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1. A program has a 30% of code that can be parallelized. Since this program is going to be run for a long time, ¿should you invest in a 2 CPU, 4 CPU or 8 CPU server?

   For n = 2 and s = 0.70

$$\frac{1}{.7+\frac{1-.7}{2}}=\frac{1}{.7+\frac{.3}{2}}=\frac{1}{0.85}=\mathbf{1.1765}\boldsymbol{x}$$

   For n = 4 and s = 0.70

$$\frac{1}{.7+\frac{1-.7}{4}}=\frac{1}{.7+\frac{.3}{4}}=\frac{1}{0.775}=\mathbf{1.2903}\boldsymbol{x}$$

   For n = 8 and s = 0.70

$$\frac{1}{.7+\frac{1-.7}{8}}=\frac{1}{.7+\frac{.3}{8}}=\frac{1}{0.7375}=\mathbf{1.3559}\boldsymbol{x}$$

   It would be recommended to invest (according to time investment) on the 8 CPU server, as it offers the higher speedup factor. However, the 4 CPU server can also be regarded as a possible solution as it has the best improvement of all 3 possible solutions (investing from 2 to 4 servers adds up to the speedup factor 0.1138x, while investing from a 4 to an 8 CPU server only adds 0.0656x). In other words, depending on the priority of the client (highest speedup factor or better cost-relation), the 4 or 8 CPU are viable alternatives.

2. Would it be better to have a program with 10% parallelism and 8 CPUs, 20% with 4 or 25% with 2?

   For n = 8 and s = 0.90

$$\frac{1}{.9+\frac{1-.9}{8}}=\frac{1}{.9+\frac{.1}{8}}=\frac{1}{0.9125}=\mathbf{1.0959}\boldsymbol{x}$$

   For n = 4 and s = 0.80

$$\frac{1}{.8+\frac{1-.8}{4}}=\frac{1}{.8+\frac{.2}{4}}=\frac{1}{0.85}=\mathbf{1.1765}\boldsymbol{x}$$

   For n = 2 and s = 0.75

$$\frac{1}{.5+\frac{1-.75}{2}}=\frac{1}{.75+\frac{.25}{2}}=\frac{1}{0.875}=\mathbf{1.1429}\boldsymbol{x}$$

   The best alternative would be a 4 CPU device with a 20% paralleled code.

3. Consider you have a program that takes 10 hours to run on a 1 core CPU. You only need to run it once, and you have an 8 CPU computer. Optimizing 5% of the code takes 20 minutes. The code can be optimized to be at most 35% parallel. How much time should you invest optimizing the code so the time for optimization+running is the lowest.

For n = 8 and s = 0.95

$$\frac{1}{.95 + \frac{1 - .95}{8}} = \frac{1}{.95 + \frac{.05}{8}} = \frac{1}{0.9563} = \mathbf{1.0457x}$$

$$\frac{10}{1.0457} = 9.5630\ hr \rightarrow 0.5630\ hr = 33.78\ min$$

$$9\ hr + 33.78\ min + 4(5\ min) = \mathbf{9\ hr\ 53.78\ min}$$

For n = 8 and s = 0.90

$$\frac{1}{.90 + \frac{1 - .90}{8}} = \frac{1}{.90 + \frac{.10}{8}} = \frac{1}{0.9125} = \mathbf{1.0959x}$$

$$\frac{10}{1.0959} = 9.1249\ hr \rightarrow 0.1249\ hr = 7.494\ min$$

$$9\ hr + 7.494\ min + 4(10\ min) = \mathbf{9\ hr\ 47.494\ min}$$

For n = 8 and s = 0.85

$$\frac{1}{.85 + \frac{1 - .85}{8}} = \frac{1}{.85 + \frac{.15}{8}} = \frac{1}{0.8688} = \mathbf{1.1510x}$$

$$\frac{10}{1.1510} = 8.6881\ hr \rightarrow 0.6881\ hr = 41.286\ min$$

$$8\ hr + 41.286\ min + 4(15\ min) = \mathbf{9\ hr\ 41.286\ min}$$

For n = 8 and s = 0.80

$$\frac{1}{.80 + \frac{1 - .80}{8}} = \frac{1}{.80 + \frac{.20}{8}} = \frac{1}{0.8250} = \mathbf{1.2121x}$$

$$\frac{10}{1.2121} = 8.2501\ hr \rightarrow 0.2501\ hr = 15.006\ min$$

$$8\ hr + 15.006\ min + 4(20\ min) = \mathbf{9\ hr\ 35.006\ min}$$

For n = 8 and s = 0.75

$$\frac{1}{.75 + \frac{1 - .75}{8}} = \frac{1}{.75 + \frac{.25}{8}} = \frac{1}{0.78125} = \mathbf{1.28x}$$

$$\frac{10}{1.28} = 7.8125\ hr \rightarrow 0.8125\ hr = 48.75\ min$$

$$7\ hr + 48.75\ min + 4(25\ min) = \mathbf{9\ hr\ 28.75\ min}$$

For n = 8 and s = 0.70

$$\frac{1}{.70 + \frac{1 - .70}{8}} = \frac{1}{.70 + \frac{.3}{8}} = \frac{1}{0.7375} = \mathbf{1.3560x}$$

$$\frac{10}{1.3560} = 7.3746\ hr \rightarrow 0.3746\ hr = 22.476\ min$$

$$7\ hr + 22.476\ min + 4(30\ min) = \mathbf{9\ hr\ 22.476\ min}$$

For n = 8 and s = 0.65

$$\frac{1}{.65 + \frac{1 - .65}{8}} = \frac{1}{.65 + \frac{.35}{8}} = \frac{1}{0..6938} = \mathbf{1.4413x}$$

$$\frac{10}{1.4413} = 6.9382\ hr \rightarrow 0.9382\ hr = 56.29\ min$$

$$6\ hr + 56.29\ min + 4(35\ min) = \mathbf{9\ hr\ 16.29\ min}$$

With a limit of 35% regarding the maximum code optimization, the best optimization+running time is found when the code has been optimized up to a 35% (the maximum percentage allowed by this exercise).