# Optimization of Distributed System Architecture for Simulations in the Heliosphere

**Author**
Ing. Daniel Slanina

**Supervisor**
Ing. Michal Solanik, PhD.

Katedra počítačov a informatiky FEI TU v Košiciach

## Motivation

Cosmic Ray Simulations in the Heliosphere are based on complex physical models. A large amount of computational resources are needed to calculate them in a reasonable time-frame. Due to hardware limitations, it is impossible to vertically scale resources infinitely.

To support any further scaling it is needed to add more independent machines to work together, so the system becomes *distributed*. However, if the system is not properly designed and optimized, performance of the system starts to degrade, due to communication synchronization overhead.

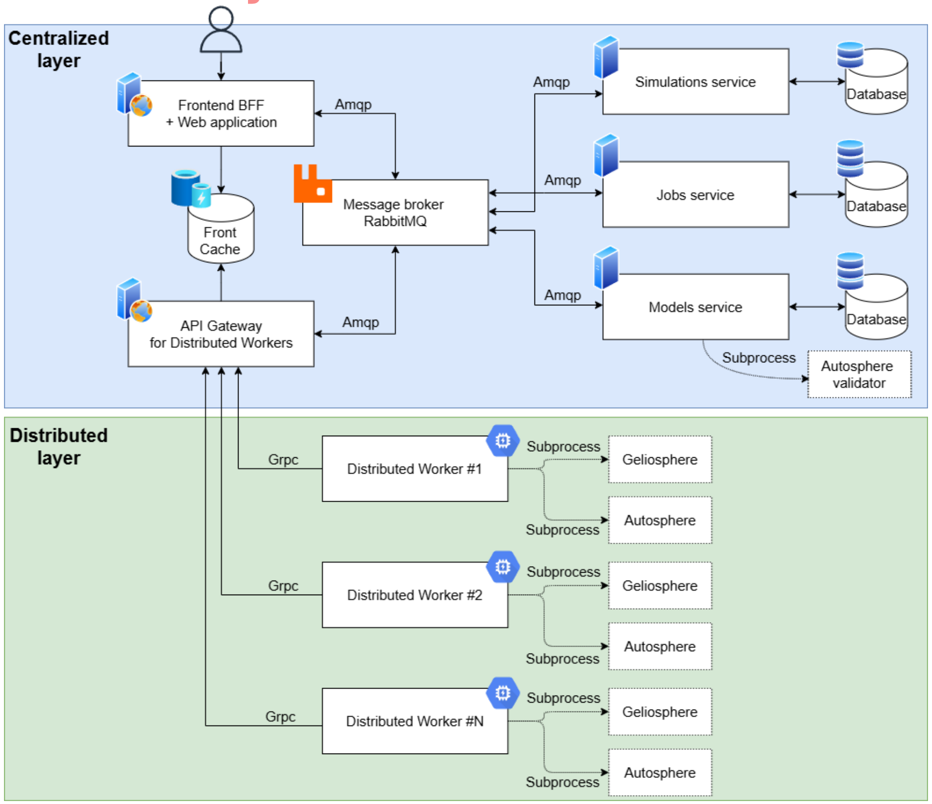
**The goal of this thesis is to design and optimize the architecture of the distributed system to ensure scalability, high performance & fault tolerance.**

## Proposed solution

New architecture of the distributed system is proposed and implemented. Some key areas of the new design include:

- ✓ **Event-driven architecture**, where system components communicates solely via asynchronous events.
- ✓ Design & Implementation of custom **demand-driven scheduler**, that manages work distribution.
- ✓ **Support for user-defined models** with dynamic compilation
- ✓ **gRPC gateway** for Distributed Workers, acting as a system bridge
- ✓ **Web application** with intuitive, simple user interface
- ✓ Easy and portable **deployment strategy and templates** (Kubernetes & Docker)

## High-level System Architecture




## Results

Various tests executed against the system have proved that system is **scalable, very performant** and **fault tolerant**. Due to asynchronous nature of the new architecture, system is able to act & respond to requests within **~50 milliseconds** interval. Communication and synchronization overhead is almost negligible.

Results of End-to-End testing have shown ~**25.3% speedup (17min and 44s)** when calculating whole specified simulation, against old prototype of the system.