

RESOURCE ALLOCATION FOR COMPUTER PROCESSING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001]]This application claims the benefit of priority to U.S. Provisional Application Serial No. 62/303,827, filed on March 04, 2016, the entire contents of which are hereby incorporated by reference.

BACKGROUND

[0002] A computer network is a collection of computers and other hardware interconnected by communication channels that allow sharing of resources and information. Communication protocols define the rules and data formats for exchanging information in a computer network.

SUMMARY

[0003] The present document relates to computer processing of input in a parallel processing environment.

[0004] In one aspect, a method is performed by a computer system. The method includes executing, in a computer system that comprises multiple processing resources, a job that receives as input a data stream, wherein the amount of data in the data stream is unbounded, wherein processing resources are assigned to workers and wherein the workers are assigned to jobs. The method includes iteratively determining, for the job: a backlog growth over a first period of time, wherein the backlog growth is a measure of a growth of unprocessed data in the received data stream that is to be input into the job and wherein the backlog growth is measured in terms of a change to a data size; a backlog volume that is a measure of unprocessed data in the received data stream that is to be input into the job and wherein the backlog volume is measured in terms of a data size; and determining, based on the backlog growth and the backlog volume, whether to adjust a quantity of processing resources allocated to the job. For an iteration of the determination: the backlog growth is determined to be zero or negative; the backlog volume is determined to be at a target; determining that the quantity of processing resources allocated to the job are determined not to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be at a target. The method includes, for each iteration for which the quantity of processing resources allocated to the job are determined to be adjusted, adjusting the

quantity of processing resources allocated to the job wherein adjusting the quantity of processing resources further comprises determining whether to reduce the processing resources and if it is determined to reduce said processing resources determining how far to reduce the allocation of processing resources, wherein a processor utilization is used as a proxy of whether the system can handle a next lower level of allocated processing resources based on: an assumption that a current number of workers w_1 having d_1 disks per worker; determining a minimum $d_2 > d_1$ disks per worker and a minimum w_2 workers necessary, such that $w_2 < w_1$ and each worker gets d_2 disks, wherein a new number of workers run at the current CPU rate multiplied by w_1/w_2 . The method includes for each iteration for which the quantity of processing resources allocated to the job are determined not to be adjusted, maintaining the quantity of processing resources allocated to the job.

[0005] Implementations can include any, all, or none of the following features. For an iteration of the determination: the backlog growth is determined to be zero or negative; the backlog volume is determined to be at a target; determining that the quantity of processing resources allocated to the job are determined not to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be at a target. For an iteration of the determination: the backlog growth is determined to be zero or negative; the backlog volume is determined to be below a target; determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be below a target; and wherein adjusting the quantity of processing resources allocated to the job comprises reducing the quantity of processing resources allocated to the job in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be below a target. For an iteration of the determination the backlog growth is determined to be zero or negative; the backlog volume is determined to be above a target; determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be above a target; and wherein adjusting the quantity of processing resources allocated to the job comprises increasing the quantity of processing resources allocated to the job in response to the backlog growth being determined to be zero or

value; determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the processor utilization being determined to be below a value; and wherein adjusting the quantity of processing resources allocated to the job comprises reducing the quantity of processing resources allocated to the job in response to the processor utilization being determined to be below a value. Reducing the quantity of processing resources allocated to the job in response to the processor utilization being determined to be below a value comprises reducing a discrete number of resources allocated to the job, the discrete number being based on the processor utilization. The discrete number is a number of computer memory disks. Determining, based on the backlog growth and the backlog volume, whether to adjust a quantity of processing resources allocated to the job comprises smoothing the determining that results in oscillation of quantity of processing resources allocated to the job. Smoothing the determining comprises waiting for a second period of time. Smoothing the determining comprises averaging a plurality of determinations whether to adjust a quantity of processing resources allocated to the job.

[0006] In one aspect, a system comprises one or more processors configured to execute computer program instructions; and computer storage media encoded with computer program instructions that, when executed by one or more processors, cause a computer device to perform operations. The operations include executing, in a computer system that comprises multiple processing resources, a job that receives as input a data stream, wherein the amount of data in the data stream is unbounded, wherein processing resources are assigned to workers and wherein the workers are assigned to jobs. The operations include iteratively determining, for the job: a backlog growth over a first period of time, wherein the backlog growth is a measure of a growth of unprocessed data in the received data stream that is to be input into the job and wherein the backlog growth is measured in terms of a change to a data size; a backlog volume that is a measure of unprocessed data in the received data stream that is to be

input into the job and wherein the backlog volume is measured in terms of a data size; determining, based on the backlog growth and the backlog volume, whether to adjust a quantity of processing resources allocated to the job. The operations can include, for an iteration of the determination: the backlog growth is determined to be zero or negative; the backlog volume is determined to be at a target; determining that the quantity of processing resources allocated to the job are determined not to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be at a target. The operations include, for each iteration for which the quantity of processing resources allocated to the job are determined to be adjusted, adjusting the quantity of processing resources allocated to the job, wherein adjusting the quantity of processing resources further comprises determining whether to reduce the processing resources and if it is determined to reduce said processing resources determining how far to reduce the allocation of processing resources, wherein a processor utilization is used as a proxy of whether the system can handle a next lower level of allocated processing resources based on: an assumption that a current number of workers w_1 having d_1 disks per worker; determining a minimum $d_2 > d_1$ disks per worker and a minimum w_2 workers necessary, such that $w_2 < w_1$ and each worker gets d_2 disks, wherein a new number of workers run at the current CPU rate multiplied by w_1/w_2 . The operations include for each iteration for which the quantity of processing resources allocated to the job are determined not to be adjusted, maintaining the quantity of processing resources allocated to the job.

[0007] The systems and processes described here may be used to provide a number of potential advantages. By using backlog measures as a metric to determine resource allocation levels, the drawbacks of overprovisioning and underprovisioning may be reduced or eliminated. Overprovisioning leads to unused or idle network resources, increasing cost and reducing the number of jobs that can be processed. By stepping down resource allocation with workload, unused resources may be freed for different jobs. Underprovisioning leads to increases in backlog, which can result in data loss and increased latency. By stepping up resource allocation

with workload, a job can be processed faster when input is increased. In many cases, data is input to a job in a stream or a constant, unbounded flow of data that may increase or decrease unpredictably. Dynamic response to this input, instead of treating it as a batch or planning for worst-case scenarios, allows for flexible responses to large spikes or dips in input.

[0008] Other features, aspects and potential advantages will be apparent from the accompanying description and figures.

DESCRIPTION OF DRAWINGS

[0009] FIG. 1 is block diagram of highly distributed computing environment that autotunes resource allocation to a group of jobs.

WHAT IS CLAIMED IS:

1. A method implemented in a computer system, the method comprising:

executing, in a computer system that comprises multiple processing resources, a job that receives as input a data stream, wherein the amount of data in the data stream is unbounded, wherein processing resources are assigned to workers and wherein the workers are assigned to jobs;

iteratively determining, for the job:

a backlog growth over a first period of time, wherein the backlog growth is a measure of a growth of unprocessed data in the received data stream that is to be input into the job, and wherein the backlog growth is measured in terms of a change to a data size;

a backlog volume that is a measure of unprocessed data in the received data stream that is to be input into the job, and wherein the backlog volume is measured in terms of a data size;

determining, based on the backlog growth and the backlog volume, whether to adjust a quantity of processing resources allocated to the job, wherein, for an iteration of the determination:

the backlog growth is determined to be zero or negative;

the backlog volume is determined to be at a target;

determining that the quantity of processing resources allocated to the job are determined not to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be at a target;

for each iteration for which the quantity of processing resources allocated to the job are determined to be adjusted, adjusting the quantity of processing resources allocated to the job, wherein adjusting the quantity of processing resources further comprises determining whether to reduce the processing resources and if it is determined to reduce said processing resources determining how far to reduce the allocation of processing resources, wherein a processor utilization is used as a proxy of whether the system can handle a next lower level of allocated processing resources based on:

an assumption that a current number of workers w_1 having d_1 disks per worker;

determining a minimum $d_2 > d_1$ disks per worker and a minimum w_2 workers necessary, such that $w_2 < w_1$ and each worker gets d_2 disks, wherein a new number of workers run at the current CPU rate multiplied by w_1/w_2 ; and

for each iteration for which the quantity of processing resources allocated to the job are determined not to be adjusted, maintaining the quantity of processing resources allocated to the job.

2. The method of claim 1, wherein, for an iteration of the determination:
 - the backlog growth is determined to be zero or negative;
 - the backlog volume is determined to be below a target;
 - determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be below a target; and
 - wherein adjusting the quantity of processing resources allocated to the job comprises reducing the quantity of processing resources allocated to the job in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be below a target.
3. The method of claim 1, wherein, for an iteration of the determination:
 - the backlog growth is determined to be zero or negative;
 - the backlog volume is determined to be above a target;
 - determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be above a target; and
 - wherein adjusting the quantity of processing resources allocated to the job comprises increasing the quantity of processing resources allocated to the job in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be above a target.
4. The method of claim 1, wherein, for an iteration of the determination:
 - the backlog growth is determined to be positive;
 - the backlog volume is determined to be below a target;
 - determining that the quantity of processing resources allocated to the job are determined not to be adjusted in response to the backlog growth being determined to be positive and the backlog volume determined to be below a target.
5. The method of claim 1, wherein, for an iteration of the determination:
 - the backlog growth is determined to be positive;
 - the backlog volume is determined to be not below a target

determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the backlog growth being determined to be positive and the backlog volume determined to be below a target; and

wherein adjusting the quantity of processing resources allocated to the job comprises increasing the quantity of processing resources allocated to the job in response to the backlog growth being determined to be positive and the backlog volume determined to be below a target.

6. The method of claim 1, wherein units of the data size is at least one of the group consisting of bits, bytes, megabytes, gigabytes, records, and cardinality.
7. The method of claim 1, the method further comprising:
 - iteratively determining, for the job, a processor utilization;
 - wherein iteratively determining whether to adjust a quantity of processing resources allocated to the job is further based on the processor utilization.
8. The method of claim 7, wherein:
 - wherein, for an iteration of the determination:
 - the processor utilization is below a value;
 - determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the processor utilization being determined to be below a value; and
 - wherein adjusting the quantity of processing resources allocated to the job comprises reducing the quantity of processing resources allocated to the job in response to the processor utilization being determined to be below a value.
9. The method of claim 8, where in reducing the quantity of processing resources allocated to the job in response to the processor utilization being determined to be below a value comprises reducing a discrete number of resources allocated to the job, the discrete number being based on the processor utilization.
10. The method of claim 9, wherein the discrete number is a number of computer memory disks.

11. The method of claim 1, wherein determining, based on the backlog growth and the backlog volume, whether to adjust a quantity of processing resources allocated to the job comprises smoothing the determining that results in oscillation of quantity of processing resources allocated to the job.
12. The method of claim 11, wherein smoothing the determining comprises waiting for a second period of time.
13. The method of claim 11, wherein smoothing the determining comprises averaging a plurality of determinations whether to adjust a quantity of processing resources allocated to the job.
14. A system comprising:
 - one or more processors configured to execute computer program instructions; and
 - computer storage media encoded with computer program instructions that, when executed by one or more processors, cause a computer device to perform operations comprising:
 - executing, in a computer system that comprises multiple processing resources, a job that receives as input a data stream, wherein the amount of data in the data stream is unbounded, wherein processing resources are assigned to workers and wherein the workers are assigned to jobs;
 - iteratively determining, for the job:
 - a backlog growth over a first period of time, wherein the backlog growth is a measure of a growth of unprocessed data in the received data stream that is to be input into the job and wherein the backlog growth is measured in terms of a change to a data size;
 - a backlog volume that is a measure of unprocessed data in the received data stream that is to be input into the job, and wherein the backlog volume is measured in terms of a data size;
 - determining, based on the backlog growth and the backlog volume, whether to adjust a quantity of processing resources allocated to the job, wherein, for an iteration of the determination:
 - the backlog growth is determined to be zero or negative;
 - the backlog volume is determined to be at a target;

determining that the quantity of processing resources allocated to the job are determined not to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be at a target;

for each iteration for which the quantity of processing resources allocated to the job are determined to be adjusted, adjusting the quantity of processing resources allocated to the job, wherein adjusting the quantity of processing resources further comprises determining whether to reduce the processing resources and if it is determined to reduce said processing resources determining how far to reduce the allocation of processing resources, wherein a processor utilization is used as a proxy of whether the system can handle a next lower level of allocated processing resources based on:

an assumption that a current number of workers w_1 having d_1 disks per worker;

determining a minimum $d_2 > d_1$ disks per worker and a minimum w_2 workers necessary, such that $w_2 < w_1$ and each worker gets d_2 disks, wherein a new number of workers run at the current CPU rate multiplied by w_1/w_2 ; and

for each iteration for which the quantity of processing resources allocated to the job are determined not to be adjusted, maintaining the quantity of processing resources allocated to the job.

15. The system of claim 14, wherein, for an iteration of the determination:

the backlog growth is determined to be zero or negative;

the backlog volume is determined to be below a target;

determining that the quantity of processing resources allocated to the job are determined not to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be below a target; and

wherein adjusting the quantity of processing resources allocated to the job comprises reducing the quantity of processing resources allocated to the job in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be below a target.

16. The system of claim 14, wherein, for an iteration of the determination:

the backlog growth is determined to be zero or negative;

the backlog volume is determined to be above a target;

determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be above a target; and

wherein adjusting the quantity of processing resources allocated to the job

comprises increasing the quantity of processing resources allocated to the job in response to the backlog growth being determined to be zero or negative and the backlog volume determined to be above a target.

17. The system of claim 14, wherein, for an iteration of the determination:

- the backlog growth is determined to be positive;
- the backlog volume is determined to be below a target;
- determining that the quantity of processing resources allocated to the job are determined not to be adjusted in response to the backlog growth being determined to be positive and the backlog volume determined to be below a target.

18. The system of claim 14, wherein, for an iteration of the determination:

- the backlog growth is determined to be positive;
- the backlog volume is determined to be not below a target
- determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the backlog growth being determined to be positive and the backlog volume determined to be below a target; and
- wherein adjusting the quantity of processing resources allocated to the job comprises increasing the quantity of processing resources allocated to the job in response to the backlog growth being determined to be positive and the backlog volume determined to be below a target.

19. The system of claim 14, wherein units of the data size is at least one of the group consisting of bits, bytes, megabytes, gigabytes, records, and cardinality.

20. The system of claim 14, the operations further comprising:

- iteratively determining, for the job, a processor utilization;
- wherein iteratively determining whether to adjust a quantity of processing resources allocated to the job is further based on the processor utilization.

21. The system of claim 20, wherein:

- wherein, for an iteration of the determination:
 - the processor utilization is below a value;
 - determining that the quantity of processing resources allocated to the job are determined to be adjusted in response to the processor utilization being determined to

be below a value; and

wherein adjusting the quantity of processing resources allocated to the job comprises reducing the quantity of processing resources allocated to the job in response to the processor utilization being determined to be below a value.

22. The system of claim 21, where in reducing the quantity of processing resources allocated to the job in response to the processor utilization being determined to be below a value comprises reducing a discrete number of resources allocated to the job, the discrete number being based on the processor utilization.
23. The system of claim 22, wherein the discrete number is a number of computer memory disks.
24. The system of claim 14, wherein determining, based on the backlog growth and the backlog volume, whether to adjust a quantity of processing resources allocated to the job comprises smoothing the determining that results in oscillation of quantity of processing resources allocated to the job.
25. The system of claim 24, wherein smoothing the determining comprises waiting for a second period of time.
26. The system of claim 24, wherein smoothing the determining comprises averaging a plurality of determinations whether to adjust a quantity of processing resources allocated to the job.