.6        0.096          439           1          20     439474 main => driver
 12.5          227          439          10      304342      43930 OMP_TSUM2
 12.5          227          439          10      304342      43930 main => driver => OMP_TSUM2
  6.0          211          211      304342           0          1 main => driver => OMP_TSUM2 => F24
  0.0        0.076        0.076          10           0          8 TAPAR
  0.0        0.076        0.076          10           0          8 main => driver => TAPAR

FUNCTION SUMMARY (mean):
--------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
             msec   total msec                            usec/call
```

```
----------------------------------------------------------------------------------------
   87.4          194          382        0.875        266294       437374 .TAU application
   49.1          214          214       304337             0            1 F24
   43.0          188          188       266294             0            1 .TAU application => F24
   12.6        0.004           54        0.125         0.125       439506 main
   12.6        0.012           54        0.125           2.5       439474 driver
   12.6        0.012           54        0.125           2.5       439474 main => driver
   12.5           28           54         1.25       38042.8        43930 OMP_TSUM2
   12.5           28           54         1.25       38042.8        43930 main => driver => OMP_TSUM2
    6.0           26           26      38042.8             0            1 main => driver => OMP_TSUM2 => F24
    0.0       0.0095       0.0095         1.25             0            8 TAPAR
    0.0       0.0095       0.0095         1.25             0            8 main => driver => TAPAR
```
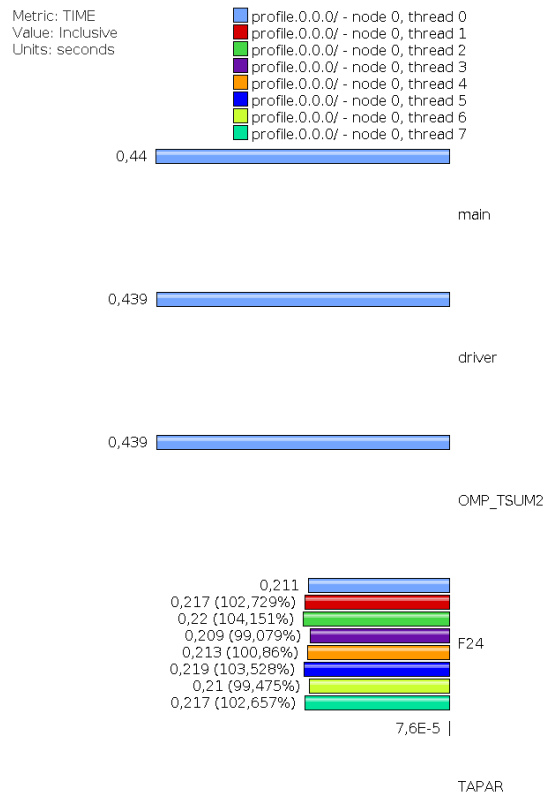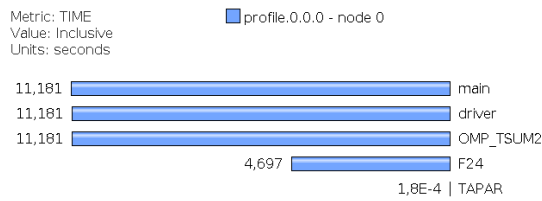
Metric: TIME
Value: Inclusive
Units: seconds

profile.0.0.0/ - node 0, thread 0
profile.0.0.0/ - node 0, thread 1
profile.0.0.0/ - node 0, thread 2
profile.0.0.0/ - node 0, thread 3
profile.0.0.0/ - node 0, thread 4
profile.0.0.0/ - node 0, thread 5
profile.0.0.0/ - node 0, thread 6
profile.0.0.0/ - node 0, thread 7

0,44

main

0,439

driver

0,439

OMP_TSUM2

0,211
0,217 (102,729%)
0,22 (104,151%)
0,209 (99,079%)
0,213 (100,86%)
0,219 (103,528%)
0,21 (99,475%)
0,217 (102,657%)

F24

7,6E-5 |

TAPAR

Figure 28: `OMP_Talbot2` on **TEST 3 - N. of Threads 8**: *Inclusive Time measured with TAU.*

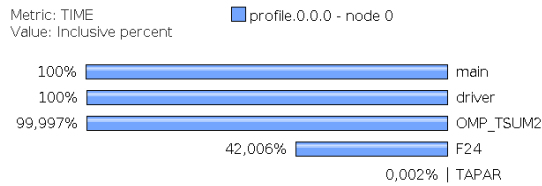**TEST 4** `OMP_Talbot2` with *Input Data*: Test Function n. 24, `NTval = 100`, `T2` interval.

    – **TEST 4 – N. of Threads=1** (see Figure 29)

```
NODE 0;CONTEXT 0;THREAD 0:
-----------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec     total msec                           usec/call
-----------------------------------------------------------------------------------
100.0       0.032       11,181           1           1   11181158 main
100.0       0.127       11,181           1         200   11181126 driver
100.0       0.127       11,181           1         200   11181126 main => driver
100.0       6,484       11,180         100 2.33309E+07     111808 OMP_TSUM2
100.0       6,484       11,180         100 2.33309E+07     111808 main => driver => OMP_TSUM2
 42.0       4,696        4,696 2.33309E+07           0          0 F24
 42.0       4,696        4,696 2.33309E+07           0          0 main => driver => OMP_TSUM2 => F24
  0.0       0.185        0.185         100           0          2 TAPAR
  0.0       0.185        0.185         100           0          2 main => driver => TAPAR
```

Metric: TIME
Value: Inclusive
Units: seconds

profile.0.0.0 - node 0

```
11,181  ██████████████████████  main
11,181  ██████████████████████  driver
11,181  ██████████████████████  OMP_TSUM2
 4,697           ████           F24
1,8E-4 | TAPAR
```

(a)

Metric: TIME
Value: Inclusive percent

profile.0.0.0 - node 0

```
 100%   ██████████████████████  main
 100%   ██████████████████████  driver
99,997% ██████████████████████  OMP_TSUM2
42,006%          ████           F24
0,002% | TAPAR
```

(b)

Figure 29: `OMP_Talbot2` on **TEST 4 - N. of Threads 1**: *Inclusive Time measured with TAU (a), values shown as percents (b).*

   – **TEST 4 – N. of Threads=4** (see Figure 30)

```
NODE 0;CONTEXT 0;THREAD 0:
-----------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec     total msec                           usec/call
-----------------------------------------------------------------------------------
100.0       0.033        4,433           1           1    4433238 main
100.0       0.155        4,433           1         200    4433205 driver
100.0       0.155        4,433           1         200    4433205 main => driver
100.0       2,574        4,432         100 5.83277E+06      44328 OMP_TSUM2
100.0       2,574        4,432         100 5.83277E+06      44328 main => driver => OMP_TSUM2
 41.9       1,858        1,858 5.83277E+06           0          0 F24
 41.9       1,858        1,858 5.83277E+06           0          0 main => driver => OMP_TSUM2 => F24
  0.0       0.248        0.248         100           0          2 TAPAR
```

54

```
  0.0          0.248         0.248           100              0          2 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                             usec/call
---------------------------------------------------------------------------------------
100.0        2,571        4,428           1 5.83274E+06    4428559 .TAU application
 41.9        1,857        1,857 5.83274E+06           0          0 .TAU application => F24
 41.9        1,857        1,857 5.83274E+06           0          0 F24

NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                             usec/call
---------------------------------------------------------------------------------------
100.0        2,608        4,430           1 5.83272E+06    4430335 .TAU application
 41.1        1,821        1,821 5.83272E+06           0          0 .TAU application => F24
 41.1        1,821        1,821 5.83272E+06           0          0 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                             usec/call
---------------------------------------------------------------------------------------
100.0        2,627        4,432           1  5.8327E+06    4432512 .TAU application
 40.7        1,805        1,805  5.8327E+06           0          0 .TAU application => F24
 40.7        1,805        1,805  5.8327E+06           0          0 F24

FUNCTION SUMMARY (total):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                             usec/call
---------------------------------------------------------------------------------------
 75.0        7,807       13,291           3 1.74982E+07    4430469 .TAU application
 41.4        7,342        7,342 2.33309E+07           0          0 F24
 30.9        5,484        5,484 1.74982E+07           0          0 .TAU application => F24
 25.0        0.033        4,433           1           1    4433238 main
 25.0        0.155        4,433           1         200    4433205 driver
 25.0        0.155        4,433           1         200    4433205 main => driver
 25.0        2,574        4,432         100 5.83277E+06      44328 OMP_TSUM2
 25.0        2,574        4,432         100 5.83277E+06      44328 main => driver => OMP_TSUM2
 10.5        1,858        1,858 5.83277E+06           0          0 main => driver => OMP_TSUM2 => F24
  0.0        0.248        0.248         100           0          2 TAPAR
  0.0        0.248        0.248         100           0          2 main => driver => TAPAR

FUNCTION SUMMARY (mean):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                             usec/call
---------------------------------------------------------------------------------------
 75.0        1,951        3,322        0.75 4.37454E+06    4430469 .TAU application
 41.4        1,835        1,835 5.83273E+06           0          0 F24
 30.9        1,371        1,371 4.37454E+06           0          0 .TAU application => F24
 25.0      0.00825        1,108        0.25        0.25    4433238 main
 25.0       0.0387        1,108        0.25          50    4433205 driver
```

```
25.0      0.0387        1,108          0.25            50  4433205 main => driver
25.0       643          1,108            25 1.45819E+06   44328 OMP_TSUM2
25.0       643          1,108            25 1.45819E+06   44328 main => driver => OMP_TSUM2
10.5       464            464 1.45819E+06             0       0 main => driver => OMP_TSUM2 => F24
 0.0      0.062          0.062            25            0       2 TAPAR
 0.0      0.062          0.062            25            0       2 main => driver => TAPAR
```
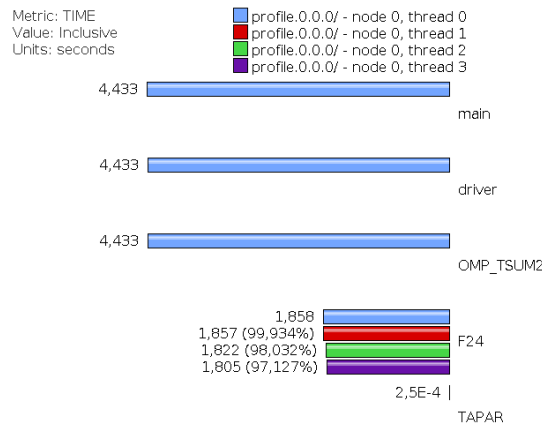

Metric: TIME
Value: Inclusive
Units: seconds

profile.0.0.0/ - node 0, thread 0
profile.0.0.0/ - node 0, thread 1
profile.0.0.0/ - node 0, thread 2
profile.0.0.0/ - node 0, thread 3

4,433 — main

4,433 — driver

4,433 — OMP_TSUM2

1,858
1,857 (99,934%) — F24
1,822 (98,032%)
1,805 (97,127%)

2,5E-4 | TAPAR

Figure 30: `OMP_Talbot2` on **TEST 4 - N. of Threads 4**: *Inclusive Time measured with TAU.*

– **TEST 4 – N. of Threads=8** (see Figure 31)

```
NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                            usec/call
---------------------------------------------------------------------------------------
100.0       0.033        4,433           1           1   4433238 main
100.0       0.155        4,433           1         200   4433205 driver
100.0       0.155        4,433           1         200   4433205 main => driver
100.0       2,574        4,432         100 5.83277E+06     44328 OMP_TSUM2
100.0       2,574        4,432         100 5.83277E+06     44328 main => driver => OMP_TSUM2
 41.9       1,858        1,858 5.83277E+06           0         0 F24
 41.9       1,858        1,858 5.83277E+06           0         0 main => driver => OMP_TSUM2 => F24
  0.0       0.248        0.248         100           0         2 TAPAR
  0.0       0.248        0.248         100           0         2 main => driver => TAPAR

NODE 0;CONTEXT 0;THREAD 1:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
            msec   total msec                            usec/call
---------------------------------------------------------------------------------------
100.0       2,571        4,428           1 5.83274E+06   4428559 .TAU application
 41.9       1,857        1,857 5.83274E+06           0         0 .TAU application => F24
 41.9       1,857        1,857 5.83274E+06           0         0 F24
```

56

```
NODE 0;CONTEXT 0;THREAD 2:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        2,608        4,430           1 5.83272E+06     4430335 .TAU application
 41.1        1,821        1,821 5.83272E+06          0           0 .TAU application => F24
 41.1        1,821        1,821 5.83272E+06          0           0 F24

NODE 0;CONTEXT 0;THREAD 3:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        2,627        4,432           1  5.8327E+06     4432512 .TAU application
 40.7        1,805        1,805 5.8327E+06           0           0 .TAU application => F24
 40.7        1,805        1,805 5.8327E+06           0           0 F24

FUNCTION SUMMARY (total):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
 75.0        7,807       13,291           3 1.74982E+07     4430469 .TAU application
 41.4        7,342        7,342 2.33309E+07          0           0 F24
 30.9        5,484        5,484 1.74982E+07          0           0 .TAU application => F24
 25.0        0.033        4,433           1           1     4433238 main
 25.0        0.155        4,433           1         200     4433205 driver
 25.0        0.155        4,433           1         200     4433205 main => driver
 25.0        2,574        4,432         100 5.83277E+06       44328 OMP_TSUM2
 25.0        2,574        4,432         100 5.83277E+06       44328 main => driver => OMP_TSUM2
 10.5        1,858        1,858 5.83277E+06          0           0 main => driver => OMP_TSUM2 => F24
  0.0        0.248        0.248         100           0           2 TAPAR
  0.0        0.248        0.248         100           0           2 main => driver => TAPAR

FUNCTION SUMMARY (mean):
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
 75.0        1,951        3,322        0.75 4.37454E+06     4430469 .TAU application
 41.4        1,835        1,835 5.83273E+06          0           0 F24
 30.9        1,371        1,371 4.37454E+06          0           0 .TAU application => F24
 25.0      0.00825        1,108        0.25        0.25     4433238 main
 25.0       0.0387        1,108        0.25          50     4433205 driver
 25.0       0.0387        1,108        0.25          50     4433205 main => driver
 25.0          643        1,108          25 1.45819E+06       44328 OMP_TSUM2
 25.0          643        1,108          25 1.45819E+06       44328 main => driver => OMP_TSUM2
 10.5          464          464 1.45819E+06          0           0 main => driver => OMP_TSUM2 => F24
  0.0        0.062        0.062          25           0           2 TAPAR
  0.0        0.062        0.062          25           0           2 main => driver => TAPAR
```
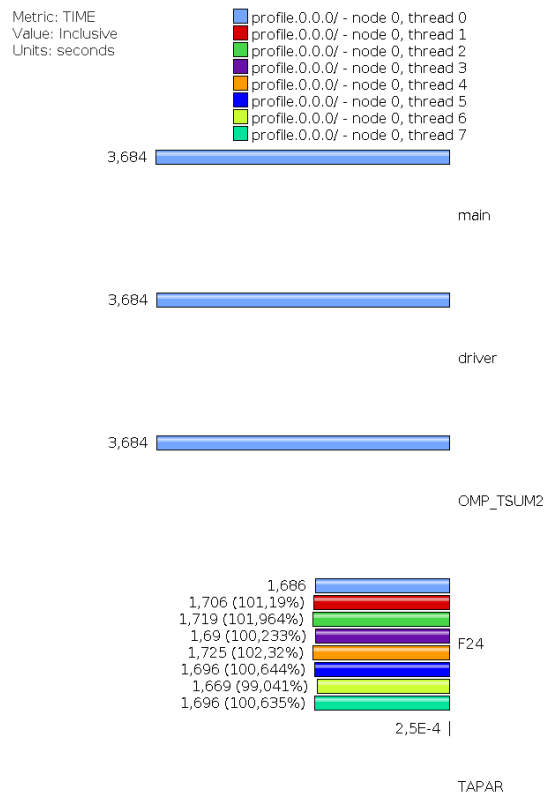
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Figure 31: `OMP_Talbot2` on **TEST 4 - N. of Threads 8**: *Inclusive Time measured with TAU.*

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