

PCT REQUEST

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0-2	International Filing Date	23 JAN 2019 (23.01.2019)
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0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
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0-7	Applicant's or agent's file reference	P85465PCT
I	Title of Invention	APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES
II	Applicant	
II-1	This person is	Applicant only
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IV-1-6	Agent's registration No.	100043299
V	DESIGNATIONS	
V-1	The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.	
VI-1	Priority claim of earlier regional application	
VI-1-1	Filing date	23 January 2018 (23.01.2018)
VI-1-2	Number	18152903.3
VI-1-3	Regional Office	EP
VI-2	Priority document request	
	The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1

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VI-3	Incorporation by reference : where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.		
VII-1	International Searching Authority Chosen	European Patent Office (EPO) (ISA/EP)	
VIII	Declarations	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	—	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	—	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	—	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	—	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	—	
IX	Check list	Number of sheets	Electronic file(s) attached
IX-1	Request (including declaration sheets)	4	✓
IX-2	Description	6	✓
IX-3	Claims	2	✓
IX-4	Abstract	1	✓
IX-5	Drawings	1	✓
IX-7	TOTAL	14	
	Accompanying Items	Paper document(s) attached	Electronic file(s) attached
IX-8	Fee calculation sheet	—	✓
IX-20	Figure of the drawings which should accompany the abstract	1	
IX-21	Language of filing of the international application	English	
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X-1-1	Name (LAST, First)	TOMLINSON, Edward James	
X-1-3	Capacity (if such capacity is not obvious from reading the request)	(Representative)	

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Patentanmeldung Nr.

Patent application No.

Demande de brevet n°

18152903.3 / EP18152903

The organisation code and number of your priority application, to be used for filing abroad under the Paris Convention, is EP18152903.

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.



V. Joseph

Anmeldung Nr:
Application no.: **18152903.3**
Demande no. :

Anmeldetag:
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Anmelder / Applicant(s) / Demandeur(s):

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Bezeichnung der Erfindung / Title of the invention / Titre de l'invention:
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Si aucun titre n'est indiqué, ou si la demande a été déposée dans une langue autre qu'une langue officielle de l'OEB, se référer à la description pour le titre original.)

**APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS
COMPUTE RESOURCES**

In Anspruch genommene Priorität(en) / Priority(Priorities) claimed / Priorité(s) revendiquée(s)
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Application runtime determined dynamical allocation
of heterogeneous compute resources

The present invention relates to a mechanism for executing computation tasks within a computation environment, in particular a heterogeneous computation environment adapted for parallel processing of a computation task.

The present invention is a development of the system described in earlier application WO 2012/049247 A1, WO '247, which describes a cluster computer architecture comprising a plurality of computation nodes and a plurality of boosters connected together via a communication interface. A resource manager is responsible for assigning one or more of the boosters and the computation nodes to each other in a dynamic manner during runtime. An example for such dynamic process management is described in Clauss et al. "Dynamic Process Management with Allocation-internal Co-Scheduling towards Interactive Supercomputing", COSH 2016 Jan 19, Prague, CZ, incorporated herein by reference for all purposes.

The arrangement of WO '247 is further described by Eicker et al. in "The DEEP Project An alternative approach to heterogeneous cluster-computing in the many core era", Concurrency Computat.: Pract. Exper. 2016; 28:2394-2411. The heterogeneous system which is described comprises a plurality of computation nodes and a plurality of booster nodes connected by a switchable network. In order to process an application, the application is "taskified" in order to provide an indication which tasks may be off-loaded from a computation node to a booster. This taskifying is achieved by the application developer annotating the code with pragmas indicating dependencies between different tasks and in addition labels indicating the highly scalable code parts which are to be processed by a booster. Scalability in this context means when the load offered to the service increases, an incremental and linear increase in hardware can maintain the same per-user level of service.

US 2017/0262319 A1 describes in one aspect runtime processes that can fully or partially automate the distribution of data and mapping of tasks to computing resources. A so-called tuning expert, i.e. a human operator, may still be required for mapping actions to available resources. In essence it is described how a given application to be computed can be mapped on a given computing hierarchy.

The present invention provides a method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of computation nodes and plurality of booster nodes being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks,
5 wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; using information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes to generate further distribution of the sub-tasks between the computation nodes and booster nodes for processing thereby in
10 further computing iteration.

Preferably, the information is provided by respective daemons operating in each of the computation and booster nodes. The information provided allows an application manager to determine if the distribution of sub-tasks between computation nodes and booster
15 nodes can be adapted or improved upon for a further computing iteration.

A resource manager may determine the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the first iteration as a function of the computation task and further parameters. The application manager processes the
20 information as input to the resource manager such that the resource manager dynamically alters further distributions during the computing of the computation task.

In a further aspect of the invention, the resource manager, based on the information dynamically alters assignment of the computation nodes and booster nodes to each other
25 during the computation of the computation task.

The initial distribution may also be determined by the application manager using information provided by a user of the system in programming code compiled for execution by the system. Alternatively, the application manager may be so arranged to generate
30 such a distribution based on an analysis of the sub-task coding.

In a further aspect, the invention provides a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes for computing one or more tasks comprising multiple sub-tasks, a communication interface connecting the
35 computation nodes with each other and the booster nodes, wherein the system comprises a resource manager for assigning booster nodes and computation nodes to each other for the computing of the tasks and wherein the system further comprises an application

manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes to update a distribution of the sub-tasks between the computation nodes and the booster nodes between a first computing iteration and a further computing iteration.

5

In still a further aspect of the invention, the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task.

Preferred embodiments of the invention will now be described, by way of example only,
10 with reference to the accompanying drawings in which:

Fig. 1 shows a schematic diagram of a cluster computer system incorporating the invention.

15 Referring to Fig. 1, there is shown a schematic representation of a cluster computer system 10 incorporating the invention. The system 10 comprises a number of computation nodes 20 and a number of booster nodes 22. The computation nodes 20 and the booster nodes are connected via a communication infrastructure 24, with the booster nodes being connected to the communication interface via a booster interface 23. Each of the
20 computation nodes 20 and the booster nodes 22 is represented schematically by a rectangle and each of these nodes in operation incorporates at least one of a respective daemon 26a and 26b, schematically illustrated by a square within the rectangle of the respective node. A daemon of the present invention is an application which runs as a background process and is capable of providing the information as used herein. Clauss et
25 al. "Dynamic Process Management with Allocation-internal Co-Scheduling towards Interactive Supercomputing", COSH 2016 Jan 19, Prague, CZ, disclose daemons as addressed herein, and the contents of this paper are incorporated herein by reference for all purposes.

30 The system 10 also includes a resource manager 28 shown connected to the communication infrastructure 24 and an application manager 30. Each of the resource manager 28 and the application manager 30 includes a respective daemon 32 and 34.

The computation nodes 20 may be identical to one another or may have differing
35 characteristics. Each computation node incorporates one or more multi-core processors such as the Intel XeonE5-2680 processor. The nodes are connected together by means of a communication interface which may be based on a Mellanox InfiniBand ConnectX fabric

capable of transferring data at a rate of many Gbit/s. The computation nodes interface via the communication interface to the plurality of booster nodes, ideally through a series of booster interfaces 40. As shown, the booster nodes host at least one accelerator-type processor, for example an Intel Xeon Phi many core processor, capable of autonomously booting and running its own operating system. Such technology is described in
5 Concurrency Computat.: Pract. Exper. 2016; 28:2394-2411 referred to above.

Further, the system 10 may include a modular computing abstraction layer as described in unpublished application PCT/EP2017/075375, incorporated herein by reference for all
10 purposes, for enabling communication between the daemons and the application manager.

A job to be computed by the system may comprise a number of tasks some of which or all may be repeated a number of times during the execution of the job. For example the job
15 may be a "Monte-Carlo" based simulation where an effect is modelled using a random number, the calculations being repeated many times in succession.

The tasks may comprise a number of sub-tasks or kernels. Each of these sub-tasks may be more or less suitable for processing by one or more of the computation nodes or one
20 or more of the boosters. In particular, the scalability of the sub-task may indicate whether it is more appropriate for the sub-task to be processed by a computation node or a booster. The system is flexible in all directions, also permitting joint processing of sub-tasks by all nodes addressed herein, as well as reshuffling of processing between the nodes.

If a task is computed with a first division of sub-tasks between a computation node and a booster, it is possible that such a division is not an optimal division for the computation of the task. Certain sub-tasks which were assigned to a booster on the first iteration might in fact not be suitable for processing by the booster such that a processing of the sub-tasks
30 by a computation node rather than a booster might optimize the computation of the task as a whole. Accordingly, for a second and possible further iterations, if needed, of the task with an altered second and/or further sub-task distribution might improve the efficiency of the computation of the task.

Accordingly, the system 10 includes a mechanism whereby each of the computation nodes and the cluster nodes are arranged such that daemons 26a, 26b and 32 feed back
35 information to the daemon 34 relating to the processing of sub-tasks and a current state of

the respective processing entity. The daemon 34 uses the information provided by the daemons 26a, 26b and 32 to determine whether the distribution of sub-tasks to computation nodes and boosters could be adjusted to optimize or adapt the computation of the task for a subsequent iteration. The resource manager can also reassign
5 computation nodes and boosters to each other, in addition to the adjusted distribution of tasks.

A job including a task in which an operator has estimated a scalability factor for each sub-task is input into the system. This task is compiled and the compiled code is executed. In
10 the execution, a task is analyzed by the application manager and sub-tasks of the task are divided into computation node suitable sub-tasks and booster suitable sub-tasks and this information is passed to the resource manager for assignment of boosters to computation nodes. During a first iteration of the task, the results of the execution of the sub-tasks are collected together with the information from the daemons concerning the processing of the
15 sub-tasks and the status of the nodes. The application manager then performs a reassignment of the sub-tasks for a subsequent iteration of the task and passes this updated assignment information to the resource manager which may also adjust the assignment of boosters to nodes accordingly.

20 For each iteration, the daemons operating in the computation nodes and the boosters report status information to the application manager and the resource manager enabling the calculation of subsequent iterations to be optimized by a further adjustments to the allocation of sub-tasks to computation nodes and boosters.

25 While the above procedure has been described incorporating a taskifying step in which an initial scalability factor may be inputted by the program coder, it is also possible for the application manager to automatically set an initial scalability factor for the sub-tasks, with subsequent iterations improving on this initial setting. Such an arrangement has the benefit that coding of the tasks is made more straightforward, thereby enabling an
30 improved usability of the system to program coders unfamiliar with cluster computing applications.

As well as adjusting the distribution of sub-tasks between computation nodes and boosters based on a scalability of the sub-task, the distribution may also be influenced by
35 information learned about the processing of the sub-task and any need to call further sub-tasks during the processing. If a first sub-task being handled by a booster requires input from a second sub-task not being handled by the booster, this may lead to an interruption

in the processing of the first sub-task. Accordingly, the daemon at the booster handling the first sub-task can report this situation to the application manager such that in a further iteration both the first and second sub-tasks are handled by the booster. Accordingly, the application manager is arranged using the information provided by the daemons operating
5 in the computation nodes and the boosters to adjust groupings of sub-tasks for assignment to the computation nodes and boosters.

While the computation nodes in Fig. 1 have been given the same reference numeral, as have the booster nodes, this does not imply that all the computation nodes are identical to each other and all the booster nodes are also identical to each other. The system
10 may have computation nodes and/or booster nodes added to the system which differ in characteristics from the other computation/booster nodes. Accordingly, particular ones of the computation nodes and /or booster nodes may be particularly suited to processing particular sub-tasks. The application manager takes this structural information into
15 account and passes such assignment information to the resource manager to ensure that the sub-tasks are distributed in an optimum manner.

An important aspect of the invention comes with the recognition that a mapping, tailoring of computation tasks, and sub-tasks onto a computer hierarchy may not provide sufficient
20 use of the inherent flexibility and adaptability of the computer architecture, as shown as an example according to WO 2012/049247 A1. Therefor, the present invention integrates tailoring the application task most sufficiently, as an example according to WO 2017/0262319 A1, as well as configuring dynamically the computation nodes and booster nodes to each other, and eventually dynamically rearranging the mapping of the
25 computation tasks during runtime, based on the information provided by Daemons about the efficiency of the execution of the computation task, and dynamically reassigning the computation nodes and computation boosters to each other.

CLAIMS

1. A method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of
5 computation nodes and plurality of booster nodes being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein
in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; and
10 information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes is used to generate a further distribution of the sub-tasks between the computation nodes and booster node for processing thereby in a further computing iteration.
- 15 2. The method according to claim 1, wherein an application manager receives the information and determines the further distribution.
3. The method according to claim 2, wherein a resource manager determines the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the
20 first iteration as a function of the computation task and wherein the application manager receives the information and processes it as input to the resource manager such that the resource manager dynamically alters further distribution during the computing of the computation task.
- 25 4. The method according to any one of the preceding claims, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task.
- 30 5. The method according to claim 1 or claim 2, wherein daemons operate in the computation nodes and the booster nodes to generate the information.
6. The method according to any preceding claim, wherein the first distribution is determined based on a rating provided in source code for each sub-task.
35
7. The method according to any preceding claim, wherein the information is used to provide a grouping of sub-tasks in at least one of the first and second iterations.

8. The method according to claim 3, wherein a daemon operating at a node generates a measure of a loading of the node during processing of a sub-task.

5 9. A heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes for computing one or more tasks comprising multiple sub-tasks, a communication interface connecting the computation nodes with each other and the booster nodes, wherein the system comprises a resource manager for assigning
10 booster nodes and computation nodes to each other for the computing of the tasks and wherein the system further comprises an application manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes to update a distribution of the sub-tasks between the computation nodes and the booster nodes for a further computing iteration.

15 10. The computing system according to claim 9, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other.

ABSTRACT

The present invention provides a method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one
5 of the plurality of computation nodes and plurality of booster nodes being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; and information relating to the processing of the plurality of sub-tasks by the
10 plurality of computation nodes and booster nodes is used to generate a further distribution of the sub-tasks between the computation nodes and booster node for processing thereby in a further computing iteration.

15

Fig. 1

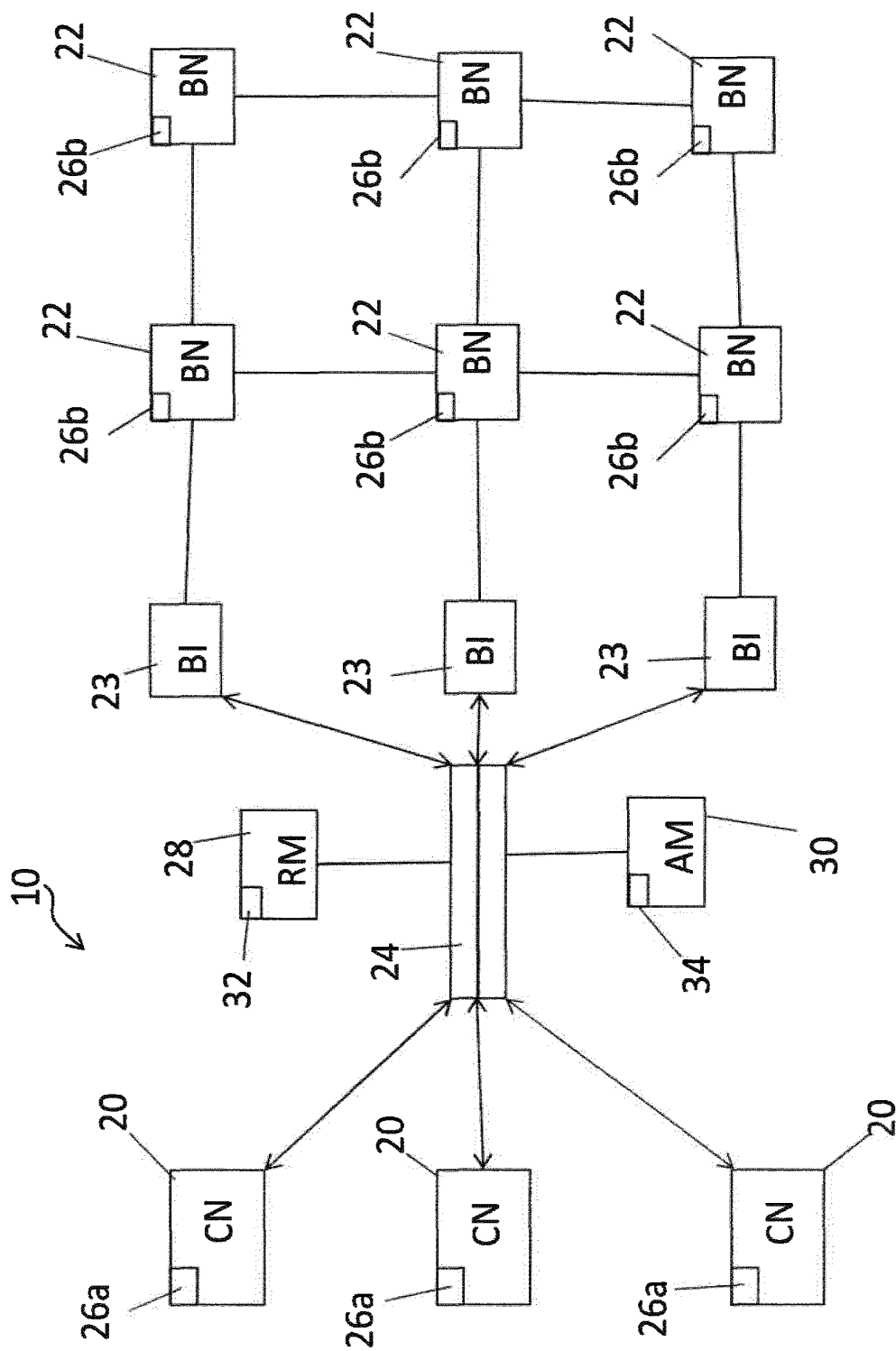


Fig. 1

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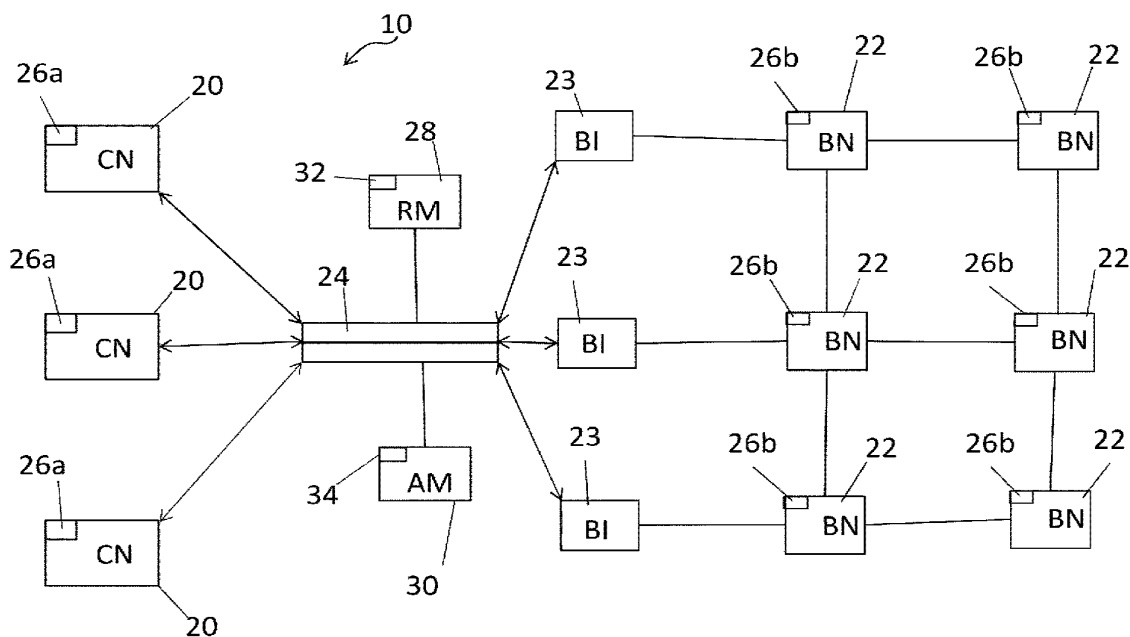


Fig. 1

(57) Abstract: The present invention provides a method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of computation nodes and plurality of booster nodes being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; and information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes is used to generate a further distribution of the sub-tasks between the computation nodes and booster node for processing thereby in a further computing iteration.

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Application runtime determined dynamical allocation
of heterogeneous compute resources

The present invention relates to a mechanism for executing computation tasks within a
5 computation environment, in particular a heterogeneous computation environment
adapted for parallel processing of a computation task.

The present invention is a development of the system described in earlier application WO
2012/049247 A1, WO '247, which describes a cluster computer architecture comprising a
10 plurality of computation nodes and a plurality of boosters connected together via a
communication interface. A resource manager is responsible for assigning one or more of
the boosters and the computation nodes to each other in a dynamic manner during
runtime. An example for such dynamic process management is described in Clauss et al.
"Dynamic Process Management with Allocation-internal Co-Scheduling towards
15 Interactive Supercomputing", COSH 2016 Jan 19, Prague, CZ, incorporated herein by
reference for all purposes. While the arrangement of WO '247 provides a flexible
arrangement for assigning boosters to computation nodes, it does not address how to
distribute tasks between computation nodes and boosters.

20 The arrangement of WO '247 is further described by Eicker et al. in "The DEEP Project An
alternative approach to heterogeneous cluster-computing in the many core era",
Concurrency Computat.: Pract. Exper. 2016; 28:2394-2411. The heterogeneous system
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The present invention provides a method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of computation nodes and plurality of booster nodes being arranged to
5 compute a computation task, the computation task comprising a plurality of sub-tasks, wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; using information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes to generate a further distribution of the
10 sub-tasks between the computation nodes and booster nodes for processing thereby in a further computing iteration.

Preferably, the information is provided by respective daemons operating in each of the computation and booster nodes. The information provided allows an application manager
15 to determine if the distribution of sub-tasks between computation nodes and booster nodes can be adapted or improved upon for a further computing iteration.

A resource manager may determine the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the first iteration as a function of the
20 computation task and further parameters. The application manager processes the information as input to the resource manager such that the resource manager dynamically alters further distributions during the computing of the computation task.

In a further aspect of the invention, the resource manager, based on the information
25 dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task.

The initial distribution may also be determined by the application manager using information provided by a user of the system in programming code compiled for execution
30 by the system. Alternatively, the application manager may be so arranged to generate such a distribution based on an analysis of the sub-task coding.

In a further aspect, the invention provides a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes for computing one or
35 more tasks comprising multiple sub-tasks, a communication interface connecting the computation nodes with each other and the booster nodes, wherein the system comprises a resource manager for assigning booster nodes and computation nodes to each other for

the computing of the tasks and wherein the system further comprises an application manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes to update a distribution of the sub-tasks between the computation nodes and the booster nodes between a first computing iteration and a further computing iteration.

In still a further aspect of the invention, the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task.

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 shows a schematic diagram of a cluster computer system incorporating the invention.

Referring to Fig. 1, there is shown a schematic representation of a cluster computer system 10 incorporating the invention. The system 10 comprises a number of computation nodes 20 and a number of booster nodes 22. The computation nodes 20 and the booster nodes are connected via a communication infrastructure 24, with the booster nodes being connected to the communication interface via a booster interface 23. Each of the computation nodes 20 and the booster nodes 22 is represented schematically by a rectangle and each of these nodes in operation incorporates at least one of a respective daemon 26a and 26b, schematically illustrated by a square within the rectangle of the respective node. A daemon of the present invention is an application which runs as a background process and is capable of providing the information as used herein. Clauss et al. "Dynamic Process Management with Allocation-internal Co-Scheduling towards Interactive Supercomputing", COSH 2016 Jan 19, Prague, CZ, disclose daemons as addressed herein, and the contents of this paper are incorporated herein by reference for all purposes.

The system 10 also includes a resource manager 28 shown connected to the communication infrastructure 24 and an application manager 30. Each of the resource manager 28 and the application manager 30 includes a respective daemon 32 and 34.

The computation nodes 20 may be identical to one another or may have differing characteristics. Each computation node incorporates one or more multi-core processors such as the Intel XeonE5-2680 processor. The nodes are connected together by means of

a communication interface which may be based on a Mellanox InfiniBand ConnectX fabric capable of transferring data at a rate of many Gbit/s. The computation nodes interface via the communication interface to the plurality of booster nodes, ideally through a series of booster interfaces 40. As shown, the booster nodes host at least one accelerator-type processor, for example an Intel Xeon Phi many core processor, capable of autonomously booting and running its own operating system. Such technology is described in Concurrency Computat.: Pract. Exper. 2016; 28:2394-2411 referred to above.

Further, the system 10 may include a modular computing abstraction layer as described in unpublished application PCT/EP2017/075375, incorporated herein by reference for all purposes, for enabling communication between the daemons and the application manager.

A job to be computed by the system may comprise a number of tasks some of which or all may be repeated a number of times during the execution of the job. For example the job may be a "Monte-Carlo" based simulation where an effect is modelled using a random number, the calculations being repeated many times in succession.

The tasks may comprise a number of sub-tasks or kernels. Each of these sub-tasks may be more or less suitable for processing by one or more of the computation nodes or one or more of the boosters. In particular, the scalability of the sub-task may indicate whether it is more appropriate for the sub-task to be processed by a computation node or a booster. The system is flexible in all directions, also permitting joint processing of sub-tasks by all nodes addressed herein, as well as reshuffling of processing between the nodes.

If a task is computed with a first division of sub-tasks between a computation node and a booster, it is possible that such a division is not an optimal division for the computation of the task. Certain sub-tasks which were assigned to a booster on the first iteration might in fact not be suitable for processing by the booster such that a processing of the sub-tasks by a computation node rather than a booster might optimize the computation of the task as a whole. Accordingly, for a second and possible further iterations, if needed, of the task with an altered second and/or further sub-task distribution might improve the efficiency of the computation of the task.

Accordingly, the system 10 includes a mechanism whereby each of the computation nodes and the cluster nodes are arranged such that daemons 26a, 26b and 32 feed back

information to the daemon 34 relating to the processing of sub-tasks and a current state of the respective processing entity. The daemon 34 uses the information provided by the daemons 26a, 26b and 32 to determine whether the distribution of sub-tasks to computation nodes and boosters could be adjusted to optimize or adapt the computation of the task for a subsequent iteration. The resource manager can also reassign computation nodes and boosters to each other, in addition to the adjusted distribution of tasks.

A job including a task in which an operator has estimated a scalability factor for each sub-task is input into the system. This task is compiled and the compiled code is executed. In the execution, a task is analyzed by the application manager and sub-tasks of the task are divided into computation node suitable sub-tasks and booster suitable sub-tasks and this information is passed to the resource manager for assignment of boosters to computation nodes. During a first iteration of the task, the results of the execution of the sub-tasks are collected together with the information from the daemons concerning the processing of the sub-tasks and the status of the nodes. The application manager then performs a reassignment of the sub-tasks for a subsequent iteration of the task and passes this updated assignment information to the resource manager which may also adjust the assignment of boosters to nodes accordingly.

For each iteration, the daemons operating in the computation nodes and the boosters report status information to the application manager and the resource manager enabling the calculation of subsequent iterations to be optimized by a further adjustments to the allocation of sub-tasks to computation nodes and boosters.

While the above procedure has been described incorporating a taskifying step in which an initial scalability factor may be inputted by the program coder, it is also possible for the application manager to automatically set an initial scalability factor for the sub-tasks, with subsequent iterations improving on this initial setting. Such an arrangement has the benefit that coding of the tasks is made more straightforward, thereby enabling an improved usability of the system to program coders unfamiliar with cluster computing applications.

As well as adjusting the distribution of sub-tasks between computation nodes and boosters based on a scalability of the sub-task, the distribution may also be influenced by information learned about the processing of the sub-task and any need to call further sub-tasks during the processing. If a first sub-task being handled by a booster requires input

from a second sub-task not being handled by the booster, this may lead to an interruption in the processing of the first sub-task. Accordingly, the daemon at the booster handling the first sub-task can report this situation to the application manager such that in a further iteration both the first and second sub-tasks are handled by the booster. Accordingly, the application manager is arranged using the information provided by the daemons operating in the computation nodes and the boosters to adjust groupings of sub-tasks for assignment to the computation nodes and boosters.

While the computation nodes in Fig. 1 have been given the same reference numeral, as have the booster nodes, this does not imply that all the computation nodes are identical to each other and all the booster nodes are also identical to each other. The system may have computation nodes and/or booster nodes added to the system which differ in characteristics from the other computation/booster nodes. Accordingly, particular ones of the computation nodes and /or booster nodes may be particularly suited to processing particular sub-tasks. The application manager takes this structural information into account and passes such assignment information to the resource manager to ensure that the sub-tasks are distributed in an optimum manner.

An important aspect of the invention comes with the recognition that a mapping, tailoring of computation tasks, and sub-tasks onto a computer hierarchy may not provide sufficient use of the inherent flexibility and adaptability of the computer architecture, as shown as an example according to WO 2012/049247 A1. Therefore, the present invention integrates tailoring the application task most sufficiently, as an example according to WO 2017/0262319 A1, as well as configuring dynamically the computation nodes and booster nodes to each other, and eventually dynamically rearranging the mapping of the computation tasks during runtime, based on the information provided by daemons about the efficiency of the execution of the computation task, and dynamically reassigning the computation nodes and computation boosters to each other.

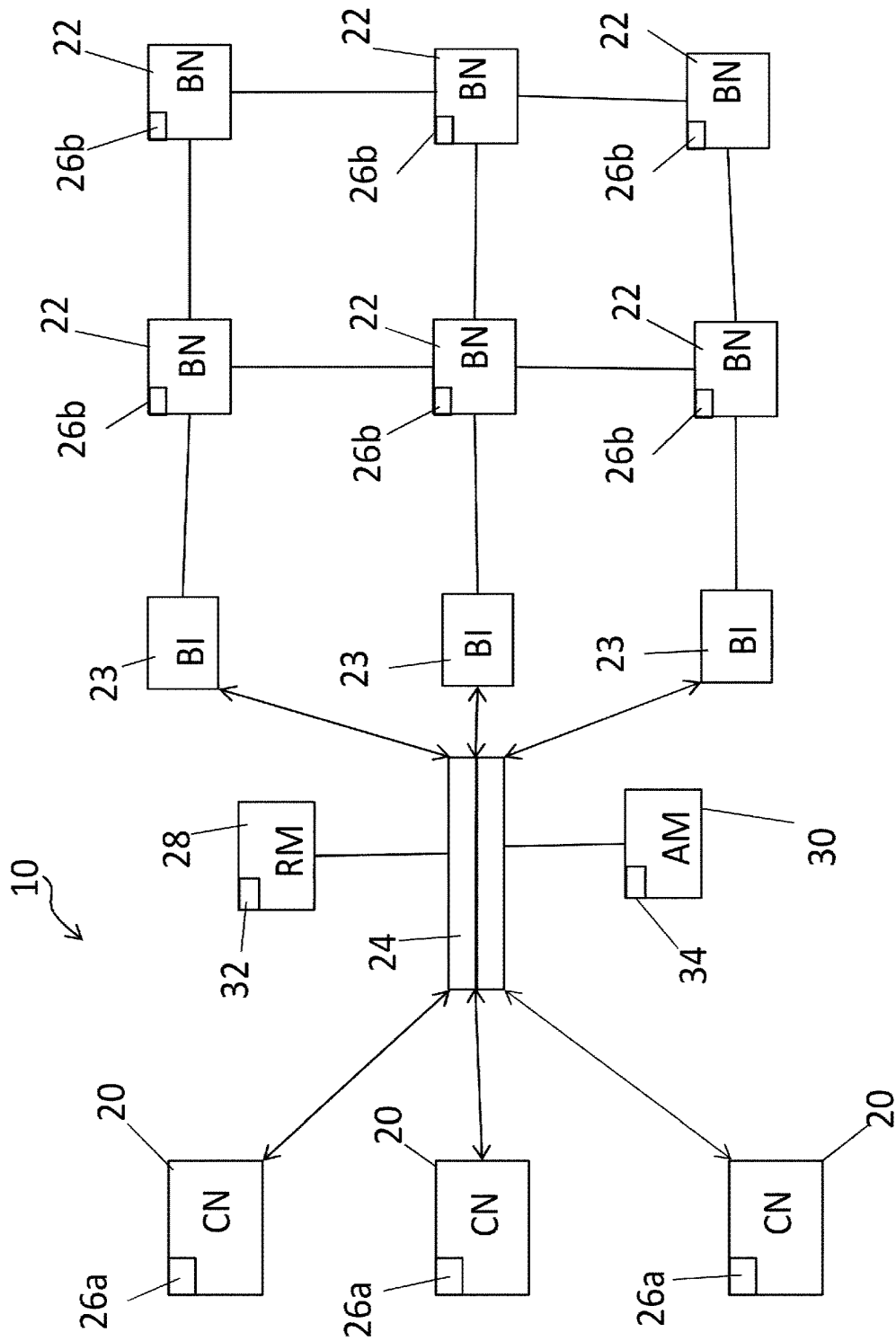


Fig. 1

CLAIMS

1. A method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of computation nodes and plurality of booster nodes being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; and

information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes is used to generate a further distribution of the sub-tasks between the computation nodes and booster node for processing thereby in a further computing iteration.

2. The method according to claim 1, wherein an application manager receives the information and determines the further distribution.

3. The method according to claim 2, wherein a resource manager determines the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the first iteration as a function of the computation task and wherein the application manager receives the information and processes it as input to the resource manager such that the resource manager dynamically alters further distribution during the computing of the computation task.

4. The method according to any one of the preceding claims, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task.

5. The method according to claim 1 or claim 2, wherein daemons operate in the computation nodes and the booster nodes to generate the information.

6. The method according to any preceding claim, wherein the first distribution is determined based on a rating provided in source code for each sub-task.

7. The method according to any preceding claim, wherein the information is used to provide a grouping of sub-tasks in at least one of the first and second iterations.

8. The method according to claim 3, wherein a daemon operating at a node generates a measure of a loading of the node during processing of a sub-task.

5 9. A heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes for computing one or more tasks comprising multiple sub-tasks, a communication interface connecting the computation nodes with each other and the booster nodes, wherein the system comprises a resource manager for assigning
10 booster nodes and computation nodes to each other for the computing of the tasks and wherein the system further comprises an application manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes to update a distribution of the sub-tasks between the computation nodes and the booster nodes for a further computing iteration.

15 10. The computing system according to claim 9, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other.

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371		Attorney Docket No. 29959/55804
		U.S. Application No. (if known, see 37 CFR 1.5) Not Yet Assigned
International Application No. PCT/EP2019/051615	International Filing Date 23 January 2019	Priority Date Claimed 23 January 2018
Title of Invention APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES		
First Named Inventor Thomas Lippert et al.		
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information. 1. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received. 2. ☒ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)). 3. An English language translation of the International Application (35 U.S.C. 371(c)(2)) a. ☐ is attached hereto. b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4). 4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) a. ☐ is attached. b. ☐ was previously filed in the international phase under PCT Rule 4.17(iv). Items 5 to 8 below concern amendments made in the international phase. <u>PCT Article 19 and 34 amendments</u> 5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)). 6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)). 7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)). <u>Cancellation of amendments made in the international phase</u> 8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19. 8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34. NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s). The following items 9 to 17 concern a document(s) or information included. 9. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 10. ☒ A preliminary amendment. 11. ☒ An Application Data Sheet under 37 CFR 1.76. 12. ☐ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b). 13. ☐ A power of attorney and/or change of address letter. 14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.3 and 37 CFR 1.821-1.825 (not required if sequence listing in text format was indicated on the PCT Request as part of the International Application and the sequence listing was published as part of the International application). 15. ☐ Assignment papers (<i>cover sheet and document(s)</i>). Name of Assignee: _____ 16. ☐ 37 CFR 3.73(c) Statement (<i>when there is an Assignee</i>). _____		

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U.S. APPLN. No. (if known – see 37 CFR 1.5) Not Yet Assigned	INTERNATIONAL APPLICATION No. PCT/EP2019/051615	ATTORNEY DOCKET No. 29959/55804
17. ☐ Other items or information:		
The following fees have been submitted.		CALCULATIONS
18. ☒ Basic national fee (37 CFR 1.492(a)).....\$300		\$ 300.00
19. ☒ Examination fee (37 CFR 1.492(c))		
• If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) \$0 • All other situations \$760		\$ 760.00
20. ☒ Search fee (37 CFR 1.492(b))		
• If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) \$0 • Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority \$140 • International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB \$520 • All other situations \$660		\$ 520.00
TOTAL OF 18, 19, and 20 =		\$ 1,580.00
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). Fee for each additional 50 sheets of paper or fraction thereof \$400		
Total Sheets	Extra Sheets	Number of each addition 50 or fraction thereof (round up to a whole number)
9 - 100 =	/ 50 =	x \$400
Surcharge for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).....\$140		\$ 140.00
CLAIMS	NUMBER FILED	NUMBER EXTRA
Total claims	10 - 20 =	0
Independent claims	2 - 3 =	0
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		+ \$820
Fee for submission of Sequence Listing text file of 300 MB to 800 MB (37 CFR 1.21(o)(1)).....\$1,000		\$
Fee for submission of Sequence Listing text file of more than 800 MB (37 CFR 1.21(o)(2)).....\$10,000		\$
Processing fee for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)).....\$140 +		\$
TOTAL OF ABOVE CALCULATIONS =		\$ 1,720.00
☒ Applicant asserts small entity status. See 37 CFR 1.27. Fees above are reduced by ½.		- 860.00
☐ Applicant certifies micro entity status. See 37 CFR 1.29. Fees above are reduced by ¾. Applicant must attach form PTO/SB/15A or B or equivalent.		
TOTAL NATIONAL FEE =		\$ 860.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31)..... \$50.00 per property +		\$
TOTAL FEES ENCLOSED =		\$ 860.00

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- c. ☒ The Director is hereby authorized to charge additional fees which may be required, or credit any overpayment, to Deposit Account No. 13-2855 as follows:
- i. ☐ any required fee.
- ii. ☒ any required fee except for excess claims fees required under 37 CFR 1.492(d) and (e) and multiple dependent claim fee required under 37 CFR 1.492(f).
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NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

- ☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013, and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE 1: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

NOTE 2: A U.S. national stage application may not claim priority to the international application of which it is the national phase. The filing date of a U.S. national stage application is the international filing date. See 35 U.S.C. 363.

Correspondence Address

- ☒ The address associated with Customer Number: 04743 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country				Telephone	
Email					

Signature	/Michael P. Furmanek, #58,495/	Date	July 21, 2020
Name (Print/Type)	Michael P. Furmanek	Registration No. (Attorney/Agent)	58,495

[Page 3 of 3]

Application Data Sheet

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Correspondence Information

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Application Information

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CD-ROM or CD-R?:: None

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Title:: APPLICATION RUNTIME
DETERMINED DYNAMICAL
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Petition included?:: No

Portions or all of the application associated with this

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Foreign Priority Information

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European Patent Office	18152903.3	01/23/18	Yes	

Applicant Information

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Applicant Type:: Assignee

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Assignee Information Including Non-Applicant Assignee Information

Authorization or Opt-Out of Authorization to Permit Access

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

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The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

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Signature:

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This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Michael P. Furmanek, #58,495/	Date (YYYY-MM-DD)	2020-07-21
Name	Michael P. Furmanek	Registration Number	58,495



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(54) Title: APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE
RESOURCES

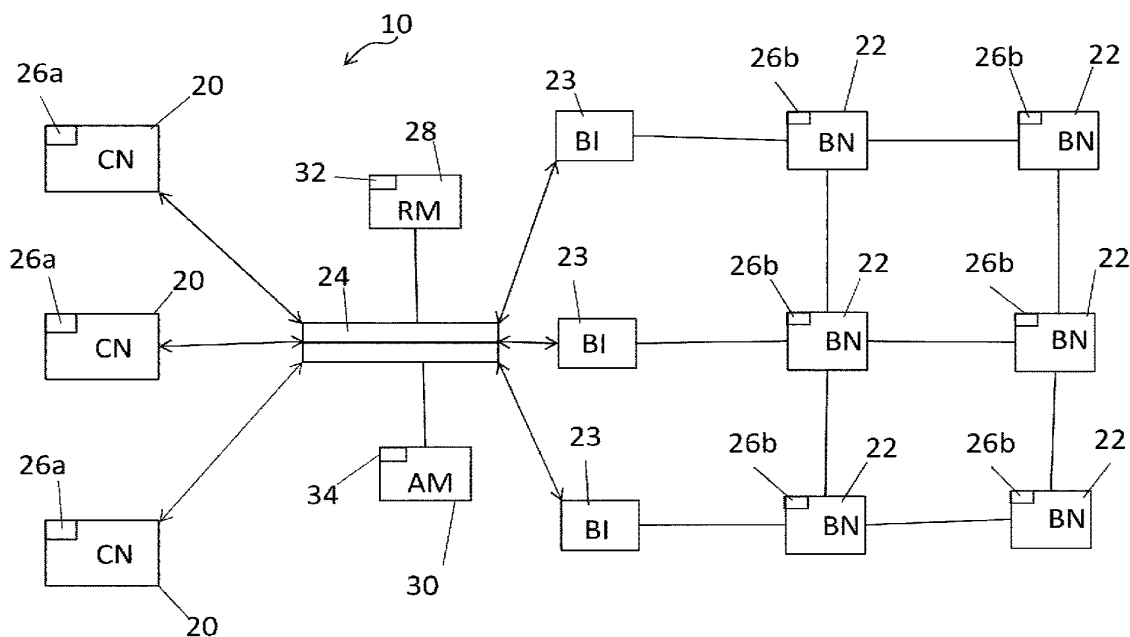


Fig. 1

(57) **Abstract:** The present invention provides a method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of computation nodes and plurality of booster nodes being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; and information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes is used to generate a further distribution of the sub-tasks between the computation nodes and booster node for processing thereby in a further computing iteration.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Application runtime determined dynamical allocation
of heterogeneous compute resources

The present invention relates to a mechanism for executing computation tasks within a
5 computation environment, in particular a heterogeneous computation environment
adapted for parallel processing of a computation task.

The present invention is a development of the system described in earlier application WO
2012/049247 A1, WO '247, which describes a cluster computer architecture comprising a
10 plurality of computation nodes and a plurality of boosters connected together via a
communication interface. A resource manager is responsible for assigning one or more of
the boosters and the computation nodes to each other in a dynamic manner during
runtime. An example for such dynamic process management is described in Clauss et al.
"Dynamic Process Management with Allocation-internal Co-Scheduling towards
15 Interactive Supercomputing", COSH 2016 Jan 19, Prague, CZ, incorporated herein by
reference for all purposes. While the arrangement of WO '247 provides a flexible
arrangement for assigning boosters to computation nodes, it does not address how to
distribute tasks between computation nodes and boosters.

20 The arrangement of WO '247 is further described by Eicker et al. in "The DEEP Project An
alternative approach to heterogeneous cluster-computing in the many core era",
Concurrency Computat.: Pract. Exper. 2016; 28:2394-2411. The heterogeneous system
which is described comprises a plurality of computation nodes and a plurality of booster
nodes connected by a switchable network. In order to process an application, the
25 application is "taskified" in order to provide an indication which tasks may be off-loaded
from a computation node to a booster. This taskifying is achieved by the application
developer annotating the code with pragmas indicating dependencies between different
tasks and in addition labels indicating the highly scalable code parts which are to be
processed by a booster. Scalability in this context means when the load offered to the
30 service increases, an incremental and linear increase in hardware can maintain the same
per-user level of service.

US 2017/0262319 A1 describes in one aspect runtime processes that can fully or partially
automate the distribution of data and mapping of tasks to computing resources. A so-
35 called tuning expert, i.e. a human operator, may still be required for mapping actions to
available resources. In essence it is described how a given application to be computed
can be mapped on a given computing hierarchy.

The present invention provides a method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of computation nodes and plurality of booster nodes being arranged to
5 compute a computation task, the computation task comprising a plurality of sub-tasks, wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; using information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes to generate a further distribution of the
10 sub-tasks between the computation nodes and booster nodes for processing thereby in a further computing iteration.

Preferably, the information is provided by respective daemons operating in each of the computation and booster nodes. The information provided allows an application manager
15 to determine if the distribution of sub-tasks between computation nodes and booster nodes can be adapted or improved upon for a further computing iteration.

A resource manager may determine the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the first iteration as a function of the
20 computation task and further parameters. The application manager processes the information as input to the resource manager such that the resource manager dynamically alters further distributions during the computing of the computation task.

In a further aspect of the invention, the resource manager, based on the information
25 dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task.

The initial distribution may also be determined by the application manager using information provided by a user of the system in programming code compiled for execution
30 by the system. Alternatively, the application manager may be so arranged to generate such a distribution based on an analysis of the sub-task coding.

In a further aspect, the invention provides a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes for computing one or
35 more tasks comprising multiple sub-tasks, a communication interface connecting the computation nodes with each other and the booster nodes, wherein the system comprises a resource manager for assigning booster nodes and computation nodes to each other for

the computing of the tasks and wherein the system further comprises an application manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes to update a distribution of the sub-tasks between the computation nodes and the booster nodes between a first computing iteration and a further computing iteration.

In still a further aspect of the invention, the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task.

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 shows a schematic diagram of a cluster computer system incorporating the invention.

Referring to Fig. 1, there is shown a schematic representation of a cluster computer system 10 incorporating the invention. The system 10 comprises a number of computation nodes 20 and a number of booster nodes 22. The computation nodes 20 and the booster nodes are connected via a communication infrastructure 24, with the booster nodes being connected to the communication interface via a booster interface 23. Each of the computation nodes 20 and the booster nodes 22 is represented schematically by a rectangle and each of these nodes in operation incorporates at least one of a respective daemon 26a and 26b, schematically illustrated by a square within the rectangle of the respective node. A daemon of the present invention is an application which runs as a background process and is capable of providing the information as used herein. Clauss et al. "Dynamic Process Management with Allocation-internal Co-Scheduling towards Interactive Supercomputing", COSH 2016 Jan 19, Prague, CZ, disclose daemons as addressed herein, and the contents of this paper are incorporated herein by reference for all purposes.

The system 10 also includes a resource manager 28 shown connected to the communication infrastructure 24 and an application manager 30. Each of the resource manager 28 and the application manager 30 includes a respective daemon 32 and 34.

The computation nodes 20 may be identical to one another or may have differing characteristics. Each computation node incorporates one or more multi-core processors such as the Intel XeonE5-2680 processor. The nodes are connected together by means of

a communication interface which may be based on a Mellanox InfiniBand ConnectX fabric capable of transferring data at a rate of many Gbit/s. The computation nodes interface via the communication interface to the plurality of booster nodes, ideally through a series of booster interfaces 40. As shown, the booster nodes host at least one accelerator-type processor, for example an Intel Xeon Phi many core processor, capable of autonomously booting and running its own operating system. Such technology is described in Concurrency Computat.: Pract. Exper. 2016; 28:2394-2411 referred to above.

Further, the system 10 may include a modular computing abstraction layer as described in unpublished application PCT/EP2017/075375, incorporated herein by reference for all purposes, for enabling communication between the daemons and the application manager.

A job to be computed by the system may comprise a number of tasks some of which or all may be repeated a number of times during the execution of the job. For example the job may be a "Monte-Carlo" based simulation where an effect is modelled using a random number, the calculations being repeated many times in succession.

The tasks may comprise a number of sub-tasks or kernels. Each of these sub-tasks may be more or less suitable for processing by one or more of the computation nodes or one or more of the boosters. In particular, the scalability of the sub-task may indicate whether it is more appropriate for the sub-task to be processed by a computation node or a booster. The system is flexible in all directions, also permitting joint processing of sub-tasks by all nodes addressed herein, as well as reshuffling of processing between the nodes.

If a task is computed with a first division of sub-tasks between a computation node and a booster, it is possible that such a division is not an optimal division for the computation of the task. Certain sub-tasks which were assigned to a booster on the first iteration might in fact not be suitable for processing by the booster such that a processing of the sub-tasks by a computation node rather than a booster might optimize the computation of the task as a whole. Accordingly, for a second and possible further iterations, if needed, of the task with an altered second and/or further sub-task distribution might improve the efficiency of the computation of the task.

Accordingly, the system 10 includes a mechanism whereby each of the computation nodes and the cluster nodes are arranged such that daemons 26a, 26b and 32 feed back

information to the daemon 34 relating to the processing of sub-tasks and a current state of the respective processing entity. The daemon 34 uses the information provided by the daemons 26a, 26b and 32 to determine whether the distribution of sub-tasks to computation nodes and boosters could be adjusted to optimize or adapt the computation of the task for a subsequent iteration. The resource manager can also reassign computation nodes and boosters to each other, in addition to the adjusted distribution of tasks.

A job including a task in which an operator has estimated a scalability factor for each sub-task is input into the system. This task is compiled and the compiled code is executed. In the execution, a task is analyzed by the application manager and sub-tasks of the task are divided into computation node suitable sub-tasks and booster suitable sub-tasks and this information is passed to the resource manager for assignment of boosters to computation nodes. During a first iteration of the task, the results of the execution of the sub-tasks are collected together with the information from the daemons concerning the processing of the sub-tasks and the status of the nodes. The application manager then performs a reassignment of the sub-tasks for a subsequent iteration of the task and passes this updated assignment information to the resource manager which may also adjust the assignment of boosters to nodes accordingly.

For each iteration, the daemons operating in the computation nodes and the boosters report status information to the application manager and the resource manager enabling the calculation of subsequent iterations to be optimized by a further adjustments to the allocation of sub-tasks to computation nodes and boosters.

While the above procedure has been described incorporating a taskifying step in which an initial scalability factor may be inputted by the program coder, it is also possible for the application manager to automatically set an initial scalability factor for the sub-tasks, with subsequent iterations improving on this initial setting. Such an arrangement has the benefit that coding of the tasks is made more straightforward, thereby enabling an improved usability of the system to program coders unfamiliar with cluster computing applications.

As well as adjusting the distribution of sub-tasks between computation nodes and boosters based on a scalability of the sub-task, the distribution may also be influenced by information learned about the processing of the sub-task and any need to call further sub-tasks during the processing. If a first sub-task being handled by a booster requires input

from a second sub-task not being handled by the booster, this may lead to an interruption in the processing of the first sub-task. Accordingly, the daemon at the booster handling the first sub-task can report this situation to the application manager such that in a further iteration both the first and second sub-tasks are handled by the booster. Accordingly, the application manager is arranged using the information provided by the daemons operating in the computation nodes and the boosters to adjust groupings of sub-tasks for assignment to the computation nodes and boosters.

While the computation nodes in Fig. 1 have been given the same reference numeral, as have the booster nodes, this does not imply that all the computation nodes are identical to each other and all the booster nodes are also identical to each other. The system may have computation nodes and/or booster nodes added to the system which differ in characteristics from the other computation/booster nodes. Accordingly, particular ones of the computation nodes and /or booster nodes may be particularly suited to processing particular sub-tasks. The application manager takes this structural information into account and passes such assignment information to the resource manager to ensure that the sub-tasks are distributed in an optimum manner.

An important aspect of the invention comes with the recognition that a mapping, tailoring of computation tasks, and sub-tasks onto a computer hierarchy may not provide sufficient use of the inherent flexibility and adaptability of the computer architecture, as shown as an example according to WO 2012/049247 A1. Therefore, the present invention integrates tailoring the application task most sufficiently, as an example according to WO 2017/0262319 A1, as well as configuring dynamically the computation nodes and booster nodes to each other, and eventually dynamically rearranging the mapping of the computation tasks during runtime, based on the information provided by daemons about the efficiency of the execution of the computation task, and dynamically reassigning the computation nodes and computation boosters to each other.

CLAIMS

1. A method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of computation nodes and plurality of booster nodes being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; and

information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes is used to generate a further distribution of the sub-tasks between the computation nodes and booster node for processing thereby in a further computing iteration.

2. The method according to claim 1, wherein an application manager receives the information and determines the further distribution.

3. The method according to claim 2, wherein a resource manager determines the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the first iteration as a function of the computation task and wherein the application manager receives the information and processes it as input to the resource manager such that the resource manager dynamically alters further distribution during the computing of the computation task.

4. The method according to any one of the preceding claims, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task.

5. The method according to claim 1 or claim 2, wherein daemons operate in the computation nodes and the booster nodes to generate the information.

6. The method according to any preceding claim, wherein the first distribution is determined based on a rating provided in source code for each sub-task.

7. The method according to any preceding claim, wherein the information is used to provide a grouping of sub-tasks in at least one of the first and second iterations.

8. The method according to claim 3, wherein a daemon operating at a node generates a measure of a loading of the node during processing of a sub-task.

5 9. A heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes for computing one or more tasks comprising multiple sub-tasks, a communication interface connecting the computation nodes with each other and the booster nodes, wherein the system comprises a resource manager for assigning
10 booster nodes and computation nodes to each other for the computing of the tasks and wherein the system further comprises an application manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes to update a distribution of the sub-tasks between the computation nodes and the booster nodes for a further computing iteration.

15 10. The computing system according to claim 9, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other.

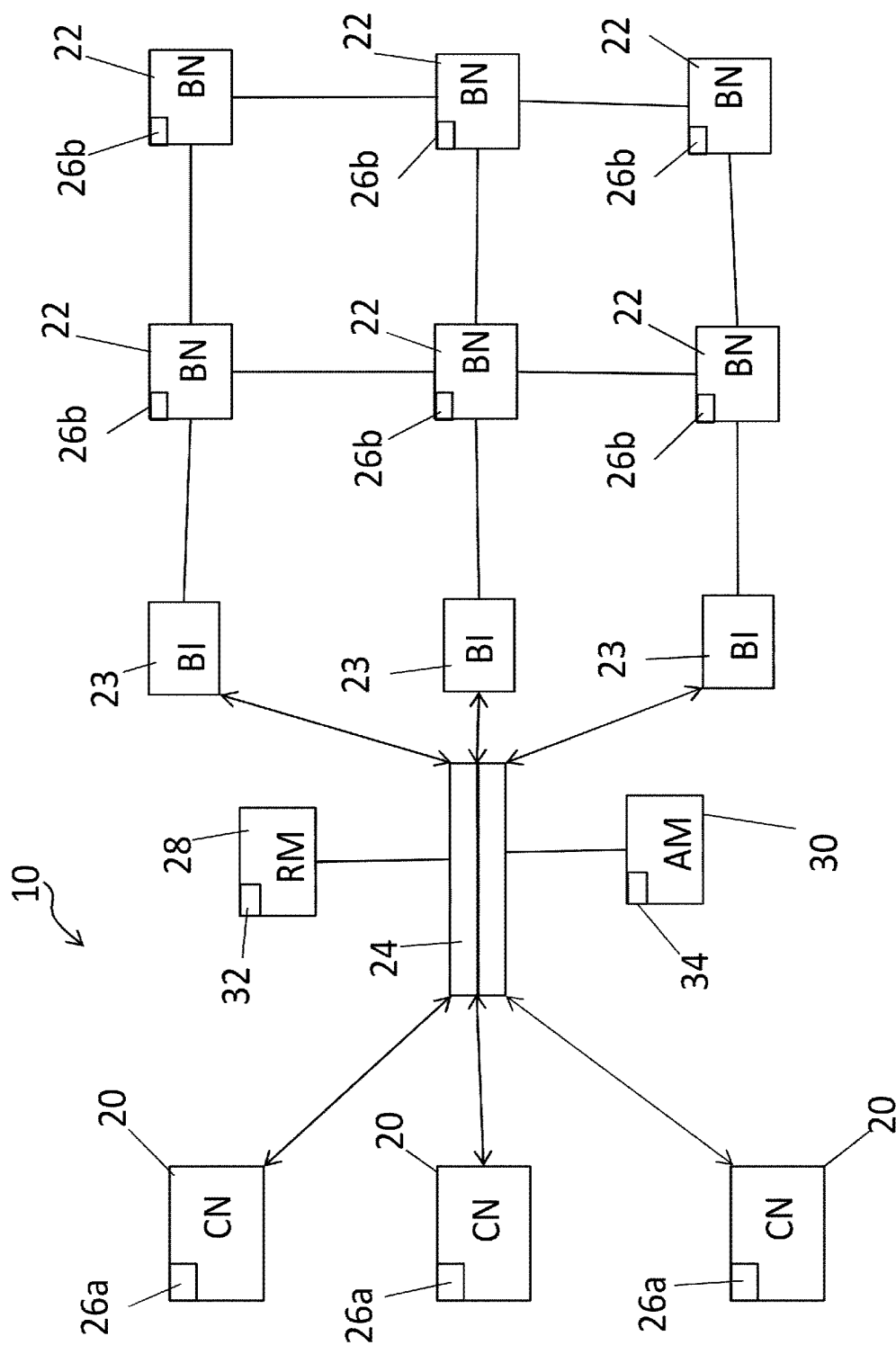


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/051615

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F9/50
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 442 228 A1 (LIPPERT THOMAS [DE]; PARTEC CLUSTER COMPETENCE CT GMBH [DE]) 18 April 2012 (2012-04-18) abstract paragraphs [0009], [0012], [0014] - [0016], [0047] - [0050] -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

16 April 2019

Date of mailing of the international search report

29/04/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Archontopoulos, E

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/051615

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2442228	A1	18-04-2012	CA 2814309 A1 19-04-2012
			CA 3027973 A1 19-04-2012
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			US 2013282787 A1 24-10-2013
			US 2019089574 A1 21-03-2019
			WO 2012049247 A1 19-04-2012

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES		
First Named Inventor/Applicant Name:		Thomas Lippert		
Filer:		Michael Paul Furmanek./Araceli Hernandez		
Attorney Docket Number:		29959/55804		
Filed as Small Entity				
Filing Fees for U.S. National Stage under 35 USC 371				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
BASIC NATIONAL STAGE FEE	2631	1	150	150
NATL STAGE SEARCH FEE - REPORT PROVIDED	2642	1	260	260
NATL STAGE EXAM FEE - ALL OTHER CASES	2633	1	380	380
Pages:				
Claims:				
Miscellaneous-Filing:				
OATH/DECL > 30 MOS FROM 371 COMMENCEMENT	2617	1	70	70
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				860

Electronic Acknowledgement Receipt

EFS ID:	40064838
Application Number:	16963749
International Application Number:	PCT/EP2019/051615
Confirmation Number:	6322
Title of Invention:	APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES
First Named Inventor/Applicant Name:	Thomas Lippert
Customer Number:	04743
Filer:	Michael Paul Furmanek./Araceli Hernandez
Filer Authorized By:	Michael Paul Furmanek.
Attorney Docket Number:	29959/55804
Receipt Date:	21-JUL-2020
Filing Date:	
Time Stamp:	16:50:33
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$860
RAM confirmation Number	E20207KG52108990
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	Transmittal_Letter_to_the_United_States_Designated-Elected_Office.PDF	49210	no	3
			ebeeeef5f5d4a218623449e5162010b24e8676a23		
Warnings:					
Information:					
2	Application Data Sheet	Application_Data_Sheet.PDF	28930	no	5
			41164aec244591f115067810eddffa785397eebd		
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
3	Specification	WIPO_Publication_WO2019145354A1.PDF	536755	no	13
			f0e7193d73781d7e88bc9498d32b46091eaa0e39		
Warnings:					
Information:					
4	Preliminary Amendment	First_Preliminary_Amendment_Under_37_CFR1.PDF	28134	no	5
			1530d7929b1d05c3b8885f20bf01ec590dec962c		
Warnings:					
Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	37260	no	2
			8ad1e9b2be6f5295ccb026456554394a59ae200c		
Warnings:					
Information:					
Total Files Size (in bytes):			680289		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Docket No.: 29959/55804
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Thomas Lippert et al.

Application No.: National Stage of
PCT/EP2019/051615

Confirmation No.: Not Yet Assigned

Filed: Concurrently Herewith

Art Unit: Not Yet Assigned

For: APPLICATION RUNTIME DETERMINED
DYNAMICAL ALLOCATION OF
HETEROGENEOUS COMPUTE RESOURCES

Examiner: Not Yet Assigned

FIRST PRELIMINARY AMENDMENT UNDER 37 C.F.R. § 1.115

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

INTRODUCTORY COMMENTS

Prior to examination on the merits, please amend the above-identified U.S. patent application as follows:

Amendments to the Specification begin on page 2.

Amendments to the Claims begin on page 3.

Remarks/Arguments begin on page 5.

AMENDMENTS TO THE SPECIFICATION

(1) Immediately after the Title, please insert the following headings and new paragraph:

CROSS-REFERENCE TO RELATED APPLICATIONS

[0000] This is the United States national phase of International Patent Application No. PCT/EP2019/051615, filed January 23, 2019, which claims priority to EP 18152903.3 filed January 23, 2018, the entire contents of each of which are hereby incorporated by reference herein.

FIELD OF THE DISCLOSURE

(2) Immediately before line 8 on page 1, please insert the following new heading:

BACKGROUND

(3) Immediately before line 1 on page 2 of the application, please insert the following new heading:

GENERAL DESCRIPTION

(4) Immediately after line 11 and before line 10 on page 3 of the application, please insert the following new heading:

BRIEF DESCRIPTION OF THE DRAWINGS

(5) Immediately after line 14 and before line 16 of the application, please insert the following new heading:

DETAILED DESCRIPTION OF THE DRAWINGS

AMENDMENTS TO THE CLAIMS

1. (Original) A method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of computation nodes and plurality of booster nodes being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein

in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution; and

information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes is used to generate a further distribution of the sub-tasks between the computation nodes and booster node for processing thereby in a further computing iteration.

2. (Original) The method according to claim 1, wherein an application manager receives the information and determines the further distribution.

3. (Original) The method according to claim 2, wherein a resource manager determines the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the first iteration as a function of the computation task and wherein the application manager receives the information and processes it as input to the resource manager such that the resource manager dynamically alters further distribution during the computing of the computation task.

4. (Currently Amended) The method according to claim 1 ~~any one of the preceding claims~~, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task.

5. (Currently Amended) The method according to claim 1 ~~or claim 2~~, wherein daemons operate in the computation nodes and the booster nodes to generate the information.

6. (Currently Amended) The method according to claim 1 ~~any preceding claim~~, wherein the first distribution is determined based on a rating provided in source code for each sub-task.

7. (Currently Amended) The method according to claim 1 ~~any preceding claim~~, wherein the information is used to provide a grouping of sub-tasks in at least one of the first and second iterations.

8. (Original) The method according to claim 3, wherein a daemon operating at a node generates a measure of a loading of the node during processing of a sub-task.

9. (Original) A heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes for computing one or more tasks comprising multiple sub-tasks, a communication interface connecting the computation nodes with each other and the booster nodes, wherein the system comprises a resource manager for assigning booster nodes and computation nodes to each other for the computing of the tasks and wherein the system further comprises an application manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes to update a distribution of the sub-tasks between the computation nodes and the booster nodes for a further computing iteration.

10. (Original) The computing system according to claim 9, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other.

REMARKS

The foregoing amendments are intended to place the application in better condition for US prosecution and to avoid excess claims fees. No new matter is added. Prompt and favorable consideration of the application is requested.

In view of the above amendment, applicant believes the pending application is in condition for allowance.

Dated: July 21, 2020

Respectfully submitted,

By /Michael P. Furmanek, #58,495/
Michael P. Furmanek
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.																	
Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center; padding: 5px;"><i>Complete if Known</i></th> </tr> <tr> <td style="width: 30%; padding: 5px;">Application Number</td> <td style="padding: 5px;">16/963,749-Conf. #6322</td> </tr> <tr> <td style="padding: 5px;">Filing Date</td> <td style="padding: 5px;">July 21, 2020</td> </tr> <tr> <td style="padding: 5px;">First Named Inventor</td> <td style="padding: 5px;">Thomas Lippert</td> </tr> <tr> <td style="padding: 5px;">Art Unit</td> <td style="padding: 5px;">0</td> </tr> <tr> <td style="padding: 5px;">Examiner Name</td> <td style="padding: 5px;">Not Yet Assigned</td> </tr> <tr> <td style="padding: 5px;">Attorney Docket Number</td> <td style="padding: 5px;">29959/55804</td> </tr> </table>		<i>Complete if Known</i>		Application Number	16/963,749-Conf. #6322	Filing Date	July 21, 2020	First Named Inventor	Thomas Lippert	Art Unit	0	Examiner Name	Not Yet Assigned	Attorney Docket Number	29959/55804
<i>Complete if Known</i>																	
Application Number	16/963,749-Conf. #6322																
Filing Date	July 21, 2020																
First Named Inventor	Thomas Lippert																
Art Unit	0																
Examiner Name	Not Yet Assigned																
Attorney Docket Number	29959/55804																
Sheet	1	of	2														

[illegible]

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No. ¹	Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T ⁶
		Country Code ³ Number ⁴ Kind Code ⁵ (if known)				
	A	EP-2442228-A1	04-18-2012	Lippert, Thomas		
	B	WO-2018065530-A1	04-12-2018	Partec Cluster Competence Center GmbH		

Examiner Signature		Date Considered	
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. ¹ Applicant's unique citation designation number (optional). ² See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. ³ Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). ⁴ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁵ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁶ Applicant is to place a check mark here if English language Translation is attached.

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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT <i>(Use as many sheets as necessary)</i>				Complete if Known	
				Application Number	16/963,749-Conf. #6322
				Filing Date	July 21, 2020
				First Named Inventor	Thomas Lippert
				Art Unit	0
				Examiner Name	Not Yet Assigned
Sheet	2	of	2	Attorney Docket Number	29959/55804

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No. ¹	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T ²
	A	International Search Report for International Application No. PCT/EP2019/0518615, dated April 29, 2019.	
	B	Written Opinion for International Application No. PCT/EP2019/0518615, dated April 29, 2019.	
	C	"DYNAMIC PROCESS MANAGEMENT WITH ALLOCATION - INTERNAL CO - SCHEDULING TOWARDS INTERACTIVE SUPERCOMPUTING," Clauss, et al., Conference Paper, DOI: 10.14459/2016md1288835, January 19, 2016.	
	D	"THE DEEP PROJECT AN ALTERNATIVE APPROACH TO HETEROGENEOUS CLUSTER-COMPUTING IN THE MANY-CORE ERA," Eicker, et al., Concurrency and Computation: Practice and Experience, Pract. Exper. 2016; 28; 2394-2411, Wiley Online Library (wileyonlinelibrary.com), Published online July 27, 2015.	

Examiner Signature		Date Considered	
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ Applicant's unique citation designation number (optional). ² Applicant is to place a check mark here if English language Translation is attached.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference P85465PCT	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/EP2019/051615	International filing date (<i>day/month/year</i>) 23 January 2019 (23-01-2019)	(Earliest) Priority Date (<i>day/month/year</i>) 23 January 2018 (23-01-2018)
Applicant PARTEC CLUSTER COMPETENCE CENTER GMBH		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of:

- ☒ the international application in the language in which it was filed
☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6**bis**(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (See Box No. II)

3. ☐ **Unity of invention is lacking** (see Box No III)

4. With regard to the **title**,

- ☒ the text is approved as submitted by the applicant
☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

- ☒ the text is approved as submitted by the applicant
☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings**,

a. the figure of the **drawings** to be published with the abstract is Figure No. 1

- ☒ as suggested by the applicant
☐ as selected by this Authority, because the applicant failed to suggest a figure
☐ as selected by this Authority, because this figure better characterizes the invention

b. ☐ none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2019/051615

A. CLASSIFICATION OF SUBJECT MATTER

INV. G06F9/50
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 442 228 A1 (LIPPERT THOMAS [DE]; PARTEC CLUSTER COMPETENCE CT GMBH [DE]) 18 April 2012 (2012-04-18) abstract paragraphs [0009], [0012], [0014] - [0016], [0047] - [0050] -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

16 April 2019

Date of mailing of the international search report

29/04/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Archontopoulos, E

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/051615

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2442228	A1	18-04-2012	CA 2814309 A1 19-04-2012
			CA 3027973 A1 19-04-2012
			CN 103229146 A 31-07-2013
			CN 109491795 A 19-03-2019
			EP 2442228 A1 18-04-2012
			EP 2628080 A1 21-08-2013
			JP 6433554 B2 05-12-2018
			JP 6494161 B2 03-04-2019
			JP 2013539881 A 28-10-2013
			JP 2017216000 A 07-12-2017
			KR 20140018187 A 12-02-2014
			KR 20180014185 A 07-02-2018
			KR 20190025746 A 11-03-2019
			RU 2013121560 A 20-11-2014
			US 2013282787 A1 24-10-2013
			US 2019089574 A1 21-03-2019
			WO 2012049247 A1 19-04-2012

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

PCT

To:

see form PCT/ISA/220

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY (PCT Rule 43bis.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.
PCT/EP2019/051615

International filing date (day/month/year)
23.01.2019

Priority date (day/month/year)
23.01.2018

International Patent Classification (IPC) or both national classification and IPC
INV. G06F9/50

Applicant
PARTEC CLUSTER COMPETENCE CENTER GMBH

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:



European Patent Office
P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk - Pays Bas
Tel. +31 70 340 - 2040
Fax: +31 70 340 - 3016

Date of completion of
this opinion

see form
PCT/ISA/210

Authorized Officer

Archontopoulos, E

Telephone No. +31 70 340-0



Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:
 - ☒ the international application in the language in which it was filed.
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).
2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))
3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
 - a. ☐ forming part of the international application as filed:
 - ☐ in the form of an Annex C/ST.25 text file.
 - ☐ on paper or in the form of an image file.
 - b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
 - c. ☐ furnished subsequent to the international filing date for the purposes of international search only:
 - ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).
 - ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).
4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>2, 3, 5-10</u>
	No: Claims	<u>1, 4</u>
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-10</u>
Industrial applicability (IA)	Yes: Claims	<u>1-10</u>
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following document:

D1: EP 2 442 228 A1, 18 April 2012.

2 D1 discloses all features defined in claim 1:

- A method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes:
 - *[abstract] computer cluster comprising computation nodes CN and boosters B*
- At least one of the plurality of computation nodes and plurality of booster nodes being arranged to compute a computation task:
 - *CNs dynamically outsource specific computation tasks to boosters B (the feature is hence implicitly disclosed as a combination of 1 CN node that outsources a task + at least 1 BN node to which the task is outsourced)*
- The computation task comprising a plurality of sub-tasks:
 - *[0012] A computation task may be defined by means of an algorithm, a source code, a binary code and may be furthermore be compound of any of them. A computation task may for instance be a simulation, which is to be computed by the computer cluster arrangement. Furthermore, the computation task may comprise several sub problems, also referred to as sub tasks, which in their entirety describe the overall computation task. It is possible to divide the computation task into several parts, for instance at least a first part of the computation task and at least a second part of the computation task. It is also possible for the computer cluster arrangement to solve the parts of the computation task in parallel or in succession.*
- In a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution:

- [0012] *solve the parts of the computation task ... in succession.*
Note: in succession covers a task being executed in a first phase and a second phase.
- [0014] *For determining an initial assignment of boosters to computation nodes, the assignment metric is predetermined but may be altered at runtime...static assignment is provided at start of the processing of computation task and dynamic assignment is provided at runtime.*
- [0047]-[0050] *deal with various variants of processing first one part of a computation task with one combination/configuration of cluster nodes, re-assignment of nodes, and processing second part of the computation task with a different configuration of cluster nodes*
- Information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes is used to generate a further distribution of the sub-tasks between the computation nodes and booster node for processing thereby in a further computing iteration:
 - [0014] *it is possible to update the assignment metric at runtime. Such assignment rules may be created as a function of a load balancing, which detects workload of the computer cluster arrangement, especially of the boosters [note: "information...", implicit that it is relating to the processing of the plurality of sub-tasks...]....dynamic assignment is provided at runtime.("further distribution").*
 - [0016] *A computation history...applied for dynamic assignment. Hence, computation tasks can be empirically evaluated by computation on at least one first booster and recording response times and furthermore by processing the same computation task on at least one further booster and recording response time, see [0047]-[0050].*

3 The subject-matter of claim 1 is therefore not new (Article 33(2) PCT).

4 The subject-matter of claim 9 differs from that of claim 1 in two additional features:

- A. The first additional feature of independent claim 9 relating to "the system comprises a resource manager for assigning booster nodes and computation nodes to each other for the computing of the tasks" is disclosed by document D1, see e.g., [0009].
- B. Regarding the second additional feature of independent claim 9 relating to "the system further comprises an application manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes", it is noted that although D1 is silent about having "an application manager", said feature is not considered inventive because it is a customary measure requiring no documentary evidence to monitor performance of a node in a cluster during execution of task(s) via a daemon running on the node, and to provide the related information (either in form of raw data or some derived metrics thereof) to some kind of a centralized manager (hence, receiving such information is also a standard practice).

5 Therefore, the subject-matter of claim 9 is not inventive (Article 33(3) PCT).

6 The dependent claims do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of novelty (claim 4) and inventive step (claims 2-3, 5-8, 10) for the following reasons:

- claim 2: application manager receives the information and determines the further distribution: The additional features of said dependent claim appear to be strongly suggested by document D1, which although silent on having "an application manager", discloses such information and determining further distribution, see, e.g., D1 [0014]...detects workload of the computer cluster arrangement, especially of the boosters. Furthermore, it is possible to detect computing capacities of boosters and furthermore detect computation task requirements and assign a selected booster, which provides the required capacities to the computation node...dynamic assignment is provided at runtime.
- claim 3: a resource manager determines the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the first iteration as a function of the computation task and wherein the application manager receives the information and processes it as input

to the resource manager such that the resource manager dynamically alters further distribution during the computing of the computation task:

- see comments for the corresponding subject-matter of claim 9

- claims 4 and 10: the resource manager receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task. The additional features of said dependent claims are known from document D1:
 - [0009] *For an assignment of a booster to a computation node a resource manager, in form of a resource manager module or resource manager node, may be provided. The resource manager may establish a static assignment at start of a processing of a computation task. Alternatively or additionally it may establish a dynamic assignment at runtime, which means during processing of the computation task. (Note: hence there is a first assignment (static), and then it is dynamically altered).*
 - [0014] *For accomplishing the assignment between boosters and computation nodes a specific set of rules is required. Therefore, an assignment metric is provided, which serves as a basis for the decision which booster is coupled with which computation node. The assignment metric may be managed by a resource manager. Managing the assignment metric refers to establishing and updating rules naming at least one booster, which is assigned to at least one further named computation node. Hence, it is possible to update the assignment metric at runtime. Such assignment rules may be created as a function of a load balancing, which detects workload of the computer cluster arrangement, especially of the boosters.*
- claims 5, 8: daemons operate in the computation nodes and the booster nodes to generate the information: It is a standard design option to monitor load of a node in a cluster via a daemon running on the node, as already indicated for claim 9; generating a measure of a loading of the node during processing of a sub-task is a routine measure for a skilled person, which a skilled person would apply according to the circumstances, e.g. to obtain performance statistics for each individual component of the compute task for a particular architecture.

- claim 6: the first distribution is determined based on a rating provided in source code for each sub-task. Determining a distribution based on tasks properties is strongly suggested by D1 [0014-15] detect computation task requirements and assign a selected booster, which provides the required capacities to the computation node...static assignment is provided at start of the processing of computation task and dynamic assignment is provided at runtime... Furthermore cost functions may be applied for evaluation of required resource capacities and furthermore for evaluation of provided computation capacities of boosters. Hence, computation tasks of certain requirements can be forwarded to appropriate boosters.
- claim 7: the information is used to provide a grouping of sub-tasks in at least one of the first and second iterations. As far as it can be understood, it is a customary practice to determine grouping and further allocation of tasks according to such information. It is noted that "the first and second iterations" of claim 7 are not defined. Under assumption that "the first iteration" of claim 7 refers to "a first computing iteration" of claim 1, it is not clear how the information which appears to be obtained in claim 1 subsequent to processing the first computing iteration is used in claim 7 to "provide a grouping of sub-tasks in ... the first iterations".

7 All claims are industrially applicable.

Re Item VII

Certain defects in the international application

- 8 To meet the requirements of Rule 5.1(a)(ii) PCT, D1 should be identified in the description and the relevant contents should be discussed in a manner adequate to allow full understanding of the subject of protection and in order to ensure that it is clear from the description which features of the subject-matter of any new independent claim are known from D1.
- 9 All independent claims are to be drafted in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from the prior art (D1) being placed in the preamble (Rule 6.3(b)(i) PCT) and the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).
- 10 The features of all claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).



(51) International Patent Classification:
G06F 9/50 (2006.01)

(21) International Application Number:
PCT/EP2017/075375

(22) International Filing Date:
05 October 2017 (05.10.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
16192430.3 05 October 2016 (05.10.2016) EP

(71) Applicant: PARTEC CLUSTER COMPETENCE
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Aschaffenburg (DE).

(74) Agent: TOMLINSON, Edward James; Frohwitter Patent-
und Rechtsanwälte, Possartstrasse 20, 81679 München
(DE).

(81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP,
KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
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TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(54) Title: HIGH PERFORMANCE COMPUTING SYSTEM AND METHOD

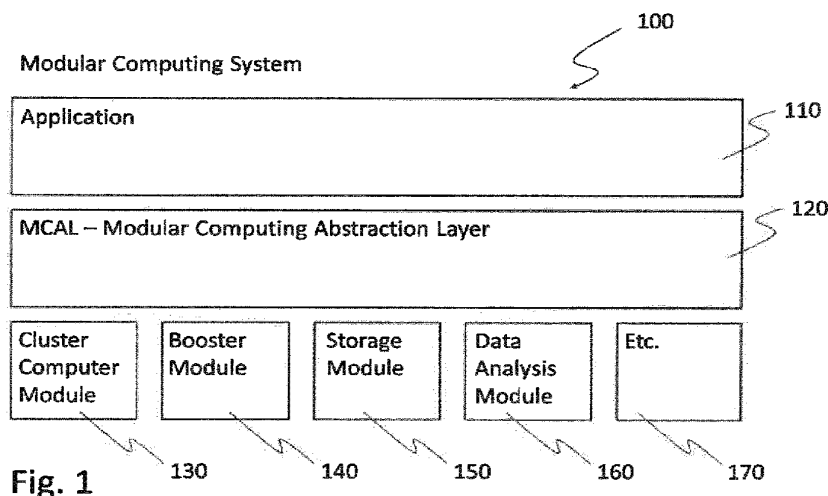


Fig. 1

(57) Abstract: The present invention relates to the technical field of high performance computing (HPC). In particular, the invention relates to a heterogeneous computing system, particularly a computing system including different modules, which can freely be assigned to jointly process a computation tasks. A control entity, referred to as module computing abstraction layer (MCAL), is provided which allows dynamic assignment of various resources provided by the different modules. Due to its flexibility in adjusting to varying demands in computing, the present invention is also applicable as an underlying system for providing cloud computing services, which provides shared computer processing resources and data to computers and other devices on demand, mostly via the Internet.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

5

High Performance Computing System and Method

The present invention relates to the technical field of high performance computing (HPC). In particular, the invention relates to a heterogeneous computing system, particularly a computing system including different modules, which can freely be assigned to jointly process a computation tasks. A control entity, referred to as module computing abstraction layer (MCAL), is provided which allows dynamic assignment of various resources provided by the different modules. Due to its flexibility in adjusting to varying demands in computing, the present invention is also applicable as an underlying system for providing cloud computing services, which provides shared computer processing resources and data to computers and other devices on demand, mostly via the Internet.

Applications for HPC systems cover a wide technical area. From simulating the human brain over weather and climate prediction, computational fluid engineering, seismic imaging, radio astronomy to data analysis, just to name a few. The demand for high performance computing is ever increasing.

Currently, the predominant HPC architectures are cluster computers and massive parallel processing (MPP) systems. Cluster computers include a plurality of cluster nodes, which communicate with each other using standard network technology. The individual cluster nodes are equipped with off-the-shelf general purpose processors. In MPP (massively parallel processing) systems, a large number of processors perform computations simultaneously, hence, in parallel. They normally also employ off-the-shelf general purpose processors. The processors, however, tend to use proprietary network technology and particularly adapted software for the communication.

In order to satisfy the thirst for more and more computation power, the number of cluster nodes in computer clusters and processors in MPP systems increased massively in recent years. However, it can already be seen that just using off-the-shelf general purpose processors and increasing its number in a system is not a solution.

Off-the-shelf general purpose processors have without any doubt positive aspects. Their single thread performance is high. They have large memory per processor or core in case of a multi-core processor. Standard programming can be used, which makes it easier to port applications to such systems. However, the technology is reaching its limits. If it comes to
5 off-the-shelf general purpose processors, their clock rate (frequency) has practically not increased in the last decade. This is closely connected to the energy consumption, which should not go far beyond 100 watt per chip before it gets critical, in particular with cooling the system. Additionally, those processors are comparably expensive and have low energy efficiency.

10 A solution is seen in employing accelerators, which can be used to compute those parts of an application that is highly scalable. Highly scalable is an application if it can handle larger loads by adding more resources in a more cost effective way. The sequential part in the code, which cannot be computed in parallel, is normally one of the most crucial limiting factors for scalability.

15 Systems using more than one kind of processor are referred to as heterogeneous computer systems. Different accelerators can be used in combination with general purpose processors, namely many core processor and GPUs (Graphics Processing Unit). Many core processors have 50 plus cores. GPUs have hundreds of simple computing cores. Both types of processors are energy efficient.

20 In heterogeneous computer systems, each cluster node is equipped with accelerators, formed by one or more multicore processors or GPUs. The accelerator basically functions as a coprocessor supplementing the functions of the cluster node's primary processor. The cluster nodes communicate via a fabric in which components pass data to each other through
25 interconnecting switches. The term "fabric" is one used in the field of high performance computing to refer to a system topology. The term interconnect is also used for the communication infrastructure between the cluster nodes, referring to an electrical or optical connection or cable that connects separate devices. The major problem of attaching an accelerator to each node is the static assignment. The ratio between the general purpose
30 processor and the GPU is fixed when the system is designed.

The international application WO2012-049247A1 tackles this shortcoming with a computer cluster arrangement and a method for operation of the introduced computer cluster arrangement. The computer cluster arrangement comprises computation nodes CN, which
35 dynamically outsource specific computation tasks to boosters B. Therefore, an assignment technique of boosters B to computation nodes CN is introduced. The assignment takes dynamically place at runtime. In this architecture cluster nodes and accelerator nodes, which

form the booster, are put into one fabric. This is more flexible in comparison to the accelerated cluster nodes since the assignment of the booster to cluster nodes for accelerating processing can be done when starting a process. This arrangement is further described by Norbert Eicker et al. in "The DEEP project Pursuing cluster-computing in the many-core era", 42nd International
5 Conference on Parallel Processing, pp 885-892, 2013, and "The DEEP Project An alternative approach to heterogenous cluster-computing in the many-core era", Concurrency and Computation: Practice and Experience, 28, pp 2394-2411. 2015.

When one application is computed by a heterogeneous system, such as the cluster booster
10 type, the individual computation tasks not only need to be processed on multiple different cluster nodes, but also on two different architectures, namely the computer cluster and the accelerator. An efficient communication between the cluster computer and the booster as well as within the cluster computer and within the booster must be ensured. Additionally, the increasing number of components causes the risk that components fail, even with a high reliability of the individual
15 parts. So the system must ensure a high resiliency, i.e. the ability to withstand failure of individual components and yet remain functional.

The present invention provides modular computing systems. A modular computing system includes different modules, such as a cluster module, and booster module, a storage module, a
20 neuromorphic module, a data analytic module, a graphics module, a quantum computing module etc. Each module might include a plurality of nodes. The cluster module includes a plurality of cluster nodes, the booster module includes a plurality of booster nodes, and the storage module includes a plurality of storage nodes, and so on.

25 The individual nodes are either all connected to one fabric. Different modules may have different interconnects. The cluster module uses e.g. an InfiniBand interconnect, whereas the booster module uses an Intel Omni-Path fabric, which is connected to the InfiniBand interconnect via special interface nodes. The same applies to the other types of modules.

30 In order to combine the different modules to one system a modular computing abstraction layer (MCAL) is provided. The MCAL provides communication functionality and management functionality. The Para Station by Par Tec Cluster Competence Center GmbH could form a starting point for realizing MCAL having the functionality and properties described in the following.

35 The MCAL allows communication within a module, referred to as intra module communication, and between modules, referred to as inter module communication. In order to do so, MCAL

provides interfaces to the respective fabrics, e.g., one fabric for entire system or specialized fabric per module, such as InfiniBand for cluster module and Intel Omni-Path fabric for the booster module. Other interconnects are also possible such as Ethernet, 10G, Gigabit or shared memory communication. MCAL can use any kind of communication and selects the particular way of communication based on availability, indications by the application program, performance or cost considerations.

Shared memory communication provides a very fast and efficient way for two or more processes to communicate. Different types of shared memory communication can be employed by MCAL. In case two or more processes of a parallel task run on the same physical node having shared memory, this shared memory can be used for shared memory communication between these processes. This is typically possible on SMP nodes, where one process per CPU is spawned. Symmetric multiprocessing (SMP) refers to an architecture where two or more identical processors connect to a single, shared main memory. Since MCAL has the knowledge about the processes and on which node they are processed, MCAL can set up shared memory communication in such a situation.

However, shared memory communication is not limited to SMP situations. In case processes run on different nodes within one module or even on nodes belonging to different modules, MCAL sets up shared virtual address space communication. Using shared virtual address space communication, larger messages are conveyed between nodes by just sharing meta data of the message and the virtual address of the data itself. The actual message can be accessed by the process via its assigned virtual address space. This allows fast communication. MCAL sets up a virtual address space communication by setting up a memory region, which is directly shared by the processes or nodes involved in the communication.

As can be seen from those examples the MCAL not only provides the communication functionality, but also selects the way to communicate, which increases performance and efficiency. MCAL can e.g. decides which interconnect can be used for communication while spawning processes, i.e., creating and executing new child processes. At the same time MCAL monitors the current process and observes the child process to terminate or may continue to execute asynchronously.

The second major function MCAL provides is management. The management function covers different aspects, namely node management, module management, process management and resource management.

Node management is directed to the individual nodes, such as the cluster nodes in a cluster module, the booster nodes in a booster module, the storage nodes in a storage module and so on regarding other types of modules, as named above, which are present in the system. MCAL first of all detects usable nodes. Usable nodes are those ready to be used. This includes that

5 MCAL is configured to identify malfunctioning nodes or nodes close to fail, e.g. based on system parameters, such as temperature, available memory, etc. and the variation of those properties over time. MCAL therefore implements fault tolerance and thereby ensures high resiliency.

This is done by MCAL employing the concept of virtual nodes. The virtual nodes represent

10 actual hardware, such as cluster nodes, booster nodes, storage nodes, etc. but MCAL has the freedom to dynamically map the nodes. For example, if an application requires X cluster nodes, Y booster nodes and Z storage nodes (X, Y, Z being integer numbers). MCAL can provide those nodes out of all available resources. In case a node is failing or added to the system, MCAL can react quickly by just changing the mapping between the virtual nodes and the physical nodes.

15 Malfunctioning nodes can be taken out of the list of available nodes without making the entire system fail.

MCAL has also the ability to select particular nodes depending on factors like reachability, latency or physical placement. This can be done completely transparently to the running

20 application.

The MCAL has the overall system view and constantly keeps the state of each node and each interconnect up to date. MCAL is informed at all times about particular properties of each node and interconnect, such as number of available CPUs per node, running services, available

25 storage, interconnect bandwidth, free memory, temperature, system clock rate etc.

Another function is module management. Module management is similar to node management, and might include node management for a particular module, but takes into consideration module specific aspect. Module management focuses on module specific aspects, such as the

30 state of interface nodes, if provided, via which the module communicates to others. Similar to nodes, MCAL monitors the module's state in order to allow increased utilization of the module.

MCAL is also responsible for process management. Each running application is divided into a plurality of individual processes, which need to be started, distributed and monitored. At the

35 same time resources need to be assigned, which correspond to the need of the process for computation power and storage. If the process requires a particular processing, MCAL assigns

one or more booster nodes or even more specific nodes such as neuromorphic nodes, data analytic nodes, graphics nodes or quantum computing nodes from the respective modules.

In order to do so, MCAL is configured to recognize and control dependencies between processes and their requirements. Based on this, MCAL creates processes on nodes, in case of a booster module or cluster module, or assigns storage in case of a storage module. Processes are monitored and dependent processes are treated as group, allowing to quickly responding to errors occurring in any one of a parallel task. This allows that processes are re-started immediately so that the overall delay for the running application is minimized.

Resource management is another task MCAL performs in the modular computing system. As part of resource management MCAL realizes off-loading mechanism, i.e. processes, which are e.g. running on a cluster module, might need some booster nodes from the booster module. In such a case MCAL can spawn processes on selected booster nodes, in order to run the task in parallel.

As part of the off-loading not just one process running on one booster may be created, but multiple processes, which are directly communicating with each other using the modules communication fabric without the need for the host processor to interfere.

The resource management also ensures reducing memory consumption, e.g. by reducing the number of connections between different processes. This is done by using on-demand connections, which are only actually established, when needed. This drastically reduces memory consumption per connection. So, not only resources such as nodes are treated in a virtual fashion, but virtual assignment is also applied to physical networks.

When assigning resources, MCAL does not only take into consideration the request by one process, but other processes as well. This allows to flexibly responding to changes of communication infrastructure based on the integrated control.

Integrated control is another functional aspect provided by MCAL. Integrated control refers to the usage of information gathered by MCAL from its management function for controlling communication and vice versa. Hence, communication function and management function is not separate but integrated in order to further optimize the overall system performance.

MCAL's knowledge about all different aspects of all nodes in all modules and the status of all interconnects, intra module communication and inter module communication is used to run the

system. This allows to dynamically adjusting to changing behavior of the system as well as to changing demand of the application running on the system.

5 The integrated control does not only take into consideration the actual system state and application demands, but also predicts upcoming requests for module or interconnect usage.

10 The information of the system state is used for dynamic assignment of nodes. This includes that the assignment of resources is done using a feedback loop registering system wide impact of assignment decisions, so that future assignments adjust correspondingly. The system also stores such information to improve assignment decisions for future cases, in a self-learning fashion.

15 Even if the main part of application normally starts on the cluster module, MCAL identifies which part of the application to run on the cluster module or the booster module. Basis for the decision are e.g. indications by the application code itself, of the observation of the codes performance while running. This allows adjustments to the assignment during the computing of the application.

20 As to the implementation of MCAL, MCAL is distributed over the entire system and it includes node managers (NM) implemented on each node. Node managers can be implemented in hardware, or software, e.g. as daemon processes running on the respective nodes. Node managers constantly gather information in order to build a global view on modules and the entire system. Applications running on system can benefit from this information by communication with the management function or directly with individual node managers. This is realized by particular
25 interface, which can be hardware or an API (application programming interface). So, not only that MCAL gets input from applications, but applications benefit from information gathered by MCAL via the individual node managers.

30 The communication traffic of node managers is strictly separated from intra and inter module communication. This allows the intra and inter module communication to run with high speed uninterrupted by management functions. Furthermore, system security can further be enhanced by such separation.

35 The use of the actual communication network is controlled by MCAL, which provides such functionality to the application via message passing interface (MPI). Part of MCAL is an MPI stack for each module as well as a system wide global MPI. Individual MPIs are realized e.g. for the computer cluster module, the booster module, storage module etc.

MCAL's communication uses an administration network. The administration network can be the same or a different physical network than the physical network used for intra and inter module communication. For example, the intra and inter module communication can be InfiniBand,
5 Myrinet etc. and the administration network can be formed by Ethernet connecting the node managers.

Special nodes can be included in the system for providing a front end allowing administrative tasks or control functions to run the system. The front-end does not need to be connected to the
10 communication network, but just to the communication network. Via the front-end node, which could be formed e.g. by a work station computer, a personal computer (PC) a laptop computer or any smart computing device, the modular computing system can be administrated.

Applications running on the modular computing systems can be scheduled, started, stopped and monitored. This can be done by batch processing, i.e. by executing a series of jobs on the
15 modular computing system without manual intervention, hence, non-interactive.

Besides running a series of jobs on the modular computing system without manual intervention, MCAL may provide interactive computing, in which the application running on the modular computing system accepts input from humans as it runs. This input may be provided via a work
20 station computer, a personal computer (PC) a laptop computer or any smart computing device. In such a scenario the modular computing system is accessible via e.g. the laptop computer, appearing as the laptop computer would have the computation power of the modular computing system. This is very useful for real time applications, which must respond within a time frame that the user senses as immediate or current. Also Big Data applications, which make
25 voluminous amount of structured, semi structured and unstructured data accessible for mining information, can make use of such an arrangement. This is also true for cloud computing services having the modular computing system as an underlying resource for the provision of computation power and storage.

30 The tight integration between MCAL and the system allows lower communication latency and improve communication in the described modular computing system.

Drawings

35 Fig. 1 shows a functional view of a modular computing system according to the present invention.

Fig. 2 shows a first embodiment of a modular computing system according to the present invention.

Fig. 3 shows a second embodiment of a modular computing system according to the present invention.

Fig. 1 shows the functional view of a modular computing system 100 according to the present invention. An application layer 110 forms the top of the modular computing system. In the application layer application programs, such as software programs may be executed in the modular computing system 100. A modular computing abstraction layer 120 (MCAL) is provided, in order to allow the application layer 110 to access the system's resources. The system's resources are formed by various modules, such as the cluster module 130, the booster module 140, the storage module 150, the data analysis module 160 and other modules 170, e.g. one or more from the following group of modules: a neuromorphic module, a graphics module, a quantum computing module. It is also possible to have multiple modules of the same kind.

The MCAL 120 allows communication within a module, referred to as intra module communication, and between modules, referred to as inter module communication. MCAL 120 can use any kind of communication and selects the particular way of communication based on availability, indications by the application program, performance or cost considerations.

Additionally MCAL 120 provides management function. The management function covers different aspects, namely node management, module management, process management and resource management. Node management is directed to the individual nodes and will be explained further with reference to Figures 2 and 3.

The MCAL 120 has the overall system view and constantly keeps the state of each module 130, 140, 150, 160 and 170 up to date. MCAL 120 is informed at all times about particular properties of module 130, 140, 150, 160 and 170, such as number of available processors, running services, available storage, interconnect bandwidth, free memory, temperature, system clock rate etc. Another function MCAL 120 provides is module management. Module management takes into consideration module specific aspect. Hence, MCAL includes functions specially adapted to manage the cluster module 130, the booster module 140, the storage module 150, the data analysis module 160 and other modules 170. MCAL 120 is also responsible for process management. Each running application 110 is divided into a plurality of individual processes, which need to be started, distributed and monitored. At the same time resources need to be assigned, which correspond to the need of the process for computation power and storage. If

the process requires a particular processing, MCAL 120 assigns one or more booster nodes or even more specific nodes such as neuromorphic nodes, data analytic nodes, graphics nodes or quantum computing nodes from the respective modules. In order to do so, MCAL 120 is configured to recognize and control dependencies between processes and their requirements.

- 5 Resource management is another task MCAL 120 performs in the modular computing system. As part of resource management MCAL 120 realizes off-loading mechanism, i.e. processes, which are e.g. running on a cluster module 130, might need some booster nodes from the booster module 140. In such a case MCAL 120 can spawn processes on selected booster nodes from the booster module 140, in order to run the task in parallel.

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Integrated control is another functional aspect provided by MCAL 120. Integrated control refers to the usage of information gathered by MCAL 120 from its management function for controlling communication and vice versa. Hence, communication function and management function is not separate but integrated in order to further optimize the overall system performance. This allows
15 to dynamically adjusting to changing behavior of the system as well as to changing demand of the application running on the system. The integrated control does not only take into consideration the actual system state and application demands, but also predicts upcoming requests for module or interconnect usage.

- 20 Fig. 2 shows a first embodiment of a modular computing system 200 according to the present invention. The modular computing system 200 includes a cluster module 202, a booster module 204 and a storage module 206.

- The cluster module 202 includes a plurality of cluster nodes 208 (CN). On each cluster node 208
25 a node manager 209 (NM) is provided, which in cooperation with other node managers 209 provides communication and management functionality to the modular computing system 200. The booster module 204 includes a plurality of booster nodes 210 (BN). On each booster node 210 a node manager 209 is provided, which in cooperation with other node managers 209 provides communication and management functionality to the modular computing system 200.
30 The storage module 206 includes a plurality of storage nodes 212 (SN). On each storage node 212 a node manager 209 is provided, which in cooperation with other node managers 209 provides communication and management functionality to the modular computing system 200.

- The cluster node may be formed by a computer having a general purpose micro processor, such
35 as an Intel Xeon processor, memory, interfaces, such as network cards. The booster nodes might be formed by processing systems equipped with GPUs or many core processors, memory and interfaces, such as network cards. The storage nodes include memory, which can be RAM

(random access memory) and non-volatile memory, such as flash memory, SSD (solid state disk), hard disk, further the storage node includes a node controller, such as a microprocessor and interfaces, such as network cards.

- 5 Two different networking infrastructures are provided. Firstly, there is a communication network 220 connecting all nodes 208, 210, 212 with each other, so that the cluster nodes 208 and the booster nodes 210 and the storage nodes 212 can communicate.

Secondly, an administration network 224 is provided connecting all node managers 209
10 provided in the various nodes 208, 210, and 212. Attached to the administration network 224 is a front-end 230 which allows controlling the entire modular computing system. The front-end 230 also includes a node manager 209, which performs the actual communication to the other node managers 209.

- 15 In order to combine the different modules to one system a modular computing abstraction layer (MCAL) is provided as described with reference to Fig. 1. The MCAL provides communication functionality and management functionality. The ParaStation by ParTec Cluster Competence Center GmbH could form a starting point for realizing MCAL having the functionality and properties described here.

20 The MCAL is implemented by the node managers 209 on the individual nodes and allows communication within a module, referred to as intra module communication, and between modules, referred to as inter module communication. In order to do so, the node managers provide interfaces to the respective fabrics, e.g., one fabric for entire system or specialized
25 fabric per module, such as InfiniBand for cluster module 202 and Intel Omni-Path fabric for the booster module 204. Other interconnects are also possible such as Ethernet, 10G, Gigabit or shared memory communication. The node managers 309 can use any kind of communication and selects the particular way of communication based on availability, indications by the application program, performance or cost considerations.

30 Shared memory communication and shared virtual address space communication can be employed, which provide a very fast and efficient way for two or more processes to communicate.

- 35 The node managers 209 collectively provide node management. Node management is directed to the individual nodes, such as the cluster nodes 208 in a cluster module 202, the booster nodes 210 in a booster module 204, the storage nodes 212 in a storage module 206.

Furthermore, the node managers 209 also select particular nodes depending on factors like reachability, latency or physical placement. This can be done completely transparently to the running application. They gather and exchange information about the overall system and constantly keep the state of each node and each interconnect up to date. This allows the node
5 managers 309 to be informed at all times about particular properties of each node and interconnect, such as number of available CPUs per node, running services, available storage, interconnect bandwidth, free memory, temperature, system clock rate etc.

Another function implemented by the node managers is module management. Module
10 management is similar to node management, and might include node management for a particular module, but takes into consideration module specific aspect. Module management focuses on module specific aspects, such as the state of interface nodes, if provided, via which the module communicates to others. Similar to nodes, the node managers 309 monitors the module's state in order to allow increased utilization of the module.

15 Resource management is another task the node managers 209 perform in the modular computing system 200. As part of resource management they realize off-loading mechanism, i.e. processes, which are e.g. running on a cluster module 202, might need some booster nodes 210 from the booster module 204. In such a case a node manager can spawn processes on
20 selected booster nodes 210, in order to run the task in parallel.

Integrated control is another functional aspect implemented by the node managers. Integrated control refers to the usage of information gathered by the node managers from its management function for controlling communication and vice versa. Hence, communication function and
25 management function is not separate but integrated in order to further optimize the overall system performance.

The node managers' 209 knowledge about all different aspects of all nodes in all modules and the status of all interconnects, intra module communication and inter module communication is
30 used to run the system. This allows to dynamically adjusting to changing behavior of the system as well as to changing demand of the application running on the system.

The integrated control does not only take into consideration the actual system state and application demands, but also predicts upcoming requests for module or interconnect usage.

35 Node managers 209 can be implemented in hardware, or software, e.g. as daemon processes running on the respective nodes. Node managers 209 constantly gather information in order to

build a global view on modules and the entire system. Applications running on system can benefit from this information by communication with the management function or directly with individual node managers 209. This is realized by particular interface, which can be hardware or an API (application programming interface).

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The communication traffic of node managers 209 is strictly separated from intra and inter module communication. This allows the intra and inter module communication to run with high speed uninterrupted by management functions. Furthermore, system security can further be enhanced by such separation.

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The use of the actual communication network 220 is controlled by the node managers 209, which provide such functionality to the application via message passing interface (MPI).

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Node managers 209 communicate with each other using the administration network 224. The administration network 224 can be the same or a different physical network than the physical network used for intra and inter module communication, here referred to as communication network 220. For example, the intra and inter module communication can be InfiniBand, Myrinet etc. and the administration network can be formed by Ethernet connecting the node managers 209.

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Special nodes can be included in the system for providing a front-end 230 allowing administrative tasks or control functions to run the system. The front-end does not need to be connected to the communication network 220, but just to the communication network 220. Via the front-end node, which could be formed e.g. by a work station computer, a personal computer (PC) a laptop computer or any smart computing device, the modular computing system 200 can be administrated. Applications running on the modular computing system 200s can be scheduled, started, stopped and monitored. This can be done by batch processing, i.e. by executing a series of jobs on the modular computing system 200 without manual intervention, hence, non-interactive.

25

Besides running a series of jobs on the modular computing system 200 without manual intervention, node managers 309 may provide interactive computing, in which the application running on the modular computing system 200 accepts input from humans as it runs. This input may be provided via a work station computer, a personal computer (PC) a laptop computer or any smart computing device. In such a scenario the modular computing system 200 is accessible via e.g. the laptop computer, appearing as the laptop computer would have the computation power of the modular computing system 200. This is very useful for real time

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applications, which must respond within a time frame that the user senses as immediate or current. Also Big Data applications, which make voluminous amount of structured, semi structured and unstructured data accessible for mining information, can make use of such an arrangement. This is also true for cloud computing services having the modular computing system 200 as an underlying resource for the provision of computation power and storage.

Fig. 3 shows a second embodiment of a modular computing system 300 according to the present invention. The modular computing system 300 includes a cluster module 302, a booster module 304 and a storage module 306.

The cluster module 302 includes a plurality of cluster nodes 310 (CN). On each cluster node 310 a node manager 309 (NM) is provided, which in cooperation with other node managers 309 provides communication and management functionality to the modular computing system 300. The cluster nodes 310 are connected to each other via a cluster interconnect 312.

The booster module 304 includes a plurality of booster nodes 320 (BN). On each booster node 320 a node manager 309 is provided, which in cooperation with other node managers 309 provides communication and management functionality to the modular computing system 300. The booster nodes 320 are connected to each other via a booster interconnect 322.

The storage module 306 includes a plurality of storage nodes 330 (SN). On each storage node 330 a node manager 309 is provided, which in cooperation with other node managers 309 provides communication and management functionality to the modular computing system 300. The storage nodes 330 are connected to each other via storage interconnect 332.

The cluster node may be formed by a computer having a general purpose micro processor, such as an Intel Xeon processor, memory, interfaces, such as network cards. The booster nodes might be formed by processing systems equipped with GPUs or many core processors, memory and interfaces, such as network cards. The storage nodes include memory, which can be RAM (random access memory) and non-volatile memory, such as flash memory, SSD (solid state disk), hard disk, further the storage node includes a node controller, such as a microprocessor and interfaces, such as network cards.

The cluster module 302 can communicate with the storage module 306 via an interface node 340 connecting the cluster interconnect 312 with the storage interconnect 332. The storage module 306 can communicate with the booster module 304 via an interface node 342 connecting the storage interconnect 332 with the booster interconnect 322. The booster module

304 can communicate with the cluster module 302 via an interface node 344 connecting the booster interconnect 322 with the cluster interconnect 312.

The cluster module 302 uses e.g. an InfiniBand interconnect, whereas the booster module 304
5 uses an Intel Omni-Path fabric, which is connected to the InfiniBand interconnect via the interface node 344. Each interface node may be formed by a plurality of nodes in order to increase performance and throughput. The same applies to the other types of modules.

All node managers 309 provided in the various nodes 310, 310, 312 are using the same
10 communication infrastructure. Attached to the cluster interconnect 312 is a front-end 350 which allows to control the entire modular computing system. The front-end 350 also includes a node manager 309, which performs the actual communication to the other node managers 309.

In order to combine the different modules to one system a modular computing abstraction layer
15 (MCAL) is provided as described with reference to Fig. 1. The MCAL provides communication functionality and management functionality. The ParaStation by ParTec Cluster Competence Center GmbH could form a starting point for realizing MCAL having the functionality and properties described in the following.

20 MCAL is implemented by the node managers 309 in each node, which can use for process to process communication any kind of communication link provided.

As aforementioned, the node managers 309 also provide node management. Node
management is directed to the individual nodes, such as the cluster nodes 310 in a cluster
25 module 302, the booster nodes 320 in a booster module 304, the storage nodes 330 in a storage module 306. The node managers 309 also have the ability to select particular nodes depending on factors like reachability, latency or physical placement. This can be done completely transparently to the running application. They always have overall system view and constantly keeps the state of each node and each interconnect up to date. The node managers
30 309 inform each other at all times about particular properties of each node and interconnect, such as number of available CPUs per node, running services, available storage, interconnect bandwidth, free memory, temperature, system clock rate etc.

Another function they implement is module management. Module management is similar to
35 node management, and might include node management for a particular module, but takes into consideration module specific aspect. Module management focuses on module specific aspects, such as the state of interface nodes, if provided, via which the module communicates to others.

The node managers 309 also implement process management. Each running application is divided into a plurality of individual processes, which need to be started, distributed and monitored. At the same time resources need to be assigned, which correspond to the need of the process for computation power and storage. They are configured to recognize and control dependencies between processes and their requirements. Based on this, the node managers 309 creates processes on nodes, in case of an booster module 304 or cluster module 302, or assigns storage in case of a storage module 306. Processes are monitored and dependent processes are treated as group, allowing to quickly responding to errors occurring in any one of a parallel task. This allows that processes are re-started immediately so that the overall delay for the running application is minimized.

Resource management is another task the node managers 309 implement in the modular computing system 300. As part of resource management they realize off-loading mechanism, i.e. processes, which are e.g. running on a cluster module 302, might need some booster nodes 320 from the booster module 304. In such a case the node manager 309 spawn processes on selected booster nodes 320, in order to run the task in parallel.

As part of the off-loading not just one process running on one booster may be created, but multiple processes, which are directly communicating with each other using the modules communication fabric without the need for the host processor to interfere.

The resource management also ensures reducing memory consumption, e.g. by reducing the number of connections between different processes. This is done by using on-demand connections, which are only actually established, when needed. This drastically reduces memory consumption per connection. So, not only resources such as nodes are treated in a virtual fashion, but virtual assignment is also applied to physical networks.

When assigning resources, the node managers 309 do not only take into consideration the request by one process, but other processes as well. This allows to flexibly responding to changes of communication infrastructure based on the integrated control.

Integrated control is another functional aspect provided by the node managers 309. Integrated control refers to the usage of information gathered by the node managers from its management function for controlling communication and vice versa. Hence, communication function and management function is not separate but integrated in order to further optimize the overall system performance.

The node managers' knowledge about all different aspects of all nodes in all modules and the status of all interconnects, intra module communication and inter module communication is used to run the system. This allows to dynamically adjusting to changing behavior of the system as well as to changing demand of the application running on the system.

The integrated control does not only take into consideration the actual system state and application demands, but also predicts upcoming requests for module or interconnect usage. The information of the system state is used for dynamic assignment of nodes. This includes that the assignment of resources is done using a feedback loop registering system wide impact of assignment decisions, so that future assignments adjust correspondingly. The system also stores such information to improve assignment decisions for future cases, in a self-learning fashion.

Even if the main part of application normally starts on the cluster module 302, the node managers identify which part of the application to run on the cluster module 302 or the booster module 304. Basis for the decision are e.g. indications by the application code itself, of the observation of the codes performance while running. This allows adjustments to the assignment during the computing of the application.

Node managers 309 can be implemented in hardware, or software, e.g. as daemon processes running on the respective nodes. Node managers 309 constantly gather information in order to build a global view on modules and the entire system. Applications running on system can benefit from this information by communication with the management function or directly with individual node managers 309. This is realized by particular interface, which can be hardware or an API (application programming interface).

The communication traffic of node managers is strictly separated from intra and inter module communication. This allows the intra and inter module communication to run with high speed uninterrupted by management functions. Furthermore, system security can further be enhanced by such separation.

The use of the actual communication network is controlled by node managers 309, which provides such functionality to the application via message passing interface (MPI). The node managers 309 uses an administration network (not shown). The administration network (not shown) can be the same or a different physical network than the physical network used for intra and inter module communication. For example, the intra and inter module communication can

be InfiniBand, Myrinet etc. and the administration network (not shown) can be formed by Ethernet connecting the node managers 309.

Special nodes can be included in the system for providing a front end allowing administrative tasks or control functions to run the system. The front-end 350 does not need to be connected to the communication network, but just to the communication network. Via the front-end 350 node, which could be formed e.g. by a work station computer, a personal computer (PC) a laptop computer or any smart computing device, the modular computing system 300 can be administrated. Applications running on the modular computing system 300s can be scheduled, started, stopped and monitored. This can be done by batch processing, i.e. by executing a series of jobs on the modular computing system 300 without manual intervention, hence, non-interactive.

Besides running a series of jobs on the modular computing system 300 without manual intervention, the node managers may provide interactive computing, in which the application running on the modular computing system 300 accepts input from humans as it runs. This input may be provided via a work station computer, a personal computer (PC) a laptop computer or any smart computing device. In such a scenario the modular computing system 300 is accessible via e.g. the laptop computer, appearing as the laptop computer would have the computation power of the modular computing system 300. This is very useful for real time applications, which must respond within a time frame that the user senses as immediate or current. Also Big Data applications, which make voluminous amount of structured, semi structured and unstructured data accessible for mining information, can make use of such an arrangement. This is also true for cloud computing services having the modular computing system 300 as an underlying resource for the provision of computation power and storage.

Claims

1. A modular computing system for performing computation of application programs including different modules, each module including a plurality of nodes, the modular
5 computing system further includes a modular computing abstraction layer distributed across the nodes and providing intra- and inter-module communication and a management function for the nodes of the different modules.

2. The modular computing system according to claim 1, characterized in that the different
10 modules are formed by at least a cluster module, a booster module and a storage module.

3. The modular computing system according to claim 1 or 2, characterized in that the modular computing abstraction layer is implemented by node managers provided in the
15 nodes.

4. The modular computing system according to claim 3, characterized in that the node managers communicate with each other via an administration network.

5. The modular computing system according to any of the preceding claims, characterized
20 in that the plurality of nodes communicate via a communication network.

6. The modular computing system according to claim 5, characterized in that the communication network is implemented using a shared memory communication.

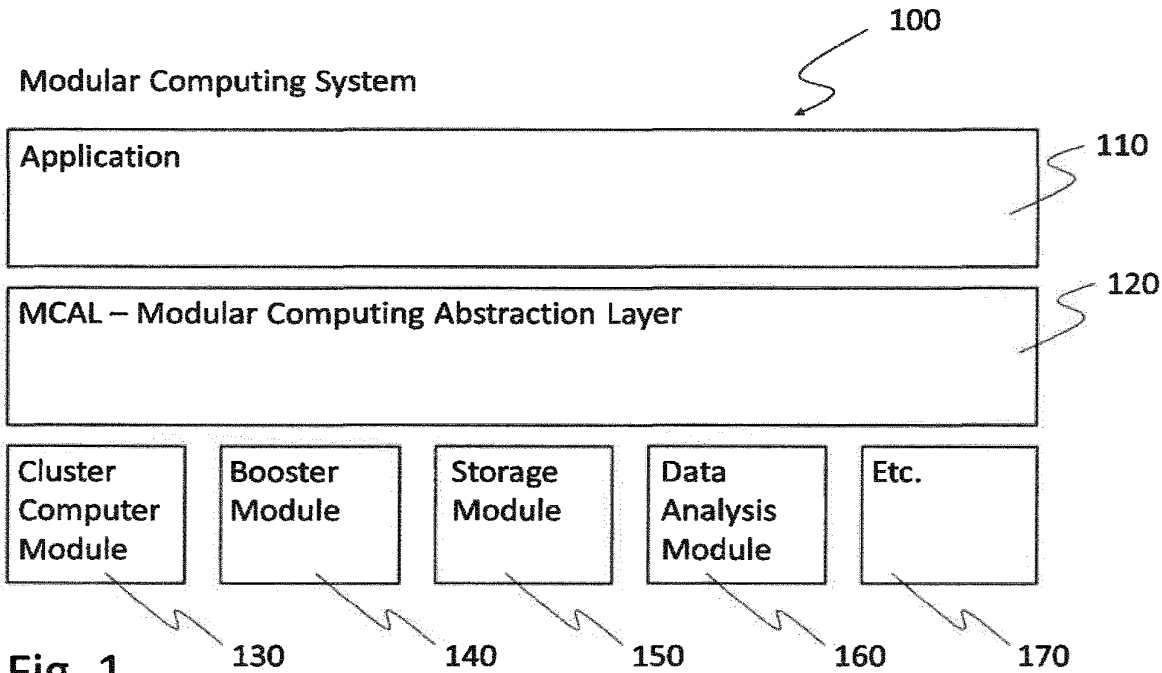
7. The modular computing system according to claim 3, wherein communication between
25 node managers is separated from communication between modules.

8. The modular computing system according to claim 3, wherein the node managers exchange information such that they each maintain a set of information about a status of
30 each node and each interconnect between the nodes.

9. The modular computing system according to claim 8, wherein the set of information is used to dynamically adjust an operation of the system by assigning resources to the nodes dependent on the set of information.
35

10. A method for managing a modular computing system for performing computation of application programs including different modules, each module having a plurality of nodes and the modular computing system having a modular computing abstraction layer distributed across the nodes, including the step of providing using the modular computing abstraction layer intra- and inter-node communication and a management function for the nodes of the different modules.

11. The method for managing a modular computing system according to claim 10, further including node managers, further including the step of the node managers collecting information about the status of the nodes and assigning resources to the nodes depending on the collected status information.



2/3

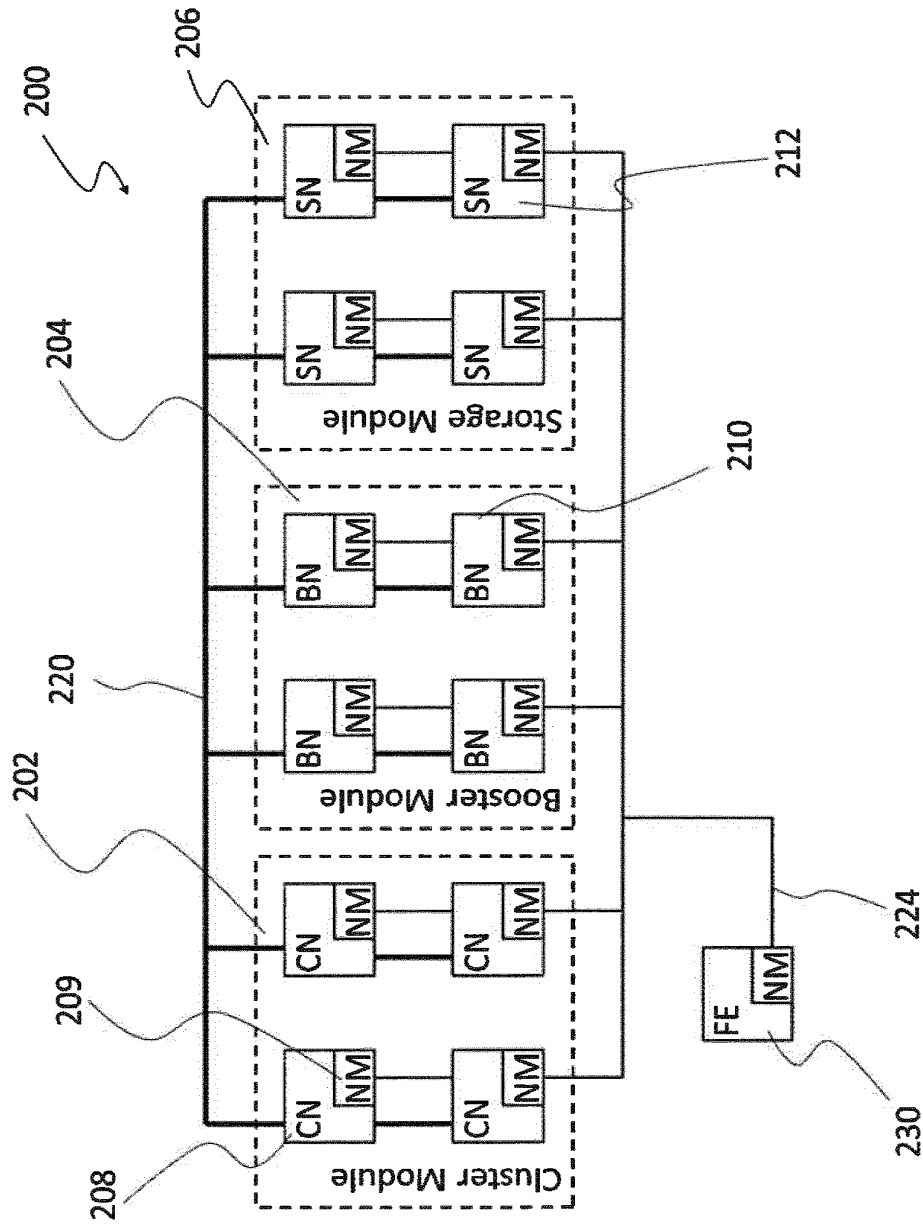


Fig. 2

3/3

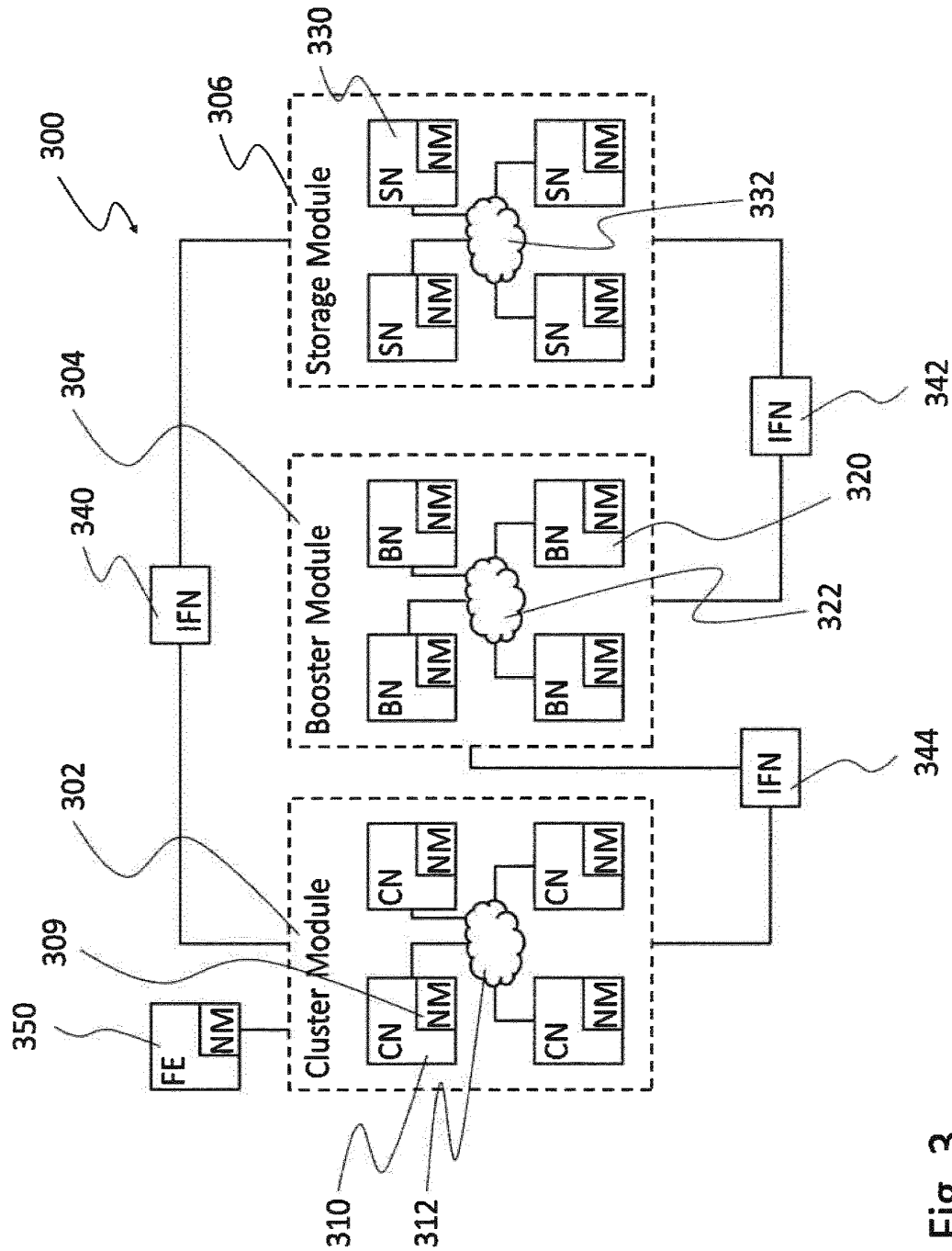


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/075375

A. CLASSIFICATION OF SUBJECT MATTER

INV. G06F9/50
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EICKER NORBERT ET AL: "The DEEP Project - Pursuing Cluster-Computing in the Many-Core Era", INTERNATIONAL CONFERENCE ON PARALLEL PROCESSING, IEEE, 1 October 2013 (2013-10-01), pages 885-892, XP032534670, ISSN: 0190-3918, DOI: 10.1109/ICPP.2013.105 [retrieved on 2013-12-18] abstract; figures 1,3 Sections I, V-A ----- -/-	1-11



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

21 November 2017

Date of mailing of the international search report

29/11/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Balevic, Ana

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/075375

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NORBERT EICKER ET AL: "The DEEP Project An alternative approach to heterogeneous cluster-computing in the many-core era", CONCURRENCY AND COMPUTATION: PRACTICE AND EXPERIENCE, vol. 28, no. 8, 27 July 2015 (2015-07-27), pages 2394-2411, XP055354288, GB ISSN: 1532-0626, DOI: 10.1002/cpe.3562 Sections 2.3, 4.3, 4.4, 5.1.3 -----	1-11
A	WO 2005/106668 A1 (RAYTHEON CO [US]; BALLEW JAMES D [US]; DAVIDSON SHANNON V [US]) 10 November 2005 (2005-11-10) paragraphs [0017], [0018], [0050] - [0052]; figure 1a -----	1-11
A	EP 1 715 405 A1 (ST MICROELECTRONICS SRL [IT]) 25 October 2006 (2006-10-25) paragraph [0023] -----	11
A	US 2016/065492 A1 (HU YONGGANG [CA] ET AL) 3 March 2016 (2016-03-03) paragraph [0032]; figure 3 -----	3,11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/075375

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2005106668	A1	10-11-2005	EP 1735708 A1 27-12-2006
			JP 4986844 B2 25-07-2012
			JP 2007533031 A 15-11-2007
			US 2005246569 A1 03-11-2005
			WO 2005106668 A1 10-11-2005

EP 1715405	A1	25-10-2006	EP 1715405 A1 25-10-2006
			US 2006259799 A1 16-11-2006
			US 2010161939 A1 24-06-2010

US 2016065492	A1	03-03-2016	US 2016062795 A1 03-03-2016
			US 2016065492 A1 03-03-2016
			US 2017052823 A1 23-02-2017
			US 2017054799 A1 23-02-2017

Electronic Acknowledgement Receipt

EFS ID:	40264409
Application Number:	16963749
International Application Number:	
Confirmation Number:	6322
Title of Invention:	APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES
First Named Inventor/Applicant Name:	Thomas Lippert
Customer Number:	4743
Filer:	Michael Paul Furmanek./Araceli Hernandez
Filer Authorized By:	Michael Paul Furmanek.
Attorney Docket Number:	29959/55804
Receipt Date:	12-AUG-2020
Filing Date:	
Time Stamp:	14:55:58
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no
------------------------	----

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	Information_Disclosure_State ment.PDF	16880	no	2
			1f3cc46a372deb7c1265695b1fd3e6456de 93017		

Warnings:

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	IDS_Citation_by_Applicant_6_References.PDF	36202	no	2
			0bc9dacc58be999dccc3b12f1c56ef690c0e6977e		
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Non Patent Literature	ISR.PDF	95459	no	3
			c85e63cd5770934241d4c1ed09b439f55ef12c50		
Warnings:					
Information:					
4	Non Patent Literature	Written_Opinion.PDF	352240	no	8
			72769e61df85a9dc4df34ef17205a95c4765db2f		
Warnings:					
Information:					
5	Foreign Reference	WO2018065530A1_PCTEP2017075375.PDF	3399970	no	28
			7c5bb44c412809c91f909340e36886820130a3a3		
Warnings:					
Information:					
6	Non Patent Literature	2016_cosh.PDF	253231	no	7
			c68740e693e273944d3620037f93ffc484d816c		
Warnings:					
Information:					
7	Non Patent Literature	Eicker_et_al_The_DEEP_Project_July_27_2015.PDF	1529387	no	18
			27135316432dda78790d2d4130bc61000725a087		
Warnings:					
Information:					
Total Files Size (in bytes):			5683369		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Thomas Lippert et al.

Application No.: 16/963,749

Confirmation No.: 6322

Filed: July 21, 2020

Art Unit: 0

For: APPLICATION RUNTIME DETERMINED
DYNAMICAL ALLOCATION OF
HETEROGENEOUS COMPUTE RESOURCES

Examiner: Not Yet Assigned

INFORMATION DISCLOSURE STATEMENT (IDS)

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Pursuant to 37 C.F.R. §§ 1.56, 1.97, and 1.98, the attention of the United States Patent and Trademark Office is hereby directed to the references listed on the attached PTO/SB/08. It is respectfully requested that the information be expressly considered during the prosecution of the above-identified application, and that the references be made of record therein and appear among the "References Cited" on any patent to issue therefrom.

This Information Disclosure Statement accompanies the new patent application submitted herewith.

In accordance with 37 C.F.R. § 1.98(a)(2)(ii), copies of U.S. patents and U.S. patent application publications are not submitted. Submitted herewith are copies of foreign patents and non-patent literature in accordance with 37 C.F.R. § 1.98(a)(2).

In accordance with 37 C.F.R. § 1.97(g), the filing of this Information Disclosure Statement shall not be construed as a representation that a search has been made. In accordance with 37 C.F.R. § 1.97(h), the filing of this Information Disclosure Statement shall not be construed to be an admission that the information cited in this

Information Disclosure Statement is, or is considered to be, material to patentability as defined in 37 C.F.R. § 1.56(b).

It is submitted that the Information Disclosure Statement is in compliance with 37 C.F.R. § 1.98, and the Examiner is respectfully requested to consider the listed references.

Dated: August 12, 2020

Respectfully submitted,

By /Michael P. Furmanek, #58,495/
Michael P. Furmanek
Registration No.: 58,495
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Attorney for Applicant



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
16/963,749	07/21/2020		860	29959/55804	10	2

CONFIRMATION NO. 6322

4743

MARSHALL, GERSTEIN & BORUN LLP
233 SOUTH WACKER DRIVE
6300 WILLIS TOWER
CHICAGO, IL 60606-6357

FILING RECEIPT



0000000122134144

Date Mailed: 12/21/2020

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Thomas Lippert, Aschaffenburg, GERMANY;
Bernhard Frohwitter, Munchen, GERMANY;

Applicant(s)

Par Tec Cluster Competence Center GmbH, München, GERMANY;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/EP2019/051615 01/23/2019

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.)
EUROPEAN PATENT OFFICE (EPO) 18152903.3 01/23/2018

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 12/17/2020

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/963,749**

Projected Publication Date: 04/01/2021

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS
COMPUTE RESOURCES

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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NOT GRANTED

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

U.S. APPLICATION NO.	FIRST NAMED INVENTOR	ATTY. DOCKET NO.
16/963,749	Thomas Lippert	29959/55804

4743

MARSHALL, GERSTEIN & BORUN LLP
233 SOUTH WACKER DRIVE
6300 WILLIS TOWER
CHICAGO, IL 60606-6357

INTERNATIONAL APPLICATION NO.

PCT/EP2019/051615

I.A. FILING DATE	PRIORITY DATE
01/23/2019	01/23/2018

CONFIRMATION NO. 6322
371 ACCEPTANCE LETTER



OC000000122134145

Date Mailed: 12/21/2020

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office, in its capacity as a Designated / Elected Office (37 CFR 1.495), has ACCEPTED the above identified international application for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above. A Filing Receipt will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE or 371(c) DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1) and (c)(2) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN BELOW.** The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363)

07/21/2020

DATE OF RECEIPT OF 35 U.S.C.
371(c)(1) and (c)(2) REQUIREMENTS

The following items have been received:

- Indication of Small Entity Status
- Copy of the International Application filed on 07/21/2020
- Copy of the International Search Report filed on 07/21/2020
- Preliminary Amendments filed on 07/21/2020
- Information Disclosure Statements filed on 07/21/2020
- U.S. Basic National Fees filed on 07/21/2020
- Authorize Access to Search Results filed on 07/21/2020
- Priority Documents filed on 07/21/2020
- Authorization to Permit Access filed on 07/21/2020
- Application Data Sheet (37 CFR 1.76) filed on 07/21/2020

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.495(c).

- Properly executed inventor's oath or declaration for the following inventor(s) has not been submitted: **Thomas Lippert and Bernhard Frohwitter**

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

CHARITTA S FLETCHER

Telephone: (571) 272-3926

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875						Application or Docket Number 16/963,749				
APPLICATION AS FILED - PART I										
(Column 1)		(Column 2)		SMALL ENTITY		OR OTHER THAN SMALL ENTITY				
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)			
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	160		N/A				
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A	270		N/A				
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A				
TOTAL CLAIMS (37 CFR 1.16(j))	10 minus 20 =	*	x 50 =	0.00	OR					
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*	x 240 =	0.00						
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00						
			TOTAL	830		TOTAL				
* If the difference in column 1 is less than zero, enter "0" in column 2.										
APPLICATION AS AMENDED - PART II										
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OR OTHER THAN SMALL ENTITY		
AMENDMENT A		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)
	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	
AMENDMENT B		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)
	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3. ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.										

MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET Substitute for Form PTO-1360 (For use with Form PTO/SB/06)							Application Number 16963749		Filing Date				
							Applicant(s) Thomas Lippert						
							* May be used for additional claims or amendments						
CLAIMS	AS FILED		AFTER FIRST AMENDMENT		AFTER SECOND AMENDMENT			*		*		*	
	Indep	Depend	Indep	Depend	Indep	Depend		Indep	Depend	Indep	Depend	Indep	Depend
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Total Indep	2		2		0								
Total Depend	11	↙	8	↙	0	↙							
Total Claims	13		10		0								

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Thomas Lippert et al.

Application No.: 16/963,749

Confirmation No.: 6322

Filed: July 21, 2020

Art Unit: 0

For: APPLICATION RUNTIME DETERMINED
DYNAMICAL ALLOCATION OF
HETEROGENEOUS COMPUTE RESOURCES

Examiner: D. G. Muller

REQUEST FOR CORRECTED FILING RECEIPT

Office of Initial Patent Examination's Filing Receipt Corrections
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Applicant hereby requests that a corrected Filing Receipt be issued in the above-identified patent application. The official Filing Receipt received by Applicant, an annotated copy of which is attached hereto, has an error in the Applicant name, where there is a space in-between "ParTec" as follows:

****Par Tec Cluster Competence Center GmbH, München, GERMANY****

should read

**** ParTec Cluster Competence Center GmbH, München, GERMANY****

Applicant additionally requests that all pertinent U.S. Patent and Trademark Office records relating to the subject application be changed to reflect this correction. Applicant believes no fee is due with this request.

Dated: March 4, 2021

Respectfully submitted,

By /Michael P. Furmanek, #58,495/
Michael P. Furmanek
Registration No.: 58,495
MARSHALL, GERSTEIN & BORUN LLP
233 S. Wacker Drive
6300 Willis Tower
Chicago, Illinois 60606-6357
(312) 474-6300
Attorney for Applicant



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
16/963,749	07/21/2020		860	29959/55804	10	2

CONFIRMATION NO. 6322

FILING RECEIPT

4743

MARSHALL, GERSTEIN & BORUN LLP
233 SOUTH WACKER DRIVE
6300 WILLIS TOWER
CHICAGO, IL 60606-6357



0000000122134144

Date Mailed: 12/21/2020

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Thomas Lippert, Aschaffenburg, GERMANY;
Bernhard Frohwitter, Munchen, GERMANY;

Applicant(s)

~~Par-Tec~~ Cluster Competence Center GmbH, München, GERMANY;
~~Par-Tec~~ Cluster Competence Center GmbH, München, GERMANY

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/EP2019/051615 01/23/2019

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.)
EUROPEAN PATENT OFFICE (EPO) 18152903.3 01/23/2018

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 12/17/2020

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/963,749**

Projected Publication Date: 04/01/2021

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS
COMPUTE RESOURCES

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

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This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

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Electronic Acknowledgement Receipt

EFS ID:	42094376
Application Number:	16963749
International Application Number:	
Confirmation Number:	6322
Title of Invention:	APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES
First Named Inventor/Applicant Name:	Thomas Lippert
Customer Number:	4743
Filer:	Michael Paul Furmanek./Araceli Hernandez
Filer Authorized By:	Michael Paul Furmanek.
Attorney Docket Number:	29959/55804
Receipt Date:	04-MAR-2021
Filing Date:	21-JUL-2020
Time Stamp:	18:17:11
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Corrected Filing Receipt	Request_for_Corrected_Filing_Receipt.PDF	26565 017f3b52728d577672312fd75f946a3301f6277f	no	1

Warnings:

Information:					
2	Request for Corrected Filing Receipt	Annotated_Filing_Receipt.PDF	186124	no	3
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Warnings:					
Information:					
Total Files Size (in bytes):				212689	
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					



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Alexandria, Virginia 22313-1450
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
16/963,749	07/21/2020	2196	860	29959/55804	10	2

4743
MARSHALL, GERSTEIN & BORUN LLP
233 SOUTH WACKER DRIVE
6300 WILLIS TOWER
CHICAGO, IL 60606-6357

CONFIRMATION NO. 6322
CORRECTED FILING RECEIPT



Date Mailed: 03/08/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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Inventor(s)

Thomas Lippert, Aschaffenburg, GERMANY;
Bernhard Frohwitter, Munchen, GERMANY;

Applicant(s)

ParTec Cluster Competence Center GmbH, München, GERMANY;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/EP2019/051615 01/23/2019

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.)
EUROPEAN PATENT OFFICE (EPO) 18152903.3 01/23/2018

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

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If Required, Foreign Filing License Granted: 12/17/2020

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/963,749**

Projected Publication Date: 04/01/2021

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS
COMPUTE RESOURCES

Preliminary Class

718

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/963,749	07/21/2020	Thomas Lippert	29959/55804

CONFIRMATION NO. 6322

PUBLICATION NOTICE



OC000000124554045

4743
MARSHALL, GERSTEIN & BORUN LLP
233 SOUTH WACKER DRIVE
6300 WILLIS TOWER
CHICAGO, IL 60606-6357

Title:APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES

Publication No.US-2021-0096923-A1

Publication Date:04/01/2021

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <https://portal.uspto.gov/pair/PublicPair>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



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United States Patent and Trademark Office
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/963,749	07/21/2020	Thomas Lippert	29959/55804	6322
4743	7590	10/28/2021	EXAMINER	
MARSHALL, GERSTEIN & BORUN LLP			KIM, SISLEY NAHYUN	
233 SOUTH WACKER DRIVE			ART UNIT	PAPER NUMBER
6300 WILLIS TOWER			2196	
CHICAGO, IL 60606-6357			NOTIFICATION DATE	DELIVERY MODE
			10/28/2021	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mgbdoCKET@marshallip.com

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

CLAIM INTERPRETATION

2. The following is a quotation of 35 U.S.C. 112(f):

(f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

3. The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

4. This application includes one or more claim limitations that do not use the word “means,” but are nonetheless being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because the claim limitation(s) uses a generic placeholder that is coupled with functional language without reciting sufficient structure to perform the recited function and the generic placeholder is not preceded by a structural modifier. Such claim limitation(s) is/are: “a plurality of computation nodes, a plurality of booster nodes, communication interface, resource manager, and application manager” in claim 9.

Because this/these claim limitation(s) is/are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, it/they is/are being interpreted to cover the corresponding structure described in the specification as performing the claimed function, and equivalents thereof.

If applicant does not intend to have this/these limitation(s) interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, applicant may: (1) amend the claim limitation(s) to avoid it/them being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph (e.g., by reciting sufficient structure to perform the claimed function); or (2) present a sufficient showing that the claim limitation(s) recite(s) sufficient structure to perform the claimed function so as to avoid it/them being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

Claim Rejections - 35 USC § 102

5. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless -

(a)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale or otherwise available to the public before the effective filing date of the claimed invention.

7. **Claims 1-10** are rejected under 35 U.S.C. 102(a)(1) as being anticipated by Driesen et al. (US 2012/0317168, hereinafter Driesen).

Regarding claim 1, Driesen discloses

A method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of

the plurality of computation nodes and plurality of booster nodes (Fig. 2, paragraph [0067]: FIG. 2 shows a computer cluster arrangement comprising a cluster C as well as a booster group BG. The cluster comprises in the present embodiment four computation nodes, also referred as CN, as well as three boosters, also referred to as B) **being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution** (paragraph [0091]: In a first step 100 at least the first part of a computation task is computed by at least two of the plurality of computation nodes CN, each computation node CN interfacing a communication infrastructure IN. Furthermore, computing of at least a second part of the computation task in step 101 by at least one booster B is performed, each booster B interfacing the communication infrastructure IN); **and**

information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes is used to generate a further distribution of the sub- tasks between the computation nodes and booster node for processing thereby in a further computing iteration (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least

a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 2, Driesen discloses

wherein an application manager receives the information and determines the further distribution (paragraph [0097]: For doing so the resource manager RM may access the assignment metric, which may be stored in a database DB or any kind of data source. The resource manager RM is arranged to update the assignment metric, which can be performed under usage of a database management system. The database DB can be implemented as any kind of storage. It may for instance be implemented as a table, a register or a cache).

Regarding claim 3, Driesen discloses

wherein a resource manager (paragraph [0097]: the resource manager RM is arranged to evaluate the resource capacities of the booster B and performs the assignment, which means the selection of the booster B, as a function of the evaluated resource capacities of each of the boosters B) **determines the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the first iteration**

as a function of the computation task (paragraph [0091]: In a first step 100 at least the first part of a computation task is computed by at least two of the plurality of computation nodes CN, each computation node CN interfacing a communication infrastructure IN. Furthermore, computing of at least a second part of the computation task in step 101 by at least one booster B is performed, each booster B interfacing the communication infrastructure IN) **and wherein the application manager receives the information and processes it as input to the resource manager** (paragraph [0097]: For doing so the resource manager RM may access the assignment metric, which may be stored in a database DB or any kind of data source. The resource manager RM is arranged to update the assignment metric, which can be performed under usage of a database management system. The database DB can be implemented as any kind of storage. It may for instance be implemented as a table, a register or a cache) **such that the resource manager dynamically alters further distribution during the computing of the computation task** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the

computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 4, Driesen discloses

wherein the resource manager (paragraph [0097]: the resource manager RM is arranged to evaluate the resource capacities of the booster B and performs the assignment, which means the selection of the booster B, as a function of the evaluated resource capacities of each of the boosters B) **receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may

use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 5, Driesen discloses

wherein daemons operate in the computation nodes and the booster nodes

(paragraph [0036]: a computer program being configured for accomplishing the introduced method; paragraph [0069]: For communication between boosters and computation nodes an application programming interface, also referred to as API, can be provided. The boosters B may be controlled transparently by the computation nodes through the respective API function calls) **to generate the information** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 6, Driesen discloses

wherein the first distribution is determined based on a rating provided in source code for each sub-task (paragraph [0084]: the distinction between highly scalable and complex is made on the level of code blocks, and we introduce the notions Exascale Code Blocks (ECB) and complex Code Blocks (CCB); paragraph [0085]: For such problems, where a decent balance between ECBs and CCBs is given in terms of the relative amounts of memory (i.e., the degrees of freedom handled in of the relative amounts of memory, i.e., the degrees of freedom handled in of ECB vs. the CCB), execution times and data to be exchanged, it suggests itself to adapt to this situation by means of a specific architectural solution. The solution consisting of a traditional cluster computer approach along with an Exascale booster with tightly connected boosters and being connected with a cluster through the cluster's network. This dualistic approach has the potential to widen the anticipated narrow application field of pure Exascale systems substantially; paragraph [0086]: A coarse-grained architectural model emerges, where the highly scalable parts or ECBs of an application code are executed on a parallel many-core architecture, which is accessed dynamically, while the CCBs are executed on a traditional cluster system suitable dimensioned, including the connectivity along with a refined dynamical resource allocation system).

Regarding claim 7, Driesen discloses

wherein the information is used to provide a grouping of sub-tasks in at least one of the first and second iterations (paragraph [0091]: at least one booster B

to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 8, Driesen discloses

wherein a daemon (paragraph [0036]: a computer program being configured for accomplishing the introduced method; paragraph [0069]: For communication between boosters and computation nodes an application programming interface, also referred to as API, can be provided. The boosters B may be controlled transparently by the computation nodes through the respective API function calls) **operating at a node generates a measure of a loading of the node during processing of a sub-task** (paragraph [0017]: The assignment metric may be managed by a resource manager. Managing the assignment metric refers to establishing and updating rules naming at

least one booster, which is assigned to at least one further named computation node.

Hence, it is possible to update the assignment metric at runtime. Such assignment rules may be created as a function of a load balancing, which detects workload of the computer cluster arrangement, especially of the boosters).

Regarding claim 9, Driesen discloses

A heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes (Fig. 2, paragraph [0067]: FIG. 2 shows a computer cluster arrangement comprising a cluster C as well as a booster group BG. The cluster comprises in the present embodiment four computation nodes, also referred as CN, as well as three boosters, also referred to as B) **for computing one or more tasks comprising multiple sub-tasks** (paragraph [0091]: In a first step 100 at least the first part of a computation task is computed by at least two of the plurality of computation nodes CN, each computation node CN interfacing a communication infrastructure IN. Furthermore, computing of at least a second part of the computation task in step 101 by at least one booster B is performed, each booster B interfacing the communication infrastructure IN), **a communication interface connecting the computation nodes with each other and the booster nodes** (Fig. 2, 3, 8 IN), **wherein the system comprises a resource manager for assigning booster nodes and computation nodes to each other for the computing of the tasks** (paragraph [0097]: the resource manager RM is arranged to evaluate the resource capacities of the booster B and performs the assignment, which means the selection of the booster B, as a function of the evaluated resource capacities of each of the boosters B) **and wherein**

the system further comprises an application manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes to update (paragraph [0097]: For doing so the resource manager RM may access the assignment metric, which may be stored in a database DB or any kind of data source. The resource manager RM is arranged to update the assignment metric, which can be performed under usage of a database management system. The database DB can be implemented as any kind of storage. It may for instance be implemented as a table, a register or a cache) **a distribution of the sub-tasks between the computation nodes and the booster nodes for a further computing iteration** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 10, Driesen discloses

wherein the resource manager receives the information (paragraph [0097]:

For doing so the resource manager RM may access the assignment metric, which may be stored in a database DB or any kind of data source. The resource manager RM is arranged to update the assignment metric, which can be performed under usage of a database management system. The database DB can be implemented as any kind of storage. It may for instance be implemented as a table, a register or a cache) **such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to SISLEY KIM whose telephone number is (571)270-7832. The examiner can normally be reached on 9:30 A.M - 6:30 P.M.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Emerson Puente can be reached on (571)272-3652. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SISLEY N KIM/
Primary Examiner, Art Unit 2196
10/16/2021

<i>Notice of References Cited</i>	Application/Control No. 16/963,749		Applicant(s)/Patent Under Reexamination Lippert et al.	
	Examiner SISLEY N KIM		Art Unit 2196	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20120317168-A1	12-2012	Driesen; Volker	G06Q30/06	709/202
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

<i>Search Notes</i> 	Application/Control No. 16/963,749	Applicant(s)/Patent Under Reexamination Lippert et al.
	Examiner SISLEY N KIM	Art Unit 2196

CPC - Searched*		
Symbol	Date	Examiner
G06F9/5061 and G06F2209/509	10/16/2021	SK

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Inventor Search for double patent issue	10/16/2021	SK
CPC and US classes search with keywords	10/16/2021	SK
NPL google search with keywords	10/16/2021	SK
Attached East Search History Above	10/16/2021	SK

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

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Web Search History

date, time	web site	search string
10/23/2021 12:28:52 AM	Google Scholar	booster node
10/23/2021 12:29:00 AM	Google Scholar	booster node SAME computation node
10/23/2021 12:29:40 AM	Google Scholar	booster node AND computation node AND (sub task or sub job or child task or child job)

PTO/SB/08a (07-09)

Approved for use through 11/30/2020. OMB 0651-0031

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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT <i>(Use as many sheets as necessary)</i>				Complete if Known	
				Application Number	16/963,749-Conf. #6322
				Filing Date	July 21, 2020
				First Named Inventor	Thomas Lippert
				Art Unit	0
				Examiner Name	Not Yet Assigned
Sheet	1	of	2	Attorney Docket Number	29959/55804

[illegible]

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No. ¹	Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T ⁶
		Country Code ³ Number ⁴ Kind Code ⁵ (if known)				
	A	EP-2442228-A1	04-18-2012	Lippert, Thomas		
	B	WO-2018065530-A1	04-12-2018	Partec Cluster Competence Center GmbH		

Examiner Signature	/SISLEY N KIM/	Date Considered	10/23/2021
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. ¹ Applicant's unique citation designation number (optional). ² See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. ³ Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). ⁴ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁵ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁶ Applicant is to place a check mark here if English language Translation is attached.

PTO/SB/08b (07-09)

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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT <i>(Use as many sheets as necessary)</i>				Complete if Known	
				Application Number	16/963,749-Conf. #6322
				Filing Date	July 21, 2020
				First Named Inventor	Thomas Lippert
				Art Unit	0
				Examiner Name	Not Yet Assigned
Sheet	2	of	2	Attorney Docket Number	29959/55804

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No. ¹	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T ²
	A	International Search Report for International Application No. PCT/EP2019/0518615, dated April 29, 2019.	
	B	Written Opinion for International Application No. PCT/EP2019/0518615, dated April 29, 2019.	
	C	"DYNAMIC PROCESS MANAGEMENT WITH ALLOCATION - INTERNAL CO - SCHEDULING TOWARDS INTERACTIVE SUPERCOMPUTING," Clauss, et al., Conference Paper, DOI: 10.14459/2016md1288835, January 19, 2016.	
	D	"THE DEEP PROJECT AN ALTERNATIVE APPROACH TO HETEROGENEOUS CLUSTER-COMPUTING IN THE MANY-CORE ERA," Eicker, et al., Concurrency and Computation: Practice and Experience, Pract. Exper. 2016; 28; 2394-2411, Wiley Online Library (wileyonlinelibrary.com), Published online July 27, 2015.	

Examiner Signature	/SISLEY N KIM/	Date Considered	10/23/2021
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ Applicant's unique citation designation number (optional). ² Applicant is to place a check mark here if English language Translation is attached.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	1	"16963749"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	OFF	2021/10/13 21:17
S2	73	((("Lippert") near3 ("Thomas"))).INV.	US-PGPUB; USPAT; USOCR	ADJ	OFF	2021/10/13 21:17
S3	3	((("Frohwitter") near3 ("Bernhard"))).INV.	US-PGPUB; USPAT; USOCR	ADJ	OFF	2021/10/13 21:17
S4	11,746	(G06F9/5061 or G06F2209/509).cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	OFF	2021/10/13 21:19
S5	199	booster node	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	OFF	2021/10/13 21:42
S6	5	booster node SAME computation node	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	OFF	2021/10/13 21:42
S7	0	booster node SAME computation node AND distribut\$3 WITH task\$1	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	OFF	2021/10/13 21:43
S8	0	booster node SAME computation node AND sub\$1task\$1	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	OFF	2021/10/13 21:43
S9	2	booster node AND computation node AND sub\$1task\$1	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	OFF	2021/10/13 21:43

10/23/2021 12:30:13 AM

C:\Users\skim7\Documents\EAST\Workspaces\16963749_1.wsp

Bibliographic Data

Application No: 16/963,749

Foreign Priority claimed: ☒ Yes ☐ No

35 USC 119 (a-d) conditions met: ☒ Yes ☐ No ☐ Met After Allowance

Verified and Acknowledged:

/SISLEY N KIM/

Examiner's Signature

Initials

Title:

APPLICATION RUNTIME DETERMINED DYNAMICAL
ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
07/21/2020	718	2196	29959/55804
RULE			

APPLICANTS

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Bernhard Frohwitter, Munchen, GERMANY

CONTINUING DATA

This application is a 371 of PCT/EP2019/051615 01/23/2019

FOREIGN APPLICATIONS

EPO EP18152903.3 01/23/2018

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12/17/2020

** SMALL ENTITY **

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MARSHALL, GERSTEIN & BORUN LLP

233 SOUTH WACKER DRIVE

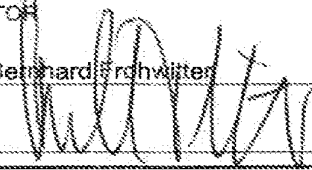
6300 WILLIS TOWER

CHICAGO, IL 60606-6357

UNITED STATES

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\$860

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)	
Title of Invention	APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES
As the below named inventor, I hereby declare that: This declaration ☐ The attached application, or is directed to: ☒ United States application or PCT international application number <u>PCT/EP2019/051615</u> filed on <u>01/23/2019</u> ☐ As Amended on _____ (if applicable) The above-identified application was made or authorized to be made by me. I believe that I am the original inventor or an original joint inventor of a claimed invention in the application. I have reviewed and understand the contents of the above identified specification, including the claims, as amended by an amendment, if any, specifically referred to herein. I acknowledge the duty to disclose information that is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information that became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application. I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both. WARNING: Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.	
LEGAL NAME OF INVENTOR Inventor: <u>Bernhard Frohwitter</u> Date (Optional): _____ Signature: 	
Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.	

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)	
Title of Invention	APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES
As the below named inventor, I hereby declare that: This declaration ☐ The attached application, or is directed to: ☒ United States application or PCT international application number <u>PCT/EP2019/051615</u> filed on <u>01/23/2019</u> ☐ As Amended on _____ (if applicable) The above-identified application was made or authorized to be made by me. I believe that I am the original inventor or an original joint inventor of a claimed invention in the application. I have reviewed and understand the contents of the above identified specification, including the claims, as amended by an amendment, if any, specifically referred to herein. I acknowledge the duty to disclose information that is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information that became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application. I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both. WARNING: Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.	
LEGAL NAME OF INVENTOR Inventor: <u>Thomas Lippert</u> Date (Optional): <u>22 October 2021</u> Signature: 	
Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.	

POWER OF ATTORNEY BY APPLICANT			
I hereby revoke all previous powers of attorney given in the application identified in <u>either the attached transmittal letter or the boxes below.</u>			
Application Number		Filing Date	
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Bernhard F. F. F.		Managing Director	
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Electronic Acknowledgement Receipt

EFS ID:	44162685
Application Number:	16963749
International Application Number:	
Confirmation Number:	6322
Title of Invention:	APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES
First Named Inventor/Applicant Name:	Thomas Lippert
Customer Number:	4743
Filer:	Michael Paul Furmanek./Araceli Hernandez
Filer Authorized By:	Michael Paul Furmanek.
Attorney Docket Number:	29959/55804
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Time Stamp:	16:39:48
Application Type:	U.S. National Stage under 35 USC 371

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	Declarations.PDF	227049	no	3
			04eab920b68ed124e040774cd6ae9fcd855d203		

Warnings:

Information:	
Total Files Size (in bytes):	227049
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.	



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/963,749	07/21/2020	Thomas Lippert	29959/55804	6322
4743	7590	04/13/2022	EXAMINER	
MARSHALL, GERSTEIN & BORUN LLP			KIM, SISLEY NAHYUN	
233 SOUTH WACKER DRIVE			ART UNIT	PAPER NUMBER
6300 WILLIS TOWER			2196	
CHICAGO, IL 60606-6357			NOTIFICATION DATE	DELIVERY MODE
			04/13/2022	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

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mgbdoCKET@marshallip.com

<i>Examiner-Initiated Interview Summary</i>	Application No. 16/963,749	Applicant(s) Lippert et al.		
	Examiner SISLEY N KIM	Art Unit 2196	AIA (First Inventor to File) Status Yes	Page 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	Title	Type
SISLEY N KIM	Primary Examiner	Telephonic
Matthew R. Carey	Attorney	

Date of Interview: 08 April 2022

Issues Discussed:

Other

Attorney called and indicated that the prior art reference cited in the 102 rejection was incorrect (Driesen). Thus, the examiner let him know the correct reference Lippert et al. (US 2013/0282787).

/SISLEY N KIM/ Primary Examiner, Art Unit 2196	
Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04 Please further see: MPEP 713.04 Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b) 37 CFR § 1.2 Business to be transacted in writing	

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.



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16/963,749	07/21/2020	Thomas Lippert	29959/55804	6322
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Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mgbdoCKET@marshallip.com

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

CLAIM INTERPRETATION

2. The following is a quotation of 35 U.S.C. 112(f):

(f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

3. The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

4. This application includes one or more claim limitations that do not use the word “means,” but are nonetheless being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because the claim limitation(s) uses a generic placeholder that is coupled with functional language without reciting sufficient structure to perform the recited function and the generic placeholder is not preceded by a structural modifier. Such claim limitation(s) is/are: “a plurality of computation nodes, a plurality of booster nodes, communication interface, resource manager, and application manager” in claim 9.

Because this/these claim limitation(s) is/are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, it/they is/are being interpreted to cover the corresponding structure described in the specification as performing the claimed function, and equivalents thereof.

If applicant does not intend to have this/these limitation(s) interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, applicant may: (1) amend the claim limitation(s) to avoid it/them being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph (e.g., by reciting sufficient structure to perform the claimed function); or (2) present a sufficient showing that the claim limitation(s) recite(s) sufficient structure to perform the claimed function so as to avoid it/them being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

Claim Rejections - 35 USC § 102

5. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless -

(a)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale or otherwise available to the public before the effective filing date of the claimed invention.

7. **Claims 1-10** are rejected under 35 U.S.C. 102(a)(1) as being anticipated by Lippert et al. (US 2013/0282787, hereinafter Lippert).

Regarding claim 1, Lippert discloses

A method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of

the plurality of computation nodes and plurality of booster nodes (Fig. 2, paragraph [0067]: FIG. 2 shows a computer cluster arrangement comprising a cluster C as well as a booster group BG. The cluster comprises in the present embodiment four computation nodes, also referred as CN, as well as three boosters, also referred to as B) **being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein in a first computing iteration, the plurality of sub-tasks are assigned to and processed by ones of the plurality of computation nodes and booster nodes in a first distribution** (paragraph [0091]: In a first step 100 at least the first part of a computation task is computed by at least two of the plurality of computation nodes CN, each computation node CN interfacing a communication infrastructure IN. Furthermore, computing of at least a second part of the computation task in step 101 by at least one booster B is performed, each booster B interfacing the communication infrastructure IN); **and**

information relating to the processing of the plurality of sub-tasks by the plurality of computation nodes and booster nodes is used to generate a further distribution of the sub- tasks between the computation nodes and booster node for processing thereby in a further computing iteration (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least

a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 2, Lippert discloses

wherein an application manager receives the information and determines the further distribution (paragraph [0097]: For doing so the resource manager RM may access the assignment metric, which may be stored in a database DB or any kind of data source. The resource manager RM is arranged to update the assignment metric, which can be performed under usage of a database management system. The database DB can be implemented as any kind of storage. It may for instance be implemented as a table, a register or a cache).

Regarding claim 3, Lippert discloses

wherein a resource manager (paragraph [0097]: the resource manager RM is arranged to evaluate the resource capacities of the booster B and performs the assignment, which means the selection of the booster B, as a function of the evaluated resource capacities of each of the boosters B) **determines the assignment of tasks and sub-tasks to the computation nodes and booster nodes for the first iteration**

as a function of the computation task (paragraph [0091]: In a first step 100 at least the first part of a computation task is computed by at least two of the plurality of computation nodes CN, each computation node CN interfacing a communication infrastructure IN. Furthermore, computing of at least a second part of the computation task in step 101 by at least one booster B is performed, each booster B interfacing the communication infrastructure IN) **and wherein the application manager receives the information and processes it as input to the resource manager** (paragraph [0097]: For doing so the resource manager RM may access the assignment metric, which may be stored in a database DB or any kind of data source. The resource manager RM is arranged to update the assignment metric, which can be performed under usage of a database management system. The database DB can be implemented as any kind of storage. It may for instance be implemented as a table, a register or a cache) **such that the resource manager dynamically alters further distribution during the computing of the computation task** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the

computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 4, Lippert discloses

wherein the resource manager (paragraph [0097]: the resource manager RM is arranged to evaluate the resource capacities of the booster B and performs the assignment, which means the selection of the booster B, as a function of the evaluated resource capacities of each of the boosters B) **receives the information such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other during the computation of the computation task** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may

use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 5, Lippert discloses

wherein daemons operate in the computation nodes and the booster nodes

(paragraph [0036]: a computer program being configured for accomplishing the introduced method; paragraph [0069]: For communication between boosters and computation nodes an application programming interface, also referred to as API, can be provided. The boosters B may be controlled transparently by the computation nodes through the respective API function calls) **to generate the information** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 6, Lippert discloses

wherein the first distribution is determined based on a rating provided in source code for each sub-task (paragraph [0084]: the distinction between highly scalable and complex is made on the level of code blocks, and we introduce the notions Exascale Code Blocks (ECB) and complex Code Blocks (CCB); paragraph [0085]: For such problems, where a decent balance between ECBs and CCBs is given in terms of the relative amounts of memory (i.e., the degrees of freedom handled in of the relative amounts of memory, i.e., the degrees of freedom handled in of ECB vs. the CCB), execution times and data to be exchanged, it suggests itself to adapt to this situation by means of a specific architectural solution. The solution consisting of a traditional cluster computer approach along with an Exascale booster with tightly connected boosters and being connected with a cluster through the cluster's network. This dualistic approach has the potential to widen the anticipated narrow application field of pure Exascale systems substantially; paragraph [0086]: A coarse-grained architectural model emerges, where the highly scalable parts or ECBs of an application code are executed on a parallel many-core architecture, which is accessed dynamically, while the CCBs are executed on a traditional cluster system suitable dimensioned, including the connectivity along with a refined dynamical resource allocation system).

Regarding claim 7, Lippert discloses

wherein the information is used to provide a grouping of sub-tasks in at least one of the first and second iterations (paragraph [0091]: at least one booster B

to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 8, Lippert discloses

wherein a daemon (paragraph [0036]: a computer program being configured for accomplishing the introduced method; paragraph [0069]: For communication between boosters and computation nodes an application programming interface, also referred to as API, can be provided. The boosters B may be controlled transparently by the computation nodes through the respective API function calls) **operating at a node generates a measure of a loading of the node during processing of a sub-task** (paragraph [0017]: The assignment metric may be managed by a resource manager. Managing the assignment metric refers to establishing and updating rules naming at

least one booster, which is assigned to at least one further named computation node.

Hence, it is possible to update the assignment metric at runtime. Such assignment rules may be created as a function of a load balancing, which detects workload of the computer cluster arrangement, especially of the boosters).

Regarding claim 9, Lippert discloses

A heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes (Fig. 2, paragraph [0067]: FIG. 2 shows a computer cluster arrangement comprising a cluster C as well as a booster group BG. The cluster comprises in the present embodiment four computation nodes, also referred as CN, as well as three boosters, also referred to as B) **for computing one or more tasks comprising multiple sub-tasks** (paragraph [0091]: In a first step 100 at least the first part of a computation task is computed by at least two of the plurality of computation nodes CN, each computation node CN interfacing a communication infrastructure IN. Furthermore, computing of at least a second part of the computation task in step 101 by at least one booster B is performed, each booster B interfacing the communication infrastructure IN), **a communication interface connecting the computation nodes with each other and the booster nodes** (Fig. 2, 3, 8 IN), **wherein the system comprises a resource manager for assigning booster nodes and computation nodes to each other for the computing of the tasks** (paragraph [0097]: the resource manager RM is arranged to evaluate the resource capacities of the booster B and performs the assignment, which means the selection of the booster B, as a function of the evaluated resource capacities of each of the boosters B) **and wherein**

the system further comprises an application manager, the application manager being arranged to receive information from daemons operating in the computation nodes and booster nodes to update (paragraph [0097]: For doing so the resource manager RM may access the assignment metric, which may be stored in a database DB or any kind of data source. The resource manager RM is arranged to update the assignment metric, which can be performed under usage of a database management system. The database DB can be implemented as any kind of storage. It may for instance be implemented as a table, a register or a cache) **a distribution of the sub-tasks between the computation nodes and the booster nodes for a further computing iteration** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Regarding claim 10, Lippert discloses

wherein the resource manager receives the information (paragraph [0097]:

For doing so the resource manager RM may access the assignment metric, which may be stored in a database DB or any kind of data source. The resource manager RM is arranged to update the assignment metric, which can be performed under usage of a database management system. The database DB can be implemented as any kind of storage. It may for instance be implemented as a table, a register or a cache) **such that the resource manager dynamically alters assignment of the computation nodes and booster nodes to each other** (paragraph [0091]: at least one booster B to one of the plurality of computation nodes CN in step 102 by a resource manager RM, for computation of the second part of the computation task is performed. As the right arrow in FIG. 4 indicates the control flow may point back to step 100. After assigning at least one booster B to at least one of the plurality of computation nodes CN in step 102 the assignment can be communicated to a computation node CN, which uses the transmitted assignment in further outsourcing steps. Hence, computing at least a second part of the computation task is performed in step 101 as a function of the assignment step 102; paragraph [0093]: Step 102 may comprise sub steps such as returning the computed at least second part of the computation task back to the computation node CN. Hence, the booster B returns the computed result back to the computation nodes CN. The computation nodes CN may use the returned value for computation of further computation tasks and may again forward at least a further part of a computation task to at least one of the boosters B).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to SISLEY KIM whose telephone number is (571)270-7832. The examiner can normally be reached on 9:30 A.M - 6:30 P.M.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Emerson Puente can be reached on (571)272-3652. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SISLEY N KIM/
Primary Examiner, Art Unit 2196
4/8/2022

Notice of References Cited	Application/Control No. 16/963,749		Applicant(s)/Patent Under Reexamination Lippert et al.	
	Examiner SISLEY N KIM		Art Unit 2196	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20130282787-A1	10-2013	Lippert; Thomas	H04L29/08081	709/201
	B					
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875				Application or Docket Number 16/963,749		Filing Date 07/21/2020		☐ To be Mailed			
ENTITY: ☐ LARGE ☒ SMALL ☐ MICRO											
APPLICATION AS FILED - PART I											
		(Column 1)		(Column 2)							
FOR		NUMBER FILED		NUMBER EXTRA		RATE (\$)		FEE (\$)			
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))		N/A		N/A		N/A					
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))		N/A		N/A		N/A					
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))		N/A		N/A		N/A					
TOTAL CLAIMS (37 CFR 1.16(i))		minus 20 = *				x \$50 =					
INDEPENDENT CLAIMS (37 CFR 1.16(h))		minus 3 = *				x \$230 =					
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))		If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).									
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))											
* If the difference in column 1 is less than zero, enter "0" in column 2.						TOTAL					
APPLICATION AS AMENDED - PART II											
		(Column 1)		(Column 2)		(Column 3)					
AMENDMENT	07/22/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR		PRESENT EXTRA		RATE (\$)		ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))	* 10	Minus	** 20	= 0			x \$50 =		0	
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0			x \$240 =		0	
	☐ Application Size Fee (37 CFR 1.16(s))										
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))										
								TOTAL ADD'L FEE		0	
		(Column 1)		(Column 2)		(Column 3)					
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR		PRESENT EXTRA		RATE (\$)		ADDITIONAL FEE (\$)	
	Total (37 CFR 1.16(i))	*	Minus	**	=			x \$0 =			
	Independent (37 CFR 1.16(h))	*	Minus	***	=			x \$0 =			
	☐ Application Size Fee (37 CFR 1.16(s))										
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))										
								TOTAL ADD'L FEE			
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.								LIE			
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".								/LAVINIA D JOHNSON/			
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".											
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.											

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Docket No.: 29959/55804
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Thomas Lippert et al.

Application No.: 16/963,749

Confirmation No.: 6322

Filed: July 21, 2020

Art Unit: 2196

For: APPLICATION RUNTIME DETERMINED
DYNAMICAL ALLOCATION OF
HETEROGENEOUS COMPUTE RESOURCES

Examiner: D. G. Muller

AMENDMENT IN RESPONSE TO NON-FINAL OFFICE ACTION UNDER 37 C.F.R. § 1.111

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

INTRODUCTORY COMMENTS

In response to the Office Action dated April 22, 2022, please amend the above-identified U.S. patent application as follows:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 4 of this paper.

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, at least one of the plurality of computation nodes and a plurality of booster nodes being arranged to compute a computation task, the computation task comprising a plurality of sub-tasks, wherein the method comprising:

in a first computing iteration, assigning and processing the plurality of sub-tasks ~~are assigned to and processed~~ by ~~[[ones]]~~ at least a portion of the plurality of computation nodes and at least a portion of the plurality of booster nodes in a first distribution; and

generating, using information relating to the processing of the plurality of sub-tasks by at least the portion of the plurality of computation nodes and at least the portion of the plurality of booster nodes ~~is used to generate~~, a further distribution of the plurality of sub-tasks between the plurality of computation nodes and the plurality of booster ~~[[node]]~~ nodes for processing thereby in a further computing iteration.

2. (Original) The method according to claim 1, wherein an application manager receives the information and determines the further distribution.

3. (Currently Amended) The method according to claim 2, wherein a resource manager determines the assignment of ~~tasks and the plurality of~~ sub-tasks to the plurality of computation nodes and the plurality of booster nodes for the first computing iteration as a function of the computation task and wherein the application manager receives the information and processes ~~[[it]]~~ the information as input to the resource manager such that the resource manager dynamically alters further distribution during the computing of the computation task.

4. (Currently Amended) The method according to claim ~~[[1]]~~ 3, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the plurality of computation nodes and the plurality of booster nodes to each other during the computation of the computation task.

5. (Currently Amended) The method according to claim 1, wherein daemons operate in the plurality of computation nodes and the plurality of booster nodes to generate the information.

6. (Currently Amended) The method according to claim 1, wherein the first distribution is determined based on a rating provided in source code for each sub-task in the plurality of sub-tasks.

7. (Currently Amended) The method according to claim 1, wherein the information is used to provide a grouping of sub-tasks in at least one of the first computing iteration and ~~second iterations~~ the further computing iteration.

8. (Currently Amended) The method according to claim 3, wherein a daemon operating at a node generates a measure of a loading of the node during processing of a sub-task of the plurality of sub-tasks.

9. (Currently Amended) A heterogeneous computing system comprising:

a plurality of computation nodes and a plurality of booster nodes for computing one or more tasks comprising multiple sub-tasks[[.]];:

a communication interface connecting the plurality of computation nodes with each other and the plurality of booster nodes, ~~wherein the system comprises;~~

a resource manager for assigning at least a portion of the plurality of booster nodes and at least a portion of the plurality of computation nodes to each other for the computing of the one or more tasks in a first computing iteration; and ~~wherein the system further comprises~~

an application manager, ~~the application manager being arranged~~ configured to receive information from daemons operating in at least the portion of the plurality of computation nodes and at least the portion of the plurality of booster nodes to update a distribution of the multiple sub-tasks between the plurality of computation nodes and the plurality of booster nodes [[for]] in a further computing iteration.

10. (Currently Amended) The heterogeneous computing system according to claim 9, wherein the resource manager receives the information such that the resource manager dynamically alters assignment of the plurality of computation nodes and the plurality of booster nodes to each other.

REMARKS

By this Amendment, Applicant amends claims 1 and 3-10. Claims 1-10 are pending in the application.

From the Office Action (OA) dated April 22, 2022, claim 9 stands interpreted under 35 U.S.C § 112(f). Further, claims 1-10 stand rejected under 35 U.S.C § 102 as allegedly being anticipated by Lippert et al. (U.S. Publication No. 2013/0282787; hereinafter "Lippert"). In view of the foregoing amendments and the following remarks, reconsideration and allowance are respectfully requested.

Claim Interpretation

Claim 9 stands interpreted under 35 U.S.C. § 112(f). In particular, the OA asserts that the claim limitations "a plurality of computation nodes," "a plurality of booster nodes," "communication interface," "resource manager," and "application manager" are generic placeholders coupled with functional language without reciting sufficient structure to perform the received function and the generic placeholders are not preceded by a structural modifier.

Applicant respectfully disagrees with this interpretation and submits that the specification includes sufficient structural support for these claim limitations, for example in paragraphs [0013]-[0015] and [0021]-[0025].

Accordingly, Applicant respectfully submits that claim 9 should not be interpreted under 35 U.S.C. § 112(f).

Claim Rejection Under 35 U.S.C. §102

Claims 1-10 stand rejected under 35 U.S.C. 102 as allegedly being anticipated by Lippert. Applicants respectfully traverse the rejection because Lippert fails to disclose each and every element of these claims.

Claim 1 as amended recites a method of operating a heterogeneous computing system comprising a plurality of computation nodes and a plurality of booster nodes, comprising "in a first computing iteration, assigning and processing the plurality of sub-tasks by at least a portion of the plurality of computation nodes and at least a portion of the plurality of booster nodes in a first distribution," and "generating, using information relating to the processing of the plurality of sub-tasks by at least the portion of the plurality of computation nodes and at least the portion of the plurality of booster nodes, a further distribution of the plurality of sub-tasks between the plurality of computation nodes and the plurality of booster nodes for processing thereby in a further computing iteration." Amended

claim 9 recites similar elements. Applicant respectfully submits that Lippert fails to disclose this combination of elements.

Lippert describes “a computer cluster arrangement and a method for operation of the introduced computer cluster arrangement” (see Abstract). In particular, Lippert discloses that the computer cluster arrangement solves “the parts of the computation task in parallel or in succession” (see paragraph [0016]). For example, a computation task may be divided into a first part and a second part and the second part may be computed parallel to the first part or subsequent to the first part. However, in contrast, amended claims 1 and 9 recite that the plurality of sub-task are processed in **multiple computing iterations**.

Additionally, paragraph [0020] of Lippert, which is cited in the OA, also fails to cure the missing disclosure of multiple computing iterations. In particular, paragraph [0020] of Lippert discloses a computation history used to empirically evaluate the response time of various boosters. For the sake of empirical evaluation and comparability of various boosters, the same computation task is computed on various boosters. In contrast to the recited limitations of amended claims 1 and 9, the computation history does not concern the present computation task, but instead concerns previous computation tasks which might be specially designed for testing purposes. Therefore, Lippert fails to disclose a plurality of sub-tasks of a specific computation task being computed in multiple computing iterations.

As depicted in FIG. 4 and described in paragraph [0091], instead of a task being computed in multiple computing iterations, Lippert describes a first part of a computation task that is computed by at least two of the plurality of computation nodes CN, and a second part of the computation task that is computed by at least one booster B. The “right arrow” in FIG. 4 identifies a returning of the results from the booster to the computation node for the computation node to use for computation of further computation tasks and optionally for forwarding at least a further part of a computation task to at least one of the boosters B (see paragraphs [0093] and [0094]).

Amended claims 1 and 9 are further distinguished over Lippert. In particular, paragraph [0017] of Lippert discloses updating an assignment metric at runtime “as a function of a **load balancing, which detects workload of the computer cluster arrangement**, especially of the boosters” (emphasis added). This merely indicates that the boosters are dynamically assigned to computation nodes based on the current workload. For such a load balancing, only the workload of the single boosters is required (i.e., information relating the **status of the computing nodes and the boosters**, but not information relating to the processing of the sub-tasks). In contrast, amended claims 1 and 9 allow for redistribution based **on information relating to the processing of the plurality of**

sub-tasks, including adjusting the distribution of sub-tasks between computation nodes and boosters based on a scalability of the sub-task. The distribution may also be influenced by information learned about the processing of the sub-task and any need to call further sub-tasks during the processing (see, e.g., paragraph [0024] of the instant application). While amended claims 1 and 9 relate to analyzing the plurality of sub-tasks and obtaining information relating to the processing of the plurality of sub-tasks, Lippert merely proposes a load balancing based on the workload of the nodes.

For at least these reasons, Lippert fails to disclose the claimed combination “in a first computing iteration, assigning and processing the plurality of sub-tasks by at least a portion of the plurality of computation nodes and at least a portion of the plurality of booster nodes in a first distribution,” and “generating, using information relating to the processing of the plurality of sub-tasks by at least the portion of the plurality of computation nodes and at least the portion of the plurality of booster nodes, a further distribution of the plurality of sub-tasks between the plurality of computation nodes and the plurality of booster nodes for processing thereby in a further computing iteration,” as recited in amended claim 1 and as similarly recited in amended claim 9. Therefore, Lippert fails to anticipate amended claims 1 and 9.

Accordingly, Applicant respectfully submits that the rejection of amended claims 1 and 9 under 35 U.S.C. § 102 is overcome and requests that the rejection be withdrawn. Further, 2-8 and 10 depend from either claim 1 or 9. Therefore, the rejection of these claims should be withdrawn for at least the reasons mentioned above.

CONCLUSION

In view of the above, Applicant submits the pending application is in condition for allowance and an early action so indicating is respectfully requested.

The Commissioner is authorized to charge any fee deficiency required by this paper, or credit any overpayment, to Deposit Account No. 13-2855, under Order No. 29959/55804, from which the undersigned is authorized to draw.

Dated: July 22, 2022

Respectfully submitted,

By /Matthew R. Carey/
Matthew R. Carey
Registration No.: 61,082
MARSHALL, GERSTEIN & BORUN LLP
233 S. Wacker Drive
6300 Willis Tower
Chicago, Illinois 60606-6357
(312) 474-6300
Attorney for Applicant

Electronic Acknowledgement Receipt

EFS ID:	46251972
Application Number:	16963749
International Application Number:	
Confirmation Number:	6322
Title of Invention:	APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES
First Named Inventor/Applicant Name:	Thomas Lippert
Customer Number:	4743
Filer:	Matthew Richard Carey/Valeria Rodriguez
Filer Authorized By:	Matthew Richard Carey
Attorney Docket Number:	29959/55804
Receipt Date:	22-JUL-2022
Filing Date:	21-JUL-2020
Time Stamp:	13:54:46
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		29959_55804_Response_to_NF OA_dated_4-22-22.pdf	37941	yes	7
			d6edd19ecc7ba9a65f93e6532aff79c4c804cab		

Multipart Description/PDF files in .zip description			
Document Description	Start	End	
Amendment/Request for Reconsideration-After Non-Final Rejection	1	1	
Claims	2	3	
Applicant Arguments/Remarks Made in an Amendment	4	7	

Warnings:

Information:

Total Files Size (in bytes):	37941
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



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NOTICE OF ALLOWANCE AND FEE(S) DUE

4743 7590 09/01/2022
MARSHALL, GERSTEIN & BORUN LLP
233 SOUTH WACKER DRIVE
6300 WILLIS TOWER
CHICAGO, IL 60606-6357

EXAMINER	
KIM, SISLEY NAHYUN	
ART UNIT	PAPER NUMBER
2196	

DATE MAILED: 09/01/2022

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/963,749	07/21/2020	Thomas Lippert	29959/55804	6322

TITLE OF INVENTION: APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	\$600	\$0.00	\$0.00	\$600	12/01/2022

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

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If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

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Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

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Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

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(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/963,749	07/21/2020	Thomas Lippert	29959/55804	6322

TITLE OF INVENTION: APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES

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nonprovisional	SMALL	\$600	\$0.00	\$0.00	\$600	12/01/2022

EXAMINER	ART UNIT	CLASS-SUBCLASS
KIM, SISLEY NAHYUN	2196	718-104000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

1 _____

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☐ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/963,749	07/21/2020	Thomas Lippert	29959/55804	6322
4743	7590	09/01/2022	EXAMINER	
MARSHALL, GERSTEIN & BORUN LLP			KIM, SISLEY NAHYUN	
233 SOUTH WACKER DRIVE			ART UNIT	
6300 WILLIS TOWER			PAPER NUMBER	
CHICAGO, IL 60606-6357			2196	

DATE MAILED: 09/01/2022

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 16/963,749	Applicant(s) Lippert et al.	
	Examiner SISLEY N KIM	Art Unit 2196	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to 07/22/2022.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 1-10. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a) ☐ All b) ☐ Some* c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☐ Certified copies of the priority documents have been received in Application No. _____.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892) 2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____. 3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____. 4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.	5. ☐ Examiner's Amendment/Comment 6. ☒ Examiner's Statement of Reasons for Allowance 7. ☐ Other _____.
--	--

/SISLEY N KIM/
Primary Examiner, Art Unit 2196

Notice of Allowability

Reasons for Allowance

1. The following is an examiner's statement of reasons for allowance:

Applicant's amendment and arguments filed on July 22, 2022 have been fully considered and they are persuasive.

The combination of elements recited in the claims as amended is not taught or suggested by the prior art(s) of the record either alone or in combination. An updated search has been performed and no prior art has been found that teaches the combination of elements present in the claims. Thus, the claims are deemed allowable.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to SISLEY KIM whose telephone number is (571)270-7832. The examiner can normally be reached on Monday through Friday from 9:30 A.M - 6:30 P.M EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Emerson Puente can be reached on (571)272-3652. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SISLEY N KIM/
Primary Examiner, Art Unit 2196
8/20/2022

Issue Classification 	Application/Control No. 16/963,749	Applicant(s)/Patent Under Reexamination Lippert et al.
	Examiner SISLEY N KIM	Art Unit 2196

CPC						
Symbol					Type	Version
G06F	/	9	/	5061	F	2013-01-01
G06F	/	2209	/	509	A	2013-01-01

CPC Combination Sets							
Symbol				Type	Set	Ranking	Version
	/		/				

NONE (Assistant Examiner) (Date)		Total Claims Allowed: 10	
/SISLEY N KIM/ Primary Examiner, Art Unit 2196 (Primary Examiner) (Date)		26 August 2022 O.G. Print Claim(s)	O.G. Print Figure 1

<i>Issue Classification</i> 	Application/Control No. 16/963,749	Applicant(s)/Patent Under Reexamination Lippert et al.
	Examiner SISLEY N KIM	Art Unit 2196

INTERNATIONAL CLASSIFICATION			
CLAIMED			
G06F9/50	/	9	/ 50

NON-CLAIMED			
/	/		

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	10	
/SISLEY N KIM/ Primary Examiner, Art Unit 2196	26 August 2022	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification 	Application/Control No. 16/963,749	Applicant(s)/Patent Under Reexamination Lippert et al.
	Examiner SISLEY N KIM	Art Unit 2196

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47															
CLAIMS															
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original

NONE (Assistant Examiner) _____ (Date) _____		Total Claims Allowed: 10	
/SISLEY N KIM/ Primary Examiner, Art Unit 2196 (Primary Examiner) _____ (Date) 26 August 2022		O.G. Print Claim(s) 1	O.G. Print Figure 1

<i>Search Notes</i> 	Application/Control No. 16/963,749	Applicant(s)/Patent Under Reexamination Lippert et al.
	Examiner SISLEY N KIM	Art Unit 2196

CPC - Searched*		
Symbol	Date	Examiner
G06F9/5061 and G06F2209/509	10/16/2021	SK

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Inventor Search for double patent issue	10/16/2021	SK
CPC and US classes search with keywords	10/16/2021	SK
NPL google search with keywords	10/16/2021	SK
Attached East Search History Above	10/16/2021	SK
Updated Attached East Search History Above	08/26/2022	SK

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	See interference search history	08/26/2022	SK

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L10	2	"16963749"	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 03:42 PM
L11	74	((("Lippert") near3 ("Thomas"))).INV.	(US-PGPUB; USPAT; USOCR)	ADJ	OFF	OFF	2022/08/20 03:42 PM
L12	4	((("Frohwitter") near3 ("Bernhard"))).INV.	(US-PGPUB; USPAT; USOCR)	ADJ	OFF	OFF	2022/08/20 03:42 PM
L13	13782	(G06F9/5061 or G06F2209/509).cpc.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 03:42 PM
L14	204	booster node	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 03:42 PM
L15	5	booster node SAME computation node	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 03:42 PM
L16	0	booster node SAME computation node AND distribut\$3 WITH task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 03:42 PM
L17	0	booster node SAME computation node AND sub\$1task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 03:42 PM
L18	2	booster node AND computation node AND sub\$1task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 03:42 PM
L19	3	"20120317168"	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 03:44 PM
L20	233	booster AND computation AND sub\$1task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 05:04 PM
L21	0	booster SAME computation SAMEsub\$1task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 05:04 PM
L22	8	booster SAME computation SAME sub\$1task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 05:04 PM
L23	0	booster AND	(US-PGPUB; USPAT;	ADJ	OFF	OFF	2022/08/20

L24	0	computation AND third sub\$1task\$1	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	05:05 PM
L25	3	accelerator SAME third sub\$1task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 05:05 PM
L26	10	accelerator SAME distribut\$3 WITH sub\$1task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 05:06 PM
L27	39	distribut\$3 WITH sub\$1task\$1 WITH iterati\$5	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 05:13 PM
L28	341	sub\$1task\$1 WITH iterati\$5	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 05:14 PM
L29	102	(boost\$3 OR accelerator) WITH sub\$1task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 09:15 PM
L30	155	(boost\$3 OR accelerator) SAME sub\$1task\$1	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	ADJ	OFF	OFF	2022/08/20 09:15 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N1	1	booster SAME computation SAME sub\$1task\$1.clm.	(US-PGPUB; USPAT)	ADJ	OFF	OFF	2022/08/20 09:16 PM
N2	5627	(G06F9/5061 OR G06F2209/509).cpc.	(US-PGPUB; USPAT)	ADJ	OFF	OFF	2022/08/20 09:16 PM
N3	1	booster SAME sub\$1task\$1.clm.	(US-PGPUB; USPAT)	ADJ	OFF	OFF	2022/08/20 09:16 PM
N4	1	boost\$3 SAME sub\$1task\$1.clm.	(US-PGPUB; USPAT)	ADJ	OFF	OFF	2022/08/20 09:16 PM
N5	20	accelerat\$5 SAME sub\$1task\$1.clm.	(US-PGPUB; USPAT)	ADJ	OFF	OFF	2022/08/20 09:16 PM
N6	2	2 AND 5	(US-PGPUB; USPAT)	ADJ	OFF	OFF	2022/08/20 09:16 PM

Web Search History

date, time	web site	search string
8/26/2022 4:20:12 PM	Google Scholar	accelerate same subtasks
8/26/2022 4:20:30 PM	Google Scholar	boost SAME subtasks
8/26/2022 4:20:46 PM	Google Scholar	booster SAME computation SAME subtasks

PART B—FEE(S) TRANSMITTAL

Complete and send this form, together with the applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

By fax, send to: (571) 273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

MARSHALL, GERSTEIN & BORUN LLP
233 S. Wacker Drive
6300 Willis Tower
Chicago, Illinois 60606-6357

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4) on the date indicated below.

Michael P. Furmanek	(Typed or printed name)
/Michael P. Furmanek/	(Signature)
November 29, 2022	(Date)

APPLICATION NO	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO	CONFIRMATION NO
16/963,749	07/21/2020	Thomas Lippert	29959/55804	6322

TITLE OF INVENTION: APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES

APPLN: TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	\$600.00			\$600.00	12/01/2022

EXAMINER	ART UNIT	CLASS-SUBCLASS
D. G. Muller	2196	

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363)	2. For printing on the patent front page, list	1. MARSHALL, GERSTEIN & BORUN LLP
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.	(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,	2.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. Use of a Customer Number is required.	(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.	3.

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE or COUNTRY)

ParTec Cluster Competence Center GmbH

Munich, Germany

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. Fees Submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment (Please first reapply any previously paid fee shown above):

☒ Electronic Payment via EFS-Web ☐ Enclosed check ☒ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 13-2855

5. Change of Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29.

NOTE: Absent a valid Certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

☐ Applicant asserting small entity status. See 37 CFR 1.27.

NOTE: If the application was previously under micro entity status, checking this box will be taken as a notification of loss of entitlement to micro entity status.

☐ Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken as a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Michael P. Furmanek, #58,495/

Date November 29, 2022

Typed or printed name Michael P. Furmanek

Registration No. 58,495

Electronic Patent Application Fee Transmittal				
Application Number:		16963749		
Filing Date:		21-Jul-2020		
Title of Invention:		APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES		
First Named Inventor/Applicant Name:		Thomas Lippert		
Filer:		Michael Paul Furmanek./Araceli Hernandez		
Attorney Docket Number:		29959/55804		
Filed as Small Entity				
Filing Fees for U.S. National Stage under 35 USC 371				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	600	600

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				600

Electronic Acknowledgement Receipt

EFS ID:	47101921
Application Number:	16963749
International Application Number:	
Confirmation Number:	6322
Title of Invention:	APPLICATION RUNTIME DETERMINED DYNAMICAL ALLOCATION OF HETEROGENEOUS COMPUTE RESOURCES
First Named Inventor/Applicant Name:	Thomas Lippert
Customer Number:	4743
Filer:	Michael Paul Furmanek./Araceli Hernandez
Filer Authorized By:	Michael Paul Furmanek.
Attorney Docket Number:	29959/55804
Receipt Date:	29-NOV-2022
Filing Date:	21-JUL-2020
Time Stamp:	07:51:29
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 600
RAM confirmation Number	E2022AS853463521
Deposit Account	132855
Authorized User	Araceli Hernandez

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.492 (National application filing, search, and examination fees)

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	Issue_Fee_Transmittal.pdf	38019	no	1
			65c6371fd9001d63c7e1244c9e0a663cbc738751		
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	38154	no	2
			229b66b18d51e30858f8a507a0588c74b5e82f9c		
Warnings:					
Information:					
Total Files Size (in bytes):			76173		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					



APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/963,749	12/27/2022	11537442	29959/55804	6322

4743 7590 12/07/2022

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ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment is 35 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

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