Exceptional service in the national interest

SAND2012-5994P

Sandia National Laboratories



Oh, $#*@! Exascale!

The effect of emerging architectures on data science

CScADS Panel, August 2, 2012

Kenneth Moreland, Sandia National Laboratories

SDAV

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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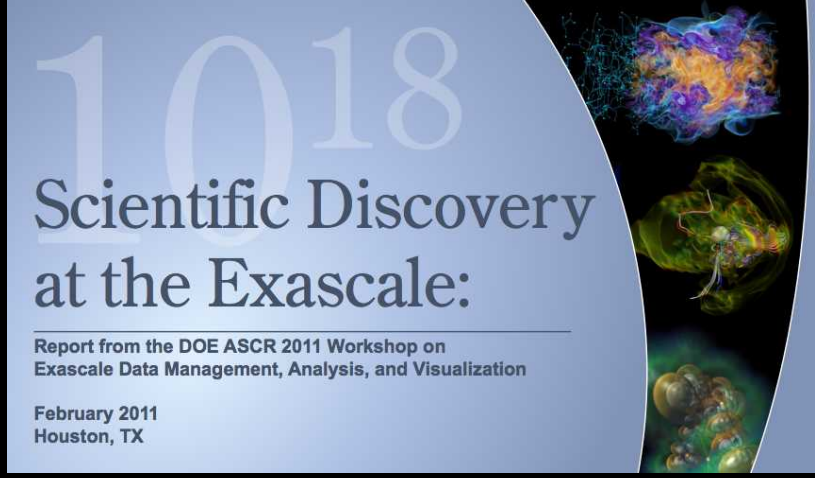
Slide of Doom



System Parameter	2011	"2018"		Factor Change
System Peak	2 PetaFLOPS	1 ExaFLOP		500
Power	6 MW	≤ 20 MW		3
System Memory	0.3 PB	32 – 64 PB		100 – 200
Total Concurrency	225K	1B × 10	1B × 100	40,000 – 400,000
Node Performance	125 GF	1 TF	10 TF	8 – 80
Node Concurrency	12	1,000	10,000	83 – 830
Network BW	1.5 KB/s	100 GB/s	1000 GB/s	66 – 660
System Size (nodes)	18,700	1,000,000	100,000	50 – 500
I/O Capacity	15 PB	300 – 1000 PB		20 – 67
I/O BW	0.2 TB/s	20 – 60 TB/s		10 – 30

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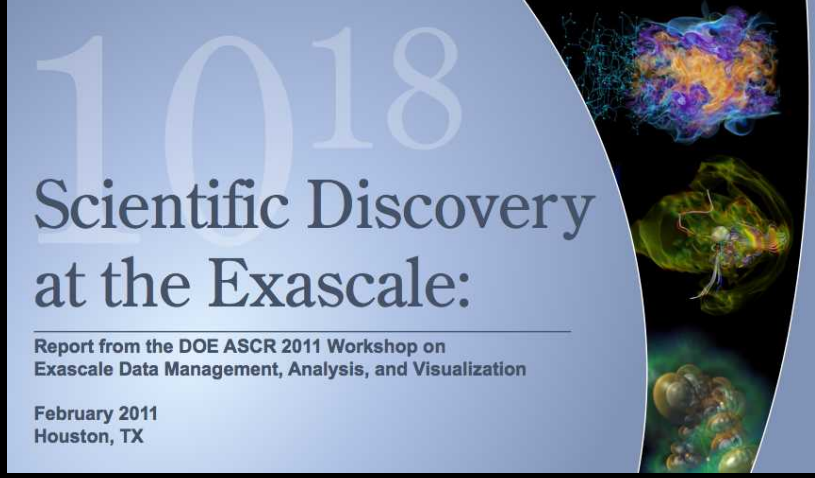

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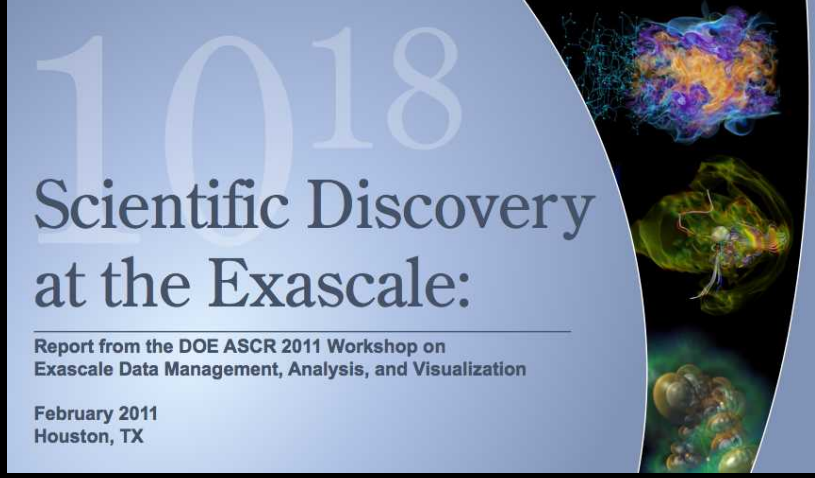

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Exascale Programming Challenges

- At some point, domain decomposition fails
  - Too many halo cells, too much communication
- Possible new architectures and programming models
  - GPU accelerators hate decomposition
- Threaded (OpenMP) programming is easier than distributed (MPI) programming.
  - Threading needs careful planning for memory affinity (inherent in distributed)
  - Sharing memory locations invites read/write collisions (explicit in distributed)
  - PGAS will save us? I'm skeptical.
- Best practice approach: Parallel Functor application (Map, Visitor)
  - Multiple DOE projects underway: Dax (ASCR), PISTON (ASC), EAVL (LDRD)
  - If successful, minimal impact on applications
  - Might be some changes in scope of what can be done

Slide of Doom

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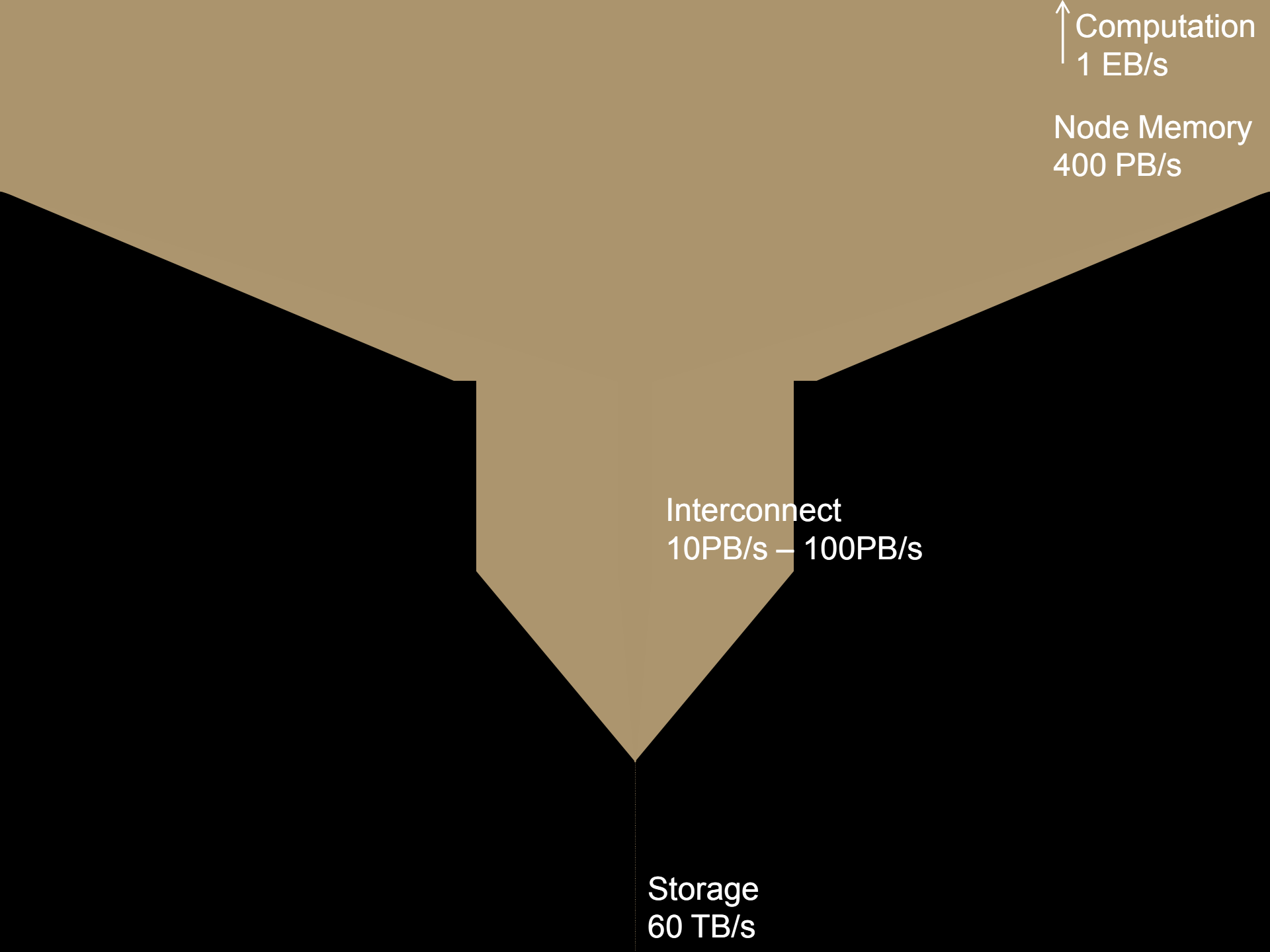
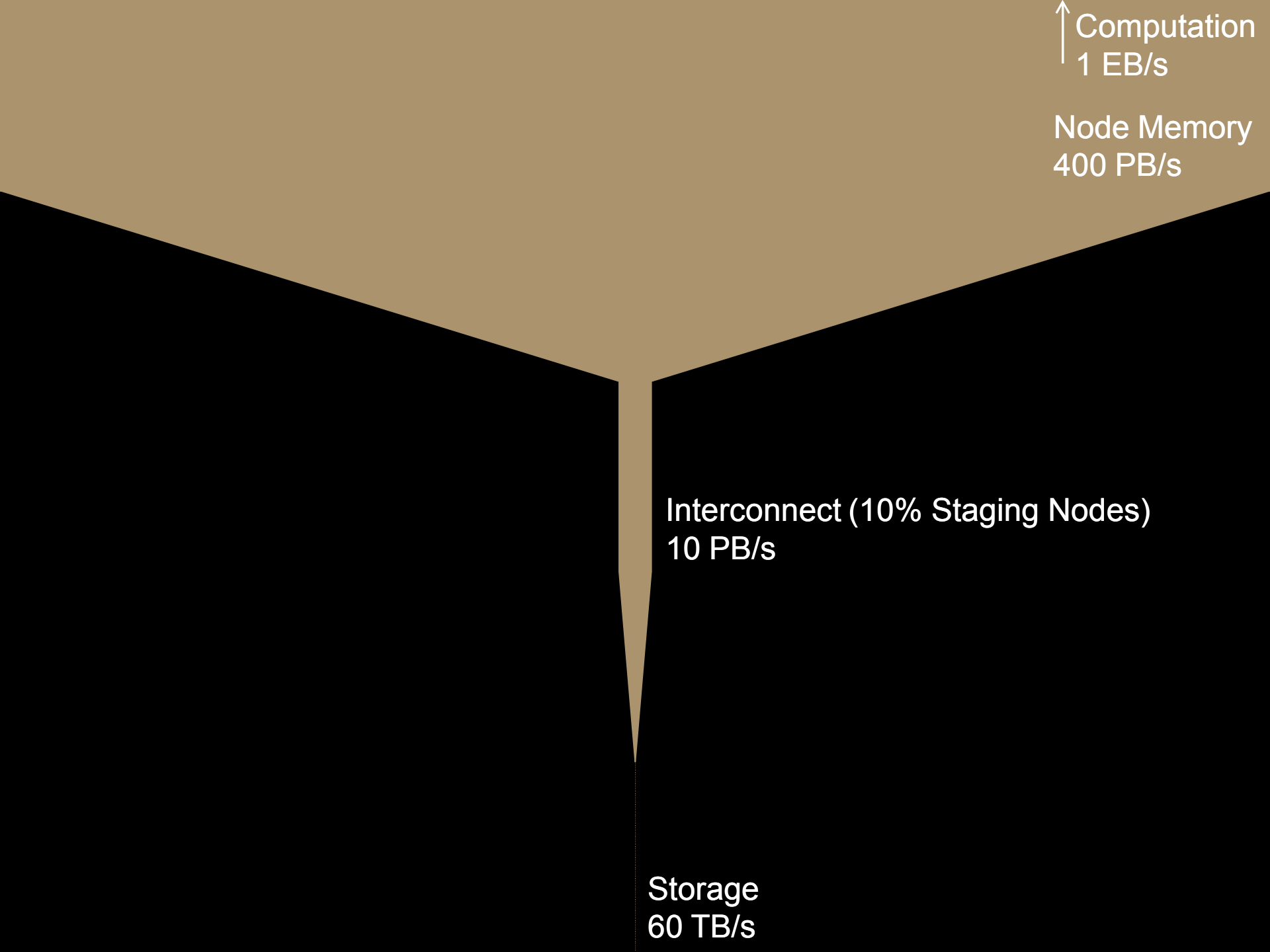
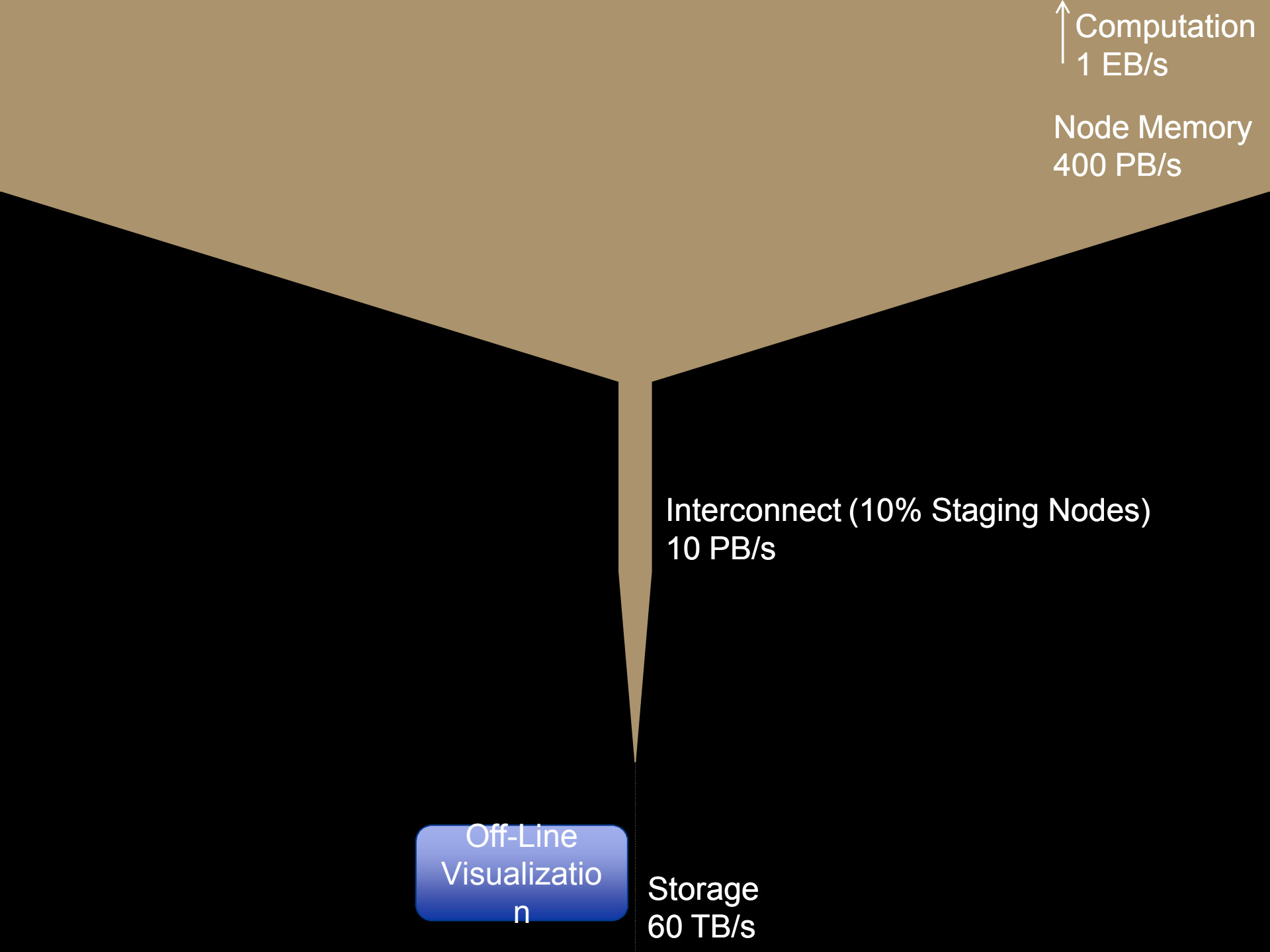
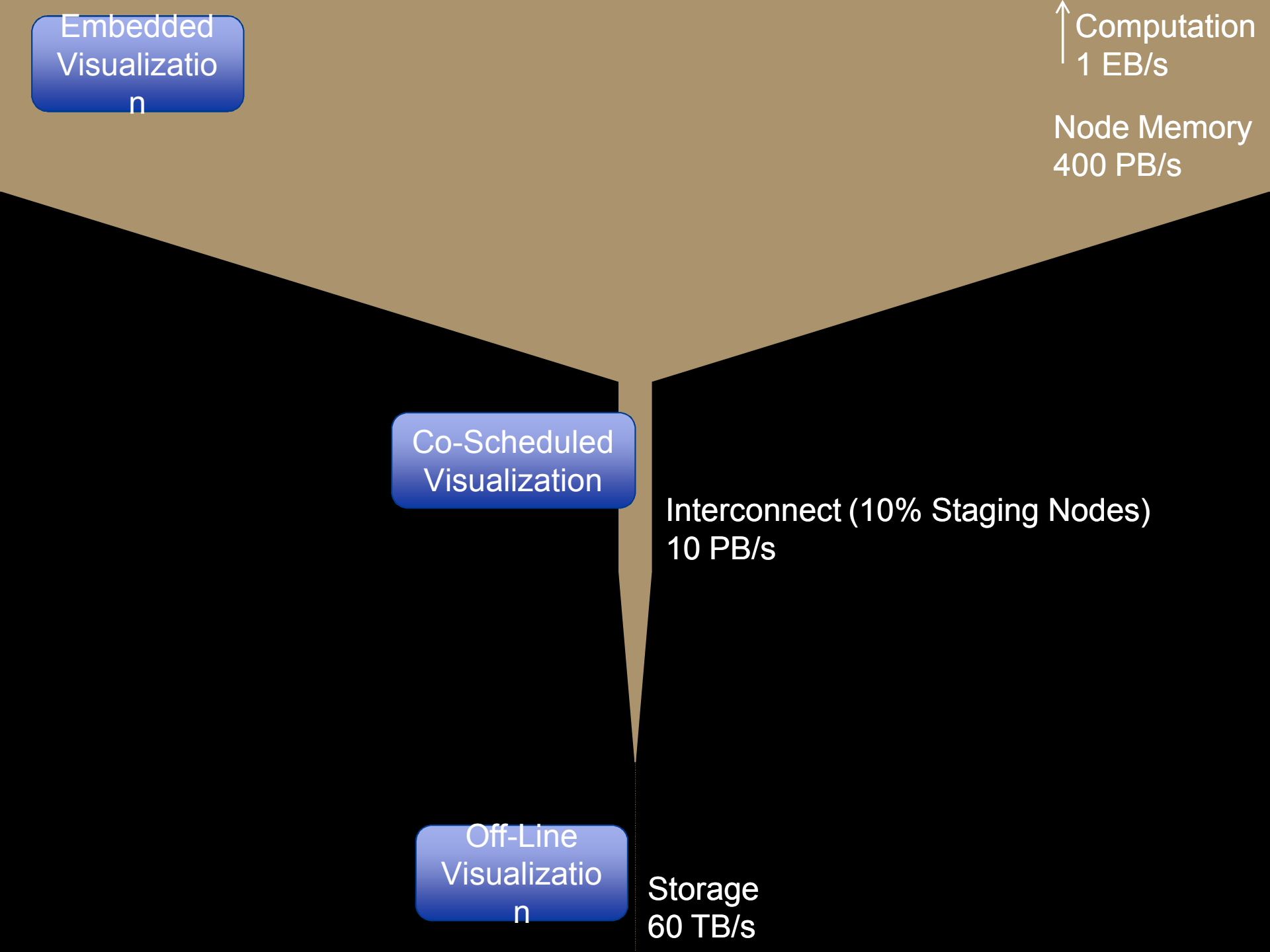

Computation
1 EB/s
Node Memory
400 PB/s
Interconnect
10PB/s – 100PB/s
Storage
60 TB/s


Computation
1 EB/s
Node Memory
400 PB/s
Interconnect (10% Staging Nodes)
10 PB/s
Storage
60 TB/s


Computation
1 EB/s
Node Memory
400 PB/s
Interconnect (10% Staging Nodes)
10 PB/s
Off-Line
Visualizatio
n
Storage
60 TB/s


Embedded Visualization
Computation
1 EB/s
Node Memory
400 PB/s
Co-Scheduled Visualization
Interconnect (10% Staging Nodes)
10 PB/s
Off-Line Visualization
Storage
60 TB/s

Space of Solutions

	Capability	Coupling	Footprint	Transfer	Interactive
Tightly Integrated	Low	Tight	**Low**	**None**	No
Embedded	**High**	Tight	High	Possible memcpy	No
Hybrid	**High**	Tight	Medium	Subset Hi Speed Transfer	**Yes**
Co-Scheduled	**High**	**Loose**	~5% Extra Nodes	Hi Speed Transfer	**Yes**
Off-Line	**High**	**Loose**	**None**	Slow Persistent Storage Cost	**Yes**