Chapter VI
Deadlocks

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Chapter overview

- ***Deadlocks***
- ***Necessary conditions for deadlocks***
- ***Deadlock prevention***

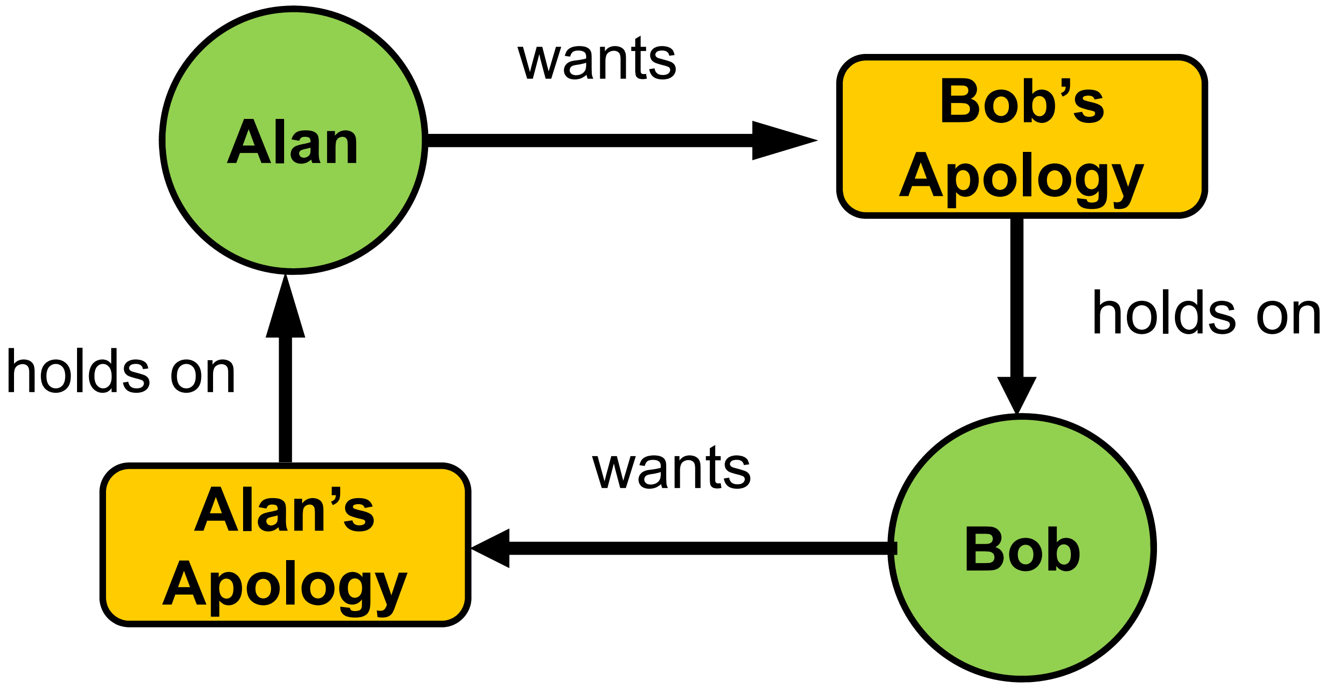
Deadlocks

- A **deadlock** is said to occur whenever
  - Two or more processes are blocked
  - Each of these processes is waiting for a resource that is held by another blocked process.

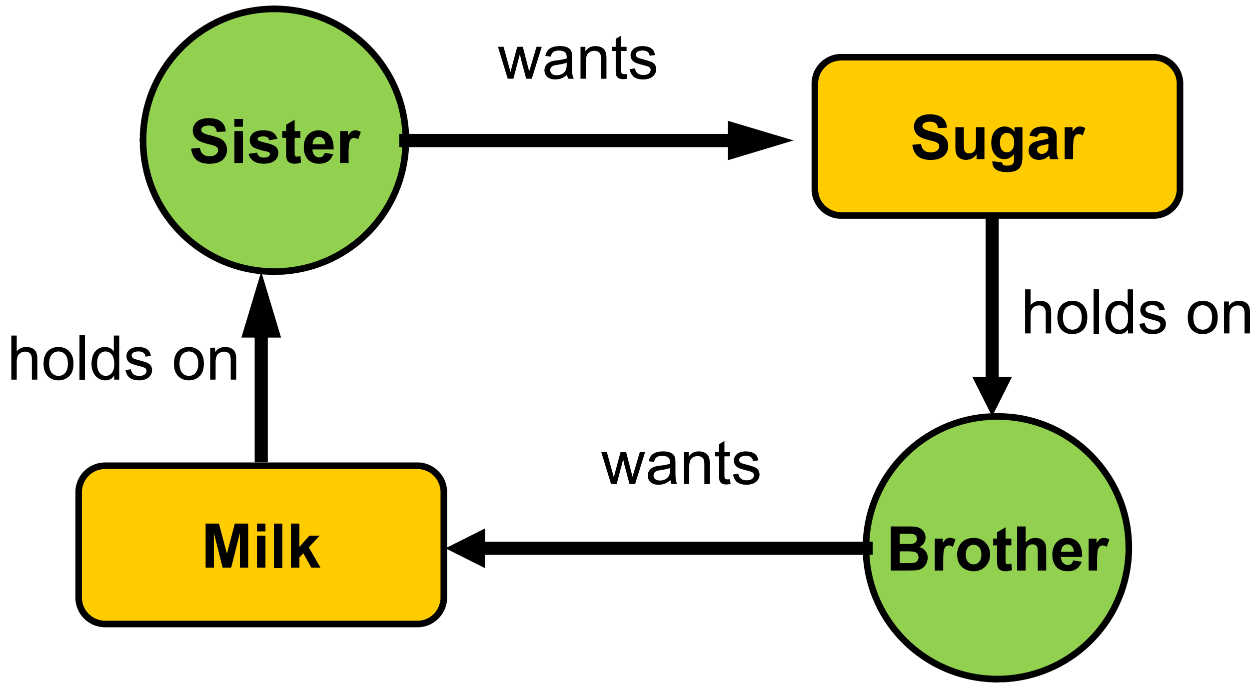
Examples

- Two friends have exchanged insults
  - Each is expecting the other to apologize first
- A rebel group does not want to cease the hostilities before being recognized by the government
  - The government is ready to negotiate but only after the hostilities have ceased

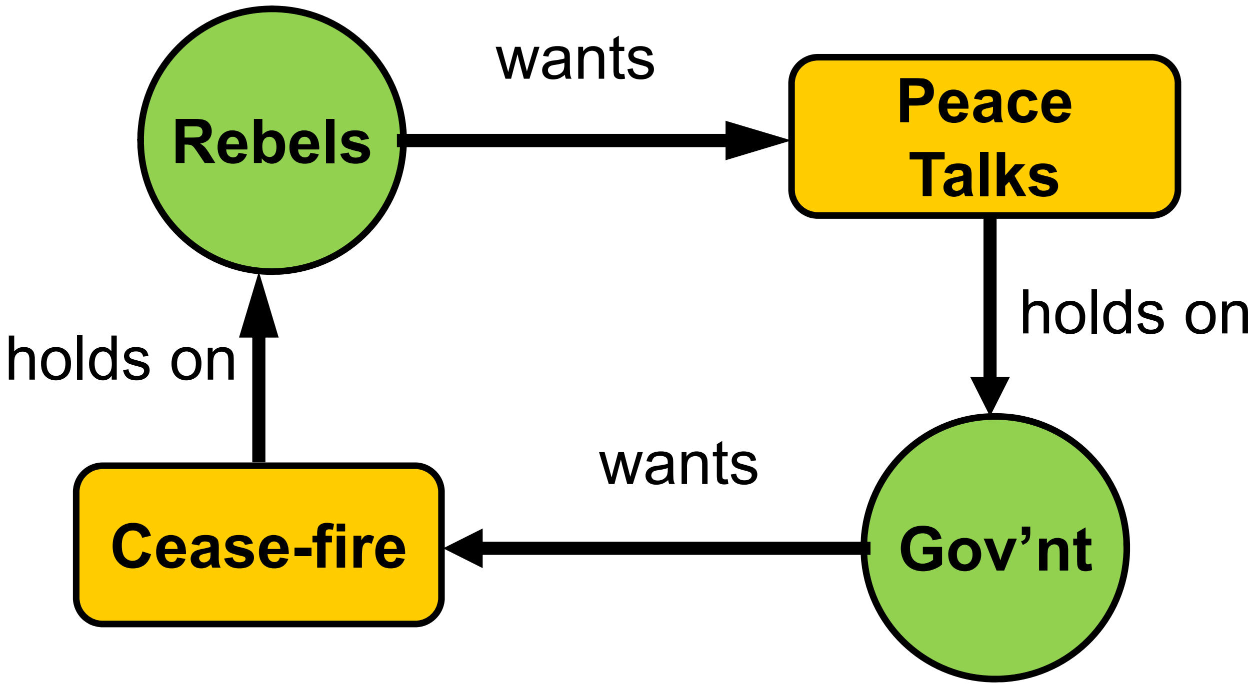
A graphic view



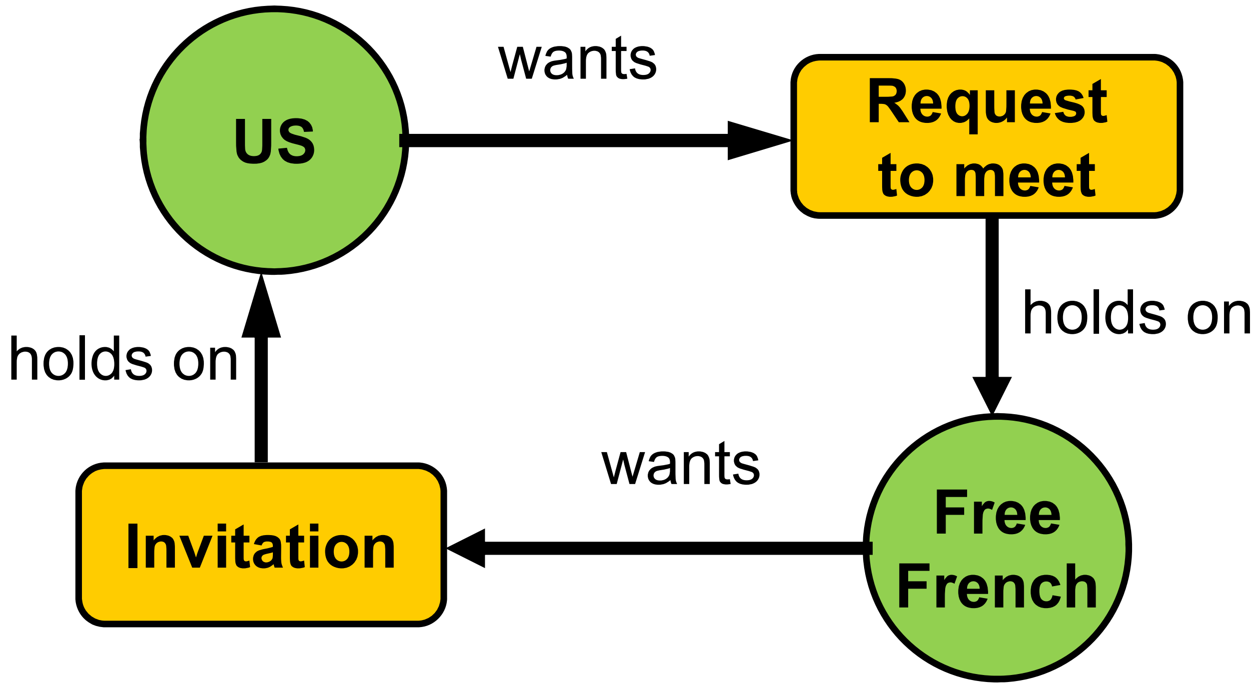
A graphic view



A graphic view

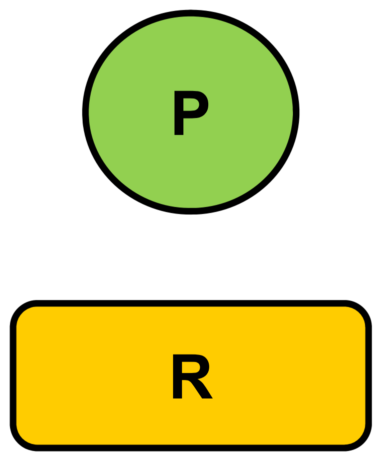


US and Free French in 1944



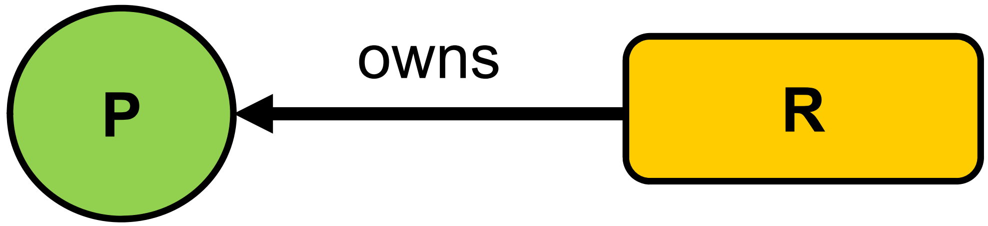
Elements

- Processes
- Resources

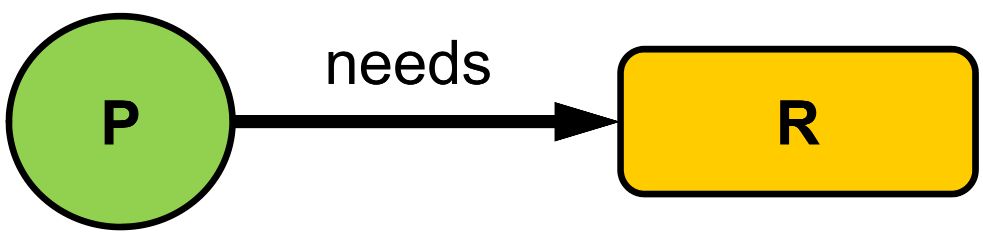


Relations

- Process P holds on/owns resource R



- Process P needs/wants resource R



Serially reusable resources

- Memory space , buffer space, disk space, USB slot to insert a flash drive
- Exist only in a ***limited quantity***
- One process may have to ***wait*** for another process to ***release*** the resources it is currently holding.

Consumable resources

- ***Cannot be reused***
- ***Messages*** are best example:
  - ***"Owned"*** by the process that creates them ***until it releases them***
  - ***"Wanted"*** by the process that waits for them

Handling deadlocks

- ***Do nothing***:
  Ignore the problem
- ***Deadlock prevention***:
  Build ***deadlock-free*** systems
- ***Deadlock avoidance***:
  Avoid system states that *could* lead to a deadlock
- ***Deadlock detection***:
  Detect and break deadlocks

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Haberman's conditions

- Four ***necessary conditions*** must ***all*** be in effect for deadlocks to happen:
    - ***Mutual Exclusion***
    - ***Hold and Wait***
    - ***No Preemption***
    - ***Circular Wait***

Mutual exclusion

- At least one of the processes involved in the deadlock must claim ***exclusive control*** of some of the resources it requires

Hold and wait

- Processes can hold the resources that have already been allocated to them while waiting for additional resources

No preemption

- Once a resource has been allocated to a process, it ***cannot be taken away or borrowed*** from that process until the process is finished with it

Circular wait

- There must be a circular chain of processes such that each process in the chain holds some resources that are needed by the next process in the chain.
  - *Formal equivalent to what we call a **vicious circle***

Deadlock prevention

- ***Any*** system that prevents ***any*** of the four necessary conditions for deadlocks will be deadlock-free
- Must find the easiest condition to deny

Denying mutual exclusion

- Prevent any process from claiming ***exclusive control*** of any the resource
- ***Drawbacks***
  - Many resources can only be used by one process at a time
  - Cannot hold on a message and send it at the same time

Denying hold and wait

- Require processes to get all the resources they will need or none of them
- ***<u>Drawbacks</u>***
  - Forces processes to acquire ahead of time all the resources they might need
  - Does not apply the consumable resources such a messages

Allowing preemption

- Let processes ***take away or borrow*** the resources they need from the processes that hold on them
- ***<u>Drawbacks</u>***
  - Will result in ***lost work*** when a process steals storage space from another process
  - Cannot force processes to send messages

Denying circular wait (I)

- Impose a total order on all resource types and force all processes to follow that order when they acquire new resources
- If a process needs more than one unit of a given resource type it should acquire all of them or none

Denying circular wait (II)

- Works very well for resources like CPU and memory
- ***<u>Drawbacks</u>***
  - Would force messages to move in only one direction
    - *Processes could not exchange messages*

A question

- When the leader of the Free French wrote to the White House:
  - *I am very happy to accept your kind invitation to come to the US*

  even though no such invitation had been issued, which deadlock condition did he deny?

The answer

- He “stole” the invitation message
  - He preempted the message that was not (yet) been sent