Context-aware distributed cloud computing using CloudScheduler

R. Seuster, C.R. Leavett-Brown, K. Casteels,
M. Murray, M. Paterson, D. Ring, R. Sobie, R. Taylor,
University of Victoria

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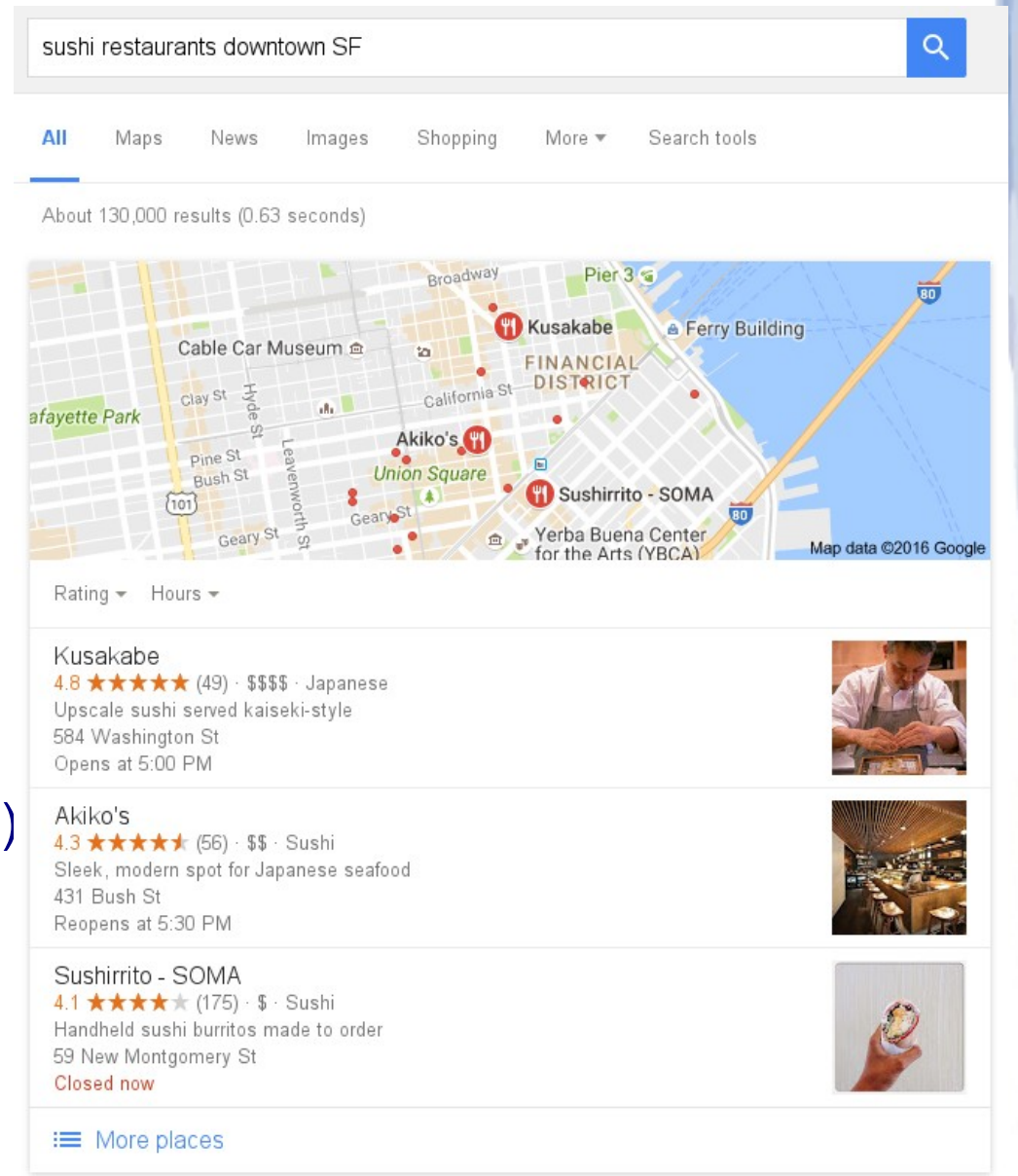
What does context aware mean ?

- compare to search engines: personalized search results

  Search engine

- user looks for good restaurant close to his/her location
  'good Indian restaurant' or 'best sushi restaurant in downtown SF'
- search engine takes (GPS) location, user's taste and budget (from search string or from profile) into account and presents personalized prioritized list



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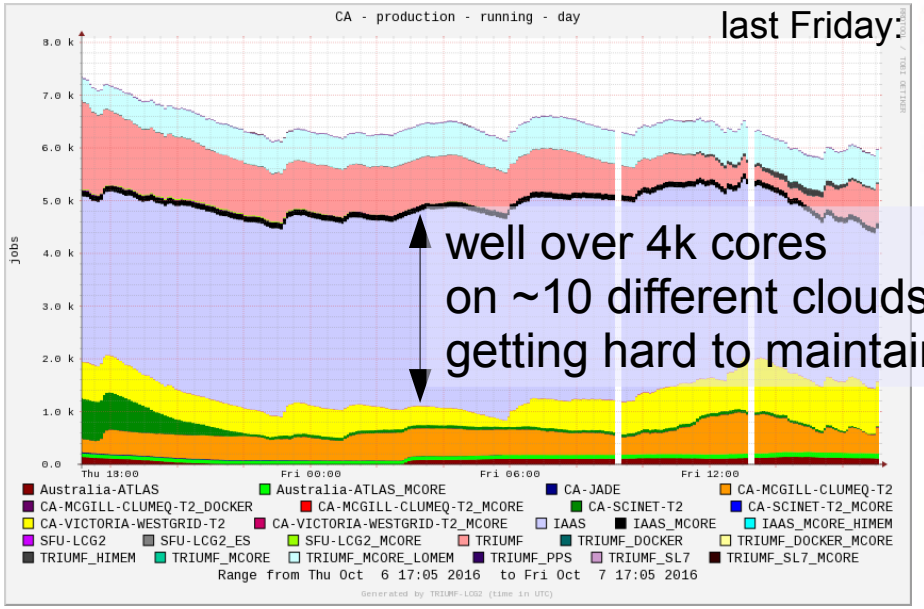
CloudScheduler (CS) simple example:

- user submits certain type of job, e.g. high IO required and n MB of memory
- clouds X and Y provide this and have free resources, but X is closer to input data
- CS starts new VM on cloud X and job runs there

What can we gain ?

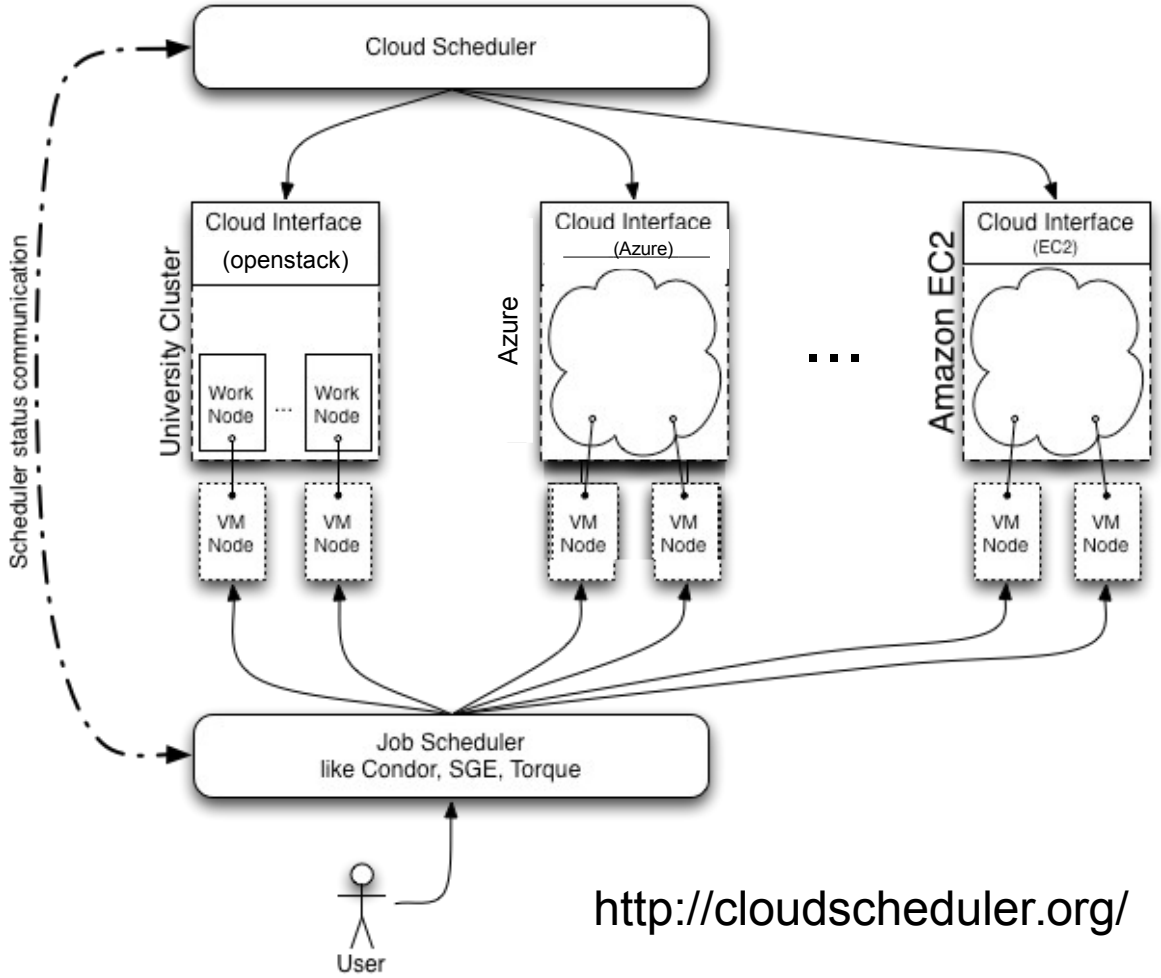
- Better utilize dynamic and opportunistic resources
  - let clouds and VMs auto-configure themselves
  - locate optimal SW caches and storage of data
- CS can more easily react to external, known problems
  - retire faulty or stressed VMs, disable unstable clouds, etc.



→ better resource utilization with less manual interaction
same team can operate more and larger clouds
easier adoption of new cloud resources worldwide

Current CloudScheduler

- CloudScheduler manages VMs in all clouds, starts and retires them as needed, use CERNVM images
- At startup VMs register with Job Scheduler, condor in our case
- Jobs are submitted by pilotfactory at TRIUMF for ATLAS and DIRAC for Belle II directly to queue
- We can run on multiple clouds: Amazon, Azure, our local development cluster, ComputeCanada clouds, several other clouds in Canada, US and Europe



http://cloudscheduler.org/

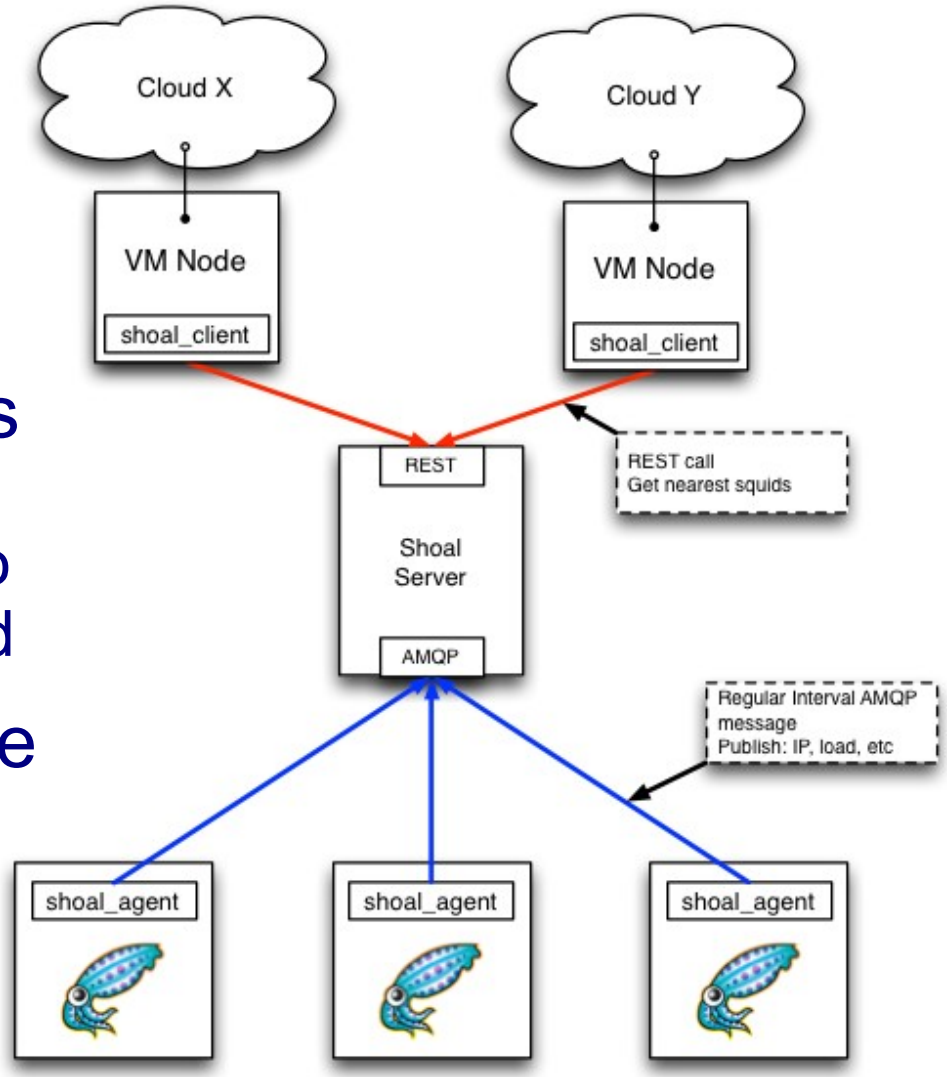
- Plan to extend to GCE and further cloud providers in Europe in near future

Auto-configure Squids: Shoal

- Shoal: 'group of squids', GeoIP based squid discovery service, basic wpad support in use since several years
  - Each cloud is configured to connect to its closest squid

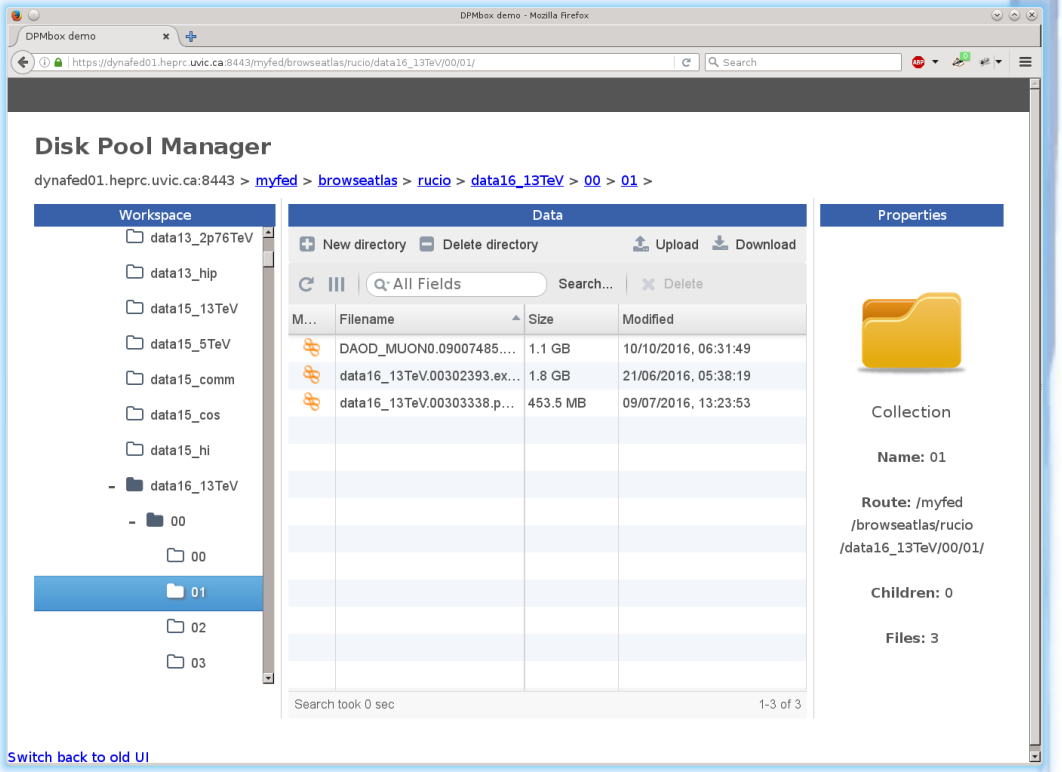
→ optimal access to code and conditions

https://github.com/hep-gc/shoal



Auto-configure Storage: DynaFed

- DynaFed: federation of storage elements using http or WebDAV protocol, to be used in near future
  - Each cloud gets data from nearest location
- Part of a WLCG demonstration project



→ optimal access also to data !
for now only for reading data, address writing later

http://lcgdm.web.cern.ch/dynafed-dynamic-federation-project

Monitoring

- Start with collecting detailed monitoring data
  - What data do we need to collect ? Start with simple things like monitor system performance and extend as necessary
    - # running and retiring jobs over time
    - # of jobs, estimate efficiencies from CPU usage
    - Process system logfiles
- Then feed back monitoring into operation
  - Learn to automatically identify 'old' problems and apply fix
  - Keep track that they don't happen too often
- Later feed back experience from monitoring and operation into auto-configuration of clouds and VMs
  - Take prior knowledge about cloud into account

New Monitoring Page

- Collecting information from different sources and display them on single page:

IAAS 04:02:47 06-Oct

amazon-east 20 | amazon-west 20 | azure 50 | beaver 6 | cc-east 92 | cc-west [illegible] | chameleon 57 | dair-ab 4 | dair-qc 6 | Jade 5

Cloud		CloudScheduler VMs: Starting	Running	Retiring	Error	Idle	Lost	HTCondor Slots: 1	2	3	4	5	6	7	8
amazon-east	atlas-worker	0	20	0	0	0		20	0	0	0	0	0	0	0
amazon-west	atlas-worker	0	20	0	0	2		18	1	0	0	0	0	0	0
azure	atlas-mcore-worker	0	46	0	0	0		39	8	0	0	0	0	0	0
beaver	atlas-worker	0	6	0	0	0		6	6	6	6	6	6	6	6
cc-east	atlas-worker	0	88	0	0	0		87	87	88	88	88	88	88	88
	atlas-mcore-worker	0	4	0	0	0		4	0	0	0	0	0	0	0
cc-west	atlas-worker	0	284	4	0	0		286	288	284	288	286	285	288	284
	atlas-mcore-worker	0	3	0	0	0		3	0	0	0	0	0	0	0

- Overall #jobs:

Jobs	HTCondor Jobs: Total	Idle	Running	Completed
All	3371	71	3283	17
1 Core	3188	21	3150	17
8 Core	133	25	108	0

Benchmarking
and health reporting

- Since recently utilize code from the HEPiX benchmarking working group here
  http://bmkwg.web.cern.ch/bmkwg/
  → poster during poster session A on Tuesday
- Runs at startup of VM and writes to database
- VM reports every 15mins of uptime, it cpu usage(s) and other information back to DB at UVic
  - Allows up to estimate VM's uptime etc. when we loose VM e.g. due to spot market pricing
- Now can calculate following information reported

Benchmarking

- Following info is calculated per cloud:

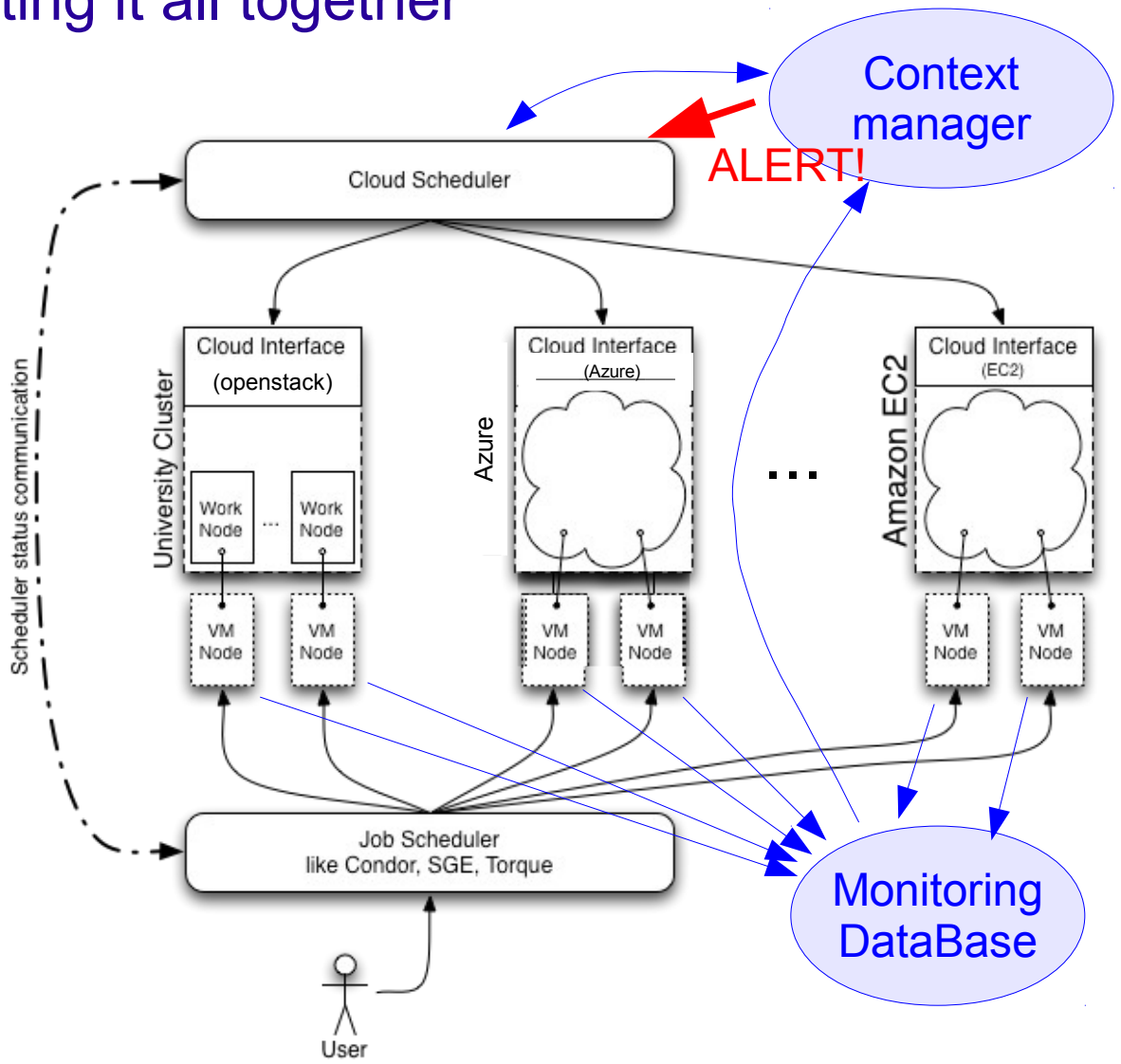
```
overlap: otype = 0 problem
Cloud          #    Bmk                 Total
                                 User    Total     Eff
cloud A       20   15.8          65.0     81.2    0.800
cloud B       53   19.9         179.7    247.1    0.727
cloud C       23   14.9          70.8     93.3    0.758
cloud D       16   21.0           4.5     11.3    0.397
cloud E       18   12.2          29.8     41.0    0.726
cloud F       18   11.9          48.0     64.0    0.750
cloud G      308    21.5         899.9   1503.1     0.599
cloud H       45    9.8          34.3    155.5    0.221
Total                           1331.9   2196.6
Monday October 10  17:00:02
```

Might not use all cpus on VM due to memory requirements of payload

A Future CloudScheduler

putting it all together

- VMs report all relevant information back into Monitoring DataBase
- ContextManager enquires DB to discover any urgent action and alerts CloudScheduler
  - CS then executes them at a 'convenient' time
- CloudScheduler consults with ContextManager about next actions, if VM needs to be started (and where!), retired, ...



Some Recent Problems

and how some could be fixed automatically

- detached 100% java process, kill -9 <pid> did not work – either delete this process (and all its threads) or retire VM after all jobs finish
- jobs which lost heartbeats – carefully monitor network to find root cause and meanwhile discard VM if too many jobs lost on it
- application failures – interface with PanDa and DIRAC and notify human if too many problems
  - no experience so far with automated detection of problems of the application and their cure

Acknowledgements

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Summary & Conclusions

- Making progress on building a context-aware CloudScheduler
  - Aim is to reduce maintenance burden on operators and enable automated checking and error fixing
- Access to code, conditions and data (soon) already optimized by Shoal and DynaFed
  - Still, adding new clouds is labour intensive, thinking abut how to reduce that
- Extending monitoring as needed as we go along
  - Will probably soon start to auto-heal from problems soon