# Communicating Sequential Processes
# Exercises 3: Interleaving, Relabelling and Nondeterminism

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1. Design a CSP process to express the following situation. A bookshop operates a system whereby customers pay for books at a cashier's counter and collect them at different counter where they had previously been lodged. The book counter can either lodge a book and issue a chit, or receive a receipt and deliver a book. Book chits must be issued by the book counter before they can be received by the cashier. Similarly receipts must be issued before they can be exchanged for books. The customer may lodge a chosen book with the counter, and have a chit issued in return. In order to claim the book to take away, a receipt must be provided by the cashier.
2. A bag is a process with channels left and right which outputs what it has input but in any order.
    - Use interleaving and the one-place-buffer process Copy to define a bag with capacity N : **N**, and explain your definition.
    - Now define a bag with unbounded capacity.
3. Prove that $COUNT_0 \,|||\, COUNT_0$ is trace equivalent to $COUNT_0$ (see Lecture 1 for the process definition). You should do this by calculating the sets of traces directly.
4. Suppose that $P$ and $Q$ are deterministic processes. Which of these are deterministic?
    - $P[]Q$
    - $P \,|\sim|\, Q$
    - $P \,|||\, Q$
    - *relabel* $P$
    - $a \rightarrow P$.
5. Find relabelling relations $R_i$ which achieve the following effects when applied to $COUNT_0$ .
    - A process with alphabet {*a, b, c*} where the number of *c*s is always at most the total number of *a*s and *b*s.
    - A process with alphabet *{up, down}* that can always perform either event.
    - A process that has the same traces as $COUNT_0$ but may nondeterministically sometimes refuse to perform *down* when $COUNT_0$ would have performed it.

6. Recall the process COPY. Suppose we want, instead, a process $CELL_f$ which inputs values $v$ on channel *left* and immediately outputs $f(v)$ on *right.* Find an appropriate alphabet transformation *gf* so that $CELL_f = gf\,[COPY]$. Under what conditions is *gf* injective?