Topics: Linda

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Linda: an adaption of the thread pool/worker idea

Like these, it is task based, with threads choosing tasks and executing them

However, now, the tasks have extra structure to guide the choice

And the view of the system is flipped from thinking of it as a thread pool to thinking of it as a task pool

Linda

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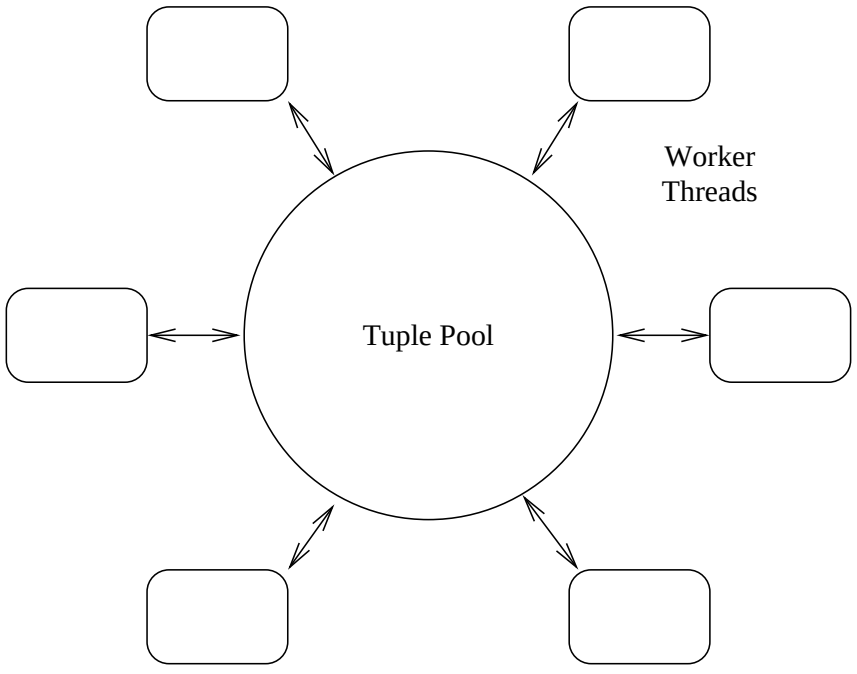
And there is a global pool or *tuplespace* containing these tuples

Threads communicate via the pool by putting tuples in and taking tuples out

Linda



Linda pool

All communications via the pool

Linda

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- `out` send a tuple to the pool
- `in` get and remove a tuple from the pool
- `read` get but don't remove a tuple from the pool
- `eval` create a new thread

Linda

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The arguments to these are either (a) a literal constant (e.g., string, integer) or (b) a pattern variable, e.g., `?s`, or something suitable for the language you are using

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A matching tuple is returned from the pool where a match is defined by

- the tuple is the same length and
- the contant literals match

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A matching tuple is returned from the pool where a match is defined by

- the tuple is the same length and
- the contant literals match

Then the pattern variables are set to the corresponding values in the chosen tuple

Linda

For example, if the pool contains

```
[1, "hello"], [2, "goodbye"], [1, "world"]
```

then there are two matches for `[1, ?s]`, namely `[1, "hello"]` and `[1, "world"]`

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One of these will be chosen, *non-deterministically*

If the former is chosen, then the variable `s` will be given the value `"hello"`

Linda

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The action of match and removal for an `in` is atomic

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- `read` before `in`: they both get the tuple
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This non-deterministic outcome would normally be considered a programmer error

Linda

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A common paradigm is to use an initial *tag*, often an integer, as in `[1, "hello"]`, to impose some structure on the tuples

Linda

Dining Philosophers in Linda

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We have five philosophers and shall prevent deadlock by only letting four sit at a time

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We have five philosophers and shall prevent deadlock by only letting four sit at a time

Initial conditions:
`out("place ticket")` four times;
`out("chopstick", i)` for $i = 0 \ldots 4$
`eval(phil, i)` for $i = 0 \ldots 4$

Linda

```
defun phil(i) {
  while true {
    think()
    in("place ticket")
    in("chopstick", i)
    in("chopstick", i+1 mod 5)
    eat()
    out("chopstick", i)
    out("chopstick", i+1 mod 5)
    out("place ticket")
  }
}
```

This example contains no patterns, only constant literals

Linda

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defun phil(i) {
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Note Linda does not eliminate the possibility of deadlock in badly written programs: just put the `(in "place ticket")` after the `in` of the chopsticks

Linda

Producers/Consumers is just as easy

```
defun producer(n) {
  out(n, make-product())
  producer(n + 1)
}
defun consumer(n) {
  var prod
  in(n, (? prod))     ; pattern
  consume-product(prod)
  consumer(n + 1)
}
```

Linda

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}
```

We use a tag to ensure we consume values in the same order as they are produced (if that is important)

Linda

Exercise Think about the assessed coursework using Linda

Questions of granularity are just as important in Linda as elsewhere

Linda

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Versions exist for C, Perl, Java and Prolog and others

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- junk can collect in the pool: tuples put in but never taken out. This can slow down the matching
- the pool can be a bottleneck

Linda

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- detecting when the program needs to terminate is a problem: this could be done by putting a special “end of program” tuple in the pool; but then threads have the overhead of constantly checking for that tuple (and you need an non-blocking `read` to do so). Or have an extra field in every tuple that is a status flag, etc.

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- *aliasing* is a problem: careful constructions of name schemes (tags, usually) are needed to ensure that tuples are not accidentally picked up by the wrong threads

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- *aliasing* is a problem: careful constructions of name schemes (tags, usually) are needed to ensure that tuples are not accidentally picked up by the wrong threads
- related is *temporal aliasing*, where information about the order tuples were put into the pool is lost: again an enumeration tag can fix this, but it has to be coded

Linda

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Now pools become first-class objects, and you can pass pools via pools to other threads

But, as always, this moves away from the initial simplicity of the Linda concept

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- can map reasonably well to different kinds of hardware (shared and distributed)
- is explicitly non-deterministic, with the non-determinism mostly well delineated
- is not suited for all kinds of problem
- is not widely used, but you do see Linda being mentioned now and again, mostly for coordination between other systems

Linda

For example, the computational chemistry (molecule simulation) package Gaussian uses OpenMP on a node and uses Linda between nodes