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1 Document information

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1.1 Dissemination Level

Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

1.2 Content

2 Introduction

2.1 Purpose of this document

As part of workstream 2 in JRA Hilado, requirements for the fast transient imager pipeline have been defined. This report describes those top-level requirements.

2.2 Background

With the advent of ever-larger datastreams, it becomes unavoidable to move data processing functions that have been traditionally carried out interactively into the domain of streaming processing. Through the development of a Fast Transient Imaging Pipeline (FTIP), Hilado will both build a specific application (boosting LOFAR Transient Processing) and develop insights and components to ease further development in this area.

This document briefly notes the major areas in which LOFAR system development is required to meet the scientific requirements of the Transients Key Science Project (TKP), along with some preliminary suggestions about the approach to be taken and manpower required.

2.3 Overview

Development is required in two distinct, but related, areas:

1. The “real-time" imaging pipeline, which is capable of producing a continuous stream of wide-field images at a range of frequency bands with the target cadence and latency being one second.

2. Making LOFAR into a “responsive" telescope, which can automatically schedule new observations or re-analyse existing data in response to targets of opportunity. This includes the ability to reconfigure the telescope and/or override a pre-existing schedule.

3 Real-time imaging

Broadly speaking, there are three stages to the imaging pipeline: compression and flagging, calibration (BBS) and imaging (cimager/awimager). None of the existing tools have been designed to perform at a real-time level. In addition, the current pipeline consist of a series of independent tools being dispatched by a control process via SSH, with data being written to disk between each stage: this execution model already introduces a latency at the multi-second level, even before any processing has been carried out.

The following development is suggested. See also Figure 1.

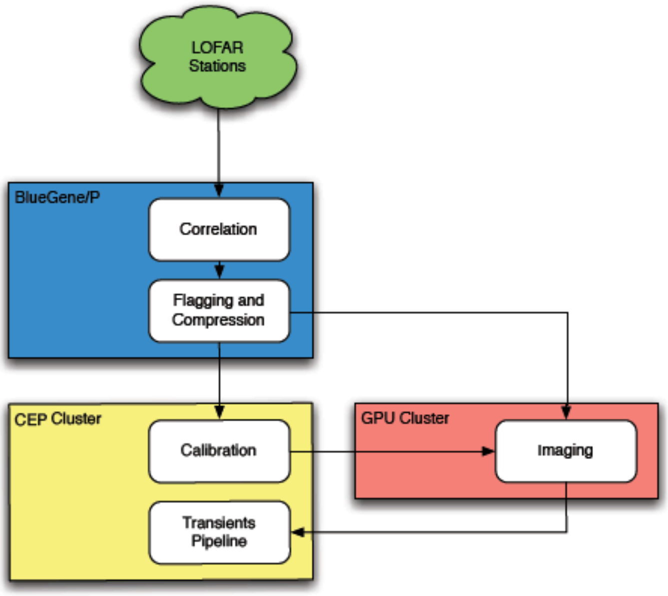

Figure 1: Example scheme for real-time imaging pipeline processing.

3.1 Pipeline framework

A streaming system is to be developed, whereby data is never written to disk unless required and pipeline component start-up and shutdown times are minimized.

The PELICAN system1 developed at the University of Oxford is already being used for various LOFAR-related projects (ARTEMIS, AARTFAAC) and provides many of the required capabilities (see https://github.com/pelican/)

3.2 Compression and flagging

Compression and flagging should be carried out BG/P before data is sent to the cluster for further processing. In principle, the existing flagger algorithms (e.g. as developed by Offringa) can be used. However, the flagger requires extensive testing by TKP members to ensure it does not reject fast transients.

3.3 Calibration

It should not be necessary to perform calibration afresh for each second of data being processed. Instead, solutions can be derived for certain time/frequency pairs and then interpolated to the rest of the data. In this way, it may be possible to use BBS to perform the calibration by shifting it out of the time-critical part of the processing. Further, it is likely that an adequate calibration for detecting (bright, at least) transients could be obtained from a single pass through BBS, rather than requiring an elaborate major cycle.

The longevity of calibration solutions in time/frequency space should be investigated by TKP members.

3.4 Imaging

Performance metrics need to be established for the LOFAR awimager package. It may be possible to use work under the performance constraints required, otherwise an update version will have to be developed. A GPU-based imager implementing both W- and A-projections is available. Use of this imager for the fast imaging pipeline has to be studied, as it may have the twin benefits of providing excellent performance and off-loading the major compute load from the standard CEP cluster, freeing it up for other tasks.

4 Responsive telescope

This section covers a number of LOFAR capabilities that are required to specify and schedule observations in such a way as to optimize it as a transients instrument. These touch on areas such as the scheduler and the MAC/SAS control system. They are therefore largely independent from the real-time pipeline insofar as implementation issues are concerned. These developments are outside the scope of Hilado but are listed here for completeness.

The telescope should:

- Support simultaneous independent observations with differing start/stop times, pointings, station selections, etc.

- Provide the ability to switch targets at the sub-second level (i.e. shut down some current beams, point at new target, start recording data).

- Provide an interface such that science pipelines or other automatic tools can request actions of the telescope and that those can be incorporated into the schedule without manual intervention. Such actions may include (but are not limited to):

    - Insertion of a new observation into the schedule, if necessary rescheduling other observations to make way;

    - Execution of a science pipeline on extant data;

    - Triggering a dump of the current contents of the Transient Buffers.

- Provide a facility for arbitrating between multiple competing requests for telescope and/or compute time, such that (for example) low-priority scheduled observations may be overridden by a high-priority transient observation without manual intervention.