Marriott Sinclair LLP
Financial Engineering

A presentation to EMiT
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Overview

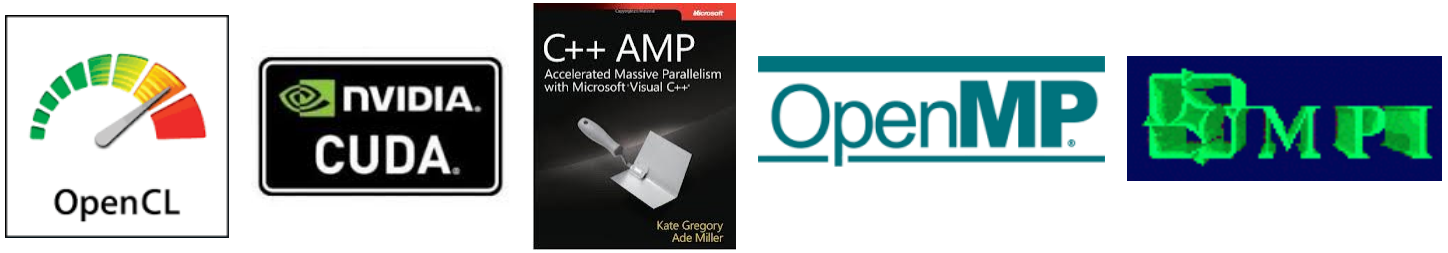
- The Problem: Technology
- The Problem: Computational Finance
- The Solution
- Tyche Design
- Future-Proofing and Modularity
- Performance
- Ease of Use
- Processing Stages
- Efficiency

The Problem: Technology

- **Moore's Law** has **ended**, at least in terms of increasing clock speed. As Herb Sutter has said, the **free lunch** is **definitely over**.

- Instead of a single CPU, we now have a **zoo** of **different architectures** to write code for: multi-core, vector processors, GPUs, FPGAs, accelerators like Intel Xeon Phi…

- Likewise, there is a **forest** of **different languages** to target these different pieces of hardware: OpenCL, CUDA, AMP, OpenMP, MPI, VHDL…



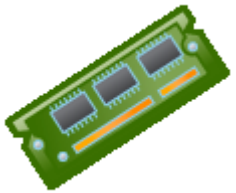
- Programming in these languages, and for this hardware, can require much expertise. It can also take a long time!

The Problem: Computational Finance

- We supply **risk management** software to insurers, banks and hedge funds.

- Increasing regulation (Solvency II, Basel II/III) means that financial institutions must maintain detailed models of the material risks to which they are exposed, and use these to manage their business as well as determining **capital requirements**.

- Models are also **large** and **complex**. Peak working set requirements can be **hundreds of GB**. Some current models can approach a working set of 1 TB. The number of Monte Carlo scenarios required can be up to 1e6.



- These models, particularly for insurers, take a long time to run! **Overnight** or **whole-week** runs are common. They also can take many man-years to build.

- SIMD is a possible solution to model runtimes as models are typically Monte Carlo, and hence **embarrassingly parallel**. However, current software, particularly in insurance, does not take advantage of the latest hardware advances. Re-coding models directly in CUDA or similar will take many years.

The Solution

- We needed a platform that was **intuitive to use**, and didn't require low-level expertise in new languages. Finance professionals often don't have the time or inclination to learn these new languages.

- We also needed a platform that **could take advantage** of the **latest advances** in **hardware**, and continue to do so in the future.

- Finally, this platform needed to be sufficiently **flexible** that it could be turned to any computational finance problem of interest:
  - Pricing portfolios of (potentially exotic) assets – e.g. for a Basel II PFE calculation.
  - Determining capital
  - Strategy optimisation – e.g. portfolio optimisation, capital optimisation, reinsurance optimisation
  - Calculating insurance premiums
  - Projecting economic variables

- In summary "**supercomputer power in a package as easy to use as a spreadsheet**."

tyche™ : Design

- tyche™ design has been based on the following pillars:

  - **Future-Proofing**. We have abstracted away the low-level SIMD languages like CUDA and MPI behind a common interface layer. As new hardware and languages become available, we can insert those beneath this layer.
  - **Modularity**. tyche™ technology and codebase has been designed in a modular fashion so that it can be used in a broad range of environments. For instance, the tyche™ Engine can be used independently of the tyche™ GUI.
  - **Performance**. Monte Carlo calculations are often **embarrassingly parallel**. This means that they can be completely parallelised by scenario. tyche™ leverages the latest SIMD technologies to take advantage of this.
  - **Ease-of-use**. tyche™ intended end-users include non-programmers (e.g. actuaries). An intuitive interface that allows fast model construction is thus essential. At the same time, more tech-savvy users (e.g. quants & scientists) can leverage their C# and C++ knowledge if they choose to do so.

tyche™ : Future-Proofing & Modularity

>1 million lines of code and counting.....

Tyche GUI

Model design via **flowcharts**. Intuitive **scripting** language.

Tyche Engine

Construction and execution of a Directed Acyclic Graph of operations (**DAG**).

SIMD Engine

Common interface of ~300 core vector operations

CUDA Engine	AMP Engine	Intel Engine	OpenCL Engine	SystemVerilog Engine*

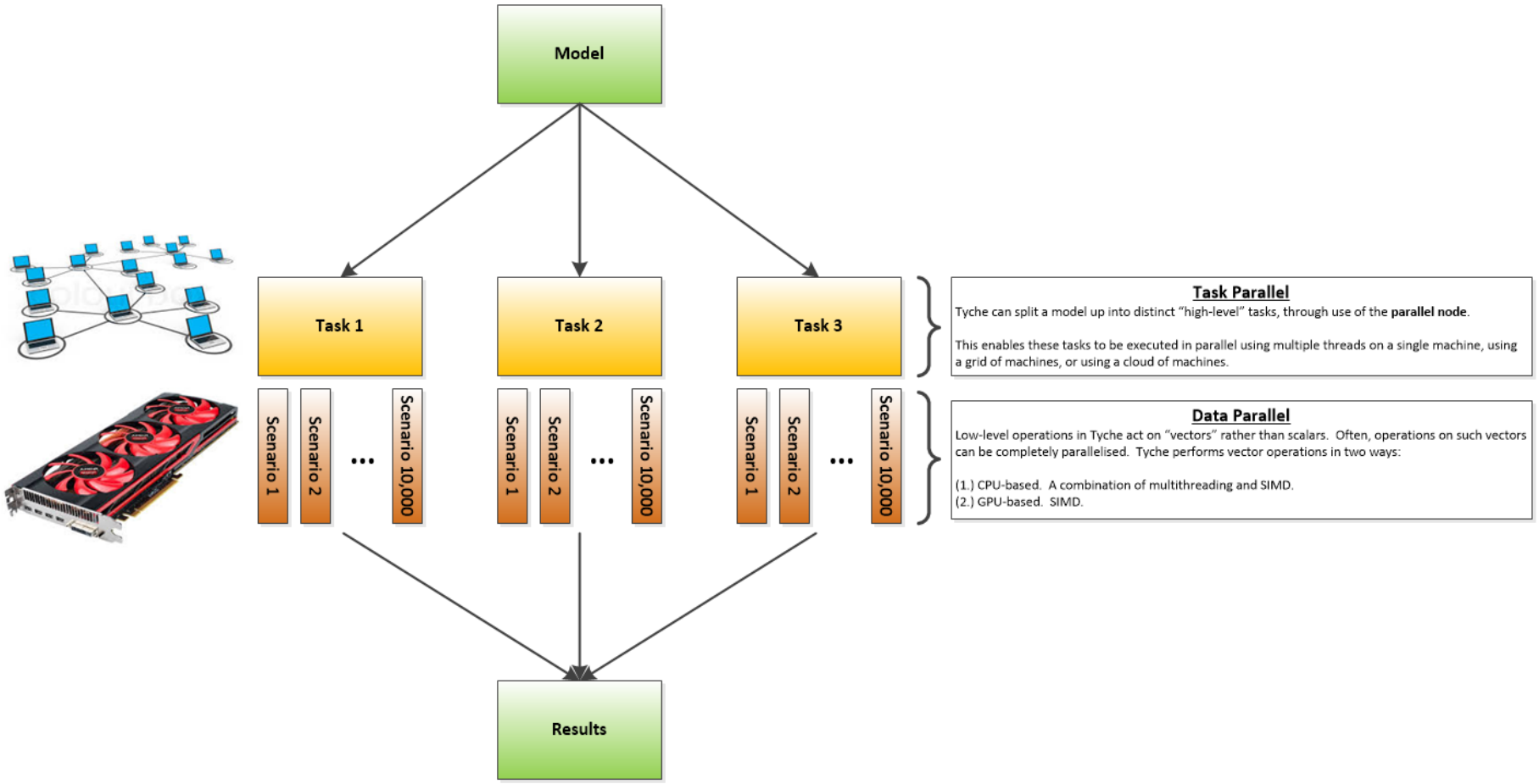
Each DAG node is executed as an **atomic operation**.

Hardware memory transfers (where relevant) are minimised.

Kernel size is minimised*.

*in progress

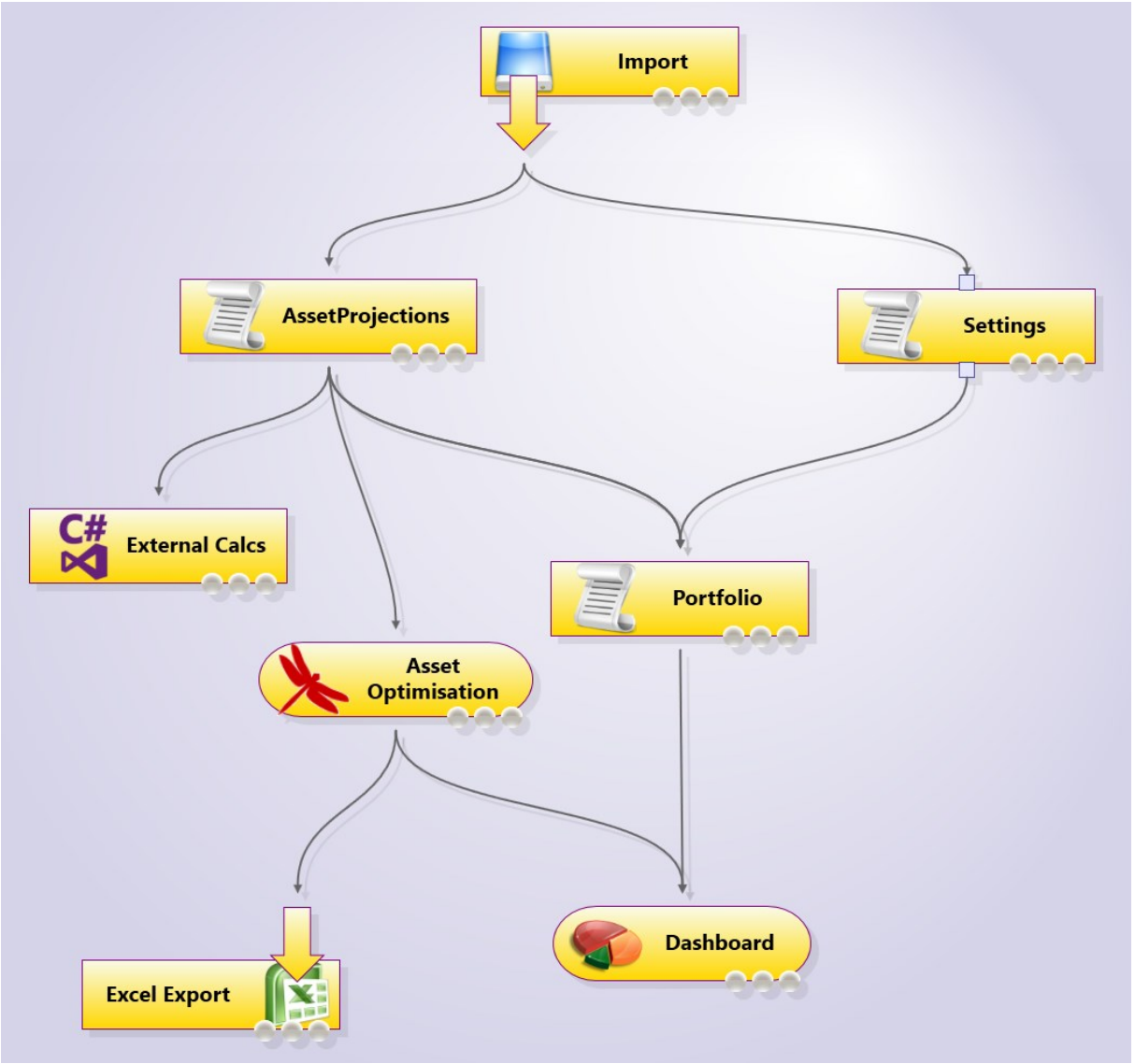
tyche™ : Performance



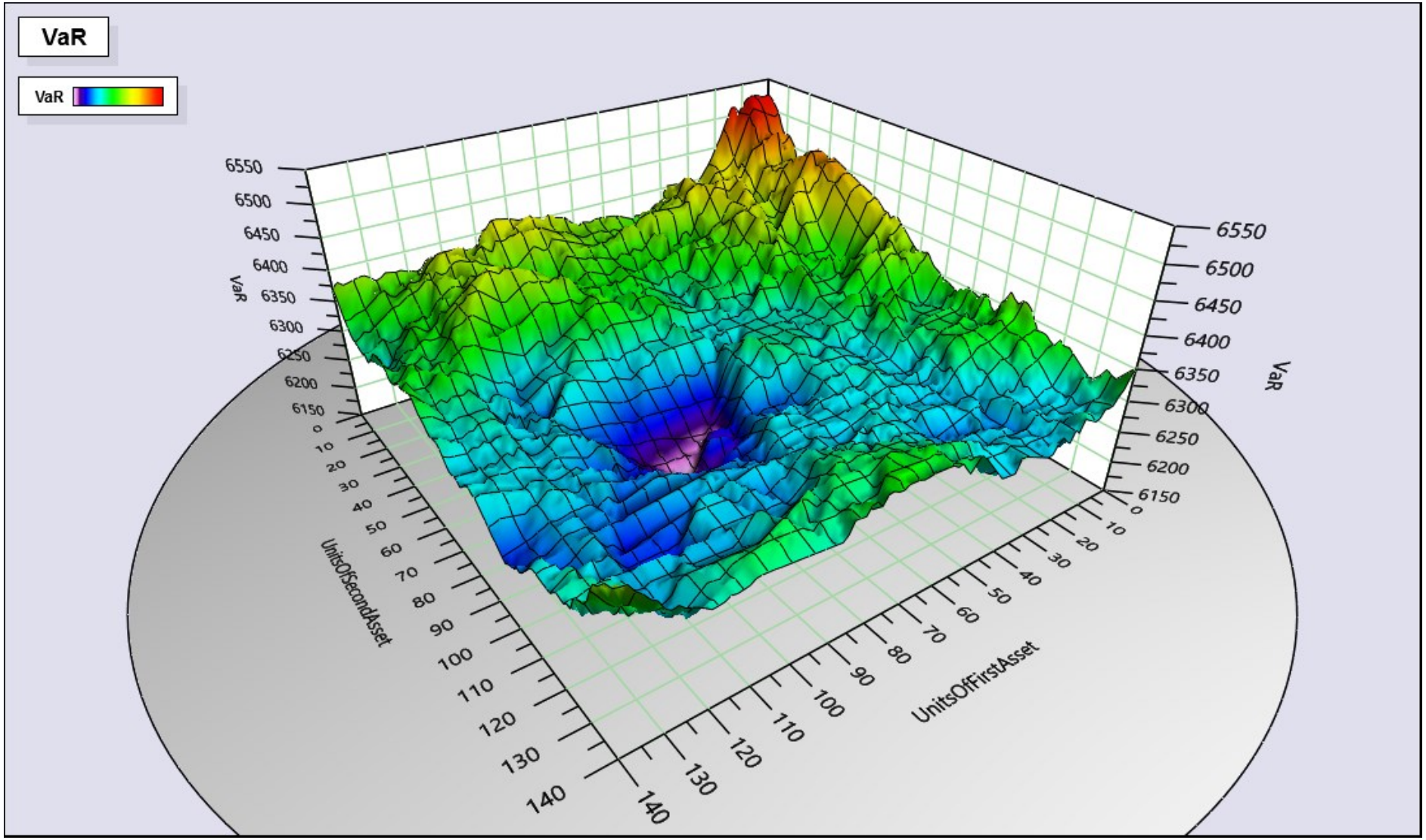
- tyche™ is designed from the ground up to leverage the latest parallel computing technologies.
- Models can be distributed over a grid of machines, and on each machine the GPU may be used to further accelerate computation.
- Models with a large "working set" of memory that are too big for the GPU can make use of SIMD on the CPU.

tyche™ : Ease-of-Use and the Flowgram

- The tyche™ user interface is based around the **flowgram™**.
- This allows flowchart-based models to be constructed quickly and intuitively.
- A **flowgram™** allows different technologies to work together in the same model, such as:
  - T#
  - C#
  - C++
  - Visual Basic
  - Numerical optimisers & rootfinders
  - Excel interaction: import, export & calculation
  - Grid- and SIMD-based computing
- Flowgrams™ may be constructed from the "core" tyche™ node types, or by making use of higher-level functionality in the tyche™ **Toolkit**.

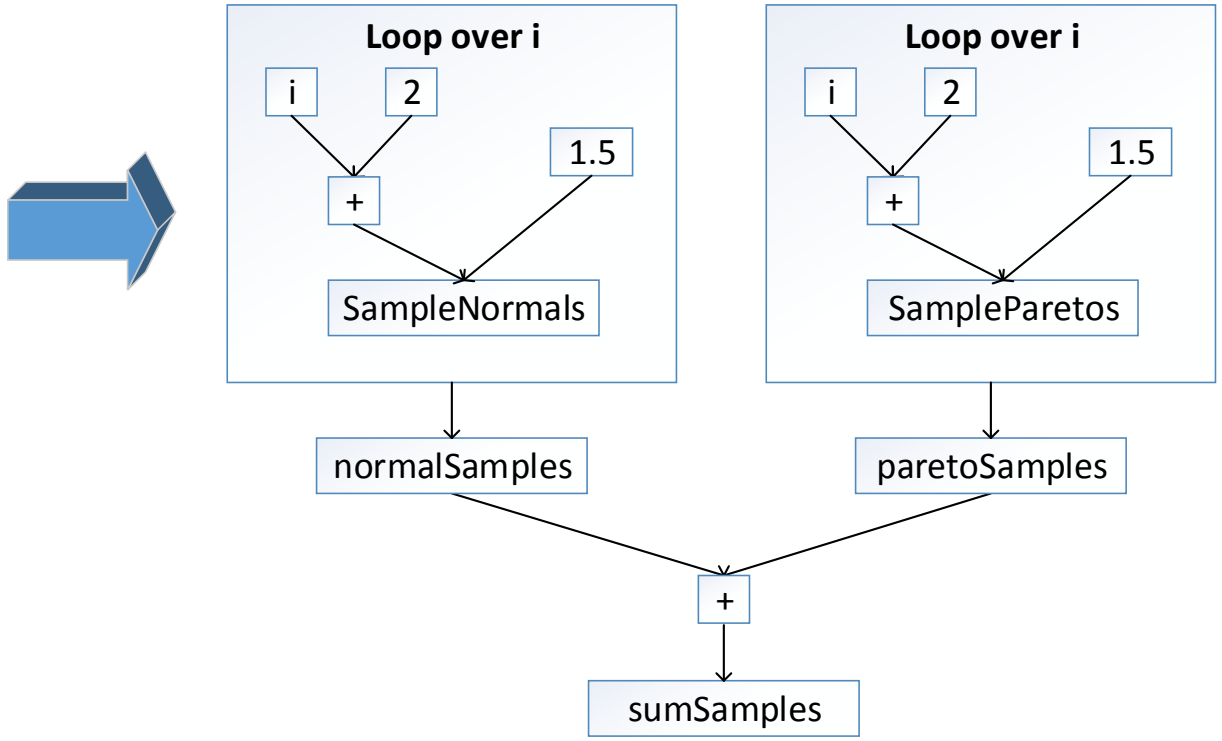


Quick Demo

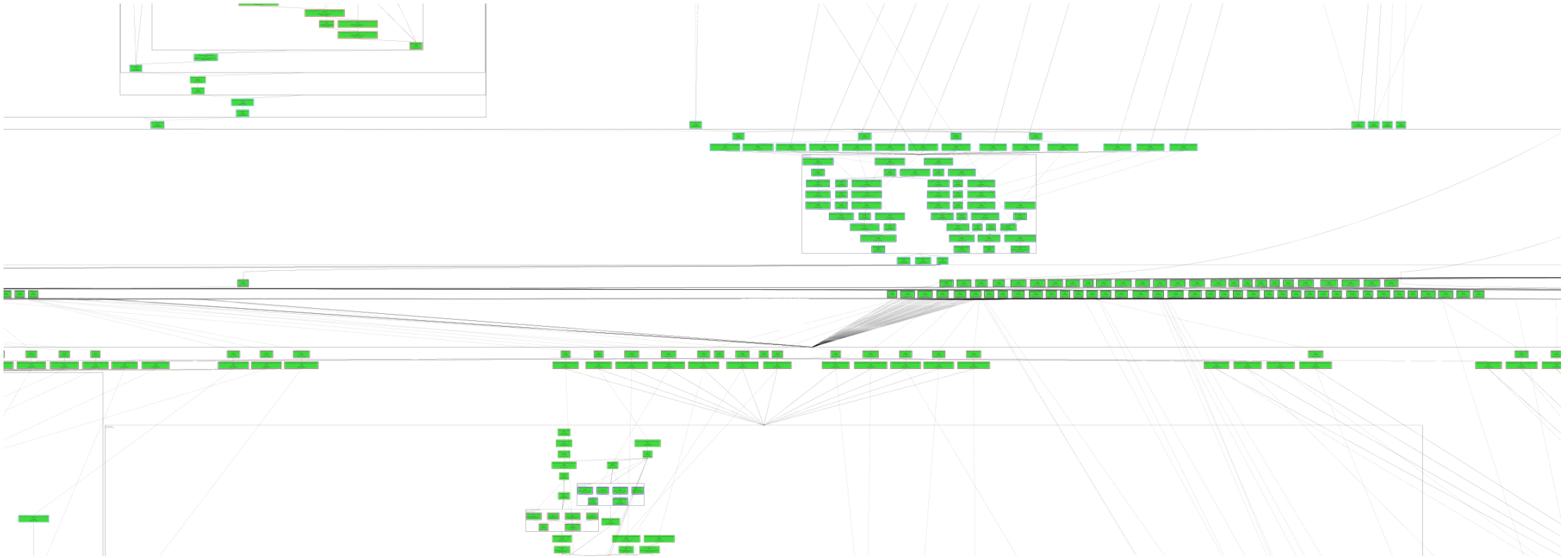


Processing Stages

```
1 // 10 groups of 10,000,000 vectorised Normal samples in total.
2 normalSamples[i][10] = Normal(2 + i,1.5);
3
4 // 10 groups of 10,000,000 vectorised Pareto samples in total.
5 paretoSamples[i][10] = Pareto(1 + i, 0.7);
6
7 // Simple vectorised sum over all samples.
8 sumSamples = normalSamples + paretoSamples;
```

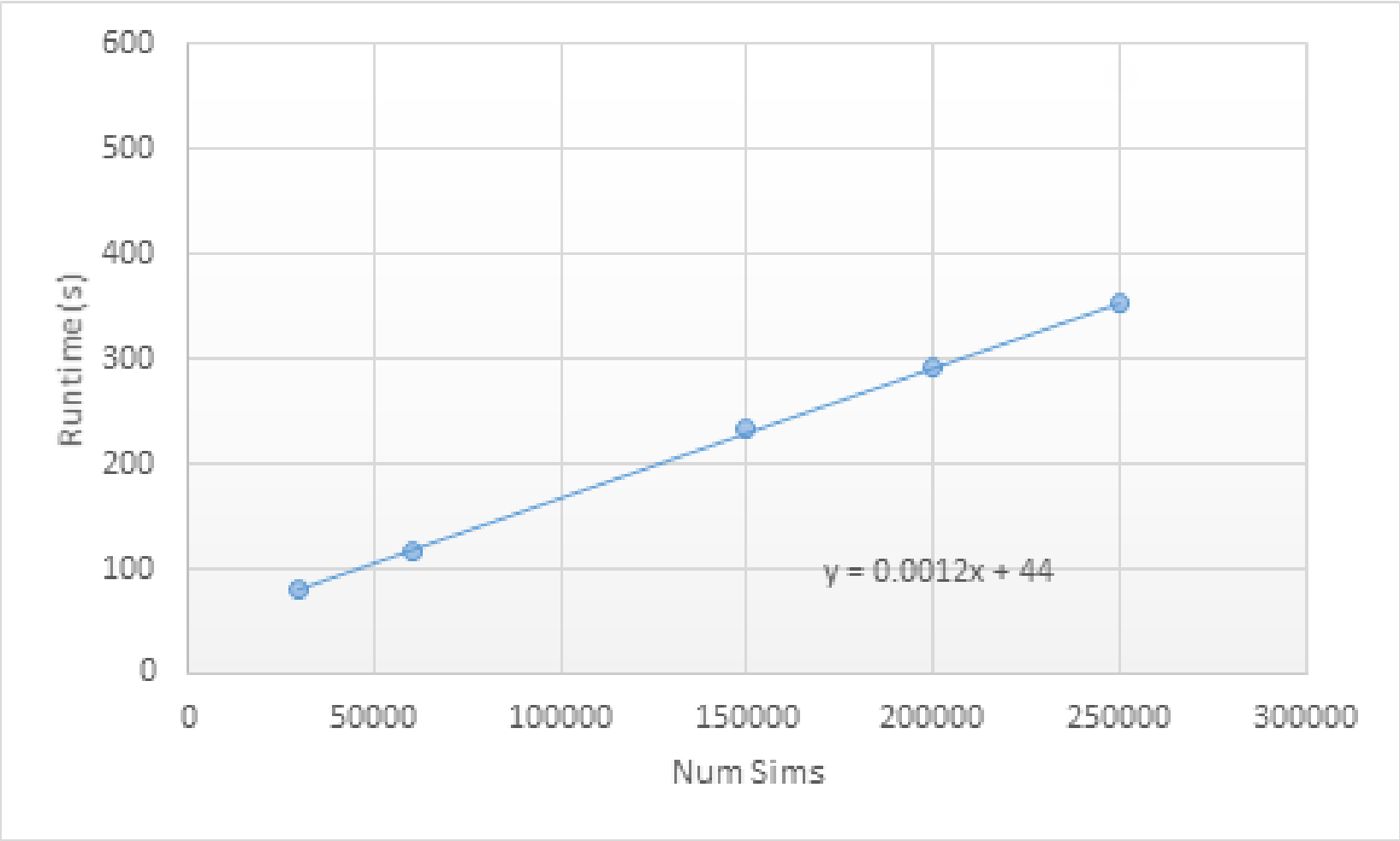


Internal Model Example



- This internal model originally took 3 years to build, and 6 hours to run on previous "state of the art" software.
- Recoding in Tyche took one month, and ran in 2 minutes.

Efficiency



Summary

- tyche™ is a SIMD Monte Carlo engine.
- Low-level SIMD languages and hardware are **abstracted away**.
- A **simple flowchart-based interface** is presented to the end-user, together with an **intuitive scripting language**.
- The **performance cost** for this layer of abstraction is **minimal**.
- The **reduction in model construction time** is **huge**.
- tyche™ is currently targeted at **computational finance**, but we anticipate more general uses in the future: the software is completely **usage-agnostic**, just like Excel.

Questions?

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