EUROPYTHON 2016 Bilbao, 17-24 July

HIGH PERFORMANCE PYTHON ON INTEL® ARCHITECTURE

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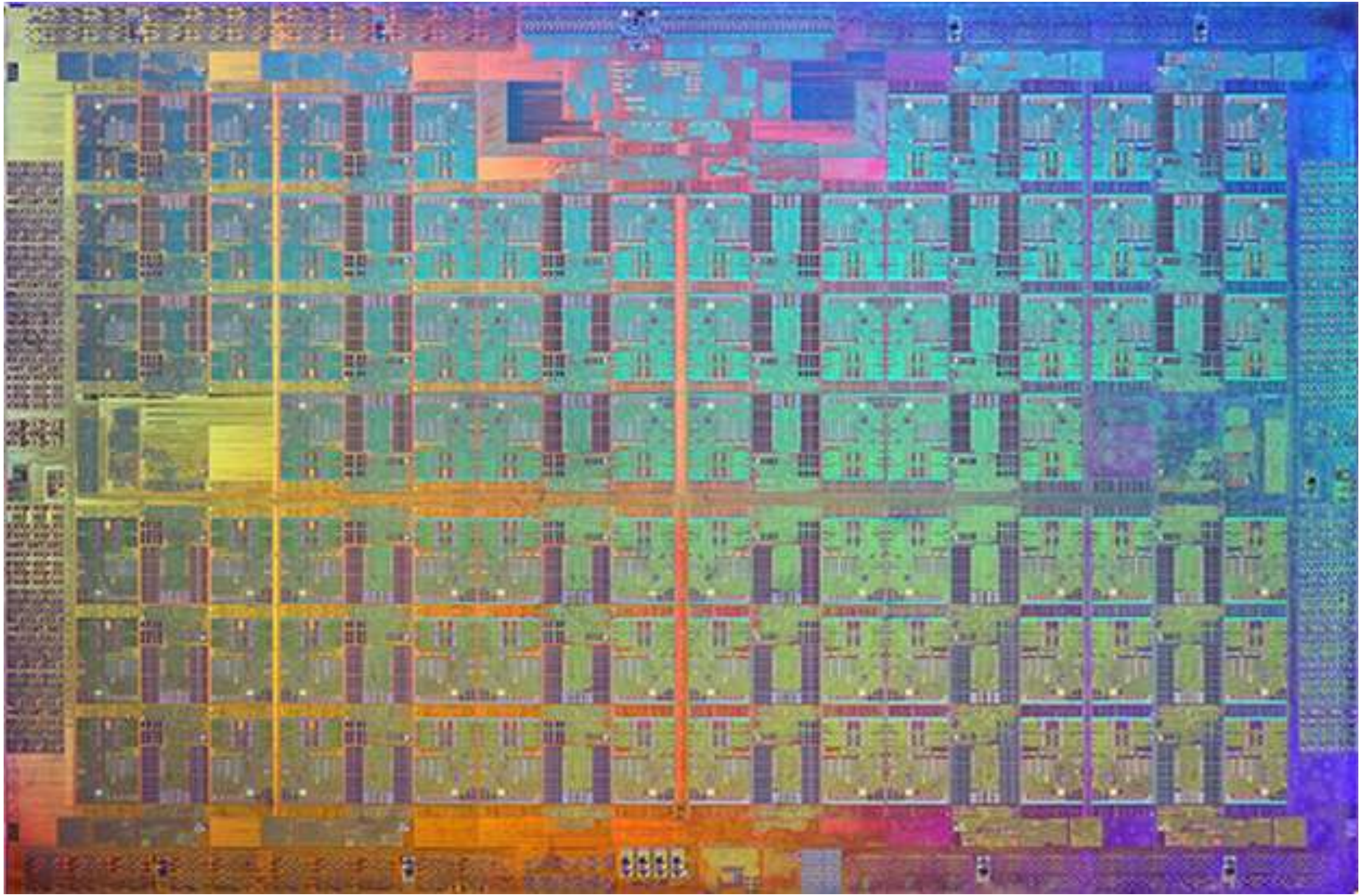
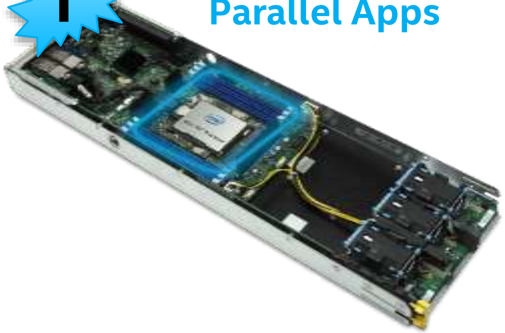


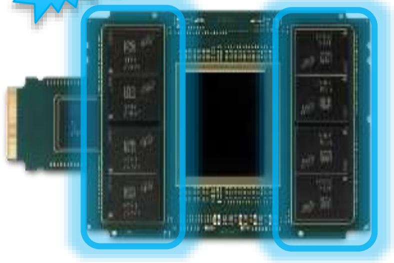
Introducing the Intel® Xeon Phi™ Processor

1st Integrated Fabric

1st Host CPU for Highly-Parallel Apps



1st Integrated Memory



LEADERSHIP PERFORMANCE ... WITH ALL THE BENEFITS OF A CPU

- ✓ Run Any Workload
- ✓ Programmability
- ✓ Power Efficient
- ✓ No PCIe Bottleneck
- ✓ Large Memory Footprint
- ✓ Scalability & Future-Ready

Intel® Xeon Phi™ Product Family x200

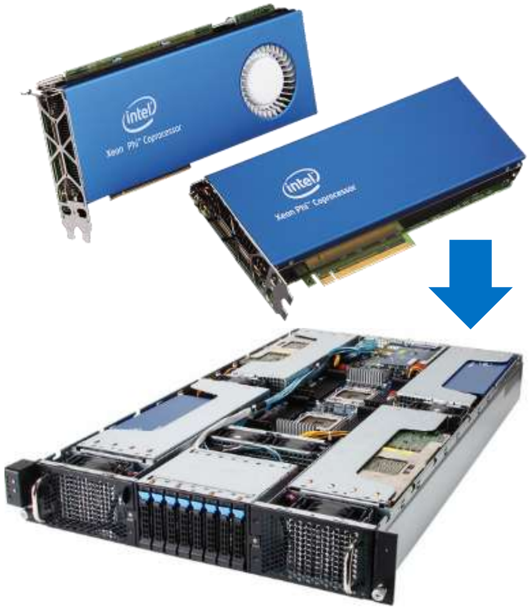
Intel® Xeon Phi™ Processor

with integrated
Intel® Omni-Path Fabric

Host Processor in Groveport Platform

Self-boot Intel® Xeon Phi™ processor

Intel® Xeon Phi™ Coprocessor x200



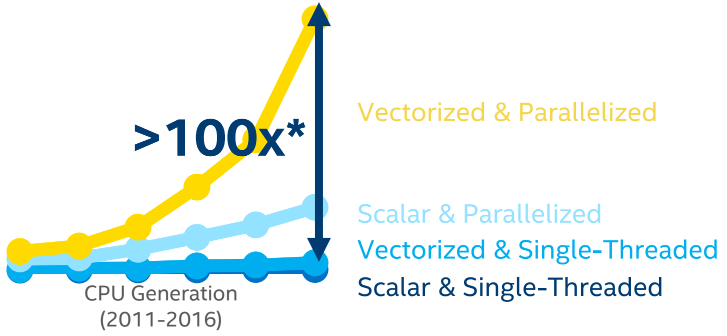
Ingredient of Grantley Platforms

Requires Intel® Xeon® processor host

Solve Biggest Challenges Faster

Highly-Parallel

Intel® Xeon® processors are increasingly parallel and require modern code



Intel® Xeon Phi™ processors are extremely parallel and use general purpose programming

Up to 72 cores (288 threads)

V[512] Intel® Advanced Vector Extensions 512 (AVX-512)

*Binomial Options DP simulation performed on Intel® Xeon® processor X5570 (formerly codenamed Nehalem), Intel® Xeon® processor x5680 (formerly codenamed Westmere), and Intel® Xeon® processor E5 2600 families v1 through v4 for 4 sets of code with varying levels of vectorization and threading optimization

Parallel is the Path Forward

More cores → More Threads → Wider vectors

	Intel® Xeon® processor 64-bit	Intel® Xeon® processor 5100 series	Intel® Xeon® processor 5500 series	Intel® Xeon® processor 5600 series	Intel® Xeon® processor 5600 v2 series	Intel® Xeon® processor 5600 v3 series	BDW	Intel® Xeon Phi™ x100 coprocessor	Intel® Xeon Phi™ x200 processor & coprocessor
Up to Core(s)	1	2	4	6	12	18	*22*	57-61	Up to 72
Up to Threads	2	2	8	12	24	36	*44*	228-244	Up to 288
SIMD Width	128	128	128	128	256	256	256	512	512
Vector ISA	Intel® SSE3	Intel® SSE3	Intel® SSE4.2	Intel® AVX	Intel® AVX	Intel® AVX2	Intel® AVX2	IMCI 512	Intel® AVX-512

Out-of-the-box **performance** is not good enough for production

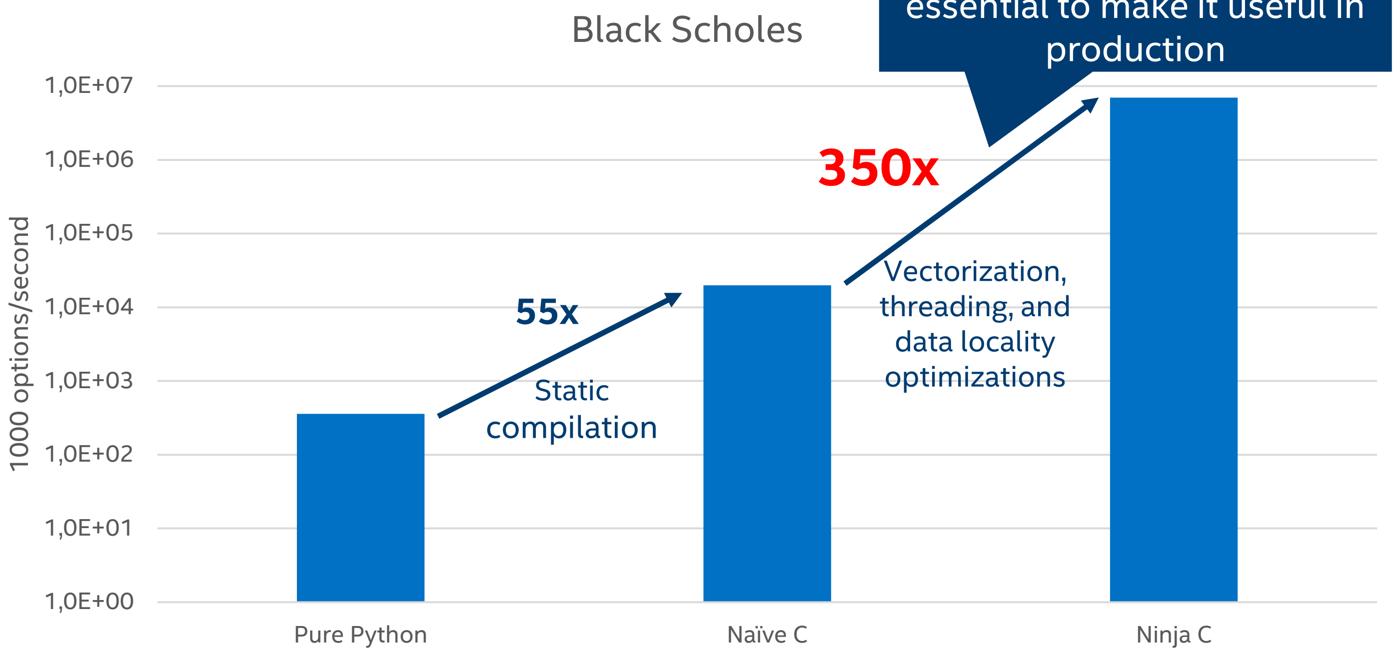
Use of high-performance extensions is hard

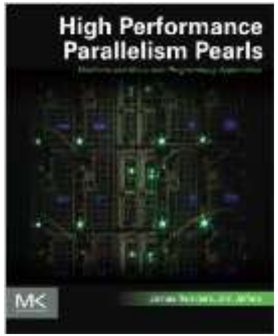
Intel® Distribution for Python*

Gives easy access to high-performance in Python*

What is required for making Python performance closer to native code?

Bringing parallelism (vectorization, threading, multi-node) to Python is essential to make it useful in production





Chapter 19. Performance Optimization of Black Scholes Pricing

$$V_{call} = S_0 \cdot CDF(d_1) - e^{-rT} \cdot X \cdot CDF(d_2)$$
$$V_{put} = e^{-rT} \cdot X \cdot CDF(-d_2) - S_0 \cdot CDF(-d_1)$$
$$d_1 = \frac{\ln\left(\frac{S_0}{X}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$
$$d_2 = \frac{\ln\left(\frac{S_0}{X}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

Configuration info: - Versions: Intel® Distribution for Python 2.7.10 Technical Preview 1 (Aug 03, 2015), icc 15.0; Hardware: Intel® Xeon® CPU E5-2698 v3 @ 2.30GHz (2 sockets, 16 cores each, HT=OFF), 64 GB of RAM, 8 DIMMS of 8GB@2133MHz; Operating System: Ubuntu 14.04 LTS.

Performance-productivity technological choices

Numerical packages acceleration with Intel® performance libraries (MKL, DAAL, IPP)

Better parallelism and composable multi-threading (TBB, MPI)

Profiling Python and mixed language codes (VTune)

Language extensions for vectorization and multi-threading (Cython, Numba, Pyston, etc)

Integration with Big Data and Machine Learning platforms and frameworks (Spark, Hadoop, Theano, etc)

Intel® and Python

1. Enable hooks in Python packages
   - Intel® MKL, Intel® DAAL, Intel® IPP
   - Most popular numerical/data processing packages
     - NumPy, SciPy, Scikit-Learn, PyTables, Scikit-Image, …

2. Provide Python interfaces for Intel® DAAL (a.k.a PyDAAL)

3. Available through Intel® Distribution for Python* and as Conda packages

4. Most optimizations eventually upstreamed to open source projects

Optimized mathematical building blocks

Intel® Math Kernel Library (Intel MKL)

Linear Algebra

- BLAS
- LAPACK
- ScaLAPACK
- Sparse BLAS
- Sparse Solvers
  - Iterative
  - PARDISO* SMP & Cluster

Up to 100x faster

Fast Fourier Transforms

- Multidimensional
- FFTW interfaces
- Cluster FFT

Up to 10x faster!

Vector Math

- Trigonometric
- Hyperbolic
- Exponential
- Log
- Power
- Root

Up to 10x faster!

Vector RNGs

- Multiple BRNG
- Support methods for independent streams creation
- Support all key probability distributions

Up to 60x faster!

Summary Statistics

- Kurtosis
- Variation coefficient
- Order statistics
- Min/max
- Variance-covariance

And More

- Splines
- Interpolation
- Trust Region
- Fast Poisson Solver

Functional domain in this color accelerate respective NumPy, SciPy, etc. domain

Configuration info: - Versions: Intel® Distribution for Python 2017 Beta, icc 15.0; Hardware: Intel® Xeon® CPU E5-2698 v3 @ 2.30GHz (2 sockets, 16 cores each, HT=OFF), 64 GB of RAM, 8 DIMMS of 8GB@2133MHz; Operating System: Ubuntu 14.04 LTS.

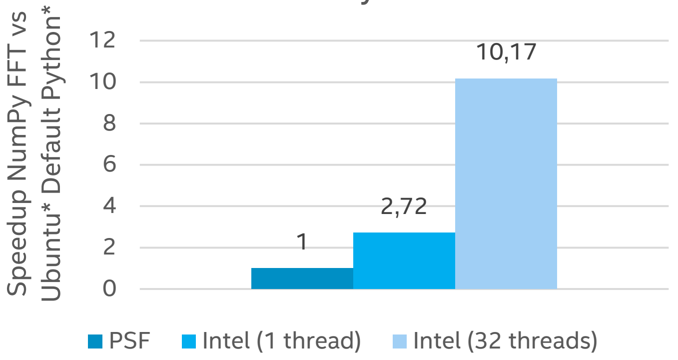
Optimized FFT show case

Intel® Math Kernel Library (Intel MKL)

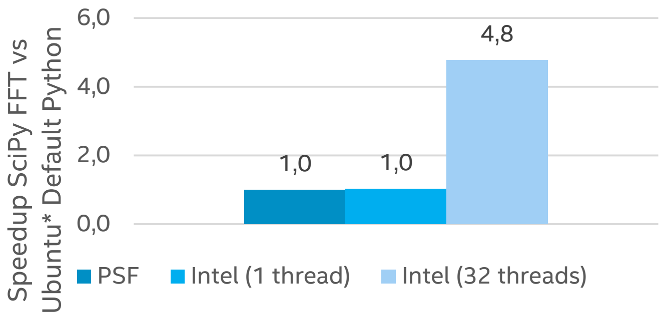
- Original SciPy FFT implementation is about 2x faster than original NumPy FFT
- Intel engineers bridged NumPy and SciPy implementations via common layer and embedded MKL FFT calls, what measurably accelerates both NumPy and SciPy
  - NumPy and SciPy are computationally compatible
  - FFT descriptors caching applied for enhanced performance in repetitive and multidimensional FFT calculations

Available starting Intel® Distribution for Python* 2017 Beta

NumPy FFT NumPy vs Ubuntu* Default Python*



SciPy FFT Intel SciPy vs Ubuntu* Vanilla Python*

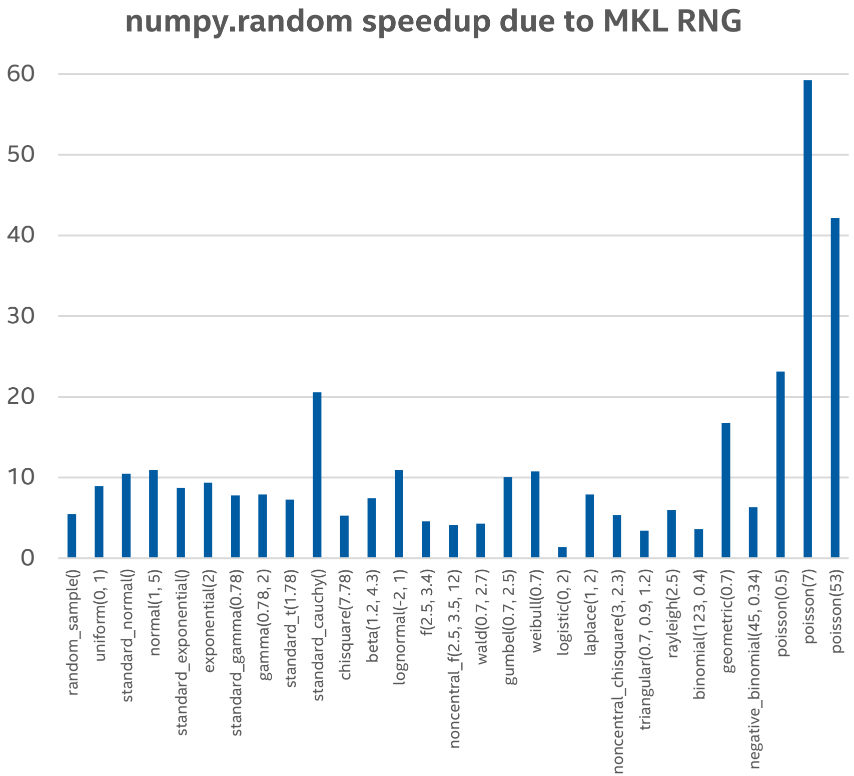


Configuration info: - Versions: Intel® Distribution for Python 2017 Beta, icc 15.0; Hardware: Intel® Xeon® CPU E5-2698 v3 @ 2.30GHz (2 sockets, 16 cores each, HT=OFF), 64 GB of RAM, 8 DIMMS of 8GB@2133MHz; Operating System: Ubuntu 14.04 LTS.

Optimized RNG show case

Intel® Math Kernel Library (Intel MKL)

- Implemented numpy.random in vector fashion to enable vector MKL RNG and VML calls
- Enabled multiple BRNG
- Enabled multiple distribution transformation methods



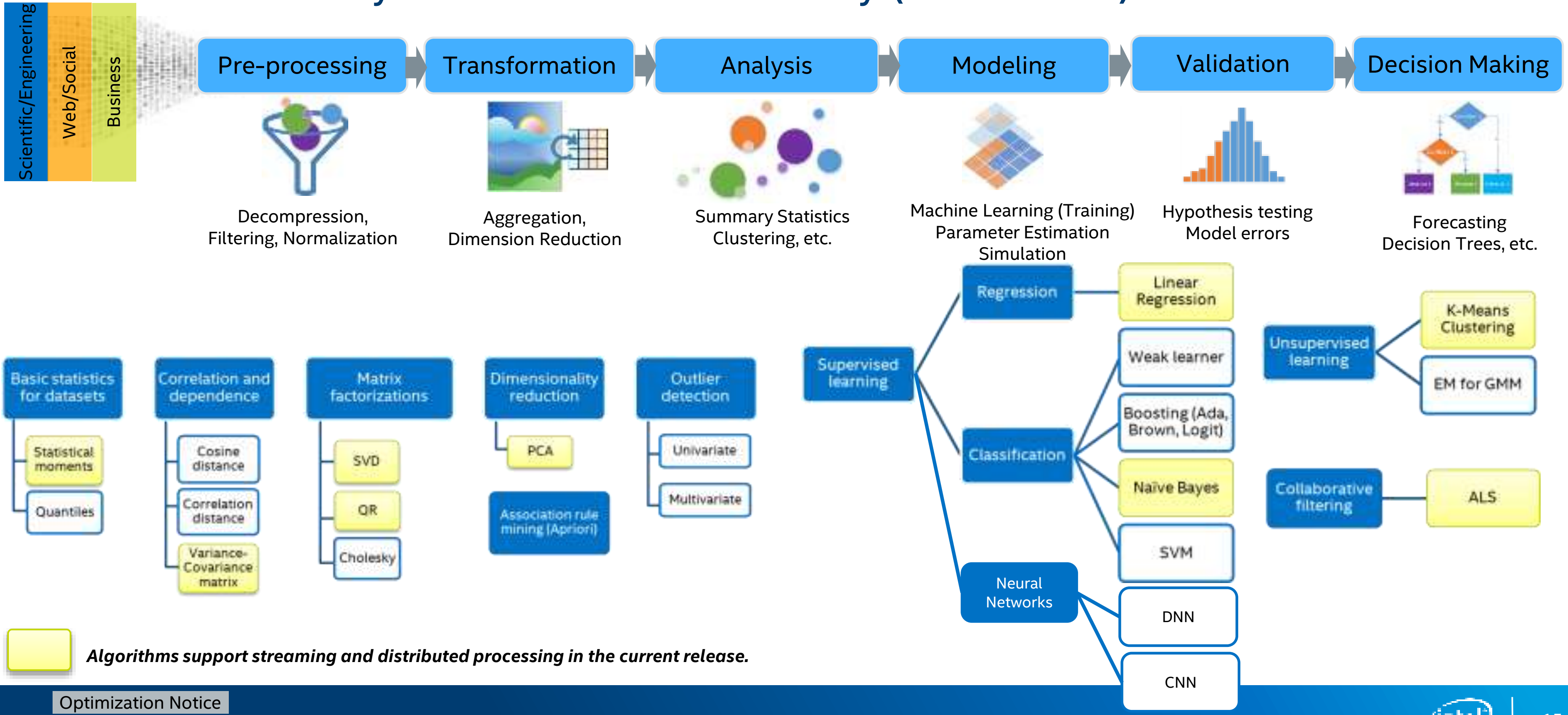
Initial data. Final data to be available in the update for Intel® Distribution for Python* 2017 Beta

Optimization Notice

Configuration info: - Versions: Intel® Distribution for Python (internal build 28.4.2016), icc 15.0; Hardware: Intel® Xeon® CPU E5-2630 v3 @ 2.40GHz (16 cores), 32 GB; Operating System: Ubuntu 14.04 LTS.

Optimized blocks for data analytics pipelines

Intel® Data Analytics Acceleration Library (Intel DAAL)

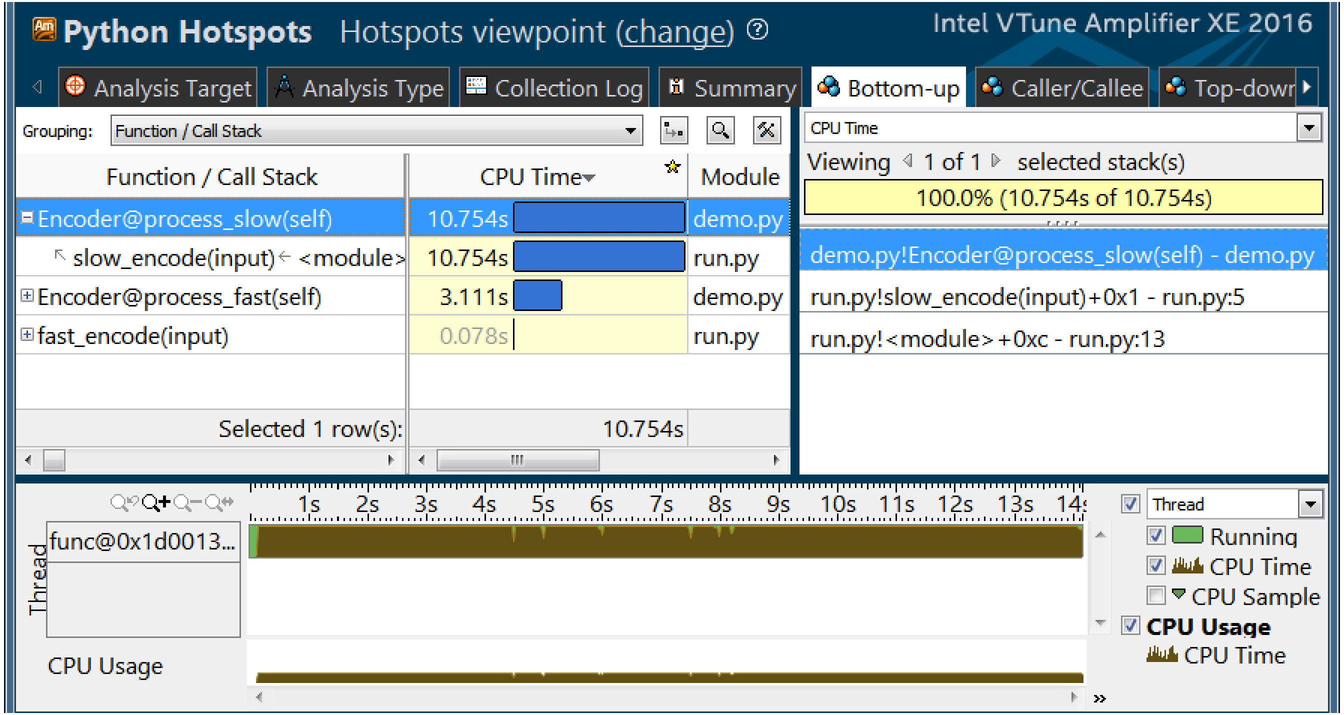


PROFILING PYTHON APPLICATIONS WITH INTEL® VTUNE™ AMPLIFIER

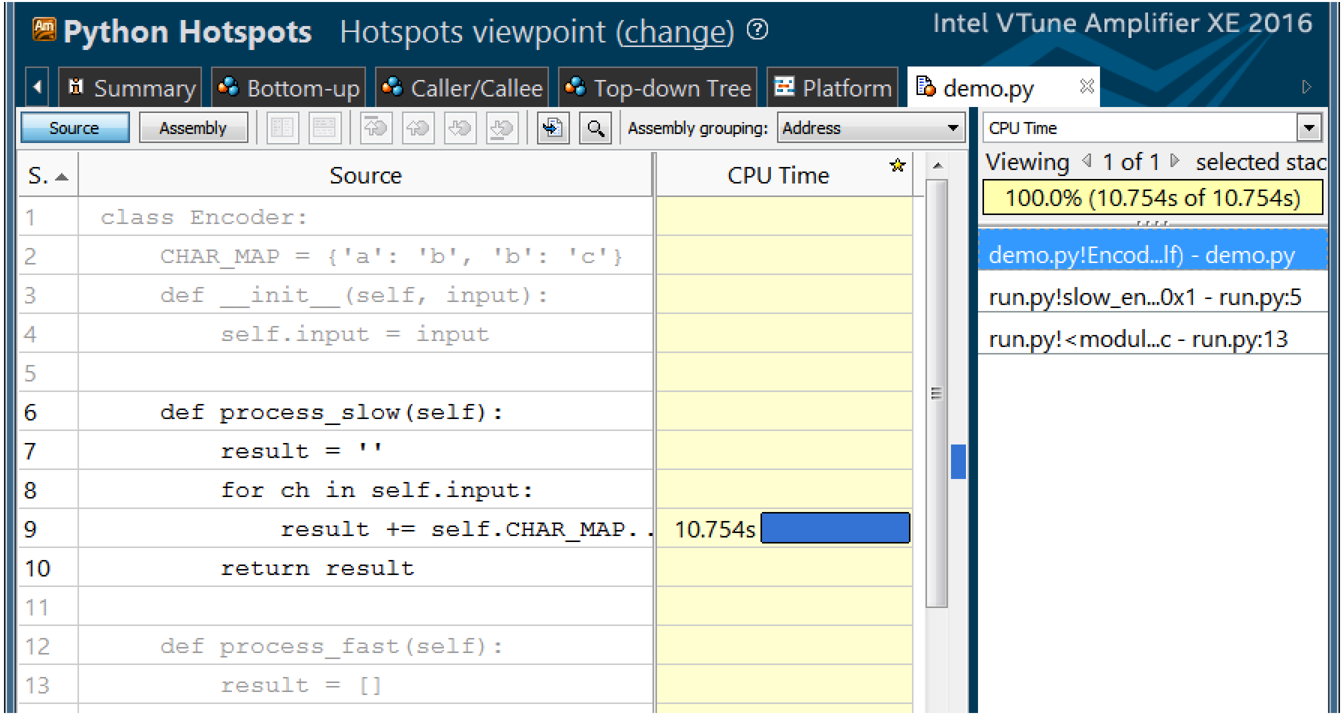
Simple Python profiling example

```
class Encoder:
    CHAR_MAP = {'a': 'b', 'b': 'c'}
    def __init__(self, input):
        self.input = input

    def process_slow(self):
        result = ''
        for ch in self.input:
            result += self.CHAR_MAP.get(ch, ch)
        return result

    def process_fast(self):
        result = []
        for ch in self.input:
            result.append(self.CHAR_MAP.get(ch, ch))
        return ''.join(result)
```

Intel® VTune™ Amplifier example



Intel® VTune™ Amplifier – source view



Intel® VTune™ Amplifier: Accurate & Easy

Line-level profiling details:

- Uses sampling profiling technique
- Average overhead ~1.1x-1.6x (on certain benchmarks)

Cross-platform:

- Windows and Linux
- Python 32- and 64-bit; 2.7.x, 3.4.x, 3.5.0 versions

Rich Graphical UI

Supported workflows:

- Start application, wait for it to finish
- Attach to application, profile for a bit, detach

Boost Your Python Performance with Intel® Distribution for Python

Easy access through full installer and conda

Full scipy-stack + selected HPC/Big-Data packages

numpy, scipy, matplotlib, ipython/jupyter, sympy, pandas, pyDAAL, scikit-*, mpi4py,...

Windows, Linux, MacOS (all 64bit)

Sign up to beta at https://software.intel.com/en-us/python-distribution

Get answers, help&support from
https://software.intel.com/en-us/forums/intel-distribution-for-python

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