



VI SPD Collaboration Meeting and Workshop on Information Technology
in Natural Sciences

Digital Twin of SPD Online filter



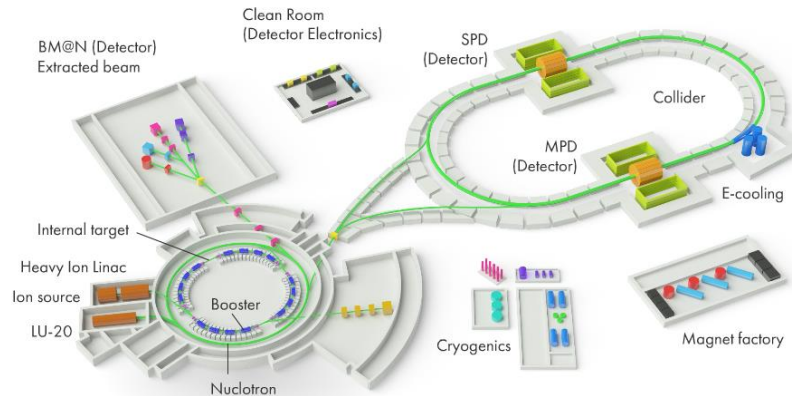
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JOINT INSTITUTE FOR NUCLEAR RESEARCH

Introduction

Nuclotron-based Ion Collider fAcility (NICA, JINR, Dubna, Russia)



- Large amounts of data per second are generated during the experiments.



- Efficient computing systems are required to store and process data in a relatively short time!



- The system should provide enough performance through balanced loading of resources.



Introduction

Nuclotron-based Ion Collider fAcility
(NICA, JINR, Dubna, Russia)

**How to ensure
designing, continuous
improvement and
scaling of such systems?**

➤ Large amounts of data per second are generated during the experiments.



➤ Efficient computing systems are required to store and process data in a relatively short time!



➤ The system should provide enough performance through balanced loading of resources.



Introduction

Nuclotron-based Ion Collider fAcility
(NICA, JINR, Dubna, Russia)



Digital twin

- Modeling of complex computing systems.
- Describes the system.
- Reflects the processes taking place in the system.
- Testing of the system with different variants of equipment parameters, data flows and jobs.

Priakhina D., Korenkov V. The relevance of creating a digital twin for managing distributed data acquisition, storage and processing centers (accepted in print)

Digital twin (DT)

Real-time operation throughout the entire computing infrastructure life cycle.

COMPUTER MODEL



INPUT DATA

- Architecture and hardware parameters of computing infrastructure.
- Characteristics of data flows and jobs flows.

FUNCTIONAL PURPOSE

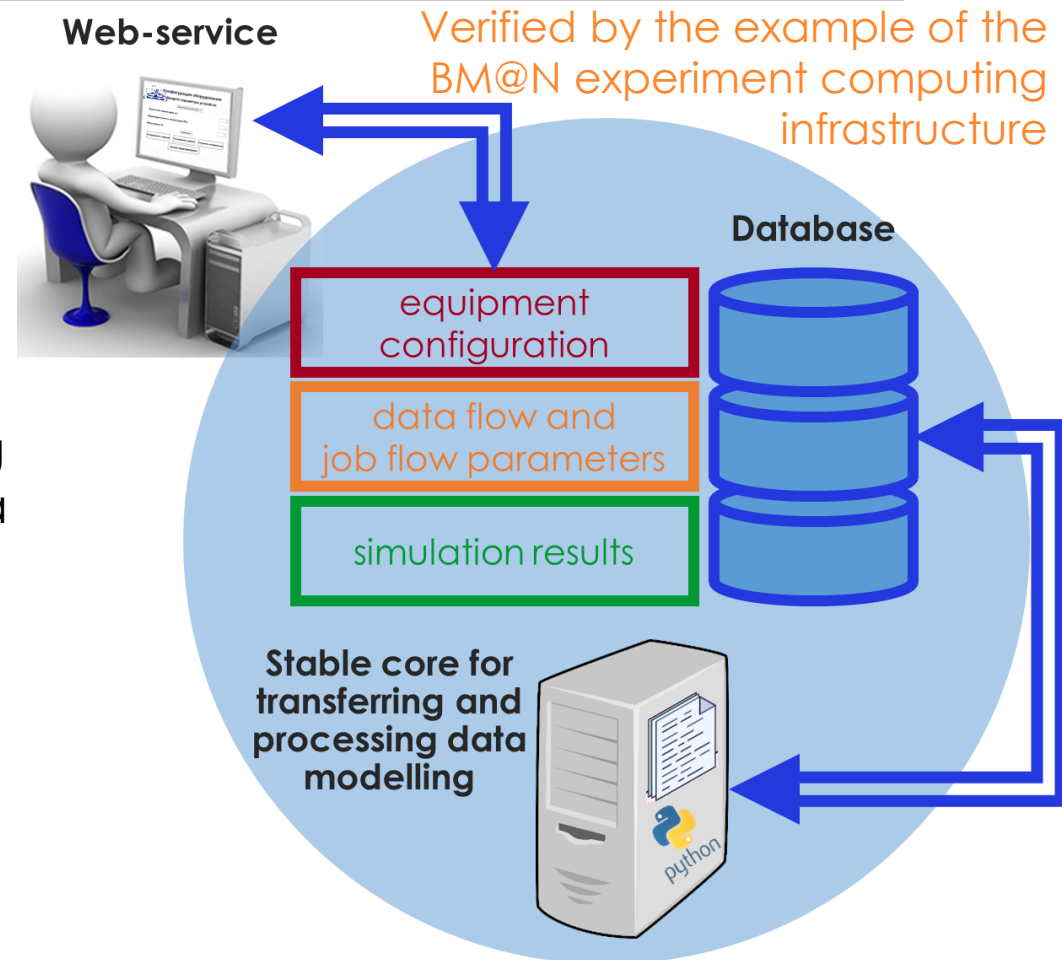
- Designing of computing infrastructure.
- Analysis of the efficiency and reliability of computing infrastructure.
- Testing scaling scenarios based on data flows and jobs flows requirements.
- Assessment of the required amount of resources for specific tasks.
- Checking jobs flows management strategies.

Priakhina D., Korenkov V., Trofimov V. A method of constructing digital twins for solving problems of effective management and development of distributed data acquisition, storage and processing centers (accepted in print)

Software complex for creating digital twins

Modeling core

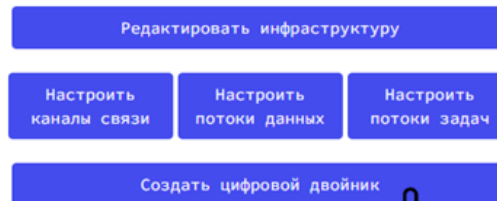
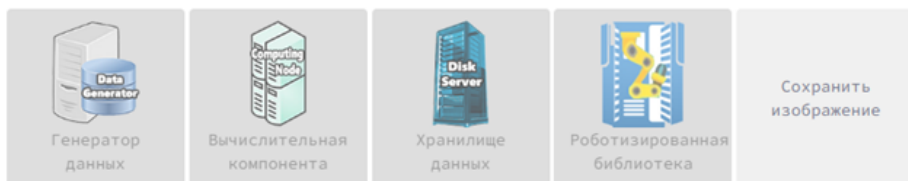
- Universal – applicable for modeling computing infrastructure without changing the program code.
- Probabilistic distributions are taken into account when forming data flows, jobs flows, and criteria for the functioning of equipment.
- Used for design tasks, system scaling during operation, searching for problem areas when data flows and jobs flows change.





Functionality of the web service

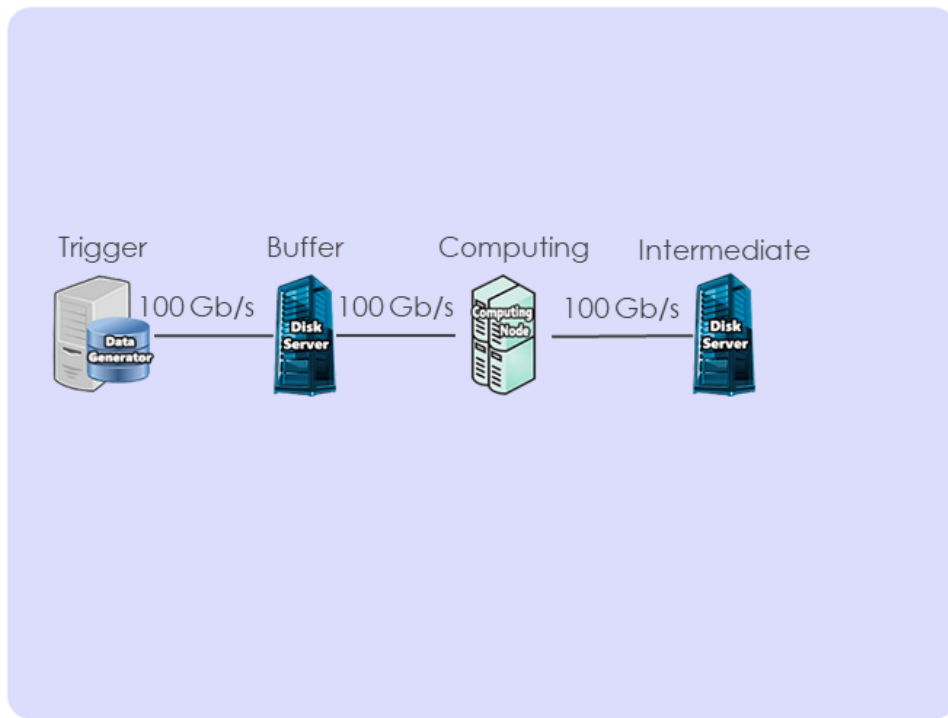
Построение инфраструктуры центра сбора, хранения и обработки данных



Create a digital twin

Building the computing infrastructure

- Setting the equipment parameters.
- Setting characteristics of data flows and jobs flows.



The prototype of the web service has not yet been localized.



Functionality of the web service

Добавление эксперимента

Заполните поля формы, чтобы добавить новый эксперимент для поиска оптимальной конфигурации оборудования

* Обязательное поле для заполнения

Название эксперимента *

Test 1

Описание эксперимента

Поиск оптимального количества ресурсов для хранения данных

Параметры моделирования

- Продолжительность работы моделируемой инфраструктуры - ч.
- Ускорение процесса моделирования в раз.

Параметры логирования

Выберите объекты и события, о которых необходимо сохранять информацию во время моделирования

- Объекты моделируемой инфраструктуры
 - Хранилища данных
 - Вычислительные компоненты
 - Каналы связи
- События
 - Генерация данных
 - Потери данных
 - Работа с файлами
 - Генерация, запуск, выполнение задач

Добавить

Очистить

Configuration of computing infrastructure scaling scenarios

Parameters for modeling:

- experiment name;
- description;
- duration of work;
- speed up of modelling;
- objects and events for logging.



Functionality of the web service

Информация об эксперименте

Дата создания: 7 февраля 2023 г. 10:36

Название эксперимента

Test 1

Описание эксперимента

Поиск оптимального количества ресурсов для хранения данных

Параметры моделирования

- Продолжительность работы моделируемой инфраструктуры – 800 ч.
- Ускорение процесса моделирования в 1000 раз.

Параметры логирования

- Объекты моделируемой инфраструктуры
 - Хранилища данных
 - Вычислительные компоненты
 - Каналы связи
- События
 - Генерация данных
 - Потери данных
 - Работа с файлами
 - Генерация, запуск, выполнение задач

Посмотреть результаты

Выбрать другой эксперимент

Базовая конфигурация

Хранилища данных

| Название | Описание | Объем (ТБ) |
|----------|-----------------------|------------|
| trigger | Trigger BM@N | 10000,0 |
| buffer | Data receipton buffer | 5400,0 |
| eoslhep | Main storage LHEP | 1000,0 |
| eoslit | Main storage LIT | 1000,0 |
| dcach | pp | 1000,0 |

Вычислительные компоненты

| Название | Описание | Количество ядер |
|----------|----------------|-----------------|
| t2lit | LIT T2 farm | 500 |
| ncxlhep | LHEP main farm | 1200 |
| super | Govorun | 190 |

Каналы связи

| Название | Описание | Пропускная способность (Гб/с) |
|----------------|------------------|-------------------------------|
| raw0 | trigger - buffer | 100,0 |
| raw1 | buffer - lhep | 10,0 |
| raw2 | buffer - lit | 10,0 |
| compute0 | lhep - farm lhep | 10,0 |
| compute1 | lit - Govorun | 10,0 |
| compute2 | lit - farm lit | 10,0 |
| dataeosLhepLit | eoslhep - eoslit | 10,0 |
| dataeosLitLhep | eoslit - eoslhep | 10,0 |

Добавить модификацию

Starting the digital twin

| № | Статус | Дата обновления | Просмотр | Запуск | Результаты |
|----|--------|------------------------|----------|--------|------------|
| 16 | NEW | 9 марта 2023 г. 14:52 | Просмотр | Запуск | Результаты |
| 15 | DONE | 10 марта 2023 г. 10:18 | Просмотр | Запуск | Результаты |

Simultaneous run of all modifications is possible



Functionality of the web service

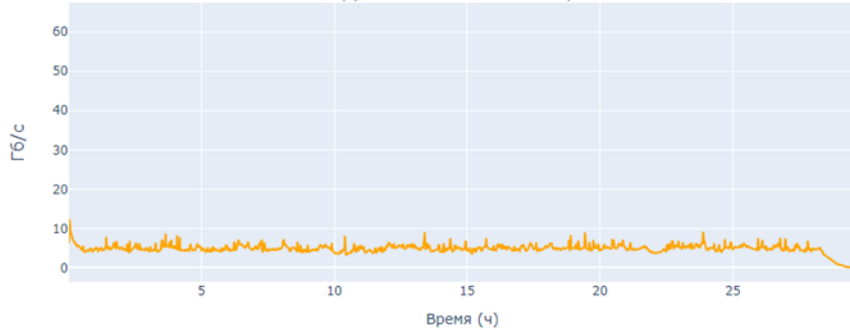
The digital twin results

Результаты эксперимента Test 1

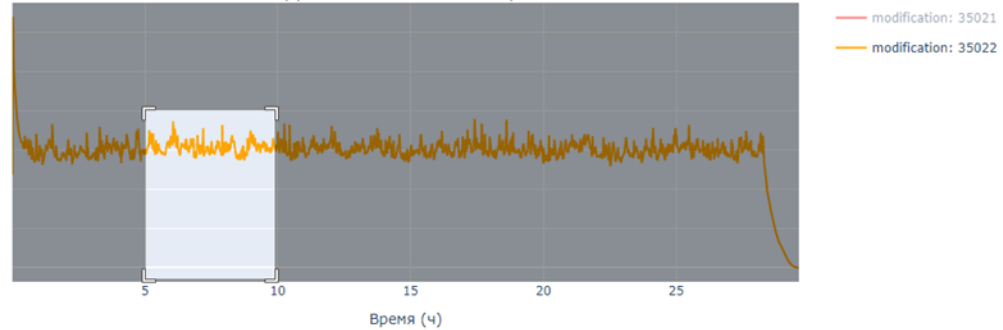
Выберите вкладку для просмотра результатов

Хранилища данных Вычислительные компоненты **Каналы связи** Очереди задач Распределения файлов

Нагрузка на канал связи compute0



Нагрузка на канал связи compute2



Available for viewing:

- data storage load volume;
- using cores on computing components;
- load on communication links;
- job queues, the number of completed jobs;
- distribution of files in storages.

Digital Twin of SPD Online filter

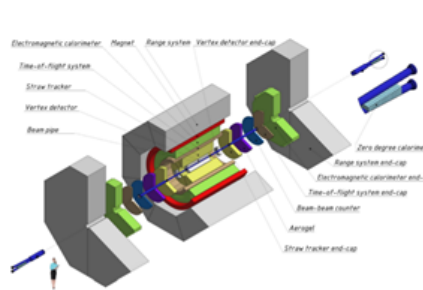
First experience

Raw data rate
20 GB/s

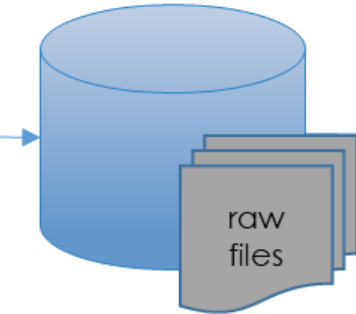
Buffer for
data received
from the detector

Computing
resources

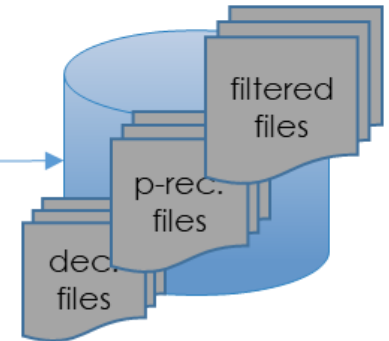
Storage for
intermediate
data



1 raw event = 7 KB



1 raw file = 4 GB



Processing raw file
to filt. file: **10 min**

1) Decryption:

raw file → *dec. file*

1 dec. file = 4 GB

2) Partial reconstruction:

dec. file → *p-rec. file*

1 p-rec. file = 8 GB

3) Filtering:

p-rec → *filt. file*

1 filtered file = 450 MB

Experiment duration: 24 hours

To calculate:

? data storage volumes;

? network load;

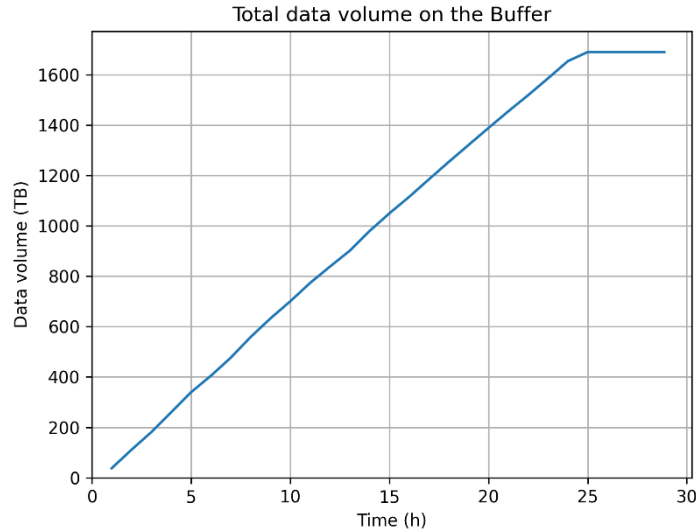
? load of computing resources etc.

Digital Twin of SPD Online filter

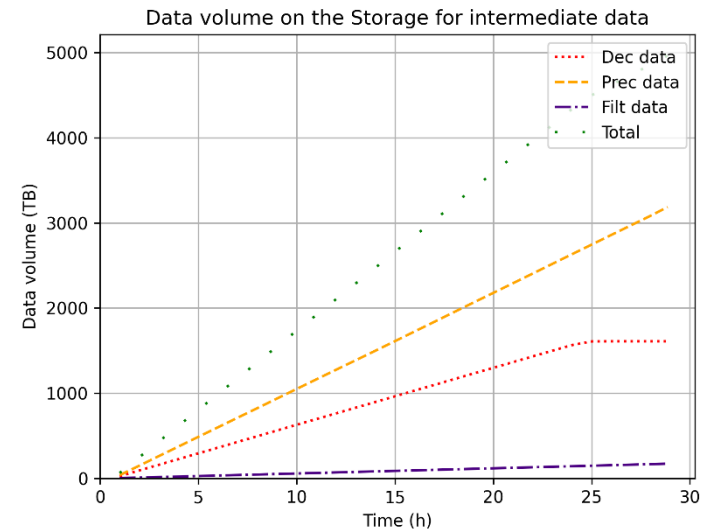
First experience

Results 1. Constant data generation

Data storages



~ 1 700 TB on the Buffer



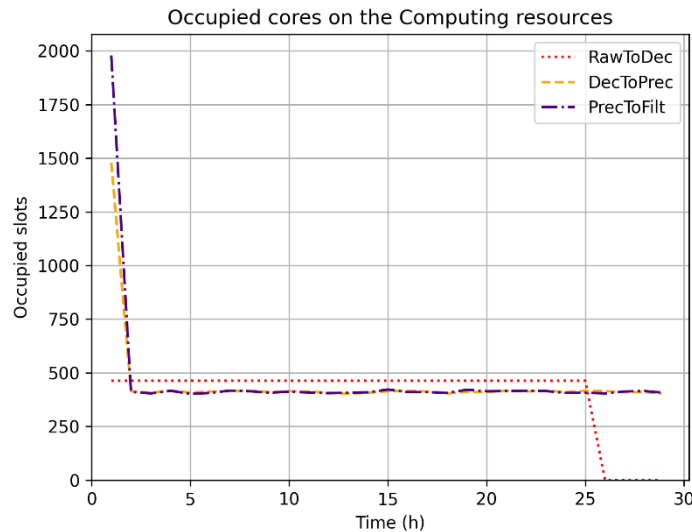
~ 5 000 TB on the Storage for intermediate data

Digital Twin of SPD Online filter

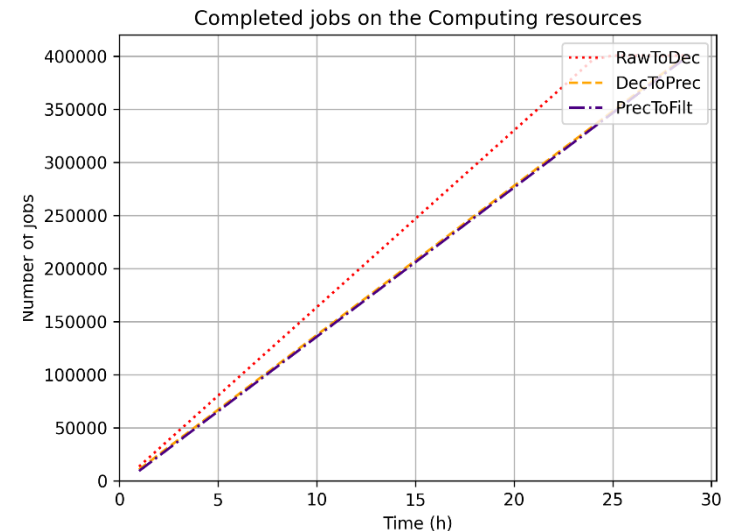
First experience

Results 1. Constant data generation

Computing resources



**~ 1 500 cores are occupied
by jobs**



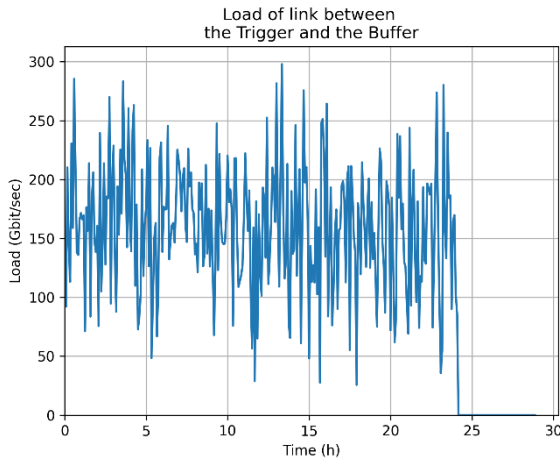
**~ 400 000 jobs will be done
for 30 hours**

Digital Twin of SPD Online filter

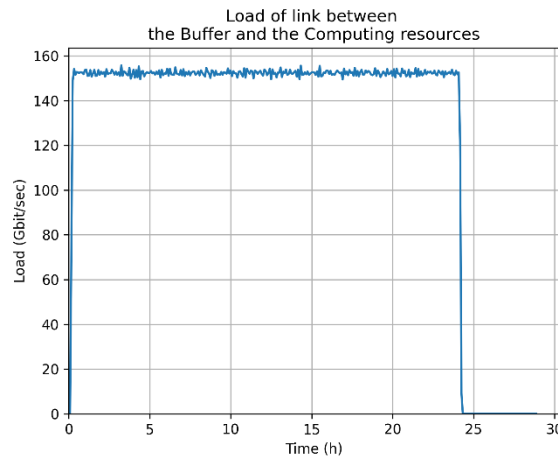
First experience

Results 1. Constant data generation

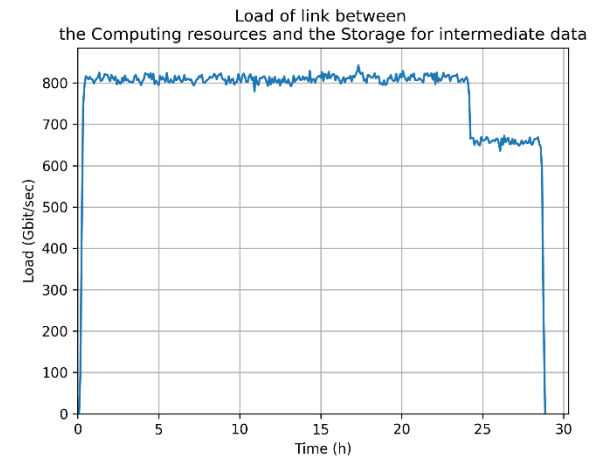
Network



**~ 150 Gbit/sec
between the Trigger
and the Buffer**



**~ 150 Gbit/sec
between the Buffer
and the Computing
resources**



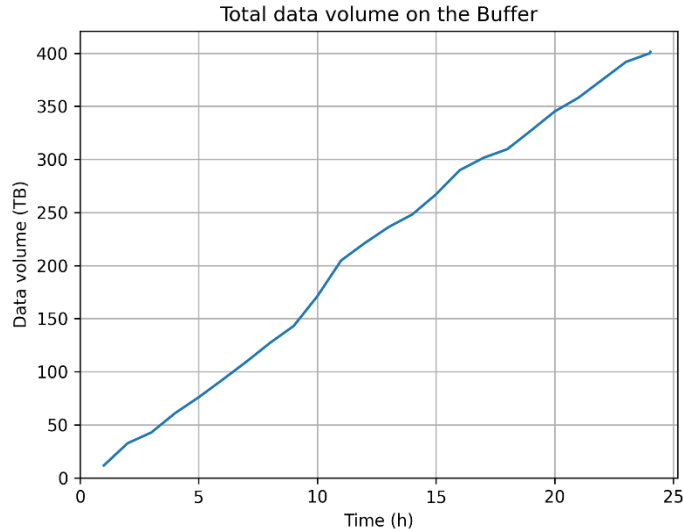
**~ 800 Gbit/sec
between the
Computing resources
and the Storage for
intermediate data**

Digital Twin of SPD Online filter

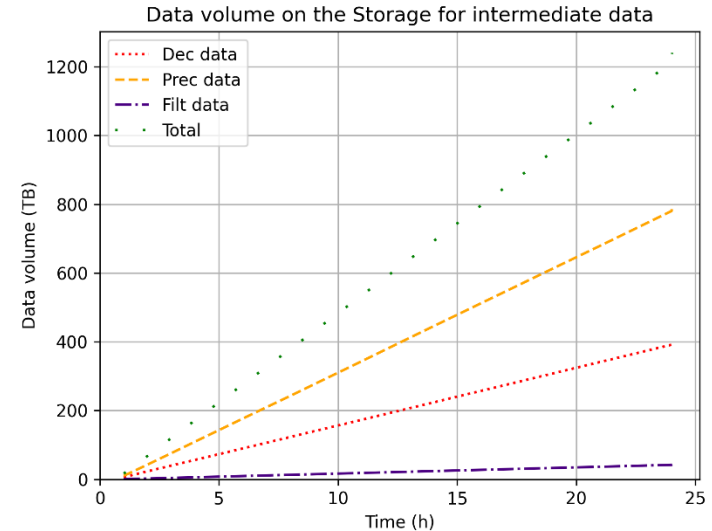
First experience

Results 2. Data generation efficiency – 20%

Data storages



~ 400 TB on the Buffer



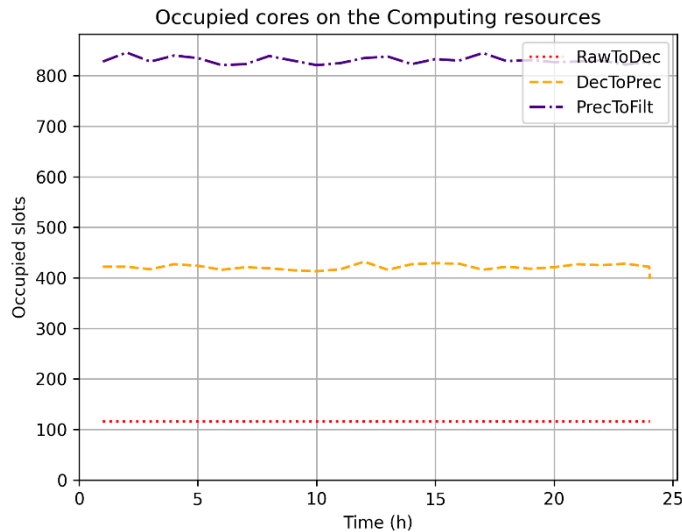
~ 1 200 TB on the Storage for intermediate data

Digital Twin of SPD Online filter

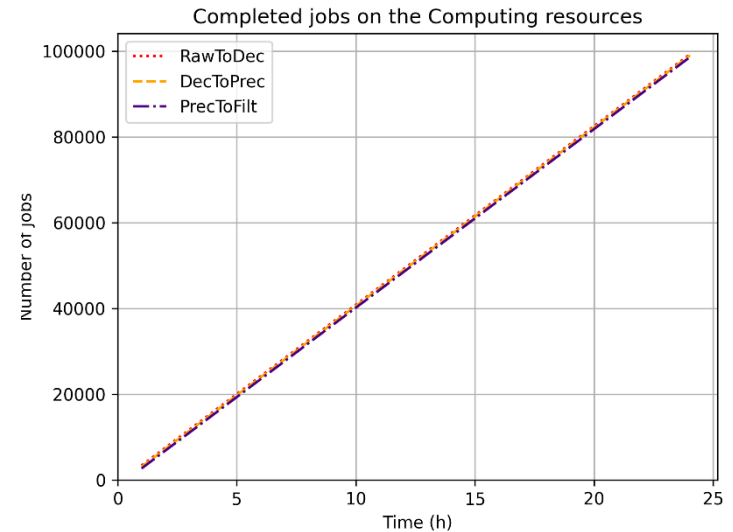
First experience

Results 2. Data generation efficiency – 20%

Computing resources



**~ 1 500 cores are occupied
by jobs**



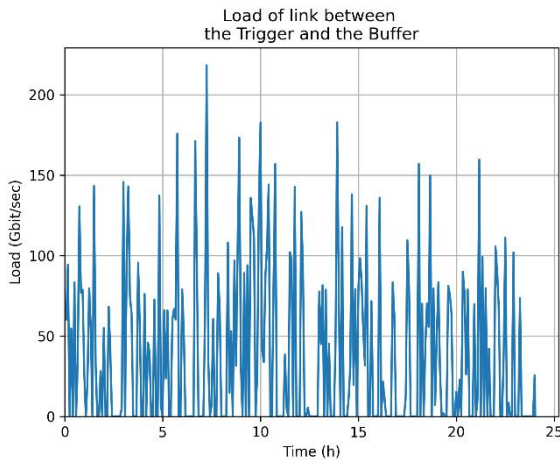
**~ 100 000 jobs will be done
“on the fly”**

Digital Twin of SPD Online filter

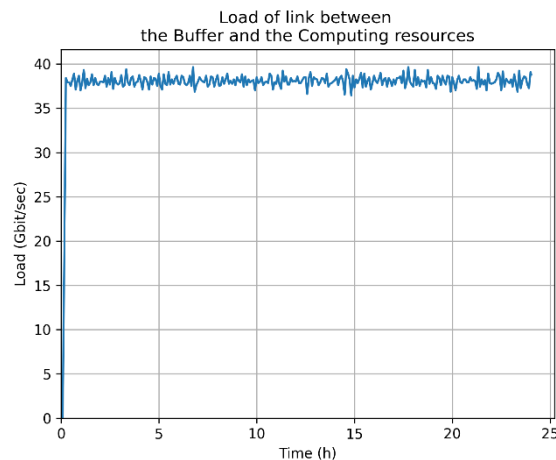
First experience

Results 2. Data generation efficiency – 20%

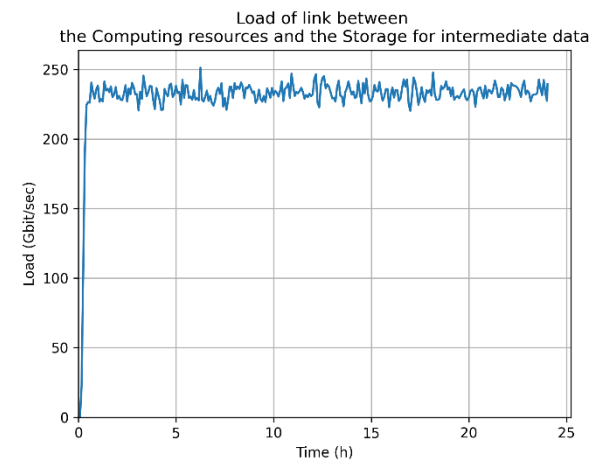
Network



**~ 50 Gbit/sec
between the Trigger
and the Buffer**



**~ 40 Gbit/sec
between the Buffer
and the Computing
resources**



**~ 250 Gbit/sec
between the
Computing resources
and the Storage for
intermediate data**

Conclusions

- Software complex can be used for create digital twins of SPD computing infrastructure.
- Digital twin of SPD online filter can help calculate:
 - the required storages volumes;
 - time for data processing;
 - use of computing resources;
 - loading of communication links, etc.
- Future plans:
 - adding the probabilities of various events in the system;
 - running digital twins for different scenarios of experiment.



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Thank you for the attention!



D. PRIAKHINA



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