

Name: _____

CIS 351 Sample P1 Problem

31 March 2022

P1: Pipeline Structure and Speedup

Consider the following process for baking cookies:

1. Mix sugar, flour, and water using a hand-held mixer for six minutes.
 2. Pour the mixture into another bowl and add chocolate chips. Stir by hand for four minutes.
 3. Spoon the cookie dough onto a baking pan (about four minutes).
 4. Place the pan in the oven for fifteen minutes. One pan of cookies takes up the entire oven – you cannot have more than one pan in the oven at once.
 5. Place the cookies on a cooling rack (about three minutes). (Assume you have unlimited space on the cooling rack.)
- (a) Estimate the total time to bake a single batch of cookies (from when you begin mixing the sugar, flour, and water until all the cookies from the batch are on a cooling rack.)
- (b) Suppose you want to pipeline the cookie-baking process, but are working alone. How many stages does your pipeline have? What steps are included in each stage?
- (c) What is the primary limitation (i.e., structural hazard) that prevents you from adding a third stage?
- (d) Draw a pipeline diagram showing the process of baking 5 batches of cookies using the pipeline you designed above.
- (e) Estimate (i) the total time to bake 10 batches of cookies and (ii) the average time per batch.
- (f) Your per-batch time is less than the time to make a single batch of cookies. What is the *primary* source of this time savings. (Be specific. Don't just say "pipelining".)
- (g) Let k be the number of stages in the pipeline you designed above. The average time per batch is more than $\frac{1}{k}$ the time for a non-pipelined batch. (Using my example, the per-batch time in the 2-stage pipeline — 19.4 minutes — is more than $\frac{1}{2}$ of the 32-minute unpipelined time.)) Explain the primary factor that contributes to this less-than-optimal speedup.

(solution)