Extracting Synthetic Multi-Cluster Platform Configurations from Grid'5000 for Driving Simulation Experiments

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Abstract: This report presents a collection of synthetic but realistic distributed computing platform configurations. These configurations are intended for simulation experiments in the study of parallel applications on multi-cluster platforms.

Key-words: Simulation, Platform generation, Grid'5000

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Extraction à partir de Grid'5000 de plates-formes multi-grappes synthétiques pour la conduite d'expériences de simulation

Résumé : Ce rapport présente un catalogue de plates-formes de calcul distribué synthétiques mais néanmoins réalistes. Ces configurations sont destinées à des expériences de simulations dans le cadre de l'étude d'applications parallèles sur des plates-formes multi-grappes.

Mots-clés : Simulation, génération de plates-formes, Grid'5000

1 Introduction

The advent of parallel scientific computing of multi-cluster distributed platforms that span multiple organizations, often termed "grid computing", over the last decade has generated tremendous research activity as several applications can take advantage of such platforms. One key challenge is the development of techniques for maximizing application performance of these multi-cluster platforms, by redesigning the applications and/or by using novel scheduling algorithms that can account for the composite and heterogeneous nature of the platform. Most research works in this area are based on simulation, as it allows repeatable results, makes it possible to explore various platform scenarios at will, is not as labor-intensive or as costly as running experiments on a real platform, and often makes it possible to run enormous numbers of experiments quickly. Several toolkits exist for running these simulations, with two recent and popular ones being SimGrid [1] and GridSim [2]. Every researcher is then faced with the question: "which platform configurations should I simulate?" One approach is to generate random platform configurations using simple uniform probability distributions (e.g., for the number of clusters, for the number of nodes per cluster, for the nodes' compute speeds). While this approach is simple and makes it possible to generate large numbers of platform configurations it is not clear that many of the generated platforms are representative of the real world. A better approach consists in building statistical models of real-world clusters and to use these models to generate cluster configurations based one a large set of real-world cluster configurations [3]. Although these models should lead to more representative platform configurations, many researchers opt for using real-world platform configurations directly. The drawback is that typically only a few such configurations are constructed. Instead, we propose the use of several configurations that correspond to subsets of one of the most prominent large-scale multi-cluster platform deployed today, Grid'5000 [4]. This report presents an overview of the performance characteristics of Grid'5000 and of its clusters, and then present a compendium of platform configurations with specific characteristics, to be used for simulation experiments.

2 The Grid'5000 Clusters

The Grid'5000 platform consists of 20 clusters available in 9 sites in France: Bordeaux, Grenoble, Lille, Lyon, Nancy, Orsay, Rennes, Sophia, and Toulouse. Table 1 shows the number of cluster per site. Each cluster is identified by a name, and the table shows the architecture of it processors, the number of such processors, and the processor compute speed in GFlop/s as measured with the HPLinpack benchmark.

site	cluster	Processors	#proc	Gflop/s
Bordeaux	IBM	Opteron 248	48	3.542
	Dell	Xeon 3GHz	51	3.464
Grenoble	IDPOT	Xeon 2.4GHz	32	N/A
	Icluster2	Itanium 2	103	N/A
Lille	e326	Opteron 248	53	3.647
	e326mMC	Opteron 252	20	4.311
	e326mDC	Opteron 285	26	4.384
Lyon	Capricorne	Opteron 246	56	3.254
	Sagittaire	Opteron 250	70	3.865
Nancy	Grillon	Opteron 246	47	3.379
	Grelon	Xeon 5110	120	3.185
Orsay	GDX	Opteron 246	216	3.388
	GDX2	Opteron 250	126	4.040
Rennes	Paravent	Opteron 246	99	3.364
	Parasol	Opteron 248	64	3.573
	Paraquad	Xeon 5148LV	66	4.603
Sophia	Azur	Opteron 246	74	3.258
	Helios	Opteron 275	56	3.675
	Sol	Opteron 2218	50	4.389
Toulouse	Sun	Opteron 248	58	3.586
			1435	

Table 1: The Grid'5000 clusters.

Note that the table omits speed measurements for the two clusters available at the Grenoble site as we were unable to launch the HPLinpack benchmark on these clusters. To help appreciate the range of processor speeds in the Grid'5000 platform Figure 1 shows processor speed (on the x-axis) for the processors/cores of the 18 clusters on which we were able to run the benchmark. We see that the platform is fairly heterogeneous, with the fastest processors computing about 45% faster than the slowest processors.

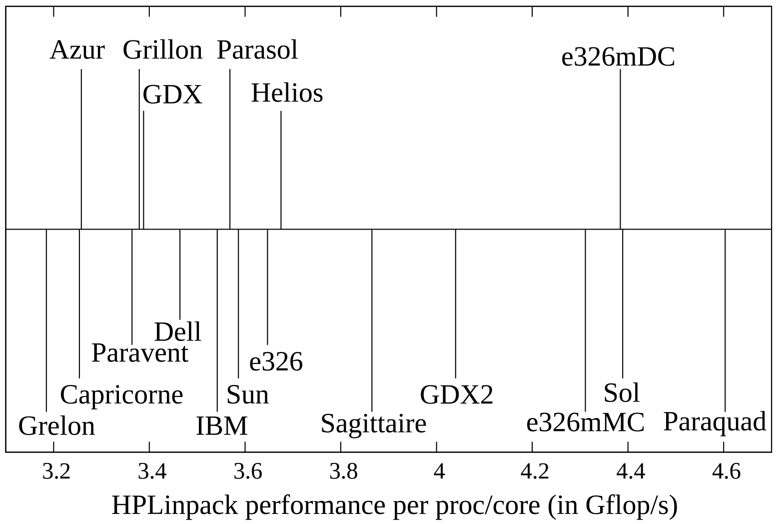

Figure 1: Grid'5000 Processor Speeds (GFlop/s).

In the next two sections we define collections of subsets of the Grid'5000 platform, in a view to spanning a sound spectrum of platform charateristics and thus to being useful for driving sound simulation experiments. One important characteristics is the degree of processor heterogeneity in the platorm. We define the degree of heterogeneity, h, as $100 \times (s_{max}/s_{min} - 1)$, where s_{max} (resp. s_{min}) is the maximum (resp. minimum) processor speed (in GFlop/s) in the platform. A value of 0 indicates a perfectly homogeneous system. The h value denotes the maximum relative difference in compute speed in the platform, in percentage. Given our 18 clusters in Grid'5000, no multi-cluster platform is homogeneous. We thus consider what we term "almost homogeneous" platforms, that is platforms with a low h value ($h < 10$).

3 Deriving *Almost* Homogeneous Platforms

Out of our 18-cluster Grid'5000 platform we can extract multi-cluster configurations that are *almost* homogeneous (in terms of compute speed) with various numbers of clusters. These configurations, which are described below, for 2, 4, and 8 clusters.

With 2 Clusters – Table 2 shows 10 almost homogeneous 2-cluster configurations, named "HOM_2.x", for $x = 1, \ldots, 10$. For each configuration the table shows which two clusters are used in the configuration, showing the number of nodes in these clusters. The last two columns of the table show the total number of processors in the configuration, as well as the configuration's degree of heterogeneity, h. Recall that for all platforms in the section $h \leq 10\%$.

With 4 Clusters – Table 2 is similar to Table 2, but shows 4-cluster configurations. There are 10 such configurations as well, names "HOM_4.x", for $x = 1, \ldots, 10$.

With 8 Clusters – Table 3 is similar to the previous two tables, but shows 8-cluster configurations. There are 10 such configurations as well, names "HOM_8.x", for $x = 1, \ldots, 10$.

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse		
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h
HOM_2.1						56									74				130	0.12
HOM_2.2					26												50		76	0.11
HOM_2.3									47	216									263	0.27
HOM_2.4													64					58	122	0.36
HOM_2.5									47			99							146	0.45
HOM_2.6										216		99							315	0.71
HOM_2.7			53													56			109	0.77
HOM_2.8	48												64						112	0.88
HOM_2.9			53															58	111	1.7
HOM_2.10	48	51																	99	2.25

Table 2: Almost homogeneous platforms with 2 clusters.

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse		
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h
HOM_4.1		51							47	216		99							413	2.97
HOM_4.2			53										64			56		58	231	2.85
HOM_4.3	48		53										64					58	223	2.96
HOM_4.4						56			47			99			74				276	3.84
HOM_4.5									47	216		99			74				436	3.99
HOM_4.6						56				216		99			74				445	4.12
HOM_4.7						56			47	216					74				393	4.12
HOM_4.8						56			47	216		99							418	4.12
HOM_4.9	48	51											64					58	221	3.52
HOM_4.10	48	51							47	216									362	4.82

Table 3: Almost homogeneous platforms with 4 clusters.

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse		
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h
HOM_8.1	48	51	53						47	216		99	64					58	636	8.41
HOM_8.2	48	51	53						47	216			64			56		58	593	8.76
HOM_8.3	48	51	53							216		99	64			56		58	645	9.24
HOM_8.4	48	51	53						47			99	64			56		58	476	9.24
HOM_8.5	48		53						47	216		99	64			56		58	641	9.24
HOM_8.6		51	53						47	216		99	64			56		58	644	9.24
HOM_8.7	48	51	53						47	216		99				56		58	628	9.24
HOM_8.8	48	51	53						47	216		99	64			56			634	9.24
HOM_8.9	48	51							47	216		99	64			56		58	639	9.24
HOM_8.10	48	51				56			47	216		99	64		74				655	9.8

Table 4: Almost homogeneous platforms with 8 clusters.

4 Deriving Heterogeneous platforms

With 2 Clusters– When deriving heterogeneous 2-cluster platforms, we define the *heterogeneity factor* as $h = ((fastest/slowest) - 1) \times 100$, where $fastest$ is the compute speed of the fastest of the two clusters, and $slowest$ is the compute speed of the slowest of the two clusters.

Table 5 shows 3 such configurations, named "HET_2_40.x", for $x = 1, \ldots, 3$, for which the heterogeneity factor is $h \geq 40$. Table 6 shows 15 configurations, named "HET_2_30.x", for $x = 1, \ldots, 15$, for which $40 > h \geq 30$. Table 7 shows 31 configurations, named "HET_2_20.x", for $x = 1, \ldots, 31$, for which the heterogeneity factor is $30 > h \geq 20$. Table 8 shows 33 configurations, named "HET_2_10.x", for $x = 1, \ldots, 33$, for which the heterogeneity factor is $20 > h \geq 10$.

For platforms that contain more than 2 clusters, or in other words platforms that consist of some "fast" clusters and of some "slow" clusters, we define h_{min} and h_{max} as follows. h_{min} is the heterogeneity factor, as defined above for 2-cluster platforms, between the fastest of the slow clusters and the slowest of the fast clusters. h_{max} is simply defined as the heterogeneity factor between the slowest cluster and the fastest cluster. Also, we limit the number of platorm configurations whenever applicable. For instance, given the clusters in Grid'5000, when trying to generate configurations with 1 fast cluster and 3 slow clusters, we could end up choosing the 3 slow clusters among 7 possibilities, for a total of 210 platform configurations, with many of these configurations virtually identical. Therefore, we chose to ignore many of these possibilities in order to keep the number of platform configurations reasonably low.

With 1 Fast and 3 Slow Clusters– Table 9 shows 14 platform configurations, named "HET_4_1f_3s_30.x", for $x = 1, \ldots, 14$, for which the heterogeneity factor is $h \geq 30$. Table 10 shows 22 configurations, named "HET_4_1f_3s_20.x", for $x = 1, \ldots, 22$, for which $30 > h \geq 10$. Table 11 shows 13 configurations, named "HET_4_1f_3s_10.x", for $x = 1, \ldots, 13$, for which $20 > h \geq 10$.

With 2 Fast and 2 Slow Clusters– Table 12 shows 14 platform configurations, named "HET_4_2f_2s_30.x", for $x = 1, \ldots, 14$, for which the heterogeneity factor is $40 > h \geq 30$. Table 13 shows 24 configurations, named "HET_4_2f_2s_20.x", for $x = 1, \ldots, 24$, for which $30 > h \geq 10$. Table 14 shows 16 configurations, named "HET_4_2f_2s_10.x", for $x = 1, \ldots, 16$, for which $20 > h \geq 10$.

With 3 Fast and 1 Slow Clusters– Table 15 shows all the platform configurations comprising 3 fast and 1 slow clusters. The first 4 configurations, named "HET_4_3f_1s_30.x", for $x = 1, \ldots, 4$, have an heterogeneity factor $h \geq 30$, the next 13 configurations, named "HET_4_3f_1s_20.x", for $x = 1, \ldots, 13$, for which $30 > h \geq 10$, and the last 13 configurations, named "HET_4_3f_1s_10.x", for $x = 1, \ldots, 13$, for which $20 > h \geq 10$.

For the 8-cluster configurations hereafter we do not separate them in different tables depending on the value of h, but simply enforce that $h > 20$ and refer the reader to the referenced tables for specific h values for each configuration.

With 1 Fast and 7 Slow Clusters– Table 16 shows 20 platform configurations, named "HET_8_1f_7s.x", for $x = 1, \ldots, 20$.

With 2 Fast and 6 Slow Clusters– Table 17 shows 33 platform configurations, named "HET_8_2f_6s.x", for $x = 1, \ldots, 33$.

With 3 Fast and 5 Slow Clusters– Table 18 shows 25 platforms, named "HET_8_3f_5s.x", for $x = 1, \ldots, 25$.

With 4 Fast and 4 Slow Clusters– Table 19 shows 11 platforms, named "HET_8_4f_4s.x", for $x = 1, \ldots, 11$.

With 5 Fast and 3 Slow Clusters– Table 20 shows 4 platforms, named "HET_8_5f_3s.x", for $x = 1, \ldots, 4$.

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse		
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h
HET_2_40.1								120						66					186	44.52
HET_2_40.2						56								66					122	41.46
HET_2_40.3														66	74				140	41.28

Table 5: Heterogeneous platforms with 2 clusters ($h \geq 40$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse		
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h
HET_2_30.1									47					66					113	36.22
HET_2_30.2										216				66					282	35.86
HET_2_30.3												99		66					165	36.83
HET_2_30.4		51												66					117	32.88
HET_2_30.5								120									50		170	37.8
HET_2_30.6						56											50		106	34.88
HET_2_30.7															74		50		124	34.71
HET_2_30.8												99					50		149	30.47
HET_2_30.9					26			120											146	37.65
HET_2_30.10					26	56													82	34.73
HET_2_30.11					26										74				100	30.32
HET_2_30.12					26							99							125	34.56
HET_2_30.13				20				120											140	35.35
HET_2_30.14				20		56													76	32.48
HET_2_30.15				20											74				94	32.32

Table 6: Heterogeneous platforms with 2 clusters ($40 > h \geq 30$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse		
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h
HET_2_20.1	48													66					114	29.95
HET_2_20.2													64	66					130	28.83
HET_2_20.3														66				58	124	28.36
HET_2_20.4			53											66					119	26.21
HET_2_20.5														66		56			122	25.25
HET_2_20.6									47								50		97	29.89
HET_2_20.7										216							50		266	29.55
HET_2_20.8		51															50		101	26.7
HET_2_20.9	48																50		98	23.91
HET_2_20.10													64				50		114	22.84
HET_2_20.11																	50	58	108	22.39
HET_2_20.12			53														50		103	20.35
HET_2_20.13					26				47										73	29.74
HET_2_20.14					26					216									242	29.4
HET_2_20.15		51			26														77	26.56
HET_2_20.16	48				26														74	23.77
HET_2_20.17					26								64						90	22.7
HET_2_20.18					26													58	84	22.25
HET_2_20.19					26											56			82	20.21
HET_2_20.20				20								99							119	28.15
HET_2_20.21				20					47										67	27.58
HET_2_20.22				20						216									236	27.24
HET_2_20.23		51		20															71	24.45
HET_2_20.24	48			20															68	21.71
HET_2_20.25				20									64						84	20.65
HET_2_20.26				20														58	78	20.22
HET_2_20.27								120			126								246	26.84
HET_2_20.28						56					126								182	24.15
HET_2_20.29											126				74				200	24
HET_2_20.30											126	99							225	20.1
HET_2_20.31							70	120											190	21.35

Table 7: Heterogeneous platforms with 2 clusters ($30 > h \geq 20$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse		
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h
HET_2_10.1							70							66					136	19.09
HET_2_10.2											126			66					192	13.94
HET_2_10.3																56	50		106	19.43
HET_2_10.4							70										50		120	13.56
HET_2_10.5					26											56			82	19.29
HET_2_10.6					26		70												96	13.43
HET_2_10.7			53	20															73	18.21
HET_2_10.8				20												56			76	17.31
HET_2_10.9				20			70												90	11.54
HET_2_10.10									47		126								173	19.56
HET_2_10.11										216	126								342	19.24
HET_2_10.12		51									126								177	16.63
HET_2_10.13	48										126								174	14.06
HET_2_10.14											126		64						190	13.07
HET_2_10.15											126							58	184	12.66
HET_2_10.16			53								126								179	10.78
HET_2_10.17						56	70												126	18.78
HET_2_10.18							70								74				144	18.63
HET_2_10.19							70					99							169	14.89
HET_2_10.20							70		47										117	14.38
HET_2_10.21							70			216									286	14.08
HET_2_10.22		51					70												121	11.58
HET_2_10.23								120								56			176	15.38
HET_2_10.24						56										56			112	12.94
HET_2_10.25															74	56			130	27.58
HET_2_10.26			53					120											173	27.24
HET_2_10.27			53			56													109	24.45
HET_2_10.28			53												74				127	21.71
HET_2_10.29								120										58	178	20.65
HET_2_10.30						56												58	114	20.22
HET_2_10.31															74			58	132	10.07
HET_2_10.32								120					64						184	13.43
HET_2_10.33	48							120											168	18.21

Table 8: Heterogeneous platforms with 2 clusters ($20 > h \geq 10$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_4_1f_3s_30.1						56		120						66	74				316	44.52	41.28
HET_4_1f_3s_30.2									47	216		99		66					428	36.83	35.86
HET_4_1f_3s_30.3		51							47			99		66					263	36.83	35.86
HET_4_1f_3s_30.4		51								216		99		66					432	36.83	35.86
HET_4_1f_3s_30.5		51							47	216				66					380	36.22	35.86
HET_4_1f_3s_30.6						56		120							74		50		300	37.8	34.71
HET_4_1f_3s_30.7						56		120				99					50		325	37.8	30.47
HET_4_1f_3s_30.8								120				99			74		50		343	37.8	30.47
HET_4_1f_3s_30.9						56						99			74		50		279	34.88	30.47
HET_4_1f_3s_30.10					26	56		120							74				276	37.65	34.56
HET_4_1f_3s_30.11					26	56		120				99							301	37.65	30.32
HET_4_1f_3s_30.12					26			120				99			74				319	37.65	30.32
HET_4_1f_3s_30.13					26	56						99			74				255	34.73	30.32
HET_4_1f_3s_30.14				20		56		120							74				270	35.35	32.32

Table 9: Heterogeneous platforms with 4 clusters (1 fast and 3 slow – $h \geq 30$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_4_1f_3s_20.1	48												64	66				58	236	29.95	28.36
HET_4_1f_3s_20.2			53										64	66				58	241	28.83	26.21
HET_4_1f_3s_20.3			53											66		56		58	233	28.36	26.21
HET_4_1f_3s_20.4		51							47	216							50		364	29.89	26.7
HET_4_1f_3s_20.5	48	51								216							50		365	29.55	26.7
HET_4_1f_3s_20.6	48	51											64				50		213	26.7	23.91
HET_4_1f_3s_20.7	48												64				50	58	220	23.91	22.84
HET_4_1f_3s_20.8			53										64				50	58	225	22.84	20.35
HET_4_1f_3s_20.9		51			26				47	216									340	29.74	26.56
HET_4_1f_3s_20.10	48	51			26					216									341	29.4	23.77
HET_4_1f_3s_20.11	48	51			26								64						189	26.56	22.7
HET_4_1f_3s_20.12	48				26								64					58	196	23.77	22.25
HET_4_1f_3s_20.13			53		26								64					58	201	22.7	20.21
HET_4_1f_3s_20.14				20					47	216		99							382	27.58	27.24
HET_4_1f_3s_20.15		51		20					47	216									334	27.24	24.45
HET_4_1f_3s_20.16	48	51		20						216									335	24.45	21.71
HET_4_1f_3s_20.17	48	51		20									64						183	21.71	20.65
HET_4_1f_3s_20.18	48			20									64					58	190	20.65	20.22
HET_4_1f_3s_20.19						56		120			126				74				376	26.84	24
HET_4_1f_3s_20.20						56		120			126	99							401	26.84	20.1
HET_4_1f_3s_20.21								120			126	99			74				419	26.84	20.1
HET_4_1f_3s_20.22						56					126	99			74				355	24.15	20.1

Table 10: Heterogeneous platforms with 4 clusters (1 fast and 3 slow – $30 > h \geq 20$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_4_1f_3s_10.1			53	20			70									56			199	18.21	11.54
HET_4_1f_3s_10.2		51							47	216	126								440	19.56	16.63
HET_4_1f_3s_10.3	48	51								216	126								441	19.24	14.06
HET_4_1f_3s_10.4	48	51									126		64						289	16.63	13.07
HET_4_1f_3s_10.5	48										126		64					58	296	14.06	12.66
HET_4_1f_3s_10.6			53								126		64					58	301	13.07	10.78
HET_4_1f_3s_10.7						56	70					99			74				299	18.78	14.89
HET_4_1f_3s_10.8							70		47			99			74				290	18.63	14.89
HET_4_1f_3s_10.9							70		47	216		99							432	18.63	14.08
HET_4_1f_3s_10.10		51					70		47	216									384	14.38	11.58
HET_4_1f_3s_10.11						56		120							74	56			306	15.38	12.8
HET_4_1f_3s_10.12			53			56		120							74				303	14.51	11.94
HET_4_1f_3s_10.13						56		120							74			58	308	12.59	10.07

Table 11: Heterogeneous platforms with 4 clusters (1 fast and 3 slow – $20 > h \geq 10$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_4_2f_2s_30.1					26	56		120									50		252	37.8	34.73
HET_4_2f_2s_30.2					26			120							74		50		270	37.8	34.56
HET_4_2f_2s_30.3					26			120				99					50		295	37.8	30.32
HET_4_2f_2s_30.4					26	56									74		50		206	34.88	34.56
HET_4_2f_2s_30.5					26	56						99					50		231	34.88	30.32
HET_4_2f_2s_30.6					26							99			74		50		249	34.71	34.56
HET_4_2f_2s_30.7				20		56		120									50		246	37.8	32.48
HET_4_2f_2s_30.8				20				120							74		50		264	37.8	32.32
HET_4_2f_2s_30.9				20		56									74		50		200	34.88	32.48
HET_4_2f_2s_30.10				20		56						99					50		225	34.88	32.48
HET_4_2f_2s_30.11				20								99			74		50		243	34.71	32.32
HET_4_2f_2s_30.12				20	26	56		120											222	37.65	32.48
HET_4_2f_2s_30.13				20	26			120							74				240	37.65	32.32
HET_4_2f_2s_30.14				20	26	56									74				176	34.73	32.32

Table 12: Heterogeneous platforms with 4 clusters (2 fast and 2 slow – $h \geq 30$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_4_2f_2s_20.1	48												64	66			50		228	29.95	22.84
HET_4_2f_2s_20.2													64	66			50	58	238	28.83	22.39
HET_4_2f_2s_20.3			53											66			50	58	227	28.36	20.35
HET_4_2f_2s_20.4	48				26								64	66					204	29.95	22.7
HET_4_2f_2s_20.5					26								64	66				58	214	28.83	22.25
HET_4_2f_2s_20.6			53		26									66				58	203	28.36	20.21
HET_4_2f_2s_20.7	48			20									64	66					198	29.95	20.65
HET_4_2f_2s_20.8				20									64	66				58	208	28.83	20.22
HET_4_2f_2s_20.9					26				47	216							50		339	29.89	29.4
HET_4_2f_2s_20.10		51			26					216							50		343	29.55	26.56
HET_4_2f_2s_20.11	48	51			26												50		175	19.24	23.77
HET_4_2f_2s_20.12	48				26								64				50		188	16.63	22.7
HET_4_2f_2s_20.13					26								64				50	58	198	14.06	22.25
HET_4_2f_2s_20.14			53		26												50	58	187	13.07	20.21
HET_4_2f_2s_20.15				20					47	216							50		333	18.78	27.24
HET_4_2f_2s_20.16		51		20						216							50		337	18.63	24.45
HET_4_2f_2s_20.17	48	51		20													50		169	26.7	21.71
HET_4_2f_2s_20.18	48			20									64				50		182	34.71	20.65
HET_4_2f_2s_20.19				20									64				50	58	192	37.8	20.22
HET_4_2f_2s_20.20				20	26				47	216									309	37.8	27.24
HET_4_2f_2s_20.21		51		20	26					216									313	34.88	24.45
HET_4_2f_2s_20.22	48	51		20	26														145	34.88	21.71
HET_4_2f_2s_20.23	48			20	26								64						158	34.71	20.65
HET_4_2f_2s_20.24				20	26								64					58	168	37.65	20.22

Table 13: Heterogeneous platforms with 4 clusters (2 fast and 2 slow – $30 > h \geq 20$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_4_2f_2s_10.1					26		70									56	50		202	34.71	13.43
HET_4_2f_2s_10.2							70		47	216	126								459	34.71	14.08
HET_4_2f_2s_10.3		51					70		47		126								294	19.24	11.58
HET_4_2f_2s_10.4		51					70			216	126								463	19.24	11.58
HET_4_2f_2s_10.5						56	70								74	56			256	34.71	12.8
HET_4_2f_2s_10.6			53			56	70								74				253	34.71	11.94
HET_4_2f_2s_10.7						56	70								74			58	258	34.71	10.07
HET_4_2f_2s_10.8			53			56		120								56			285	37.8	12.08
HET_4_2f_2s_10.9			53					120							74	56			303	15.38	11.94
HET_4_2f_2s_10.10			53			56									74	56			239	12.94	11.94
HET_4_2f_2s_10.11						56		120								56		58	290	15.38	10.2
HET_4_2f_2s_10.12								120							74	56		58	308	15.38	10.07
HET_4_2f_2s_10.13						56									74	56		58	244	12.94	10.07
HET_4_2f_2s_10.14			53			56		120										58	287	14.51	10.2
HET_4_2f_2s_10.15			53					120							74			58	305	14.51	10.07
HET_4_2f_2s_10.16			53			56									74			58	241	12.08	10.07

Table 14: Heterogeneous platforms with 4 clusters (2 fast and 2 slow – $20 > h \geq 10$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_4_3f_1s_30.1					26							99		66			50		241	36.83	30.32
HET_4_3f_1s_30.2				20	26			120									50		216	37.8	35.35
HET_4_3f_1s_30.3				20	26	56											50		152	34.88	32.48
HET_4_3f_1s_30.4				20	26										74		50		170	34.71	32.32
HET_4_3f_1s_20.1	48				26									66			50		190	29.95	23.77
HET_4_3f_1s_20.2					26								64	66			50		206	28.83	22.7
HET_4_3f_1s_20.3					26									66			50	58	200	28.36	22.25
HET_4_3f_1s_20.4			53		26									66			50		195	26.21	20.21
HET_4_3f_1s_20.5	48			20										66			50		184	29.95	21.71
HET_4_3f_1s_20.6				20									64	66			50		200	28.83	20.65
HET_4_3f_1s_20.7				20										66			50	58	194	28.36	20.22
HET_4_3f_1s_20.8				20	26				47								50		143	29.89	27.58
HET_4_3f_1s_20.9				20	26					216							50		312	29.55	27.24
HET_4_3f_1s_20.10		51		20	26												50		147	26.7	24.45
HET_4_3f_1s_20.11	48			20	26												50		144	23.91	21.71
HET_4_3f_1s_20.12				20	26								64				50		160	22.84	20.65
HET_4_3f_1s_20.13				20	26												50	58	154	22.39	20.22
HET_4_3f_1s_10.1					26		70							66			50		212	19.09	13.43
HET_4_3f_1s_10.2				20			70							66			50		206	19.09	11.54
HET_4_3f_1s_10.3				20	26											56	50		152	19.43	17.31
HET_4_3f_1s_10.4				20	26		70										50		166	13.56	11.54
HET_4_3f_1s_10.5			53			56	70									56			235	18.78	12.08
HET_4_3f_1s_10.6			53				70								74	56			253	18.63	11.94
HET_4_3f_1s_10.7						56	70									56		58	240	18.78	10.2
HET_4_3f_1s_10.8							70								74	56		58	258	18.63	10.07
HET_4_3f_1s_10.9			53			56	70											58	237	18.78	10.2
HET_4_3f_1s_10.10			53				70								74			58	255	18.63	10.07
HET_4_3f_1s_10.11			53					120								56		58	287	15.38	12.59
HET_4_3f_1s_10.12			53			56										56		58	223	12.94	10.2
HET_4_3f_1s_10.13			53												74	56		58	241	12.8	10.07

Table 15: Heterogeneous platforms with 4 clusters (3 fast and 1 slow – $40 > h \geq 10$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_8_1f_7s.1		51				56		120	47	216		99		66	74				729	44.52	32.88
HET_8_1f_7s.2	48	51				56			47	216		99		66	74				657	41.46	29.95
HET_8_1f_7s.3	48	51							47	216		99	64	66	74				665	41.28	28.83
HET_8_1f_7s.4	48	51							47	216		99	64	66				58	649	36.83	28.36
HET_8_1f_7s.5	48	51	53						47	216			64	66				58	603	36.22	26.21
HET_8_1f_7s.6	48	51	53							216			64	66		56		58	612	35.86	25.25
HET_8_1f_7s.7		51				56		120	47	216		99			74		50		713	37.8	26.7
HET_8_1f_7s.8	48	51				56			47	216		99			74		50		641	34.88	23.91
HET_8_1f_7s.9	48	51							47	216		99	64		74		50		649	34.71	22.84
HET_8_1f_7s.10	48	51							47	216		99	64				50	58	633	30.47	22.39
HET_8_1f_7s.11	48	51	53						47	216			64				50	58	587	29.89	20.35
HET_8_1f_7s.12		51			26	56		120	47	216		99			74				689	37.65	26.56
HET_8_1f_7s.13	48	51			26	56			47	216		99			74				617	34.73	23.77
HET_8_1f_7s.14	48	51			26				47	216		99	64		74				625	34.56	22.7
HET_8_1f_7s.15	48	51			26				47	216		99	64					58	609	30.32	22.25
HET_8_1f_7s.16	48	51	53		26				47	216			64					58	563	29.74	20.21
HET_8_1f_7s.17		51		20		56		120	47	216		99			74				683	35.35	24.45
HET_8_1f_7s.18	48	51		20		56			47	216		99			74				611	32.48	21.71
HET_8_1f_7s.19	48	51		20					47	216		99	64		74				619	32.32	20.65
HET_8_1f_7s.20	48	51		20					47	216		99	64					58	603	28.15	20.22

Table 16: Heterogeneous platforms with 8 clusters (1 fast and 7 slow – $40 > h \geq 20$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_8_2f_6s.1						56		120	47	216		99		66	74		50		728	44.52	29.55
HET_8_2f_6s.2		51				56			47	216		99		66	74		50		659	41.46	26.7
HET_8_2f_6s.3	48	51							47	216		99		66	74		50		651	41.28	23.91
HET_8_2f_6s.4	48	51							47	216		99	64	66			50		641	36.83	22.84
HET_8_2f_6s.5	48	51							47	216			64	66			50	58	600	36.22	22.39
HET_8_2f_6s.6	48	51	53							216			64	66			50	58	606	35.86	20.35
HET_8_2f_6s.7					26	56		120	47	216		99		66	74				704	44.52	29.4
HET_8_2f_6s.8		51			26	56			47	216		99		66	74				635	41.46	26.56
HET_8_2f_6s.9	48	51			26				47	216		99		66	74				627	41.28	23.77
HET_8_2f_6s.10	48	51			26				47	216		99	64	66					617	36.83	22.7
HET_8_2f_6s.11	48	51			26				47	216			64	66				58	576	36.22	22.25
HET_8_2f_6s.12	48	51	53		26					216			64	66				58	582	35.86	20.21
HET_8_2f_6s.13				20		56		120	47	216		99		66	74				698	44.52	27.24
HET_8_2f_6s.14		51		20		56			47	216		99		66	74				629	41.46	24.45
HET_8_2f_6s.15	48	51		20					47	216		99		66	74				621	41.28	21.71
HET_8_2f_6s.16	48	51		20					47	216		99	64	66					611	36.83	20.65
HET_8_2f_6s.17	48	51		20					47	216			64	66				58	570	36.22	20.22
HET_8_2f_6s.18					26	56		120	47	216		99			74		50		688	37.8	29.4
HET_8_2f_6s.19		51			26	56			47	216		99			74		50		619	34.88	26.56
HET_8_2f_6s.20	48	51			26				47	216		99			74		50		611	34.71	23.77
HET_8_2f_6s.21	48	51			26				47	216		99	64				50		601	30.47	22.7
HET_8_2f_6s.22	48	51			26				47	216			64				50	58	560	29.89	22.25
HET_8_2f_6s.23	48	51	53		26					216			64				50	58	566	29.55	20.21
HET_8_2f_6s.24				20		56		120	47	216		99			74		50		682	37.8	27.24
HET_8_2f_6s.25		51		20		56			47	216		99			74		50		613	34.88	24.45
HET_8_2f_6s.26	48	51		20					47	216		99			74		50		605	34.71	21.71
HET_8_2f_6s.27	48	51		20					47	216		99	64				50		595	30.47	20.65
HET_8_2f_6s.28	48	51		20					47	216			64				50	58	554	29.89	20.22
HET_8_2f_6s.29				20	26	56		120	47	216		99			74				658	37.65	27.24
HET_8_2f_6s.30		51		20	26	56			47	216		99			74				589	34.73	24.45
HET_8_2f_6s.31	48	51		20	26				47	216		99			74				581	34.56	21.71
HET_8_2f_6s.32	48	51		20	26				47	216		99	64						571	30.32	20.65
HET_8_2f_6s.33	48	51		20	26				47	216			64					58	530	29.74	20.22

Table 17: Heterogeneous platforms with 8 clusters (2 fast and 6 slow – $40 > h \geq 20$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_8_3f_5s.1					26	56		120	47			99		66	74		50		538	44.52	29.74
HET_8_3f_5s.2					26	56			47	216		99		66	74		50		634	41.46	29.4
HET_8_3f_5s.3		51			26				47	216		99		66	74		50		629	41.28	26.56
HET_8_3f_5s.4	48	51			26				47	216		99		66			50		603	36.83	23.77
HET_8_3f_5s.5	48	51			26				47	216			64	66			50		568	36.22	22.7
HET_8_3f_5s.6	48	51			26					216			64	66			50	58	579	35.86	22.25
HET_8_3f_5s.7	48	51	53		26					216			64	66			50	58	632	32.88	20.21
HET_8_3f_5s.8				20		56		120	47			99		66	74		50		532	44.52	27.58
HET_8_3f_5s.9				20		56			47	216		99		66	74		50		628	41.46	27.24
HET_8_3f_5s.10		51		20					47	216		99		66	74		50		623	41.28	24.45
HET_8_3f_5s.11	48	51		20					47	216		99		66			50		597	36.83	21.71
HET_8_3f_5s.12	48	51		20					47	216			64	66			50		562	36.22	20.65
HET_8_3f_5s.13	48	51		20						216			64	66			50	58	573	35.86	20.22
HET_8_3f_5s.14				20	26	56		120	47			99		66	74				508	44.52	27.58
HET_8_3f_5s.15				20	26	56			47	216		99		66	74				604	41.46	27.24
HET_8_3f_5s.16		51		20	26				47	216		99		66	74				599	41.28	24.45
HET_8_3f_5s.17	48	51		20	26				47	216		99		66					573	36.83	21.71
HET_8_3f_5s.18	48	51		20	26				47	216			64	66					538	36.22	20.65
HET_8_3f_5s.19	48	51		20	26					216			64	66				58	549	35.86	20.22
HET_8_3f_5s.20				20	26	56		120	47			99			74		50		492	37.8	27.58
HET_8_3f_5s.21				20	26	56			47	216		99			74		50		588	34.88	27.24
HET_8_3f_5s.22		51		20	26				47	216		99			74		50		583	34.71	24.45
HET_8_3f_5s.23	48	51		20	26				47	216		99					50		557	30.47	21.71
HET_8_3f_5s.24	48	51		20	26				47	216			64				50		522	29.89	20.65
HET_8_3f_5s.25	48	51		20	26					216			64				50	58	533	29.55	20.22

Table 18: Heterogeneous platforms with 8 clusters (3 fast and 5 slow – $40 > h \geq 20$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_8_4f_4s.1				20	26	56		120				99		66	74		50		511	44.52	28.15
HET_8_4f_4s.2				20	26	56			47			99		66	74		50		438	41.46	27.58
HET_8_4f_4s.3				20	26				47	216		99		66	74		50		598	41.28	27.24
HET_8_4f_4s.4		51		20	26				47	216		99		66			50		575	36.83	24.45
HET_8_4f_4s.5	48	51		20	26				47	216				66			50		524	36.22	21.71
HET_8_4f_4s.6	48	51		20	26					216			64	66			50		541	35.86	20.65
HET_8_4f_4s.7	48	51		20	26								64	66			50	58	383	32.88	20.22
HET_8_4f_4s.8					26	56		120			126	99		66	74		50		617	44.52	20.1
HET_8_4f_4s.9				20		56		120			126	99		66	74		50		611	44.52	20.1
HET_8_4f_4s.10				20	26	56		120			126	99		66	74				587	44.52	20.1
HET_8_4f_4s.11				20	26	56		120			126	99			74		50		571	37.8	20.1

Table 19: Heterogeneous platforms with 8 clusters (4 fast and 4 slow – $40 > h \geq 20$).

	Bordeaux		Lille			Lyon		Nancy		Orsay		Rennes			Sophia			Toulouse			
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total	h_{max}	h_{min}
HET_8_5f_3s.1				20	26	56		120			126			66	74		50		538	44.52	24
HET_8_5f_3s.2				20	26	56		120			126	99		66			50		563	44.52	20.1
HET_8_5f_3s.3				20	26			120			126	99		66	74		50		581	44.52	20.1
HET_8_5f_3s.4				20	26	56					126	99		66	74		50		517	41.46	20.1

Table 20: Heterogeneous platforms with 8 clusters (5 fast and 3 slow – $40 > h \geq 20$).

5 Conclusion

In this report we have listed a number of multi-cluster platform configurations extracted from a real-world grid deployment, Grid'5000, for a total of 356 individual configurations. These configurations contain 1, 2, 4, or 8 clusters, and can be categorized as homogeneous or heterogeneous, as summarized in Table 21. We argue that these configurations provide a sound basis for driving simulation experiments that explore the execution of parallel applications on multi-cluster platforms.

type	1 cluster	2 clusters	4 clusters	8 clusters	total
homogeneous	18	10	10	10	48
heterogeneous	-	82	133	93	308
Total	18	92	143	103	**356**

Table 21: Summary of platform configurations extracted from Grid'5000.

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