Development of the Online Data Processing System (ODP) for the BM@N experiment at NICA

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Baryonic Matter at Nuclotron (BM@N) is a fixed-target experiment and the first experiment in the NICA project.

It’s an ongoing experiment. The first physics run was from December 2022 to February 2023.
Purpose and requirements

The purpose of the ODP system is selective data processing for data quality analysis.

The system must be able to customize the task flow, since a number of tasks and their types may change from run to run.
Distributed architecture of the ODP system

The messaging system allows you to **customise the task flow** as each task publishes the results of its work to which other tasks can subscribe.

It can enable **parallel processing of tasks** because multiple replicas of a task can be run.
Chosen solutions

Message exchange

**FairMQ**\(^*\) is a messaging framework focused on building modular systems for data processing in high-energy physics experiments.

It represents an abstraction over various messaging technologies such as ZeroMQ, Nanomsg, etc.

Deployment

**DDS**\(^*\) (Dynamic Deployment System) is a set of tools that facilitates the process of system deployment.

As a Remote Manipulator System (RMS), it initially provides SSH or SLURM, but also allows you to use other methods.

\(^*\) Developed by the FAIR collaboration at the GSI Institute, Germany.
Each data processing task is represented as a **separate** FairMQ device.

It is **an independent** module of the system.

The task processing flow is created by **connecting devices together**.
Life cycle of FairMQ Device
**BmnRoot Framework** is a software for BM@N experiment.

It provides tools for simulation, reconstruction and physics analysis of the data using ROOT macros*

BmnRoot is based on the ROOT and the FairRoot frameworks.

* The ROOT macro contains pure C++ code, which is interpreted at runtime.
## Comparison of reconstruction processes

<table>
<thead>
<tr>
<th>run_reco_bmn.C (macro)</th>
<th>FairMQ Device</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FairRunAna</strong> is used to store and manage the list of reconstruction tasks (initialization, execution, completion).</td>
<td>Reconstruction tasks are stored in a special array. They are managed through a sequential call to the methods <code>InitTask</code>, <code>Exec</code> and <code>FinishTask</code> when the device is in the running state.</td>
</tr>
</tbody>
</table>
The converter to event digits transforms raw data into ROOT format and applies channel mapping.

The Fast Reconstruction module converts digits into reconstructed hits, track data, finds the primary vertex, etc.

The Condition Database stores various parameters that are used in the data processing algorithms.

The Online Histogramming module and the Event Display are used to visualize event data.
Process management system

The Online Configuration System (OCS) is a process management system based on the DDS deployment system.

The OCS system consists of the central manager, the database, the web interface and a set of workers.

Data processing tasks are configured and run using the web interface.
Implemented solution

Raw data conversion

1 Raw file

2 Macro

BmnDataToRoot.C

ROOT Digits File

Standard Flow

Online Flow

2 FairMQ Device

runBmnOnlineDigitizer.cxx

ZeroMQ

1 Macro

3 FairMQ Device

runBmnOnlineProcessor.cxx

FairMQ

Reconstruction

3 Macro

run_reco_bmn.C

DST File

4 Macro

eventdisplay.C

Standard Mode

Visualization

4 Macro

eventdisplay.C

5 Macro

Online Mode
OCS Designer and Task Monitor

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**Configuration Manager**

*Select Setup Run:* BMN Run 7

**Task Monitor**

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Setup Run</th>
<th>Module</th>
<th>Status</th>
<th>Log</th>
<th>Start Time</th>
<th>End Time</th>
<th>Host</th>
</tr>
</thead>
<tbody>
<tr>
<td>bmn_event_display_init</td>
<td>BMN:7</td>
<td>OnlineControl</td>
<td>Started</td>
<td></td>
<td>2023-05-05 18:39:16</td>
<td></td>
<td>vps104.jinr.ru</td>
</tr>
<tr>
<td>bmn_fast_event_reco_init</td>
<td>BMN:7</td>
<td>OnlineControl</td>
<td>Started</td>
<td></td>
<td>2023-05-05 18:39:16</td>
<td></td>
<td>vm221-85.jinr.ru</td>
</tr>
<tr>
<td>bmn_online_histo_init</td>
<td>BMN:7</td>
<td>OnlineControl</td>
<td>Started</td>
<td></td>
<td>2023-05-05 18:39:16</td>
<td></td>
<td>vps104.jinr.ru</td>
</tr>
<tr>
<td>bmn_root_digi_init</td>
<td>BMN:7</td>
<td>OnlineControl</td>
<td>Started</td>
<td></td>
<td>2023-05-05 18:39:16</td>
<td></td>
<td>vps104.jinr.ru</td>
</tr>
</tbody>
</table>
Conclusions

- The distributed architecture has been designed for the ODP system
- The ODP system has been implemented using FairMQ
- The system is run and managed using the OCS system based on DDS
Thank you for your attention!