SKA 2010 Science and Engineering Meeting

Panel Discussion on Dense Aperture Arrays for SKA-mid

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Representative Design

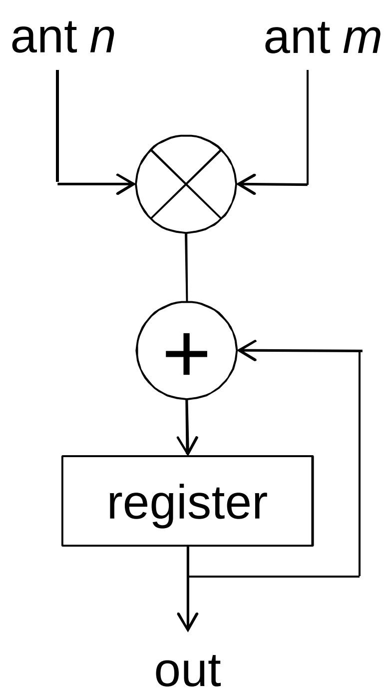
- From "High Level SKA System Description" by W. Turner et al., Rev. E, 2010-02-11 (for System CoDR)
- 400 to 1400 MHz
- 250 stations, each 56m diameter
- 75000 elements/station => 18,750,000 elements total
- Element spacing = 21 cm (thus "dense" only below 700 MHz)
- 1200 beams/station (enough for 250 sq deg at 400 GHz)
- Instantaneous bandwidth = 1 GHz (full range)

Difficulties

- Huge number of elements: 250 * 75000 = 19M elements
  - would be 75M elements if maintained dense up to 1.4 GHz
  - construction cost per element needs to be very low
    - cost includes: antenna, LNA, weather protection, digitizer, signal transmission, and element's share of each of 1200 beamformers
    - budget of 300M Euros (or is it 150M?) allows 15 Euros/element to cover all of the above components (but not correlator, see below)
- Large correlator needed. Can it be shared with other SKA arrays?
  - Correlator size = beams * baselines * bandwidth = 3.7e16 Hz
  - Corresponding number for dish-PAF strawman   = 1.5e17 Hz
- Huge number of beamformers (1200*250=300,000)
  - Beamformer array is not included in correlator above
  - May be bigger than correlator
  - To cover the all of the accessible FoV (to 45 deg zenith angle) would require 29,000 beams at 400 MHz, or 350,000 beams at 1.4 GHz.
- Calibration and noise matching?

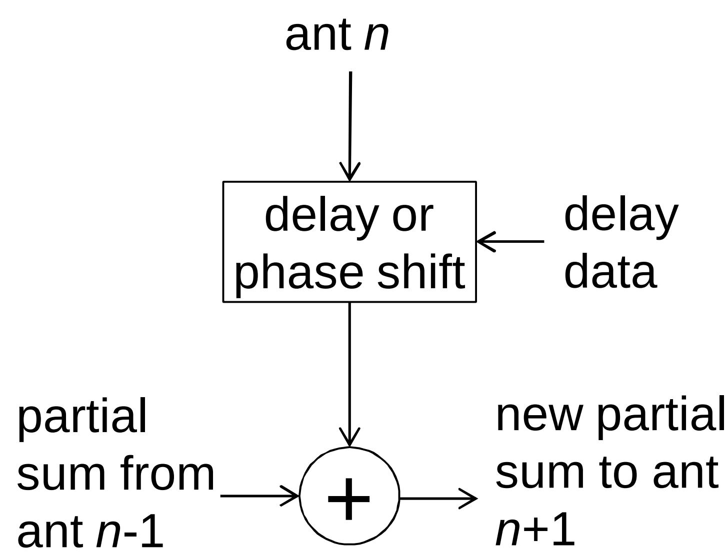
Beamforming vs. Correlation

Correlator Unit Cell



$N_b N_s (N_s+1)/2$ required

Beamformer Unit Cell



$N_s\ N_b\ N_{e/s}$ required

Station Size Optimization

- Unlike the situation with dishes, cost of aperture in AAs is linear in area, and mostly *independent* of its partitioning into stations.
- However, cost of signal transport and signal processing does depend on how the aperture is partitioned.

$$c_{dsp} = B(c_c N_s{}^2 N_b + c_b N_b N_{e/s} N_s)$$

$$= \tfrac{\pi}{2} B N_{e/s} \left[c_c \left(\frac{N_e}{N_{e/s}} \right)^2 + c_b \tfrac{\pi}{2} N_{e/s} N_e \right]$$

$$\min(N_{e/s}) = \left(\frac{4}{\pi} \frac{c_c}{c_b} N_e \right)^{1/3}$$

- If $c_b = 100 c_c$ and $N_e = 19\text{E}6$, optimum $N_{e/s}$ is 54
- If $c_b = c_c$ and $N_e = 19\text{E}6$, optimum $N_{e/s}$ is 250
- But "representative" design uses $N_{e/s} = 75{,}000$