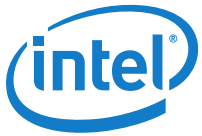


Heterogeneous applications

Using Intel® Threading Building Blocks and Intel® Cilk Plus

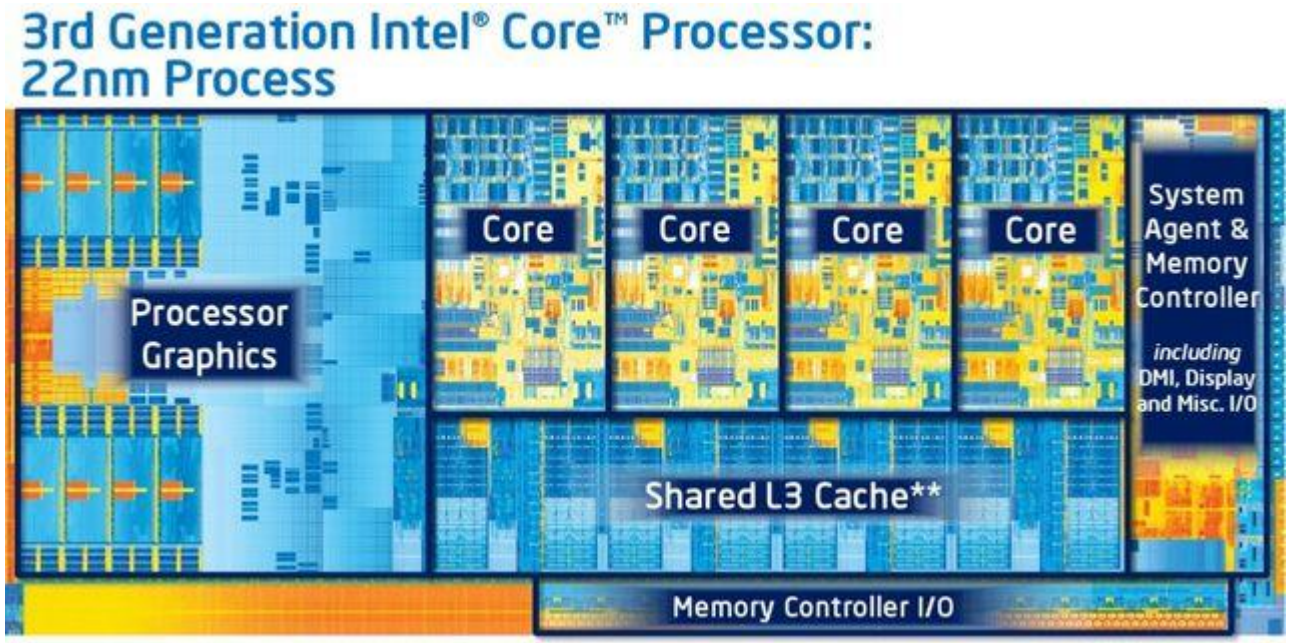
Based on Intel TBB fractal package example

Vladimir Polin

Threading Runtimes Engineering Manager

Rock your code.

Past



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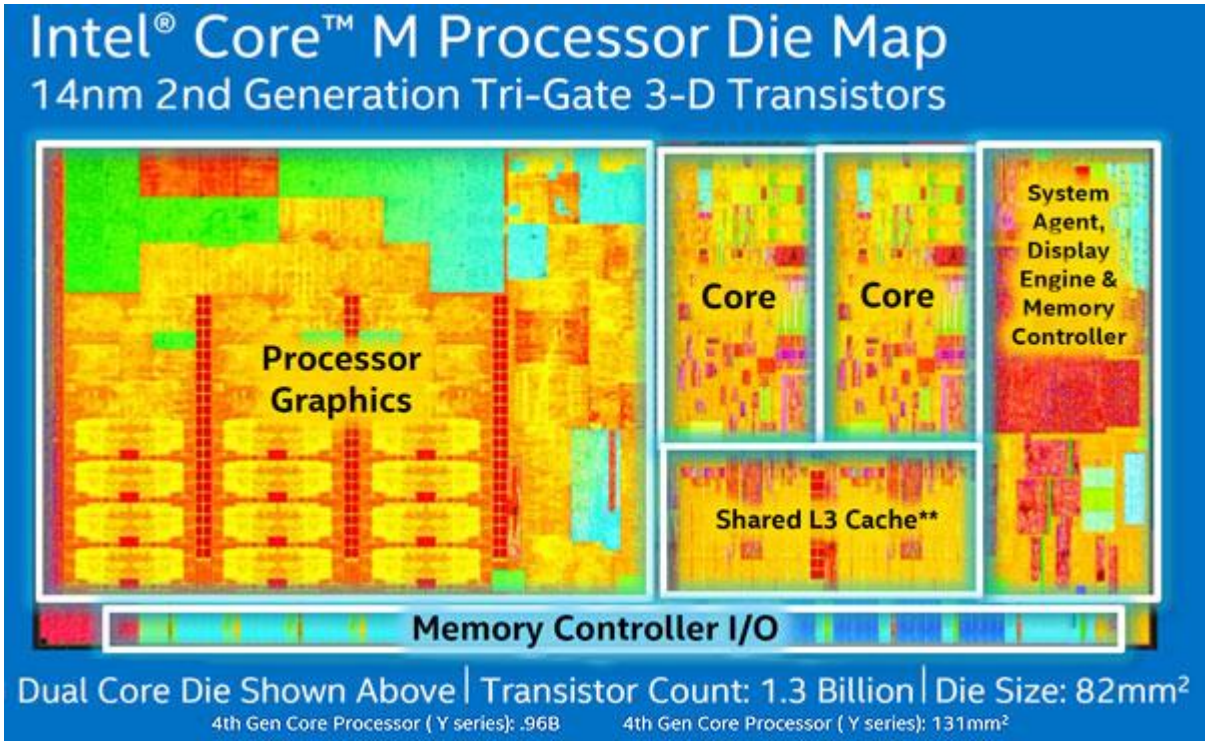
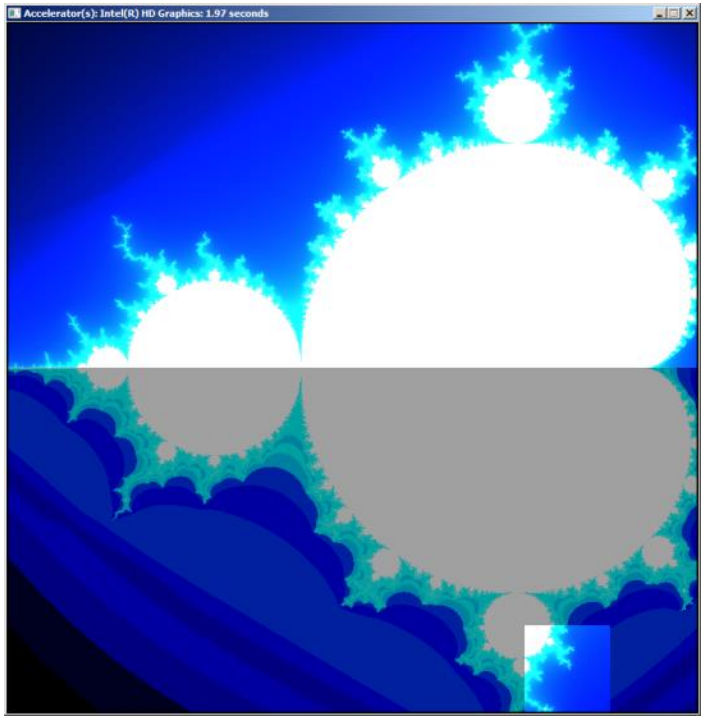
Present



How we can use and utilize this processor graphics?

Rock your code.

Mandelbrot set



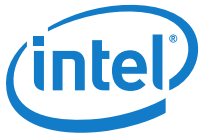
- Simple Mandelbrot set
- Open Source
- Part of the Intel TBB package
- Important:
  - Demo purposes only
  - Vivid picture

Example of parallel_for work

?	**?**	**?**	**?**	**?**	**?**	**?**	**?**
?	?	?	?	?	?	?	?
?	?	?	?	?	?	?	?
1	**3**	?	?	?	?	?	?
2	?	?	?	?	?	?	?
?	?	?	?	?	?	?	?
?	?	?	?	?	?	?	?
?	?	?	?	?	?	?	?

? – means stealing.
Nobody knows where calculation will be started and how stealing will work

Initial Code



Calling calculation of a set parts in parallel

```
tbb::parallel_for(tbb::blocked_range2d<int>(0, size_y, grain_size, 0, size_x, grain_size),
    [&] (tbb::blocked_range2d<int> &r){
    if ( v->next_frame() )
        render_rect(r.cols().begin(), r.rows().begin(), r.cols().end(), r.rows().end());
},
    tbb::auto_partitioner());
```

Processing every set part

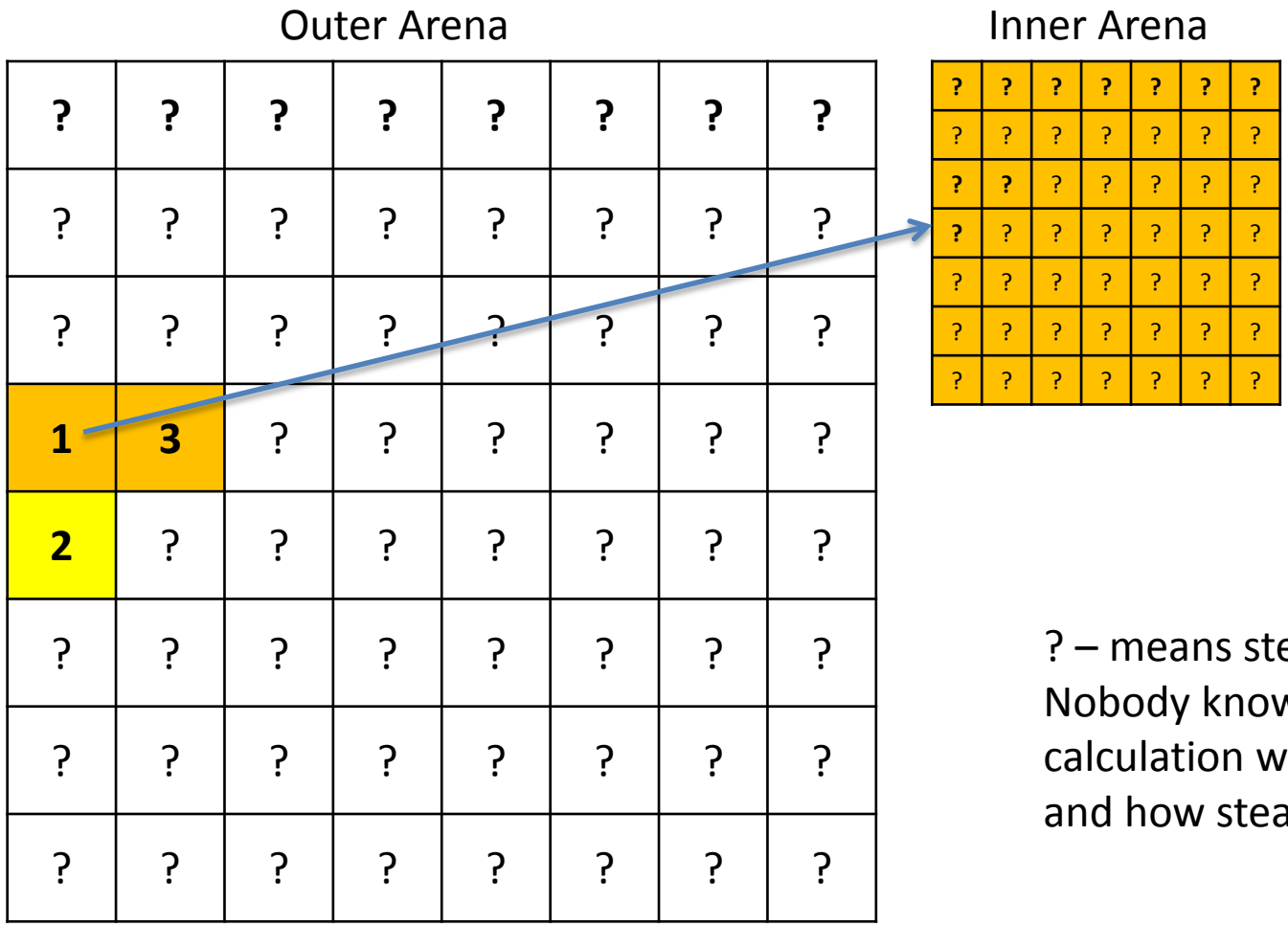
```
color_t fractal::calc_one_pixel(float x0, float y0)
{
    return calc_one_pixel(x0, y0, max_iterations, size_x, size_y, magn, cx, cy, 255);
}

void fractal::render_rect( int x0, int y0, int x1, int y1 ) {
    // render the specified rectangle area
    drawing_area area(off_x+x0, off_y+y0, x1-x0, y1-y0, dm);
    for ( int y=y0; y<y1; ++y ) {
        area.set_pos( 0, y-y0 );
        for ( int x=x0; x<x1; ++x ) {
            area.put_pixel( calc_one_pixel( x, y ) );
        }
    }
}
```

Rock your code.

User-Managed Task Arenas

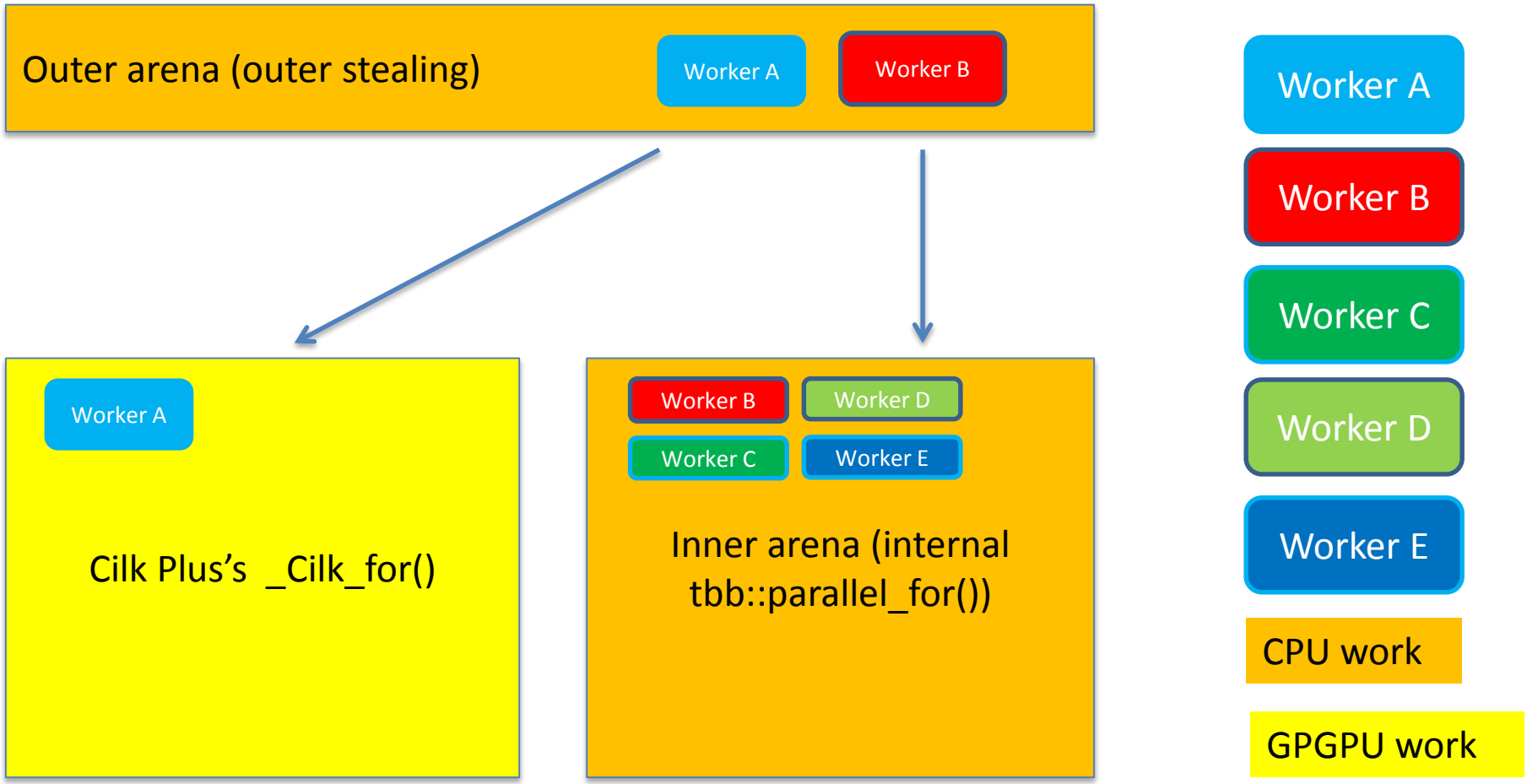
- an arena is a place for threads to share and steal tasks
- Name - task_arena class
- represents an internal task scheduler object where a number of threads, limited by a maximal concurrency level, share and execute tasks.
- The concurrency level of a task_arena is isolated and not affected by previous task_scheduler_init specifications.

Example of parallel_for work with 2 arenas

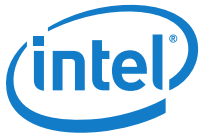


? – means stealing.
Nobody knows where calculation will be started and how stealing will work

Task arenas in action



Outer arena (outer stealing)

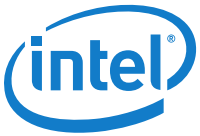



```
tbb::task_arena outer_arena(2);
outer_arena.execute([&] (){
    tbb::parallel_for(tbb::blocked_range2d<int>(0, size_y, grain_size, 0, size_x, grain_size),
        [&] (tbb::blocked_range2d<int> &r){
        if ( v->next_frame() )
            render_rect(r.cols().begin(), r.rows().begin(), r.cols().end(), r.rows().end());
    },
        tbb::auto_partitioner());
});
```

Rock your code.

Worker A

Cilk Plus's _Cilk_for()



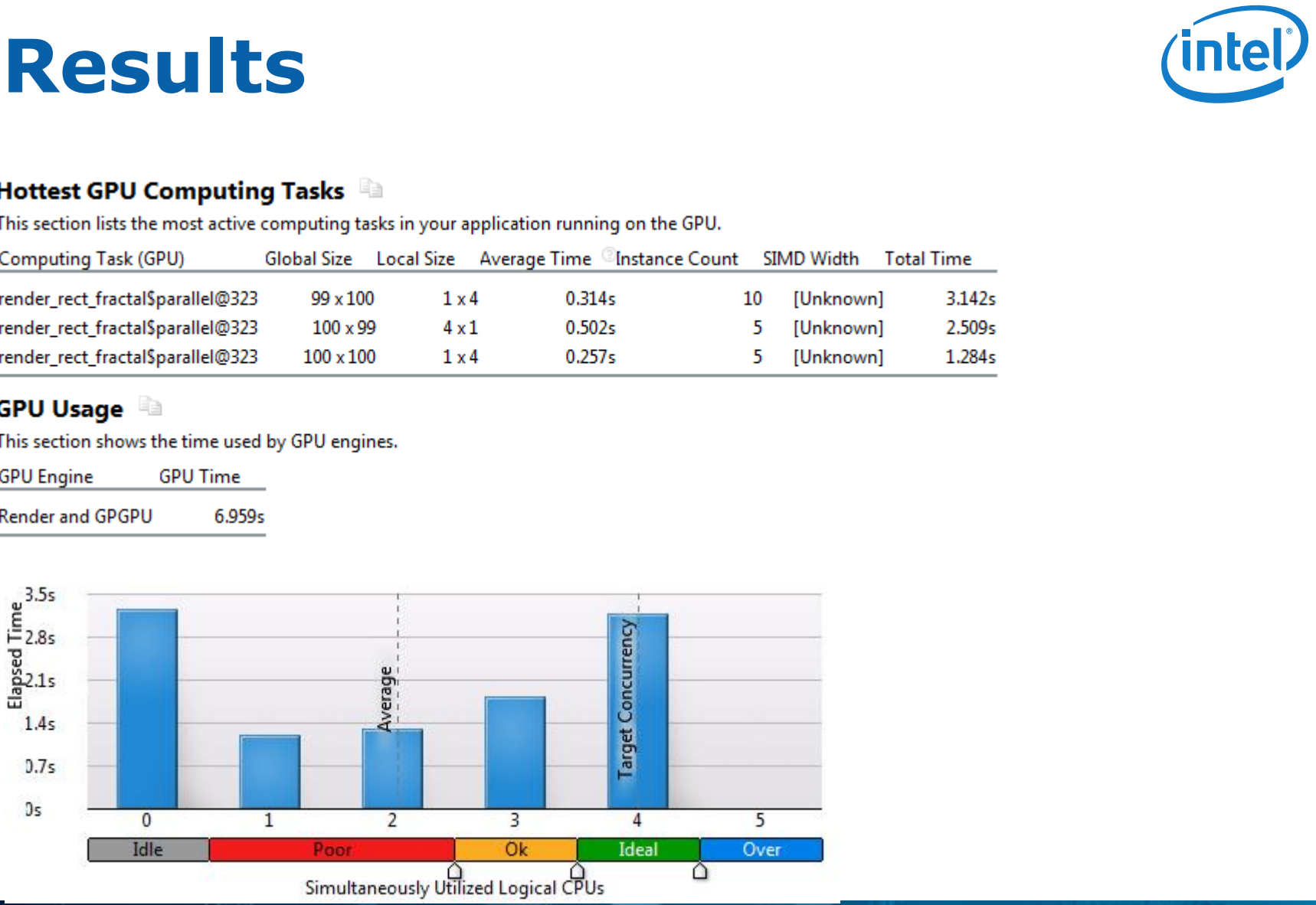
```
    const int delta_x = x1 - x0; const int delta_y = y1 - y0; int delta_y2; int idx = 0; int status;
    unsigned __int32 fractal_data_array[delta_x][delta_y];
#pragma offload target(gfx) pin(fractal_data_array: length((delta_x)* (delta_y)))
    _Cilk_for(int y = 0; y < delta_y; ++y) {
        _Cilk_for(int x = 0; x < delta_x; ++x) {
            fractal_data_array[x][y] =
                calc_one_pixel(tmp_off_x + x, tmp_off_y + y, tmp_max_iterations, tmp_size_x, tmp_size_y, tmp_magn, tmp_cx, tmp_cy, 160);
        }
    }
    drawing_area area(off_x + x0, off_y + y0, x1 - x0, y1 - y0, dm);
    for ( int y = y0, y_temp = 0; y < y1; ++y, ++y_temp ) {
        area.set_pos(0, y - y0);
        for ( int x = x0, x_temp = 0; x < x1; ++x, ++x_temp ) {
            area.put_pixel(fractal_data_array[x_temp][y_temp]);
        }
    }
```

Rock your code.


```
cpu_arena = new tbb::task_arena(<Number of CPU threads>);
cpu_arena->execute([&]{
    tbb::parallel_for(tbb::blocked_range2d<int>(y0, y1, inner_grain_size, x0, x1, inner_grain_size),
        [&] (tbb::blocked_range2d<int> &r){
        int x0 = r.cols().begin(), y0 = r.rows().begin(), x1 = r.cols().end(), y1 = r.rows().end();
        drawing_area area(off_x + x0, off_y + y0, x1 - x0, y1 - y0, dm);
        for ( int y = y0; y < y1; ++y ) {
            area.set_pos(0, y - y0);
            int x;
            color_t pixels_colors[8];
            for ( int x = x0; x < x1; ++x ) {
                area.put_pixel(calc_one_pixel(x, y, tmp_max_iterations, tmp_size_x, tmp_size_y, tmp_magn, tmp_cx, tmp_cy, 255));
            }
        }
    });
});
```

Rock your code.

Results



Hottest GPU Computing Tasks

This section lists the most active computing tasks in your application running on the GPU.

Computing Task (GPU)	Global Size	Local Size	Average Time	Instance Count	SIMD Width	Total Time
render_rect_fractal$parallel@323	99 x 100	1 x 4	0.314s	10	[Unknown]	3.142s
render_rect_fractal$parallel@323	100 x 99	4 x 1	0.502s	5	[Unknown]	2.509s
render_rect_fractal$parallel@323	100 x 100	1 x 4	0.257s	5	[Unknown]	1.284s

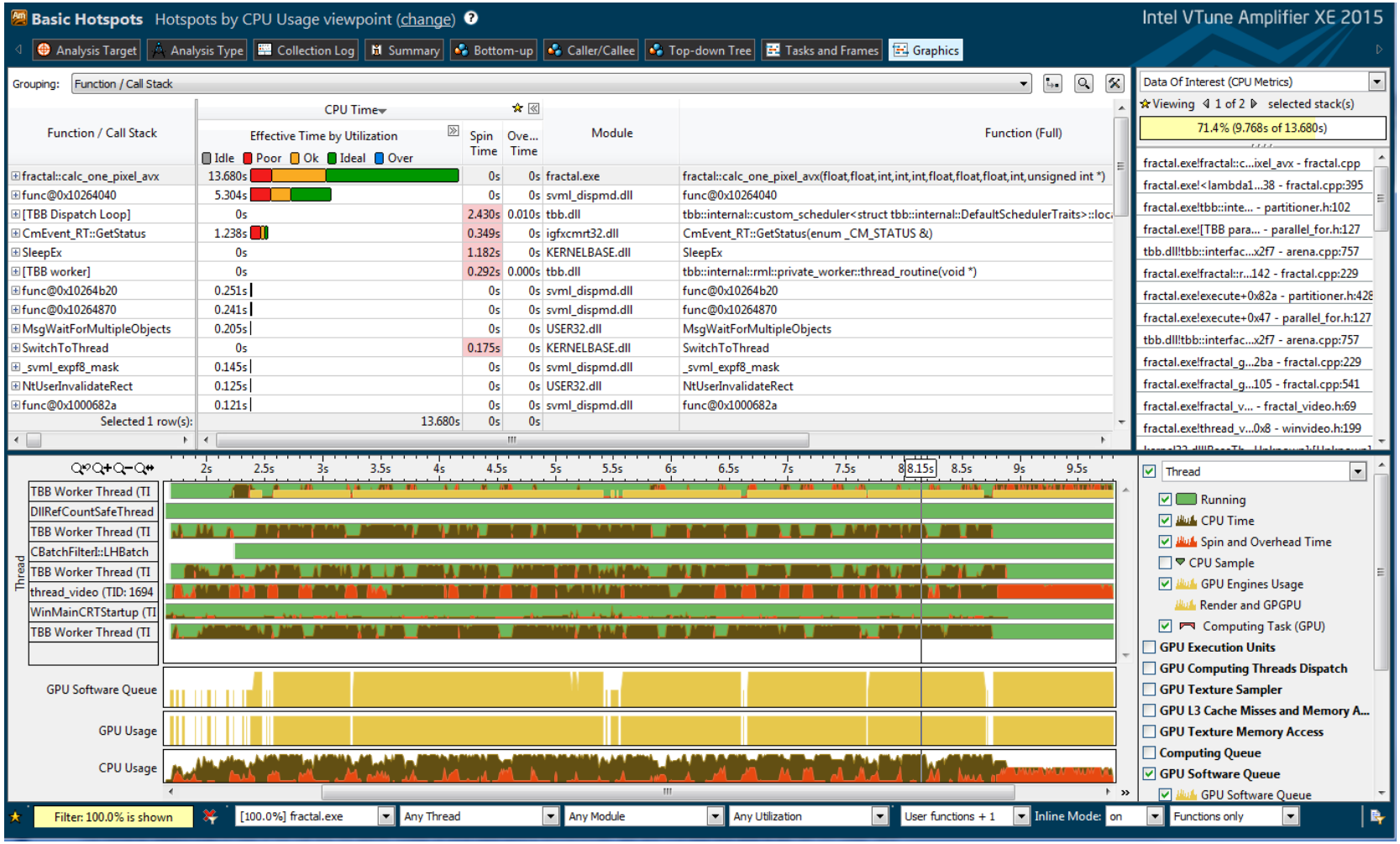
GPU Usage

This section shows the time used by GPU engines.

GPU Engine	GPU Time
Render and GPGPU	6.959s

Rock your code.

Results (Graphics view)



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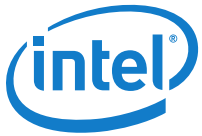
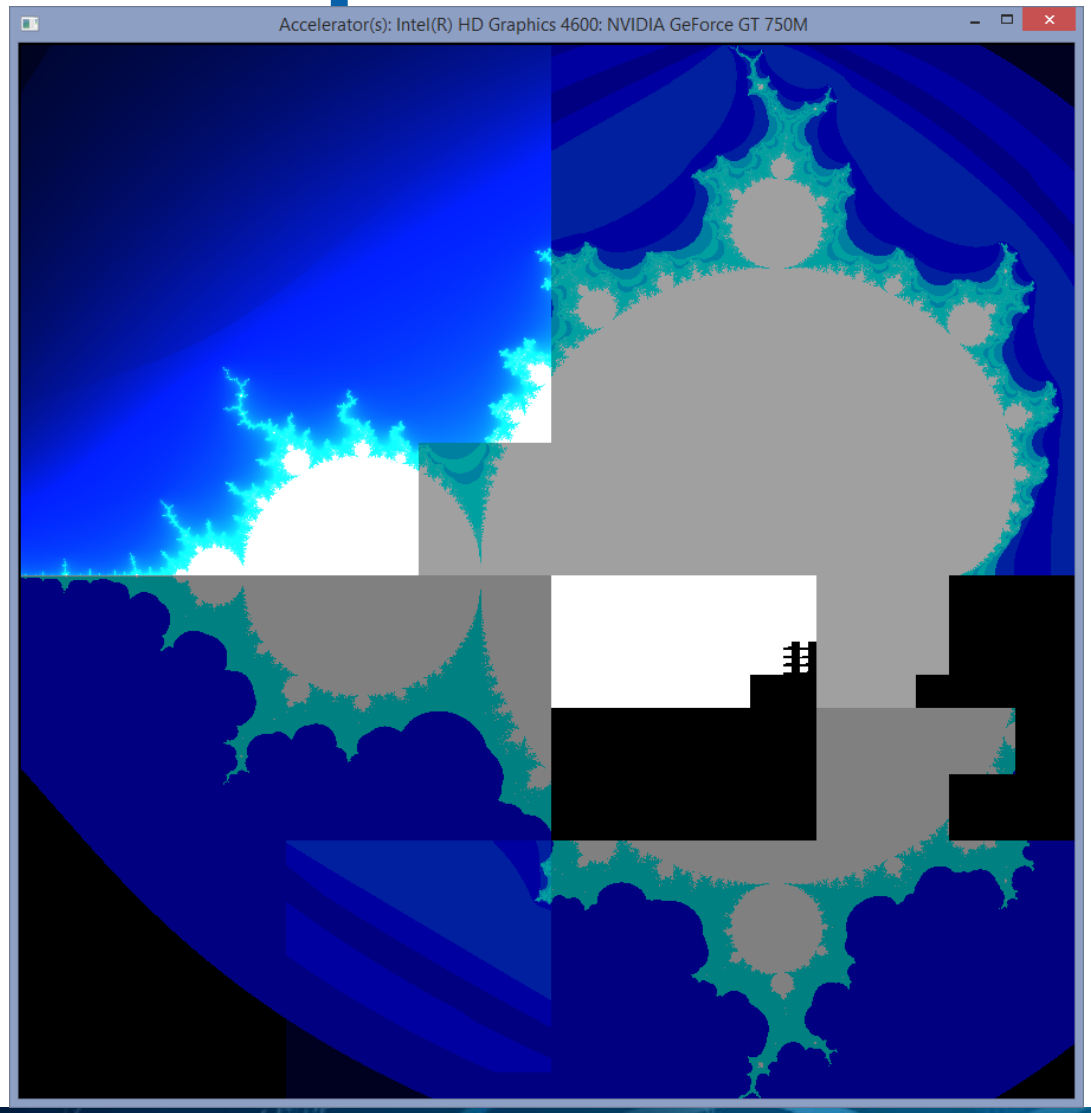
Tomorrow?



Can you application utilize all resources efficiently?

Backup



Rock your code.

Conclusion

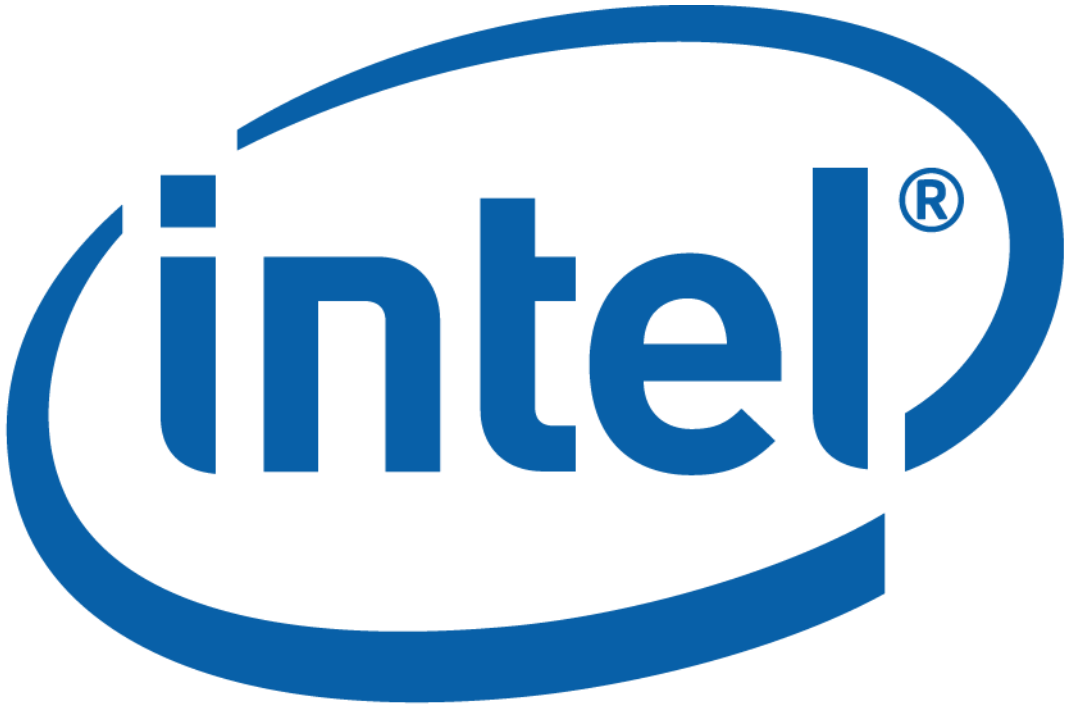
Scale productive
Tune and debug for more cores and nodes

Scale effectively
Keep performance

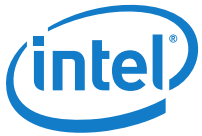
Scale for the future
Multicore today, Many-core tomorrow

Intel® Parallel Studio XE: The Suite for developing of applications for shared and distributed memory models

Rock your code.



Software



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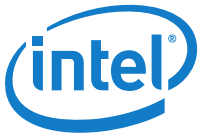

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