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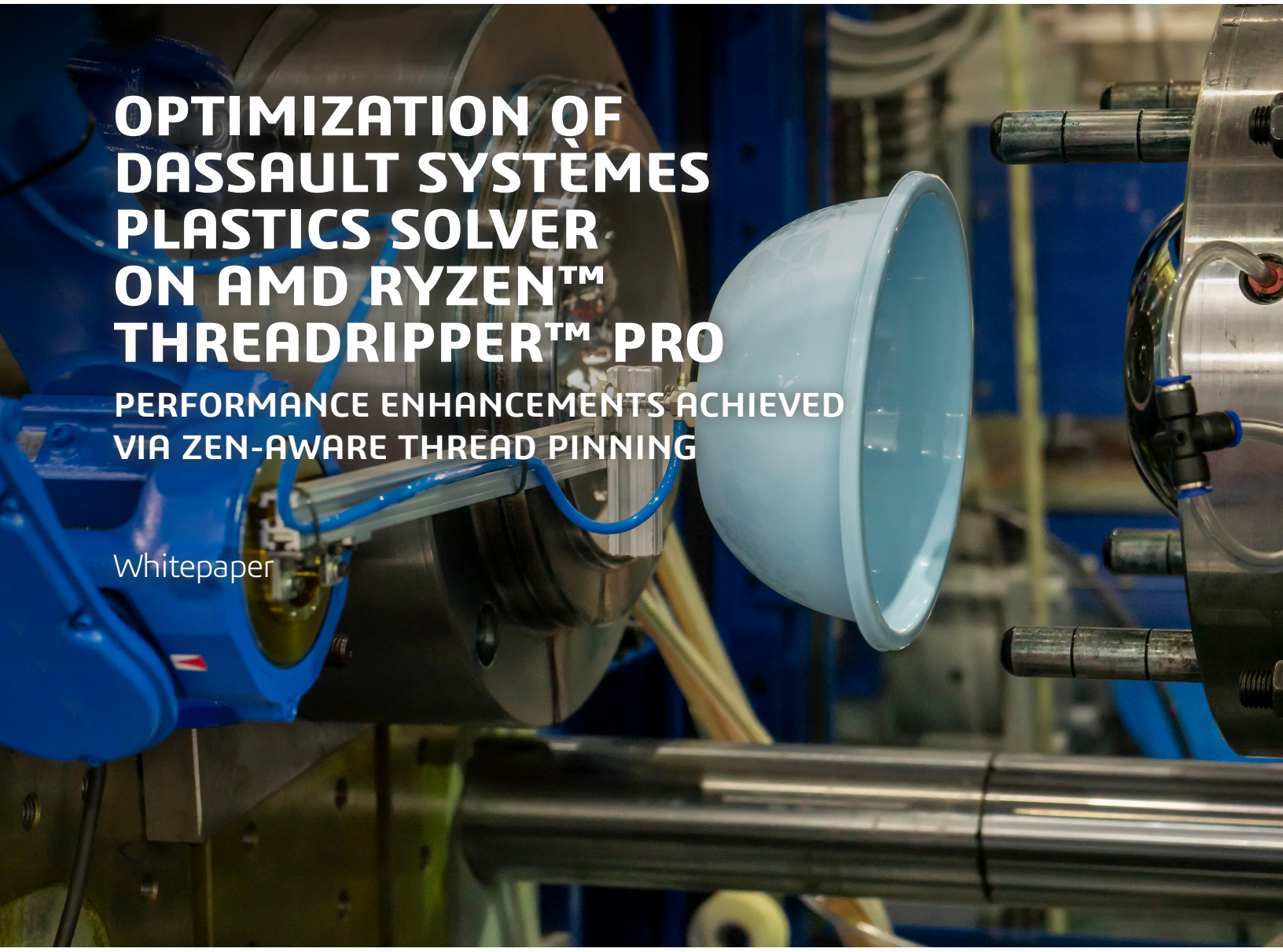

OPTIMIZATION OF DASSAULT SYSTÈMES PLASTICS SOLVER ON AMD RYZEN™ THREADRIPPER™ PRO

PERFORMANCE ENHANCEMENTS ACHIEVED VIA ZEN-AWARE THREAD PINNING

Whitepaper

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INTRODUCTION

Modern computer-aided design (CAD) workflows are increasingly reliant upon computer-aided engineering (CAE) software to determine whether a designed part is structurally sound, how the part interacts with electromagnetic signals, the acoustic properties of the part, and many other aspects of design and manufacturability.

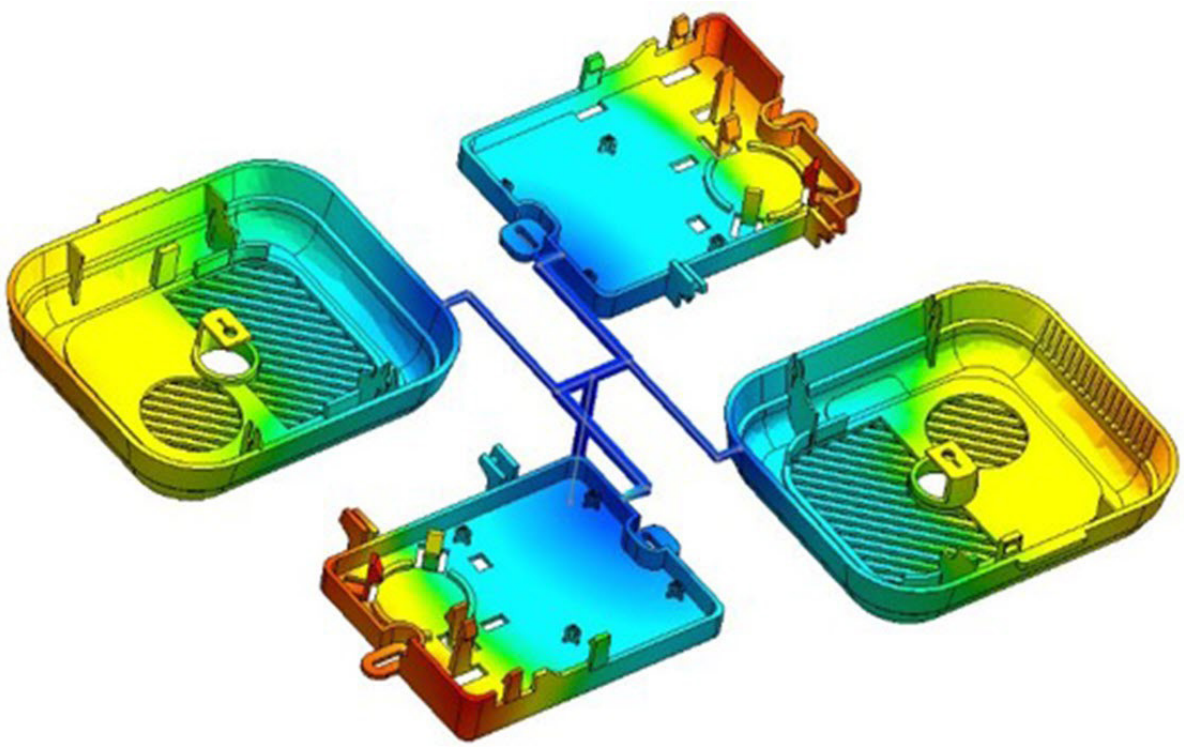
The design of parts made of plastics, however, is particularly dependent upon sophisticated physics simulations of the flow of the plastics in its molten form, the thermal distributions as the molten plastic solidifies, and the structural integrity/strength of the resulting fully cooled part.

SOLIDWORKS Plastics is an industry-leading CAE simulation tool used to analyze the filling, packing and cooling phases of the injection-molding process, which is the manufacturing method used to produce more than 80 percent of all plastics products. In addition, there is a structural solver used to predict molded part warpage that can occur due to a variety of causes including non-uniform stress, shrinkage and cooling. SOLIDWORKS Plastics (Desktop), as well as the Plastic Injection Engineer role on the 3DEXPERIENCE platform (on-premise and on-cloud), enables designers to optimize the material and processing conditions to minimize defects, thereby saving energy, natural resources, time, and money.

Using Plastics simulation during the earliest stages of part and mold design helps mechanical designers working on plastic parts and mold tooling engineers designing injection molds to:

- Predict and avoid injection molding manufacturing defects
- Eliminate costly mold rework
- Improve part quality
- Decrease time to market

In order to ensure the highest level of injection molding simulation results accuracy, Dassault Systèmes engages with the world's leading plastics manufacturers to ensure that their clients have access to the most up-to-date, complete, trusted and accurate CAE simulation plastics material data. As a result of those engagements, new materials are being added to the plastics database in every SOLIDWORKS Plastics Service Pack and every 3DEXPERIENCE Functional Delivery.



THREAD-PINNING TECHNOLOGIES

The sophisticated algorithms required to simulate the fluid, thermal, and structural physics of plastics manufacturing are computationally intensive and generally scale well with multiple CPU cores. AMD Ryzen™ Threadripper™ PRO processors offer key attributes to meet the computing demands of these algorithms: the "Zen" micro-architecture gains in superscalar throughput, a consistent progression in manufacturing to enable higher-density on-chip cores, and AMD Infinity Fabric™ architecture, a novel approach that allows ease of performance scaling while mitigating challenges in thermal dissipation and product costs. Along with "Zen" and its leading-edge manufacturing process, AMD chiplet technology, enabled by the AMD Infinity Fabric™ architecture interconnect, forms a linchpin to AMD Ryzen™ Threadripper™ PRO processors' outstanding combination of core count and sustained clock rates. Rather than simply forcing geometrically higher core counts onto the same monolithic die, AMD Ryzen™ Threadripper™ PRO processors integrate multiple 8-core "Zen" CCX (Core Complex) chiplets, each tied to memory, I/O and each other via AMD Infinity Fabric™ architecture interconnect.

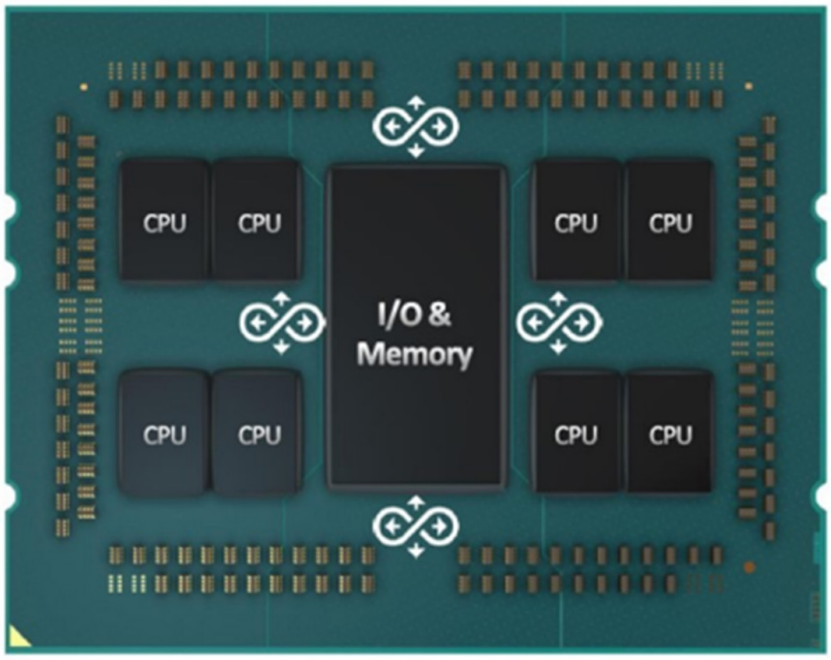


Figure 1: AMD Infinity Fabric™ enables AMD Ryzen™ Threadripper™ PRO processors' chiplet implementation, providing an outstanding combination of cores running at high clock rates

Each 8-core "Zen" chiplet has 32MB of L3 cache, and therefore a 64-core AMD Ryzen™ Threadripper™ PRO 5995WX processor has an industry leading total of 256MB of L3 cache. Software that is designed to utilize many cores and take advantage of large L3 cache tends to perform especially well on AMD Ryzen™ Threadripper™ PRO processors. Through the implementation of an elegant and effective Zen-aware "thread pinning" optimization, SOLIDWORKS Plastics was able to extract even better performance from AMD Ryzen™ Threadripper™ PRO processors while maintaining the historical performance levels on competing x86 platforms.

If an application does not explicitly "pin" threads (or processes) to specific cores, then the operating system will do its best to distribute the workload across the cores, chiplets, and L3 cache. By working closely with AMD and developing and testing code on AMD Ryzen™ Threadripper™ PRO processors SOLIDWORKS Plastics determined that the most compute-intensive elements of the Plastics simulation workload run best when threads are pinned in the "Spread" approach shown in the graphic below.

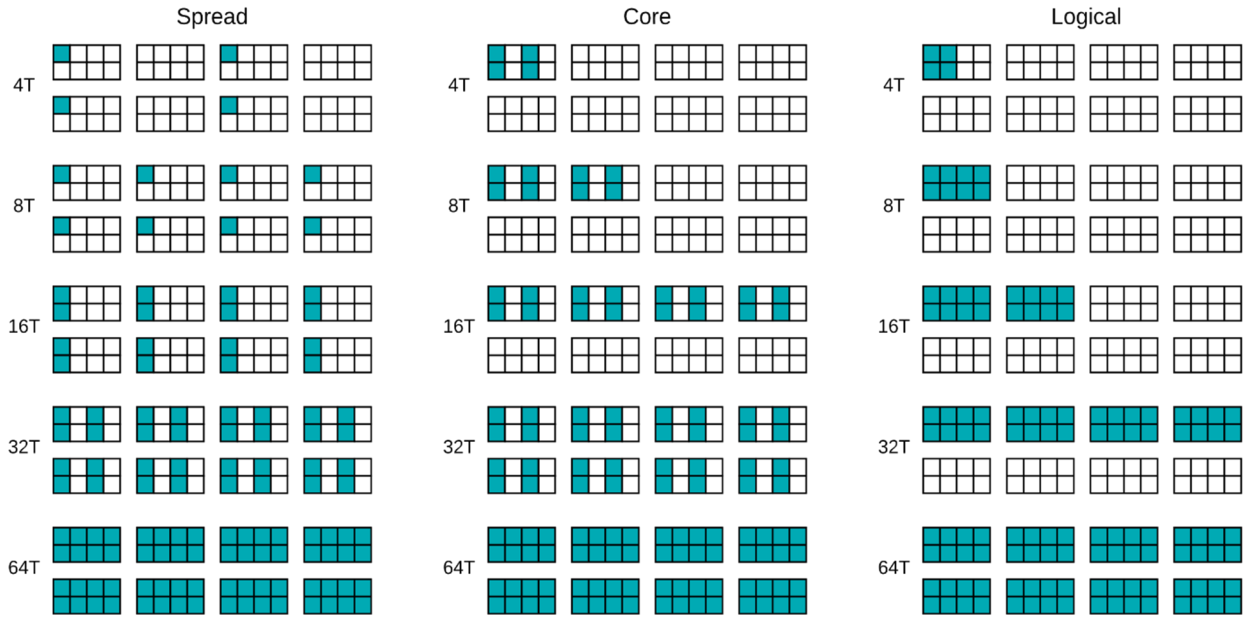


Figure 2: Options for thread pinning on a 64-core AMD Ryzen™ Threadripper™ PRO processor.

When the thread scheduling was left to the Windows operating system, running 16 processes of SOLIDWORKS Plastics on a 64-core AMD Ryzen™ Threadripper™ PRO it Looked like this:

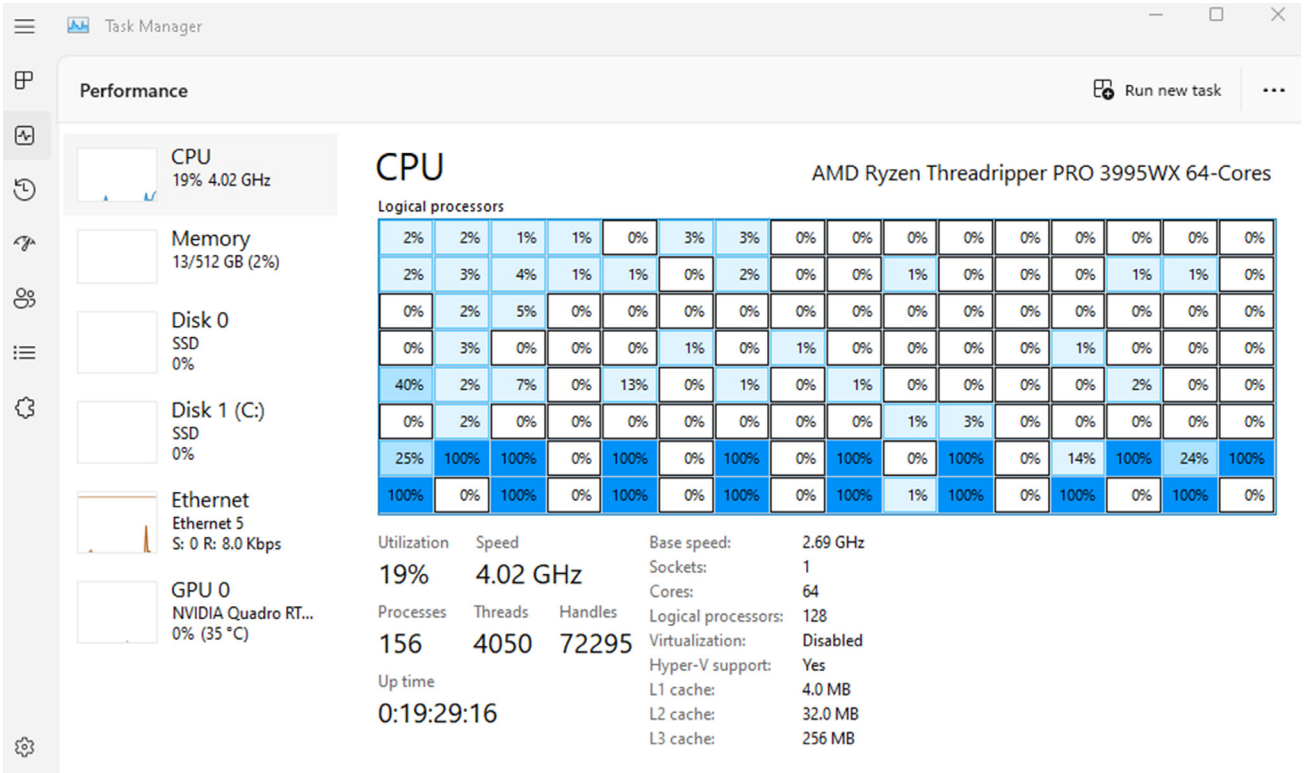


Figure 3: Windows Task Manager when running SOLIDWORKS Plastics 2023 SP0 with 16 processes on a 64 core AMD Ryzen™ Threadripper™ PRO 3995WX CPU

As indicated by the most active cores, all of the work is happening on two chiplets, and the operating system scheduler may allow some threads to migrate from one core to another. If that thread migration occurs across chiplets, then this causes an L3 cache "miss," which is computationally expensive.

In SOLIDWORKS Plastics 2023 SP1, threads are automatically pinned to the CPU cores in a manner that optimizes the sharing of L3 cache and disperses the workload across four physical chiplets. Furthermore, when processes are "pinned" to cores by the application that spawns the processes, those processes are not subject to the thread migration that can introduce L3 cache misses. This is evident when viewing the Windows Task Manager while running 16 processes of SOLIDWORKS Plastics 2023 SP1 (with Zen-aware thread pinning integrated) on the same 64-core AMD Ryzen™ Threadripper™ PRO processor

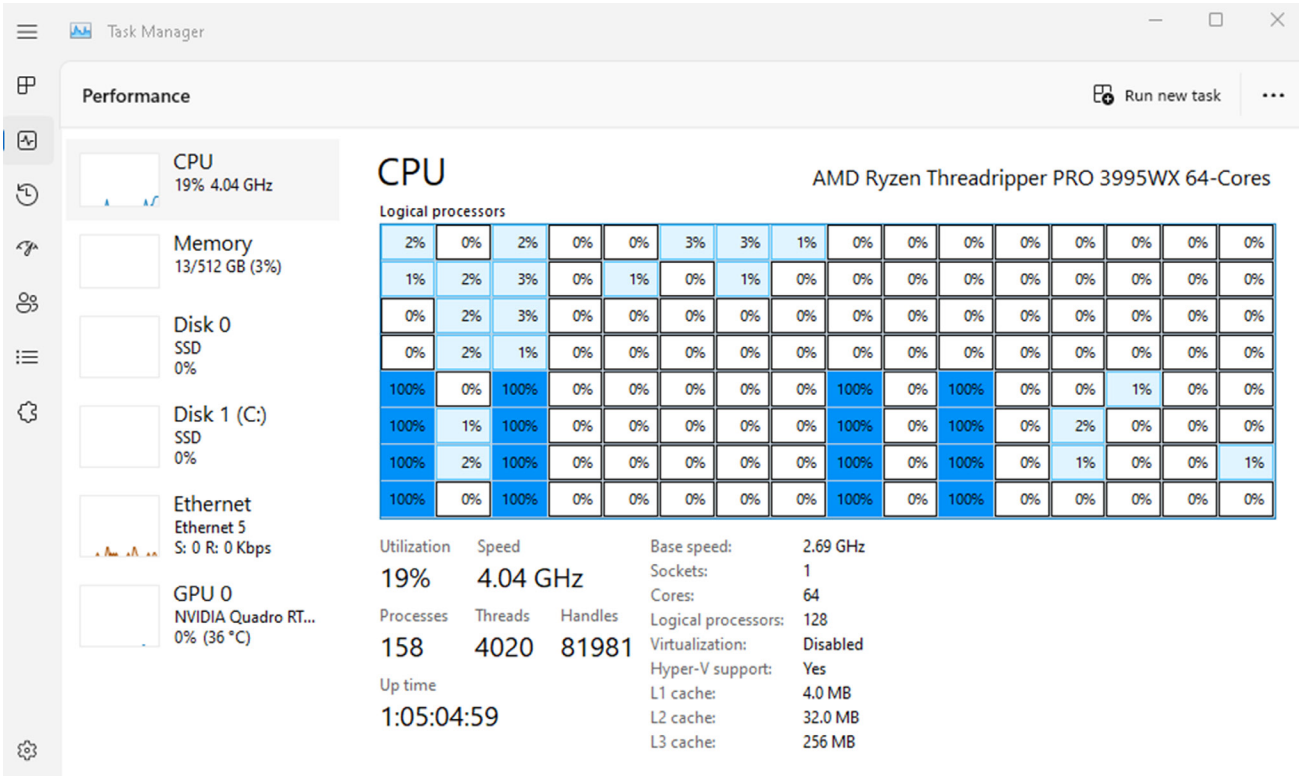


Figure 4: Windows Task Manager when running SOLIDWORKS Plastics 2023 SP1 with 16 processes on a 64 core AMD Ryzen™ Threadripper™ PRO 3995WX CPU

PERFORMANCE GAINS

As one of the leading injection molding simulation software packages, SOLIDWORKS Plastics features are available directly inside of the SOLIDWORKS CAD environment for easy access by plastics part and injection mold designers. The Plastic Injection Engineer role, running on the 3DEXPERIENCE platform, moves injection molding simulation into the cloud and further allows Dassault Systèmes clients to increase collaboration, improve execution and accelerate innovation.

The SOLIDWORKS Plastics R&D solver team has been working closely with AMD engineers and implemented the Thread-pinning technologies listed above, namely, the three approaches: spread, core and LP, and tested the performance gains with NUMA on and off.

There are two performance test indicators, one for the pure matrix solver, which is a Fortran code-based, third-party AMG solver labeled as "solver," and the other for the overhead code that is called "other." In the table below, "total" then means the performance gain a user will see with "solver" and "other" together.

As can be seen, the tests were performed with 1, 2, 4, 8, 16, 32, and 64 processors, and the performance measures include the consistency and average speed-up in percentage over the baseline, which is the performance prior to the thread-pinning implementation.

#Threads	Spead with SMT on		
	Total	**Solver**	**Other**
1	9.19%	7.09%	10.51%
2	9.58%	2.12%	14.81%
4	10.97%	4.15%	15.71%
8	13.90%	3.90%	20.86%
16	18.19%	9.38%	24.89%
32	18.16%	7.74%	26.88%
64	12.84%	5.34%	21.00%
	13.26%	5.67%	19.24%

Core with SMT on		
Total	**Solver**	**Other**
7.91%	4.12%	10.29%
12.85%	10.07%	14.80%
12.46%	9.84%	14.29%
6.12%	-9.89%	17.28%
15.44%	4.77%	23.56%
19.10%	8.73%	27.78%
-2.85%	-7.52%	2.24%
10.15%	2.87%	15.75%

LP with SMT on		
Total	**Solver**	**Other**
8.55%	5.69%	10.34%
-10.95%	-10.66%	-11.15%
-9.43%	-15.62%	-5.12%
-3.55%	-11.88%	2.26%
-6.42%	-25.21%	7.88%
3.59%	-11.65%	16.33%
12.86%	4.57%	21.89%
-0.76%	-9.25%	6.06%

Figure 5: Performance gains of SOLIDWORKS Plastics 2023 SP1 with 1,2,4,8,16,32 and 64 processors on a 64 core AMD Ryzen™ Threadripper™ PRO 3995WX CPU

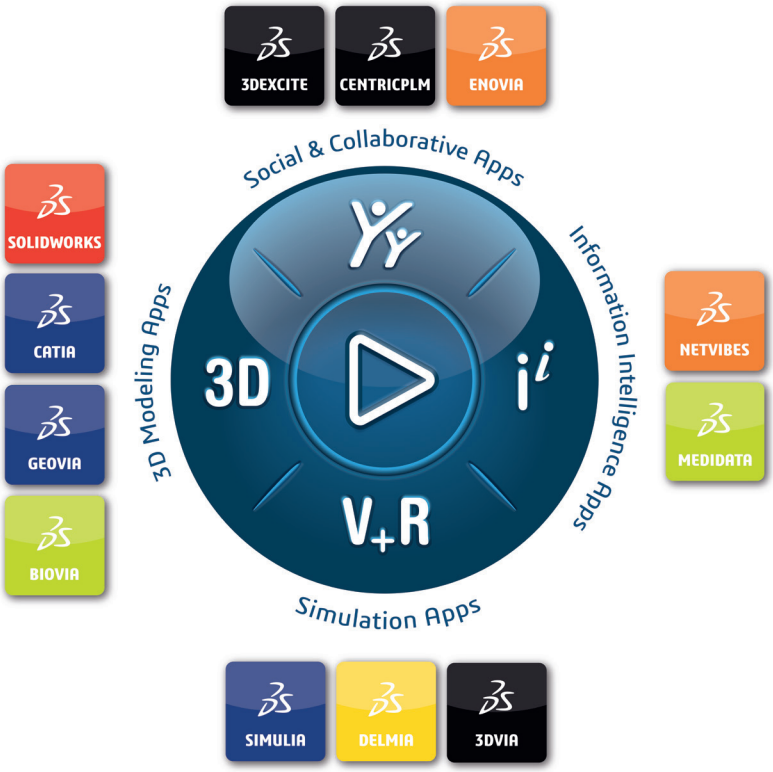
The best performer highlighted in green is the spread approach, which shows both maximum speed-up gains and consistency with all different number of processors, as well as in both the matrix solver part and the over-head part of the solver codes.

CONCLUSION

The impact of Zen-aware thread pinning is immediately obvious when one understands the Zen microarchitecture and views the Windows Task Manager in that context while running multi-threaded software applications, such as SOLIDWORKS Plastics 2023. The SOLIDWORKS Plastics team analyzed multiple scenarios involving workloads of varying sizes, use of different numbers of processes, and all three available thread pinning strategies for Zen-based processors. As a result of that analysis, the SOLIDWORKS Plastics team integrated an optimized Zen-aware thread pinning strategy directly into the solver code for SOLIDWORKS Plastics 2023 SP1. In the example shown above running 16 processes on a 64-core AMD Ryzen™ Threadripper™ PRO processor, the Zen-aware thread pinning in SOLIDWORKS Plastics 2023 SP1 results in a 4% faster execution time compared to SOLIDWORKS Plastics 2023 SP0.

If end users choose to run SOLIDWORKS Plastics 2023 with a number of processes that is equal to the total number of cores available, then thread pinning is not applicable because all of the cores are occupied and therefore the operating system has no available cores on which to migrate threads. However, many users appreciate the flexibility of running SOLIDWORKS Plastics at the highest level of performance on a subset of the total available cores, while leveraging the other cores for multi-tasking. The best overall performance of SOLIDWORKS Plastics 2023 when running on a 64-core AMD Ryzen™ Threadripper™ PRO processor occurs when running 32 processes. Whether thread pinning is applied is completely seamless and transparent to the end user beginning with SOLIDWORKS Plastics 2023 SP1.

End users who have invested in state-of-the-art workstation hardware based on the AMD Ryzen™ Threadripper™ PRO processor expect the utmost in performance from the software that drives their business, and the flexibility to multi-task efficiently in order to maintain user productivity. AMD and the SOLIDWORKS team will continue to explore ways to optimize software performance and help users maximize the performance potential when running SOLIDWORKS Plastics on AMD Ryzen™ Threadripper™ PRO processors.



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Americas
Dassault Systèmes
175 Wyman Street
Waltham, Massachusetts
02451-1223
USA

Europe/Middle East/Africa
Dassault Systèmes
10, rue Marcel Dassault
CS 40501
78946 Vélizy-Villacoublay Cedex
France

Asia-Pacific
Dassault Systèmes K.K.
ThinkPark Tower
2-1-1 Osaki, Shinagawa-ku,
Tokyo 141-6020
Japan

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SIMTEK
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SIM Technologies Pvt. Ltd.

3rd Floor, "Mamanjee Centre" ,
S7-A, Thiru-Vi-Ka Industrial Estate,
Guindy, Chennai – 600 032

+91-8754447021 **marketing@simtek.in**