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SmartNICs in Radio Astronomy

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1 Extended Abstract

Wider bandwidths, more antennas and higher data resolutions are examples of characteristics that are generally desirable in radio astronomy. These result in instruments that produce very large data rates[1]. Processing this data economically is a difficult task and efficient use of network infrastructure and processing nodes is crucial. Next generation instruments consist of GPUs performing the processing in data centres and the Ethernet standard is advancing to support multi-hundred Gigabit data rates in off-the-shelf technology[2].

A problem that is still in active development is the interface between these technologies. Traditionally, Network Interface Cards (NICs) have contained very little logic, and the task of processing the incoming and outgoing packets has fallen to the host CPU. The CPU is often overwhelmed when faced with high data rates.

One solution involves the use of smartNICs. These are NICs with added infrastructure and functionality to reduce the load on the host CPU. This can include catering for various Ethernet, driver, or Operating System limitations and overheads with the aim of increasing network data rates. SmartNICs can also include hard or configurable silicon for application specific processing capabilities. This could add functionality better suited to the SmartNIC infrastructure, or add functionality to a system that is constrained in some way.

To explore this space, the South African Radio Astronomy Observatory (SARAO) is investigating a smartNIC prototype framework based on Alveo U50 hardware and the Corundum SmartNIC development shell. An typical application could be to perform the dual purpose of data ingest and first stage real-time data processing for the new MeerKAT radio telescope digital back-end. Application options include data reorder, chunking and buffering as well as early stage RFI detection and flagging.

As a first light proof-of-concept, a simple RFI detection algorithm was implemented that processed simulated raw L-Band antenna data. The application forms a useful place holder to test the smartNIC data processing framework and aids in discovering bottlenecks and evaluating hardware and system performance as well as a test bed for other application development. This presentation will focus on the smartNIC framework and detail how it can be used in radio astronomy applications and will highlight how a single framework can be used and enable different applications to be interchanged within the data pipeline for first stage processing.

References

[1] A. van der Byl, et al., "MeerKAT correlator-beamformer: a real-time processing back-end for astronomical observations," *J. Astron. Telesc. Instrum. Syst., 8 (1)*, 011006, https://doi.org/10.1117/1.JATIS.8.1.011006 (2021).

[2] B. Merry, "Efficient channelization on a graphics processing unit," *Journal of Astronomical Telescopes, Instruments, and Systems*, **11**, 12, July 2023, 9(3), 038001, https://doi.org/10.1117/1.JATIS.9.3.038001.