Introduction to AMD Zen Software Studio Version 4

Steve Bassett, product manager

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Supercomputing Japan

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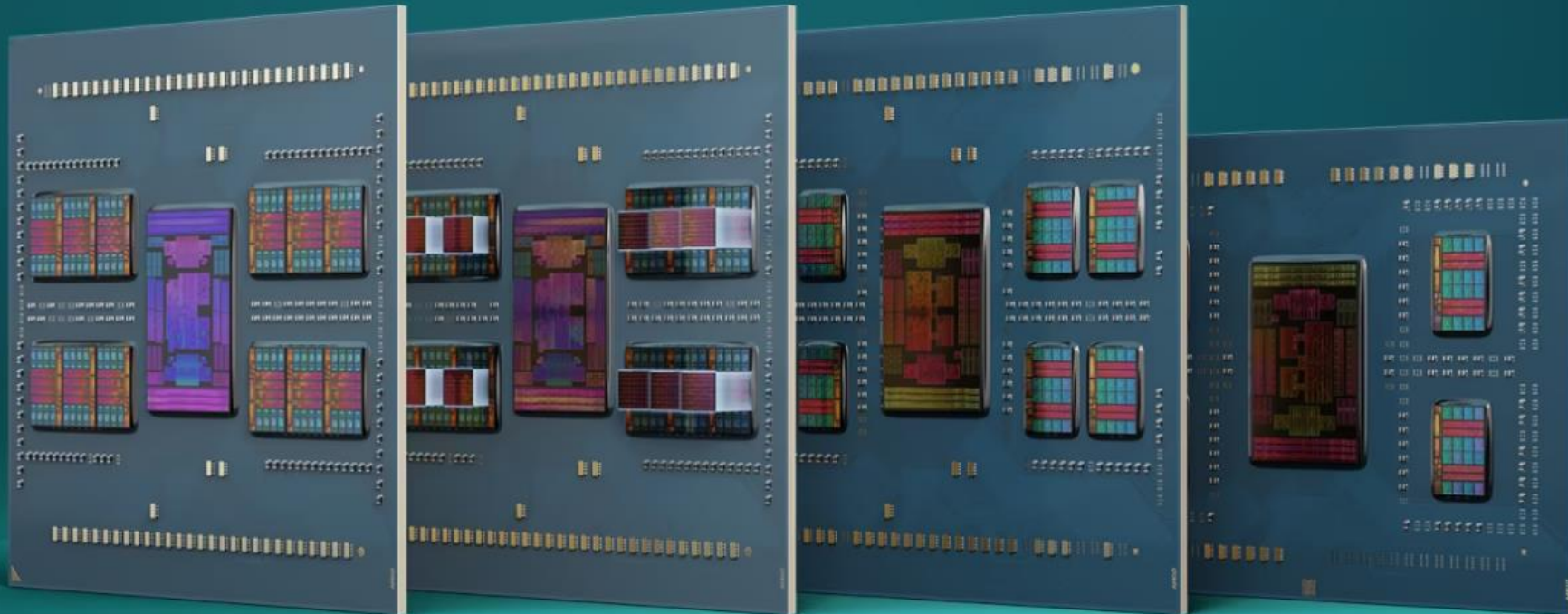
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AMD Zen Software Studio supports
AMD EPYC™ Server Processors

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AMD Zen Software Studio
Toolchain Ecosystem

Applications

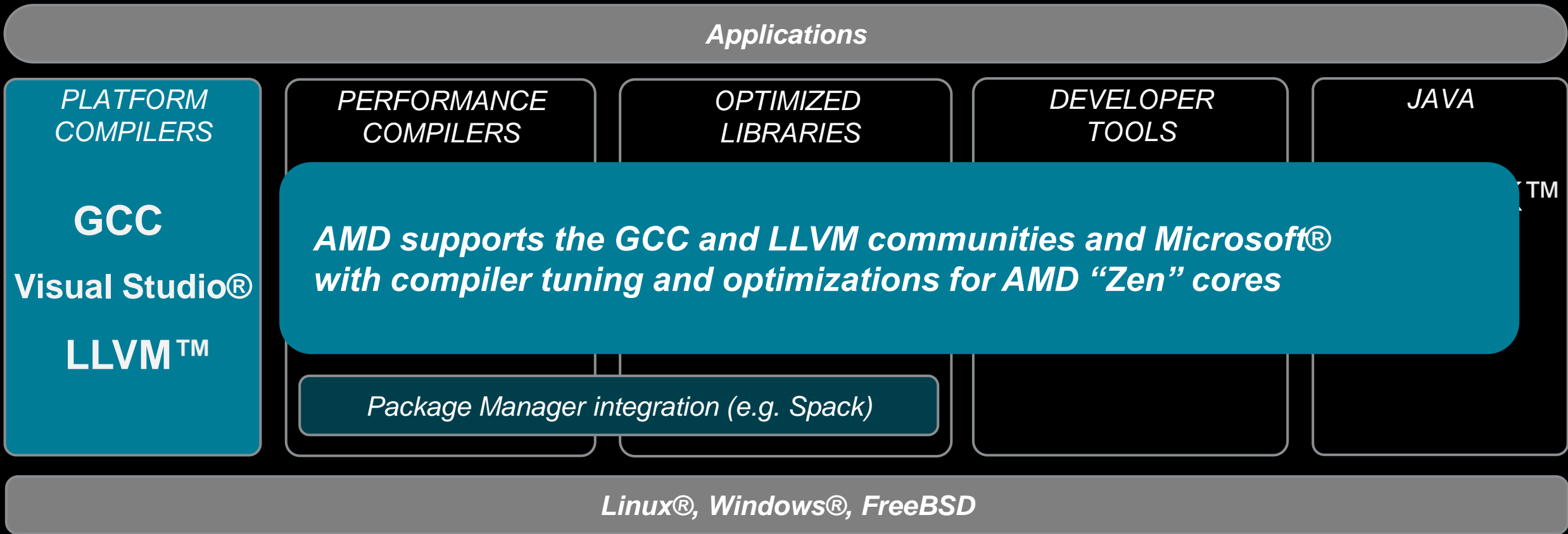| PERFORMANCE COMPILERS	OPTIMIZED LIBRARIES	DEVELOPER TOOLS	JAVA
AOCC *AMD Optimizing CPU Compilers C, C++, Fortran*	**AOCL** *AMD Optimizing CPU Libraries* **ZenDNN** *CPU Inference Acceleration*	**AMD µProf** *Performance & Power Profiling Tools*	OpenJDK™ ⬇ Java®

Package Manager integration (e.g. Spack)

Linux®, Windows®, FreeBSD

AMD offers professional software development tools optimized for Enterprise & HPC applications on AMD "Zen" CPUs

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AMD Zen Software Studio
Toolchain Ecosystem

Applications

PLATFORM COMPILERS	PERFORMANCE COMPILERS	OPTIMIZED LIBRARIES	DEVELOPER TOOLS	JAVA

GCC

Visual Studio®

LLVM™

™

AMD supports the GCC and LLVM communities and Microsoft® with compiler tuning and optimizations for AMD "Zen" cores

Package Manager integration (e.g. Spack)

Linux®, Windows®, FreeBSD

*AMD offers professional software development tools
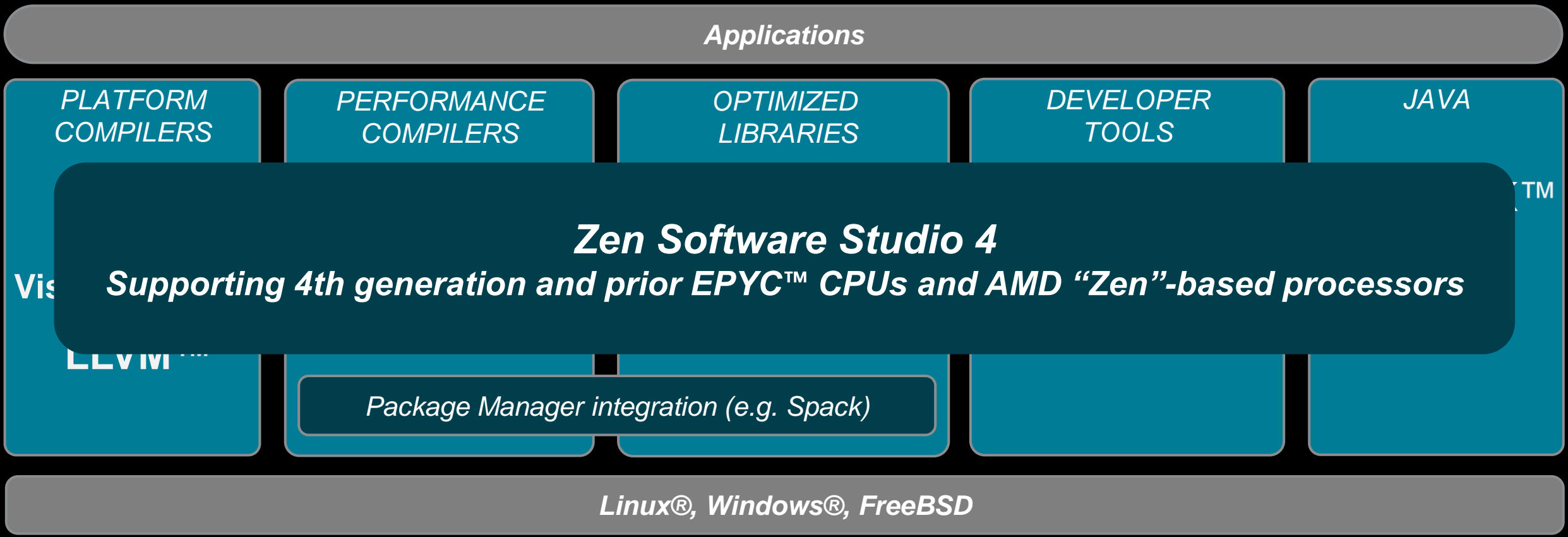optimized for Enterprise & HPC applications on AMD "Zen" CPUs*

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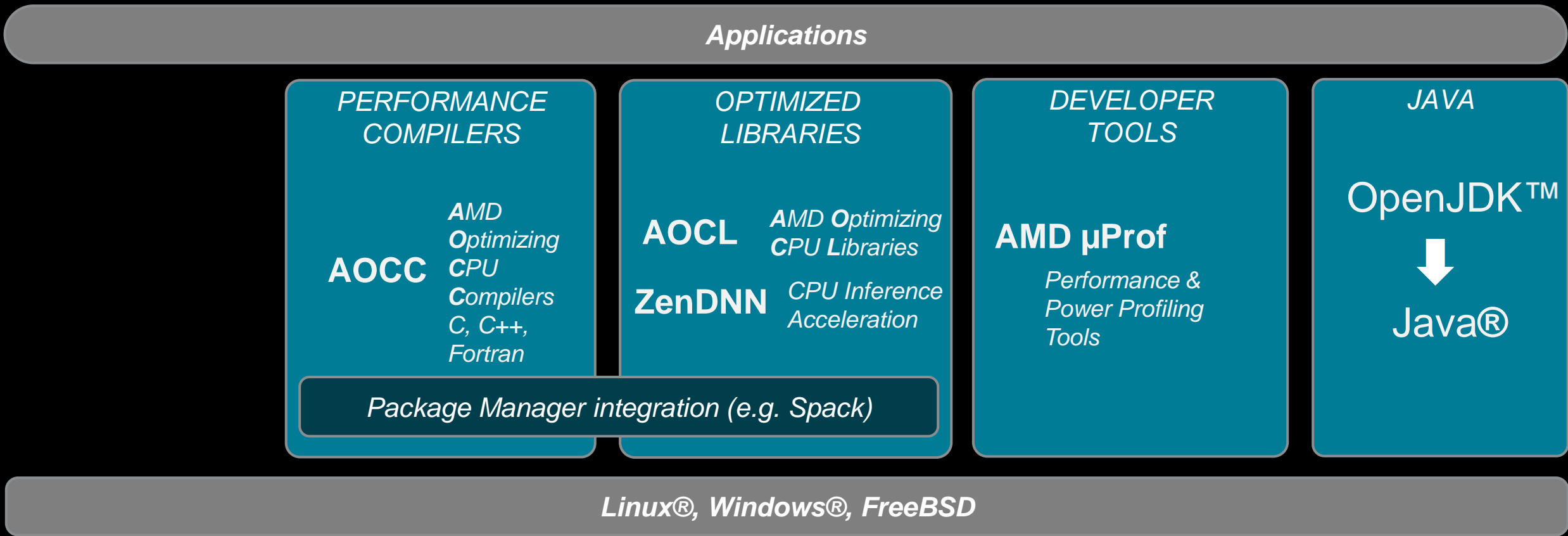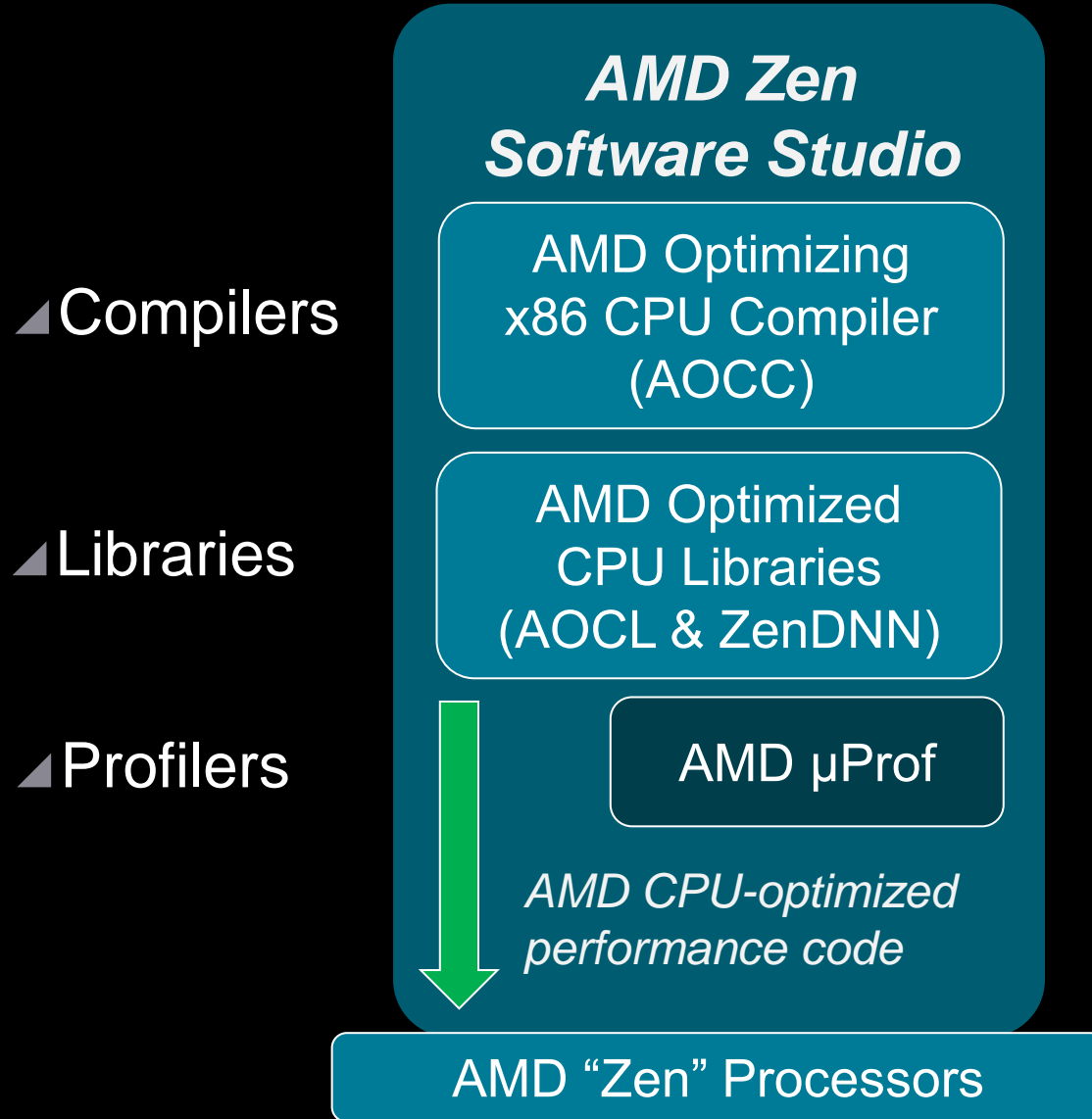
AMD Zen Software Studio 4
Toolchain Ecosystem

Applications

| PLATFORM COMPILERS | PERFORMANCE COMPILERS | OPTIMIZED LIBRARIES | DEVELOPER TOOLS | JAVA |

™

Vis

LLVM…

Zen Software Studio 4
Supporting 4th generation and prior EPYC™ CPUs and AMD "Zen"-based processors

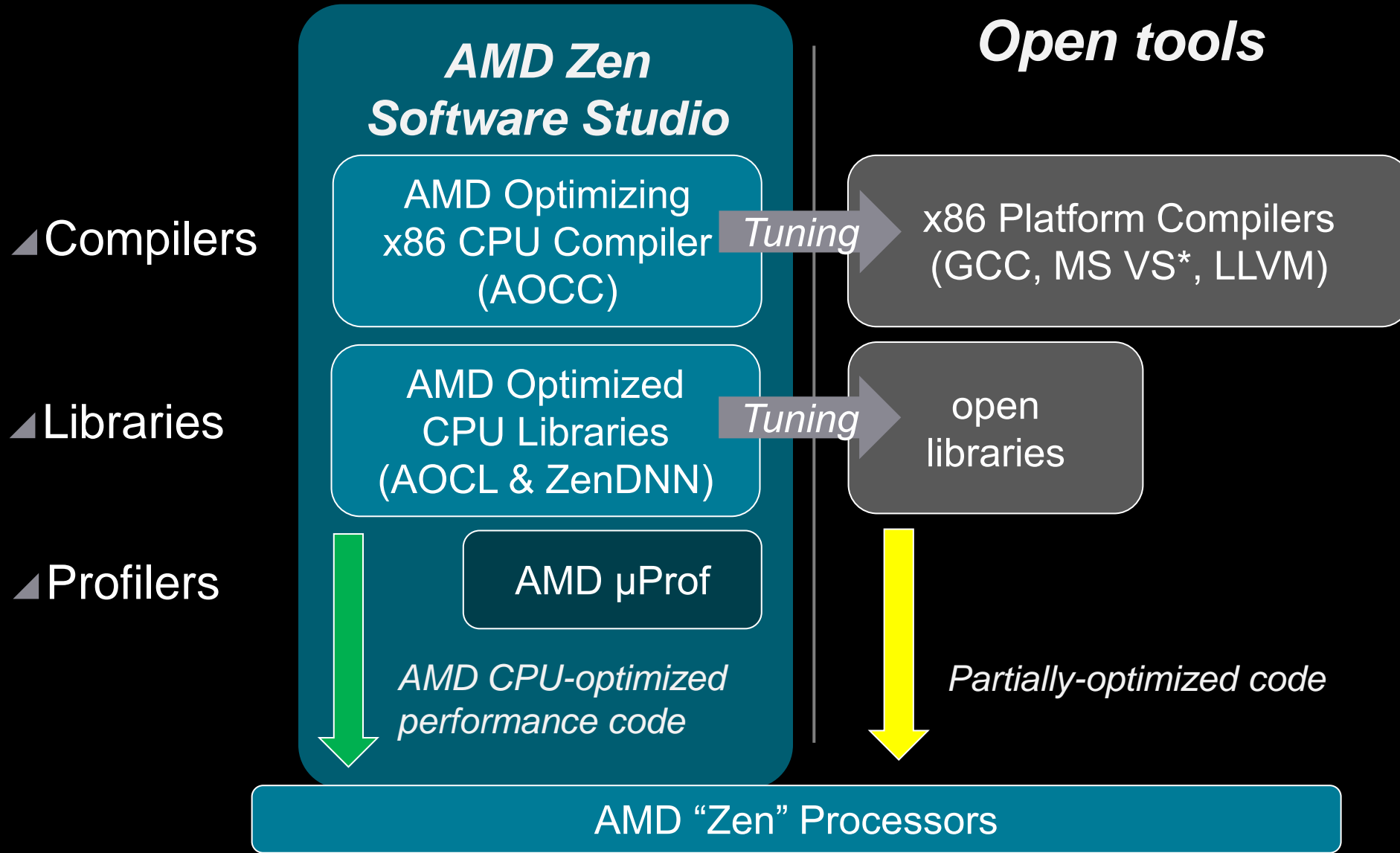*Package Manager integration (e.g. Spack)*

Linux®, Windows®, FreeBSD

Professional software development tools
optimized for Enterprise & HPC applications on AMD "Zen" CPUs
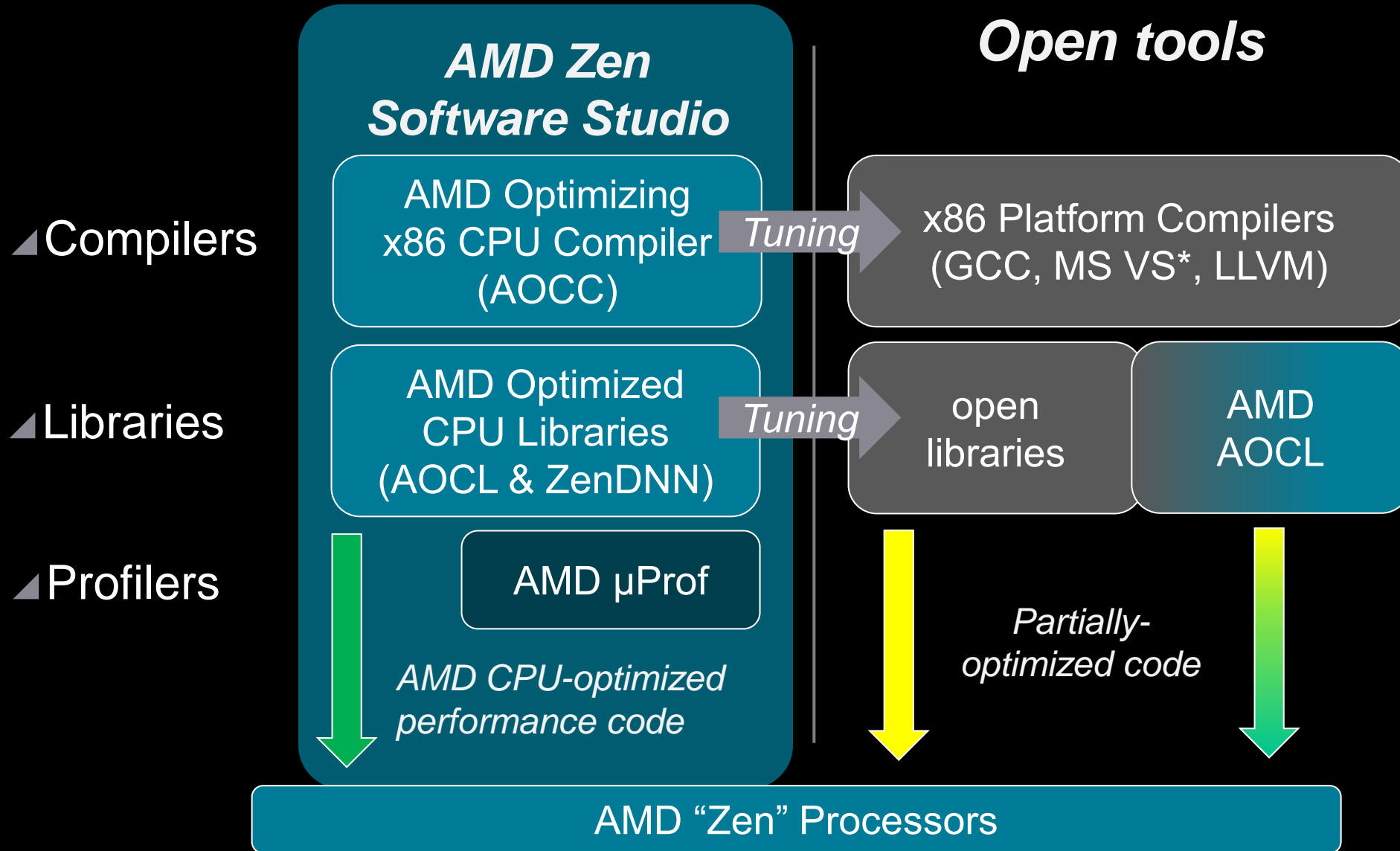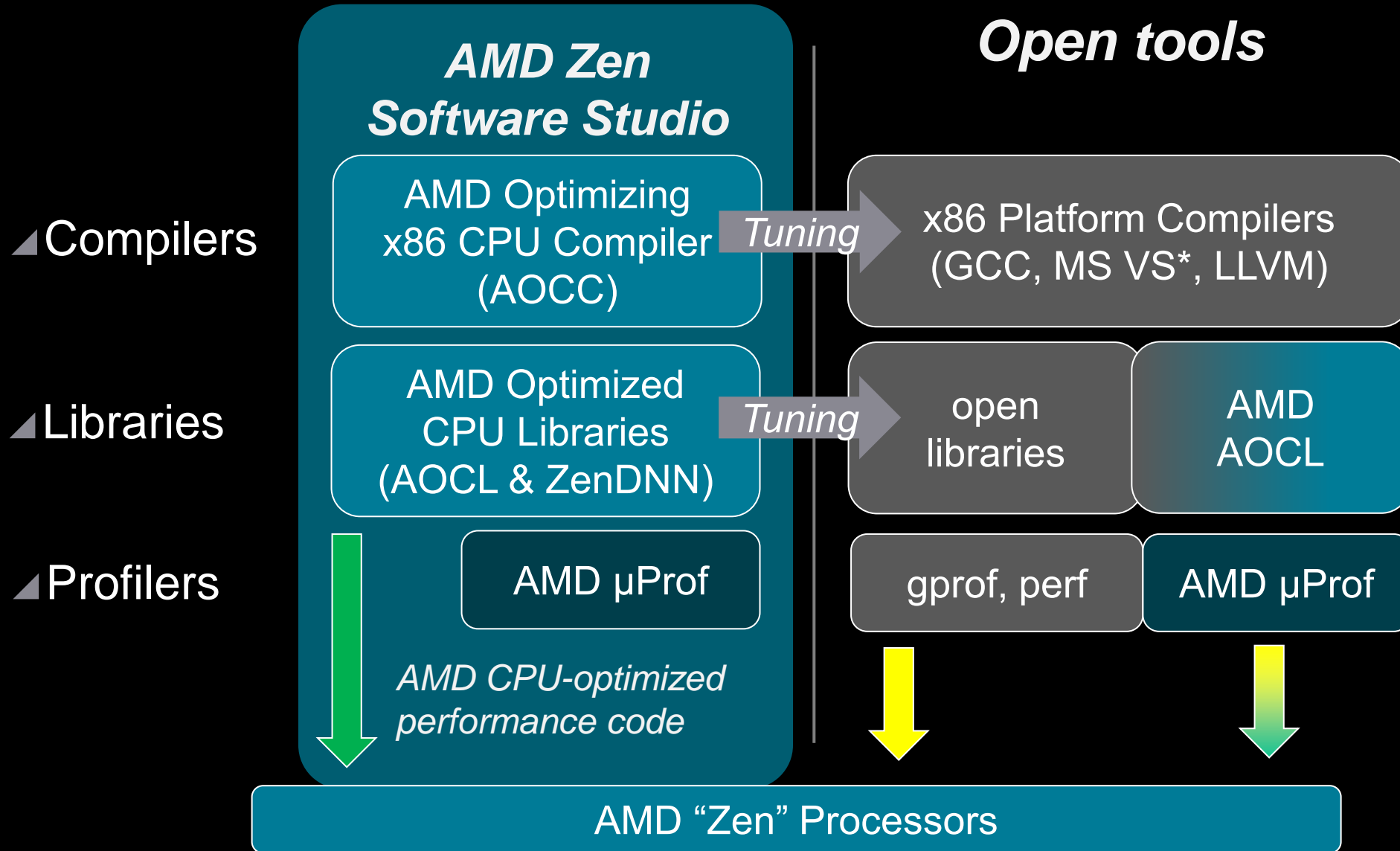*with commercial support available*

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AMD CPU Software Development Options

AMD Zen Software Studio

Compilers
AMD Optimizing x86 CPU Compiler (AOCC)

Libraries
AMD Optimized CPU Libraries (AOCL & ZenDNN)

Profilers
AMD µProf

AMD CPU-optimized performance code

AMD "Zen" Processors

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AMD CPU Software Development Options

AMD Zen Software Studio

Open tools

Compilers

AMD Optimizing x86 CPU Compiler (AOCC) → *Tuning* → x86 Platform Compilers (GCC, MS VS*, LLVM)

Libraries

AMD Optimized CPU Libraries (AOCL & ZenDNN) → *Tuning* → open libraries

Profilers

AMD µProf

AMD CPU-optimized performance code

Partially-optimized code

AMD "Zen" Processors

* Microsoft® Visual Studio®

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AMD CPU Software Development Options

AMD Zen Software Studio

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Libraries

AMD Optimized CPU Libraries (AOCL & ZenDNN) → *Tuning* → open libraries | AMD AOCL

Profilers

AMD µProf | gprof, perf | AMD µProf

AMD CPU-optimized performance code

AMD "Zen" Processors

* Microsoft® Visual Studio®

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AMD CPU Software Development Options

	AMD Zen Software Studio	*Open tools*	*x86-64 standard Vendor-specific tools*
Compilers	AMD Optimizing x86 CPU Compiler (AOCC)	x86 Compilers (GCC, LLVM, MS VS)	Compilers
Libraries	AMD Optimized CPU Libraries (AOCL & ZenDNN)	open libraries	Libraries
Profilers	AMD μProf	gprof, perf	Profiler
	AMD CPU-optimized performance code	*Partially-optimized code*	*ISA standard code*

AMD "Zen" Processors

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Operating System support

	Zen Software Studio tool	Support on Linux Distributions*	Support on Windows 10
Compilers	AOCC >	Yes	No. Use Microsoft Visual Studio.
Libraries	AOCL >	Yes	Yes
	ZenDNN >	Yes	No
Profilers	AMD uProf >	Yes	Yes

* Primarily Red Hat© Enterprise Linux ©, Canonical Ubuntu ©, SUSE © Linux Enterprises Server and Rocky Linux™ distributions.
See AMD Zen Software Studio release documentation for specific support details.

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◢ Zen Software Studio 4.2

◢ Available at no charge

◢ Documentation and downloads

- https://www.amd.com/en/developer/zen-software-studio.html

◢ Support options

- General email inquiry
  – toolchainsupport@amd.com

- Commercial support service is available - See AMD for details

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AMD Zen Software Studio

AMD Optimizing C/C++ and Fortran Compilers ("AOCC")

The AOCC compiler system is a high performance, production software generation tool optimized for AMD processors based on the AMD "Zen" core architecture.

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AMD µProf

AMD µProf is a suite of powerful tools that help developers optimize software for performance and power, optimized for AMD processors based on the AMD "Zen" core architecture.

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AMD Optimizing CPU Libraries ("AOCL")

AOCL is a set of numerical libraries optimized for AMD processors based on the AMD "Zen" core architecture.

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AMD Zen Deep Neural Network ("ZenDNN")

ZenDNN library, which includes APIs for basic neural network building blocks optimized for AMD CPU architecture, targets deep learning application and framework developers with the goal of improving deep learning inference performance on AMD CPUs.

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Applications

AMD offers specific, pre-built applications and also supports the Spack package management framework.

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OVERVIEW

- PROFILING

- LIBRARIES

- **COMPILERS**

- APPLICATION SUPPORT

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AMD leverages the LLVM™ compiler framework

| LLVM Open-source Compiler Project | → | AMD "Zen" Optimizations | → | AOCC | → | Linux Applications |
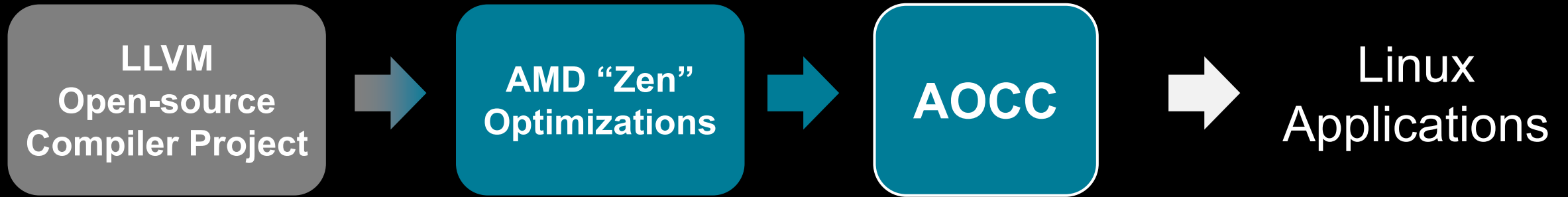
Why start with LLVM?

◢ LLVM is a popular, open-source framework for building compilers
- Robust framework for compiler developers
- Clang and Flang front-end compilers
- LLVM optimizing back-end compiler
- Very active and diverse development community

◢ AMD creates AOCC from LLVM
- Optimizations for x86 and also unique to the AMD "Zen" architecture
- Released in support of and timed with AMD "Zen"-based CPUs
- Production Fortran front-end with language compliance
- With developer support

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AOCC Optimization Report

⊿ AOCC supports a range of optimization levels through the "-O…" flags typical of other compilers

⊿ AOCC also supports sets of options for vector, loop, math, in-line, memory layout, instruction-level, and scalar optimizations

⊿ The AOCC Optimization Report identifies the optimizations the compiler chose to use and not to use

　• Compile-time and link-time optimization reporting options

⊿ Use the report to identify code that does not readily optimize for opportunities for performance improvement

See the AOCC User Guide for details

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Open compilers

▲ GCC 13.1 and LLVM 16

- Release branches support all AMD "Zen" microarchitectures through "Zen 4"
- -march = znver1, znver2, znver3, znver4

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OVERVIEW

- PROFILING

- **LIBRARIES**

- COMPILERS

- APPLICATION SUPPORT

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AMD Optimizing CPU Libraries (AOCL)

- AOCL are a set of numerical libraries tuned specifically for the AMD EPYC™ processor family.

- Optimized implementations of industry-standard math libraries enable fast development of high-performance computing applications.

- Simple interfaces to take advantage of the latest AMD processor hardware innovations.

- All libraries contributed to the open-source communities.*

Library type	AMD Name	Description
Basic Linear Algebra	**BLAS**	Optimized high-performance Basic Linear Algebra Subprograms (BLAS)
Linear Algebra	**libFlame & ScaLAPACK**	Optimized dense matrix computations as found in Linear Algebra Package (LAPACK)
Sparse matrices	**Sparse**	Sparse matrix and vector operations and solvers. Includes support for MUMPS Sparse Solver
Fast Fourier Transforms	**FFTW**	Fast C routines for computing Discrete Fourier Transform in 1D, 2D and 3D
Core Math & functions	**LibM**	Subset of standard C99 math functions optimized for x86-64;
Cryptography & Compression	**Cryptography, Compression**	Optimized cryptographic (AES, SHA2) and compression (LZ4, Snappy, ZLIB) functions
Memory access	**LibMem**	Optimized memory and string functions
Secure Random Number Generator	**SecureRNG**	Single and Double Precision Secure Random Number Generator library

*Subject to community acceptance and integration.

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Building and linking in AOCL libraries

◢ Linking a "Zen"-optimized library from AOCL is a common step in evaluating performance improvement for an application

◢ Libraries with commonly implemented interfaces typically migrate to the equivalent AOCL libraries with minimal source and build changes.

◢ Each library has specific compilation and linking requirements and dependencies

  • Note also differences in use on Linux and Windows systems
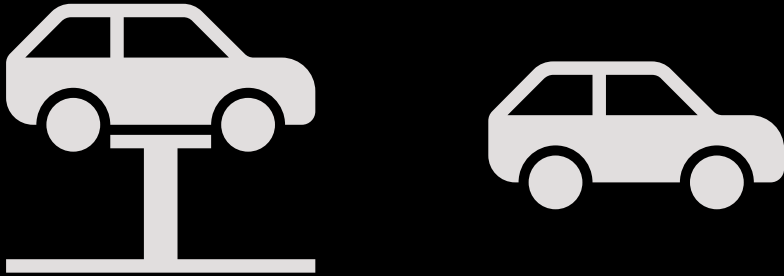
See the AOCL User Guide for details

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OVERVIEW

- **PROFILING**

- **LIBRARIES**

- **COMPILERS**

- **APPLICATION SUPPORT**

AMD ZEN SOFTWARE STUDIO_4 | PUBLIC

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What is application software "profiling"?

◢ Does a car just run or does it run well?

- Debug for functionality = run

Debug for functionality and quality

- Profile and optimize for performance = run well, fast, fuel-efficient

Optimize for performance

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What is software "profiling"?

◢ Does the application run or does it run well?

- Debug for functionality = run
- Profile and optimize for performance = run well

◢ Profiling an application highlights where the limitations are to performance, efficiency, power

- One single-thread function that everything else waits for?
- Compute capacity or memory bandwidth?
- Dataset too big for the system's memory?

◢ Several ways to observe the application's behavior

- Watch the application from the operating system's perspective – using standard information
- Add instructions to the software and recompile for custom observability – labor intensive and intrusive

Write new source code, leverage open-source code

Leverage pre-written code

Compile for processor to run

Debug for functionality and quality

Optimize for performance

Scale up for many processors

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AMD µProf Profiler Overview

Measure and analyze the performance of an application or the entire system running Linux® or Windows®

◤ Command line or GUI

◤ System Analysis

- Monitors basic core, level 3 cache and data fabric performance metrics

◤ Application Analysis

- CPU Profiling to identify runtime performance bottlenecks of an application or the entire system

◤ Power Profiling
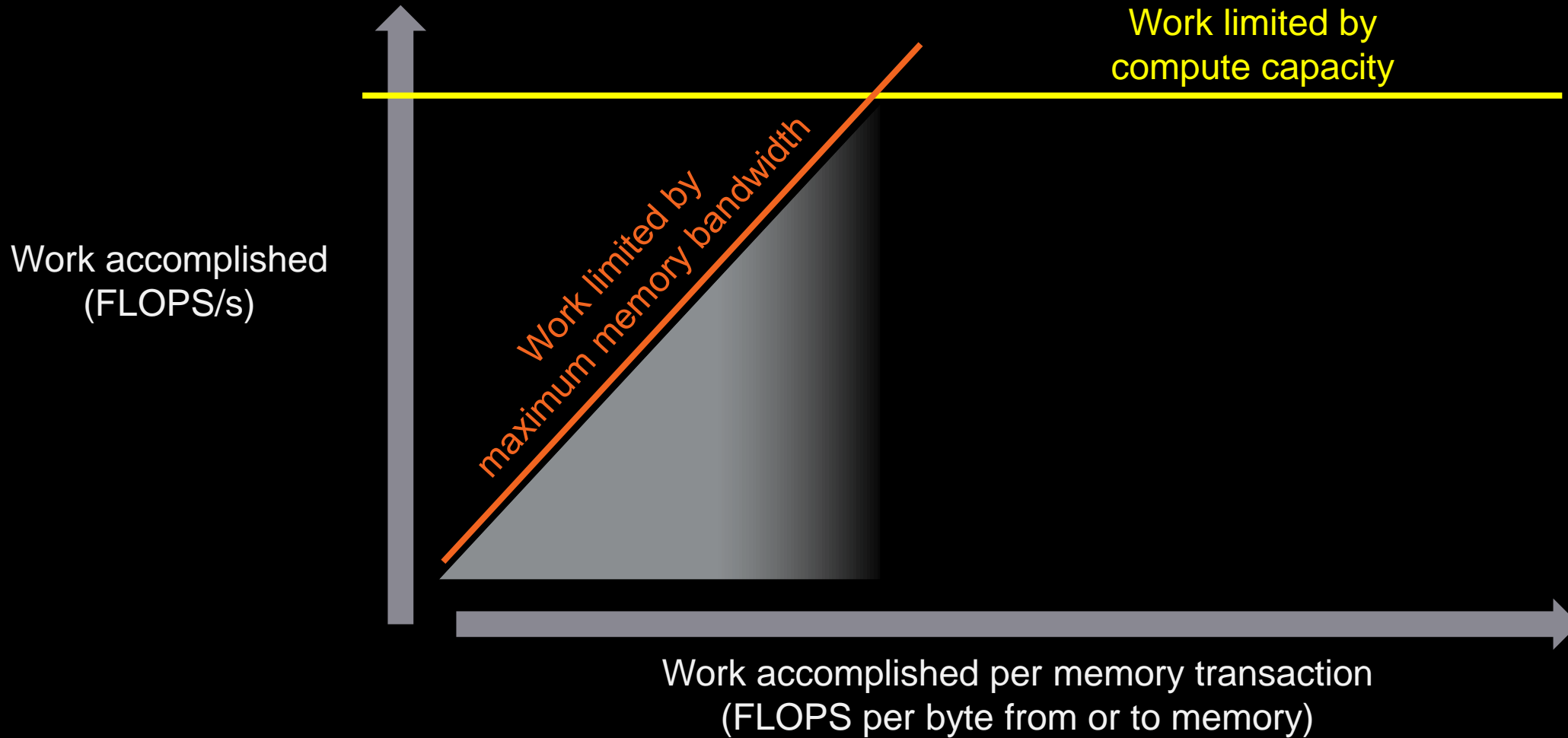
- Monitors thermal & power characteristics of system
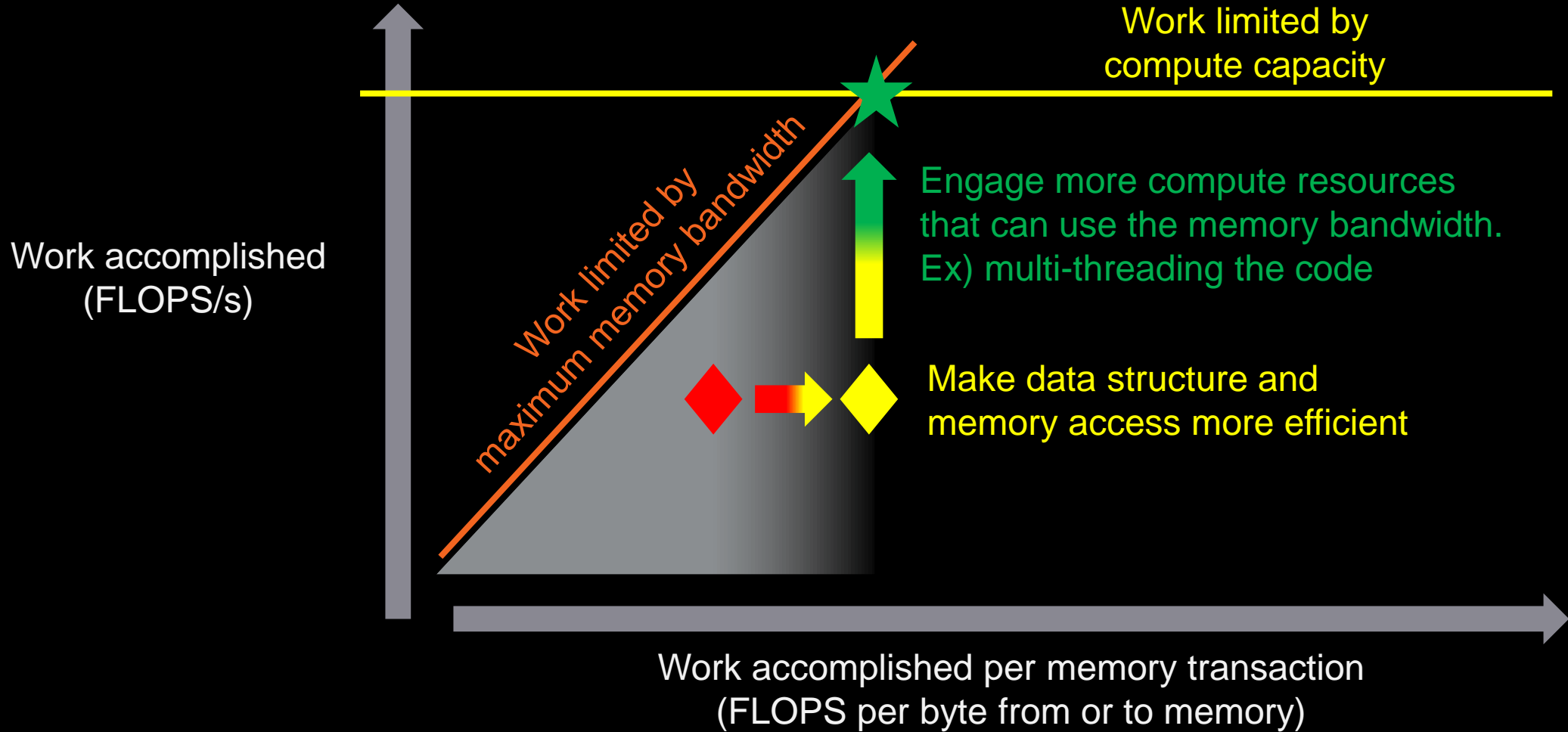
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Software profiling options

◢ Open-source linux "perf" tool

◢ Other x86-64 standard profiling tools

◢ AMD µProf offers a richer experience with AMD support

- Use an intuitive graphic user interface or script via command line interfaces
- Running on Linux®, Windows® and FreeBSD
- No source code instrumentation needed – but optional for added visibility
- Supporting performance monitoring recipes

  – Data from set of events with calculations associated with the events

◢ uProf 4

- Supporting AMD "Zen 4" and AVX-512 instructions
- Improved operation in virtualized environments
- *Now with roofline modeling*

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Roofline modeling – Modeling the application

Work limited by
compute capacity

Work accomplished
(FLOPS/s)

Work limited by
maximum memory bandwidth

Work accomplished per memory transaction
(FLOPS per byte from or to memory)

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Roofline modeling – Modeling the application

Work limited by
compute capacity

Work accomplished
(FLOPS/s)

Work limited by
maximum memory bandwidth

Engage more compute resources
that can use the memory bandwidth.
Ex) multi-threading the code

Make data structure and
memory access more efficient

Work accomplished per memory transaction
(FLOPS per byte from or to memory)

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OVERVIEW

- ## PROFILING

- ## LIBRARIES

- ## COMPILERS

- ## HPC APPLICATION SUPPORT

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AMD supports Spack for optimized Linux® application build

- Users need flexibility and efficiency when compiling an optimized HPC application
  - Complexity creates overhead and poor experience

- Spack is an open-source project and utility
  - Focused on Linux® open-source HPC and scientific applications
  - Simplifies installing the AMD compiler and libraries and building HPC applications
  - AMD one-click "recipes" deliver consistent, optimized HPC application performance

- AMD supports Spack recipes:
  - Generic recipes through https://github.com/spack/spack
  - AMD recommended command lines per application https://www.amd.com/en/developer/spack.html

- Refreshed for AMD 4th Generation EPYC and AVX-512 capability

Recipes supported for AMD optimized compiler and libraries

Generic and optimized recipes supported or in development for HPC

Benchmarks

Climate & Weather Modeling

Quantum Chemistry

Molecular Dynamics

CFD/FEA

Cosmology

Genomics

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HPC application focus for build and performance optimization

Open-Source & Licensed Applications Available				
App	**Version**		**App**	**Version**
Cloverleaf	1.3		Quantum Espresso	6.7
CP2K	6.1, 7.1		NEMO	4.0
GROMACS	2021.2		Tealeaf	1.403
Hmmer	3.3.1		VASP®**	6.2
LAMMPS	21072020		ROMS	3.8
NAMD	2.14			
NWChem	7.0.2			
OpenFOAM®	2012			
WRF	4.2			

See developer.amd.com/spack for build optimization details.
**Proprietary/licensed

Commercial Applications Available*	
App	**Version**
Ansys® Mechanical™	2022 R1
Ansys® LS-Dyna®	2022 R2
Ansys® HFSS™	2022 R2
COMSOL Multiphysics®	6.0 Update 2
MathWorks® MATLAB®	R2022a

*Enablement may be by user option or application configuration.

◢ AMD is actively supporting developers with optimization and performance improvement for AMD "Zen" processors.

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Optimized HPC benchmark executables

▲ AMD offers key HPC benchmarks in binaries for ease of use

- Optimized for performance on AMD 4TH Generation EPYC
- Based on the Zen Software Studio 4 compiler and customized libraries
- AMD Zen HPL (proprietary)
- AMD Zen HPL-MxP (proprietary)
- AMD Zen HPCG (proprietary)
- AMD Zen STREAM

▲ See https://www.amd.com/en/developer/zen-software-studio/applications/pre-built-applications.html for details and downloads

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🏠 > Developer > AMD Zen Software Studio > Applications > Pre-built-applications

Pre-built-applications

Downloads   Documentation

AMD offers the following applications pre-built with Zen Software Studio
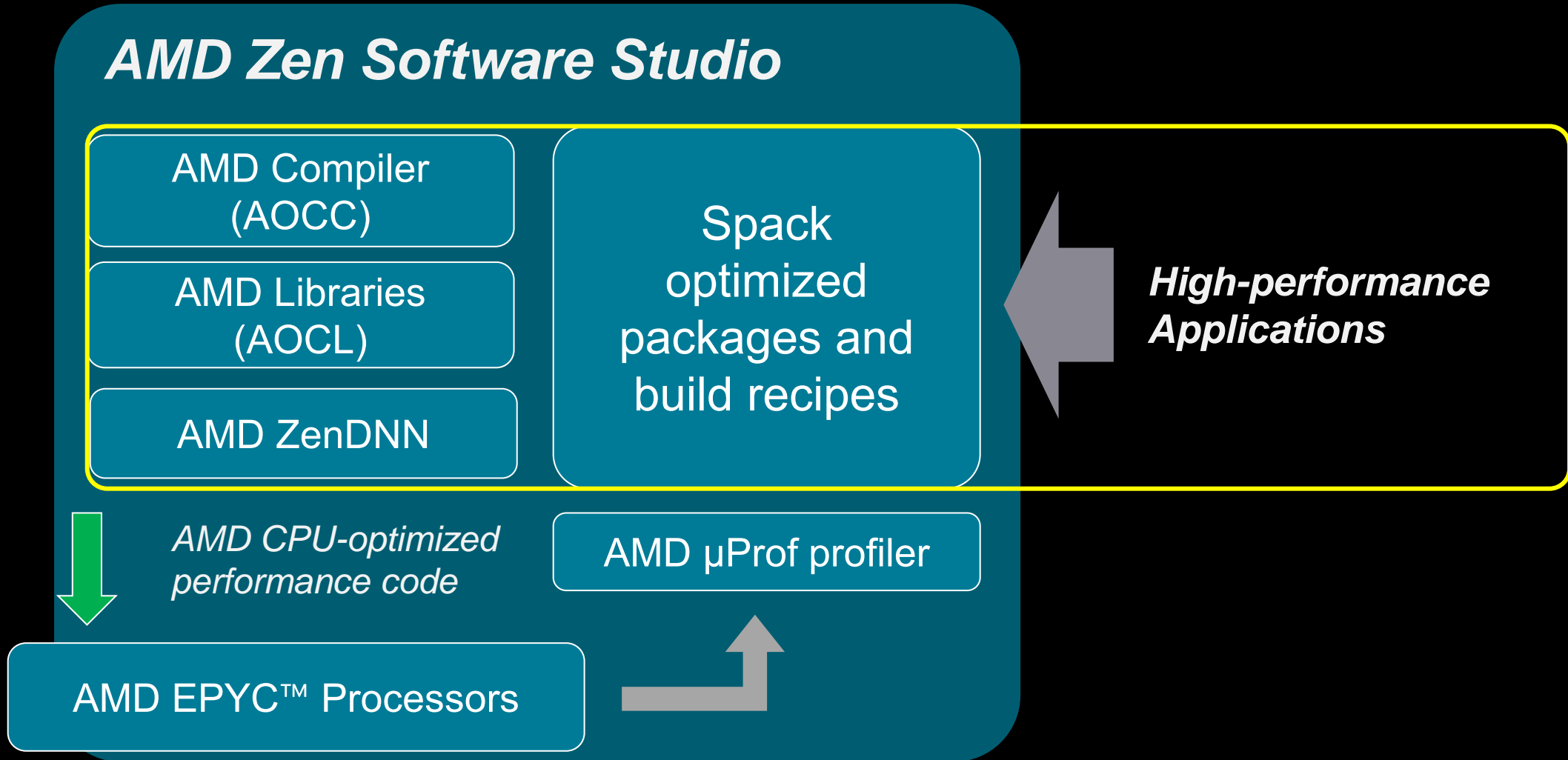
AMD Zen HPL optimized for AMD "Zen4"-based processors

- AMD's optimized version of HPL version 2.3
- This product includes software developed at the University of Tennessee, Knoxville, Innovating Computing Laboratory.
- Built with AMD's AOCC 4.0 compiler using a customized version of AMD's AOCL 4.0 libraries
- Applicable to running on 4th generation EPYC™ CPUs and other AMD "Zen4"-based processors
- Focused on single-node, dual-socket performance
- Offered as a static binary executable
- **See applications note** for additional details and running the benchmark executable

AMD Zen HPCG optimized for AMD "Zen4"-based processors

- AMD's optimized version of the High Performance Conjugate Gradient Benchmark for Linux, version 3.1
- Built with AMD's AOCC 4.0 compiler using a customized version of AMD's AOCL 4.0 libraries
- Applicable to running on 4th generation EPYC™ CPUs and other AMD "Zen4"-based processors
- Focused on single-node, dual-socket performance
- Offered as a static binary executable
- **See applications note** for additional details and running the benchmark executable

Note: Performance of these benchmarks is influenced and varies by processor model, system configuration, and resources.

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AMD Recommends the AMD Zen Software Studio for optimized application performance

AMD Zen Software Studio

AMD Compiler (AOCC)

AMD Libraries (AOCL)

AMD ZenDNN

Spack optimized packages and build recipes

High-performance Applications

AMD CPU-optimized performance code

AMD µProf profiler

AMD EPYC™ Processors

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AMD Zen Software Studio Access & Support

◢ Zen Software Studio 4.2

◢ Available at no charge

◢ Documentation and downloads

- https://www.amd.com/en/developer/zen-software-studio.html

◢ Support options

- General email inquiry
  - toolchainsupport@amd.com

- Commercial support service is available - See AMD for details

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AMD Zen Software Studio

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