

# Insurance - Technology, Architecture, Services

# Agenda

1. Technology
2. Architecture
3. Services

1

Technology

# **AXIS – 64-bit**

Calculation engine & model data storage

## **Advantages**

- » Access to much larger memory space
- » Eliminate paging during stochastic processing – reduce runtime
- » New storage engine – no size limit for dataset files

## **Challenges**

- » Support legacy import / export options (MS Access format)
- » Massive data conversion
- » Potential for differences in results vs. 32-bit version

# GPGPU

- » Research project with NVIDIA completed in 2022
- » Prototype built in AXIS code (450x speed up for pricing simple equity annuity option)
- » Potential applications for VA / Hedging
- » Plan to re-visit in 2023 (pending AXIS 64-bit conversion)

# Advanced Optimization Tools

- » Policy Compression
- » Scenario Compression
- » Proxy functions for modeling structured securities
- » Artificial Intelligence - Machine Learning / Neural Networks technology to train / parametrize compression models

# Automation

## FormulaLink

- » Advanced scripting & programmability for AXIS Formula Tables
- » Referencing .NET DLLs
- » Integration with EnterpriseLink Jobs
- » 3<sup>rd</sup> party DLLs & data files embedding
- » Full scripting support for GaaS
- » Version Control & Permission Framework

## External API's

- » ELinkTask DLL
- » GaaS API's (available via GaaSPublicLibrary.dll)
- » Planning to introduce Web API's for hosted environments

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Architecture

# Model Development & Governance

## Super Dataset

- » Develop and hydrate models in parallel streams
- » Centralize common objects
- » No need to merge data
- » Aggregate results from multiple datasets
- » Fully version controlled

<https://www.ggy.com/kb/article/2360>

## Basis Reference

- » Externalize assumptions, manage outside of the cells
- » Fast switching of the assumptions basis without rebuilding the model
- » Easy audit / reporting

<https://www.ggy.com/Basis-Reference-Technique/Webinar-2021-03-11>

# User Interface & User Experience Initiative

| Look & Feel   | Input Control   | Information   | Documentation   |
|---|---|---|---|
| <p>Modernize AXIS User Interface</p>  | <p>Give better control to the user &amp; reduce learning time</p>   | <p>Provide more informative content</p>   | <p>Redesign AXIS Help system.</p>   |
| <ul style="list-style-type: none"> <li>» Improve icons and remove menus clutter</li> <li>» Add color to highlight most important elements on screens</li> <li>» Improve usage of fonts</li> </ul> | <ul style="list-style-type: none"> <li>» More intuitive navigation</li> <li>» Automatic guidance</li> <li>» Auto hide unnecessary objects and UI elements</li> <li>» Add more screen customization options</li> </ul> | <ul style="list-style-type: none"> <li>» Improve search and shortcut features</li> <li>» Add more metadata &amp; tooltips</li> <li>» Add analytics (e.g. model setup completion progress)</li> <li>» Make screen and log messages more informative</li> </ul> | <ul style="list-style-type: none"> <li>» Web based (Moody's InfoWeb)</li> <li>» Context sensitive</li> <li>» Improved search</li> <li>» Versioning</li> <li>» Bookmarks</li> <li>» Favorites</li> </ul> |

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Services

# Cloud Services

## Cloud Compute

### GlaaS (GridLink as a Service)

- » SaaS offering for running actuarial calculations in the cloud
- » Multi-region – for capacity & data residence
- » Full automation via scripting
- » Industry standard security

## Scenario Generator Cloud

### Risk Integrity (SaaS)

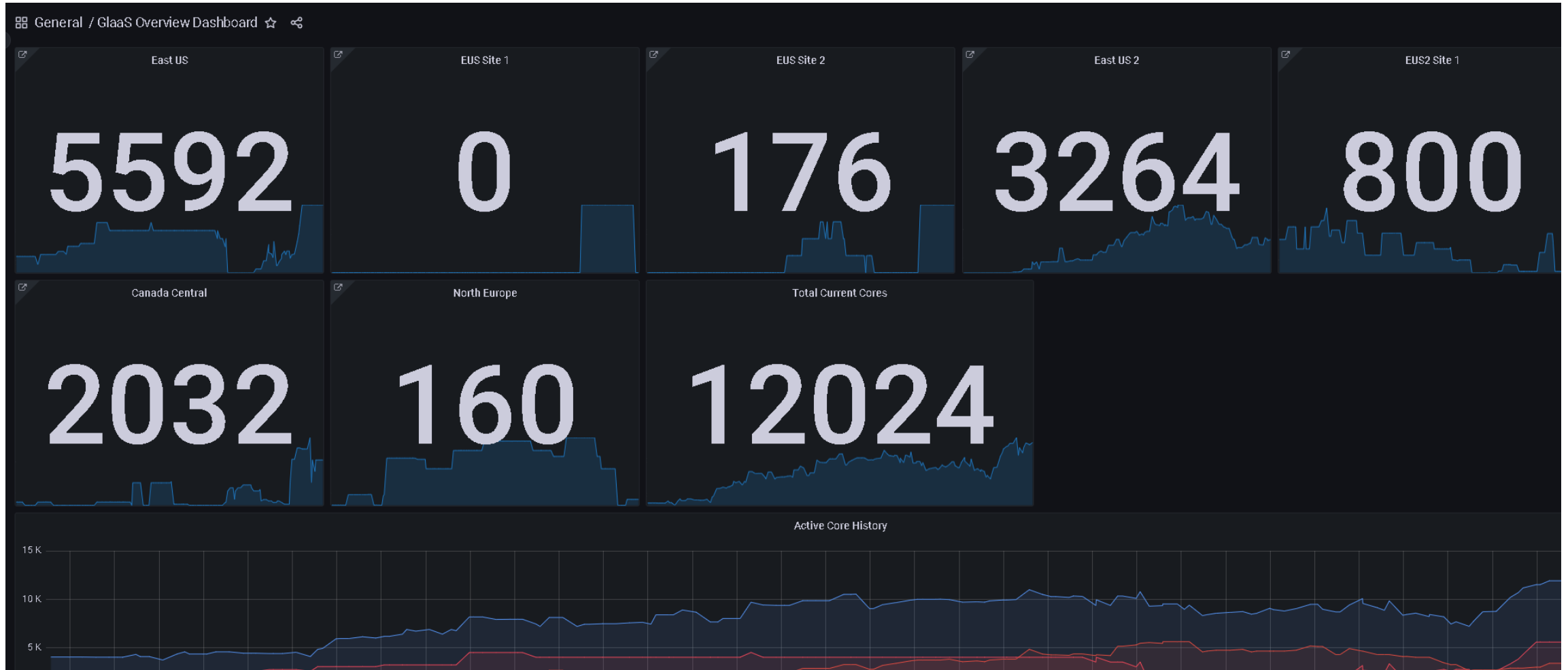
## Cloud Hosting

- » Fully managed service
- » Hosting EnterpriseLink, SQL Servers
- » Resizable data storage
- » Fast on-boarding
- » Audit and monitoring

## Cloud Operations & Support Team

- » Common Operations Team across all insurance products
- » Common Help Desk
- » Common SLAs & audits

# GlaaS Dashboard



# New GridLink Licensing and Billing Portal

- » New look & feel
- » All farm types in one portal
- » Consolidated usage reports
- » Role based access control

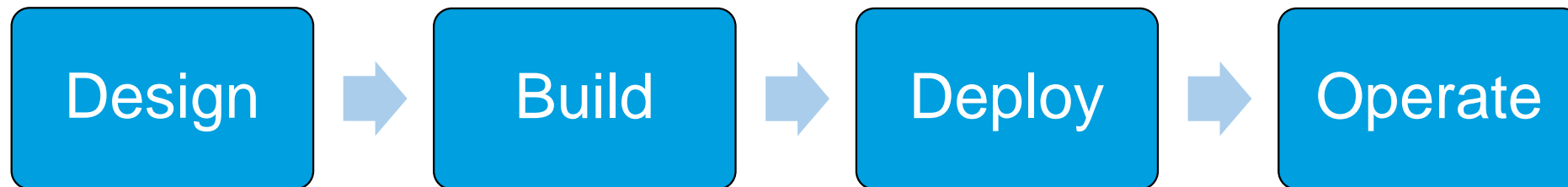
The screenshot displays the 'GridLink License Administration Internal Portal' interface. On the left is a dark sidebar with navigation options: Company, Contract, Division, Farm, Internal Roles, Users, Report (with a dropdown arrow), All company usages, Farm usage, Company usage, and Bulk package balance. The main content area is titled 'Companies' and includes a '+ New' button and a search bar. Below is a table with the following data:

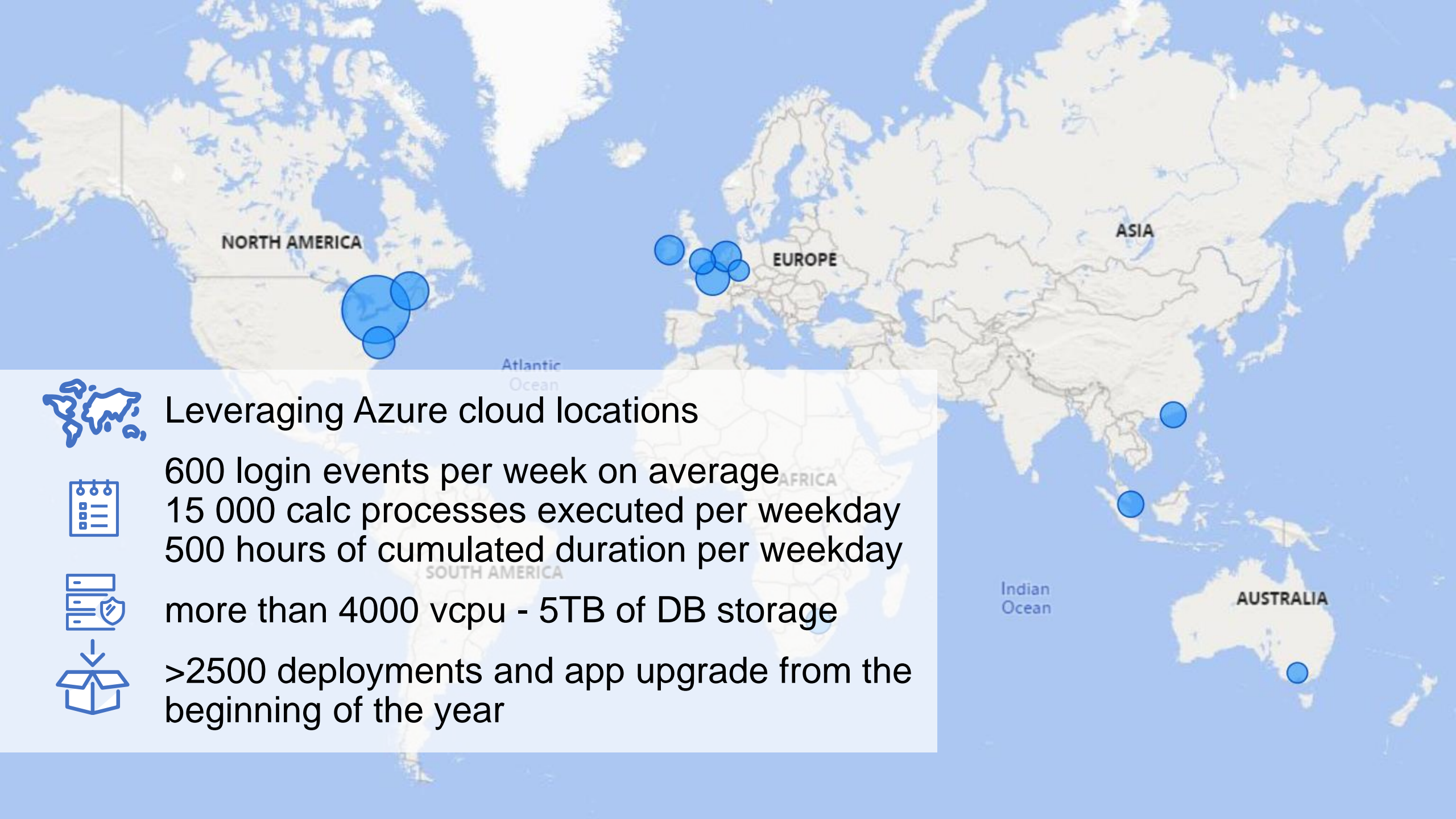
| Company                                  | Active                              | UGL                                 | Farms | Base Billable Cores | Current Cores |
|--|-------------------------------------|-------------------------------------|-------|---------------------|---------------|
| & co                                     | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 0     | 0                   | 0             |
| Test Adding Company - 638013445737803376 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 0     | 288                 | 0             |
| Test Adding Company - 638013445421076459 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 0     | 288                 | 0             |
| Test Adding Company - 638013445098790148 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 0     | 288                 | 0             |
| Test Adding Company - 638013444364628969 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 0     | 288                 | 0             |
| Test Adding Company - 638013443628154349 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 0     | 288                 | 0             |
| Test Adding Company - 638013442914674511 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 0     | 288                 | 0             |
| Test Adding Company - 638013441690431101 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 0     | 288                 | 0             |
| Test Adding Company - 638013030883115638 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 0     | 288                 | 0             |
| Test Adding Company - 638013030568733816 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 0     | 288                 | 0             |

# Risk Integrity for IFRS17 SaaS

# Agenda

1. Availability
2. Usability
3. Security
4. Performance
5. Continuous Improvement





## Leveraging Azure cloud locations



600 login events per week on average  
15 000 calc processes executed per weekday  
500 hours of cumulated duration per weekday



more than 4000 vcpu - 5TB of DB storage



>2500 deployments and app upgrade from the beginning of the year

# 1. Design for Availability

Reliability despite infrastructure failures

## Facts

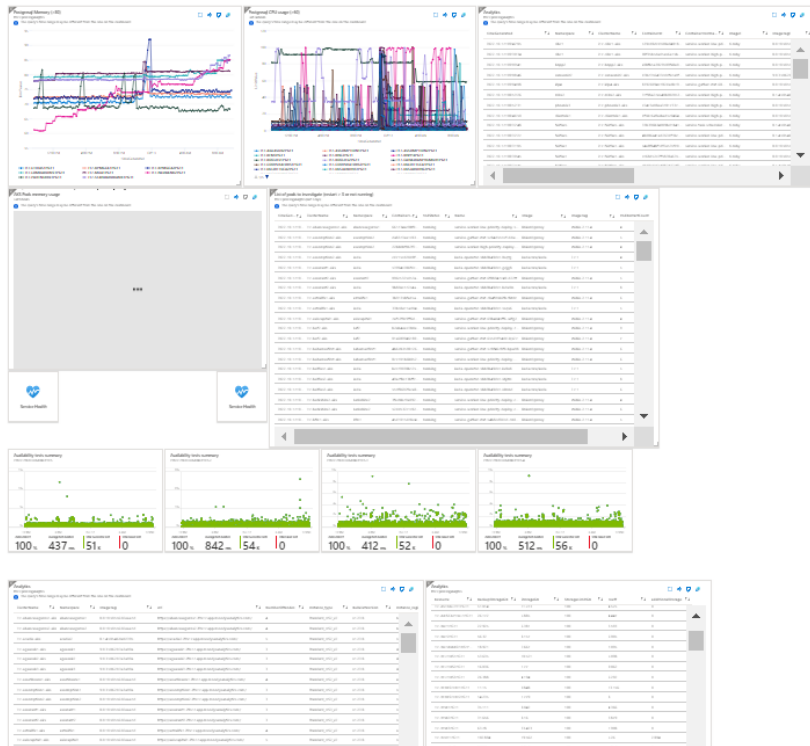
- ~150 connections to the database interrupted every day
- ~300 failed connections to Azure Blob Storage every day
- 0.2% of the underlying VM are unavailable

## Strategy

- Managed Azure services: AKS, VM scaleset, Azure DB.
- Redundancy, avoid stateful components
- Retry! Not always so simple  
Requires to identify each individual possible source of failure and retry at this level

# 1. Operate for Availability

## Monitoring & On Call Alerts



 Availability sensors

- For critical components of the application
  - Application server
  - Authentication component (keycloak)

 Anomaly detection

- From logs and metrics
- Azure Log Analytics / Azure Application Insight

# 1. Build and Deploy for Availability

## Quality & Build chain

### Code review

- » Code changes are reviewed and discussed  
> 8000 Pull Requests from Feb 2020

### Regression tests

- » Executed for each Pull Request  
> 200x per week on average  
~ 10h of automated test per deployment executed in 20 minutes.
- » Cover all features and are updated after each bug fix  
> 2500 control points split in 24 test suites

### User Acceptance tests

- » New build are available 20 minutes after a code change

« Don't fail the same way twice »

Build and Deployment fully automated

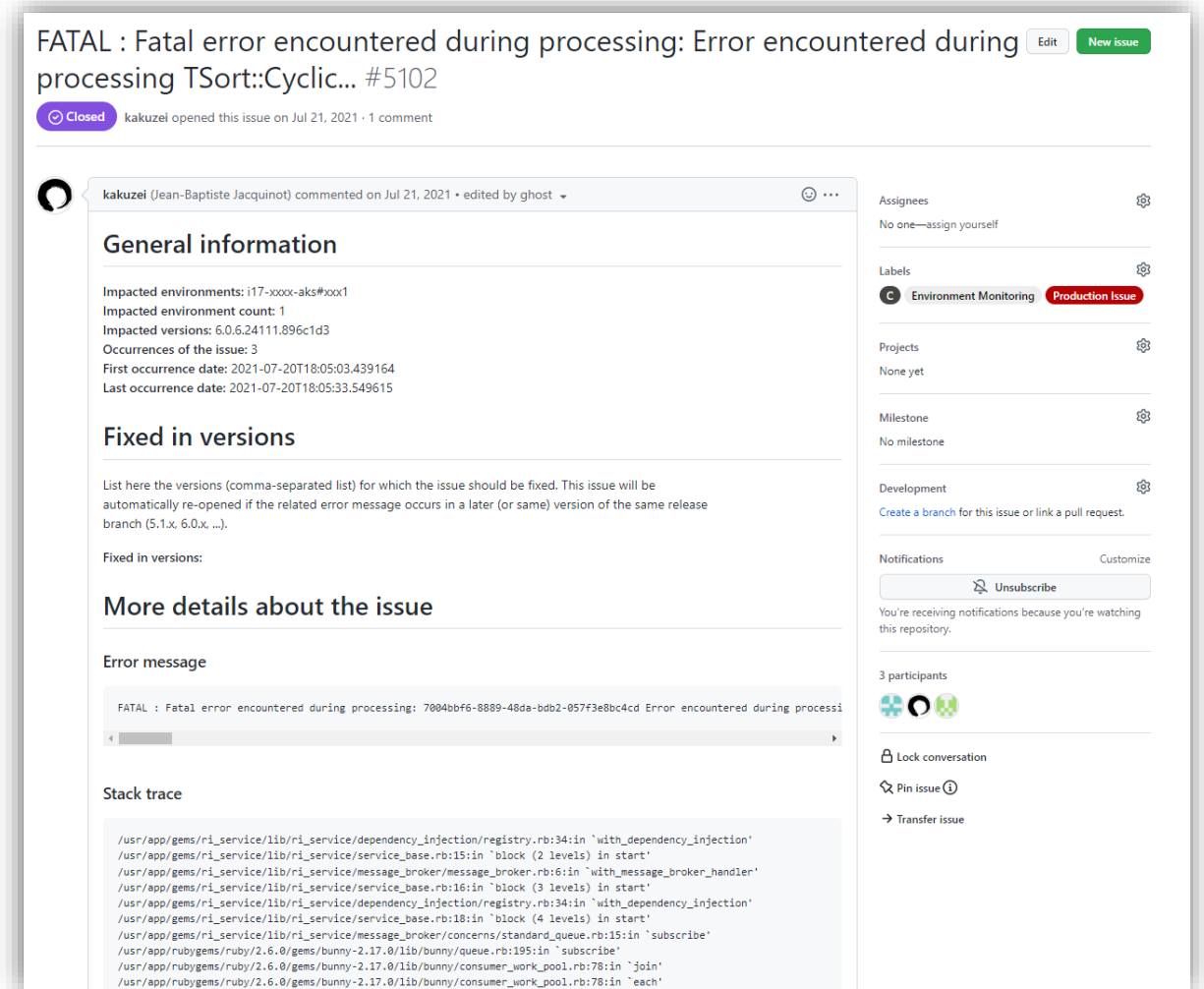
Early adopter of Github CI in Feb 2020

# 1. Build and Operate for Availability

## Pro-active resolution of software defects

Errors are automatically captured from production environments and reported to the dev team.

Example of issue solved before it was raised by our customers



The screenshot shows a GitHub issue titled "FATAL : Fatal error encountered during processing: Error encountered during processing TSort::Cyclic... #5102". The issue is marked as "Closed" and was opened by user "kakuzei" on July 21, 2021. The issue description includes a comment from "kakuzei" and a "General information" section with the following details:

- Impacted environments: i17-xxxx-aks#xxx1
- Impacted environment count: 1
- Impacted versions: 6.0.6.24111.896c1d3
- Occurrences of the issue: 3
- First occurrence date: 2021-07-20T18:05:03.439164
- Last occurrence date: 2021-07-20T18:05:33.549615

The "Fixed in versions" section is currently empty, with a note that it should contain a comma-separated list of versions where the issue was resolved. The "Error message" section contains the following text:

```
FATAL : Fatal error encountered during processing: 7904bbf6-8889-48da-bdb2-057f3e8bc4cd Error encountered during processi
```

The "Stack trace" section shows the following error details:

```
/usr/app/gems/ri_service/lib/ri_service/dependency_injection/registry.rb:34:in `with_dependency_injection'  
/usr/app/gems/ri_service/lib/ri_service/service_base.rb:15:in `block (2 levels) in start'  
/usr/app/gems/ri_service/lib/ri_service/message_broker/message_broker.rb:6:in `with_message_broker_handler'  
/usr/app/gems/ri_service/lib/ri_service/service_base.rb:16:in `block (3 levels) in start'  
/usr/app/gems/ri_service/lib/ri_service/dependency_injection/registry.rb:34:in `with_dependency_injection'  
/usr/app/gems/ri_service/lib/ri_service/service_base.rb:18:in `block (4 levels) in start'  
/usr/app/gems/ri_service/lib/ri_service/message_broker/concerns/standard_queue.rb:15:in `subscribe'  
/usr/app/rubygems/ruby/2.6.0/gems/bunny-2.17.0/lib/bunny/queue.rb:195:in `subscribe'  
/usr/app/rubygems/ruby/2.6.0/gems/bunny-2.17.0/lib/bunny/consumer_work_pool.rb:78:in `join'  
/usr/app/rubygems/ruby/2.6.0/gems/bunny-2.17.0/lib/bunny/consumer_work_pool.rb:78:in `each'
```

The right sidebar of the issue page shows metadata such as "Assignees" (No one—assign yourself), "Labels" (Environment Monitoring, Production Issue), "Projects" (None yet), "Milestone" (No milestone), "Development" (Create a branch for this issue or link a pull request), "Notifications" (Unsubscribe), "3 participants", and "Lock conversation".

# 1. Operate for Availability

## New releases and patching

>2500 deployments and upgrades from the beginning of the year

- » Monthly security and critical bug fixes
- » On-demand application upgrade or when a version reaches its end of life
- » Automated end to end  
Activate maintenance page, Apply changes on the infrastructure, New docker images are deployed, Database changes are applied, Notification that upgrade has been completed / rollback in case of upgrade issue



**Our site is under maintenance.**  
Please try again later.

# 2. Operate for Usability

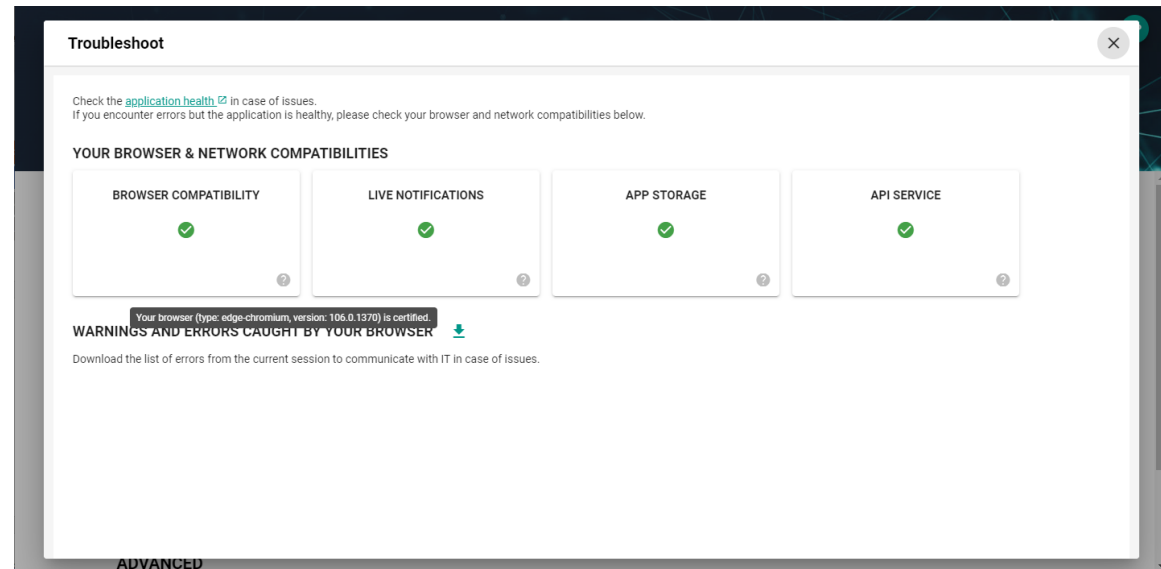
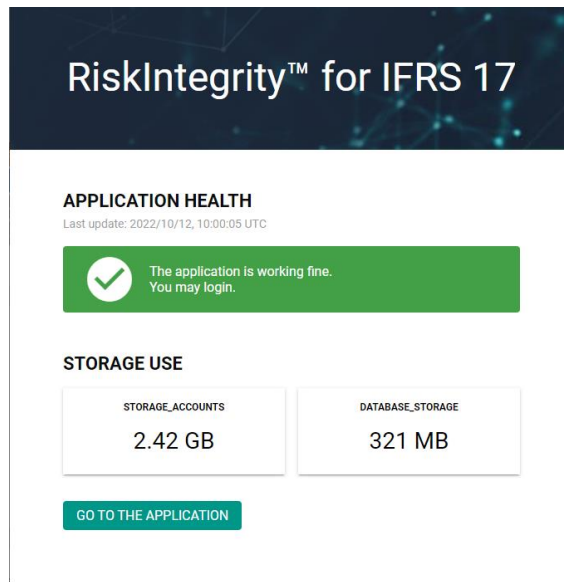
Classify errors

Application unhealthy or bad configuration on customer side ?

For each env: **Health Status**

and

**Troubleshoot** page.



# 2. Design, Build, Deploy and Operate for Usability

## Better error reporting

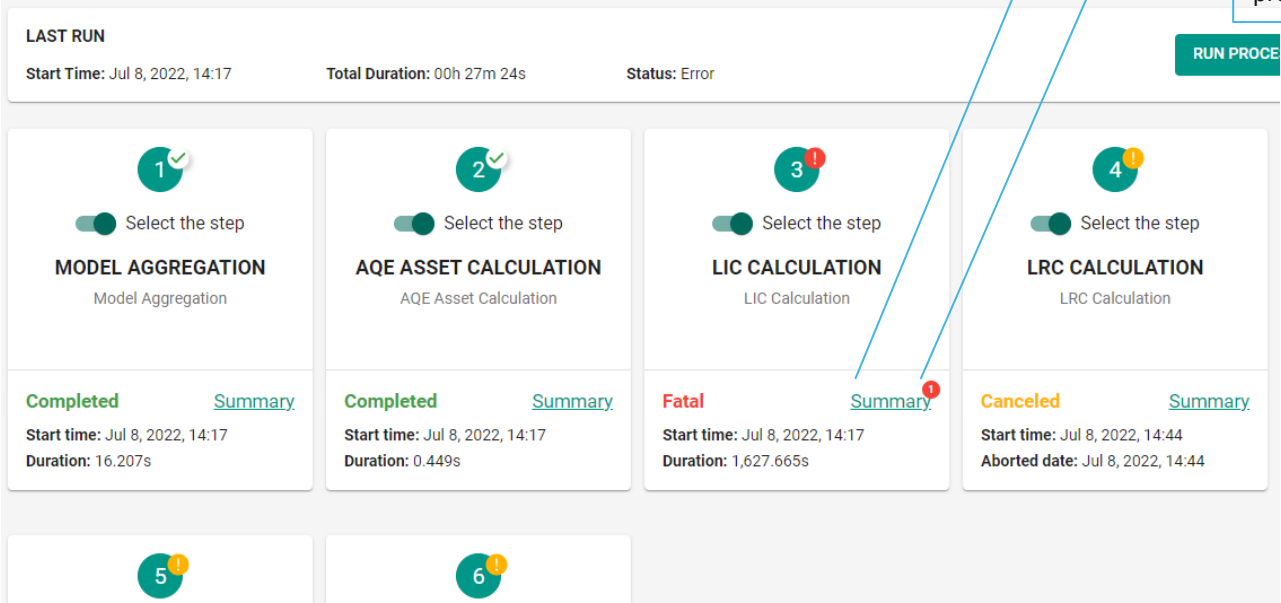
Software error or bad configuration ?

Makes sure the warnings/errors are **explicit, understandable, precise** and provide a clear **directive** to fix the issue

Improve the resolution time of software errors

Previously:  
« The service has been executed several times and failed ».

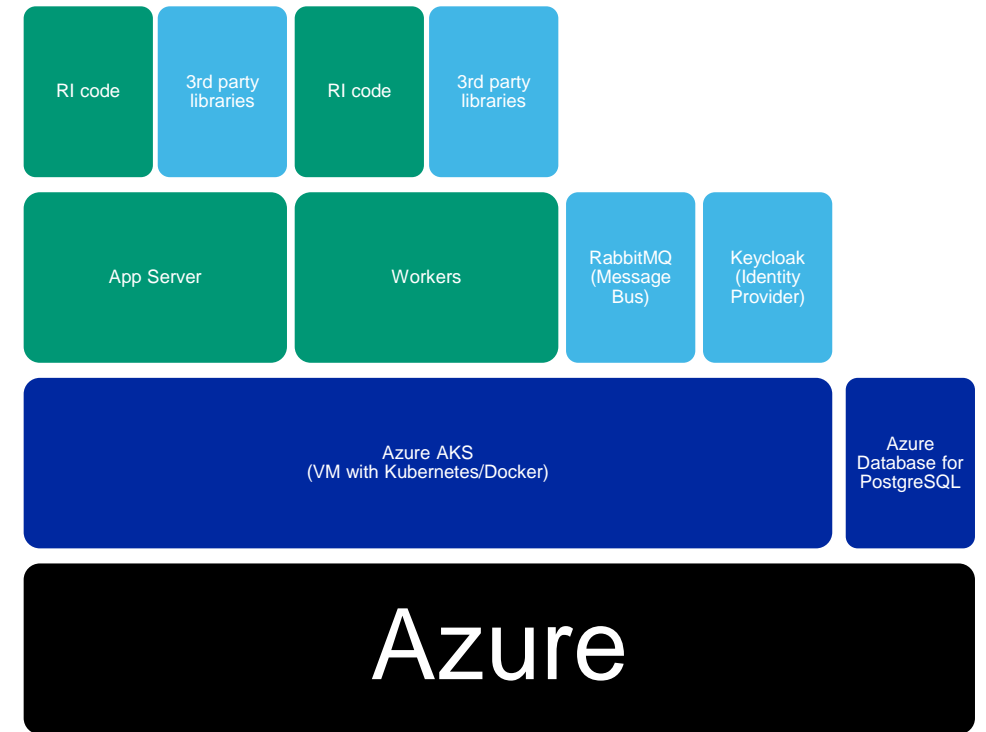
Now:  
« The service has been executed several times and failed. Please contact Moody's support team with the following technical details: error\_id=xxx, timestamp=2022-07-08 12:17:12 UTC, app\_url=xxx, project\_id=xxx, task\_name=xxx ».



# 3. Design, Build, Deploy and Operate for Security

## Automation at every level

- » Attack surface limited when deployed
  - **network config** (your env can only be accessed by your IP addresses), **Encryption** of data (in motion and at rest), App **firewall**, Azure best practices, Moody's InfoSec review
  - **Continuous patching** by Azure (VM, firewall)
- » We continuously monitor threats when developing:
  - **Static and dynamic code analysis**
  - **Review CVE** from 3rd party components and **apply monthly security patches** to the app
- » Certified by external auditors after pen test – **SOC2**



RI simplified component stack

# 4. Design, Build and Operate for Performances

## Auto scaling - What happens when a calculation is executed

1. Process is triggered
2. Process is split in subtasks
3. Subtasks are queued
4. Subtasks are picked from the queue by the workers
5. RI notices pending tasks in the queue and starts new workers
6. Azure detects a need for more cpu/memory and adds new VM to the cluster

The screenshot displays the RiskIntegrity™ for IFRS 17 interface. The top navigation bar shows the project path: Projects > LPE TEST (Dec 31, 2019 - Dec 31, 2020) > Data Management. The main content area is titled 'Data Import' and shows 'Import in progress...'. A table lists the import tasks:

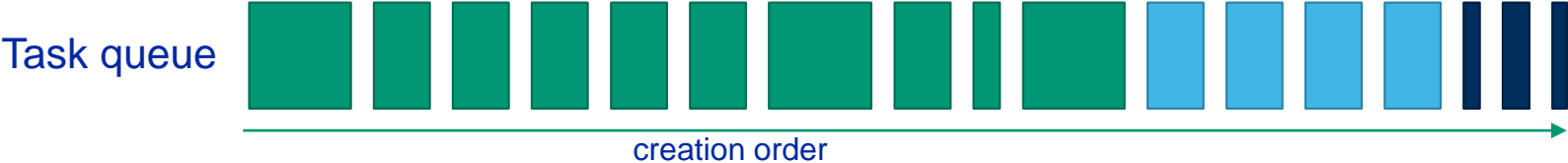
| Filename                             | Status | Import Type | Description | Destination                | Module                   | Lock... | Run Number Sour... |
|--------------------------------------|--------|-------------|-------------|----------------------------|--------------------------|---------|--------------------|
| macro_level_variable_definition.csv  | ✓      | Standard    | -           | Macro-Level Variable D...  | Non Standard Level Data  | -       | -                  |
| data_manipulation_output_mapping.csv | ✓      | Standard    | -           | Data Manipulation Outp...  | Non Standard Level Data  | -       | -                  |
| data_manipulation_driver_mapping.csv | ✓      | Standard    | -           | Data Manipulation Drive... | Non Standard Level Data  | -       | -                  |
| ifrs_group_cashflow_99.csv           | 🔄      | Standard    | -           | IFRS 17 Group Cashflows    | IFRS 17 Group Level Data | -       | Fixed run number   |
| ifrs_group_cashflow_10.csv           | 🔄      | Standard    | -           | IFRS 17 Group Cashflows    | IFRS 17 Group Level Data | -       | Fixed run number   |
| ifrs_group_cashflow_20.csv           | 🔄      | Standard    | -           | IFRS 17 Group Cashflows    | IFRS 17 Group Level Data | -       | Fixed run number   |
| ifrs_group_cashflow_201.csv          | 🔄      | Standard    | -           | IFRS 17 Group Cashflows    | IFRS 17 Group Level Data | -       | Fixed run number   |

Below the table, a terminal window shows the status of various VMs:

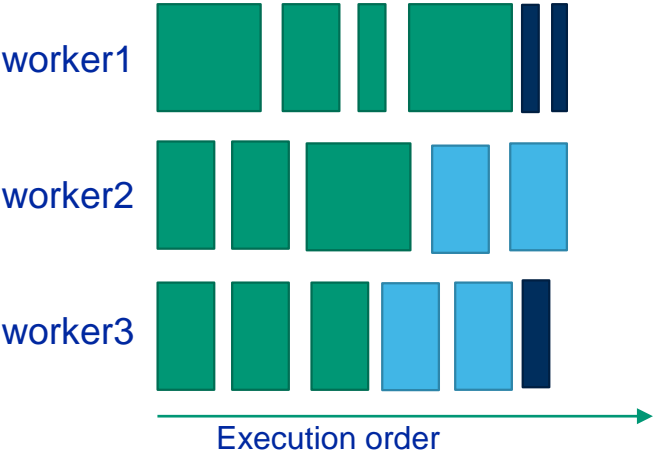
| NAME  | READY | STATUS  | RESTARTS | AGE   | NAME                             | STATUS | ROLES | AGE   | VERSION |
|---|-------|---------|----------|-------|----------------------------------|--------|-------|-------|---------|
| service-worker-low-priority-deploy-6f87ff7b5d-jr7kb | 2/2   | Running | 0        | 8m28s | aks-nodepool1-10122467-vms000029 | Ready  | agent | 8h    | v1.23.8 |
| service-worker-low-priority-deploy-6f87ff7b5d-m6ld  | 2/2   | Running | 0        | 8m13s | aks-nodepool1-10122467-vms00002b | Ready  | agent | 8h    | v1.23.8 |
| service-worker-low-priority-deploy-6f87ff7b5d-mhcxp | 2/2   | Running | 0        | 8m13s | aks-nodepool1-10122467-vms00002c | Ready  | agent | 8h    | v1.23.8 |
| service-worker-low-priority-deploy-6f87ff7b5d-nshcr | 2/2   | Running | 0        | 8m28s | aks-nodepool1-10122467-vms00002d | Ready  | agent | 8h    | v1.23.8 |
| service-worker-low-priority-deploy-6f87ff7b5d-r6k9b | 2/2   | Running | 0        | 17s   | aks-nodepool1-10122467-vms00002f | Ready  | agent | 8h    | v1.23.8 |
| service-worker-low-priority-deploy-6f87ff7b5d-zwrrn | 2/2   | Running | 0        | 8m28s | aks-nodepool1-10122467-vms00002h | Ready  | agent | 8h    | v1.23.8 |
|   |       |         |          |       | aks-nodepool1-10122467-vms00002i | Ready  | agent | 8h    | v1.23.8 |
|   |       |         |          |       | aks-nodepool1-10122467-vms00002n | Ready  | agent | 152m  | v1.23.8 |
|   |       |         |          |       | aks-nodepool1-10122467-vms00002p | Ready  | agent | 6m13s | v1.23.8 |
|   |       |         |          |       | aks-nodepool1-10122467-vms00002q | Ready  | agent | 5m59s | v1.23.8 |
|   |       |         |          |       | aks-nodepool1-10122467-vms00002r | Ready  | agent | 6m1s  | v1.23.8 |
|   |       |         |          |       | aks-nodepool1-10122467-vms00002s | Ready  | agent | 6m36s | v1.23.8 |
|   |       |         |          |       | aks-nodepool1-10122467-vms00002t | Ready  | agent | 6m36s | v1.23.8 |

# 4. Design and Build for Performances

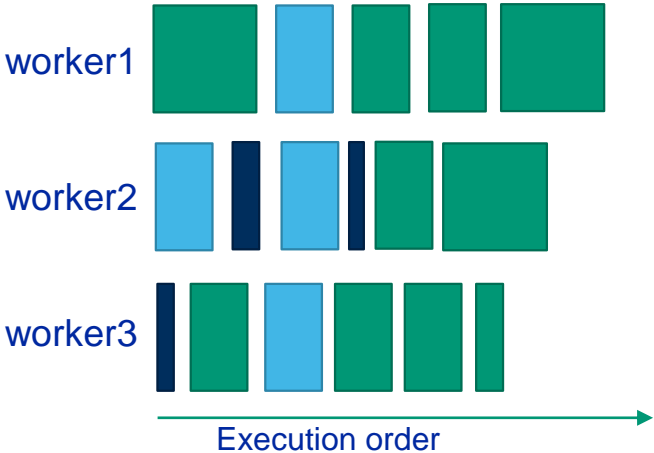
New in 9.0 - Fairness of the calculations by project



**Before: execution by creation order**



**Now: fair use of the workers**



**When a large calculation is executed on one project, it is now possible to get the result of smaller calculations, without waiting for the large one to be completed.**

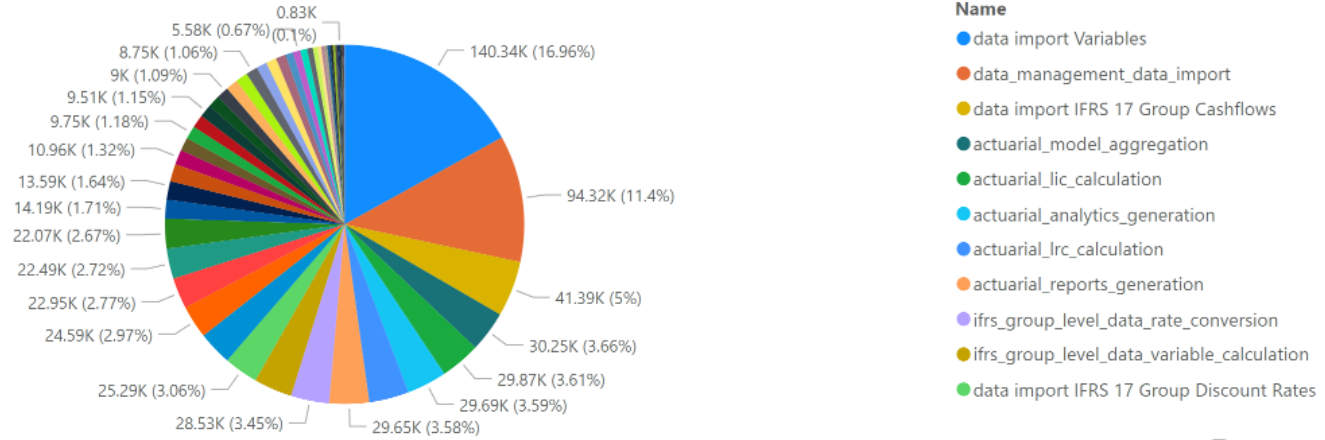
# 5. Continuous Improvement

## Analysis of the usage of the application

We capture stats about the usage of the application and data volumes.

- » Input for the roadmap
- » Prioritize improvements: UI, Performances, ...
- » Optimize our test strategy

Count of Id by Name



MOODY'S  
ANALYTICS

*Better  
Faster  
Decisions*

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