



TRACKING DOWN MEMORY BOTTLENECKS WITH THE INTEGRATED ROOFLINE MODEL IN INTEL® ADVISOR

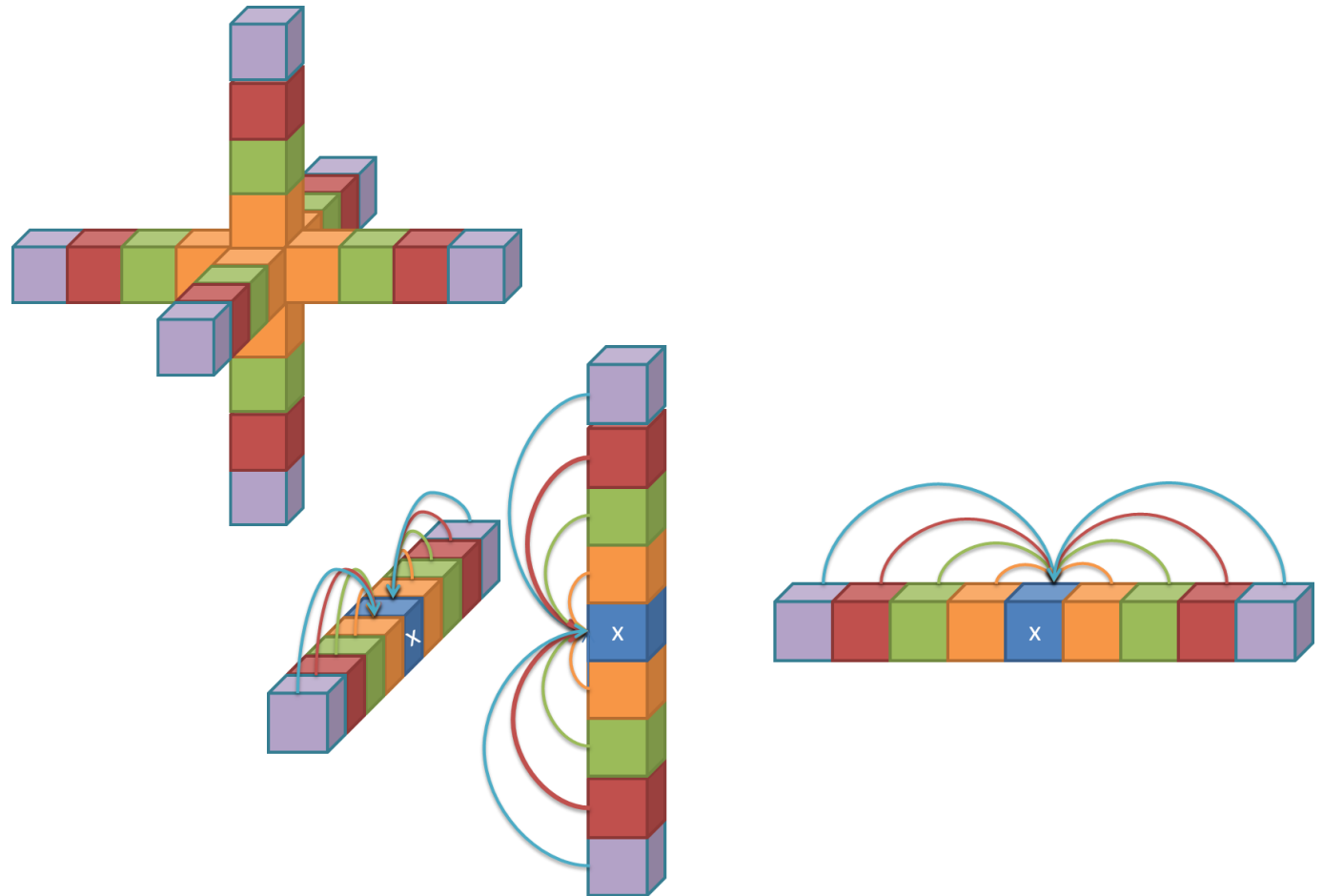
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ISO3DFD

A memory bounded application ?

How does a stencil work ?

- For computing $P_{t+1}(x,y,z)$, we need to use all neighbors in the 3 dimensions of $P_t(x,y,z)$
- The stencil looks like a 3D cross in Iso3DFD



Iso3DFD – A wave propagation kernel

```
For (int iz=0; iz<n3; iz++)
For (int iy=0; iy<n2; iy++)
For (int ix=0; ix<n1; ix++) {
    int offset = iz*dimn1n2 + iy*n1 + ix;
    float value = 0.0;
    value += ptr_prev[offset]*coeff[0];
    for(int ir=1; ir<= 8 ; ir++) {
        value += coeff[ir] * (ptr_prev[offset + ir] + ptr_prev[offset - ir]);
        value += coeff[ir] * (ptr_prev[offset + ir*n1] + ptr_prev[offset - ir*n1]);
        value += coeff[ir] * (ptr_prev[offset + ir*dimn1n2] + ptr_prev[offset -
ir*dimn1n2]);
    }
    ptr_next[offset] = 2.0f* ptr_prev[offset] - ptr_next[offset] + value*ptr_vel[offset];
}
```

- 3D Finite Difference
- Acoustic isotropic, pressure only scheme,
- 16th order in space 2nd order in time
- No boundary conditions
- OpenMP (no MPI)

DEV01 – INTEL[®] VTUNE HOTSPOTS

Is everything as expected ?

Running the Integrated Roofline Model on Dev00

Dev00 is an unoptimized implementation of iso3DFD

- It's time for a demo
- Intel® Vtune™ Hotspots

time: 196.61 sec
throughput: 7.03 MPoints/s
flops: 0.43 GFlops

Running the Integrated Roofline Model on Dev00

Dev00 is an unoptimized implementation of iso3DFD

time: 196.61 sec
throughput: 7.03 MPoints/s
flops: 0.43 GFlops

time: 10.37 sec
throughput: 133.33
MPoints/s
flops: 8.13 GFlops

DEV02 – FIRST STEP WITH INTEGRATED ROOFLINE MODEL

Is everything as expected ?

Running the Integrated Roofline Model on Dev00

Dev01 only implements the threading

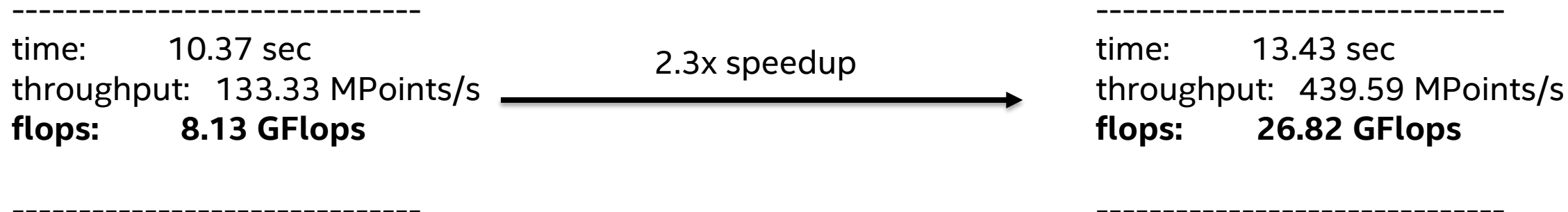
- It's time for a demo
- Intel® Advisor's new summary
- Column configurator
- Integrated Roofline Model
- Intel® VTune™ Memory Access

time: 10.37 sec
throughput: 133.33 MPoints/s
flops: 8.13 GFlops

Creation of dev02

Based on Intel® Advisor analysis, we need to reverse the loops

- Reversing the loops generated unit strides
- The performance is improving



DEV03 – VECTORIZATION

Following recommendations

Enabling vectorization

Dev02 has still many room for improvement

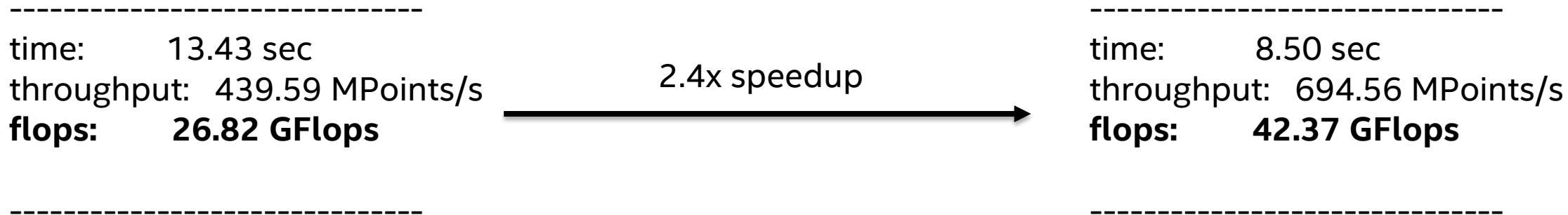
- It's time for a demo
- Intel Advisor's new summary
- Intel® Advisor's recommendations
- Roofline Compare
- Dependency analysis

time: 13.43 sec
throughput: 439.59 MPoints/s
flops: 26.82 GFlops

Dev03 – Vectorization done

Dev03 is enabling vectorization

- We only need to use a simple `#pragma omp simd` here



DEV04 – CACHE BLOCKING

What does the Roofline say ?

Enabling Cache Blocking

Dev03 has still many room for improvement

- It's time for a demo
- Integrated Roofline
- Check the position of the dot to their respective roofline
- Roofline Compare

time: 8.50 sec
throughput: 694.56 MPoints/s
flops: 42.37 GFlops

2.25x speedup

time: 3.89 sec
throughput: 1518.47 MPoints/s
flops: 92.63 GFlops

Dev04 – Cache Blocking done

Just specifying export KMP_AFFINITY=scatter

time: 3.89 sec
throughput: 1518.47 MPoints/s
flops: 92.63 GFlops

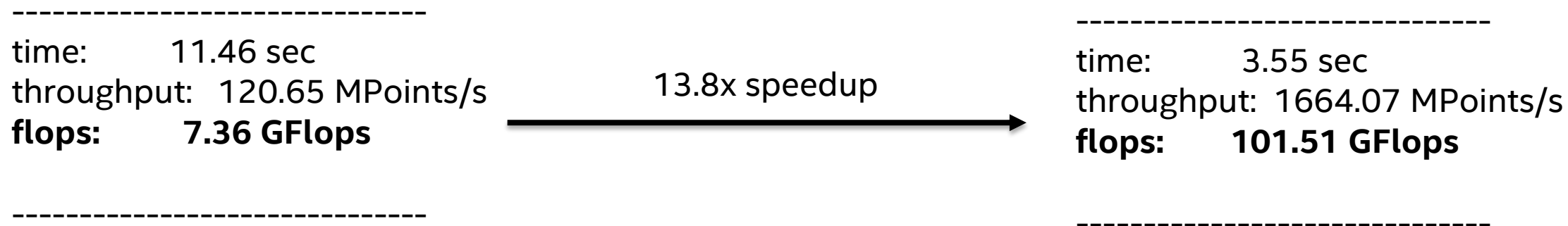
1.1x speedup

time: 3.50 sec
throughput: 1686.58 MPoints/s
flops: 102.88 GFlops

CONCLUSION

Conclusion

- **13x speedup but the initial application was suboptimal**
- **Intel® Advisor helped for:**
 - **Solving memory accesses problems**
 - **Improving vectorization**
 - **Detecting L3 bottleneck**
- **Next step: Recommendation engine based on Integrated Roofline Model**



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QUESTIONS & ANSWERS



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