SAND2010-4573P

Visualization Work Supporting Data Staging and Code Coupling

Data Staging, In-Transit Processing, and Code Coupling in HPC Systems

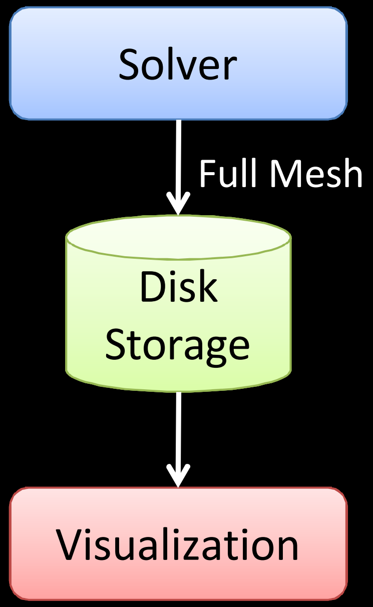
Friday, July 16, 2010

Kenneth Moreland
Sandia National Laboratories

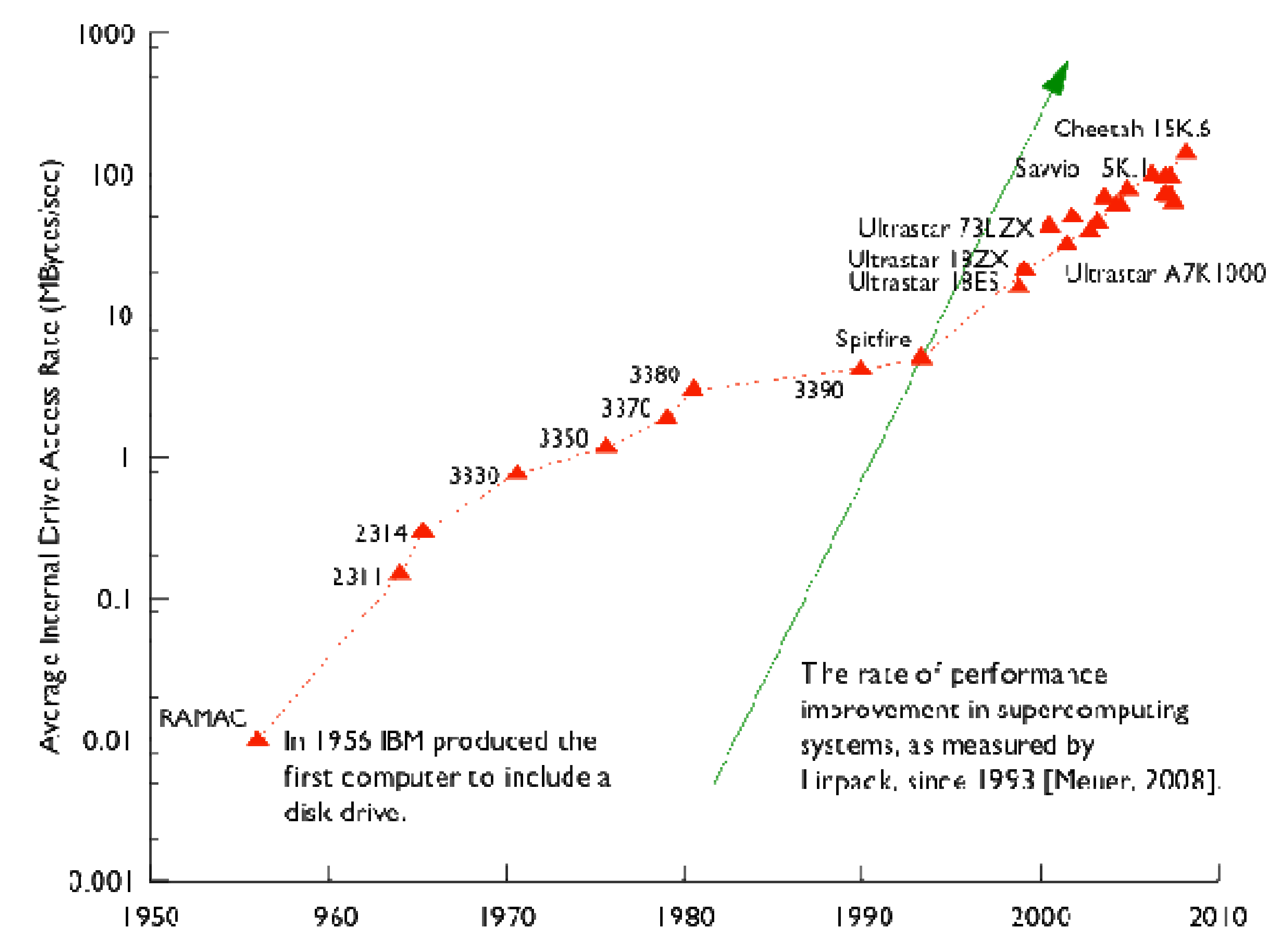
Release Marking (e.g. Not Approved for Release, SAND XXXX, etc.)

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
for the United States Department of Energy's National Nuclear Security Administration
under contract DE-AC04-94AL85000.

Traditional Visualization Workflow



Traditional Visualization Workflow is Breaking Down

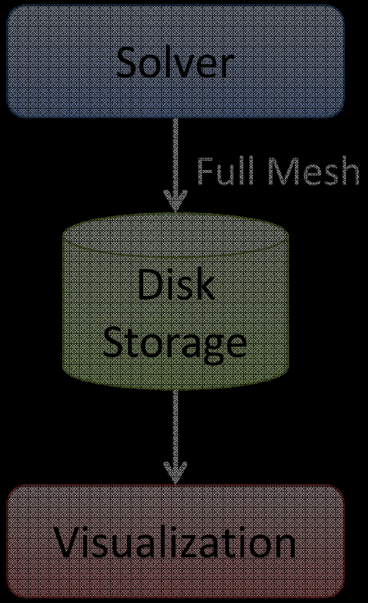


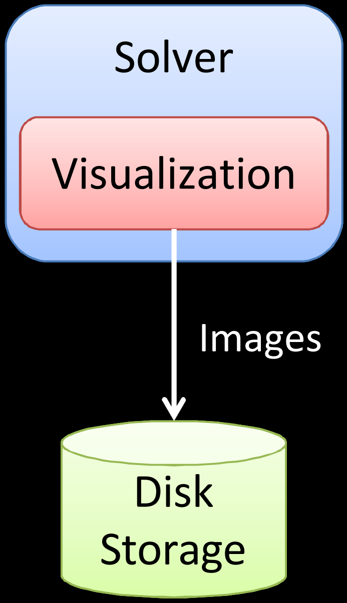
In 1956 IBM produced the first computer to include a disk drive.

The rate of performance improvement in supercomputing systems, as measured by Linpack, since 1993 [Meuer, 2008].

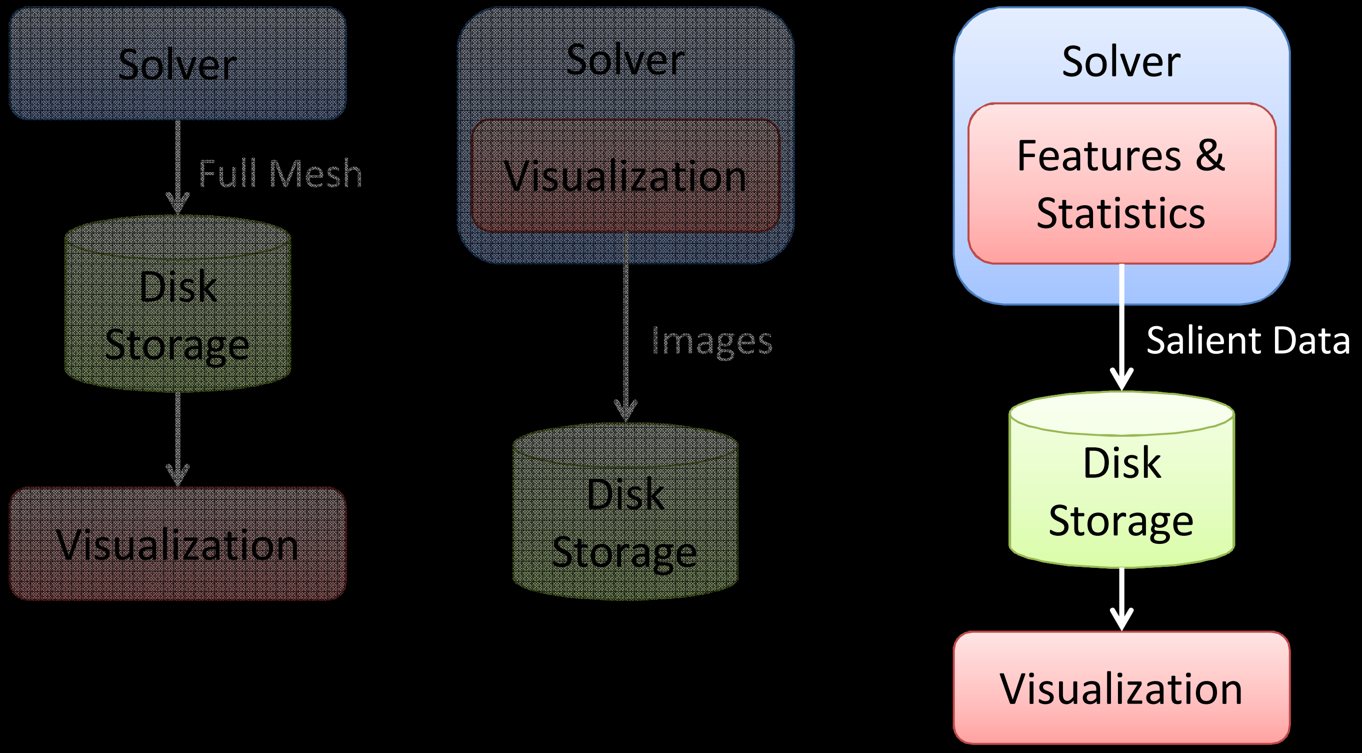
Image from Rob Ross,
Argonne National Laboratory

Traditional *In-Situ* Visualization

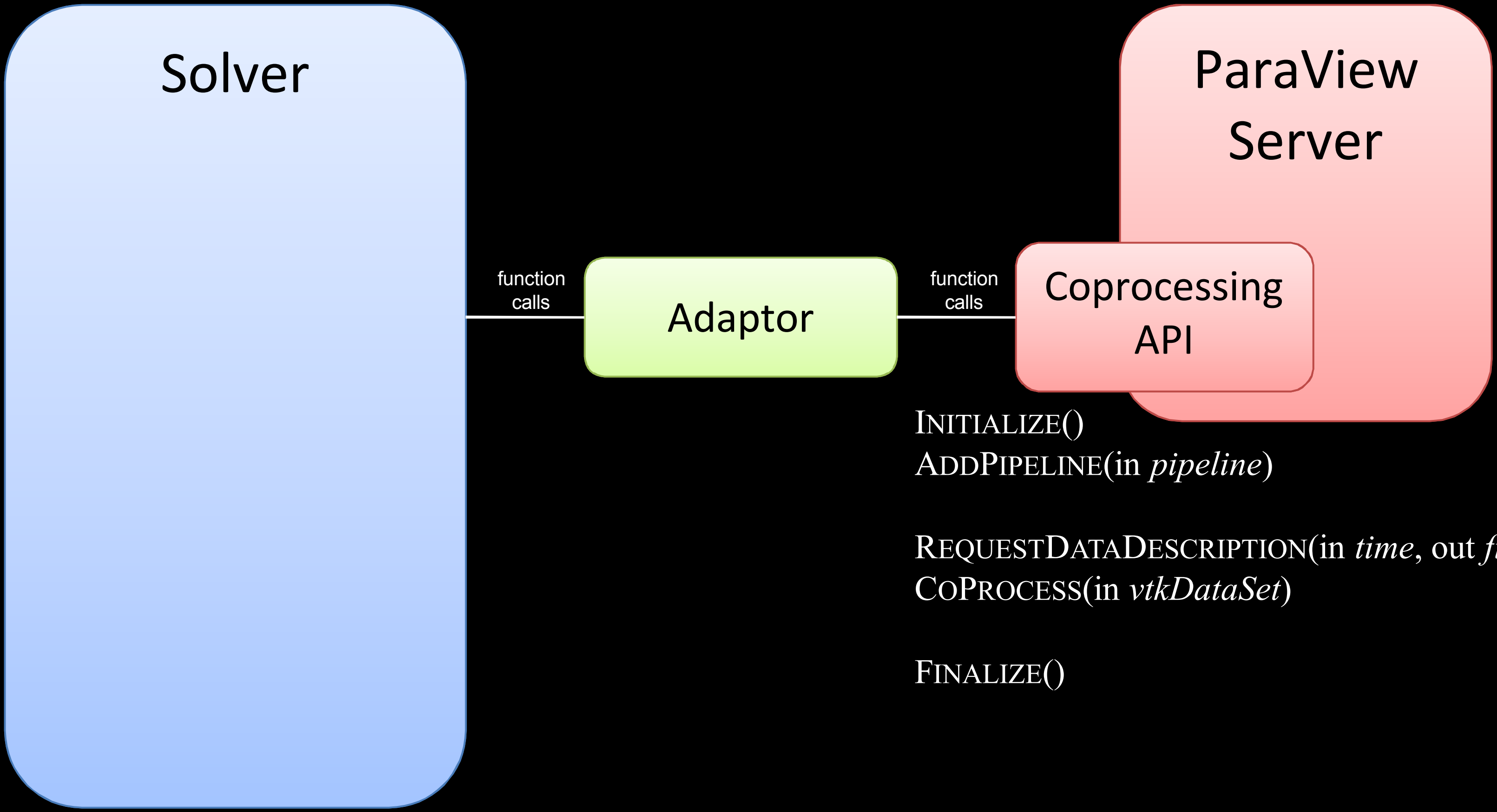




Coprocessing



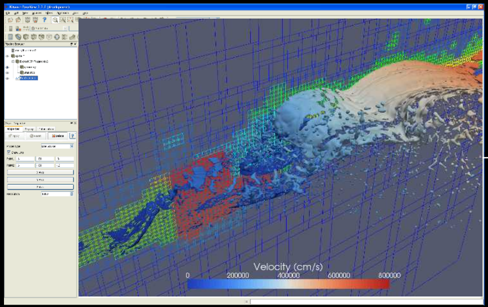
Coprocessing Library



Initialize()
AddPipeline(in *pipeline*)

RequestDataDescription(in *time*, out *fields*)
CoProcess(in *vtkDataSet*)

Finalize()



Script Export

```
# Create the reader and set the filename.
reader = servermanager.sources.Reader(FileNames=path)
view = servermanager.CreateRenderView()
repr = servermanager.CreateRepresentation(reader, view)
reader.UpdatePipeline()
dataInfo = reader.GetDataInformation()
pDinfo = dataInfo.GetPointDataInformation()
arrayInfo = pDInfo.GetArrayInformation("displacement9")
if arrayInfo:
  # get the range for the magnitude of displacement9
  range = arrayInfo.GetComponentRange(-1)
  lut = servermanager.rendering.PVLookupTable()
  lut.RGBPoints  = [range[0], 0.0, 0.0, 1.0,
                    range[1], 1.0, 0.0, 0.0]
  lut.VectorMode = "Magnitude"
  repr.LookupTable = lut
  repr.ColorArrayName = "displacement9"
  repr.ColorAttributeType = "POINT_DATA"
```

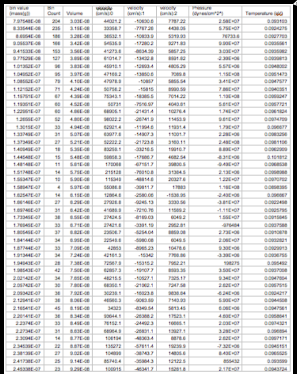
Augmented
script in
input deck.

Simulation

(CTH, Presto, S3D, etc.)

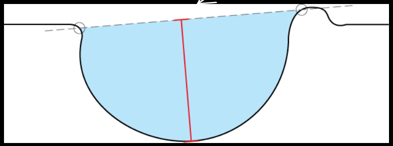
ParaVie
w

Output
Processed
Data

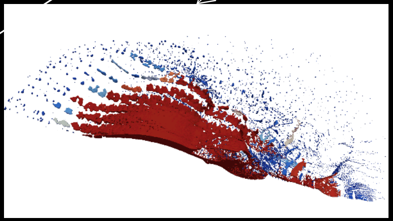


Bin value (mass(g))	Bin Count	Volume	velocity (cm/s):0	velocity (cm/s):1	velocity (cm/s):2	Pressure (dynes/cm^2^)	Temperature (eV)
7.97548E-08	204	3.03E-08	44021.2	-10630.6	7787.22	2.58E+07	0.093103
8.33544E-08	235	3.15E-08	33358.7	-7767.26	4438.05	5.75E+07	0.0924275
8.6954E-08	188	3.28E-08	36532.1	-10833.9	5319.93	76733.6	0.0927703
9.05537E-08	168	3.42E-08	54535.9	-17280.2	9271.83	9.90E+07	0.0935561
9.41533E-08	153	3.56E-08	41273.6	-8634.39	5857.25	3.03E+07	0.0935982
9.77529E-08	127	3.69E-08	61014.7	-13432.8	8591.82	-2.39E+06	0.0939813
1.01352E-07	98	3.83E-08	45910.1	-12693.4	4805.29	5.57E+06	0.0948002
1.04952E-07	95	3.97E-08	47169.2	-13850.6	7089.8	1.15E+08	0.0951473
1.08552E-07	79	4.10E-08	47978.9	-10857	5855.54	3.41E+07	0.0947577
1.12152E-07	71	4.24E-08	50758.2	-15815	8990.59	7.88E+07	0.0940351
1.15751E-07	67	4.39E-08	75343.1	-18385.5	7014.22	1.10E+08	0.0959247
1.19351E-07	60	4.52E-08	50731	-7516.97	4040.81	5.61E+07	0.0957721
1.22951E-07	60	4.66E-08	68905.1	-21431.4	10276.4	1.74E+07	0.0961824
1.2655E-07	52	4.80E-08	98022.2	-26741.9	11453.9	9.61E+07	0.0974709
1.3015E-07	33	4.94E-08	62921.4	-11994.6	11931.4	1.79E+07	0.096677
1.33749E-07	31	5.07E-08	63977.8	-14907.3	11001.7	2.28E+06	0.0983256
1.37349E-07	27	5.21E-08	52222.2	-21723.8	3160.11	2.48E+08	0.0981106
1.40949E-07	18	5.35E-08	83259.1	-33216.5	19910.7	8.89E+07	0.0962909
1.44548E-07	15	5.48E-08	59858.3	-17686.7	4682.54	-8.31E+06	0.101812
1.48148E-07	11	5.61E-08	170068	-67151.7	39800.5	-9.49E+07	0.0968538
1.51748E-07	14	5.75E-08	215128	-76010.8	31384.5	2.13E+06	0.0998088
1.55347E-07	10	5.90E-08	115349	-48814.6	20327.6	1.22E+07	0.0970702
1.58947E-07	4	5.97E-08	55088.8	-39811.7	17883	1.16E+08	0.0898395
1.62547E-07	14	6.15E-08	12864.6	-2580.06	-1538.95	-2.40E+06	0.096667
1.66146E-07	27	6.29E-08	27928.8	-9245.13	3330.56	-3.81E+07	0.0922498
1.69746E-07	31	6.42E-08	41689.9	-7210.76	11569.2	-1.11E+07	0.0925795
1.73346E-07	38	6.55E-08	27424.5	-8169.03	6049.2	1.55E+07	0.0915845
1.76945E-07	33	6.71E-08	27421.6	-3391.19	2952.81	-976484	0.0937588
1.80545E-07	37	6.82E-08	23506.7	-5254.04	6859.08	2.73E+06	0.0910878
1.84144E-07	34	6.95E-08	22549.6	-5980.08	6049.5	2.06E+07	0.0932821
1.87744E-07	33	7.09E-08	42853	-8965.23	10478.6	9.30E+06	0.0929913
1.91344E-07	34	7.24E-08	42161.3	-15342	7768.86	-3.39E+06	0.0936755
1.94943E-07	28	7.38E-08	72567.9	-15315.2	7952.21	198275	0.095492
1.98543E-07	42	7.50E-08	62857.3	-19107.7	8593.35	3.50E+07	0.0937008
2.02142E-07	34	7.65E-08	48215.5	-10527.1	7325.17	9.34E+07	0.0947604
2.05742E-07	30	7.80E-08	68350.1	-21062.1	7247.58	2.62E+07	0.0957515
2.09342E-07	38	7.92E-08	30239.1	-16023.8	9838.84	-6.24E+06	0.0924217
2.12941E-07	38	8.06E-08	46560.3	-9063.59	7140.93	5.90E+07	0.0944508
2.16541E-07	45	8.19E-08	34323	-8349.54	5813.45	6.06E+06	0.0947561
2.20141E-07	38	8.34E-08	93644.1	-26388.2	17523.1	4.60E+07	0.0958841
2.2374E-07	33	8.49E-08	76152.1	-24492.3	16685.1	2.03E+07	0.0974321
2.2734E-07	31	8.63E-08	68964.9	-26831.1	13927.1	3.28E+07	0.096894
2.3094E-07	14	8.77E-08	108194	-48363.4	8878.6	2.62E+07	0.0997171
2.34539E-07	22	8.87E-08	135272	-57611.4	19239.9	-7.32E+06	0.0945151
2.38139E-07	27	9.02E-08	104899	-38743.7	14805.6	8.40E+07	0.0985525
2.41738E-07	25	9.14E-08	85740.4	-35984.3	12122.5	855432	0.093599
2.45338E-07	23	9.29E-08	100915	-46341.7	15281.8	2.17E+07	0.0943724

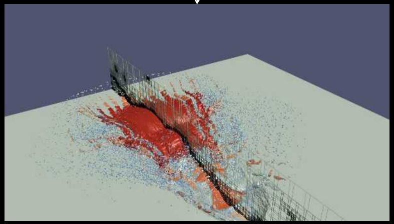
Fragment Statistics



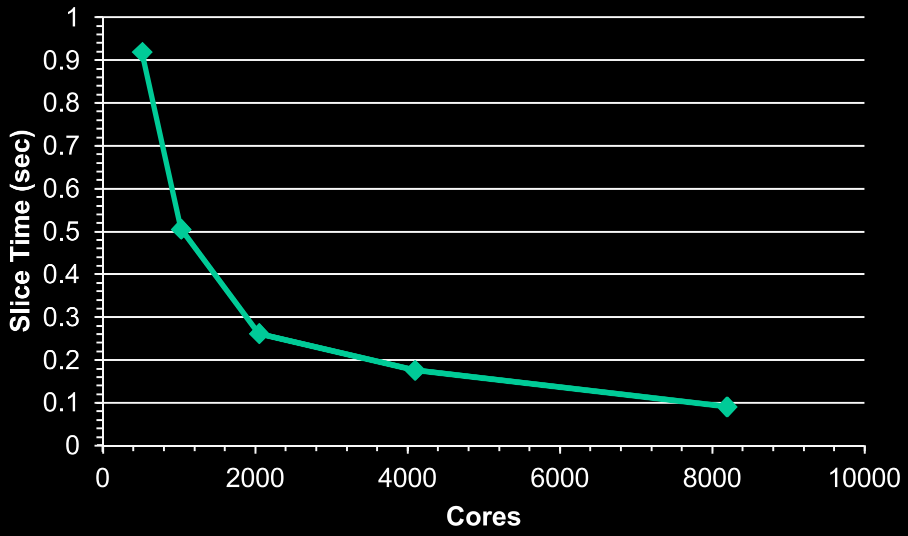
Crater Statistics

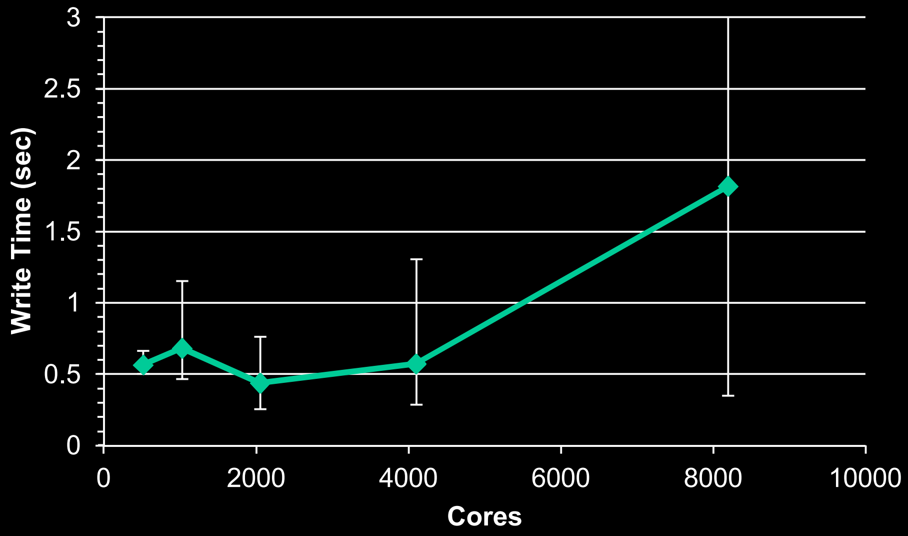


Polygonal Output
with Field Data



Rendered Images

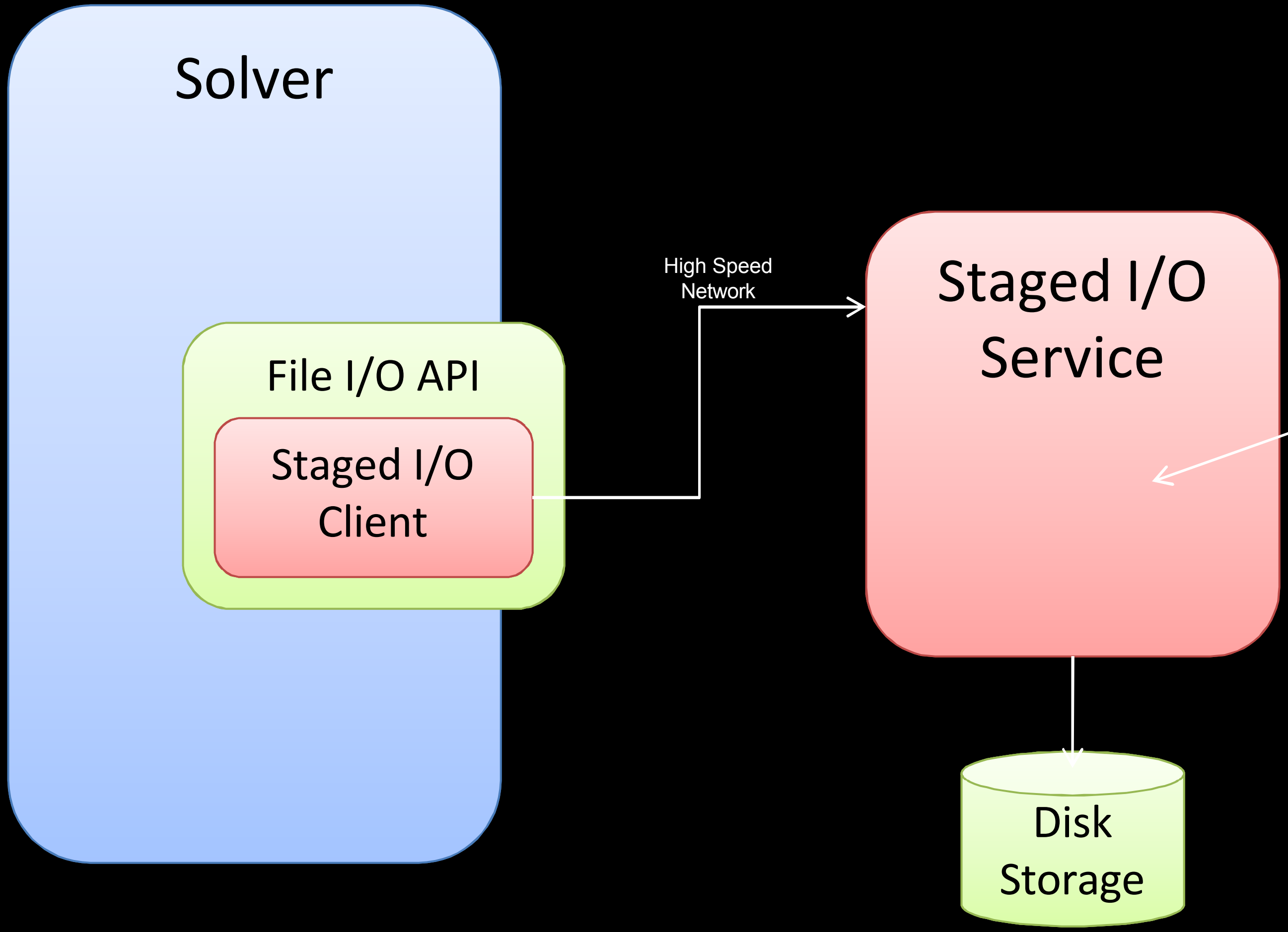

Slice Time (sec)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2000
4000
6000
8000
10000
Cores


Write Time (sec)
3
2.5
2
1.5
1
0.5
0
0
2000
4000
6000
8000
10000
Cores

Risks with Direct Coupling

- Running at Scale
  - Most likely some algorithms will scale, others will not.
- Bloat
  - Linker can significantly reduce code overhead *if* visualizations are known *a-priori*.
    - Python scripting is problematic for a variety of reasons.
  - Adapting memory structures is tricky.
    - Some algorithms will create their own data anyway.
- Stability (real and perceived)
  - Adding any coprocessing increases complexity, which can compromise stability.
  - What if coprocessing blamed for hero-sized crash?
  - What if coprocessing really is at fault?

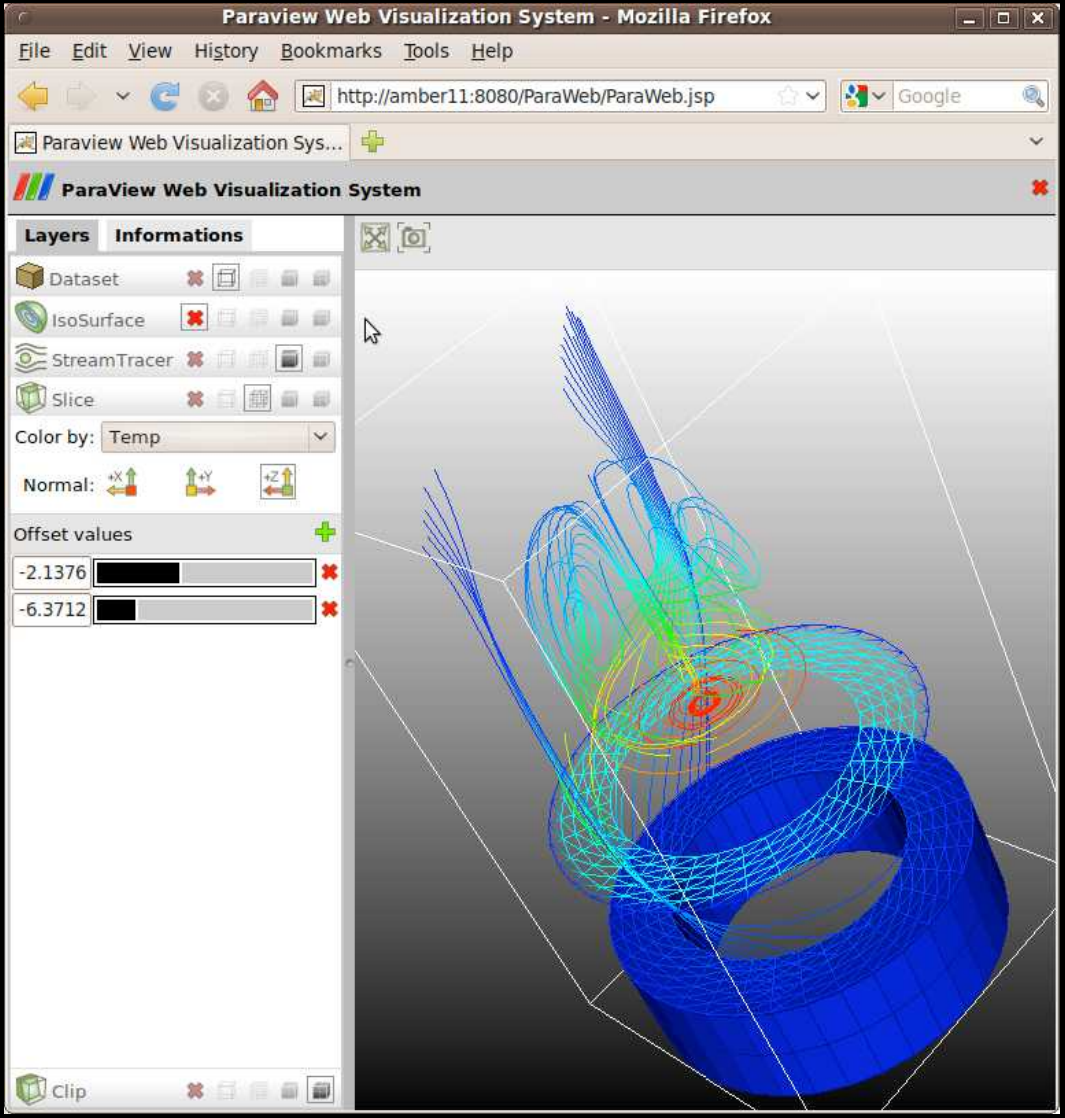
Loose Coupling via Staged I/O



You can do post processing here

The coprocessing library is perfect for this.

ParaView Web Services

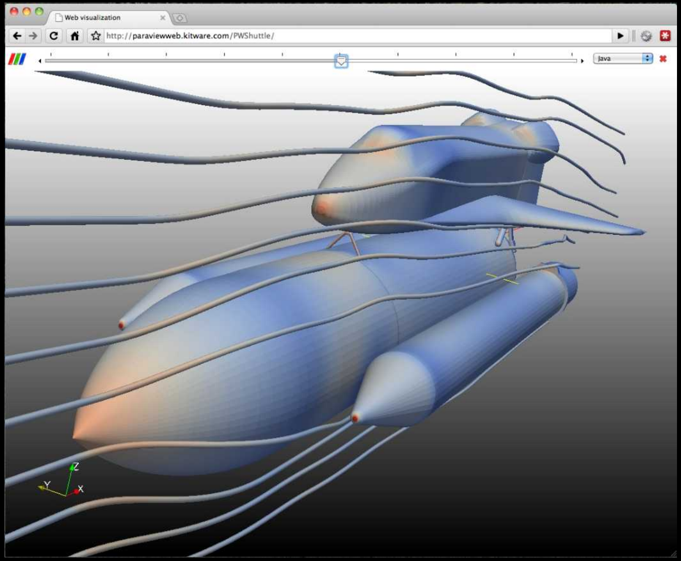

Paraview Web Visualization System - Mozilla Firefox
File
Edit
View
History
Bookmarks
Tools
Help
http://amber11:8080/ParaWeb/ParaWeb.jsp
Google
Paraview Web Visualization Sys...
ParaView Web Visualization System
Layers
Informations
Dataset
IsoSurface
StreamTracer
Slice
Normal:
Clip

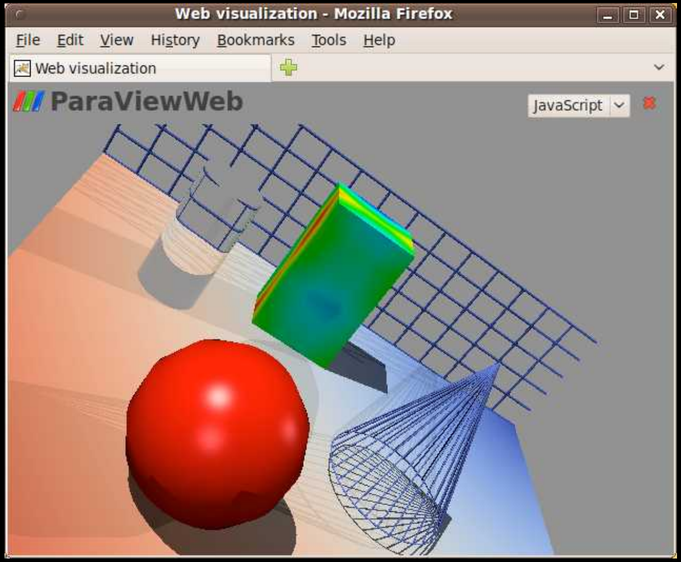
Color by: Temp

Offset values

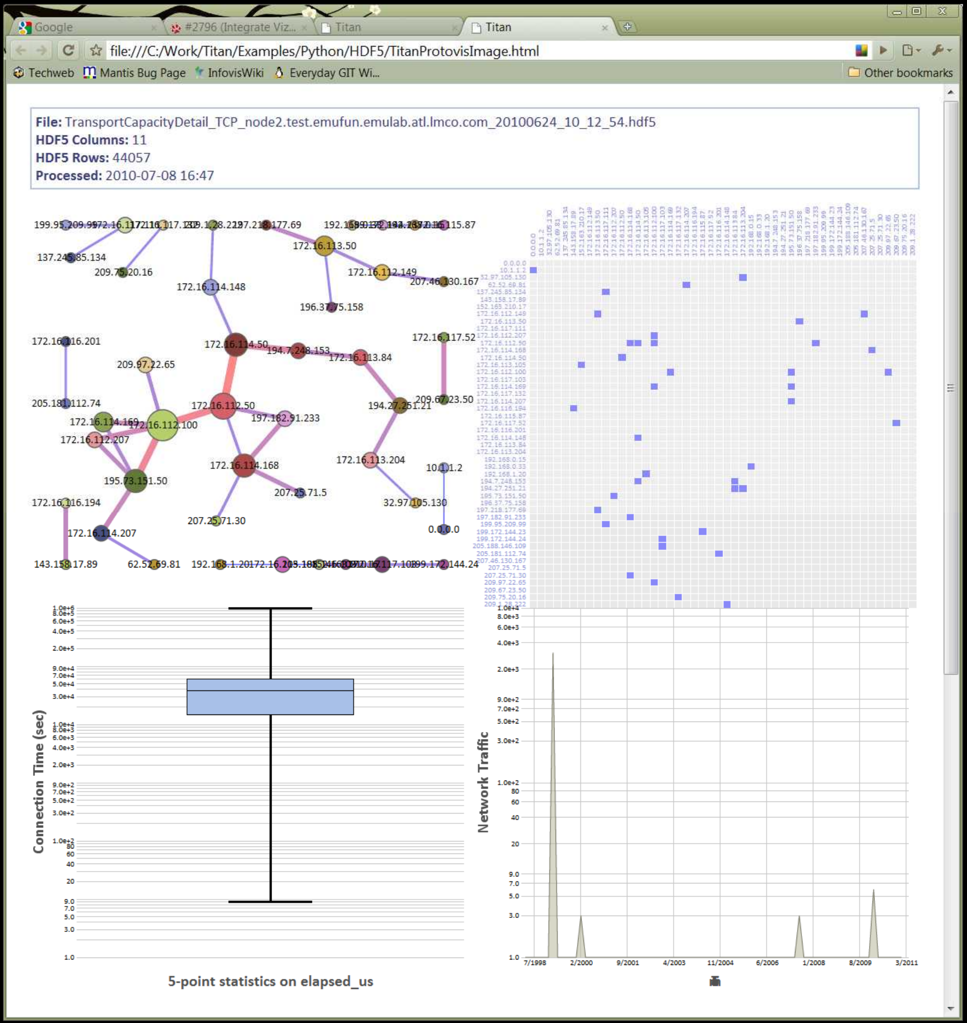
-2.1376

-6.3712

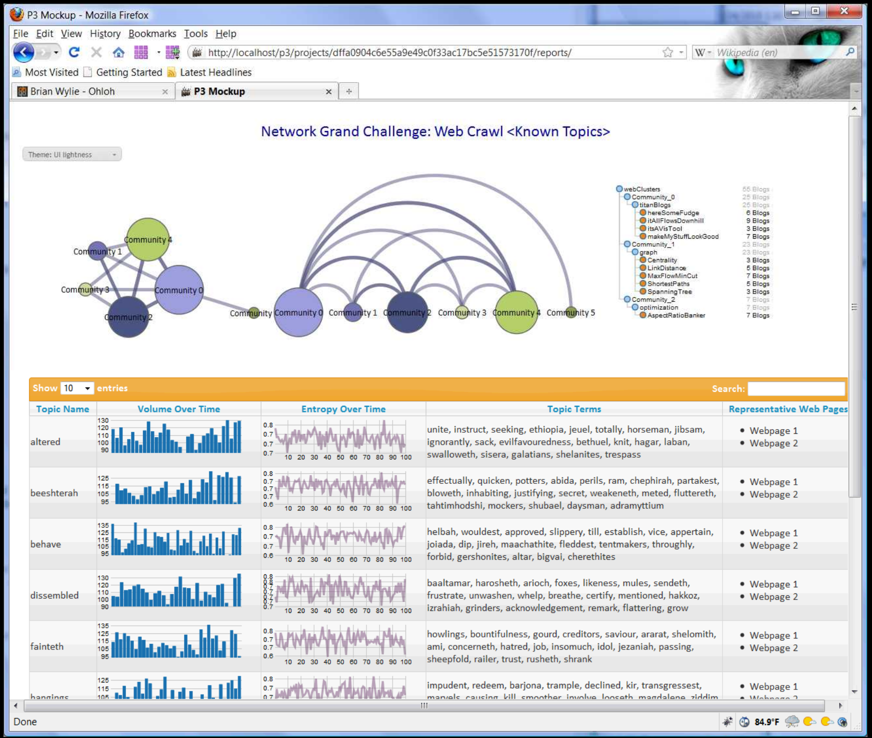




Titan Web Services



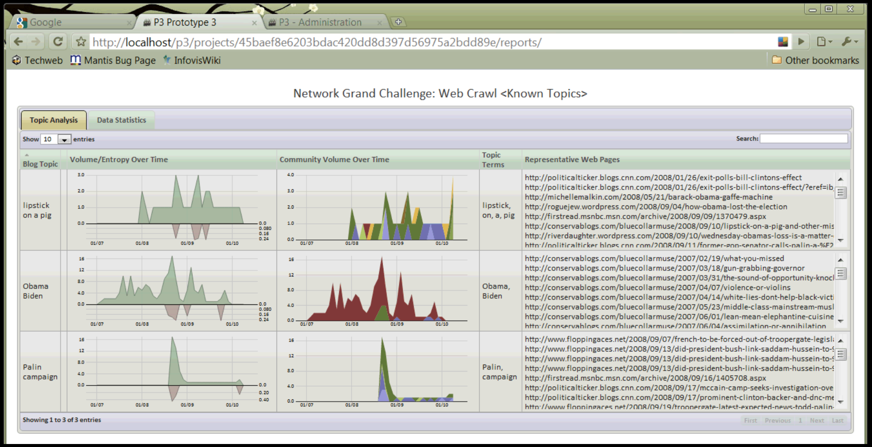
File: TransportCapacityDetail_TCP_node2.test.emufun.emulab.atl.lmco.com_20100624_10_12_54.hdf5
HDF5 Columns: 11
HDF5 Rows: 44057
Processed: 2010-07-08 16:47



Network Grand Challenge: Web Crawl <Known Topics>

Show 10 entries Search:

Topic Name	Volume Over Time	Entropy Over Time	Topic Terms	Representative Web Pages
altered			unite, instruct, seeking, ethiopia, jeuel, totally, horseman, jibsam, ignorantly, sack, evilfavouredness, bethuel, knit, hagar, laban, swalloweth, sisera, galatians, shelanites, trespass	• Webpage 1 • Webpage 2
beeshterah			effectually, quicken, potters, abida, perils, ram, chephirah, partakest, bloweth, inhabiting, justifying, secret, weakeneth, meted, fluttereth, tahtimhodshi, mockers, shubael, daysman, adramyttium	• Webpage 1 • Webpage 2
behave			helbah, wouldest, approved, slippery, till, establish, vice, appertain, joiada, dip, jireh, maachathite, fleddest, tentmakers, throughly, forbid, gershonites, altar, bigvai, cherethites	• Webpage 1 • Webpage 2
dissembled			baaltamar, harosheth, arioch, foxes, likeness, mules, sendeth, frustrate, unwashen, whelp, breathe, certify, mentioned, hakkoz, izrahiah, grinders, acknowledgement, remark, flattering, grow	• Webpage 1 • Webpage 2
fainteth			howlings, bountifulness, gourd, creditors, saviour, ararat, shelomith, ami, concerneth, hatred, job, insomuch, idol, jezaniah, passing, sheepfold, railer, trust, rusheth, shrank	• Webpage 1 • Webpage 2
hangings			impudent, redeem, barjona, trample, declined, kir, transgressest, marvels, causing, kill, smoother, involve, looseth, magdalene, ziddim	• Webpage 1



Network Grand Challenge: Web Crawl <Known Topics>

Show 10 entries Search:

Blog Topic	Volume/Entropy Over Time	Community Volume Over Time	Topic Terms	Representative Web Pages
lipstick on a pig			lipstick, on, a, pig	http://politicalticker.blogs.cnn.com/2008/01/26/exit-polls-bill-clintons-effect http://politicalticker.blogs.cnn.com/2008/01/26/exit-polls-bill-clintons-effect/?eref=ib http://michellemalkin.com/2008/05/21/barack-obama-gaffe-machine http://roguejew.wordpress.com/2008/09/04/how-obama-lost-the-election http://firstread.msnbc.msn.com/archive/2008/09/09/1370479.aspx http://conservablogs.com/bluecollarmuse/2008/09/10/lipstick-on-a-pig-and-other-mis http://riverdaughter.wordpress.com/2008/09/10/wednesday-obamas-loss-is-a-matter- http://politicalticker.blogs.cnn.com/2008/09/11/former-gop-senator-calls-palin-a-%F2
Obama Biden			Obama, Biden	http://conservablogs.com/bluecollarmuse/2007/02/19/what-you-missed http://conservablogs.com/bluecollarmuse/2007/03/18/gun-grabbing-governor http://conservablogs.com/bluecollarmuse/2007/03/31/the-sound-of-opportunity-knocl http://conservablogs.com/bluecollarmuse/2007/04/07/violence-or-violins http://conservablogs.com/bluecollarmuse/2007/04/14/white-lies-dont-help-black-victi http://conservablogs.com/bluecollarmuse/2007/05/23/middle-class-mainstream-musl http://conservablogs.com/bluecollarmuse/2007/06/01/lean-mean-elephantine-cuisine http://conservablogs.com/bluecollarmuse/2007/06/04/assimilation-or-annihilation
Palin campaign			Palin, campaign	http://www.floppingaces.net/2008/09/07/french-to-be-forced-out-of-troopergate-legisl http://www.floppingaces.net/2008/09/13/did-president-bush-link-saddam-hussein-to- http://www.floppingaces.net/2008/09/13/did-president-bush-link-saddam-hussein-to- http://www.floppingaces.net/2008/09/13/did-president-bush-link-saddam-hussein-to- http://firstread.msnbc.msn.com/archive/2008/09/16/1405708.aspx http://politicalticker.blogs.cnn.com/2008/09/17/mccain-camp-seeks-investigation-ove http://politicalticker.blogs.cnn.com/2008/09/17/prominent-clinton-backer-and-dnc-me http://www.floppingaces.net/2008/09/19/troopergate-latest-expected-news-todd-palin-

Showing 1 to 3 of 3 entries

First Previous 1 Next Last