

From 20 Years of Beowulf MPI & Cluster Computing

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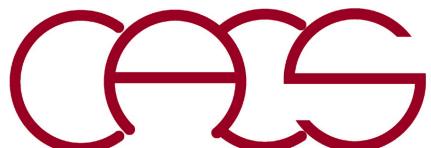
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<http://dl.acm.org/citation.cfm?id=2737911&CFID=717321656&CFTOKEN=85686577>



<http://www.crest.iu.edu/beowulf14>



Beowulf Cluster

- Parallel computer made of commodity components
- Open software (Linux; network driver developed)
- Started by Thomas Sterling & Don Becker in '94

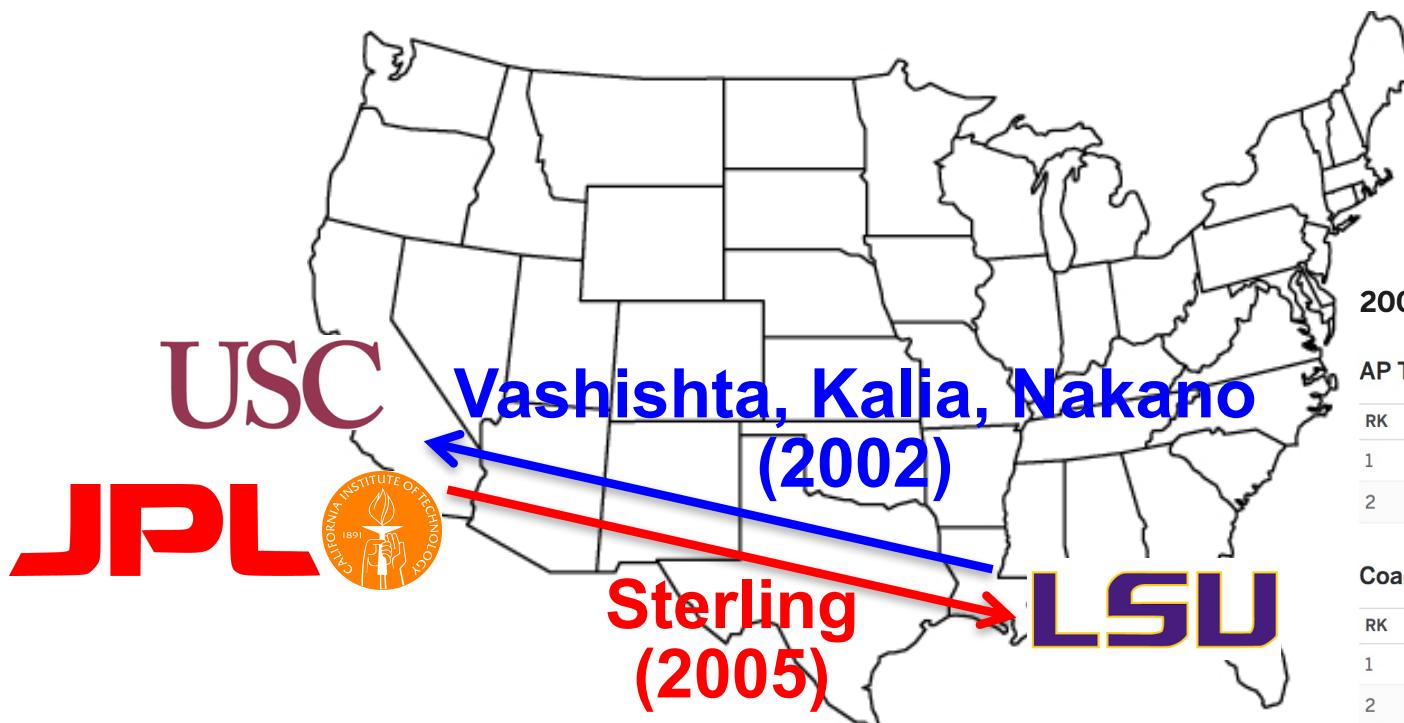


(Left) Caltech's Thomas Sterling (left) and John Salmon discuss the building of *Naegling*, one of the largest Beowulf computers. Each of its 120 processors performs 70 million floating-point operations per second (flops) across a range of applications. (Right) Don Becker, Goddard Space Flight Center, holds a personal computer network adapter. He has developed, and is constantly updating, software to drive nearly all adapters for use with the Linux operating system.

Thomas Sterling and Me

Top500 List - November 2002

Rank	Site	System	Cores	Rmax (GFlop/s)	Rpeak (GFlop/s)	Power (kW)
1	Japan Agency for Marine -Earth Science and Technology Japan	Earth-Simulator NEC	5120	35860.0	40960.0	3200
17	Louisiana State University United States	SuperMike - P4 Xeon 1.8 GHz - Myrinet Atipa Technology	1024	2207.0	3686.4	



2003 College Football Rankings - Postseason

AP Top 25

RK	TEAM	REC	PTS	TREND
1	SC USC (48)	12-1	0	—
2	LSU LSU (17)	13-1	0	—

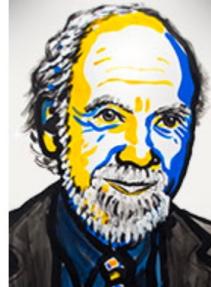
Coaches Poll

RK	TEAM	REC	PTS	TREND
1	LSU LSU (60)	13-1	1572	—
2	SC USC (3)	12-1	1514	—

Digress: LIGO



© Nobel Media. III. N.
Elmehed
Rainer Weiss
Prize share: 1/2



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Elmehed
Barry C. Barish
Prize share: 1/4



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Elmehed
Kip S. Thorne
Prize share: 1/4



The Nobel Prize in Physics 2017 was divided, one half awarded to Rainer Weiss, the other half jointly to Barry C. Barish and Kip S. Thorne "for decisive contributions to the LIGO detector and the observation of gravitational waves".



Gravitational-wave research in Louisiana



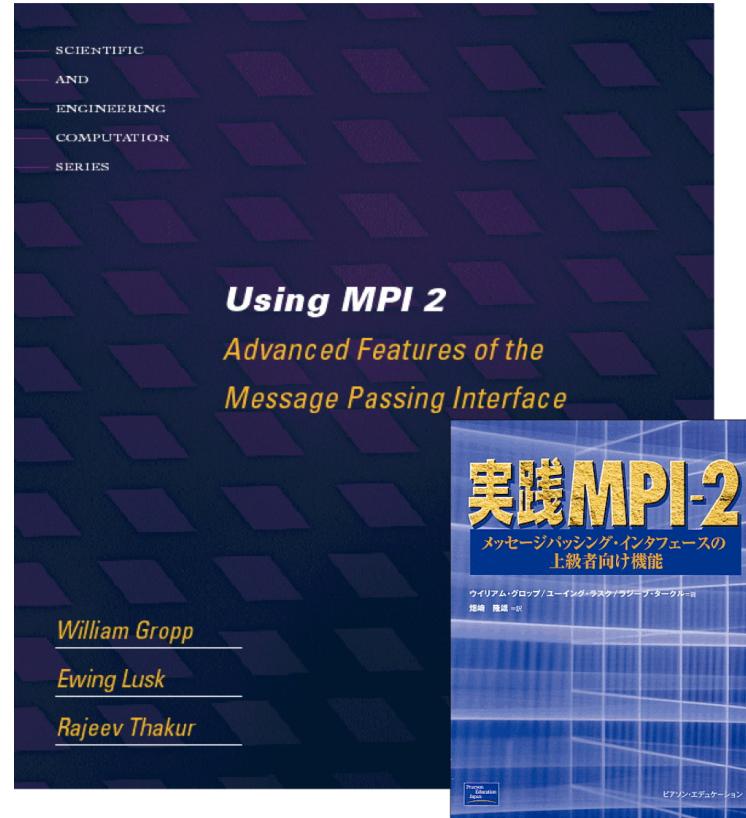
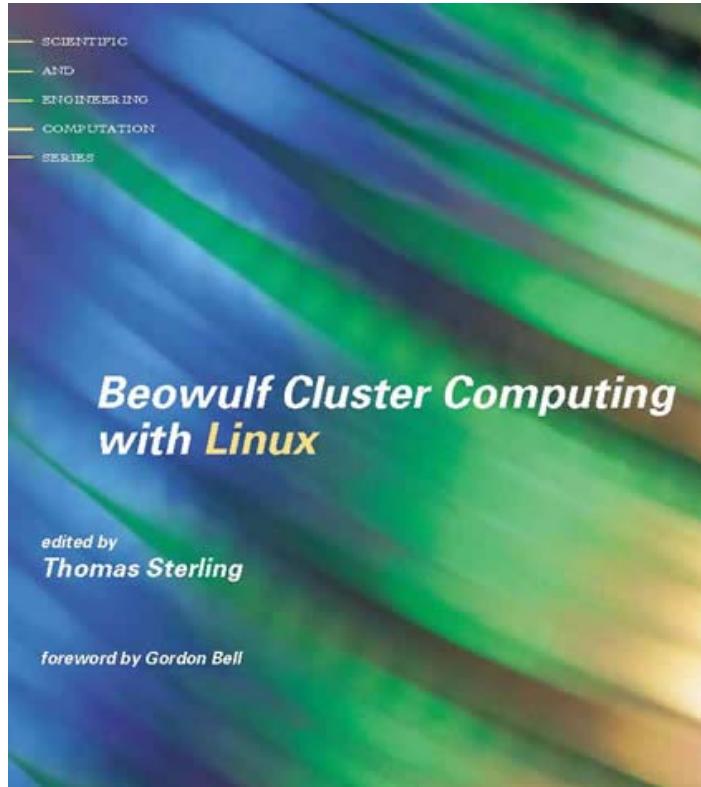
**LIGO (Laser
Interferometer
Gravitational-Wave
Observatory)
in Livingston, LA**

- Early 70's: Bill Hamilton started building a cryogenic gravitational-wave detector at LSU
- Mid 90's: LIGO construction started



20 Years of Beowulf and MPI

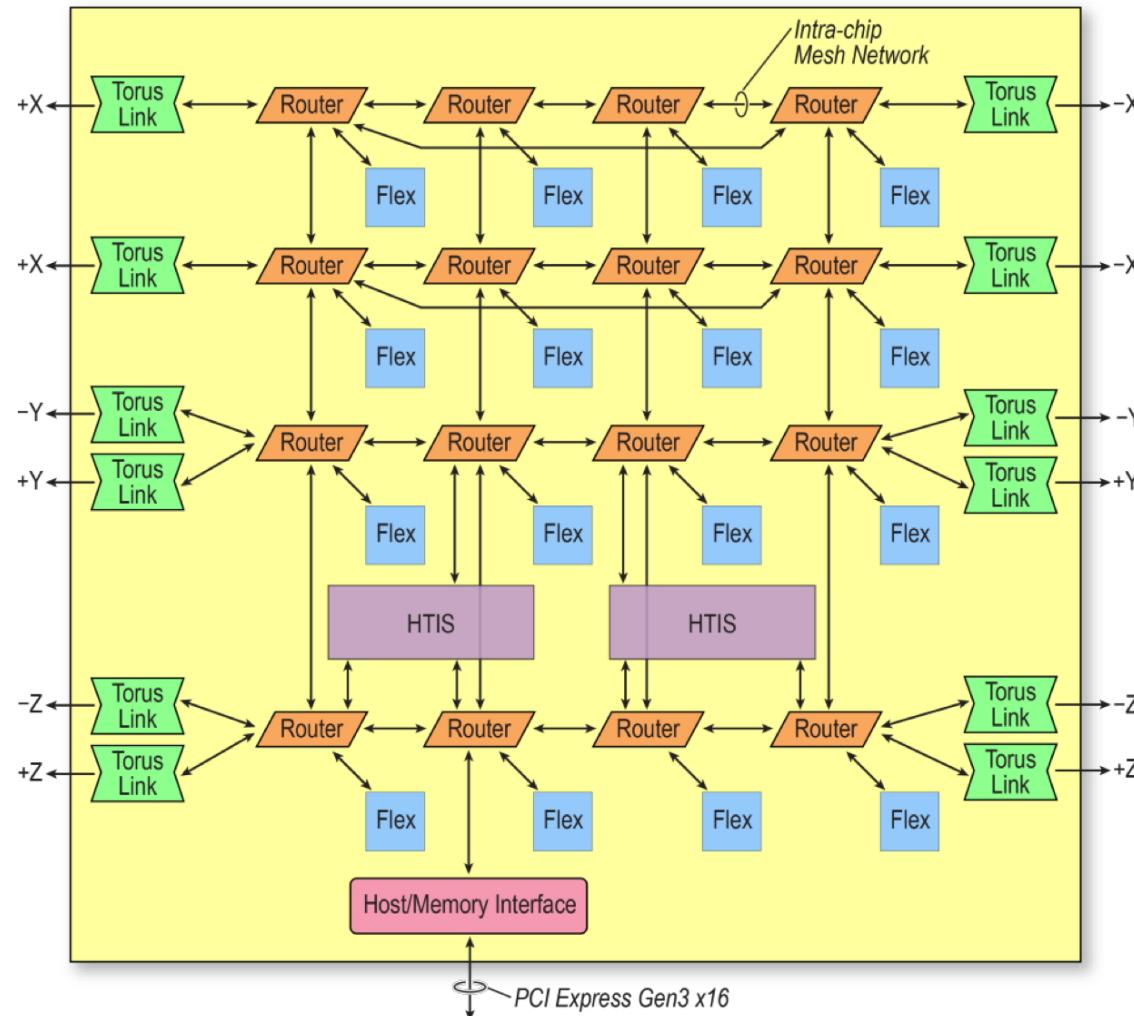
- Dominant parallel-computing paradigm for the past 20 years:
Distributed processes communicating via message passing



- First Beowulf ('94)
- Evolving by embracing multicore & accelerators per computing node
- MPI 1 ('94)
- Evolving: *Using Advanced MPI*

Counter-Approach: Anton 2

- Unified on-chip & inter-node networks
- New algorithm: Gaussian series expansion of the Coulombic interaction (no FFT required)



Massive Data Analytics

- Scalable data-analytics/machine-learning algorithms are critically needed, e.g., $O(N^2) \rightarrow O(N)$ pair statistics
- Seven computational giants
 1. Basic statistics
 2. Generalized N -body problem
 3. Graph-theoretic computations
 4. Linear algebraic computations
 5. Optimization
 6. Integration
 7. Alignment problems

$O(N^3)$ Linpack to $O(N)$ HPCG

- High performance conjugate gradient (HPCG) proposed toward exaflop/s, but ...

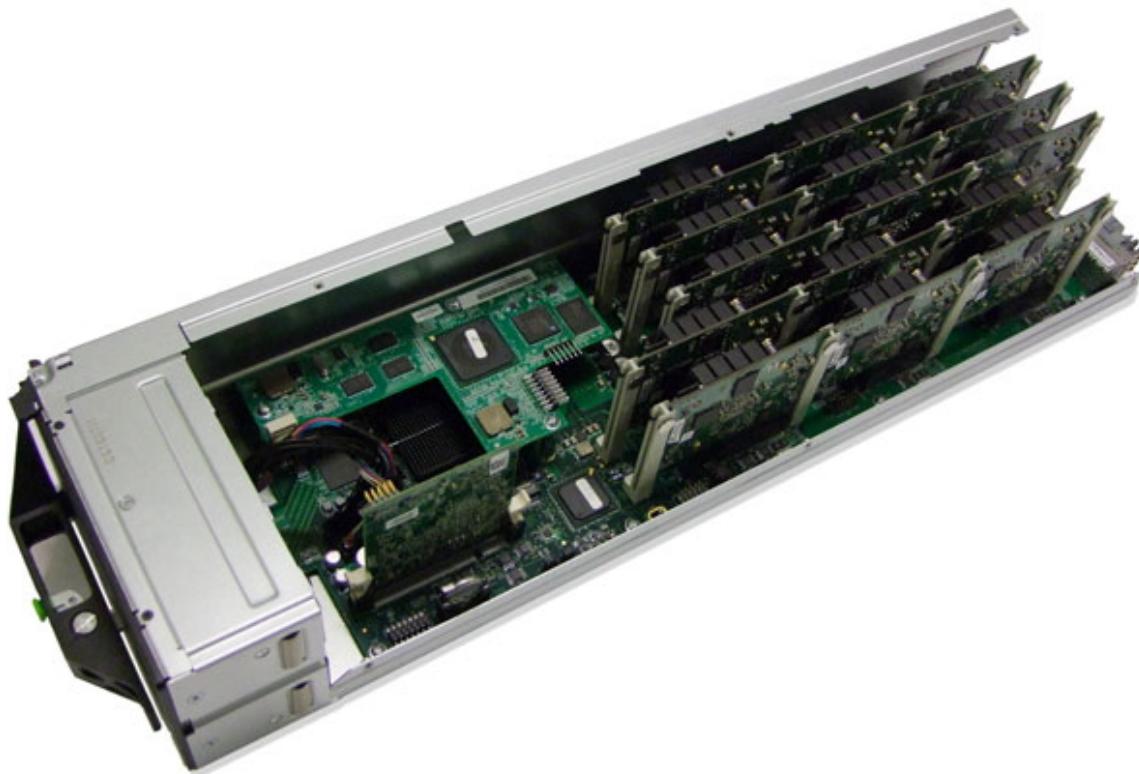


Site	Computer	Cores	HPL Rmax (Pflops)	HPL Rank	HPCG (Pflops)	HPCG/HPL
NSCC / Guangzhou	Tianhe-2 NUDT, Xeon 12C 2.2GHz + Intel Xeon Phi 57C + Custom	3,120,000	33.9	1	.580	1.7%
RIKEN Advanced Inst for Comp Sci	K computer Fujitsu SPARC64 VIIIfx 8C + Custom	705,024	10.5	4	.427	4.1%
DOE/OS Oak Ridge Nat Lab	Titan, Cray XK7 AMD 16C + Nvidia Kepler GPU 14C + Custom	560,640	17.6	2	.322	1.8%
DOE/OS Argonne Nat Lab	Mira BlueGene/Q, Power BQC 16C 1.60GHz + Custom	786,432	8.59	5	.101#	1.2%
Swiss CSCS	Piz Daint, Cray XC30, Xeon 8C + Nvidia Kepler 14C + Custom	115,984	6.27	6	.099	1.6%

HPL
HPCG

Smartphones as Exascale Nodes

- Building an exaflop/s computer from commodity components (again, but with smartphones this time?)



Blades of Glory: Mont-Blanc's prototype contains 15 nodes made up of ARM-core processors.

IEEE Spectrum (May '14)



Or Raspberry Pi?