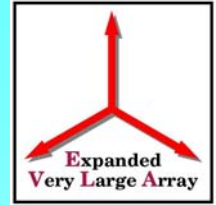# EVLA Data Processing PDR

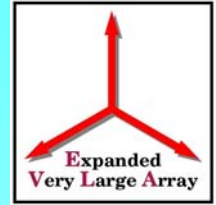# Scale of processing needs

Tim Cornwell, NRAO

Background

- EVLA correlator data rate will ~ 1000 times current correlator data rate

- Can 2009-era hardware handle the processing load?

- Can the software handle the processing load?

Scale of EVLA data processing

- Peak data rate out of correlator backend ~ 25 MB/s
- Total data volume for Peak 8-hr observation ~ 700GB
- Floating point operations per float ~ 100 - 10000
- Peak compute rate ~ 5Tflop
- Average/Peak computing load ~ 0.1
- Average compute rate ~ 0.5Tflop
- Turnaround for 8-hr peak observation ~ 40 minutes
- Average/Peak data volume ~ 0.1
- Data for Average 8-hr observation ~ 70GB
- Data for Average 1-yr ~ 80TB

Scaling laws in computing

- "Rules of Thumb" by Gray and Shenoy
  - *http://www.research.microsoft.com/~jgray*

- Examples:
  - 1 Moore's law: *Things get 4x better every 3 years*
  - 2 *You need an extra bit of addressing every 18 months*
  - 3 *Storage capacities increase 100x per decade*
  - 4 *Storage device throughput increases 10x per decade*
  - 7 *NearlineTape:OnlineDisk:RAM storage cost ratios are approximately 1:3:300*
  - 8 *In ten years RAM will cost what disk costs today*
  - 9 *A person can administer $1M of disk storage*
  - 14 *Gilder's law: Deployed bandwidth triples every year*
  - 15 *Link bandwidth increases 4x every 3 years*

Ops per second per $
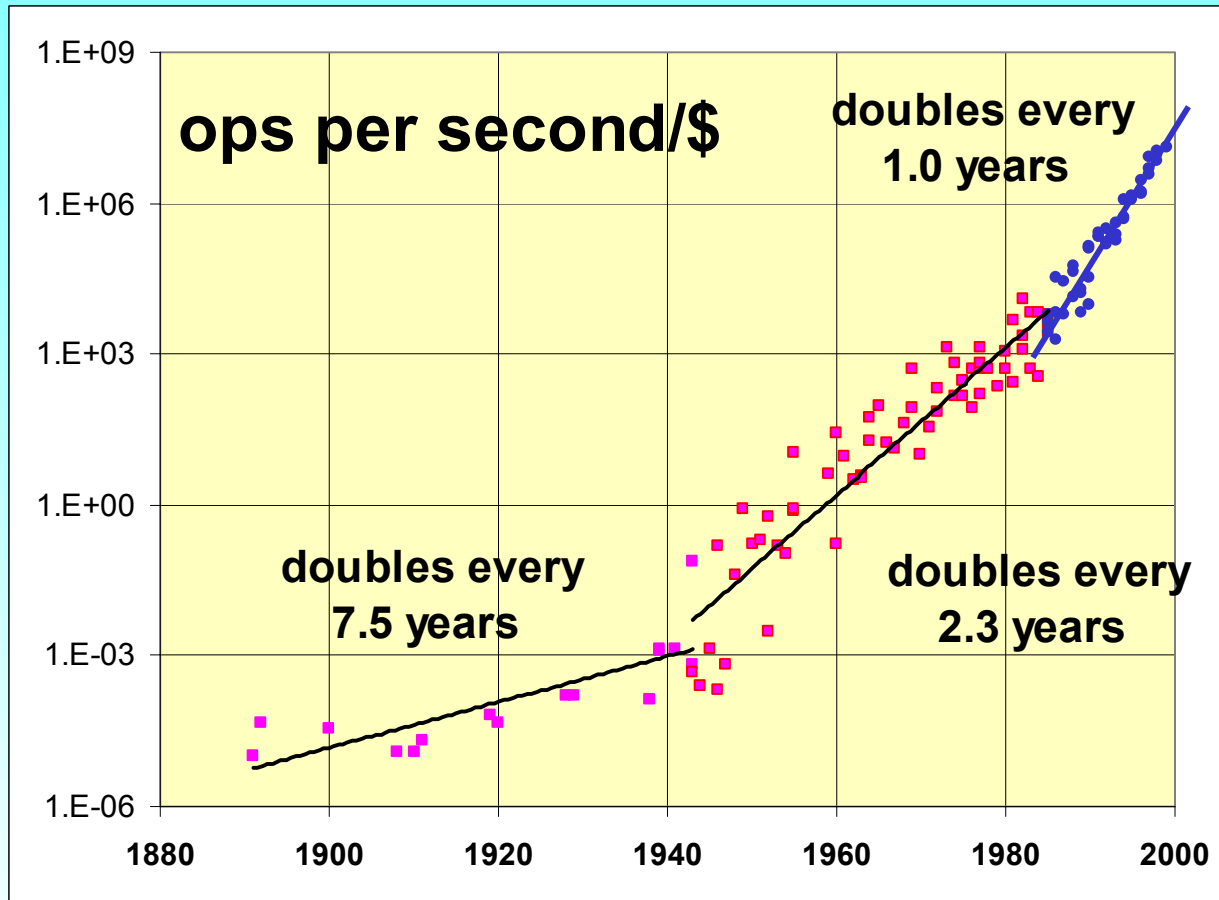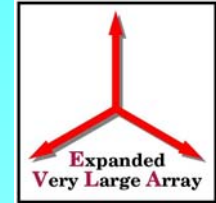
ops per second/$

doubles every 1.0 years

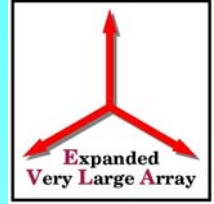doubles every 7.5 years

doubles every 2.3 years

Detailed analysis

- Analyze processing in terms of FFT and Gridding costs

- Find scaling laws for various types of processing

- Express in terms of 450MHz Pentium III with Ultra-SCSI disk

- Use Moore's Law to scale to *e.g.* 2009
  - Performance/cost doubles every 18 months

- Many more details in EVLA Memo 24
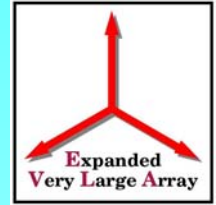
Scale of EVLA data processing

- Typical cost equation

$$T^{mosaic} \sim 4.N_{mega-vis}.t_{mega-grid} + 16.N_{cycles}.N_{mega-pixel}.t_{mega-FFT}$$

where units are in millions of visibilities or pixels

Detailed analysis

- Analyze processing in terms of FFT and Gridding costs
- Find scaling laws for various types of processing
- Express in terms of 450MHz Pentium III with Ultra-SCSI disk
- Use Moore's Law to scale to *e.g.* 2009
  - Performance/cost doubles every 18 months
  - Many more details in EVLA memo 24

servation	# pol	FOV arcsec	Cellsize arcsec	Pointings	Facets	Pixels	BW MHz	Freq res MHz	Vis chan	Image chan	IF's	T
primary beam (2D)	4	7200	0.3	1	256	24000	500	1.00	500	1	1	
primary beam (3D)	4	7200	0.3	1	1	24000	500	1.00	500	16	1	
ic of SGRA West	2	200	0.2	64	1	1000	70	0.5468	128	128	8	
nearby galaxy	2	600	0.5	1	1	1200	7	0.006	1166	1024	1	

| servation	Data rate Mb/s	Total data GB	Image Mpixel	Visibilities Mvis	Minor cycles	single d	multiple d	mosaic d	Time d	# processors	rate TB/year
primary beam (2D)	1.87	80.87	576	10108.80	10	28.50	35972.08	40.88	35972.08	71944.16	59.04
primary beam (3D)	1.87	80.87	9216	10108.80	10	130.48	194.08	232.88	130.48	260.96	59.04
ic of SGRA West	0.58	16.56	128	2070.28	100	19.97	296.85	34.20	34.20	102.59	18.14
nearby galaxy	0.65	56.58	1679.04	7072.12	10	38.30	122.53	56.96	38.30	38.30	20.65

For NRAO….

- Assume Moore's Law holds to 2009
  - Moore himself believes this……..
- Cost of computing for EVLA
  - ~ 10 – 20 processor parallel machine
    - ~ $100K - $200K (2009)
  - Archive ~ 50TB per year
    - ~ $5K - $10K (2009)
- Comparable to computing cost for ALMA
- Software costs
  - AIPS++ *as-is* can do much of the processing
  - Some development needed for high-end, pipelined processing
  - Some scientific/algorithmic work *e.g.* achieving full sensitivity, high dynamic range

For the observer….
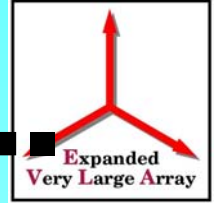
- Moore's Law gives ~ 64 fold increase for a desktop
  - *I.e.* $nK where n ~ 1-3
- Many projects do-able on (2009-era) desktop
  - *e.g.* 1000 km/s velocity range of HI for galaxy
  - *e.g.* Mosaic of SGRA West in all H recombination lines between 28 and 41 GHz
- Larger projects may require parallel machine or many days on a desktop
  - *e.g.* Full sensitivity continuum image of full resolution 20cm field
  - NRAO would provide access over the net

Current activities

- Installed SAN at the AOC

    – Increasing disk storage to 4TB

- Eight processor IBM Netfinity 370 server

    – Running RedHat Linux

    – 8GB memory

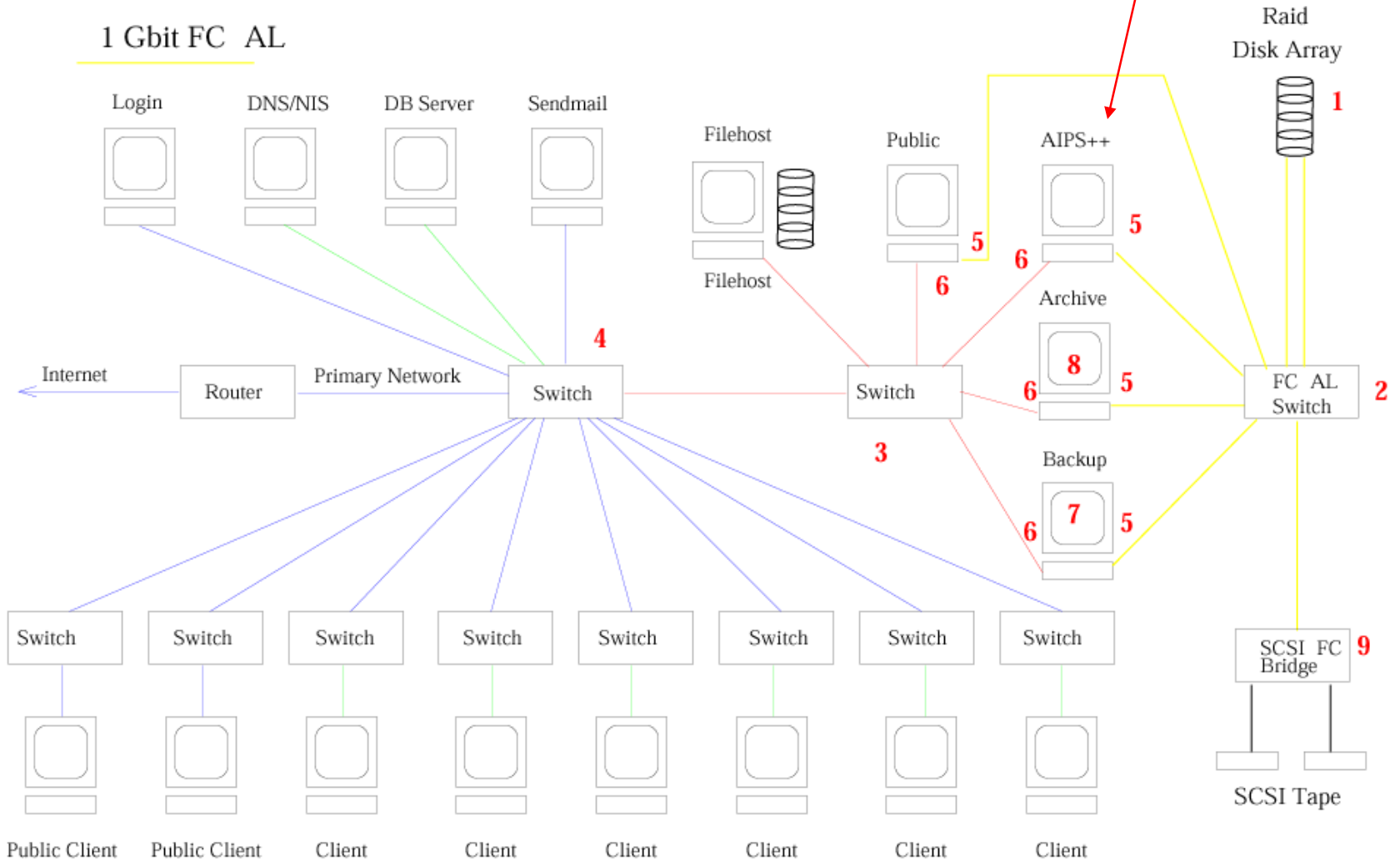   – 1 TB disk

AOC Storage Area Network Diagram

Caveats
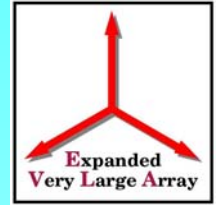
- Order of magnitude estimate
  - Development of computing uncertain
- Mix of science uncertain
- Processing requirements could escalate
  - Historically true
  - May be especially true for pipeline processing
- Moore's Law will throttle EVLA
  - As it did for the VLA