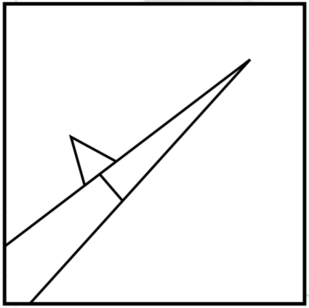
Martin is getting the projector to work with his laptop.

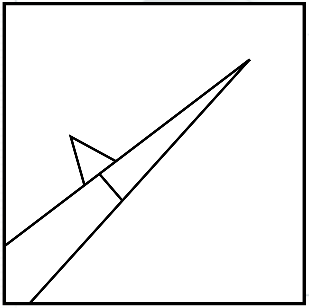
Beyond Threads

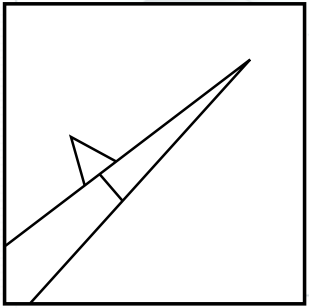


Concurrency, E, and Smalltalk

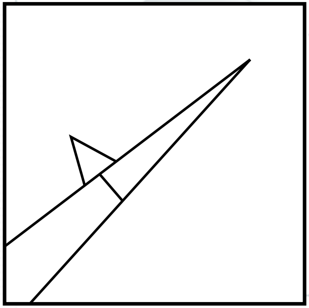
Martin McClure

GEMTALK SYSTEMS





A unicorn at a birthday party



A unicorn at a birthday party

(Thanks, Nancy!)

Beyond Threads

Threads

Sequential Model

Sequential Model

- One
- Thing
- After
- Another

Sequential Model

- One
- Thing
- After
- Another
- (branching, call/return)

Sequential Model

- One
- Thing
- At
- A
- Time

Shared-State Thread Model

- Many threads
- Each is sequential
- State is shared

Thread Advantages

- >1 thing "at once"
- Program sequentially

Thread Drawbacks

- Program sequentially
- Execute randomly

Thread Drawbacks

- Race conditions

Thread Drawbacks

- Race conditions
- Deadlock

Thread Drawbacks

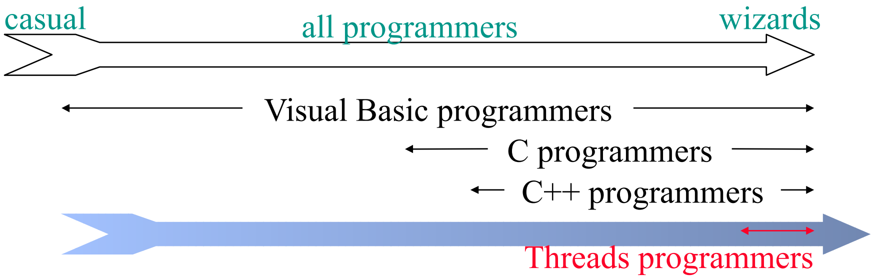
- Must understand entire system. Impossible.

Threads

are

Bad

What's Wrong With Threads?



Too hard for most programmers to use.

Even for experts, development is painful.

“The Problem with Threads”

Edward A. Lee

Beyond Threads

Beyond Threads

E

These ideas are not new.

What's E all about?

When separately written programs are composed so that they may cooperate, they may instead destructively interfere in unanticipated ways. These hazards limit the scale and functionality of the software systems we can successfully compose.

Great progress on the composition problem has been made within the object paradigm, chiefly in the context of sequential, single-machine programming among benign components.

We ... extend this success to support robust composition of concurrent and potentially malicious components distributed over potentially malicious machines.

E

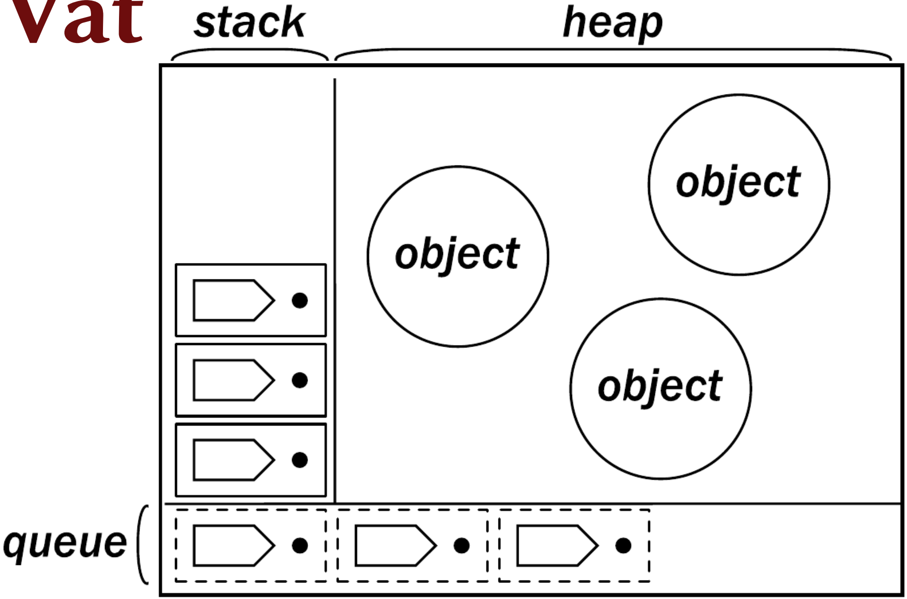
- Objects
- Composition
- Concurrency
- Distribution
- Security

Vat

Two kinds of send

- immediate
- eventual

Vat



Two kinds of object reference

Object Reference

- Assign to a variable
- Send a message

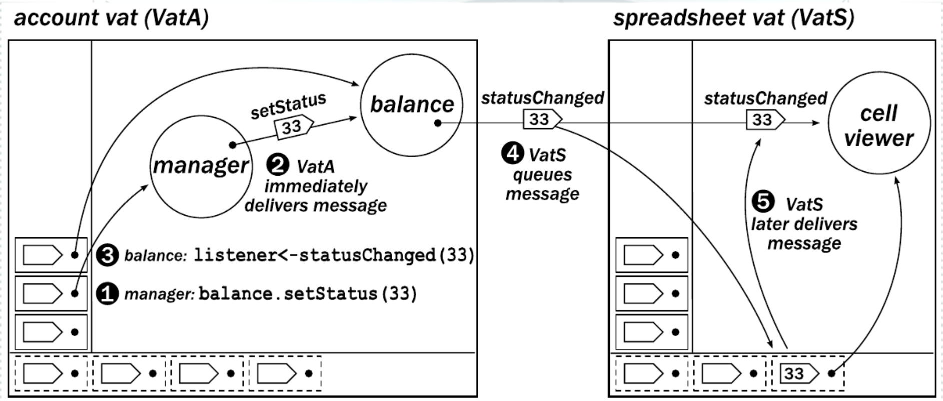
An Object Reference is a channel through which you can send a message.

Two kinds of object reference

- near
- eventual

Two kinds of object reference

- near
  - immediate send
  - eventual send
- eventual
  - eventual send only


account vat (VatA)
spreadsheet vat (VatS)
balance
setStatus
33
manager
❷ VatA immediately delivers message
statusChanged
33
❹ VatS queues message
statusChanged
33
cell viewer
❺ VatS later delivers message
❸ balance: listener<-statusChanged(33)
❶ manager: balance.setStatus(33)
33

Message

- receiver
- selector
- arguments

Arguments

- Near references in the sending vat become eventual references when the message is received in another vat.

Data Objects

- Transitively immutable
- Passed by copying
- Receiver sees a near reference in its vat

(breathe)

Immediate send waits for a response before returning

Eventual send returns immediately

Eventual send returns immediately

But what does it return?

Promise

- Eventual reference to the result

Promise

- Resolver
  - One for each promise
  - Sent with message
  - Tells promise what object it represents

Promise

- Messages sent to promise
  - Before resolved
    - Queued
  - When resolved
    - Queued messages sent
  - Once resolved
    - Equivalent to resolution

Latency

```
workQueue removeFirst
   process = 'done'.
```

Pipelining

```
workQueue removeFirst
   process = 'done'.
```

When Things go Wrong

Exceptions

- Promise resolves to broken reference
- Any message sent to the promise signals the exception in the sending vat

Odds & Ends

- When-Catch expression
  - Multi-way join
- Guaranteed order of delivery

Is all this a good idea?

Advantages

- No race conditions
- No deadlock
- Fairly straightforward model
- Enables distribution
- More easily enables multi-core use

Drawbacks

- Datalock
- Multi-vat recursive algorithms require special handling

Is all this a good idea?

What would it take?

Changes

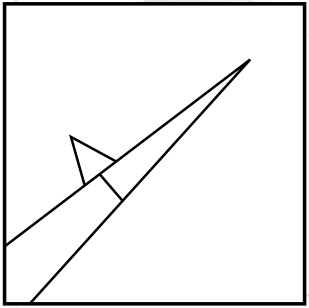
- Syntax for eventual send
- Better support for data objects

#= == #==

E

erights.org

Beyond Threads



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