Analyzing Scalability of Parallel Algorithm and Architectures

Vipin Kumar and Anshul Gupta

Objectives of this paper

- 1.Survey various metrics
- 2.Relations between these metrics
- 3.Critically asses these metrics
- 4.Directions for future research

Typical metrics

- Amdahl's law
- Isoefficiency function
- Gustafson
- Zorbas
- Isospeed
- Sizeup

Definition

- W is problem size
- Tp(W,p) is Parallel excution time on p processors for W problem size
- Ts(W) is Serial excution time for W problem size
- T0(W,p) is Overhead
- T0 = pTp – Ts
- Efficiency E = Ts/pTp = 1/(1+T0/TS);

Amdahl's law

- If s is serial fraction in an algorithm.

  Then the maxium speedup is bounded by 1/s.

Isoefficiency

- Solve fixed size problem.

  Efficiency decrease when processor increase.
- If the problem size increase on fixed number of processors,then the efficiency increase.
- If the system is 'scalable parallel system'

  Efficiency E can be maintained at some fixed value for increasing of number of processors and problem size

Isoefficiency

- fE(p) is Isoefficiency function
- fE(p) return problem size that can maintain efficiency E on number of p processors.
- If fE(p) grows exponential, then it's poorly scalable
- If fE(p) grows linearly, then it's highly scalable

•Gustafson

- Scaled speedup
- Speedup obtained when the problem size is increased linearly with the number of processors.
- If speedup curve is good(close to linear)

  then the system is scalable system.

•Gustafson

- Two ways to increase problem size

  1. the size of memory be used.

  2.the size of problem growths with p subject to an upper bound on execution time.

•Zorbas

- This metric consider the system is ideally scalable if system's overhead function remains constant when the problem size is increased sufficitently fast with respect to number of processors

Isospeed

- Isospeed measure trying to find problem size W',

  for the averge unit speed of computation remain constant when number of processors increased

  to p' from p
- isospeed(p,p') = p'W/pW'
- For perfectly paralleliable algorithm with no communication isospeed(p,p') = 1
- W' = p'W/p

Sizeup

- Unfair mesure
- Sizeup is ratio of

  Size of problem solved on the parallel computer

  Size of problem solved on the sequential computer

  in fixed time

- Is there exists one measure that is better than all others?
- NO

Examples

- If problem size fixed, and one is trying to solve by increase number of proessors, in this case, try to find optimal number of processors, Amdahl's law is good measure
- If number of processor is fixed, then use isoefficiency function to find best problem size is good measure

Hardware Factor

- Improve technology in only one direction may not be a wise idea
- Increasing speed of the processors alone without improving the communication speed will result in diminishing returns in terms of overall speedup and efficiency.

Thoughts

- How to define problem size
- How to increase problem size

Ideas

- Gustafson's suggestion:

  1. memory

  2.excution time on sequential computer

- Others:

  1. If there are iterations, increase iteration.

Conclusion

- No single scalability metric would be better than all others
- Different measures will be useful in different contexts and further research is needed along serveral directions
- Hardware cost factors in the scalability analysis is important but still very preliminary