Reduce

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- Finish Erlang Processes
- Example Problem
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Objectives

- Understand how reduce combines values using a tree.
- Describe the performance issues for reduce: trade-offs of time for computation and time for communication
- Describe 2 or 3 examples or reduce.

CPSC 418 Poetry Competition

- The competition:
  - Everyone writes a poem.
  - Everyone submits to poem to Mark (the contest judge).
  - Mark reads all of the poems, compares them, selects the best poem.
  - The winner receives an original manuscript of the complete poems of Lu Bai, signed by the author.

Sequential Time for the Poetry Competition

- N students in the class.
- t_r to read and rank two poems.
- Total time $(N-1)t_r$.
- Works fine until N becomes so large that we can't judge all the poems in a reasonable amount of time.

Parallel version

- The procedure
  - Clone P copies of Mark.
  - Each Mark-clone reads and ranks N/P poems and sends the best poem to the original Mark.
  - The original Mark receives P candidates for the best poem, and selects the best one.
  - The winner receives the prize.
- Parallel Time
  - Each Mark clone takes time ______________________, but they all judge their poems in
  - The original Mark takes time ______________________.
  - The total time is ______________________.
  - Simplify this to get______________________.
  - *SpeedUp* $= \frac{T_{\text{seq}}}{T_{\text{par}}} =$ ______________________.

Bureaucratic Overhead

- To satisfy UBC privacy policies, the messages between the Mark-clones and the original mark must be sent in special envelopes.
- There's lots of special procedure for handling these envelopes, takes time λ to send or receive a message.
- The original Mark receives P messages from the P clones. This takes time λP.
- The total time is now: ____________________.
- $SpeedUp = \frac{T_{\text{seq}}}{T_{\text{par}}} =$ ____________________.

Can we do better?

Revenge of the Clones

- While Mark is working through the pile of envelopes, some of the clones realize that they could pair up and combine their results.
  - This costs λ time, the clones have to follow the rules as well.
  - The original Mark ends up with half as many envelopes to handle.
- What is the total time? ______________________.
- What is the speed-up? ______________________.

Up a Tree with the Poetry

- The optimization on the previous slide worked great.
  - We're computer scientists, let's apply the optimization recursively.
  - Viewed from another angle, this is an example of divide-and-conquer.
- Combine the results in a tree.
  - How many levels in the tree?
  - How much time at each level?
- What is the total time? ____________________.
- What is the speed-up? ____________________.

Is there more to life than poetry?

- Find the largest element in a list.
- Find the sum of the elements in a list.
- Count the number of 3s in a list.
- What to these all have in common?
- We'll look at more examples on Friday

The Reduce Pattern

- We have a problem that takes $T_{\text{seq}}(N)$ sequential time, where N is the "size" of the problem instance.
- We can divide this into P tasks with "perfect" speed-up:
  - Each task takes time $T_{\text{seq}}(N)/P$ time.
  - Combining the results takes $\lceil \log_2(P) \rceil \lambda$ time.
- $\mathit{SpeedUp} \;=\; \frac{T_{\text{seq}}(N)}{T_{\text{seq}}(N)/P + \lceil \log_2(P) \rceil \lambda}$
- What happens to *SpeedUp* as P goes large (for fixed N)?
- What happens to *SpeedUp* as N goes large (for fixed P)?