# Deadlock

## Detection and Breaking

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The earliest detection system was *Detection by Operator*

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## Detection and Breaking

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The earliest detection system was *Detection by Operator*

“The machine seems to have stopped…”

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## Detection and Breaking

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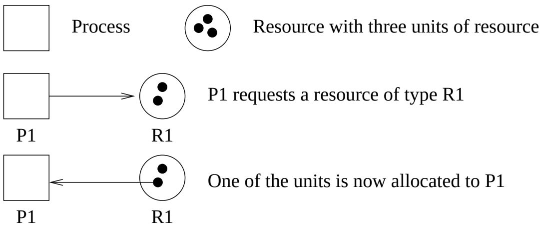
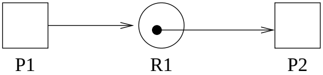



RRAGs

# Deadlock

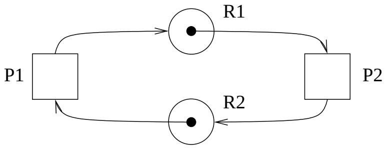
## Detection and Breaking




P1 requests from R1, but it has no free units, so P1 will be blocked

# Deadlock

## Detection and Breaking




Circular Wait

P1 requests from R1, but it has been allocated to P2;
P2 requests from R2, but it has been allocated to R1:
deadlock

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So deadlock detection is just finding these kinds of loops in RRAGs

This can be done by *graph reduction*

For each process repeatedly

1. Remove all request links from the process to resources that are available (perhaps available after a reduction step)
2. When there are no requests links left, remove all links from allocated units of resource to the process

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## Detection and Breaking

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## Detection and Breaking

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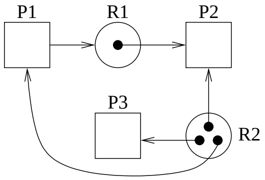
An example:

# Deadlock

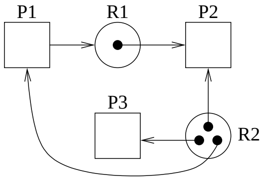
## Detection and Breaking




A RAAG

# Deadlock

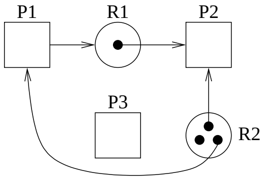
## Detection and Breaking




We can satisfy P3's requests (none)

# Deadlock

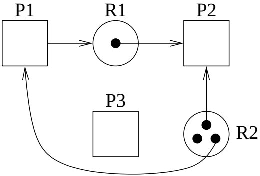
## Detection and Breaking




Reduce P3's allocations

# Deadlock

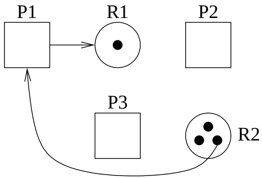
## Detection and Breaking




We can satisfy P2's requests

# Deadlock

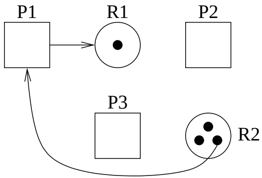
## Detection and Breaking




Reduce P2

# Deadlock

## Detection and Breaking




Now P1's requests can be granted

# Deadlock

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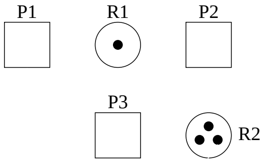
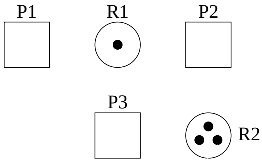



Reduce P1

# Deadlock

## Detection and Breaking




Reduce P1

No more links, so this graph has been completely reduced and there will be no deadlock

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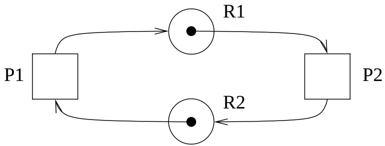


Circular Wait

We can't reduce this as no request links are removable

□

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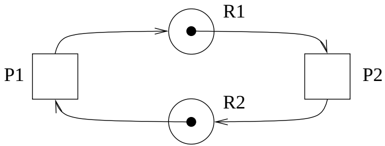


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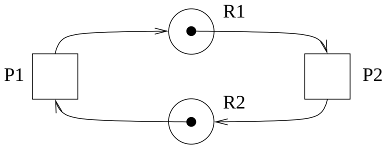


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An advantage of this technique is that it isolates the parts that are deadlocking: we can see them in the graph