OPEN DISTRIBUTED SYSTEMS

- Addition of new components.
- Replacement of existing components.
- Changes in interconnections.

ACTOR CONFIGURATIONS

model open system components:

- set of individually named actors.
- messages "en-route".
- interface to environment:
  * receptionists
  * external actors

SYNCHRONOUS VS ASYNCHRONOUS COMMUNICATION

- π-Calculus (and other process algebras such as CCS, CSP) take synchronous communication as a primitive.

- Actors assume asynchronous communication is more primitive.

COMMUNICATION MEDIUM

- In π-Calculus, channels are explicitly modelled. Multiple processes can share a channel, potentially causing interference.

- In the actor model, the communication medium is not explicit. Actors (active objects) are first-class, history-sensitive entities with an explicit identity used for communication.

FAIRNESS

The actor model theory assumes fair computations:

1. message delivery is guaranteed.
2. individual actor computations are guaranteed to progress.

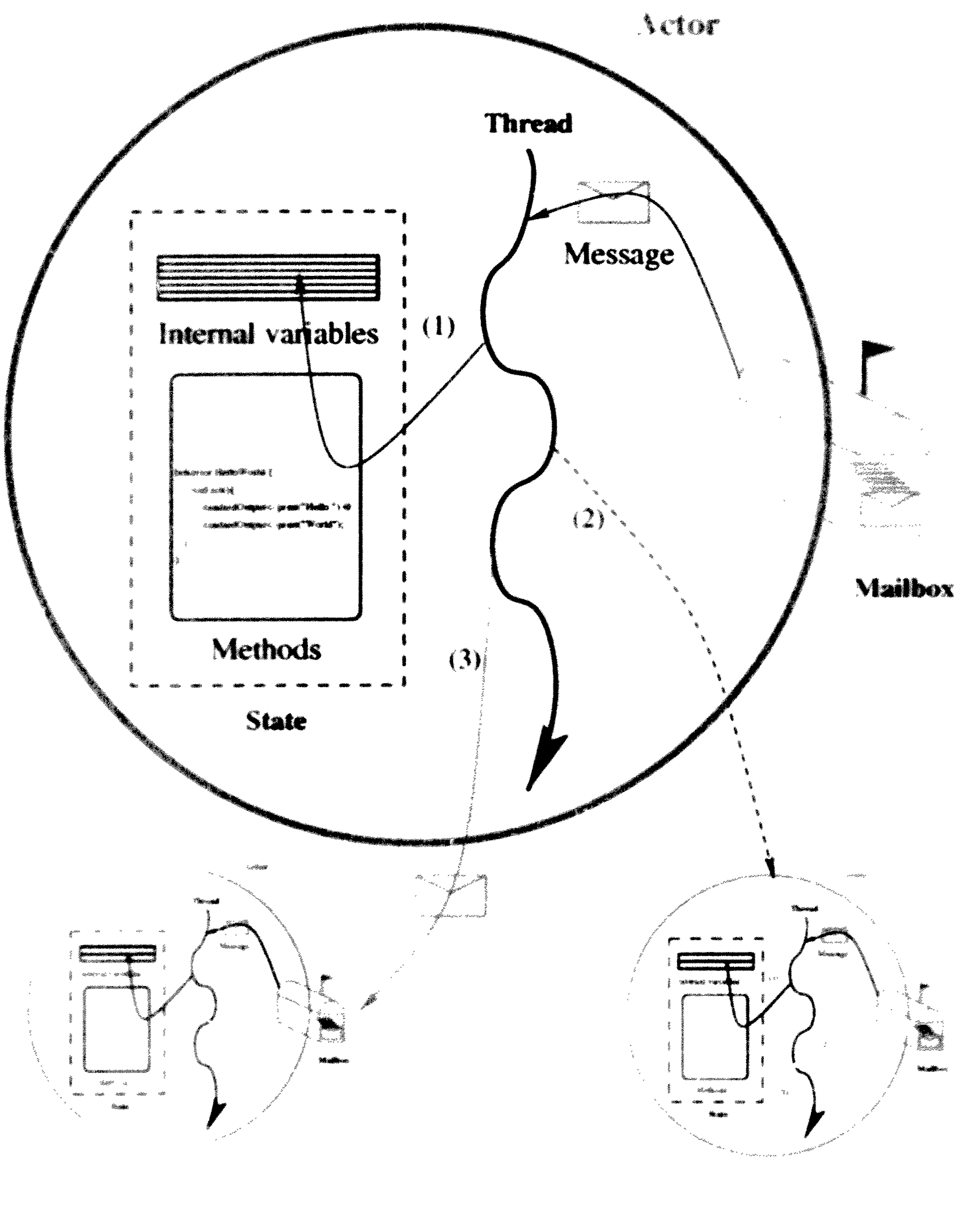
Fairness is very useful for reasoning about equivalences of actor programs but can be hard/expensive to guarantee; in particular when distribution and failures are considered.

PROGRAMMING LANGUAGES INFLUENCED BY π-CALCULUS AND ACTORS.

- Scheme '75
- Act1 '87
- Acore '87
- Rosette '89
- Obliq '94
- Erlang '93
- ABCL '90
- SALSA '99

- Amber '86
- Facile '89
- CML '91
- Pict '94
- Nomadic Pict '99
- JOCAML '99

Actor (Agent) Model



AGHA, MASON, SMITH & TALCOTT

1. Extend a functional language (λ-calculus + ifs + pairs) with actor primitives

2. Define an operational semantics for actor configurations.

3. Study various notions of equivalence of actor expressions and configurations.

4. Assume fairness:
   - guaranteed message delivery.
   - individual actor progress.

λ-CALCULUS

SYNTAX

$$
\begin{aligned}
e ::= \ & v \\
| \ & \lambda v . e \\
| \ & (e \ e)
\end{aligned}
$$

value

function abstraction

application

EXAMPLE

$$((\lambda x . x) \ 5)$$

$$5$$

π

$$x\{5/x\}$$

$$[5/x]\, x$$

?

$pr(x, y)$ returns a pair containing x & y.

$ispr(x)$ returns t if x is a pair; f otherwise

$1st(pr(x, y)) = x$ 1st returns the first value of a pair

$2nd(pr(x, y)) = y$ 2nd returns the second value.

ACTOR PRIMITIVES

send(a,v)

sends value v to actor a.

new(b)

creates a new actor with behavior b and returns the identity/name of the newly created actor.

ready(b)

becomes ready to receive a new message with behavior b.

ACTOR LANGUAGE EXAMPLE

$$b5 = rec(\lambda y.\lambda x.seq(send(x,5), ready(y)))$$

receives an actor name x and sends the number 5 to that actor, then it becomes ready to process new messages with the same behavior y.

SAMPLE USAGE

$$send(new(b5), a)$$

A SINK

$$sink = rec(\lambda b.\lambda m.ready(b))$$

an actor that disregards all messages.

```
cell = rec (λb. λc. λm.
   if (get?(m),
         seq (send (cust(m), c),
               ready (b(c))),
         if (set? (m),
               ready (b(contents(m))),
               ready (b(c)))))
```

Using the cell:

```
let a = new(cell(0)) in
     seq ( send (a, mkset(7)),
           send (a, mkset(2)),
           send (a, mkget(c)))
```

EXERCISES

① Write get?
cust
set?
contents
mkset
mkget

to complete the reference cell example in the AMST actor language.

② Modify Bcell to notify a customer when the cell value is updated (such as in the Π-calculus cell example).

DINING PHILOSOPHERS IN ACTOR LANGUAGE

```
phil = rec (λb. λl. λr. λself. λsticks. λm.
    if (eq? (sticks, 0),
        ready (b(l, r, self, 1)),
        seq ( send (l, mkrelease (self)),
              send (r, mkrelease (self)),
              send (l, mkpickup (self)),
              send (r, mkpickup (self)),
              ready (b(l, r, self, 0)))))
```

DINING PHILOSOPHERS IN ACTOR LANGUAGE [2]

```
chopstick = rec(λb. λh. λw. λm.
    if(pickup?(m),
        if(eq?(h, nil),
            seq(send(getphil(m), nil),
                ready(b(getphil(m), nil))),
            ready(b(h, getphil(m)))),
        if(release?(m),
            if(eq?(w, nil),
                ready(b(nil, nil)),
                seq(send(w, nil),
                    ready(b(w, nil)))),
            ready(b(h, w)))))
```

Dining Philosophers in Actor Lang. (?)


```
letrec c1 = new(chopstick(nil, nil)),
       c2 = new(chopstick(nil, nil)),
       p1 = new(phil(c1, c2, p1, 0)),
       p2 = new(phil(c2, c1, p2, 0)) in e
```

where e is defined as:

```
e = seq(send(c1, mkpickup(p1)),
        send(c2, mkpickup(p1)),
        send(c1, mkpickup(p2)),
        send(c2, mkpickup(p2)))
```

DINING PHILOSOPHERS IN ACTOR LANG (4)

Auxiliary definitions:

mkpickup = $\lambda p.p$

mkrelease = nil

pickup? = λm. not (eq?(m, nil))

release? = λm. eq?(m, nil)

getphil = $\lambda m.m$

ACTOR GARBAGE COLLECTION