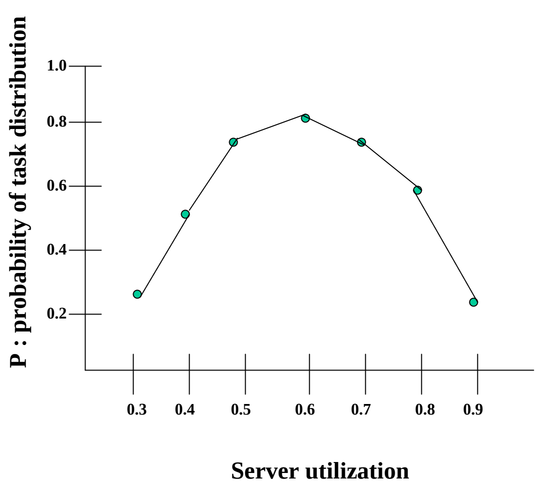
Distributed Scheduling

Goal: enable transparent execution of programs on networked computing systems

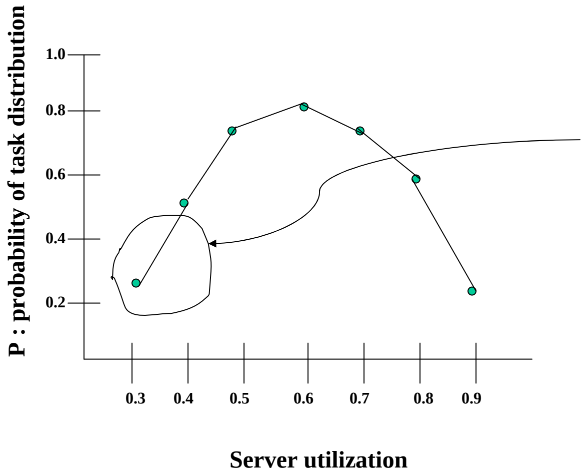
Motivations: reduce response time of program execution through load balancing

An aspect of current interest in "grid computing" systems
- globus
- legion

Opportunities for Task Distribution

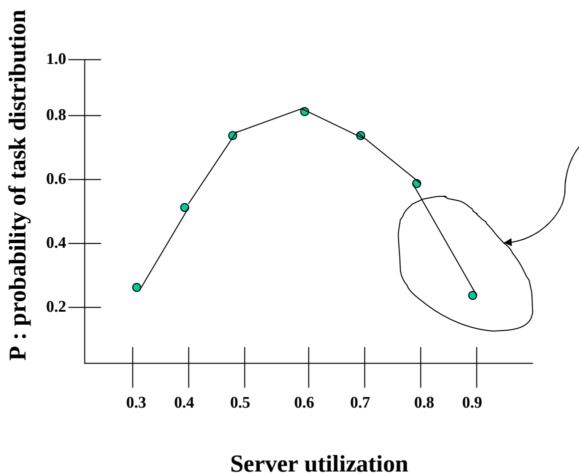


Task Distribution



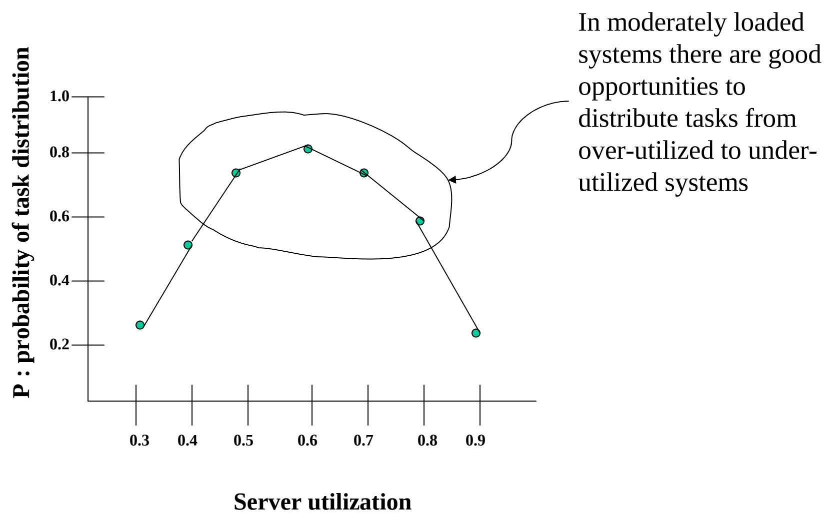
In lightly loaded systems there is not much opportunity for task distribution because most servers are underutilized

Task Distribution



In heavily loaded systems there is not much opportunity for task distribution because no server is free to accept a task

Task Distribution



Characteristics of Approaches

Goals:
- load sharing (distribute load) vs.
- load balancing (equalize load)

Information:
- static (invariant of system state)
- dynamic (uses system state)
- adaptive (changes actions with system state)

Transfers:
- preemptive (interrupts task for transfer) vs.
- non-preemptive (transfers only new tasks)

Component Policies

•Transfer determines whether a node is in a state to participate in load transfers and in what role

•Selection determines which local task is involved in the transfer

•Location determines a pair of nodes to participate in task transfer

•Information determines what information is collected and how

- •demand-driven (obtained when needed)
- •periodic (at regular intervals)
- •state-change-driven (obtained when nodes change state)

Kinds of Algorithms

sender-initiated : an overloaded node searches for a underloaded node to take one of its tasks

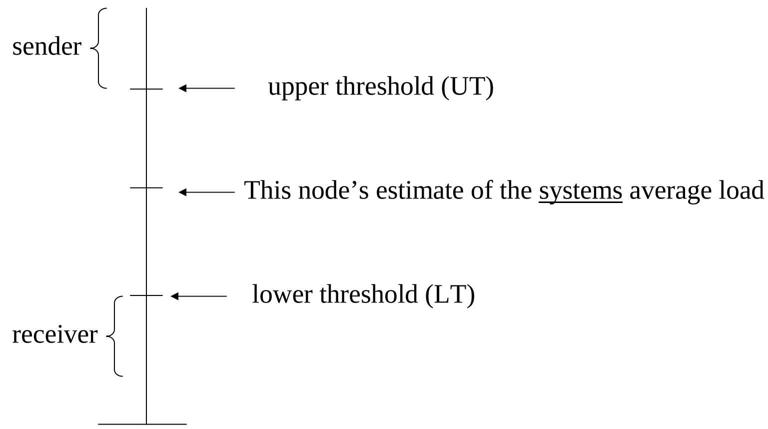
location policies: random, polling-first found, polling-least loaded
stability: unstable/ineffective at high system loads

receiver-initiated : an underloaded node searches for a task to take from an overloaded node

location policies: random, polling
stability: stable at high system loads
drawback: uses preemptive transfers in many cases

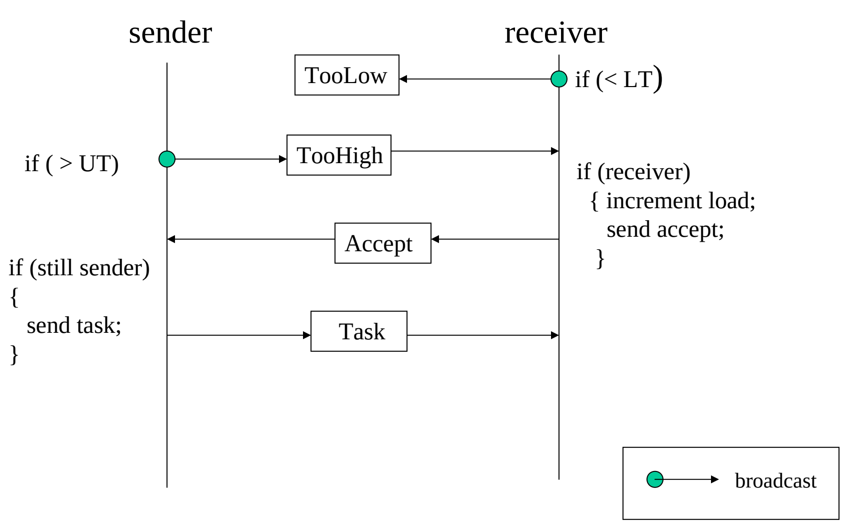
symmetrically-initiated : senders and receivers search for each other

Above-Average Algorithm

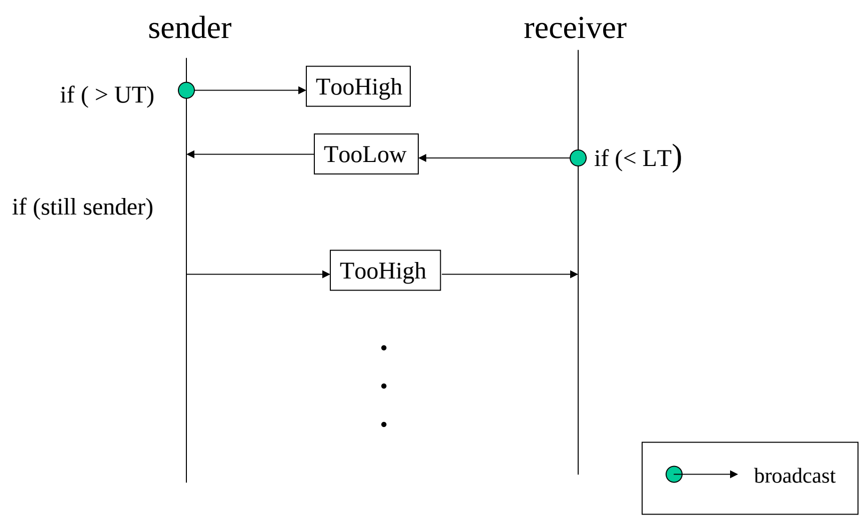


*thresholds equidistant from average

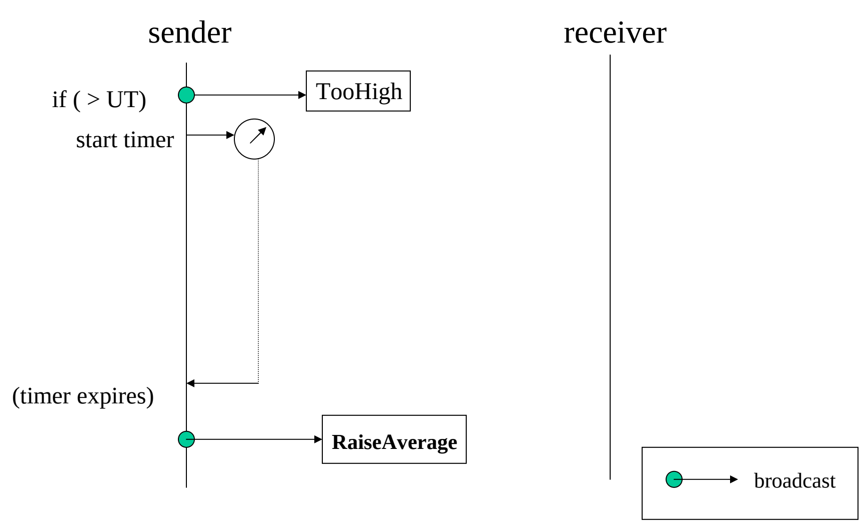
Basic Step



Basic Step



Timers



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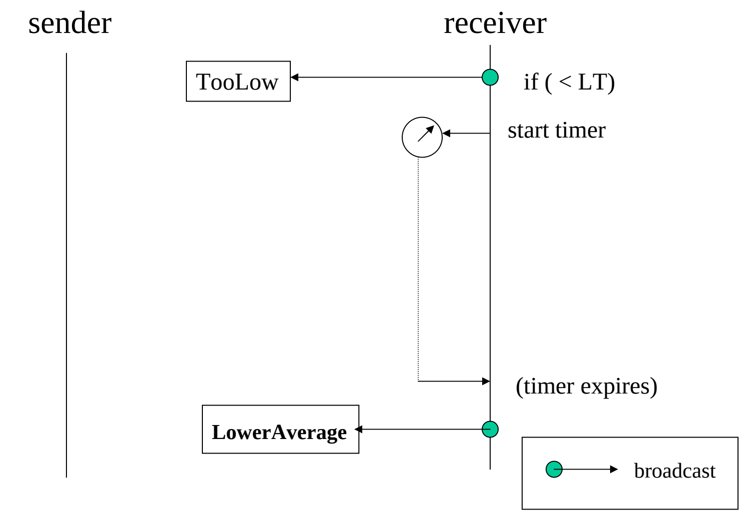
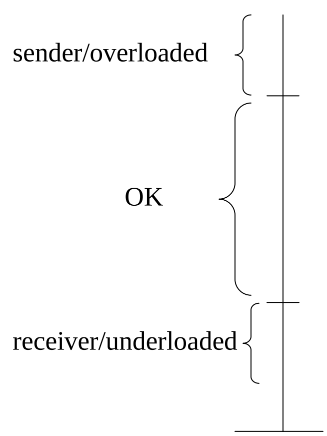


A Stable, Symmetrically Initiated Algorithm

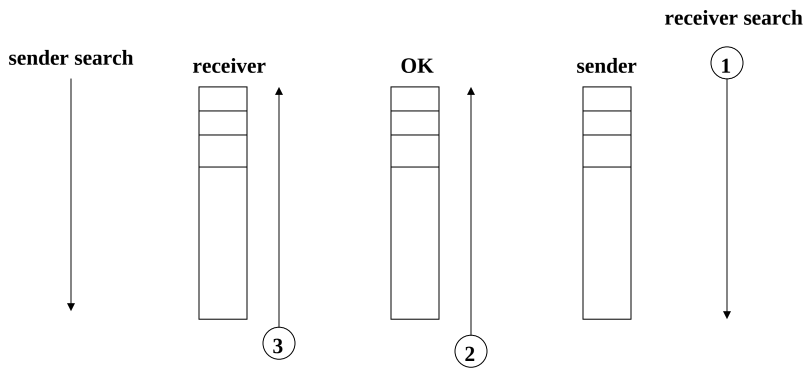
Transfer Policy:



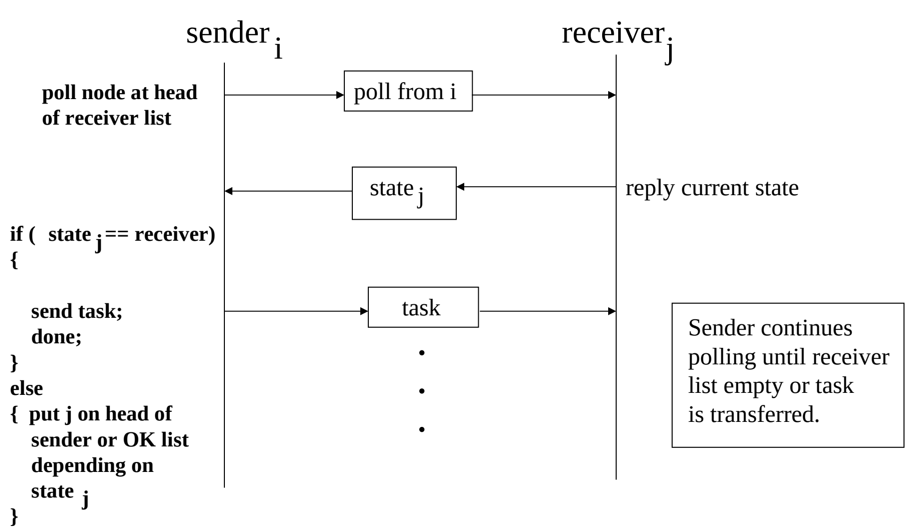
Load is measured by CPU queue length

Stable, Symmetrically Initiated Algorithm

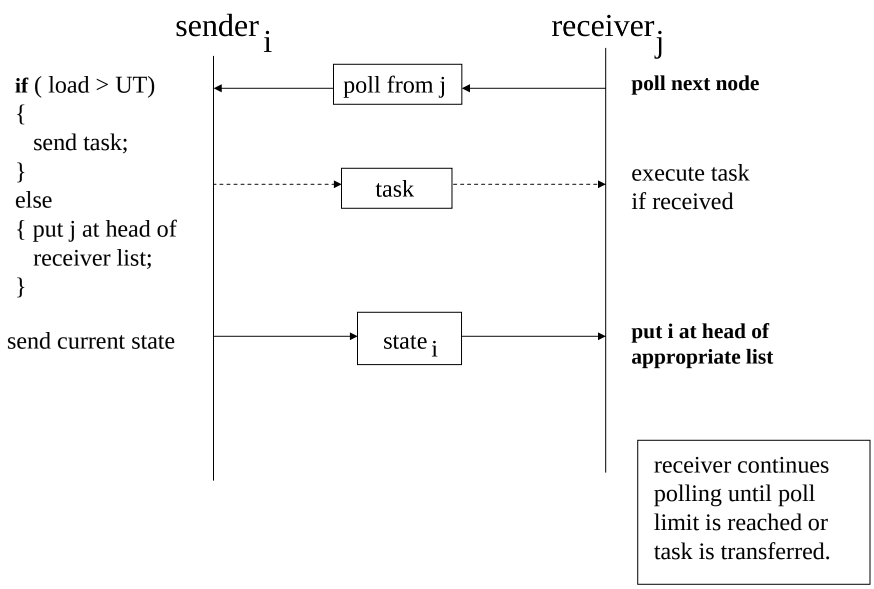
Each node maintains three lists that are searched in the following orders:



Sender Protocol



Receiver Protocol



Stability

At high loads:

- sender-initiated polling stops
  because receiver list becomes empty

- receiver-initiated polling has low overhead
  because it will quickly find a task to transfer

At low loads:

- receiver-initiated polling will usually fail
  but overhead is acceptable and other nodes are updated

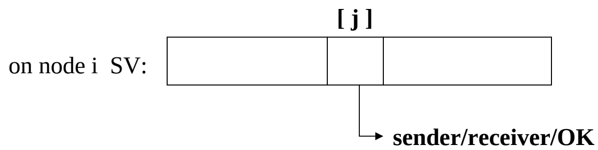
- sender initiated polling will quickly succeed

At intermediate loads:

- receiver-initiated and sender-initiated both work

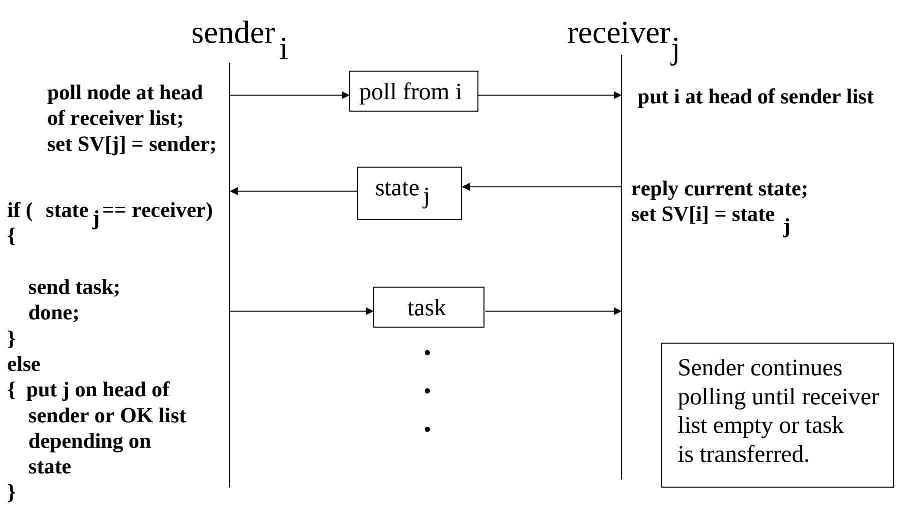
A Stable Sender-Initiated Algorithm

Similar to previous algorithm except that it has a modified receiver protocol. Each node maintains a state vector, SV, indicating on which list the node is on at all other nodes.

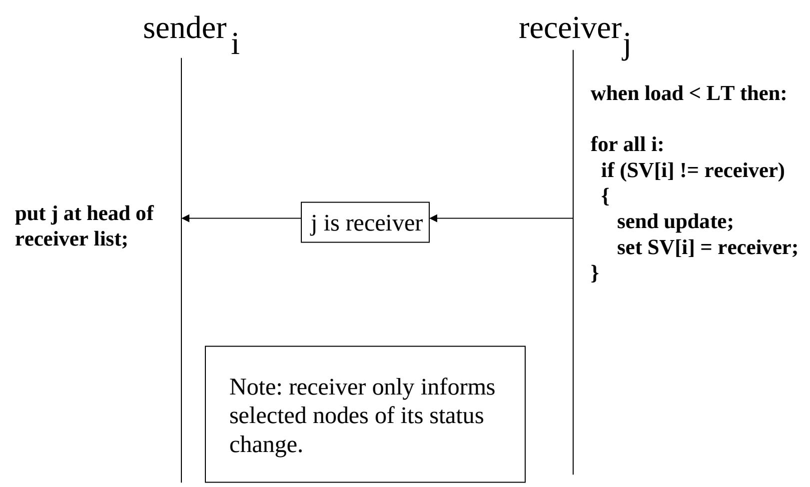


Note: the movement of node i to a different list on node j can only occur as a result of an interaction between nodes i and j. Thus, it is possible for node i to keep its information current.

Sender Protocol



Receiver Protocol



Advantages

The sender-initiated algorithm:

- avoids broadcasting of receiver state
- does not transfer preempted tasks (because it is sender-initiated)
- is stable (as for previous algorithm)

Selecting a Scheduling Algorithm

no high loads	sender-initiated
has high loads	stable algorithm
wide fluctuations	stable symmetric
wide fluctuations and high migration cost	stable sender-initiated