AccessionIndex: TCD-SCSS-T.20121208.106
Accession Date: 8-Dec-2012
Accession By: Dr.Brian Coghlan
Object name: csTCDie PS3 Cluster
Vintage: c.2009
Synopsis: Ten nodes from a 16-node Sony Playstation PS3 cluster plus build machine, using 1Gbps Ethernet interconnect and running Yellow Dog Linux.

Description:
The first Irish Beowulf cluster was constructed in 1997 by the School of Cosmic Physics in the Dublin Institute for Advanced Studies. The second Irish Beowulf cluster was constructed in the middle of the same year by the Department of Computer Science in Trinity College Dublin, a highly experimental configuration of 4-nodes that used a SCSI interconnect, the first of a number of clusters constructed by the department, some very production-oriented, others more adventurous, see elsewhere in this catalog.

In 2009 the second-last of these, this PS3 cluster, was constructed by Dr.Brian Coghlan, firstly for local computing of the eHiTS high-throughput drug candidate screening software in collaboration with the Royal College of Surgeons of Ireland (RCSI), and then for grid access via the Grid-Ireland infrastructure (see elsewhere in this catalog). After the closure of the Grid-Ireland infrastructure in 2012 the cluster was decommissioned.

The PS3 cluster, essentially a Beowulf cluster [1] but with games-oriented hardware, consisted of sixteen Sony Playstation PS3 compute nodes [2][3][4], each with a *Cell Broadband Engine* (Cell B./E.) [5], plus a seventeenth as a Build Machine. Each Cell BE included a primary CPU (power processing element [PPE]) and seven secondary CPUs (synergistic processing elements [SPE]) on a high-speed internal ring-structured interconnect. The PS3 used the same IBM/Sony-designed Cell BE as IBM's own *BladeCenter* QS20 [6] (see elsewhere in this catalog), but selected from fabricated chips with only seven working SPEs, whereas the BladeCenter only used fully-working chips with eight SPEs.

The cluster nodes were distributed over two large custom shelving units. It was essentially a 16-node Beowulf cluster with seven accelerators per node, where there were a total of 16 PPEs and 112 SPEs, an aggregate of 128 non-symmetric cores. Each node was capable of about 0.25Tflops, so the cluster was capable of a maximum of 4Tflops. The eHiTS application was well tuned to exploit this, generating speedups between 26-fold and 60-fold over Intel-based CPUs. The nodes ran Yellow Dog Linux (PPC64). A concerted and ultimately successful effort was made to port the gLite grid middleware to these machines and to enable remote submission of jobs while remaining within the existing grid information standards. However, it was not possible at that time to avail of the generalised broking facilities of gLite, instead the users had to be instructed how to target job submission to a specific gLite queue that was dedicated to the PS3 cluster.

This work was done by Dr.Brian Coghlan, Dr.Eamonn Kenny, Peter Lavin (then a postgraduate student) and John Walsh.

A number of nodes were paid for by and therefore property of Dr.B.A.Coghlan, and when decommissioning were distributed to members of his research team. Given that SONY blocked installation of Linux on PS3s after 2010, and that the remainder would still function correctly but with fewer compute nodes, these nodes from this unusual cluster are preserved with their installed Linux software in this collection, see Figures 5, 6 and 7 below.

The homepage for this catalog is at: https://www.scss.tcd.ie/SCSSTreasuresCatalog/
Click *'Accession Index'* (1st column listed) for related folder, or *'About'* for further guidance. Some of the items below may be more properly part of the other categories of this catalog, but listed here for convenience.

Accession Index	Object with Identification
TCD-SCSS-T.20121208.106.001-010	csTCDie PS3 Cluster, Ten nodes from a 16-node Sony Playstation PS3 cluster plus build machine, using 1Gbps Ethernet interconnect and running Yellow Dog Linux, c.2009, S/N of each node as below: 02-27438173-1921502-CECHL04 02-27437420-1334399-CECHK03 02-27453120-1099989-CECHL03 02-27453120-1123361-CECHL03 02-27438173-1921501-CECHL04 02-27453120-1123362-CECHL03 03-27438172-5497145-CECHL04 02-2747970x-0381081-CECHM03 (Cell 7) 03-27438172-5497146-CECHL04 02-27434623-7563483-CECHH04 (TestGrid Build Machine)
TCD-SCSS-T.20150116.001	IBM BladeCenter chassis with seven BladeCenter QS20 blades, IBM blade product using the same IBM/Sony-designed Cell Broadband Engine (Cell BE) processor as in the Sony PlayStation 3 (PS3).
TCD-SCSS-T.20121208.094	Experimental SCSI Cluster, 4-node prototype cluster using SCSI as interconnect, the first cluster constructed in the Department of Computer Science, Trinity College Dublin, and second cluster constructed in the Republic of Ireland, 1997.
TCD-SCSS-T.20121208.095	csTCDie Beowulf Cluster, Departmental cluster using 100Mbps Ethernet as interconnect, the second cluster constructed in the Department of Computer Science, Trinity College Dublin, 1998.
TCD-SCSS-T.20141120.003	csTCDie Grid-Ireland SCI Cluster, 16-node cluster using 400MB/s SCI switched interconnect, the third cluster constructed in the Department of Computer Science, Trinity College Dublin, c.1999.

TCD-SCSS-T.20121208.097	VRengine, 9-node virtual reality engine using 600MB/s SCI 2-d toroidal interconnect, c.2005.
TCD-SCSS-T.20121208.098	csTCDie Grid Site Beowulf Clusters and Datastore, Complex of clusters & storage (1500 cores/600 TB) using 1Gbps Ethernet interconnect and 10Gbps backbone, participant in DataGrid, EGEE, EGI, and CERN LHC computing. From 2013 repurposed as SCSS Cloud, c.2009.
TCD-SCSS-T.20121208.099	csTCDie GPU Cluster, 64-core/32-GPU/16-node cluster using 1Gbps Ethernet interconnect, c.2011.

References:

1. Wikipedia, *Beowulf cluster*, see (last browsed to 18-Jan-2016): *https://en.wikipedia.org/wiki/Beowulf_cluster*

2. Wikipedia, *PlayStation 3*, see (last browsed to 18-Jan-2016): *https://en.wikipedia.org/wiki/PlayStation_3*

3. Wikipedia, *PlayStation 3 Models*, see (last browsed to 18-Jan-2016): *https://en.wikipedia.org/wiki/PlayStation_3_models*

4. Wikipedia, *PlayStation 3 Technical Specifications*, see (last browsed to 18-Jan-2016): *https://en.wikipedia.org/wiki/PlayStation_3_technical_specifications*

5. IBM, *Cell Architecture*, IBM Systems and Technology Group, 2006. See in related folder in this catalog: *https://www.scss.tcd.ie/SCSSTreasuresCatalog/hardware/TCD-SCSS-T.20121208.106/Day1-03-CourseCode-L1T1H1-10-CellArchitecture.pdf*

6. IBM, *IBM BladeCenter QS20 blade with new Cell BE processor offers unique capabilities for graphic-intensive, numeric applications*, see: https://www-01.ibm.com/common/ssi/rep_ca/7/897/ENUS106-677/index.html Last browsed to on 24-Jun-2018.

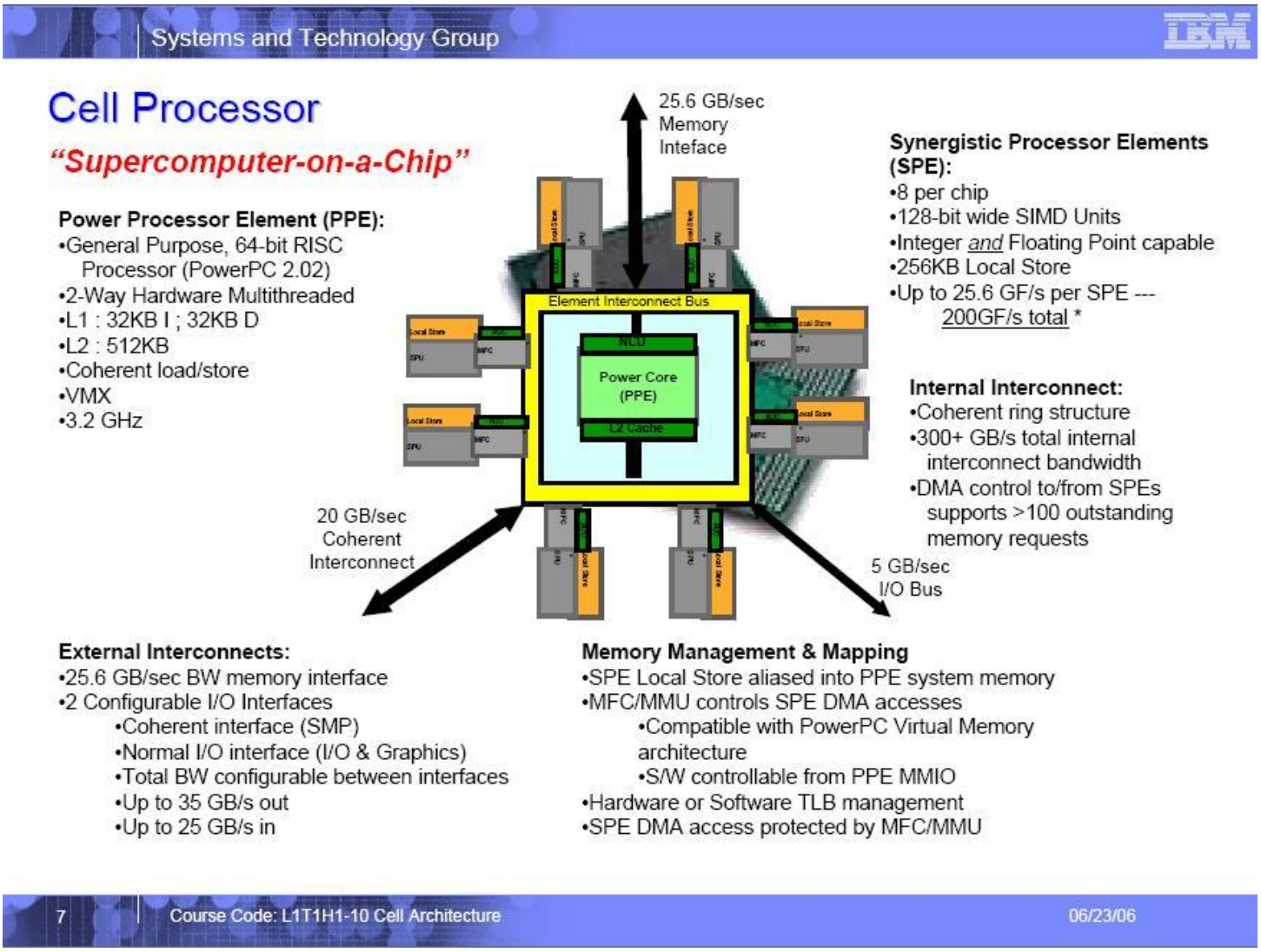


Figure 1: Cell Broadband Engine architecture (from reference [1])

Figure 2: (a) PS3 node, (b) PS3 cluster

gLite Porting to the PS3 using ETICS for electronic High Throughput Screening (eHiTS®)

E. Kenny, P. Lavin, J.Walsh, B. Coghlan (Trinity College Dublin)

Since 2003 TCD has invested heavily in middleware porting, constantly engaging with the middleware development groups of the EU DataGrid (EDG), LHC computing Grid (LCG) and EGEE projects. As a result of the accumulated expertise, TCD was invited in 2006 to join a new EGEE-II integration and testing activity (SA3) as the main portability partner for further development in this area, and then for EGEE-III, Trinity College Dublin handled the porting and multi-platform coordination.

The build system has evolved from a primitive python based system to a metadata-rich system called ETICS. In 2008, TCD ported gLite to the PS3. TCD produces its own local ETICS builds for the Play Station 3 running Yellow Dog Linux 6.1 (PPC64), Mac OS X 10.5 (Leopard-i386), Debian 4.0/5.0 (x86/AMD64), CentOS 4.x/5.x (x86/x86_64), openSUSE 11.1 (x86_64), and has previously performed partial ports of the glite-WN/LCG-WN, on AIX 5.3 (PPC), SGI-IRIX (MIPS), Fedora Core 2/4, Mac OS X 10.4, openSUSE 9.3/10.3 (x86) and Solaris 10 (x86).

The images in Figure 1 show the TCD local build results with report tables auto-generated using python scripts wrapping the ETICS client 1.4.9-1.

Two images show that LCG-DM successfully builds to 100% on the PS3 using the locally ported VDT globus and IBM Java 6.0 compiler.

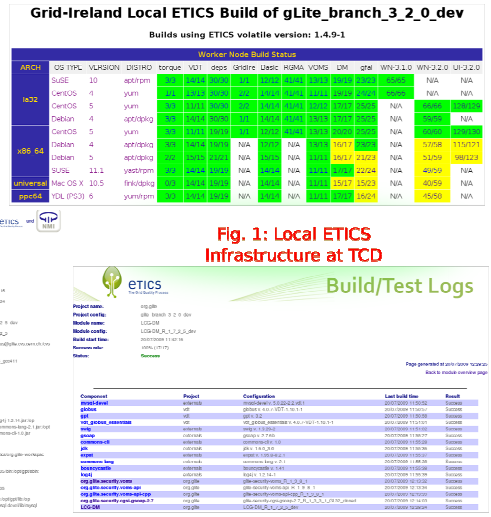


Fig. 1: Local ETICS Infrastructure at TCD

Fig. 2: XML build rules for multi-platform support

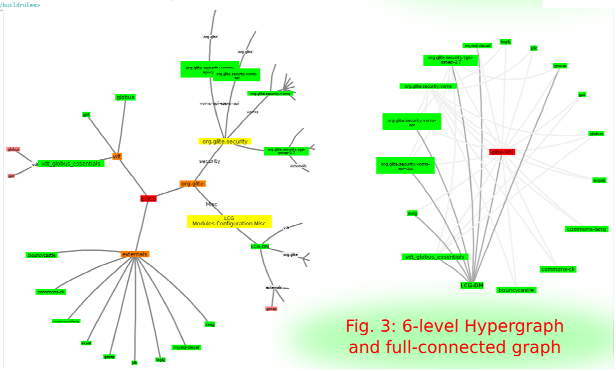


Fig. 3: 6-level Hypergraph and full-connected graph

The TCD ETICS wrapper contains many extra pieces of functionality:

1. XML based build descriptions (see Figure 2).
2. Per platform patching with XML descriptions.
3. Per platform property overrides (in XML).
4. Automatic sync and storage of XML/HTML in a directory structure allowing HTML table generation (see Figure 1).
5. Hypergraph generation based on the ETICS XML results set (see Figure 3).
6. Automatic RPM/deb to tarball generators in a form ready for integration into ETICS.
7. A http_proxy patched wrapper for the ETICS client to allow it to work on sites using squid proxy.
8. Automated GNU patch generation based on fixes to ETICS components, timestamped and stored for future patching.
9. An intermediate patching system applied between checkout and builds to help debug dependent components and keep ahead of the centralised build and test environment.
10. Automated timestamped checkouts of ETICS configurations to be patched from the ETICS command-line interface.
11. Python scripts used to create wiki tables showing differences between multiple build result files.

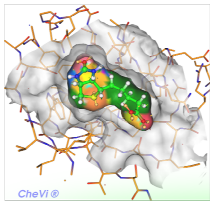
The initial gLite port to the PS3 allows job submission, but not data management, however much of the data management code now builds in ETICS. The initial release is a minimal glite-WN containing VDT globus, VOMS, yaim and noarch components.

Jobs are submitted using the following process:

```
glite-voms-proxy-init –voms <vo_name>
glite-wms-job-submit -a -r <ce>:2119/jobmanager-pbs-<queue> -o job.id job.jdl
glite-wms-job-output –dir <dir_name> -i job.id
```

To become a sustainable infrastructure for Grid usage, the PS3 and other platforms must become production ready, centrally distributed nodes of the gLite middleware. In the meantime, TCD has the means to provide a partially maintained experimental minimal workernode.

eHiTS® Lightning 2009, is the electronic High Throughput Screening software ported by SimBioSys Inc. (www.simbiosys.ca) for the PS3 to fully utilise the Cell Broadband Engine™ (Cell B./E.).



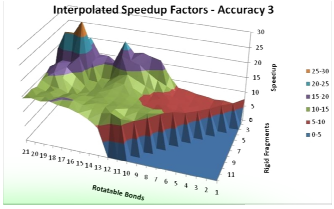


Fig. 4: An example ligand docked with eHiTS, and the docking speedup on the PS3 versus Intel platform

The ported eHiTS® software runs natively on the Cell B./E. fully utilizing the vector processing power of the SPEs. The speedup depends on the input data (see Figure 4) generating speedups ranging between 26-fold and 60-fold over Intel based processors.

TCD constructed an 8-node grid-enabled PS3 cluster, to which eHiTS® related jobs may be submitted via the EGEE Grid.

Supported by HEA, EGEE, EU

Figure 3: Grid-Ireland 2009 poster describing porting to and use of csTCDie PS3 Cluster

gLite Porting to the Play Station 3 using ETICS for electronic High Throughput Screening (eHiTS)

E. Kenny, P. Lavin, J.Walsh, B. Coghlan (Trinity College Dublin)

Enabling Grids for E-sciencE

Since 2003 TCD has invested heavily in middleware porting, constantly engaging with the middleware development groups of the EU DataGrid (EDG), LHC computing Grid (LCG) and EGEE projects. As a result of the accumulated expertise, TCD was invited in 2006 to join a new EGEE-II integration and testing activity (SA3) as the main portability partner for further development in this area, and then for EGEE-III, Trinity College Dublin handled the porting and multi-platform coordination.

The build system has evolved from a primitive python based system to a metadata-rich system called ETICS. In 2008, TCD ported gLite to the PS3. TCD produces its own local ETICS builds for the Play Station 3 running Yellow Dog Linux 6.2 (PPC64), Mac OS X 10.6 (Snow Leopard-i386), Debian 5.0 (x86/AMD64), CentOS 4.x/5.x (x86/x86_64), openSUSE 11.2 (x86_64), and has previously performed partial ports of the glite-WN/LCG-WN, on AIX 5.3 (PPC), SGI-IRIX (MIPS), Fedora Core 2/4, Mac OS X 10.4, openSUSE 9.3/10.3 (x86) and Solaris 10/11 (x86).

The images in Figure 1 show the TCD local build results with report tables auto-generated using python scripts wrapping the ETICS client 1.4.10-1.

Figure 2 shows that the gLite-WN successfully builds to 100% on the PS3 using the locally ported VDT globus and IBM Java 6.0 compiler.

Grid-Ireland Local Nightly ETICS Build of gLite_branch_3_2_0_dev

Builds using ETICS version: 1.4.13-1

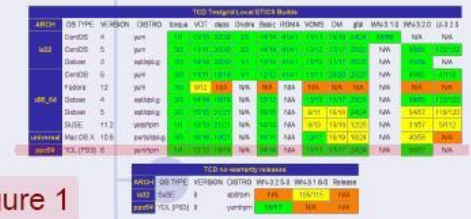


Figure 1

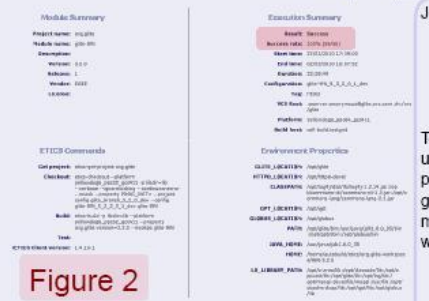


Figure 2

The initial gLite port to the PS3 allowed job submission, excluding data management, however, the latest version builds to 100% in ETICS and passes the certification tests for data-management and job submission.

The port includes VDT globus and client utilities for the WMS, AMGA, LFC/DPM and dCache.

A TCD ETICS wrapper was developed to provide automated local builds containing many extra pieces of functionality. This wrapper allows extra flags and patches to be injected into the build system in a repeatable way, per platform. The main features are described as:

1. XML based build descriptions.
2. Per platform patching with XML descriptions.
3. Per platform property overrides (in XML).
4. Automatic sync and storage of XML/HTML in a directory structure allowing HTML table generation (see Figure 1).
5. Hypergraph generation based on the ETICS XML results set (see Figure 3).
6. Automatic RPM/deb to tarball generators in a form ready for integration into ETICS.
7. A http_proxy patched wrapper for the ETICS client to allow it to work on sites using squid proxy.
8. Automated GNU patch generation based on fixes to ETICS components, timestamped and stored for future patching.
9. An intermediate patching system applied between checkout and builds to help debug dependent components and keep ahead of the centralised build and test environment.
10. Automated timestamped checkouts of ETICS configurations to be patched from the ETICS command-line interface.
11. Python scripts used to create wiki tables showing differences between multiple build result files.

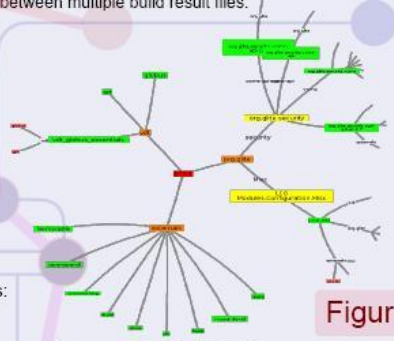


Figure 3

Jobs are submitted using the following process:

```
glite-voms-proxy-init --voms <vo_name>
glite-wms-job-submit -a -r <ce>:2119/jobmanager-pbs-<queue> -o job.id job.jdl
glite-wms-job-output --dir <dir_name> -i job.id
```

To become a sustainable infrastructure for Grid usage, the PS3 and other platforms must become production ready, centrally distributed nodes of the gLite middleware. In the meantime, TCD has the means to provide a partially certified no-warranty workernode (gLite-WN).

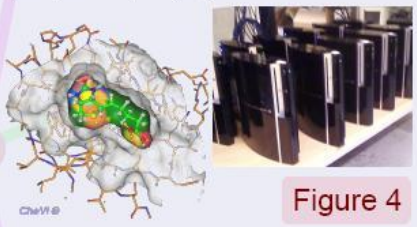


Figure 4

The ported eHiTS® lightning software runs natively on the Cell B./E. fully utilizing the vector processing power of the SPEs. The speedup depends on the input data (Figure 5) generating speedups ranging between 26-fold and 60-fold over Intel based processors.

TCD is constructing a 16-node grid-enabled PS3 cluster (Figure 4), to allow eHiTS® related jobs to be submitted via the EGEE Grid.

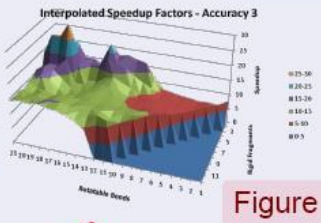


Figure 5

The EGEE project is building a Grid infrastructure for the scientific community. Grids are networks of computers spread across many sites but able to act together to provide a range of large scale facilities, from incredible processing power and mass storage to a platform for international collaboration.

e-INIS The Irish National e-Infrastructure

SimBioSys Inc. NDP HEA

Supported by HEA, EGEE, EU

www.eu-egee.org

EGEE-III is co-funded by the European Commission under contract number INFSO-RI-222667

Figure 4: EGEE 2010 poster describing porting to and use of csTCDie PS3 Cluster

Figure 5: Ten nodes of csTCDie PS3 Cluster preserved in the Collection

Figure 6: Ten nodes of csTCDie PS3 Cluster preserved in the Collection

Figure 7: Ten nodes of csTCDie PS3 Cluster preserved in the Collection