What will happen when the high-performance computing centre is connected to the production line in real time?

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Abstract

For the fault detection or fault prediction of a production line, we always need to find a balance between efficiency and accuracy. Complex models usually lead to higher precision but reduce detection (or prediction) efficiency at the same time, especially for complex large-scale production lines. High-performance computer (HPC) provides more freedom for the diagnostic or prediction model while ensuring the efficiency.

In this study, we established the connection between the production lines from a large milk manufacturer and the HPC from EPCC. With the help of the powerful computing capabilities, we achieved near real-time diagnosis, prediction, and visualization of multiple complex systems.

Introduction

As shown in Figure 1, IoT-connected devices have maintained an annual growth rate of nearly 20% in recent years and are expected to reach 7.5 billion in 2025[1]. These IoT-connected devices bring many new business opportunities, and predictive maintenance is one of them. In this context, the massive data brought by IoT and the new business model also bring challenges to the real-time performance and computational accuracy of data mining algorithms. Because they are usually a trad-off relationship, that is, based on algorithmic optimisation, we can only optimize one by sacrificing the other. High-performance computers are an ideal solution through which both real-time performance and computational accuracy of the algorithm can be improved.

In this study we collaborated with EPCC to verify our high-precision near-real-time predictive maintenance ideas with their advanced high-performance computer clusters.

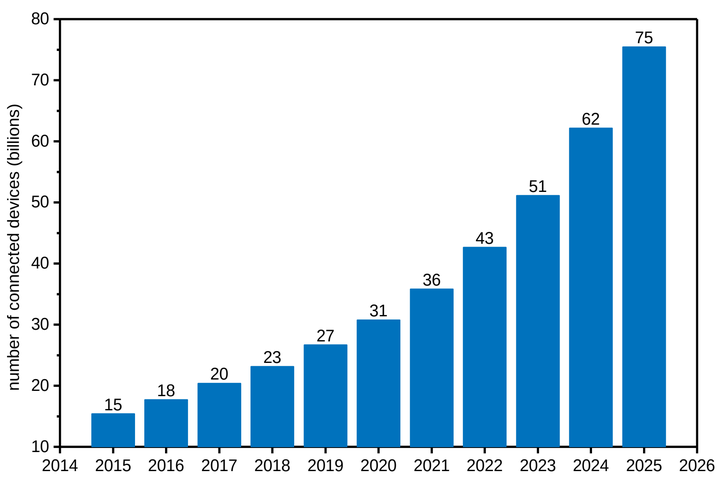

Figure 1: Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions).

Architecture

The architecture of this study is shown in Figure 2. It consists of the following four parts:

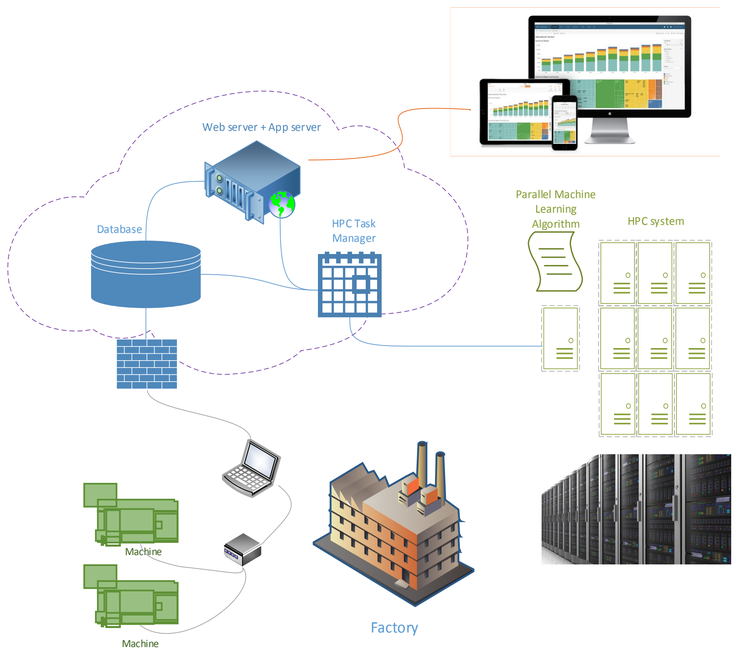

Figure 2: Architecture of proposed system

[1]. **Data acquisition system**: It consists by data acquisition box and sensors. Real-time sensors' data is compressed and uploaded to the cloud. In this project, each milk filling machine was equipped with 12 vibration sensors and a speed sensor. The sampling frequency was 2.4 kHz, which produced about 15 MB of raw data per minute.

[2]. **Cloud Services**: It consists storage server, HPC task scheduler, and web server. Real-time data is stored on the storage server after being uploaded, and then the HPC task scheduler will apply for reasonable computing resources from HPC according to the data volume and the idle state of HPC. The calculation results will be retrieved and written to the storage server for web server access.

[3]. **High-performance computer**: It is provided by EPCC. The system is a state-of-the art SGI ICE XA system with 280 compute nodes(10,080 physical cores), utilising a superfast infiniband interconnect[2]. HPC is used to calculate vibration data features and predictive diagnosis model.

[4]. **User Interfaces**: The user interfaces are divided into different levels according to the users facing, which include maintenance Engineer, researchers, and manager. An example of the user interface is shown in Figure 3.

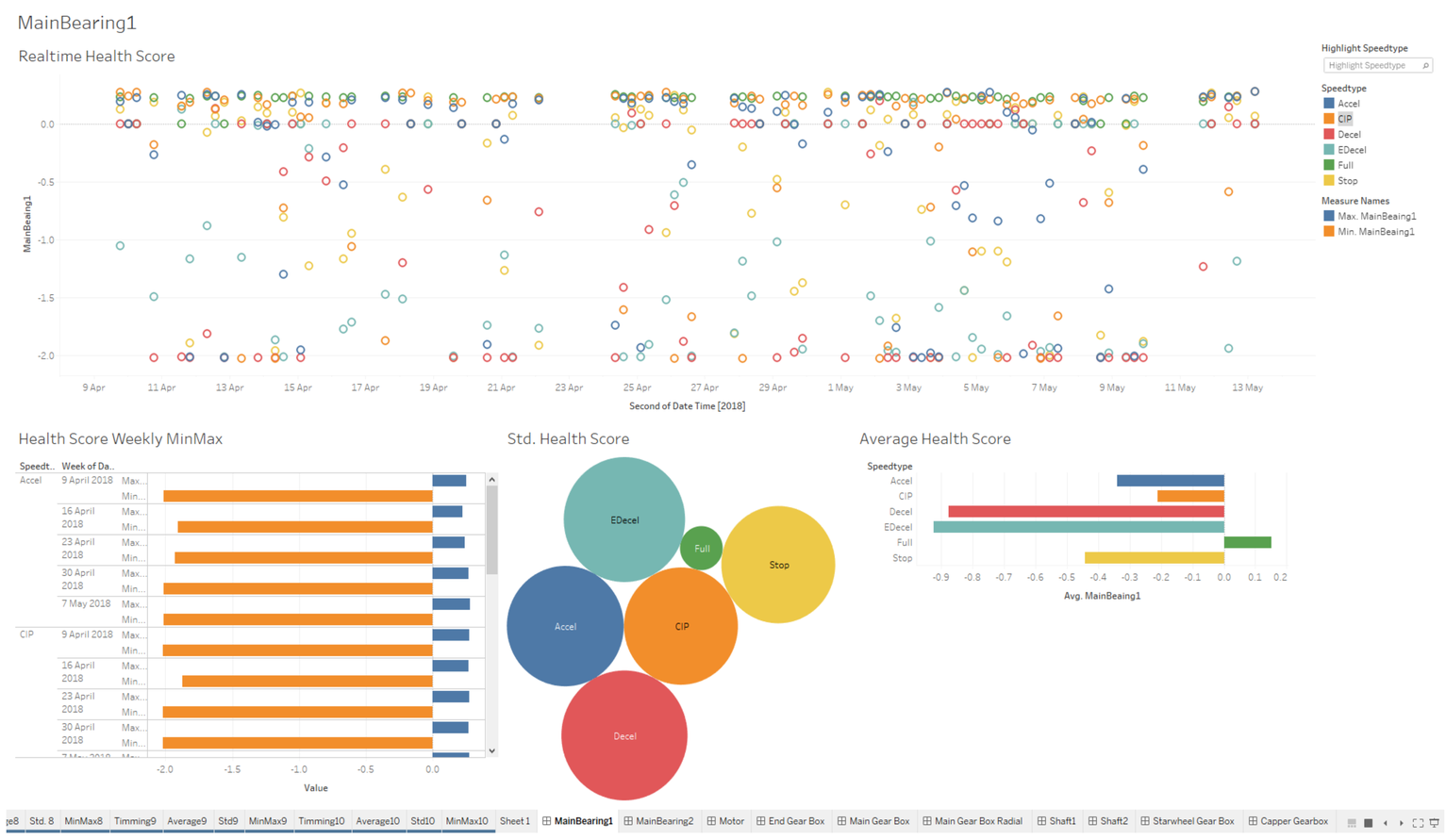

Figure 3: An example of the user interfaces

Results

In order to optimize the parallel processing performance of HPC, the parallel architecture of machine learning code and different HPC configurations were tested.

Figure 4 shows the HPC processing times for different tests. For the best configuration, 172 seconds are required to process a 10-minute sampling result with a machine equipped with 12 vibration sensors, which means that the application of this system can achieve the goal of near-real-time diagnostic maintenance.

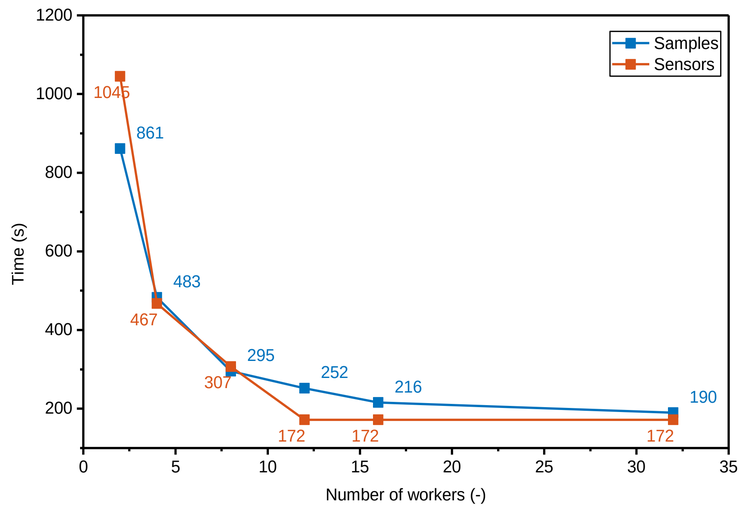

Figure 4: Processing time for an individual machine of the proposed system with different HPC configuration..

Acknowledgments

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References:

[1] IHS. Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions). https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/ (accessed 5/15/18, 4:24 PM).

[2] EPCC. Cirrus. https://www.epcc.ed.ac.uk/facilities/demand-computing/cirrus (accessed 5/15/18, 2:24 PM).