Towards distributed image reconstruction

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Image reconstruction problem

Fourier space

Visibilities ➔ Gridding ➔ Uniform-gridded Visibilities ➔ iFFT ➔ Dirty image ➔ Deconvolution ➔ Reconstructed image

Image space

PSF
Why do we need distribution?

![Bar chart showing TB/hr for VLA, ASKAP, MeerKAT, and MWA]
Distributed gridding and deconvolution

- Implementation: .netcore (C#)
- MPI for node communication
- Hardware: 4 Linux nodes, 1 CPU each
- Speedup on 1GB LMC MeerKAT observation

Preliminary results and algorithms
Image Domain Gridding (IDG)

Distributed gridding

- Visibilities → IDG Node 0
- Visibilities → IDG Node 1
- Visibilities → IDG Node 2
- Visibilities → IDG Node 3

MPI_Reduce

Grid 1024 * 1024
~8 MB
Distributed gridding

- IDG (.netcore)

Minutes

- Single Node
- 4 Nodes
Distributed deconvolution
Methods for distributed deconvolution

• ADMM methods in Radio Astronomy
  • …

• Coordinate Descent methods in Signal Processing
  • …
Coordinate Descent deconvolution

$residuals = dirty\ image$

1. Search pixel with the value that can be modified the most (optimum of a parabola)
2. Optimize maximum pixel
3. Update residuals
4. Repeat until residuals are small

More sophisticated CD methods, but that is the core algorithm
Distributed Coordinate Descent deconvolution

Distributed CD:
1. Search local pixel with the value that can be modified the most
2. Find best global pixel (MPI_ReduceAll)
3. Update local residuals
4. Repeat
Distributed Coordinate Descent

![Bar chart showing comparison between IDG (.netcore) and CD Deconvolution for Single Node and 4 Nodes scenarios. The bar for IDG (.netcore) in Single Node is significantly higher than that in 4 Nodes, while the bar for CD Deconvolution is comparable for both scenarios.](image)
Baseline distributed gridding + deconvolution

• Distributed gridding: More effective with a lot of input data
• Distributed deconvolution:
  • We have more communication efficient CD methods to explore:
    • Shotgun
    • PCDM
    • Hydra
    • ...
Questions