Ingest pipeline for ASKAP

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ASKAP: Wide Field of View

- Required 1200 hours observing with the Australia Telescope Compact Array

- ASKAP will take about 10 minutes

Cen A image credit: Tim Cornwell / Ilana Feain
ASKAP – system architecture (I)

Digital Receiver

Correlator

Central Site DSP: FPGA Hardware

36 dual pol beams

~12 Gb per cycle

Raw Visibilities

Also computes ACM (Array Covariance Matrix)
Plans vs. reality

• Initial design aimed at automatic processing of data
  • Largely due to inability to store data (run out of current storage in 2 weeks)
  • One size fits all approach with on-the-fly calibration – just 1 read of dataset

• Traditional processing model for now
  • User preference, more storage/better algorithms, lesser push for commensality

• Commissioning, staged deployment and support of BETA
  • Additional requirements never envisaged at the design stage
  • Lots of data inconsistencies in various ways, sometimes transient
  • Intermediate s/w solutions allowed to get science faster
The role of ingest

- Prepare/re-format data for calibration & imaging pipelines
- Synchronisation is the main part (especially if something doesn’t work right)
- Standard formats allow us to have more generic imaging & calibration tools
- Some processing which has to be done on-the-fly to reduce I/O
- Crucial part of the online calibration loop (when/if we do it)

ASKAP - system architecture (II)

Ingest cluster @ Pawsey
- 16 nodes, 2 sockets per node
- 8 cores CPUs, 64 Gb of RAM per node
- Shared Lustre storage with 30 Gb/s peak I/O performance

VLAN covering this fibre & 4 nodes

galaxy-ingest09  galaxy-ingest11
Ingestor for block 3  Spare (writer)
galaxy-ingest10  galaxy-ingest12
Ingestor for block 4  Spare (writer)
Tasks and data streams

- Ingest can be viewed as a chain of “processing” tasks
  - Configurable (via `tasklist Facility Control Manager` parameter)
  - Processing usually starts with a source task (two options available)
  - Any task except source can occur in the chain any number of times (with the same or different parameters)
  - Sink task doesn’t have to be the last (or even doesn’t have to be present)

- Both parallel and serial modes are supported
  - Source tasks are rank-aware and would listen different UDP ports
  - Some tasks (merging, splitting) are specific to the distributed mode
  - Service ranks (i.e. those which do not run source task) are now also supported
Splitting and merging data streams

• Each stream can be active or deactivated (behind the scene)
  • Splitting/merging tasks can change the state + can use service ranks
  • These tasks are specific to the parallel mode
  • Not all setup combinations are supported
  • Support of 5s cycle requires some work
Data monitoring via TCPSink/vispublisher

Spectra (spd)

Frequency average (vis)
Commissioning experiments

- Intermediate mode to control fringe rotator from ingest
  - Grew up from the need to support early BETA array, extended to early ASKAP
  - Investigate relative timing + well-controlled baseline system
  - Early science done a few years earlier
Performance monitoring

• Many performance metrics are published every cycle via Ice
  • Figures for representative ranks can be monitored (monica or Grafana)
  • As many tasks have implicit synchronisation barriers, interpretation requires knowledge of the system architecture and configuration of ingest pipeline
• Buffer usage and writing times are the most straightforward metrics
Various performance lessons

• Logical vs. physical isolation of ingest
  • Writing data to shared lustre file system (with dedicated OST/metadata nodes)
  • It took surprisingly long time to get to an acceptable level
    – May be not over yet (new disks now, going through same issues again)
    – Our own processing also affects performance
    – Strange locks ups inside 3rd party libraries, so can’t really time out

• Real-world astronomy data formats vs. idealistic I/O benchmarks

• Implicit barriers
  • Data sent in staggered fashion (if you need more than one chunk, you wait)
  • Metadata are not available until the end of the cycle
  • Logging at scale may be non-trivial, especially for a synchronous system
  • Consistency cross-checks may require additional communication

• Not in the regime how HPC is typically used – watch out for bugs
  • It matters where each rank goes
What wasn’t in the design, but is in use now

- **On-the-fly averaging as a separate mode**
  - Instead of full spectral resolution mode, not in addition to
  - This is largely to save disk space / for projects which don’t need full resolution
  - Prior (automatic) flagging is essential
- **Per-beam partitioning of the data (one beam in one MS)**
  - Single beam mode is a special case
- **Flexible partitioning in frequency (merge/split)**
- **Real-time monitoring of data after ingest (i.e. vis/spd)**
- **Various data consistency cross-checks**
- **Flexible configuration options**
  - Zoom modes (user-controlled)
  - Adding correlator hardware (FCM controlled, but requires expert knowledge)
  - Changing antennas included in the array
    - We used to have the main and commissioning array
Summary

• Ingest is a flexible adapter s/w between correlator and processing
  • Allows us to debug/test processing jobs from a standard MS
  • Synchronise parallel data and metadata streams
  • Aggregate/split data as required
  • On-the-fly flagging, if necessary
  • On-the-fly calibration application in the future (may be)
  • Optional on-the-fly averaging in frequency
  • Interface to on-the-fly data monitoring (vispublisher -> vis and spd)

• Invaluable tool for commissioning
  • Detect oddities in data stream
  • Non-standard experiments
  • Intermediate solutions (e.g. fringe rotation) to get science results faster
We acknowledge the Wajarri Yamatji people as the traditional owners of the Observatory site

Thank you

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