METHOD AND SYSTEM FOR SHARING COMPUTING RESOURCES USING WIRELESS MOBILE DEVICES ON AN AD-HOC BASIS

Field of the Invention

The present invention relates to a method and system for sharing computing resources among a plurality of wireless mobile devices on an ad-hoc basis. In particular, the wireless mobile devices are mobile phones. The wireless mobile devices receive jobs to be processed but do not require application software to be installed in order to process the jobs.

Background of the Invention

Grid computing is a form of distributed computing that involves coordinating and sharing computing, application, data, storage or network resources across dynamic and geographically dispersed organisations.

Recently, there has been a demand to extend grid computing capabilities to wireless mobile devices, such as mobile phones, personal digital assistants (PDA), laptops etc. These mobile devices currently employ grid computing over wireless local area networks (LAN) and IPv6. However, grid middleware on mobile devices has been considered to be too demanding for mobile devices as grid computing was initially designed to handle resource intensive jobs on non-mobile computing platforms.

The present invention relates to a method and system for sharing computing resources among a plurality of wireless mobile devices on an ad-hoc basis. With this infrastructure in place, wireless mobile devices can be pooled together anytime to aggregate computational power for demanding tasks in environment with no

access to computers. Typically, ad-hoc aggregation of mobile computing power is used in situations including disaster recovery, outdoor empirical studies and research, where computers are inaccessible. Ad-hoc communication amongst wireless mobile devices is achieved by current standards of Bluetooth™ technology.

In the prior art document US 2004/0148336, a massively distributed processing system and associated methods are described that utilise a processing architecture for a multitude of widely distributed devices to process distributed workloads for a plurality of distributed processing projects. To provide the infrastructure processing power for the distributed processing system, a modular client agent program, including a system component with a core agent module and a separate project component with at least one task module, is configured to operate on the distributed devices and to process a variety of project workloads. For each different distributed project, different project components or task modules may be provided by a server system to the distributed devices to run on the core agent module or system component. In addition, a capabilities database can be used by a server system to schedule workloads based upon the capabilities of the distributed devices. Furthermore, scheduling, device ID, task wrapper and further infrastructure and application development implementations are also provided.

As such, there is a need for a method and a system for sharing computing resources using wireless mobile devices on an ad-hoc basis that overcome or at least alleviate problems in the prior art.

Summary of the Invention

The present invention seeks to provide a method for sharing computing resources among a plurality of wireless mobile devices, comprising steps of initiating communications automatically among the plurality of wireless mobile devices using a wireless communication protocol; receiving job submitted; preparing a

plurality of co-worker jobs to be distributed among the plurality of wireless mobile devices by an initiator wireless mobile device; distributing the plurality of co-worker jobs among the plurality of wireless mobile devices by the initiator wireless mobile device; processing the plurality of co-worker jobs by the plurality of wireless mobile devices; and finalising result of completed job submitted.

In another aspect, the present invention provides a system for sharing computing resources comprising an initiator wireless mobile device and at least one co-worker wireless mobile device, wherein the plurality of wireless mobile devices are connected to one another in the system using a wireless communication protocol.

In yet another aspect, the present invention provides a method for sharing computing resources among a plurality of wireless mobile devices, comprising steps of receiving job submitted; initiating communications among the plurality of wireless mobile devices using a wireless communication protocol; preparing a plurality of co-worker jobs to be distributed among the plurality of wireless mobile devices by an initiator wireless mobile device; distributing the plurality of co-worker jobs among the plurality of wireless mobile devices by the initiator wireless mobile device; processing the plurality of co-worker jobs by the plurality of wireless mobile devices; and finalising result of completed job submitted,
wherein the step of preparing a plurality of co-worker jobs to be distributed among the plurality of wireless mobile devices by an initiator wireless mobile device further comprises steps of serialising an instruction set; calculating optimum data size of data submitted to be split into a plurality of co-worker data; splitting data submitted into optimum size to form the plurality of co-worker data; and attaching the split plurality of co-worker data with the serialised instruction set to form the plurality of co-worker jobs.

Brief Description of the Drawings

A preferred embodiment of the present invention will now be more fully described, by way of example, with reference to the drawings of which:

FIG. 1 illustrates a set-up of a preferred embodiment in accordance with the present invention;

FIG. 2 illustrates a set-up of a wireless mobile device in FIG.1;

FIG. 3 illustrates the timeline of sending and receiving of jobs between two wireless mobile devices;

FIG. 4 illustrates a flow chart of a method in accordance with the present invention;

FIG. 5 illustrates a flow chart of the preparing co-worker jobs to be distributed step of FIG. 4;

FIG. 6 illustrates a flow chart of the initiating communication step of FIG. 4;

FIG. 7 illustrates a flow chart of the finalising results step of FIG. 4;

FIG. 8 illustrates a flow chart of the creating server thread step of FIG. 6; and

FIG. 9 illustrates a flow chart of the creating client thread step of FIG. 6.

Detailed Description of the Drawings

In the following description, details are provided to describe the preferred embodiment. It shall be apparent to one skilled in the art, however, that the invention may be practiced without such details. Some of these details may not be described at length so as not to obscure the invention.

With the present invention, a leaner infrastructure or middleware for sharing computing resources among wireless mobile devices with similar benefits of grid computing is achieved. Processing power and memory of wireless mobile devices within range can be aggregated using a wireless communication protocol to process jobs. One of the advantages is that there is no need for all wireless mobile devices to install application software to process the job. Whilst the need for installation of application software in all the wireless mobile devices is not necessary, all wireless mobile devices require the installation of the middleware, which enables the coordinating and sharing of computing resources amongst all wireless mobile devices.

The method and system in accordance with the present invention is the aggregation of processing powers of wireless mobile devices within the range of wireless communication protocol of the wireless mobile devices 130 on an ad-hoc basis. In the preferred embodiment, the wireless mobile device is a mobile phone. The initiator wireless mobile device 130 splits up a job submitted into a plurality of co-worker jobs. The plurality of co-worker jobs to be processed, are sent to co-worker wireless mobile devices 120. The co-worker wireless mobile devices 120 do not need the application software to be installed.

Referring to FIG.1, an illustration is shown of a network 100 of wireless mobile devices of a preferred embodiment in accordance with the present invention. An initiator wireless mobile device 130 communicates with a plurality of co-worker wireless mobile devices 120 using a wireless communication protocol. In the preferred embodiment, the wireless communication protocol is Bluetooth™. All wireless mobile devices in the network 100 are connected to one another using Bluetooth™ technology on an ad-hoc basis.

Referring to FIG.2, a set-up of the wireless mobile devices in FIG.1 is shown. The wireless mobile devices 130, 120 in accordance with the preferred embodiment comprises a user interface 220 which instructs the processor 230 to perform a

certain task. The user interface 220 typically includes a display screen 260 and keypad 270 for the user to input information and instructions. The processor 230 is coupled to a Bluetooth™ module 210 and activates the Bluetooth™ module when it receives instructions from the user interface 220. The processor 230 is further coupled to random access memory (RAM) 240 and read only memory (ROM) 250.

Referring to FIG. 3, the initiator wireless mobile device 130 sends a co-worker job to the co-worker wireless mobile device 120 at time T0, 915. The co-worker wireless mobile device 120 receives the co-worker job after a delay, at time T1, 910. The initiator wireless mobile device 130 finishes sending the co-worker job to the co-worker wireless mobile device 120 at time T2, 925, while the co-worker wireless mobile device 120 finishes receiving the co-worker job at time T3, 920. Both wireless mobile devices 130, 120 start to process the co-worker job thereafter. The initiator wireless mobile device 130 finishes processing the co-worker job at T4, 930. The co-worker wireless mobile device finishes processing the co-worker job at T5, 935 and sends 935 the completed co-worker job back to the initiator wireless mobile device 130. The sending of the completed co-worker job to the initiator wireless mobile device 130 ends at T7, 945. The initiator wireless mobile device 130 receives the completed co-worker job from the co-worker wireless mobile device 120 at T6, 940 and completes receiving the completed co-worker job at T8, 950.

Referring to FIG. 4, the method 300 of sharing computing resources starts 310 with initiating communications 312 among the initiator wireless mobile device 130 and co-worker wireless mobile devices 120 within range of the one another using the wireless communication protocol. The initiation of communication 312 among wireless mobile devices starts automatically without initiation from the user. This is followed by the initiator wireless mobile device 130 receiving job submitted 315 by the user through the user interface 220.

The initiator wireless mobile device 130 then determines 320 whether the job is to be processed locally 355 or to be distributed among the co-worker wireless mobile

devices 120 for processing. In the preferred embodiment of the invention, this is determined 320 by considering two factors. The two factors are time comparator factor and compute-to-data (c2d) ratio factor.

The time comparator factor involves the comparison of two timings. The first timing, hereinafter known as job processing timing, is the time taken by the wireless mobile device to complete a given job. The second timing, hereinafter known as transmission timing, is the time taken to send the job and receive the results. The transmission timing is calculated based on the wireless communication protocol transmission speed (bits per second), which varies depending on the wireless communication protocol technology employed by the wireless mobile devices 120, 130 and the round trip delay of the transmission.

If the transmission timing is higher than the job processing timing, the time comparator factor is FALSE. If the transmission timing is equal or lower than the job processing timing, the time comparator factor will be TRUE.

The c2d ratio factor is determined by analysing the job to determine the c2d ratio. It is defined as the number of individual operations required processing the job versus the amount of data and code that must be distributed in support of that operation. The c2d ratio algorithm is well known in the state of the art and will not be discussed in detail herein.

If the c2d ratio is lower than 1.5, the process demand for computing power is low and the c2d ratio factor will be FALSE. If the ratio is equal to or higher than 1.5, the process demand for computing power is high and the c2d ratio factor will be TRUE.

If any one of the two factors is FALSE, the job will be processed locally in the initiator wireless mobile device 130. When both factors are TRUE, the job will be sent out to the co-worker wireless mobile devices 120 to be processed.

The job is then prepared 325 by the initiator wireless mobile device 130 and distributed 335 to the co-worker wireless mobile devices 120. Both the initiator wireless mobile device 130 and co-worker wireless mobile devices 120 will process 340 the jobs 325 and finalising of results 345 follows thereafter.

Referring to FIG. 5, the step of preparing co-worker jobs to be processed 325 in both initiator wireless mobile device 130 and co-worker wireless mobile devices 120 starts with the serialisation of instruction set 415. The instruction set provides computing instructions to co-worker wireless mobile devices. In the preferred embodiment of Java™ implementation, during serialisation of the instruction set 415, the instruction set is read and converted to byte array through an application programming interface (API). The step of serialisation of instruction set 415 is well known in the state of the art and will not be discussed in detail hereinafter. In other embodiments of the step of serialisation of instruction set 415, the step is modified accordingly such that the implementation in another platform can be achieved.

In the next step, the data of the job submitted, also known as data submitted, are split into co-worker data. In the preferred embodiment of the invention, the optimum data sizes of the data submitted to be split are calculated 420 based on the number of wireless mobile devices 120 remaining in the network (K), overlap time (L), sending time (S), waiting time (W) and receiving time (R).

Referring to FIG. 3 and Table 1 below, the sending time, S, is defined as the time taken for the initiator wireless mobile device 130 to complete sending the job to the co-worker wireless mobile device. The overlap time, L, is defined as time taken for the co-worker wireless mobile device 120 to start processing the job at T3, 920 to the completion of processing of job at T4, 930 by the initiator wireless mobile device 130. The waiting time, W, is defined as the time taken from the completion of processing of job at T4, 930 by the initiator wireless mobile device 130, to the time the initiator wireless mobile device 130 receives the completed job at T6, 940 from the co-worker wireless mobile device 120. The receiving time, R, is defined

as the time taken for the initiator wireless mobile device 130 to complete receiving the completed job from the co-worker wireless mobile device 120.

Table 1

Factors	**Time Taken**
Sending time, *S*	From T0 to T2
Overlap time, *L*	From T3 to T4
Waiting time, *W*	From T4 to T6
Receiving time, *R*	From T6 to T8

$$(N-1)\times L > S + W + R \qquad (1)$$

where N is the number of the co-worker data to be split into;

L is overlap time;

S is sending time;

W is waiting time; and

R is receiving time.

Conditional equation (1) above is checked for every singular incremental of N, starting from $N = 2$ until the conditional equation is satisfied. If N is more than the number of wireless mobile devices K, remaining in the network, the data submitted will be split into K number of co-worker data. If N is equal or less than the number of wireless mobile devices K, remaining in the network, the data will be split into N number of co-worker data. After splitting of the data submitted into co-worker data, the co-worker data are then converted 427 to byte array.

The co-worker data are then attached 430 to serialised instruction set 415 in a byte array to form co-worker jobs. These co-worker jobs are packages of jobs each including a serialised instruction set and the co-worker data in byte array to be processed in each wireless mobile device.

Referring to FIG. 6, the step of initiating communication 312 further comprises simultaneously creating a server thread 515 and creating a client thread 520.

The server thread 515 detects new wireless mobile devices requesting new communication to join the network 100. When new wireless mobile devices are detected, authentication of new wireless mobile devices requesting new connection is performed using existing Bluetooth™ security protocol. The client thread 520 scans the vicinity for existing Bluetooth™ devices and connects to the client thread of other Bluetooth™ devices within range.

After the server thread 515 and client thread 520 are created, connections among wireless mobile devices 130, 120 are established 525. Thereafter, a list of active connections 530 is maintained in real time. Any connections lost or new connections established are to be updated accordingly.

Referring to FIG. 7, the step of finalising results 345 further comprises the step of the co-worker wireless mobile devices 120 returning results 615 of completed co-worker jobs to the initiator wireless mobile device 130. The initiator wireless mobile device 130 then collates the results 620 of completed co-worker jobs from all co-worker wireless mobile devices and the initiator wireless mobile device 130. The initiator wireless mobile device 130 then presents the collated results 625 as result of completed job submitted through the user interface 220 to the user.

Referring to FIG. 8, the step of creating server thread 515 comprises the step of initiating the wireless communication protocol. In the preferred embodiment, the wireless communication protocol is Bluetooth™. Details of the initiation of Bluetooth™ modules are not discussed here, as the steps of initiating Bluetooth™ are well known to the person skilled in the art. When the network 100 receives incoming connection requests 710 from new co-worker wireless mobile devices, remote device objects are retrieved 715. Remote device object is used in Java™ as a connection handle to other Bluetooth™ devices.

The new co-worker wireless mobile device is checked against 720 the list of active connections 530. If the new co-worker wireless mobile device is registered in the

list of active connections 530, the server thread operation ends 740. If the device is not registered in the list of connections 530, a sender thread is created 725 for sending information to the device. Thereafter, a reader thread is created 730 for receiving information from the device. This is to essentially ensure that no co-worker wireless mobile device is registered twice in the list of active connections 530.

Referring to FIG. 9, the step of creating client thread 520 comprises initiating wireless communication protocol general inquiry 805. In the preferred embodiment, the wireless communication protocol is Bluetooth™. This step detects all devices in the range that uses Bluetooth™ as the wireless communication protocol. Then a list of Bluetooth™ device addresses (BDA), unique to each Bluetooth™ device such as a laptop, a wireless mobile device, a personal digital assistant (PDA) etc., is retrieved 810. This is followed by an initiation of service discovery of devices 815. Service discovery of devices 815 determines the type of application, such as chatting, file transferring, audio reception etc. that the device is running. Only devices and the applications that are compatible for communication and processing of jobs will be connected via Bluetooth™.

Then a sender thread is created 820 for sending information to the wireless mobile device, followed by the creation of a reader thread 825 for receiving information from the wireless mobile device before the operation is completed 835.

It will be appreciated that although one preferred embodiment has been described in detail, various modifications and improvements can be made by a person skilled in the art without departing from the scope of the present invention.

Claims

1. A method for sharing computing resources among a plurality of wireless mobile devices, comprising steps of:

(a) initiating communications automatically among the plurality of wireless mobile devices using a wireless communication protocol;

(b) receiving job submitted;

(c) preparing a plurality of co-worker jobs to be distributed among the plurality of wireless mobile devices by an initiator wireless mobile device;

(d) distributing the plurality of co-worker jobs among the plurality of wireless mobile devices by the initiator wireless mobile device;

(e) processing the plurality of co-worker jobs by the plurality of wireless mobile devices; and

(f) finalising result of completed job submitted.

2. A method of claim 1, wherein the initiator wireless mobile device proceeds to process the job submitted without proceeding to step (c) after step (b) if

time comparator factor or

compute-to-data ratio factor

is FALSE.

4. A method of claim 2, wherein the time comparator factor is FALSE when transmission timing is higher than job processing timing.

5. A method of claim 2, wherein the compute-to-data ratio factor is FALSE if the compute-to-data ratio is lower than 1.5.

6. A method of claim 1, wherein the step (b) further comprises steps of:

(b1) creating a server thread;

(b2) creating a client thread;

(b3) establishing connections among the plurality of wireless mobile devices; and

(b4) updating a list of active connections,

wherein steps (b1) and (b2) are performed simultaneously.

7. A method of claim 6, wherein the step (b1) further comprises step of:

(b5) initiating wireless communication protocol;

(b6) receiving at least one incoming connection requests;

(b7) retrieving remote device objects;

(b8) creating sender thread for sending information to one of the plurality of wireless mobile devices; and

(b9) creating reader thread for receiving information from one of the plurality of wireless mobile devices.

8. A method of claim 7, wherein steps (b8) and (b9) do not follow after the step (b7) if the one of the plurality of wireless mobile devices requesting connection in step (b6) is registered in the list of active connections.

9. A method of claim 6, wherein the step (b2) further comprises step of:

(b10) initiating wireless communication protocol general inquiry;

(b11) retrieving list of Bluetooth™ Device Addresses of a plurality of wireless mobile devices within range;

(b12) initiating service discovery of a plurality of wireless mobile devices;

(b13) creating sender thread for sending information to one of the plurality of wireless mobile devices; and

(b14) creating reader thread for receiving information from one of the plurality of the wireless mobile devices.

10. A method of claim 1, wherein the step (c) further comprises steps of:

(c1) serialising an instruction set;

(c2) calculating optimum data size of data submitted to be split into a plurality of co-worker data;

(c3) splitting data submitted into optimum size to form the plurality of co-worker data;

(c4) converting the plurality of co-worker data to byte array; and

(c5) attaching the split plurality of co-worker data with the serialised instruction set to form the plurality of co-worker jobs.

11. A method of claim 10, wherein the step (c2) is performed to establish the number of co-worker data for the data submitted to be split into, by checking a conditional equation $(N-1)\times L > S + W + R$ with every singular incremental of N starting from $N = 2$ until the conditional equation is satisfied, where

N is the number of the co-worker data for the data submitted to be split into;

L is overlap time;

S is sending time;

W is waiting time; and

R is receiving time.

12. A method of claim 11, wherein the number of co-worker data for the data submitted to be split into is the number of wireless mobile devices remaining in the network if the number of co-worker data for the data submitted to be split into is higher than the number of wireless mobile devices remaining in the network.

13. A method of claim 1, wherein the step of finalising the step (f) further comprises steps of:

(f1) returning results of the plurality of co-worker jobs completed by at least one co-worker wireless mobile device to the initiator wireless mobile device;

(f2) collating results of the plurality of co-worker jobs completed by at least one co-worker wireless mobile device and the initiator wireless mobile device; and

(f3) presenting the result of completed job submitted.

14. A system for sharing computing resources comprising:

an initiator wireless mobile device; and

at least one co-worker wireless mobile device,

wherein initiation of communication among the initiator wireless mobile devices and the at least one co-worker wireless mobile devices starts automatically.

15. A system of claim 14, wherein the plurality of wireless mobile devices are connected to one another in the system using a wireless communication protocol.

16. A system of claim 14, wherein the initiator wireless mobile device prepares a job submitted to be processed by the plurality wireless mobile devices,

further wherein the job submitted is to be split into a plurality of co-worker jobs, each of the plurality of co-worker jobs comprising

co-worker data and

a serialised instruction set.

17. A system of claim 16, wherein the initiator wireless mobile device further processes the one of the plurality of the co-worker jobs prepared by the initiator wireless mobile device.

18. A system of claim 16, wherein the initiator wireless mobile device further

collates results of the plurality of co-worker jobs completed by at least one co-worker wireless mobile device and the initiator wireless mobile device; and

presents the result of completed job submitted.

19. A system of claim 16, wherein the at least one co-worker wireless mobile device

processes one of the plurality of the co-worker jobs prepared by the initiator wireless mobile device; and

returns result of completed co-worker job to the initiator wireless mobile device.

20. A method for sharing computing resources among a plurality of wireless mobile devices, comprising steps of:

(a) receiving job submitted;

(b) initiating communications among the plurality of wireless mobile devices using a wireless communication protocol;

(c) preparing a plurality of co-worker jobs to be distributed among the plurality of wireless mobile devices by an initiator wireless mobile device;

(d) distributing the plurality of co-worker jobs among the plurality of wireless mobile devices by the initiator wireless mobile device;

(e) processing the plurality of co-worker jobs by the plurality of wireless mobile devices; and

(f) finalising result of completed job submitted,

wherein the step (c) further comprises steps of:

(c1) serialising an instruction set;

(c2) calculating optimum data size of data submitted to be split into a plurality of co-worker data;

(c3) splitting data submitted into optimum size to form the plurality of co-worker data; and

(c4) attaching the split plurality of co-worker data with the serialised instruction set to form the plurality of co-worker jobs.