

CSE 451: Operating Systems

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Deadlock

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(Is Google the greatest, or what?)

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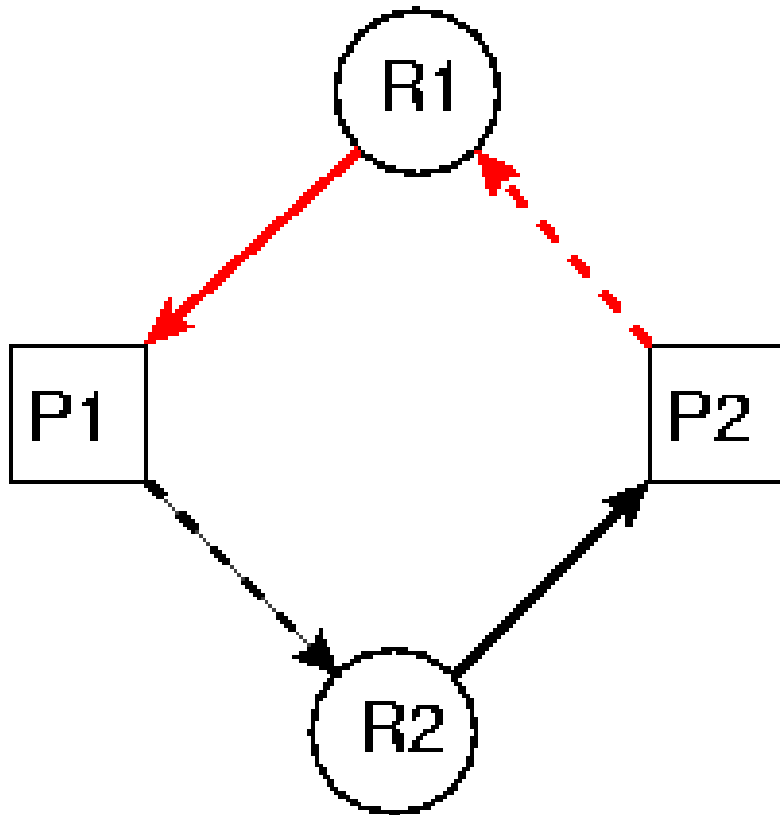
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Definition

- A thread is deadlocked when it's waiting for an event that can never occur
 - I'm waiting for you to clear the intersection, so I can proceed
 - but you can't move until he moves, and he can't move until she moves, and she can't move until I move
 - thread A is in critical section 1, waiting for access to critical section 2; thread B is in critical section 2, waiting for access to critical section 1
 - I'm trying to book a vacation package to Tahiti – air transportation, ground transportation, hotel, side-trips. It's all-or-nothing – one high-level transaction – with the four databases locked in that order. You're trying to do the same thing in the opposite order.

Resource graph



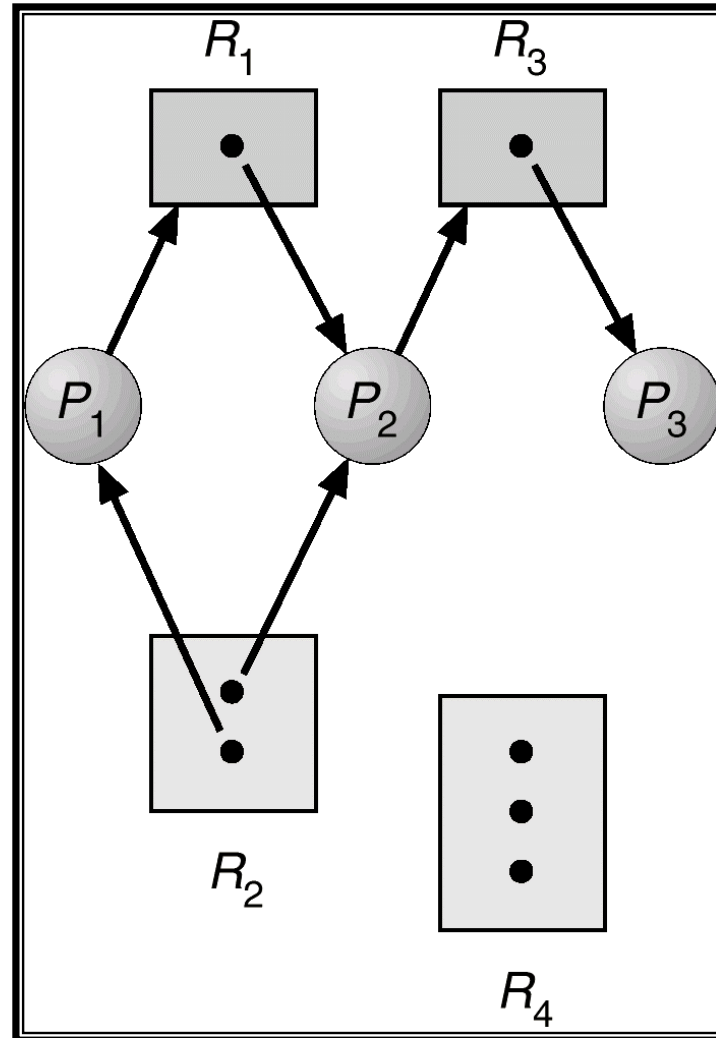
-  R1 is held by
-  is waiting for R1
-  R2 is held by
-  is waiting for R2

- A deadlock exists if there is an *irreducible cycle* in the resource graph (such as the one above)

Graph reduction

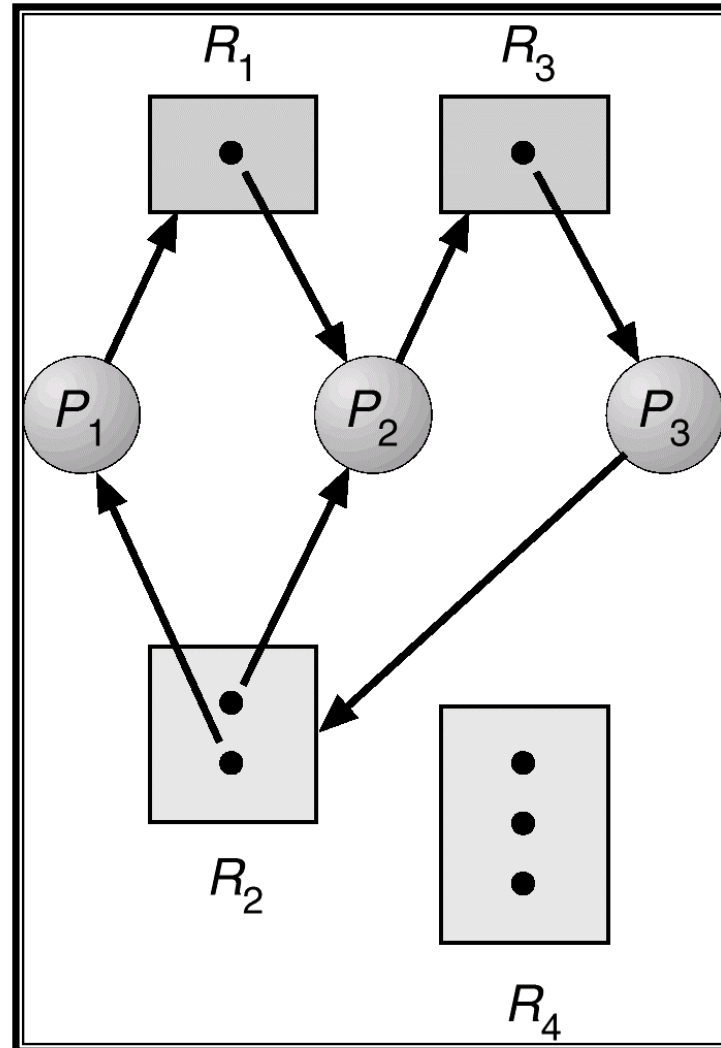
- A graph can be *reduced* by a thread if all of that thread's requests can be granted
 - in this case, the thread eventually will terminate – all resources are freed – all arcs (allocations) to it in the graph are deleted
- Miscellaneous theorems (Holt, Havender):
 - There are no deadlocked threads iff the graph is completely reducible
 - The order of reductions is irrelevant
- (Detail: resources with multiple units)

Resource allocation graph with no cycle

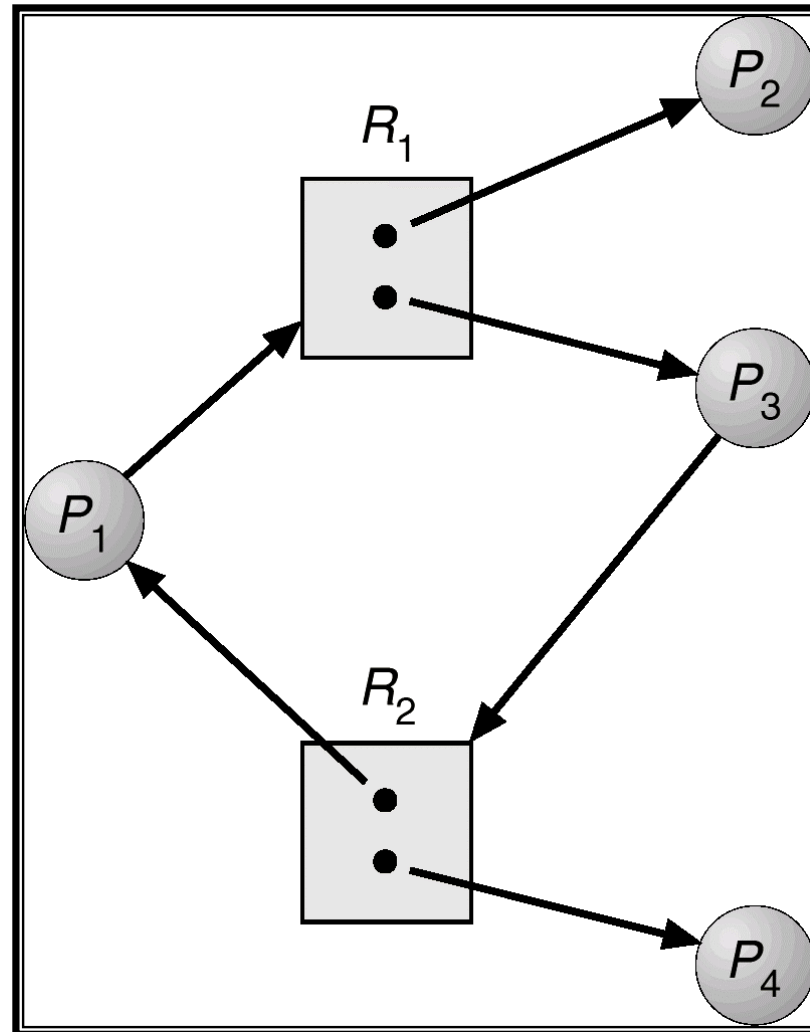


What would cause a deadlock?

Resource allocation graph with a deadlock



Resource allocation graph with a cycle but no deadlock



Approaches to deadlock

- Prevention – don't let deadlock occur
 1. each thread obtains all resources at the beginning; blocks until all are available
 - drawback?
 2. resources are numbered; each thread obtains them in sequence (which means acquiring some before they are actually needed)
 - why does this work?
 - pros and cons?
 3. each thread states its maximum claim for every resource type; system runs the Banker's algorithm at each allocation request
 - if I were to allocate you that resource, and then everyone were to request their maximum claim for every resource, would there be a deadlock?
 - how do I tell if there would be a deadlock?

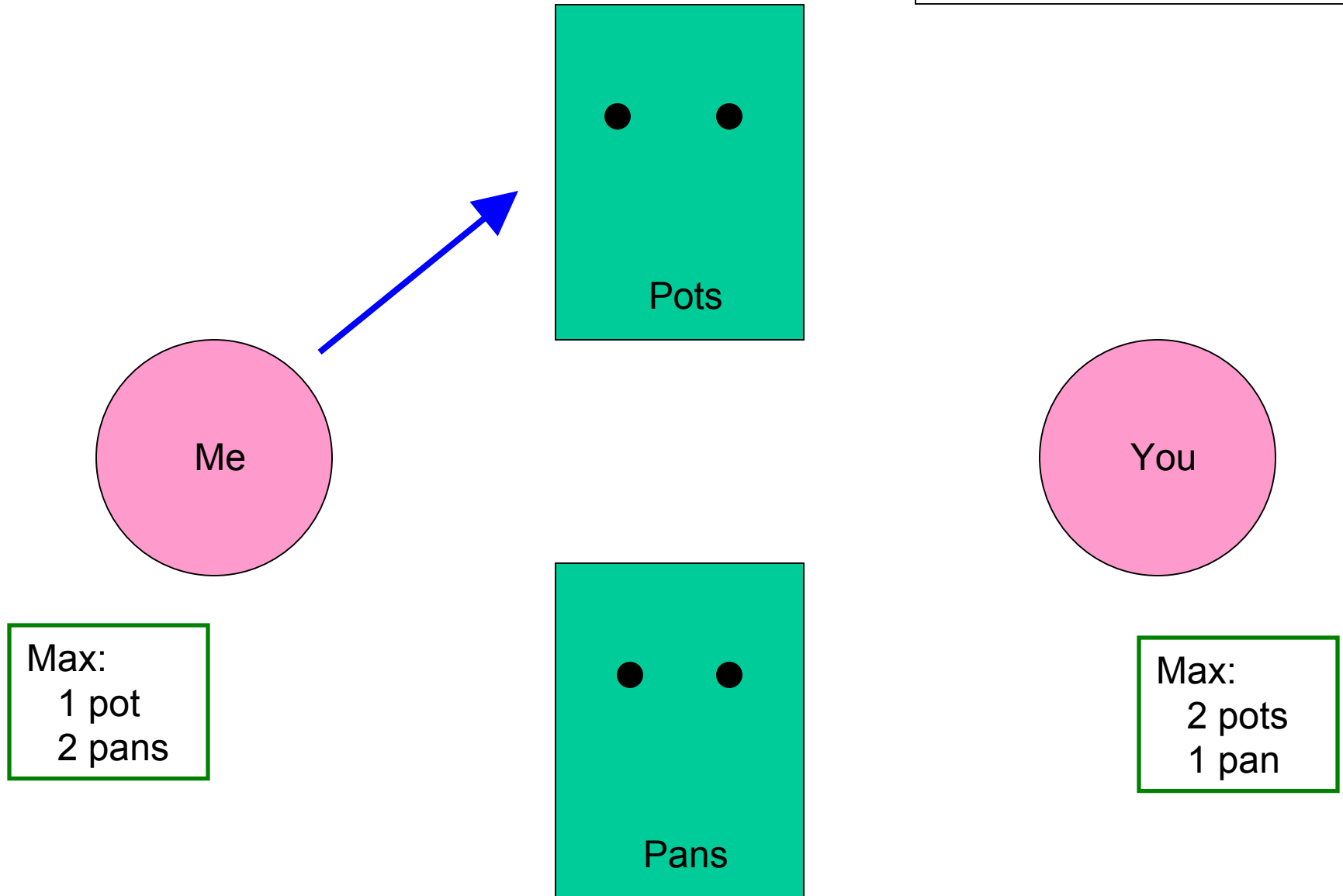
Approaches (cont'd.)

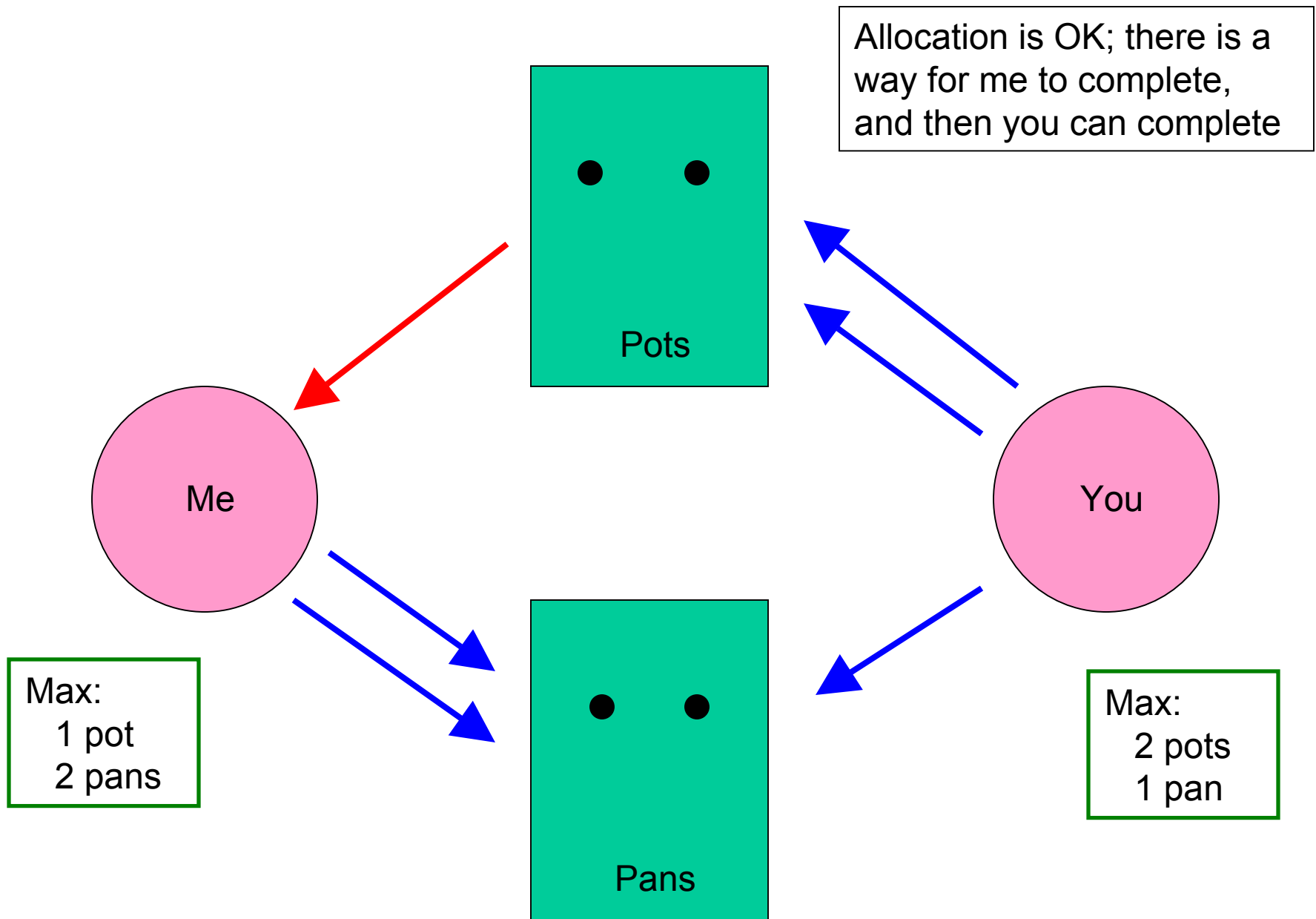
- Detection and correction
 - every once in a while, check to see if there's a deadlock
 - how?
 - if so, eliminate it
 - how?

Banker's Algorithm example

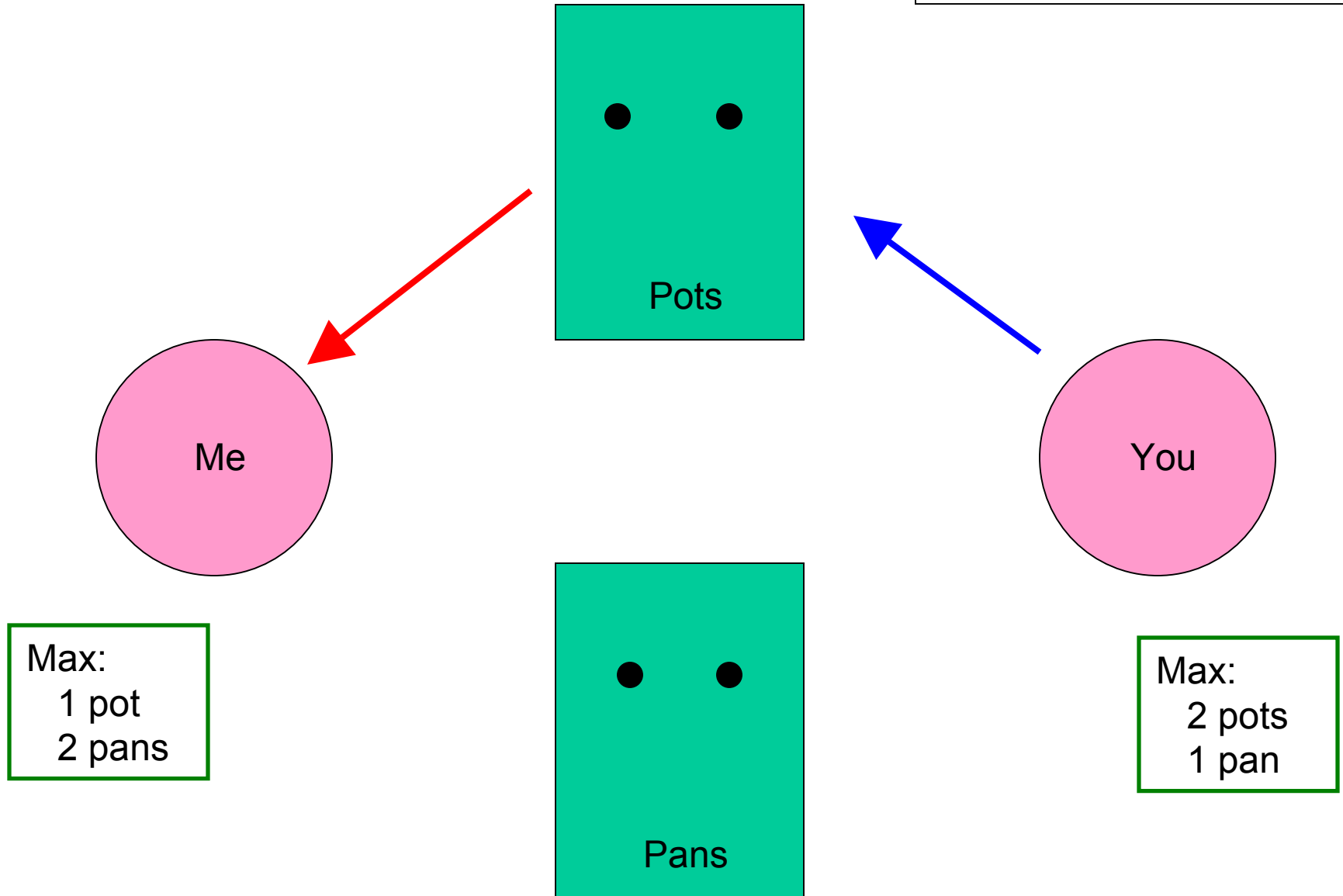
- When a request is made
 - pretend you granted it
 - pretend all other legal requests were made
 - can the graph be reduced?
 - if so, allocate the requested resource
 - if not, block the thread

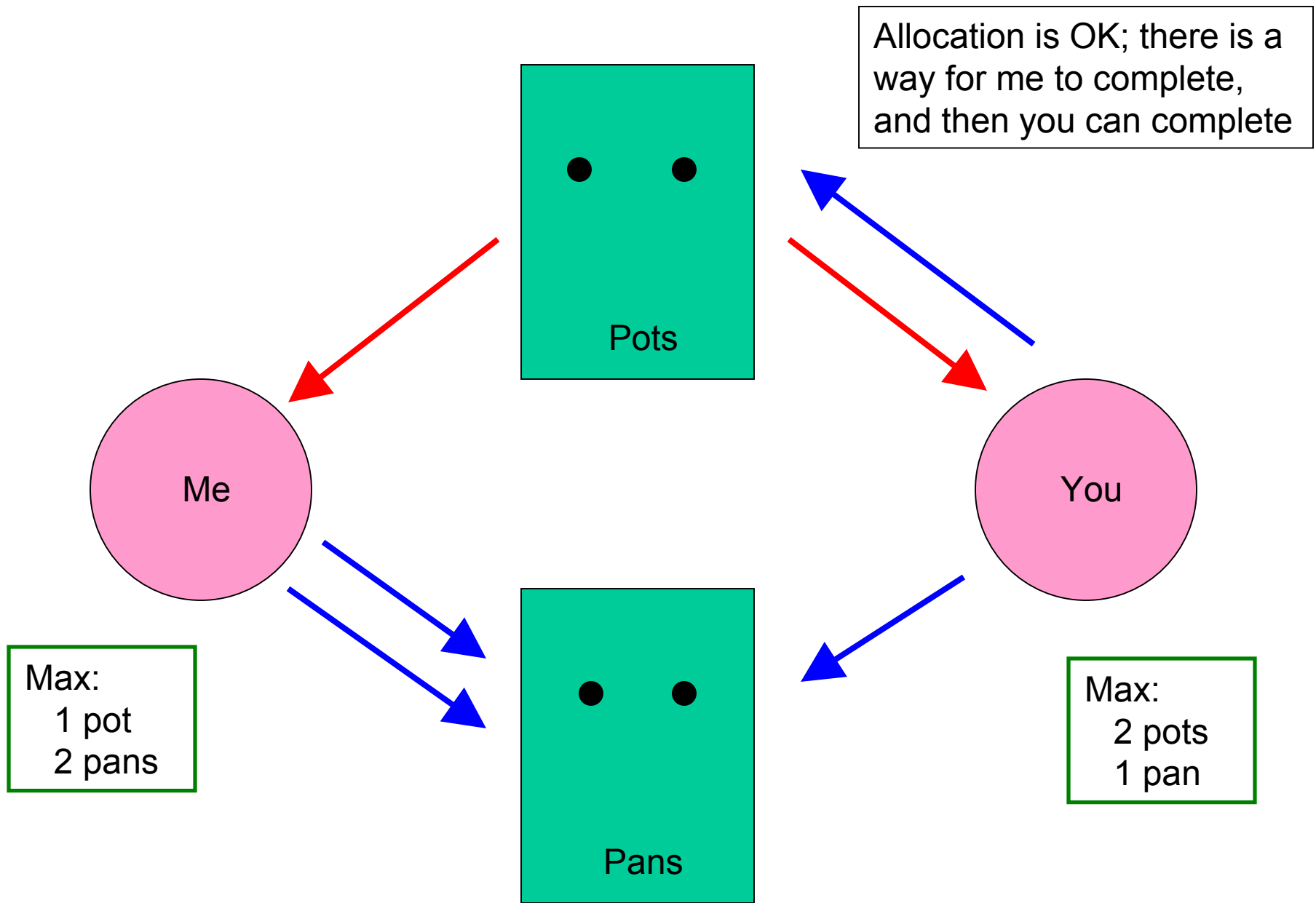
1. I request a pot



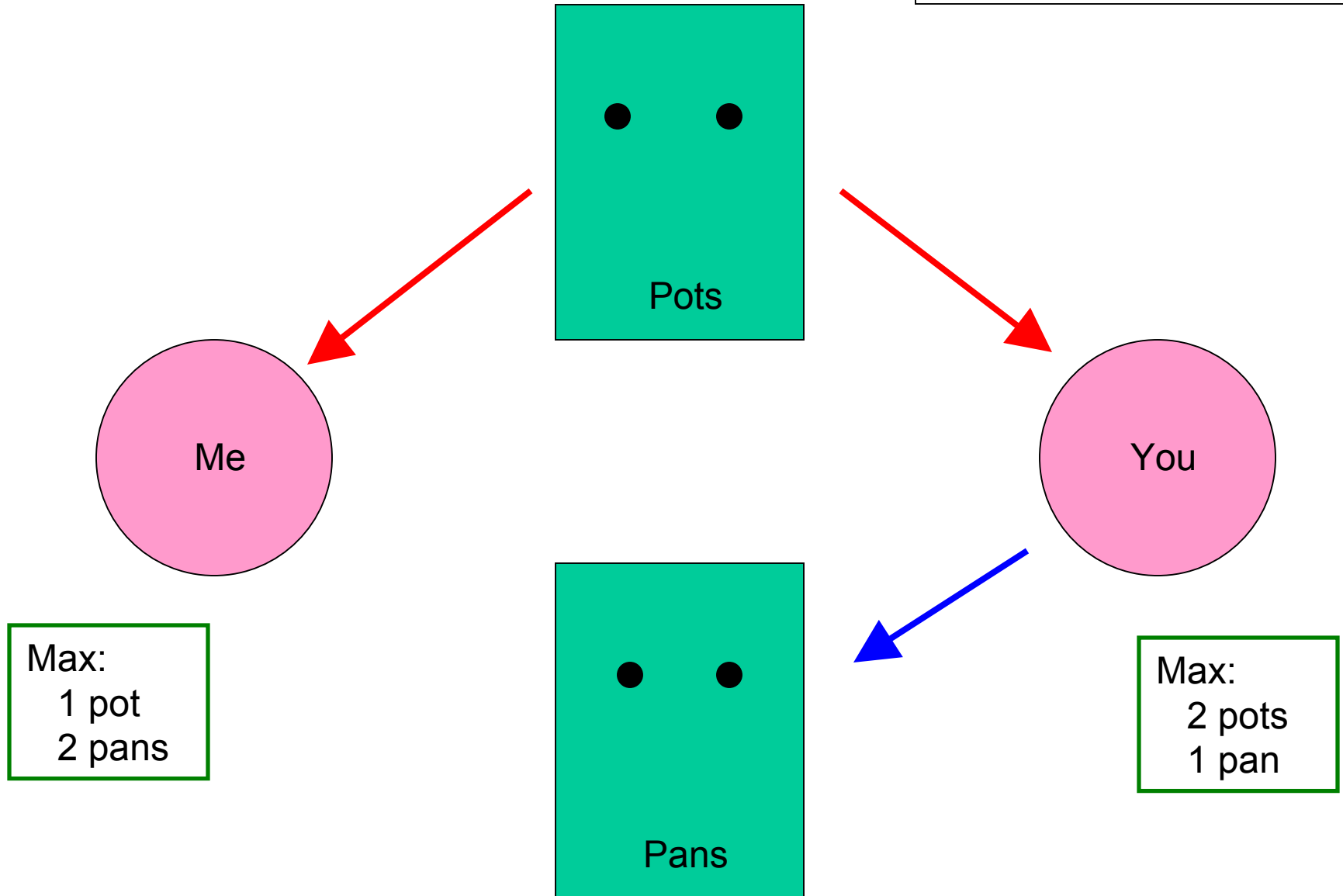


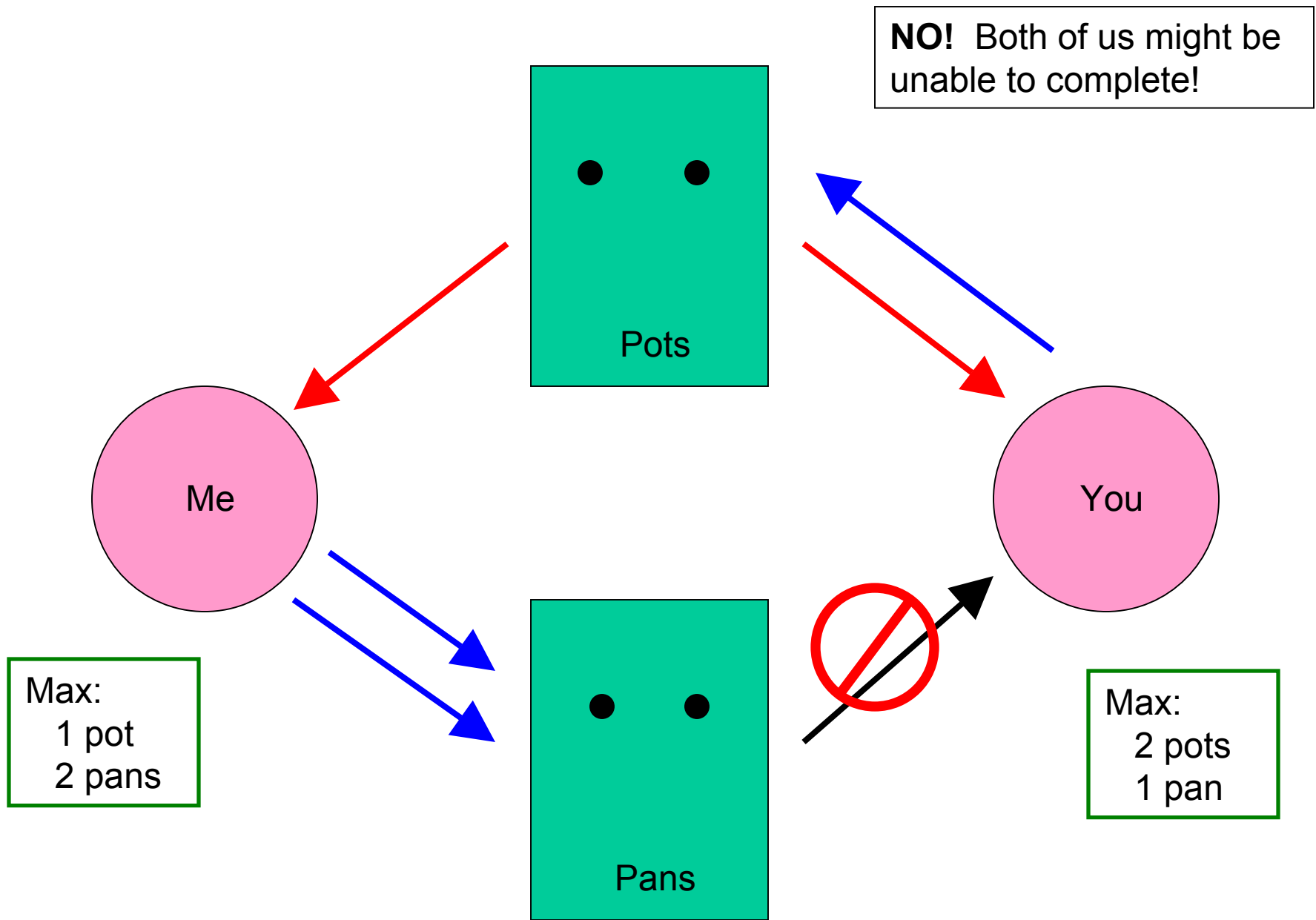
2. You request a pot





3a. You request a pan





3b. I request a pan

