Ambient-oriented Programming & AmbientTalk

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Agenda

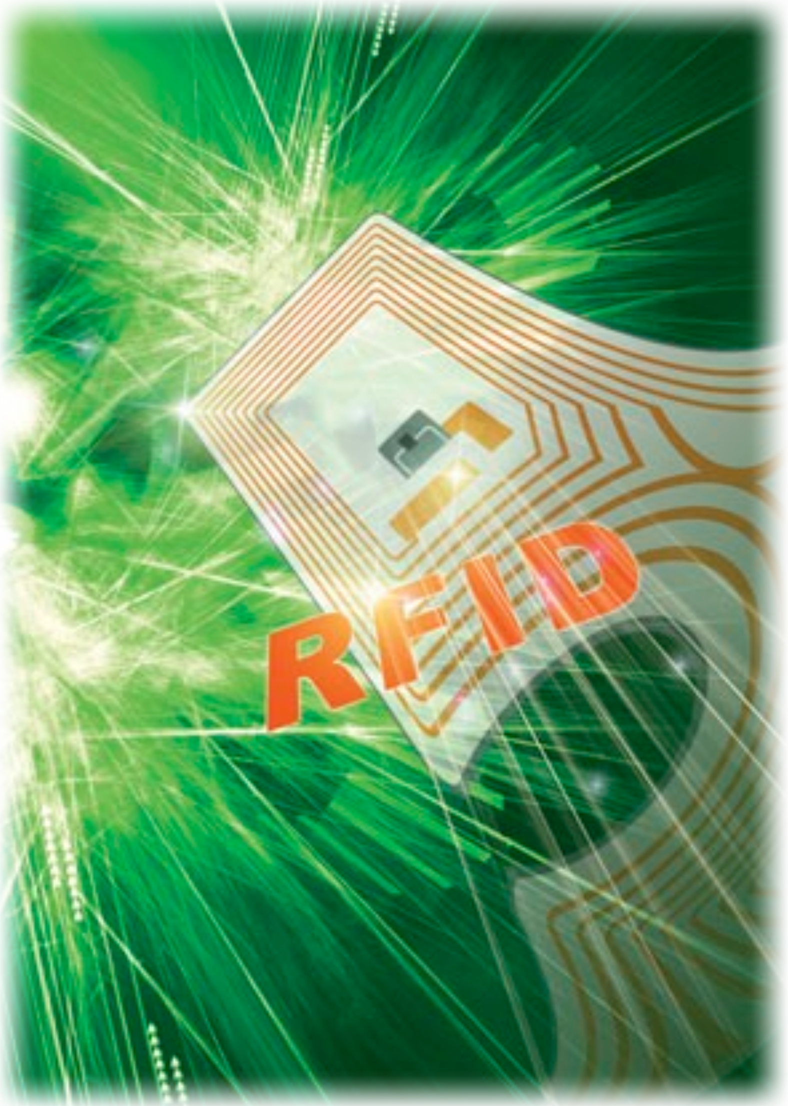
- Context: Mobile & Ubiquitous computing
- Approach: Ambient-oriented programming
- Tool: AmbientTalk
- Experiments: Demo applications

Context

Mobile & Ubiquitous Computing

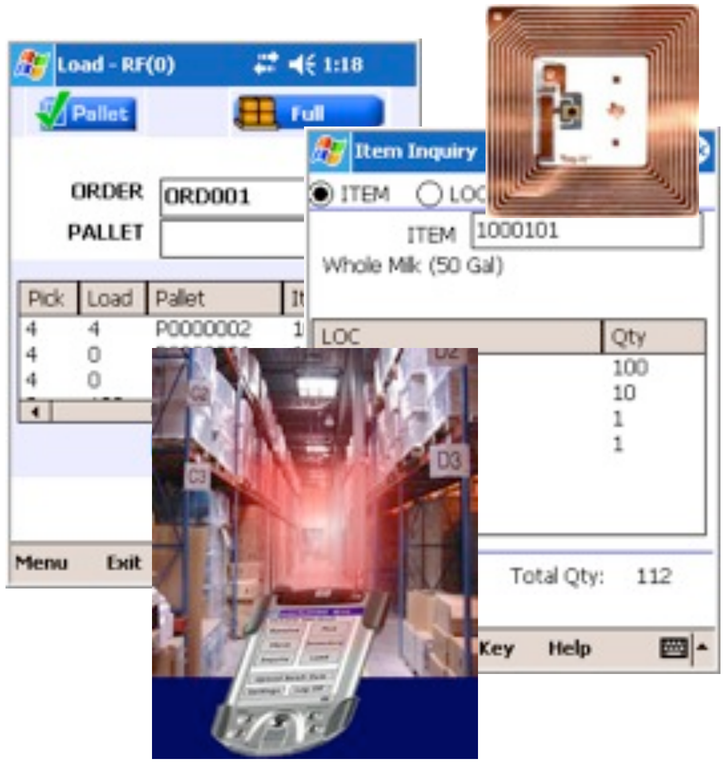
Ubiquitous Computing

- Research vision postulated by Mark Weiser (1988, Xerox PARC)



Today’s Applications

Smart Homes/Domotics



ORDER ORD001

PALLET

Pick	Load	Pallet	It
4	4	P0000002	1
4	0		
4	0		

● ITEM ○ LOC

ITEM 1000101

Whole Milk (50 Gal)

LOC	Qty
	100
	10
	1
	1

Total Qty: 112

RFID Inventory Management

Tourism/City Guide Software

Personal Area Networks

Issues

- Hardware Issues:
  - Miniaturisation
  - Device Autonomy
  - Interoperability
  - Processor Speed
  - Limited Memory
  - Integration
  - Cost

- Software Issues:
  - Context-awareness
  - Interaction with real world
  - Portability
  - New user interfaces
  - Standards
  - Distributed Applications

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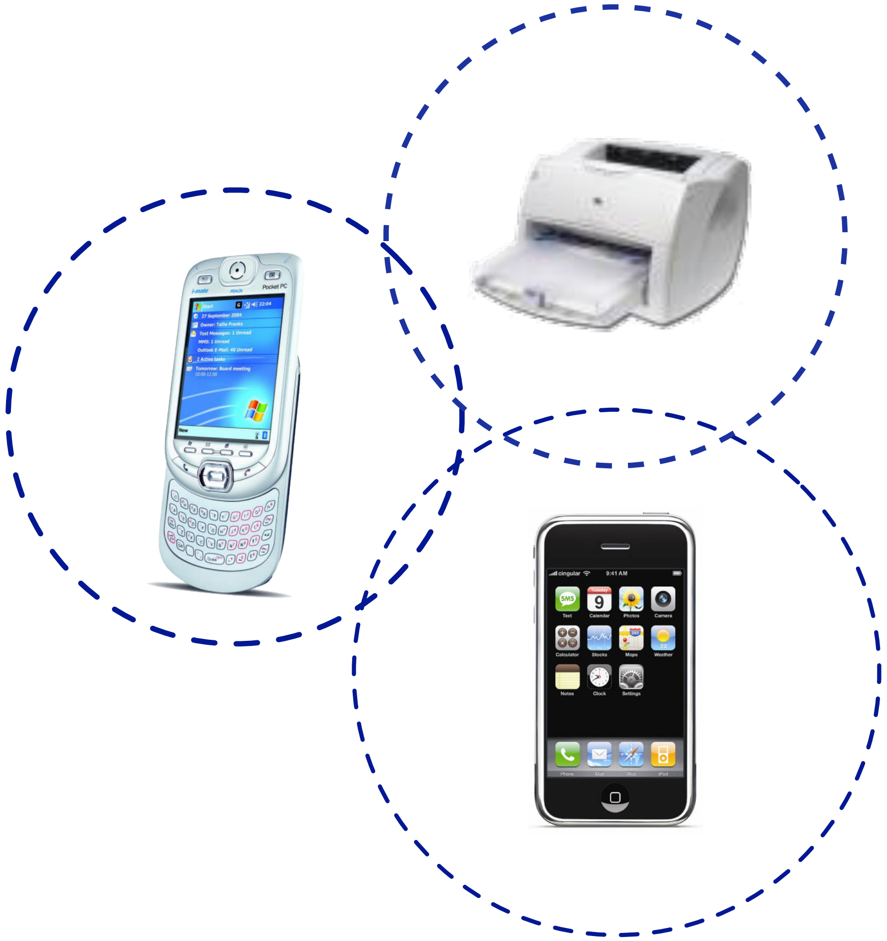
Mobile Ad Hoc Networks

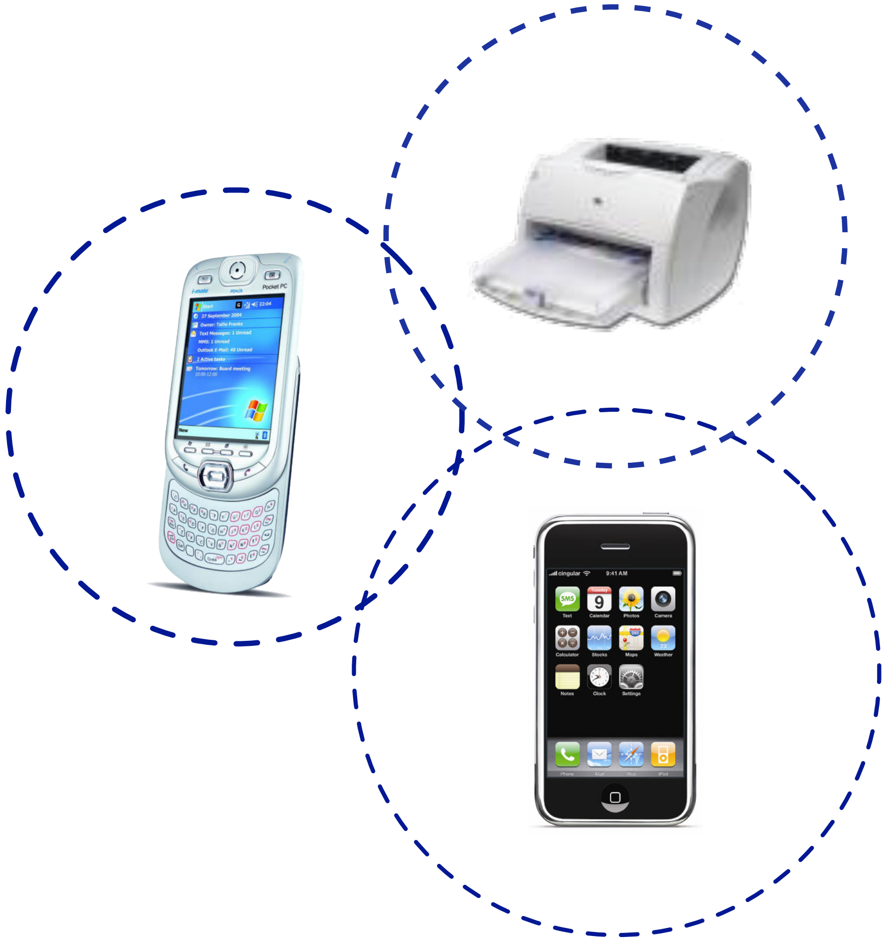
Networks composed of **mobile** devices that communicate **wirelessly**



Mobile Ad Hoc Networks

Networks composed of **mobile** devices that communicate **wirelessly**

Zero Infrastructure



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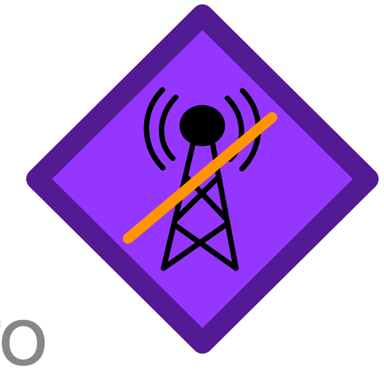
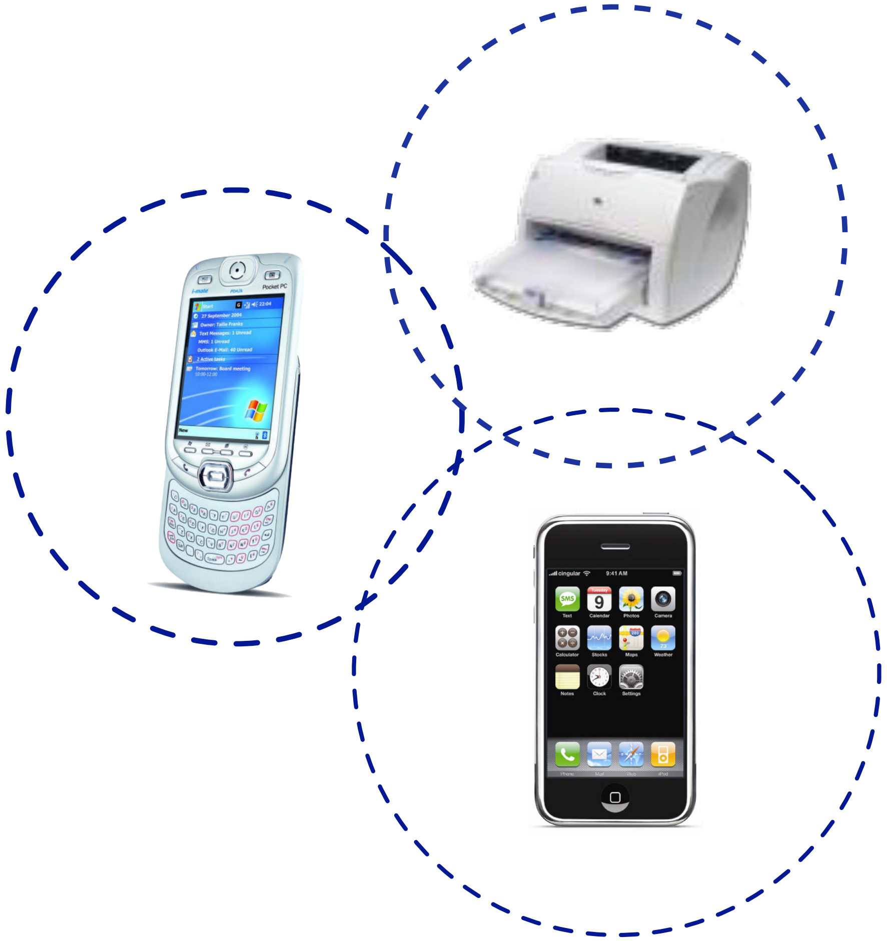
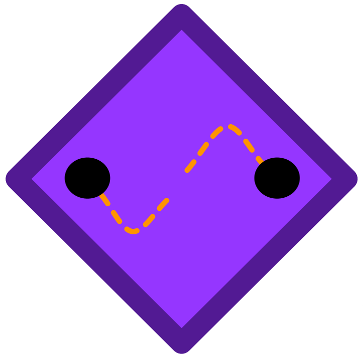


Zero Infrastructure





Volatile Connections

Approach

Ambient-oriented Programming

Observation #1: interaction with proximate peers

Example: match making between proximate peers

demand

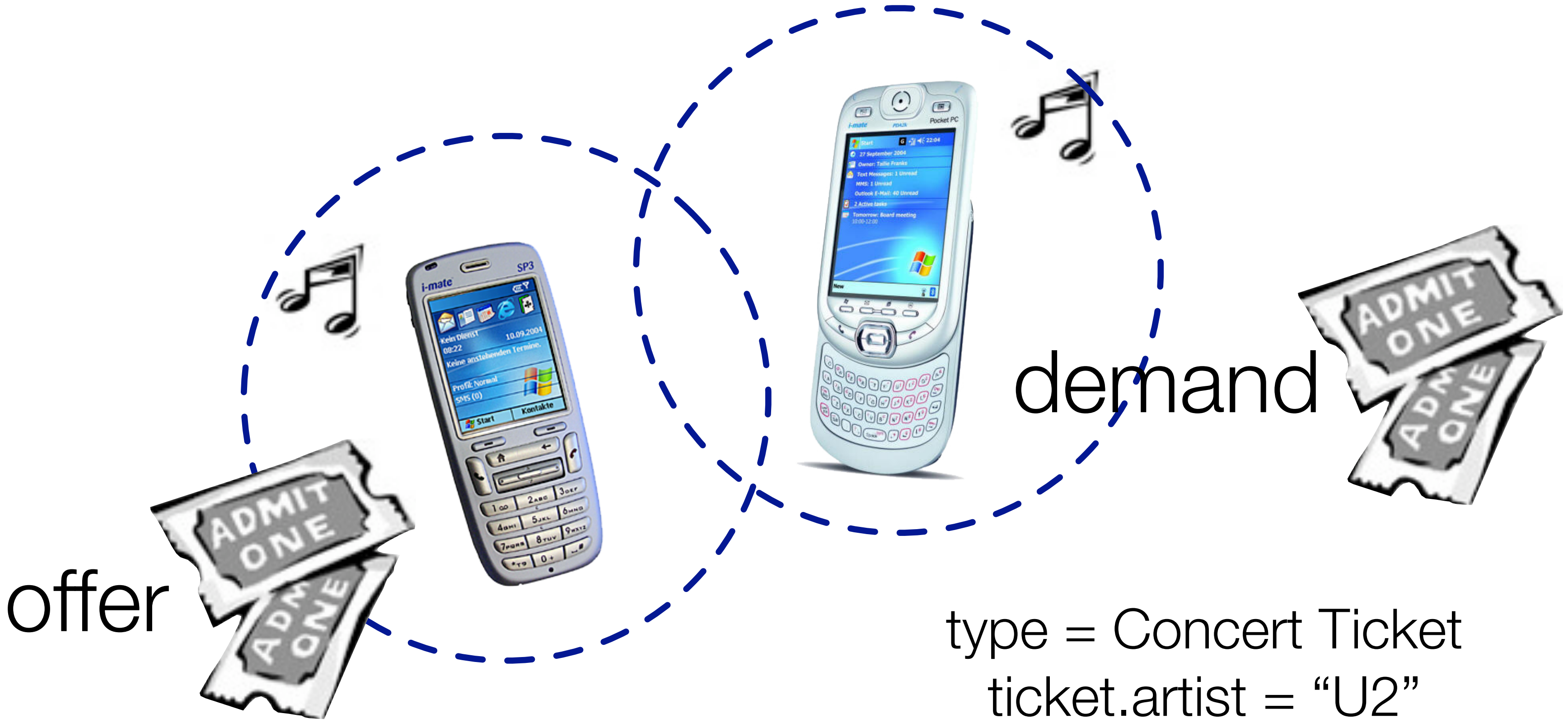
type = Concert Ticket
ticket.artist = “U2”
ticket.location = *

offer

type = Concert Ticket
ticket.artist = “U2”
ticket.location = “Hyde Park”

Observation #1: interaction with proximate peers

Example: match making between proximate peers



offer

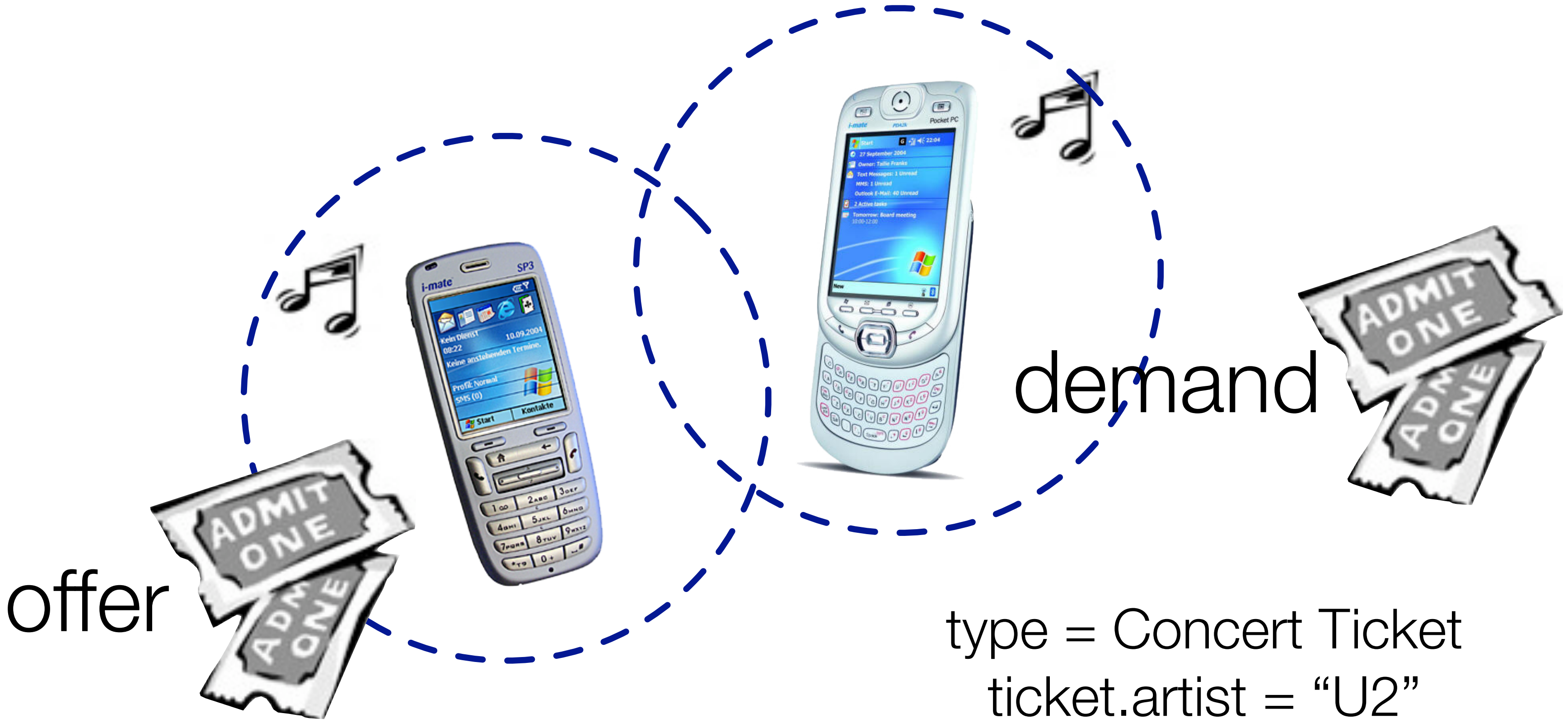
demand

type = Concert Ticket
ticket.artist = “U2”
ticket.location = “Hyde Park”

type = Concert Ticket
ticket.artist = “U2”
ticket.location = *

Observation #1: interaction with proximate peers

Example: match making between proximate peers

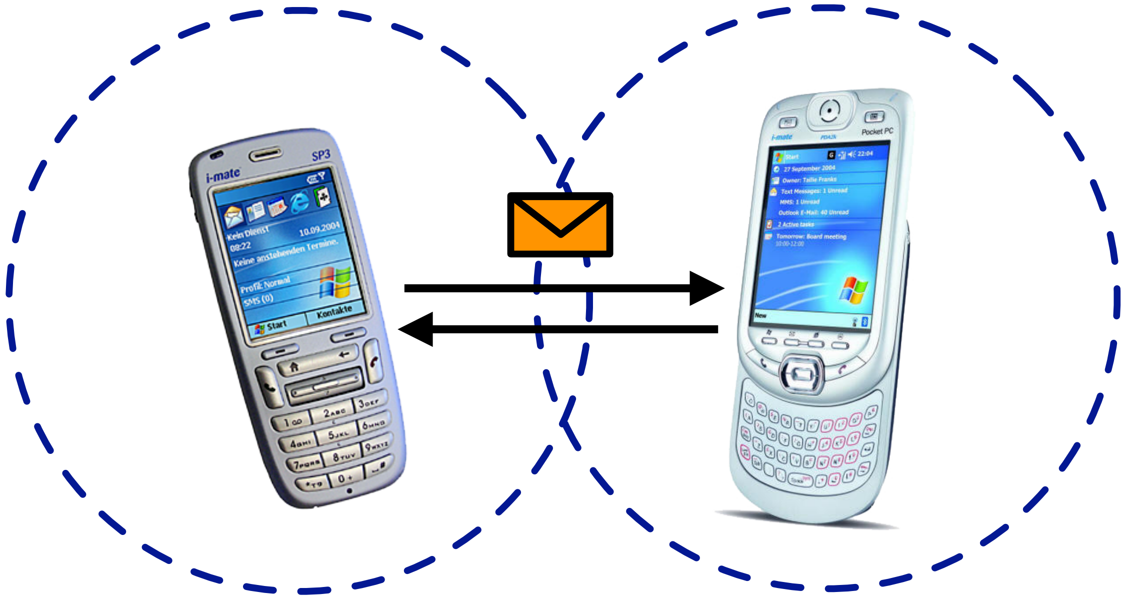


type = Concert Ticket
ticket.artist = “U2”
ticket.location = *

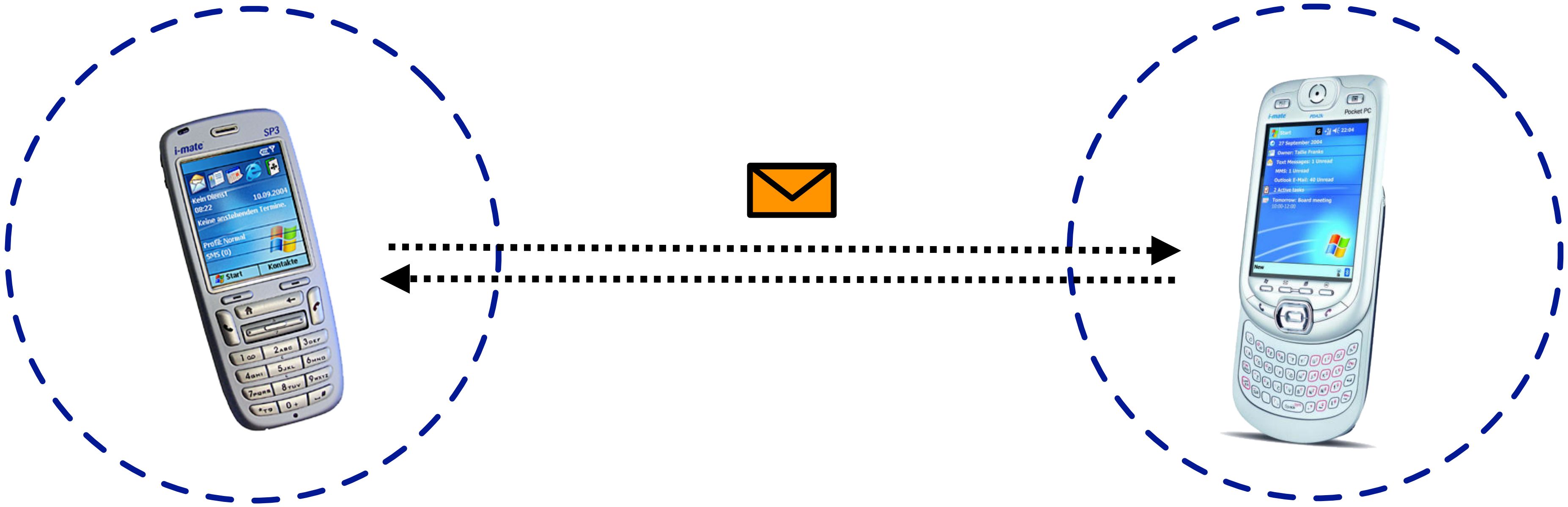
type = Concert Ticket
ticket.artist = “U2”
ticket.location = “Hyde Park”

No reliance on fixed, always-available server infrastructure

Observation #2: intermittent connectivity



Observation #2: intermittent connectivity



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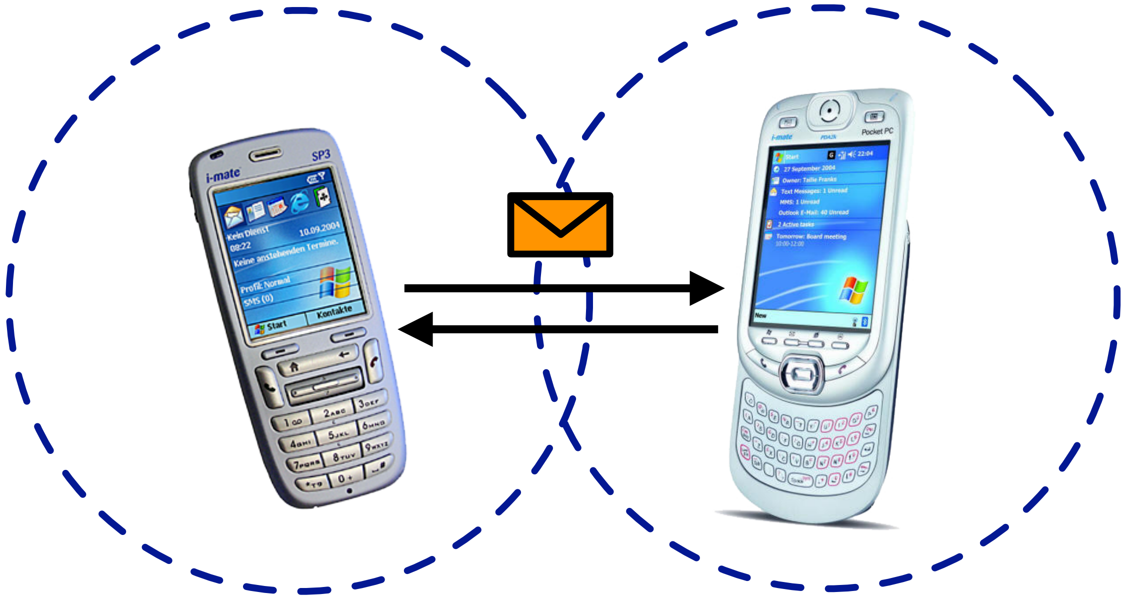

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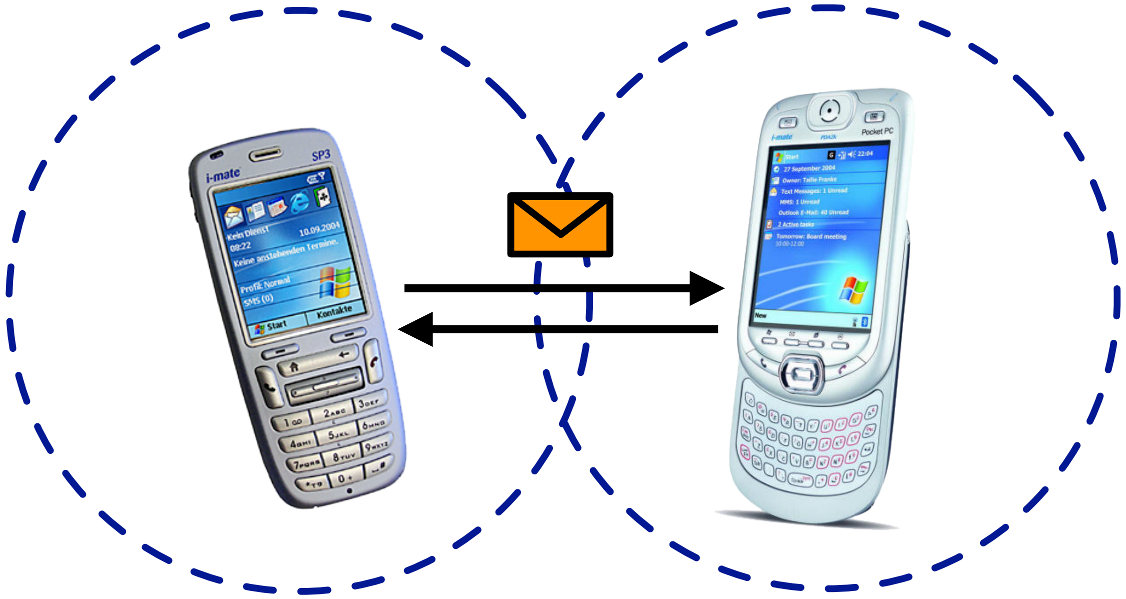
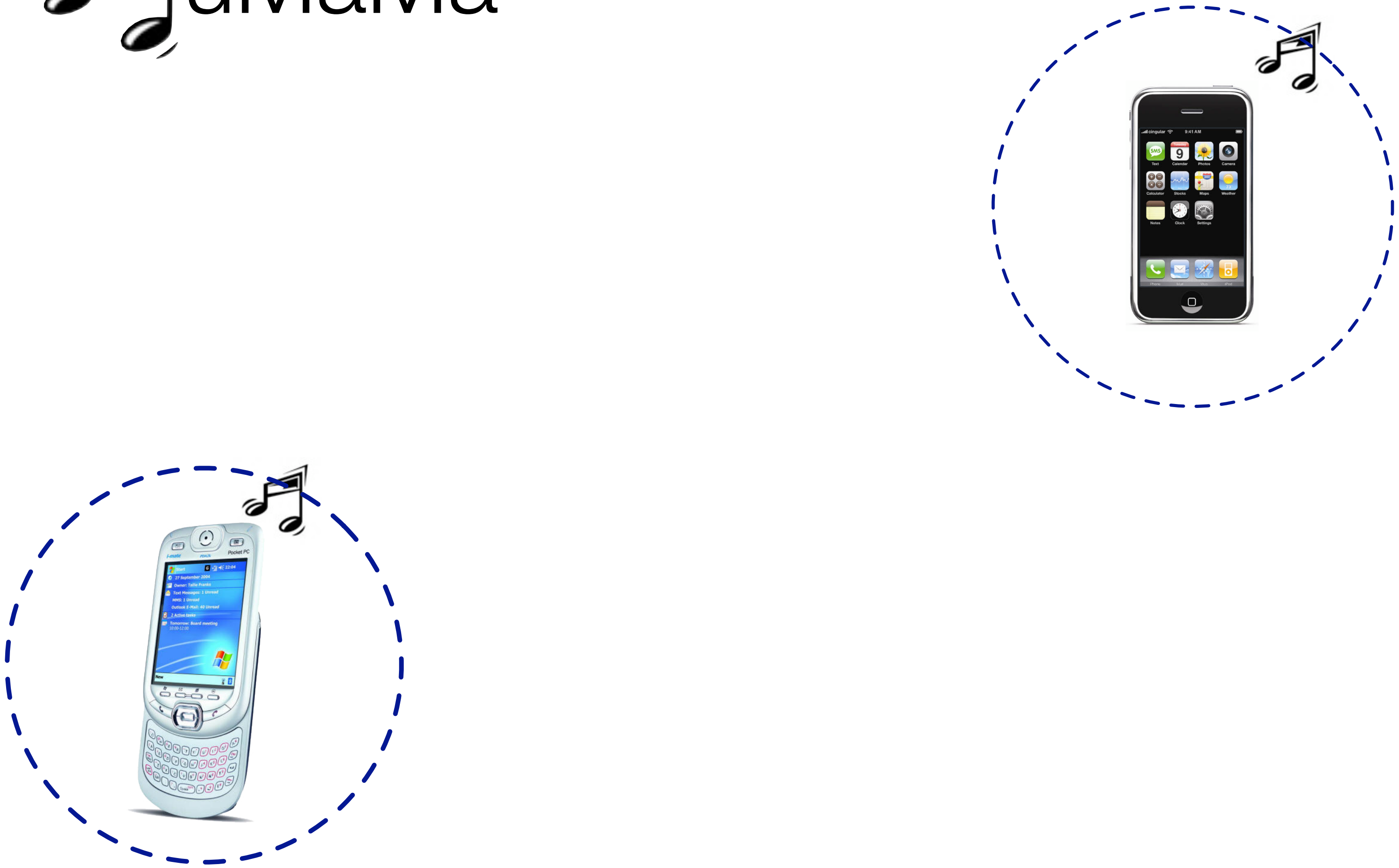


Tolerate disconnections, because they occur frequently rather than exceptionally

Software concerns

uMaMa



Software concerns

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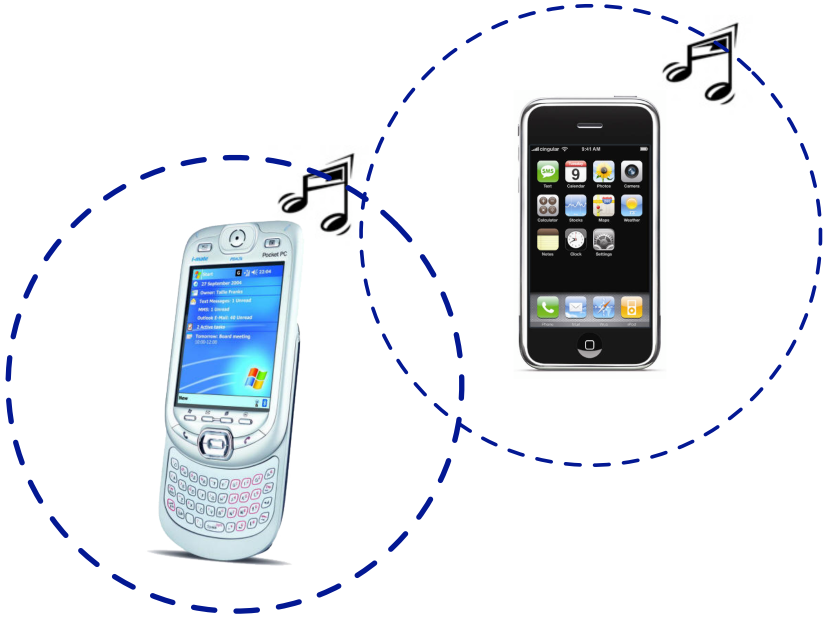

Discovery

Software concerns

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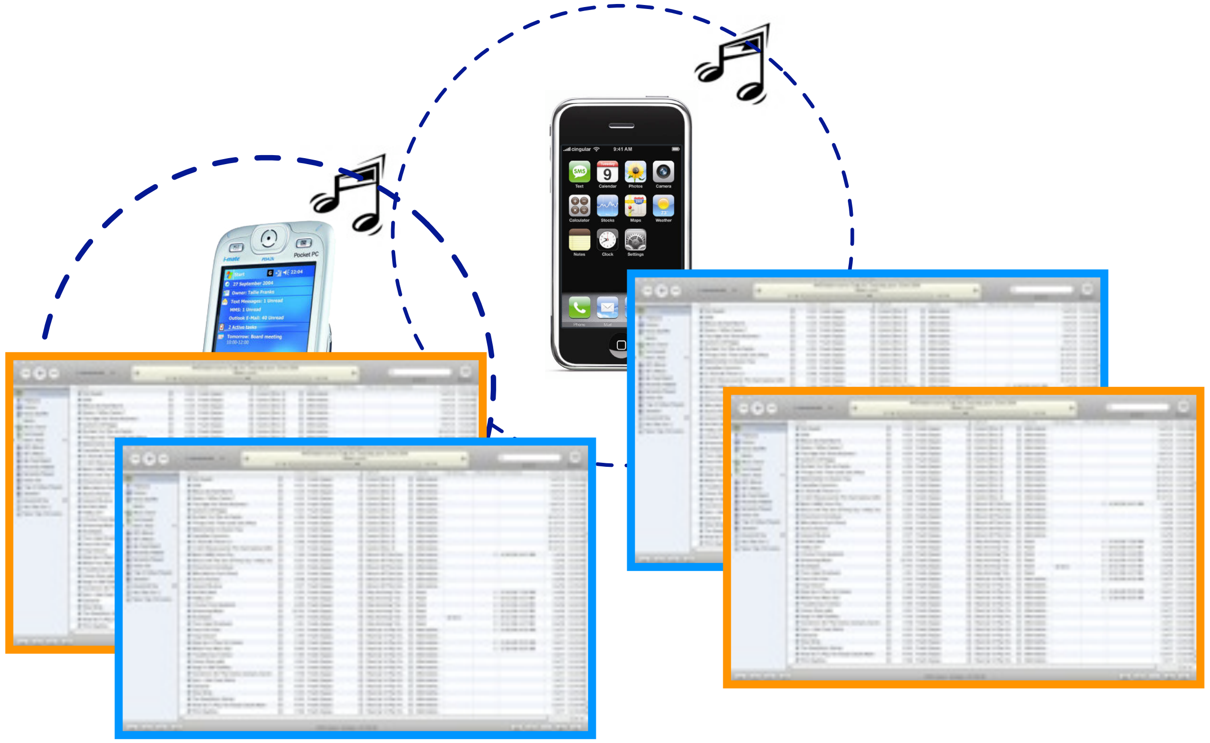
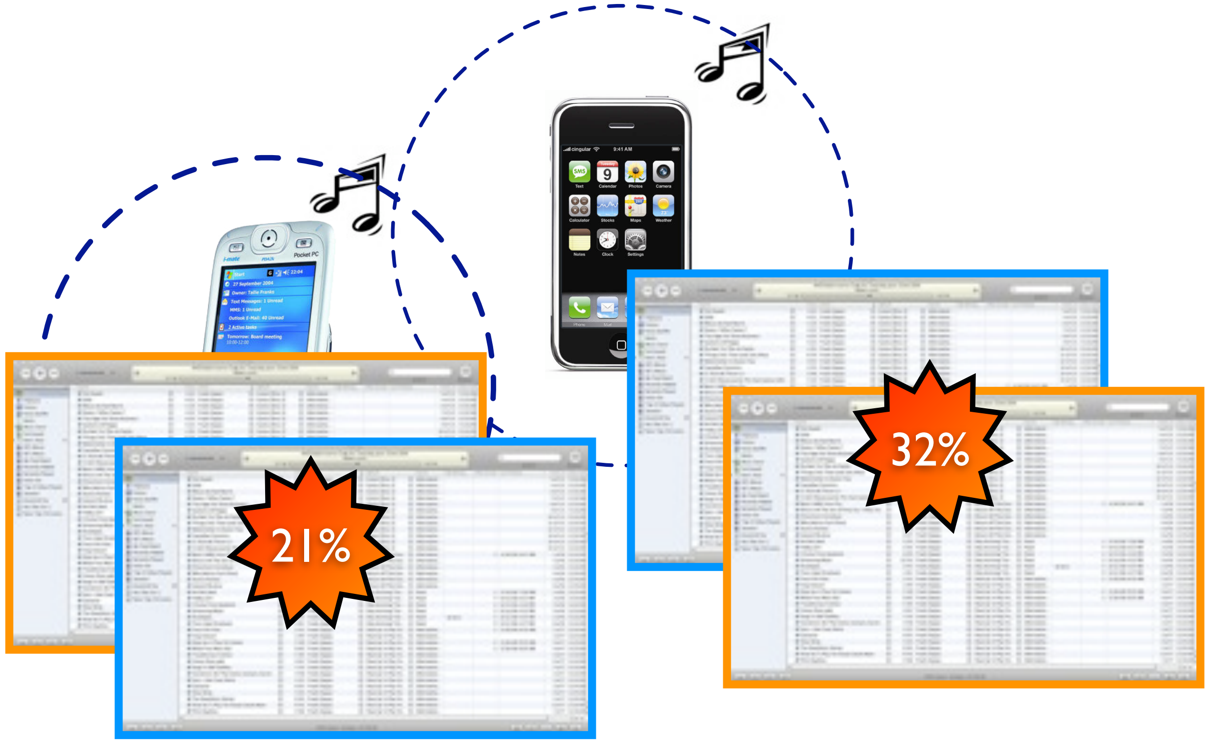


Discovery

Communication

Software concerns

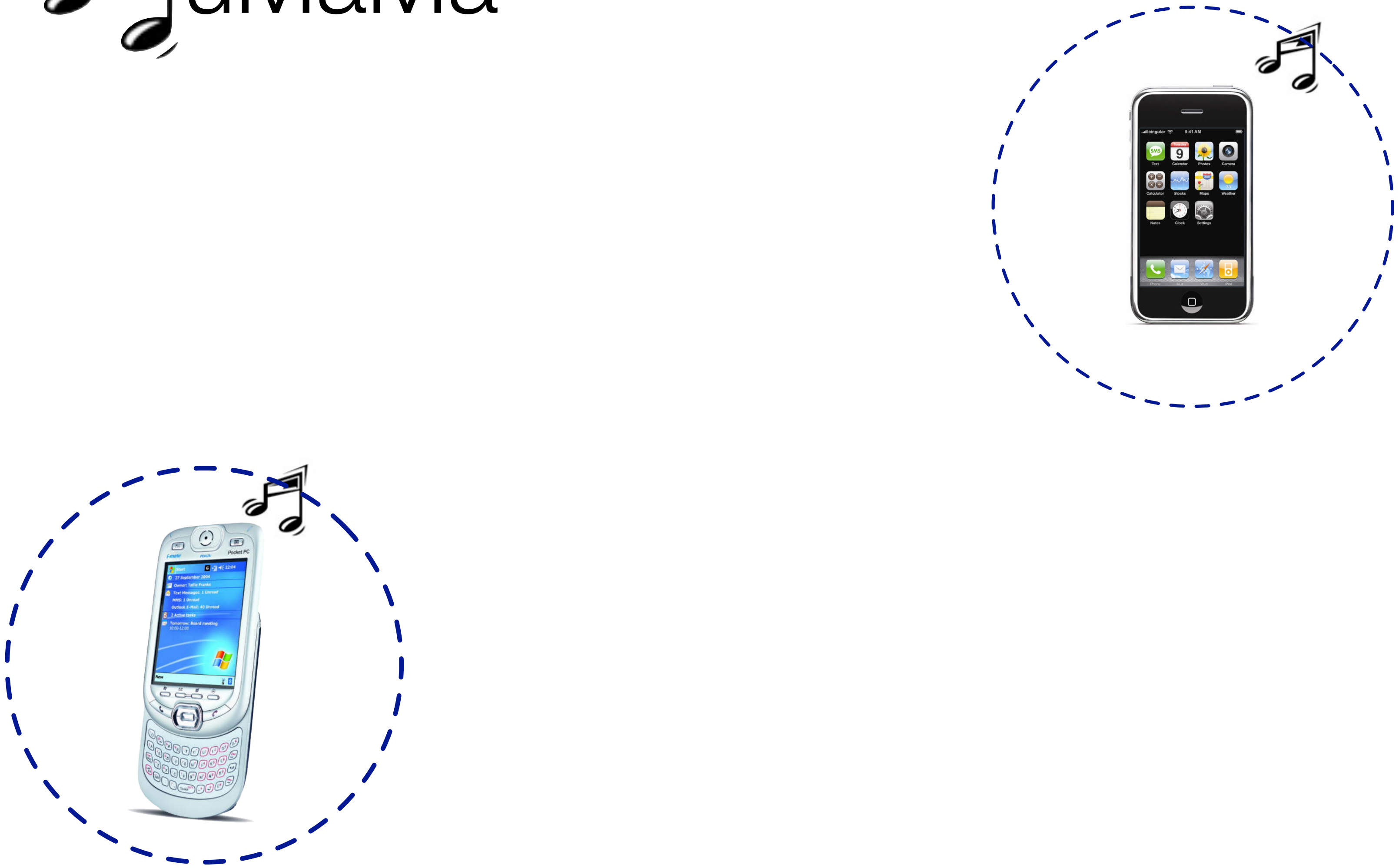
uMaMa



Discovery Communication Synchronisation

Software concerns

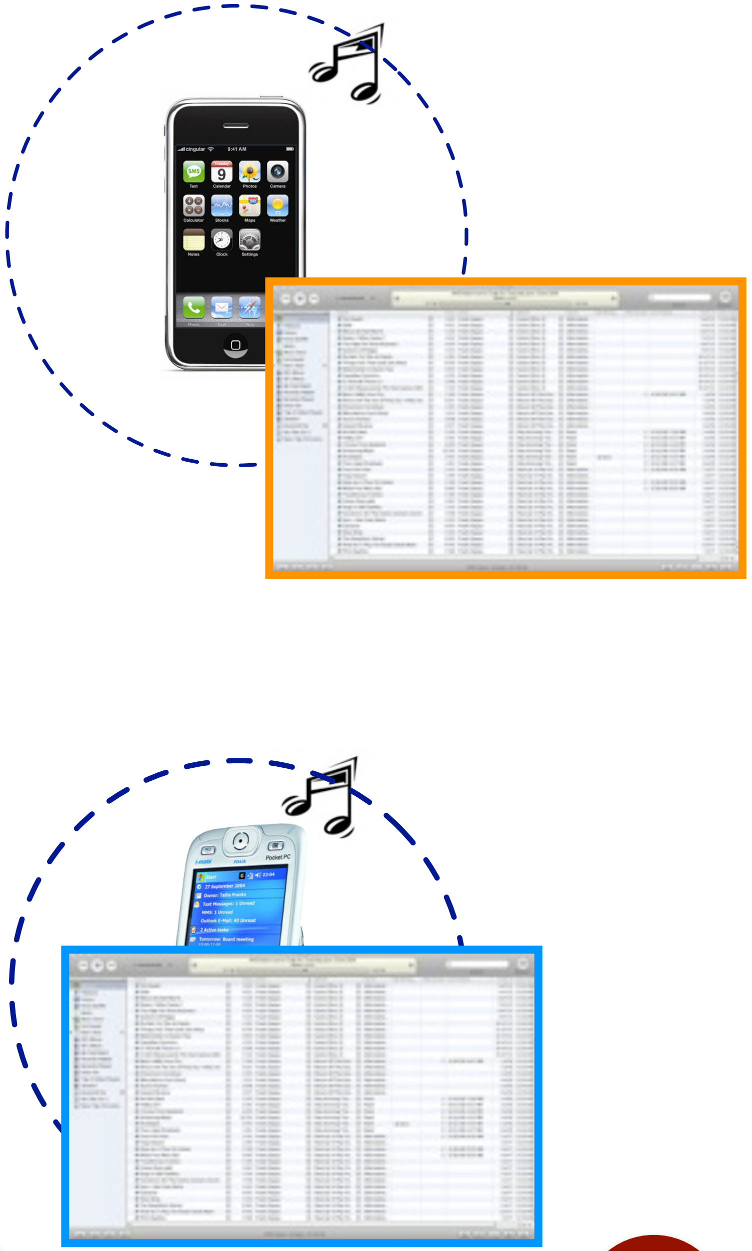
uMaMa



Discovery Communication Synchronisation

Software concerns

uMaMa



● Discovery ⇄ Communication ✓ Synchronisation ✖ Failure handling

Tool

AmbientTalk

AmbientTalk: fact sheet

- Object-oriented scripting language
- Started in 2005
- Pure Java implementation
- Runs on J2ME/CDC phones
- Open source implementation

code.google.com/p/ambienttalk

Google Code

AMBIENTTALK

How does AmbientTalk help?

Volatile Connections

network connections are resilient to failures by default

Zero Infrastructure

service discovery protocol built into the language

AMBIENTTALK

Object-oriented

```
def makeSong(artist, title) {
  object: {
    def printArtist() {
      if: (artist == nil) then: {
        “unknown artist”;
      } else: {
        artist;
      }
    }
  }
}
```

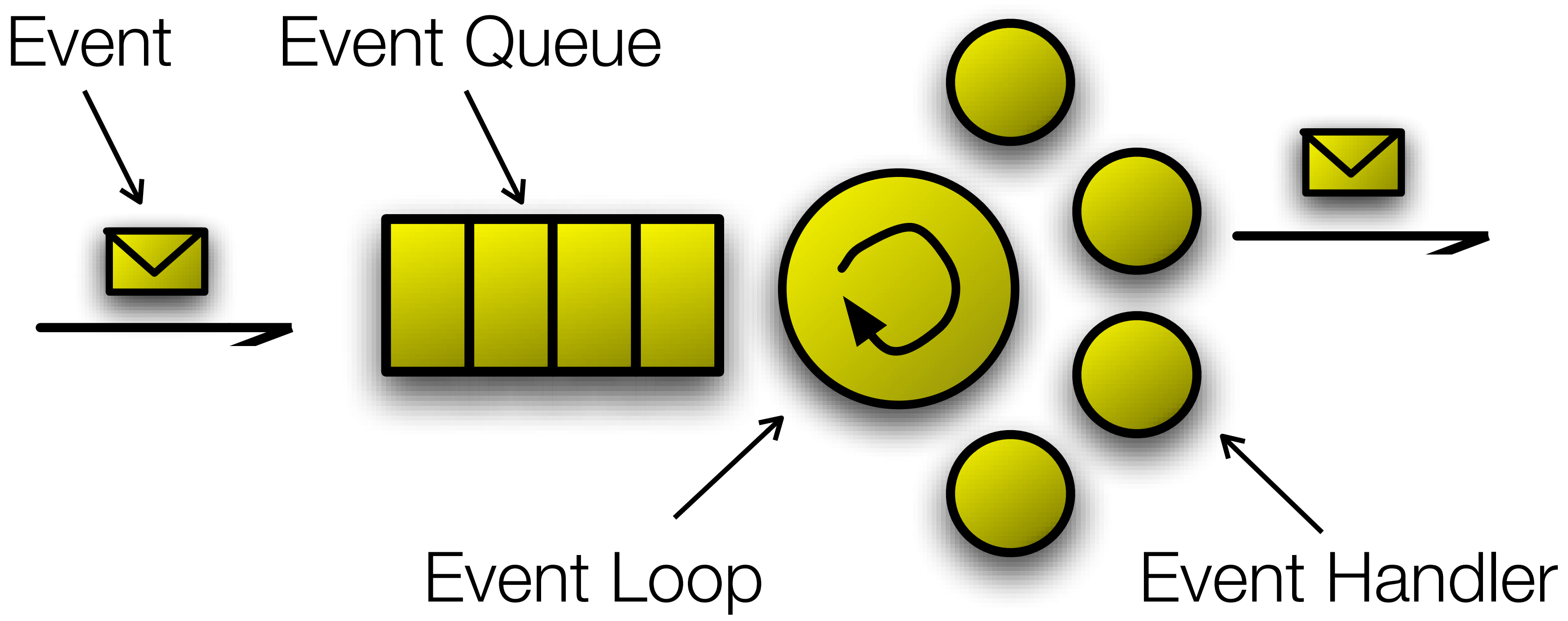
Object-oriented

```
def makeSong(artist, title) {
  object: {
    def printArtist() {
      if: (artist == nil) then: {
        “unknown artist”;
      } else: {
        artist;
      }
    }
  }
}

def song := makeSong(“U2”, “One”);
song.printArtist();
```

Event Loop Concurrency

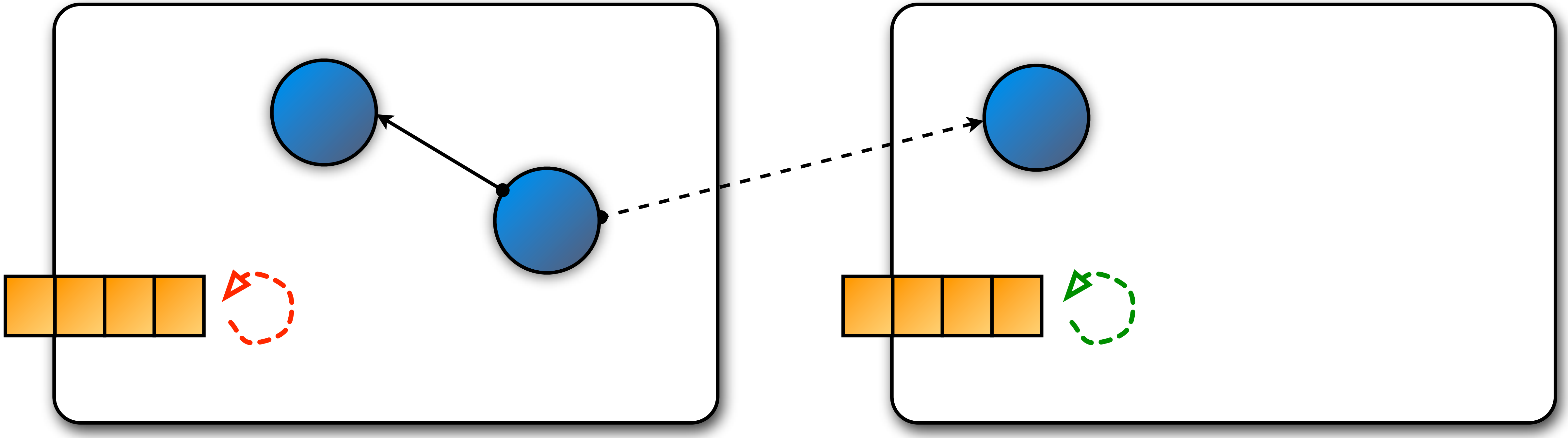
- AmbientTalk programs are event loops
- They react to events from the outside world
- They communicate asynchronously



Examples of event loops

- GUI Frameworks (e.g. Java AWT)
- Highly interactive applications (e.g. games)
- IPC in Operating Systems
- Discrete Event Modelling (e.g. simulations)
- Web servers

Event Loop Concurrency in AmbientTalk



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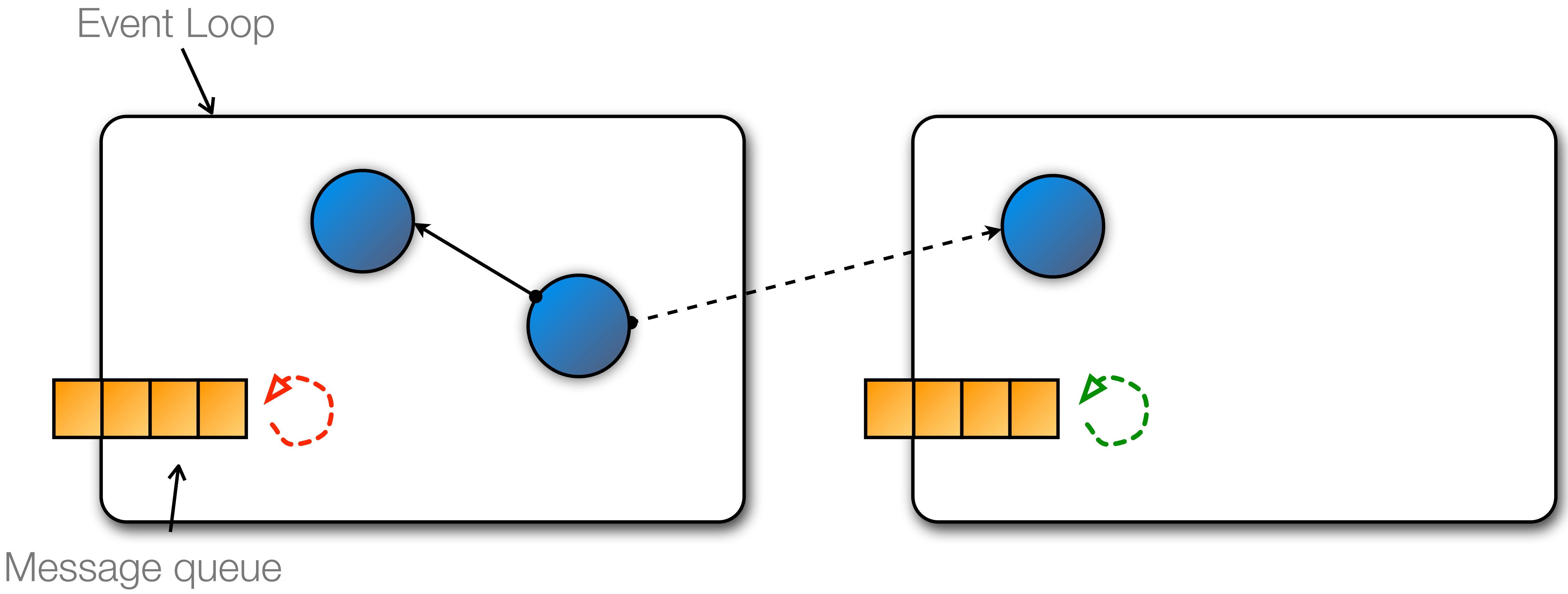

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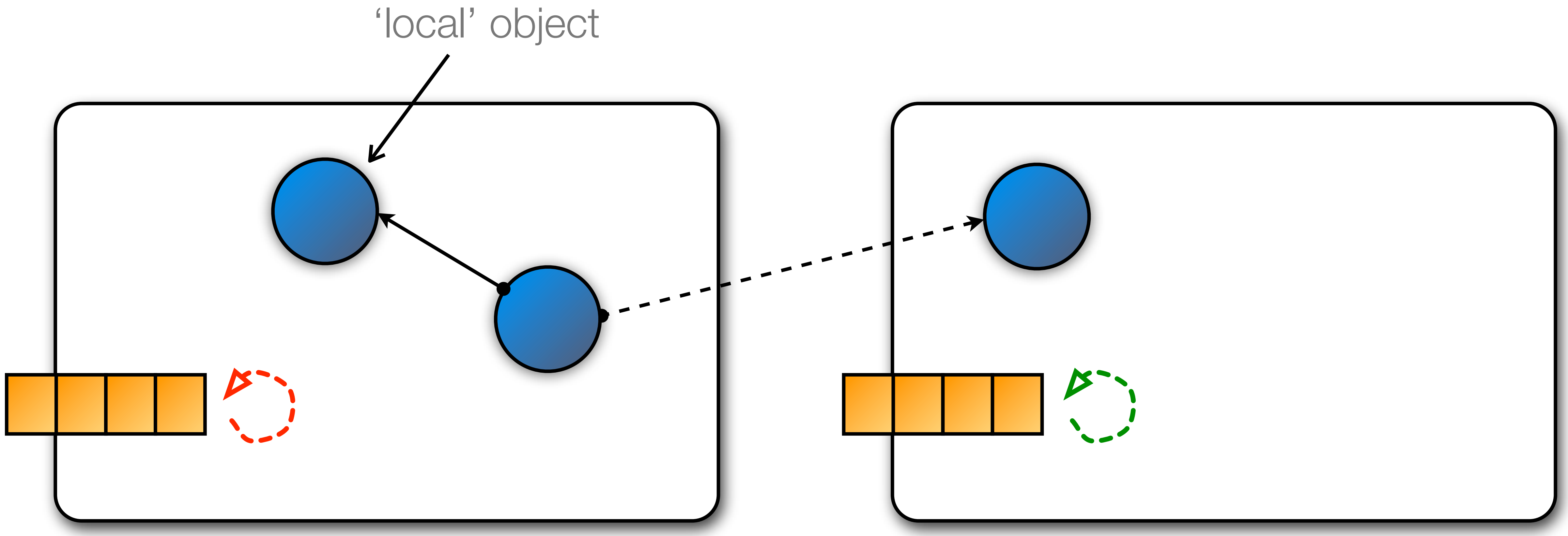

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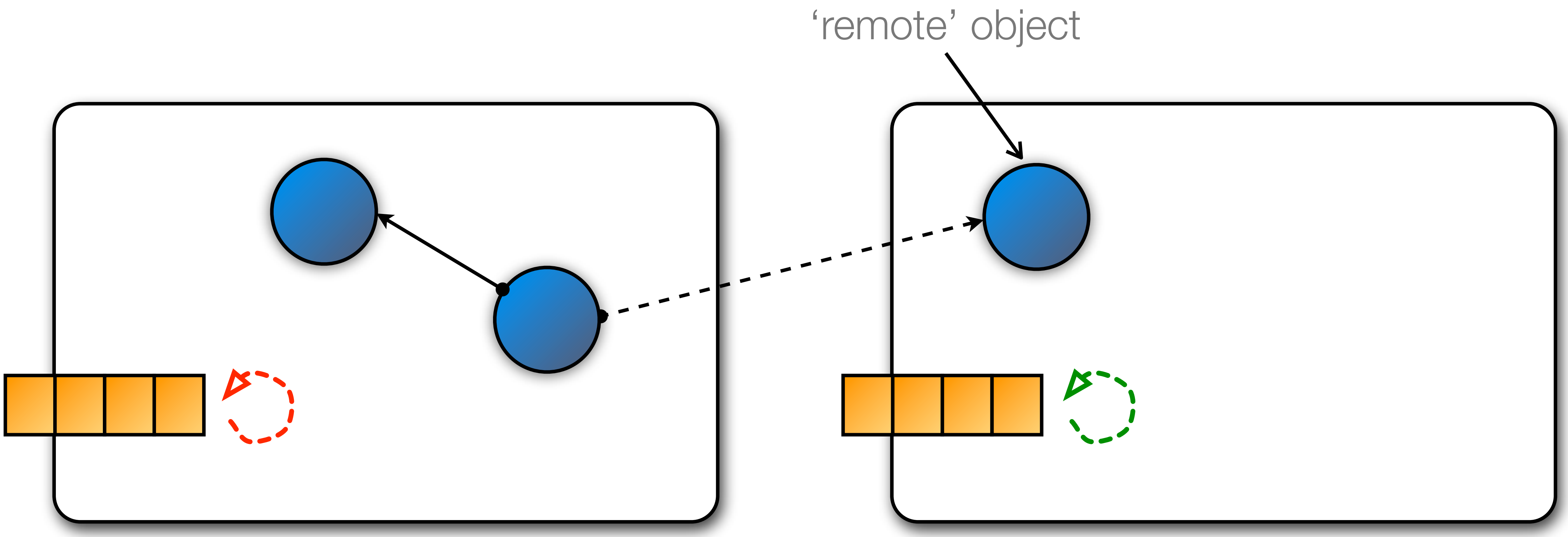

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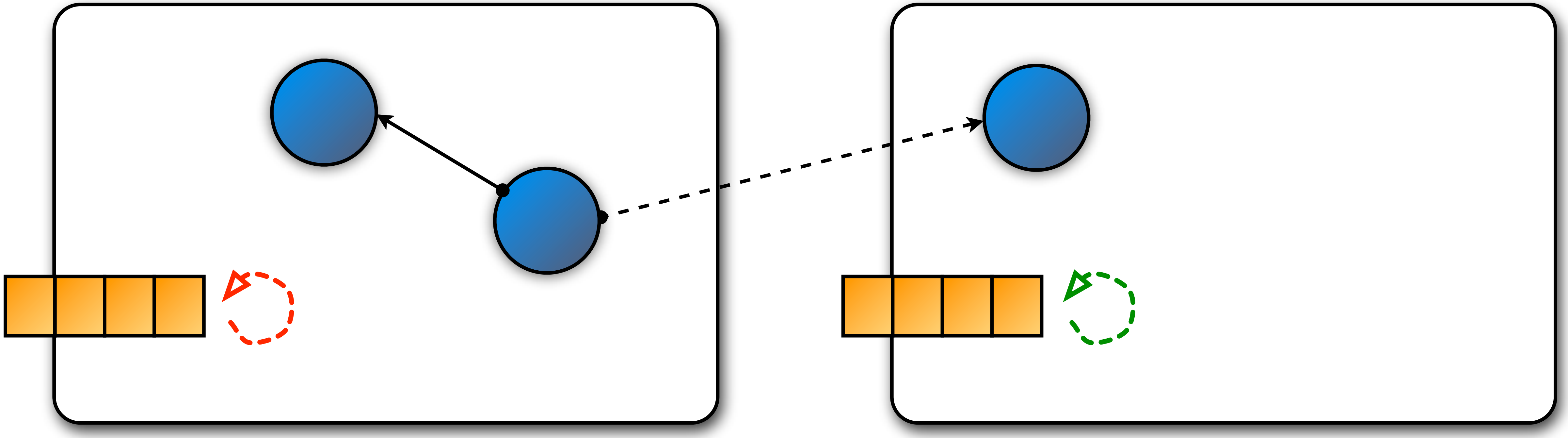

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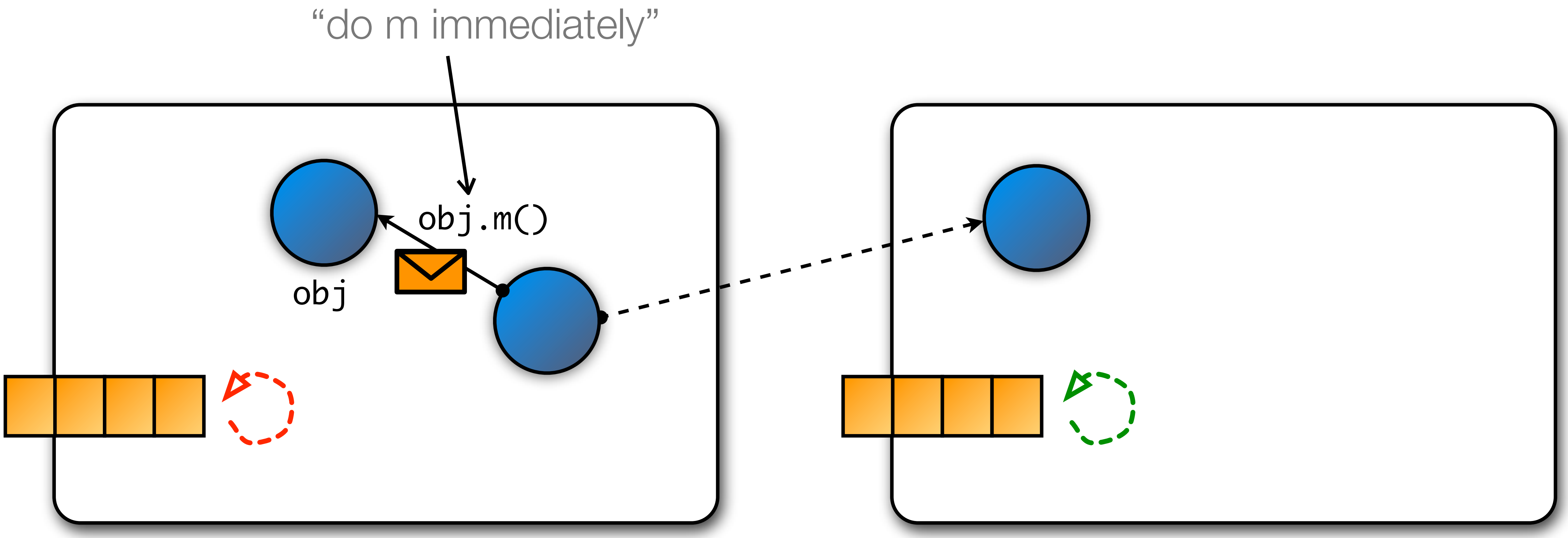

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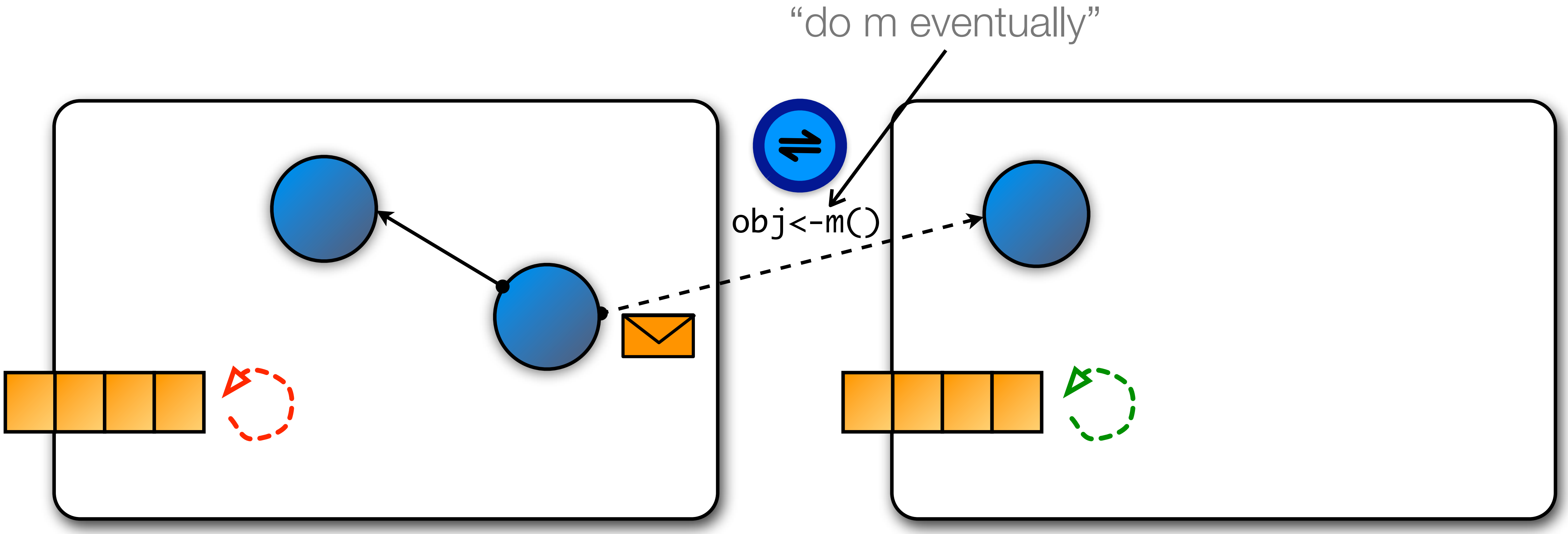

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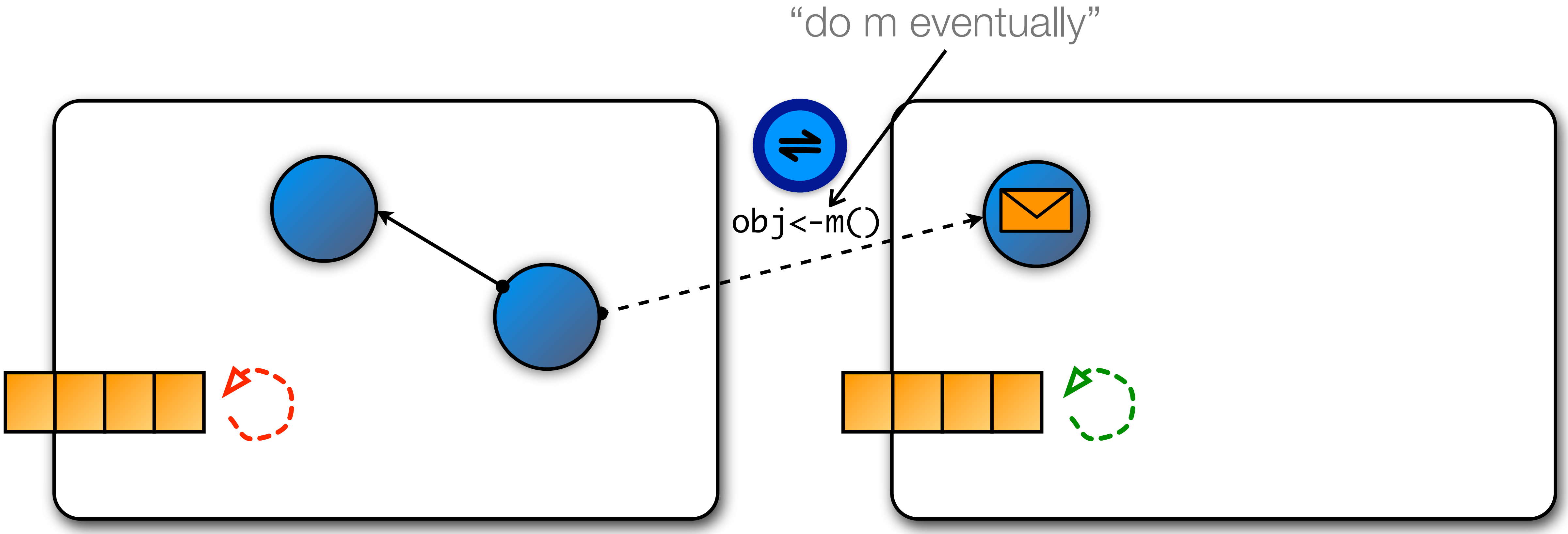

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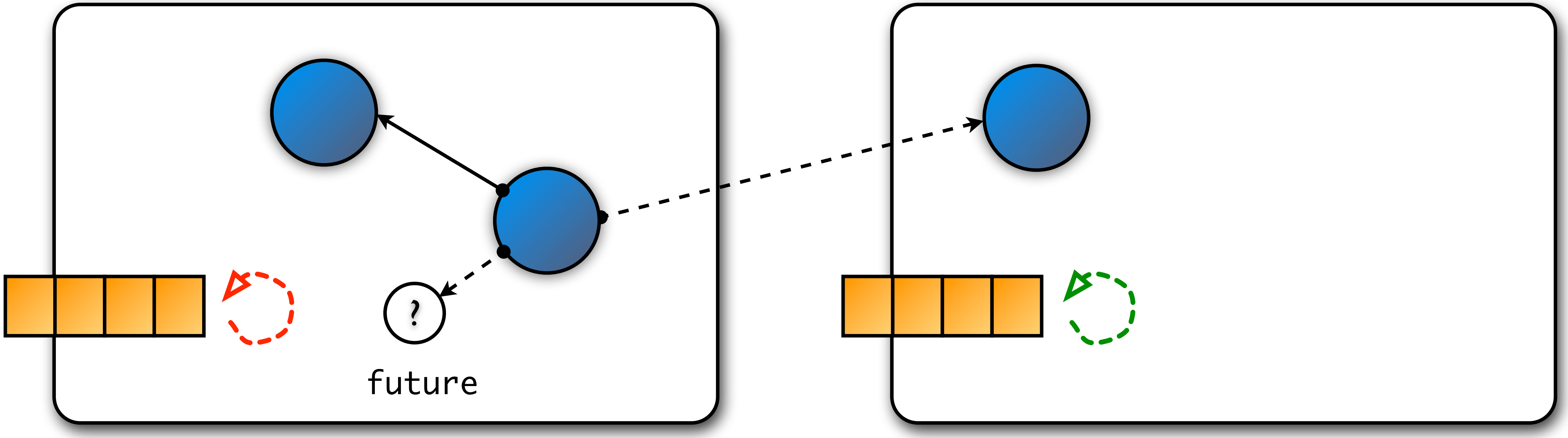

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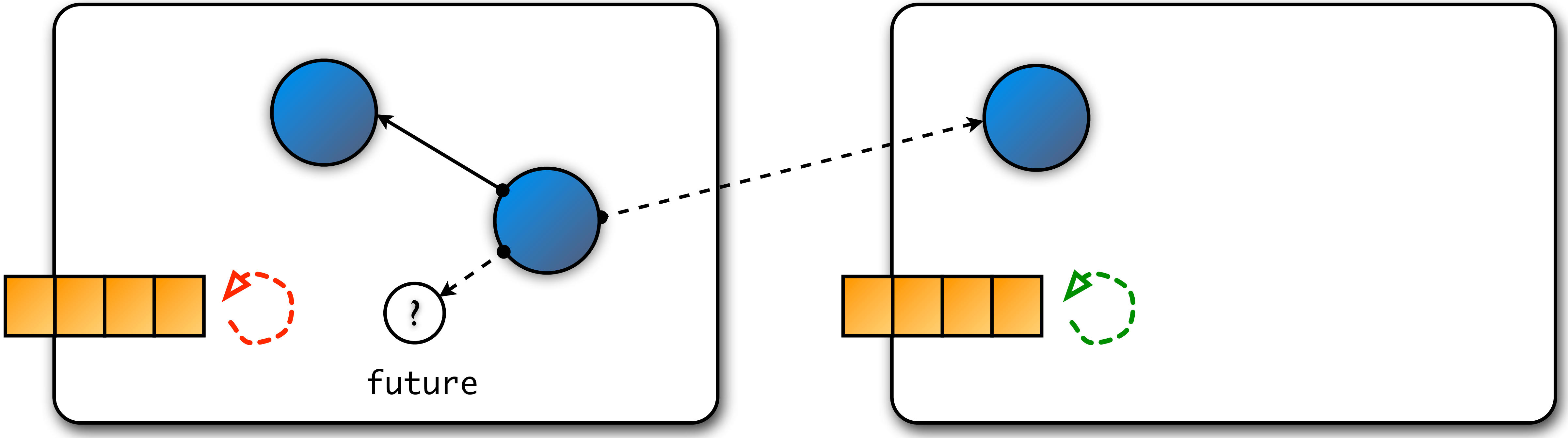
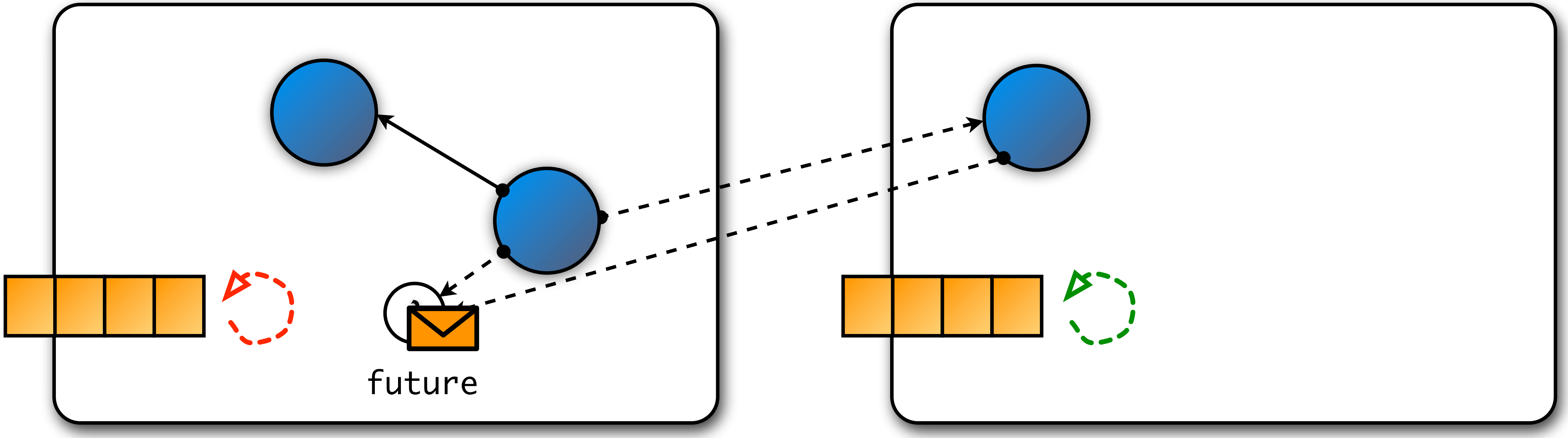


```
when: future becomes: { |value|
  // process reply
}
```

Event Loop Concurrency in AmbientTalk



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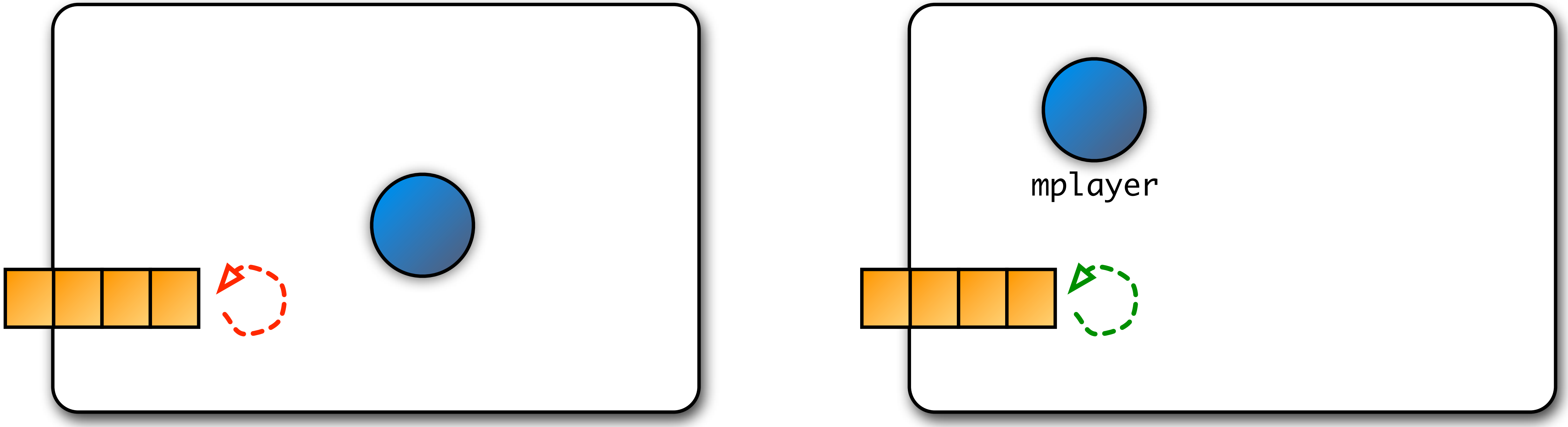
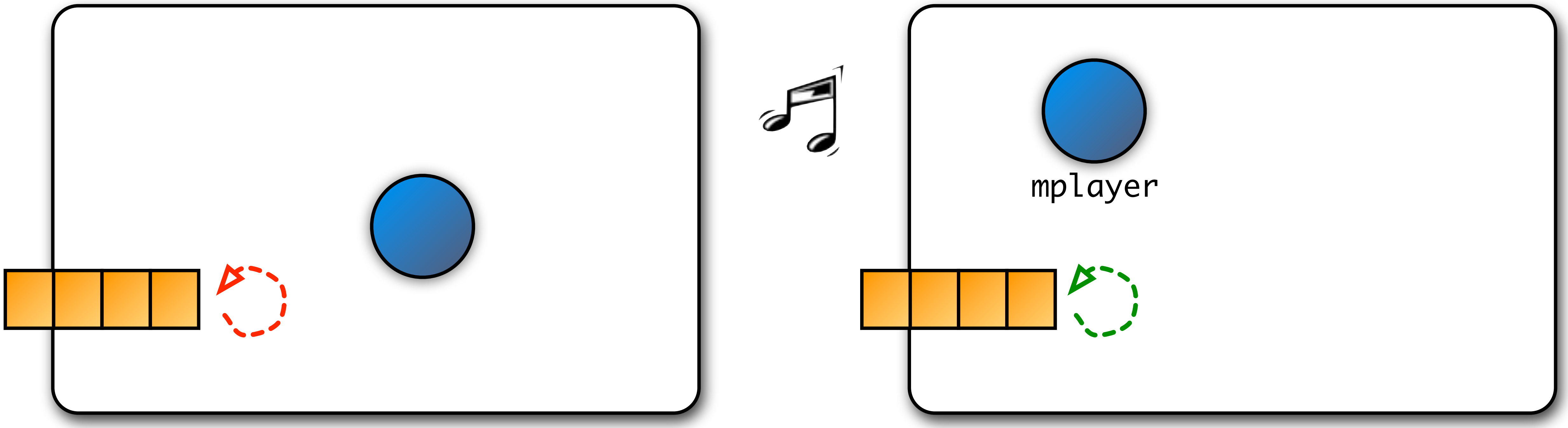
Exporting & discovering objects



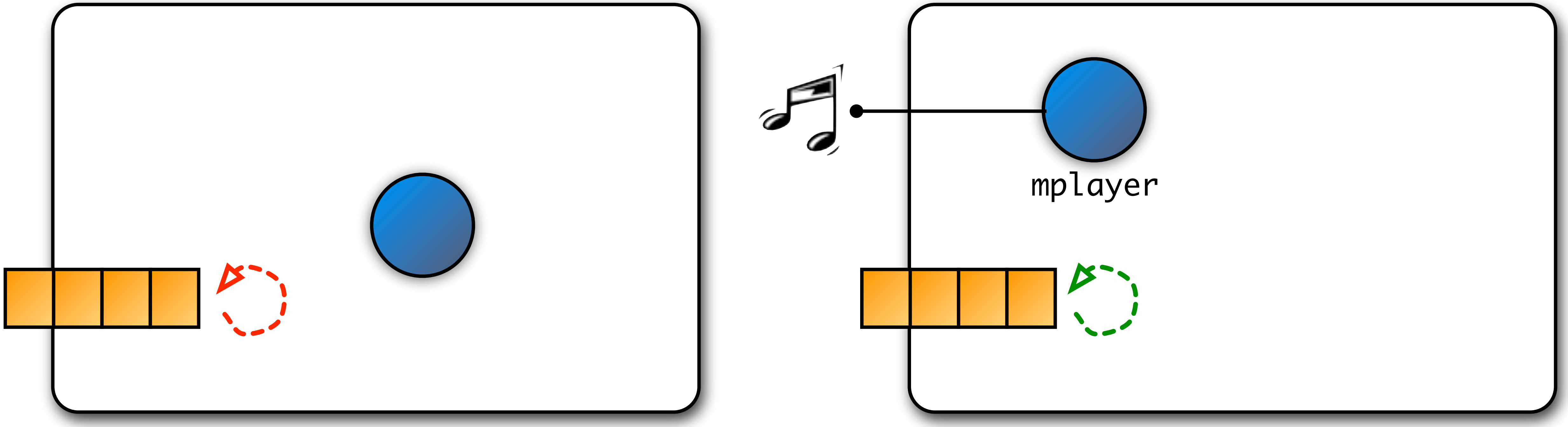
Exporting & discovering objects



`deftype MusicPlayer`

`deftype MusicPlayer`

Exporting & discovering objects

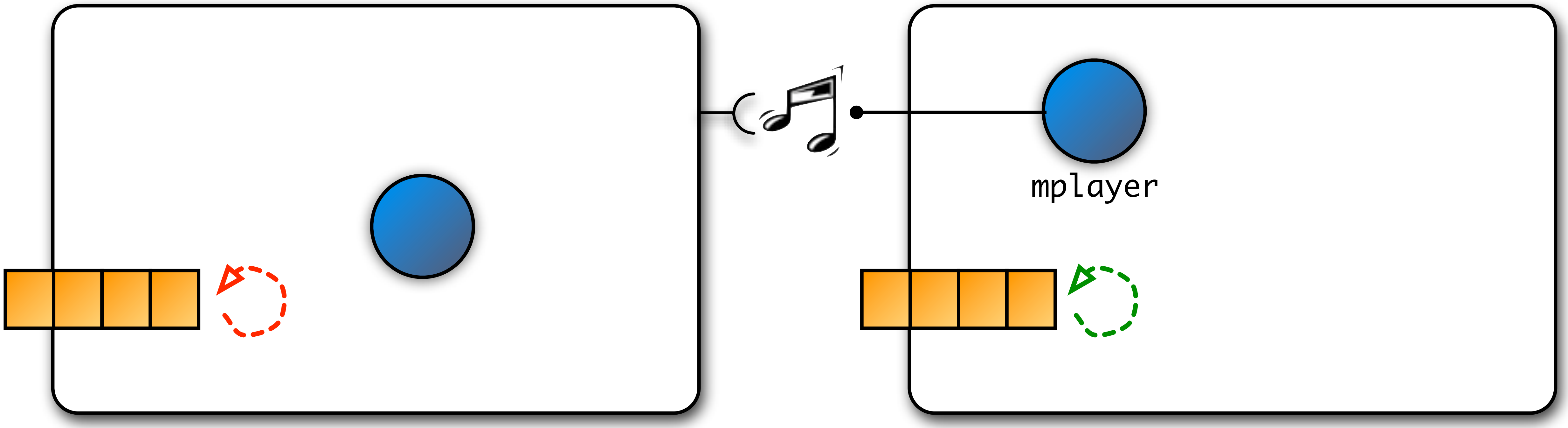


```
deftype MusicPlayer
```

```
deftype MusicPlayer

export: mplayer as: MusicPlayer
```

Exporting & discovering objects

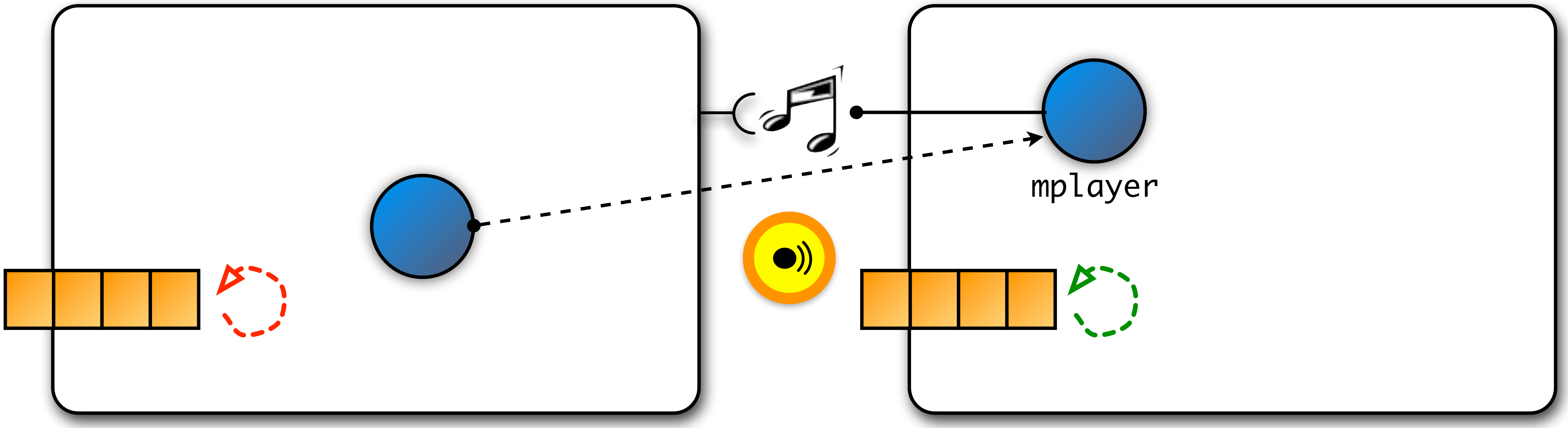


```
deftype MusicPlayer                     deftype MusicPlayer

                                        export: mplayer as: MusicPlayer
```

```
whenever: MusicPlayer discovered: { |mplayer|
  // open a session
}
```

Exporting & discovering objects



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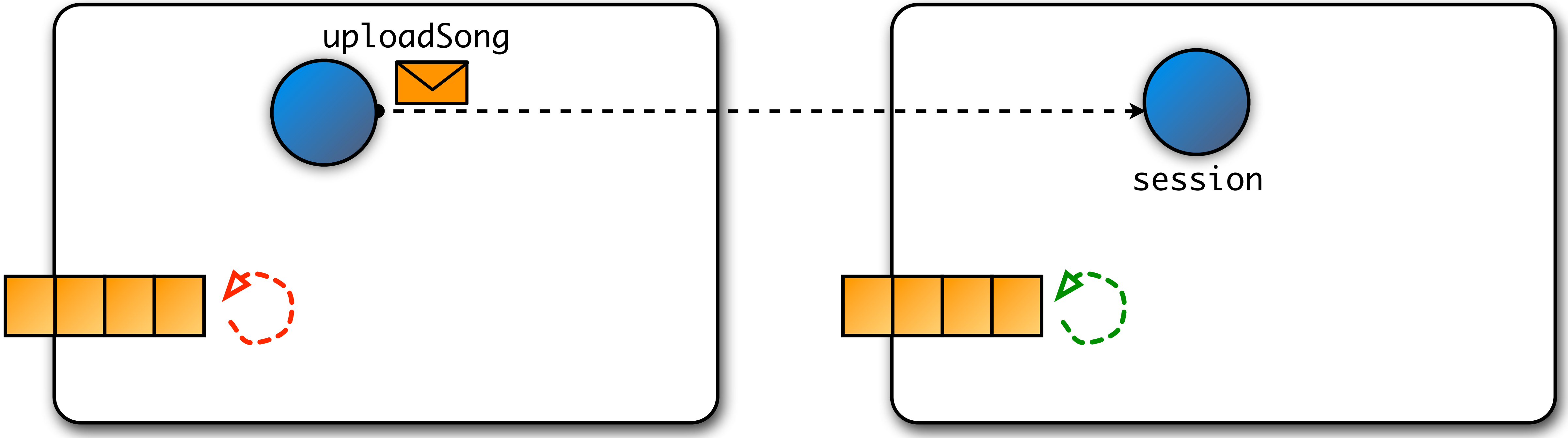

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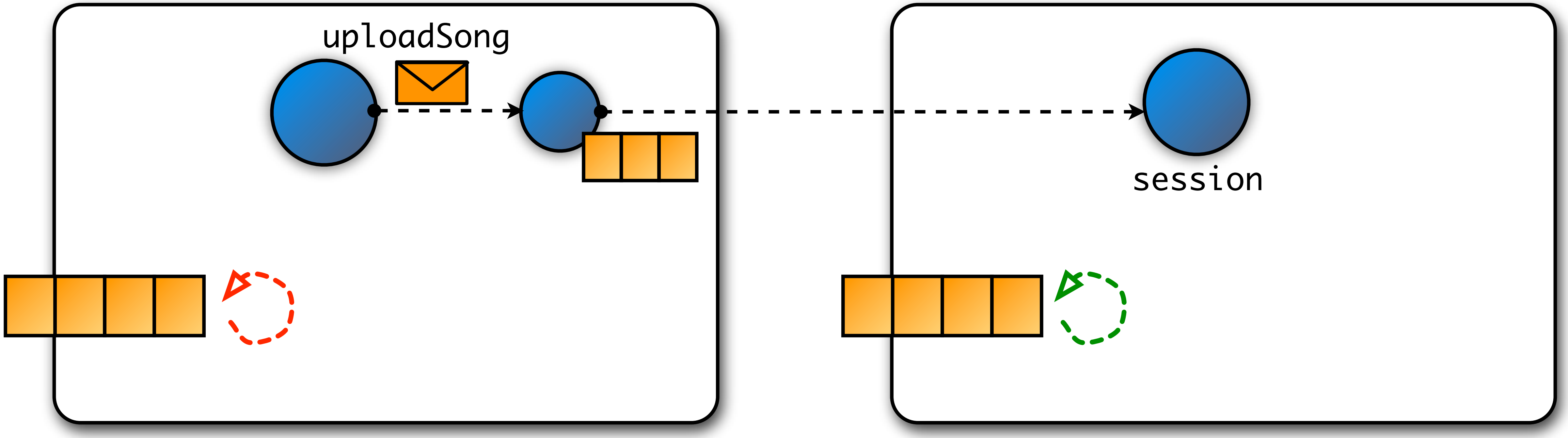

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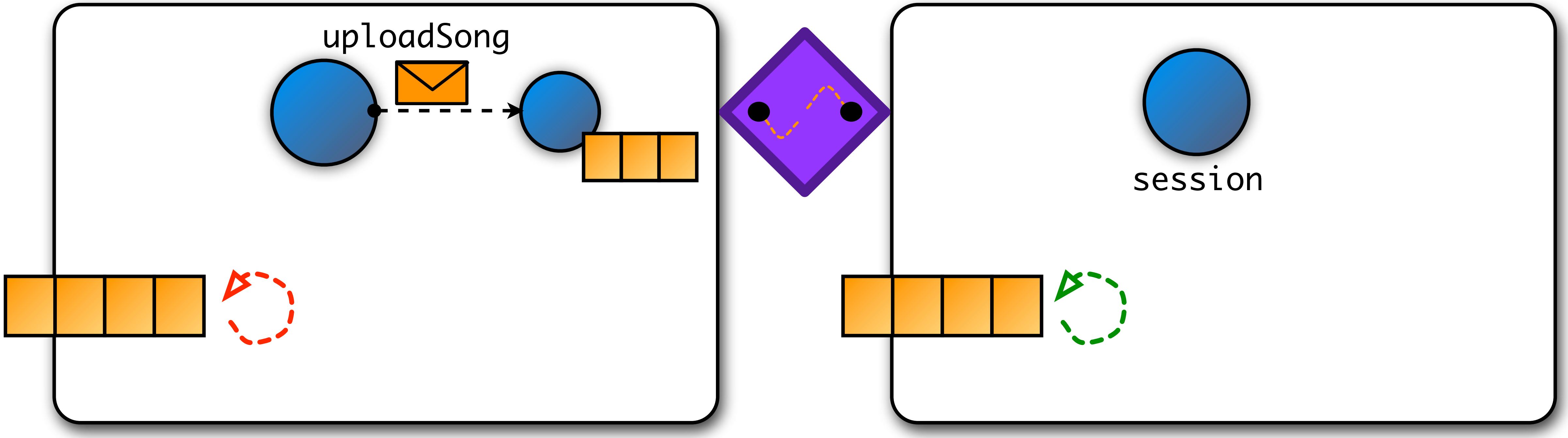

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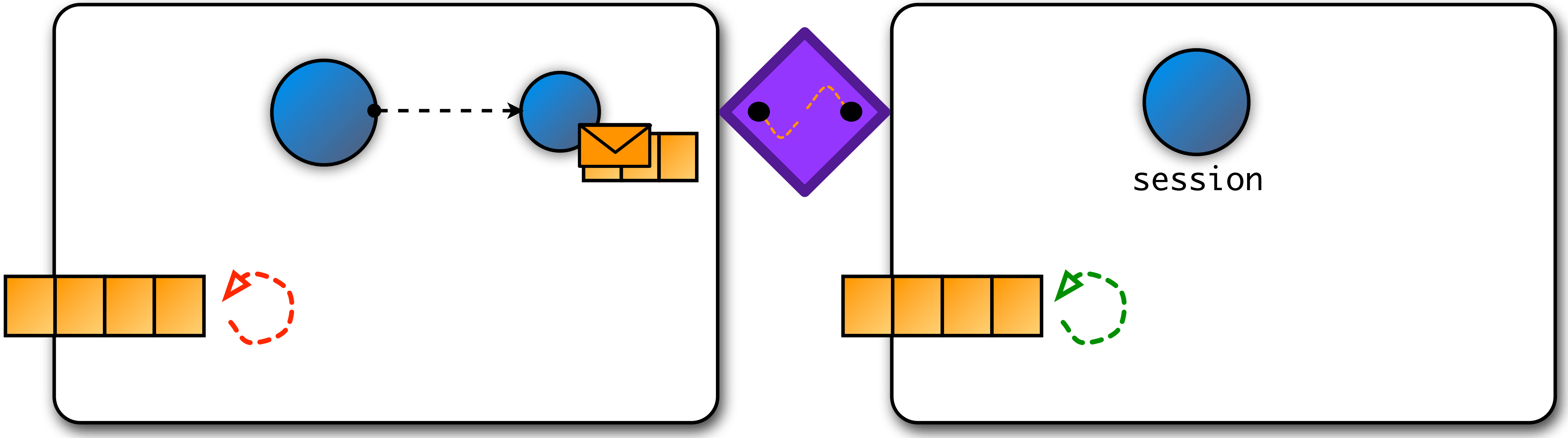

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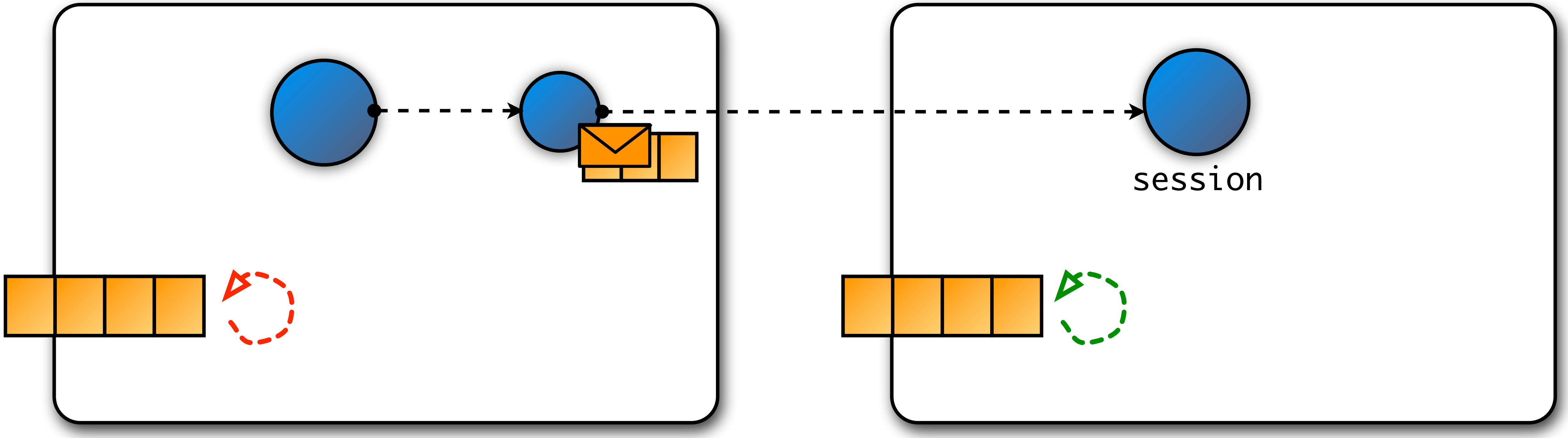

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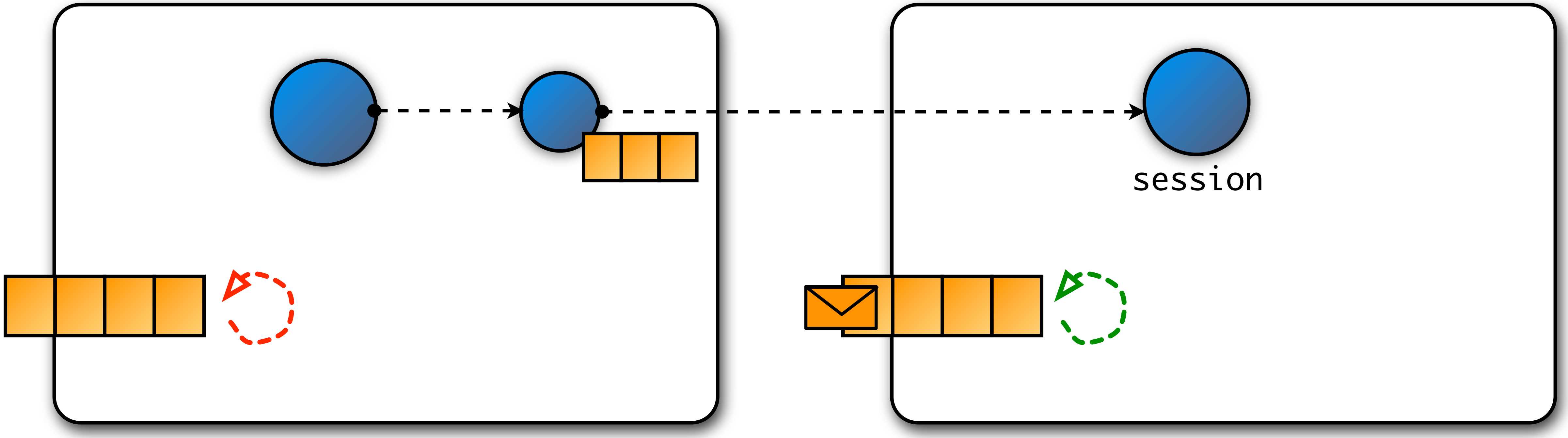

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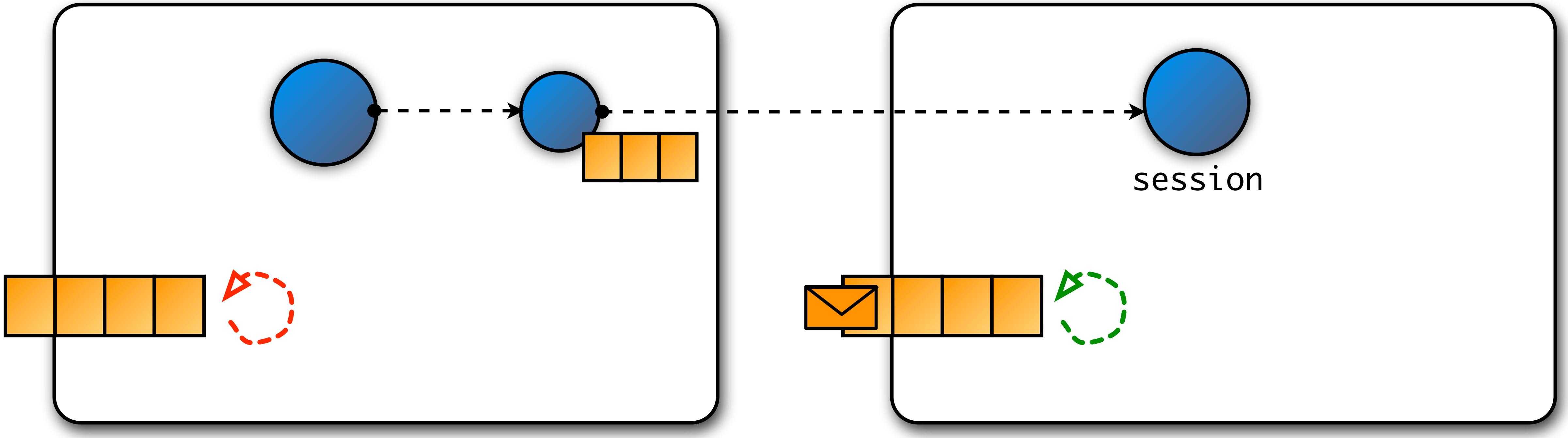
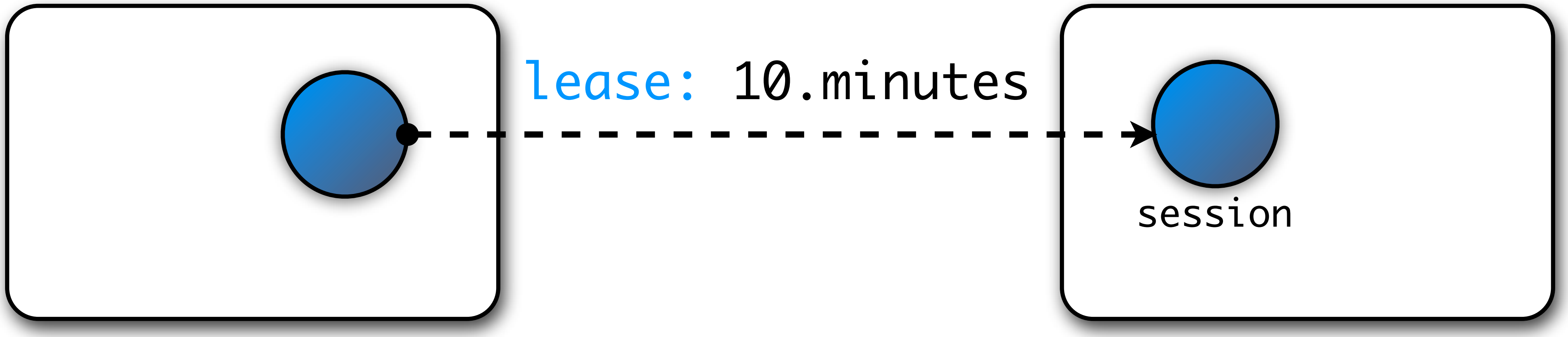
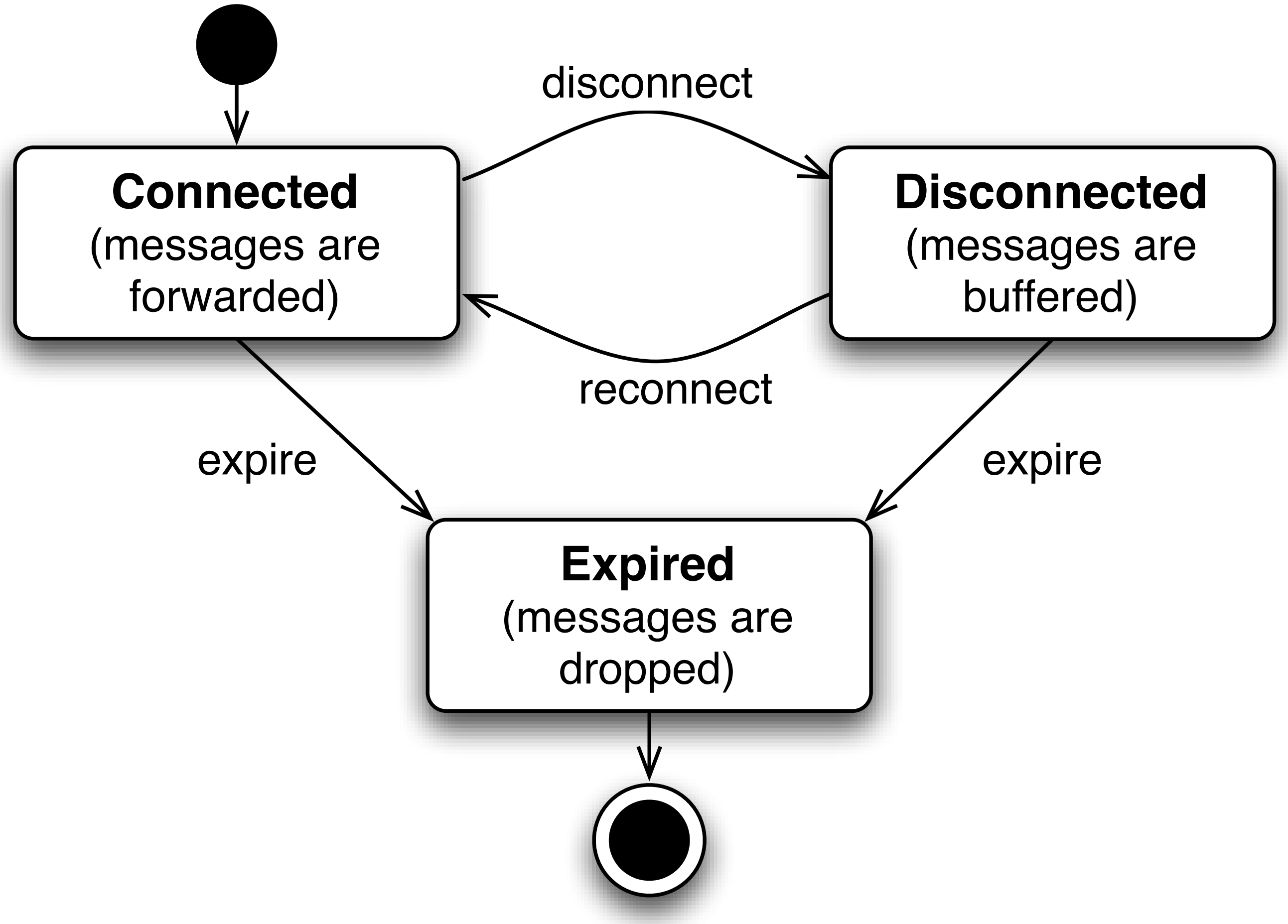


✖

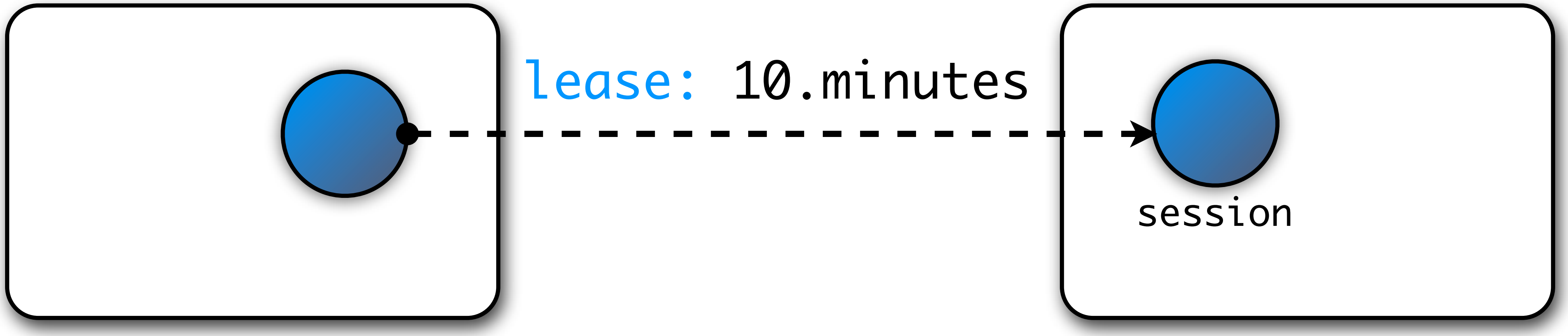
```
when: session<-uploadSong(s)@Due(timeout) becomes: { |ack|
  // continue exchange
} catch: TimeoutException using: { |e|
  // stop exchange
}
```

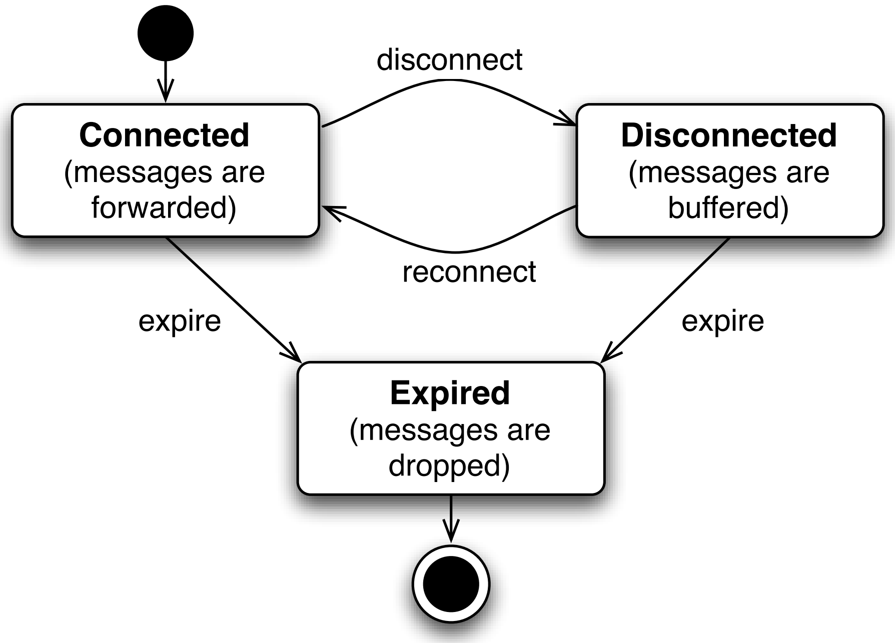
Leasing


lease: 10.minutes
session


disconnect
Connected (messages are forwarded)
Disconnected (messages are buffered)
reconnect
expire
expire
Expired (messages are dropped)

Reacting to failures





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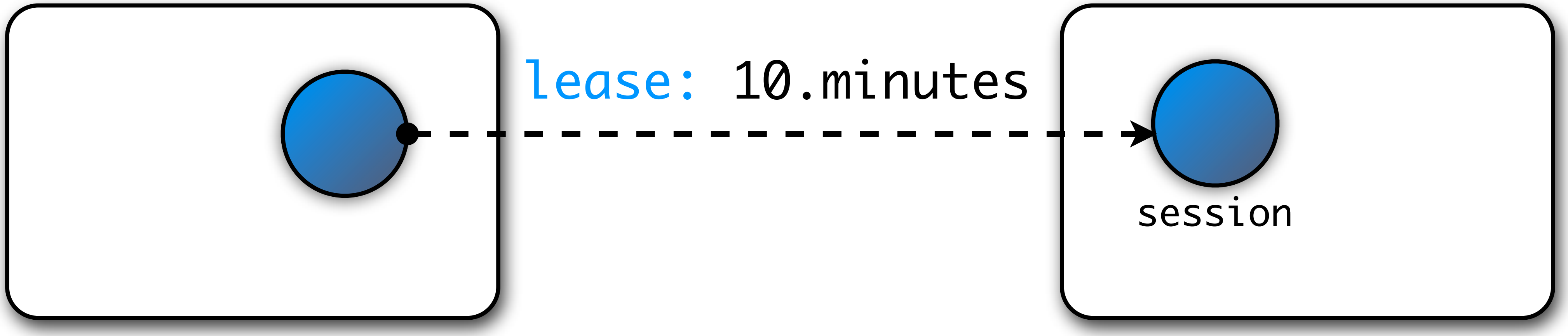
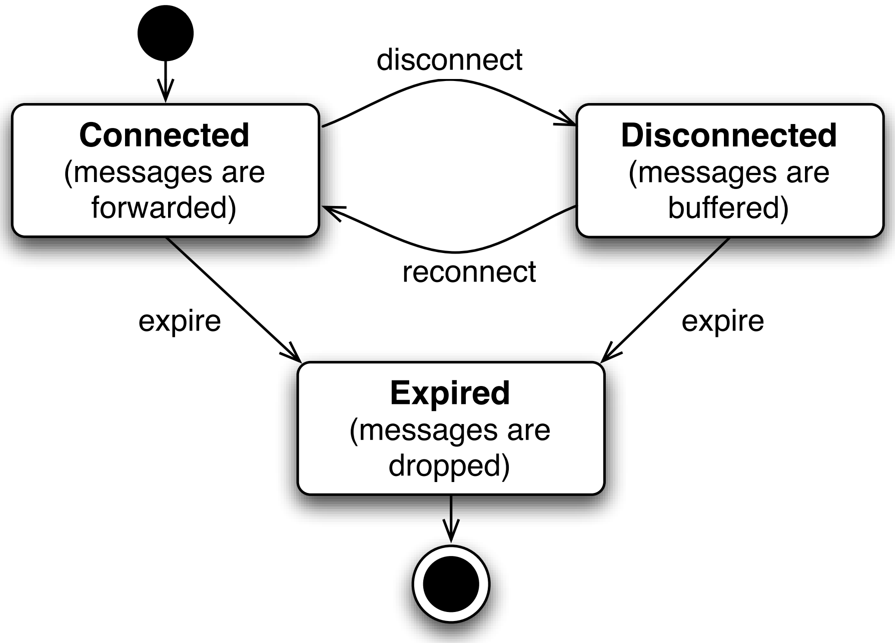


lease: 10.minutes

session

```
when: session disconnected: {
  // pause transmission
}
```



Connected
(messages are forwarded)

Disconnected
(messages are buffered)

Expired
(messages are dropped)

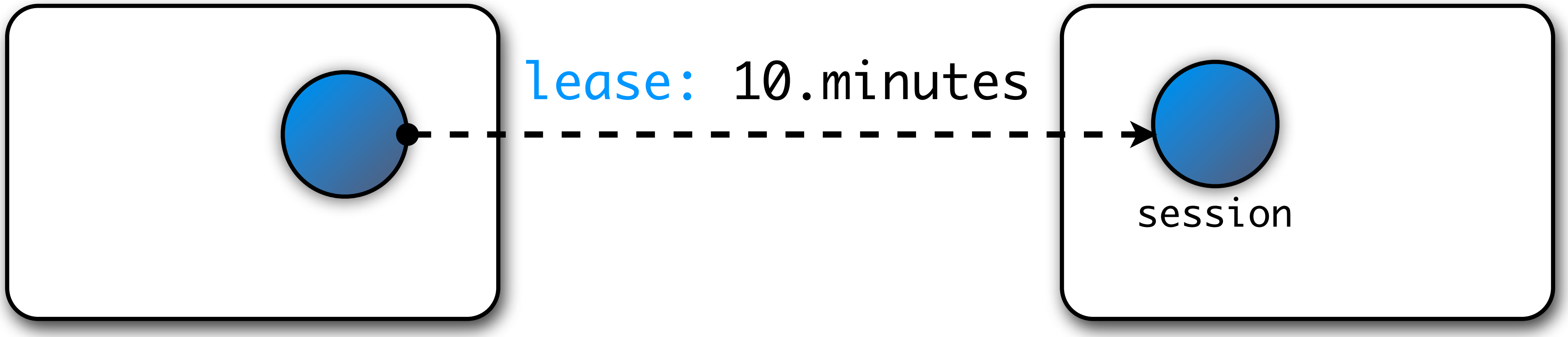
disconnect

reconnect

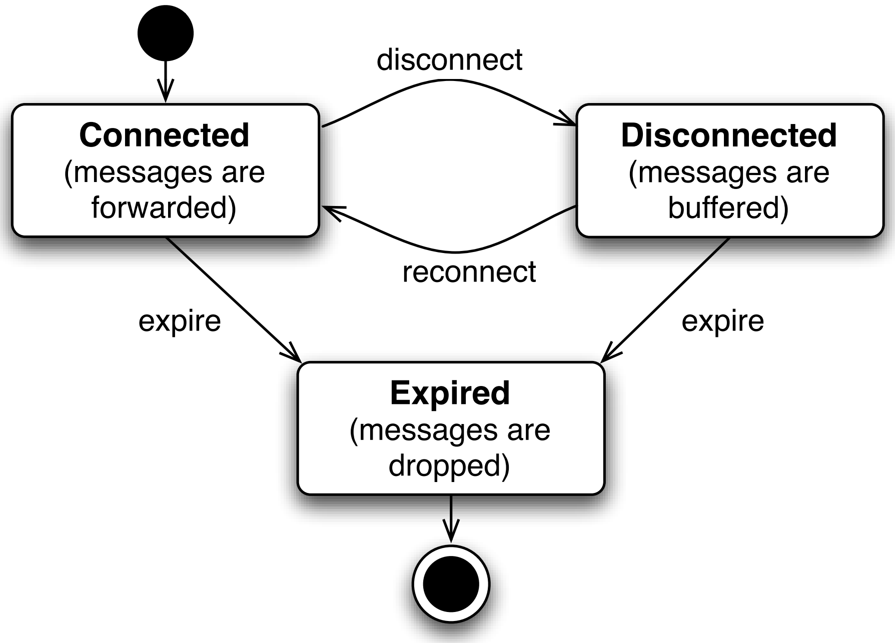
expire

expire

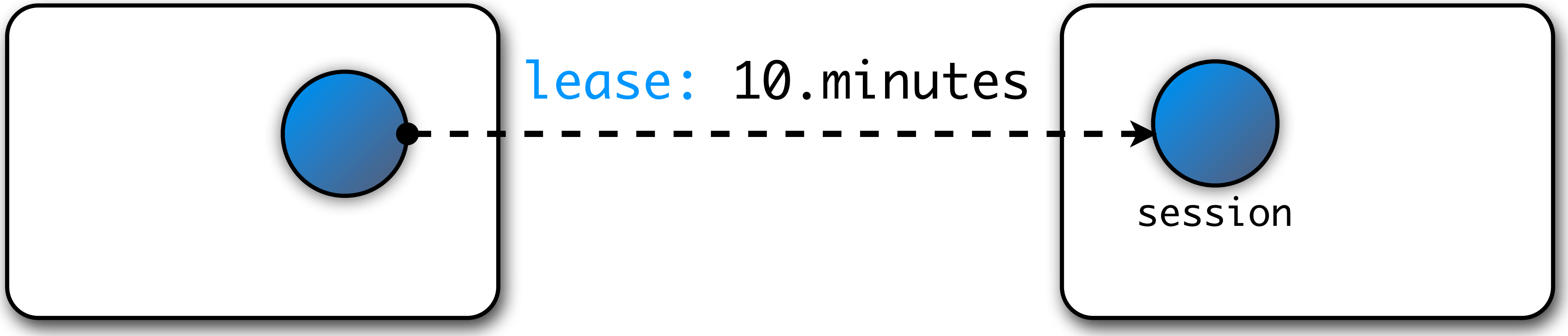
Reacting to failures



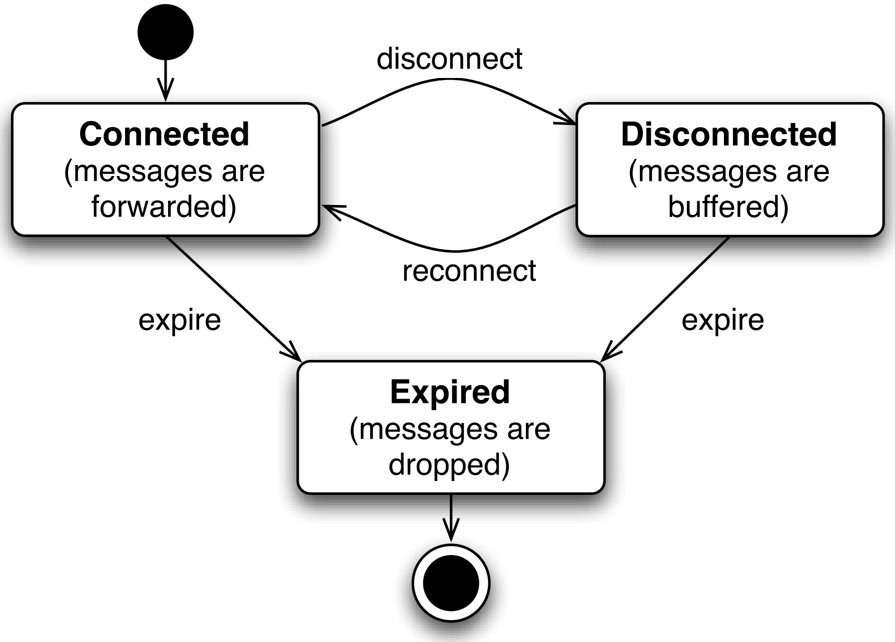
```
when: session disconnected: {
  // pause transmission
}
when: session reconnected: {
  // resume transmission
}
```



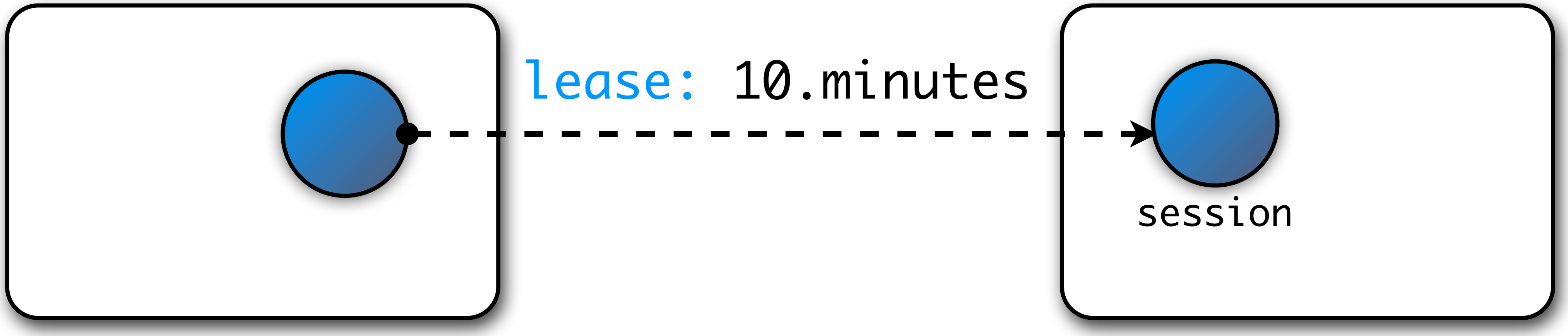
Reacting to failures



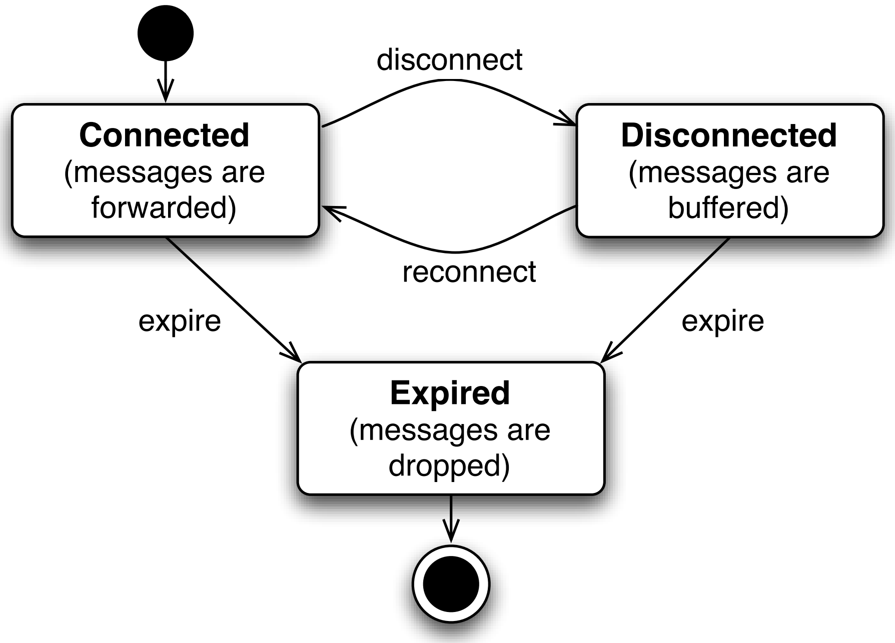
```
when: session disconnected: {
  // pause transmission
}
when: session reconnected: {
  // resume transmission
}
when: session expired: {
  // stop transmission
}
```



Reacting to failures



```
when: session disconnected: {
  // pause transmission
}
when: session reconnected: {
  // resume transmission
}
when: session expired: {
  // stop transmission
}
```



```
when: session expired: {
  // clean up resources
}
```

Event Notifications

when: type discovered: { |obj| ... }	whenever: type discovered: { |obj| ... }
when: obj disconnected: { ... }	whenever: obj disconnected: { ... }
when: obj reconnected: { ... }	whenever: obj reconnected: { ... }
when: obj expired: { ... }	
when: 5.minutes elapsed: { ... }	whenever: 5.minutes elapsed: { ... }
when: future becomes: { |result| ... }	

Event Notifications

Discovery

```
when: type discovered: { |obj| ... }          whenever: type discovered: { |obj| ... }

when: obj disconnected: { ... }               whenever: obj disconnected: { ... }

when: obj reconnected: { ... }                whenever: obj reconnected: { ... }

when: obj expired: { ... }

when: 5.minutes elapsed: { ... }              whenever: 5.minutes elapsed: { ... }

when: future becomes: { |result| ... }
```

Event Notifications

```
when: type discovered: { |obj| ... }          whenever: type discovered: { |obj| ... }
```

Failure Handling

```
when: obj disconnected: { ... }               whenever: obj disconnected: { ... }

when: obj reconnected: { ... }                whenever: obj reconnected: { ... }

when: obj expired: { ... }
```

```
when: 5.minutes elapsed: { ... }              whenever: 5.minutes elapsed: { ... }

when: future becomes: { |result| ... }
```

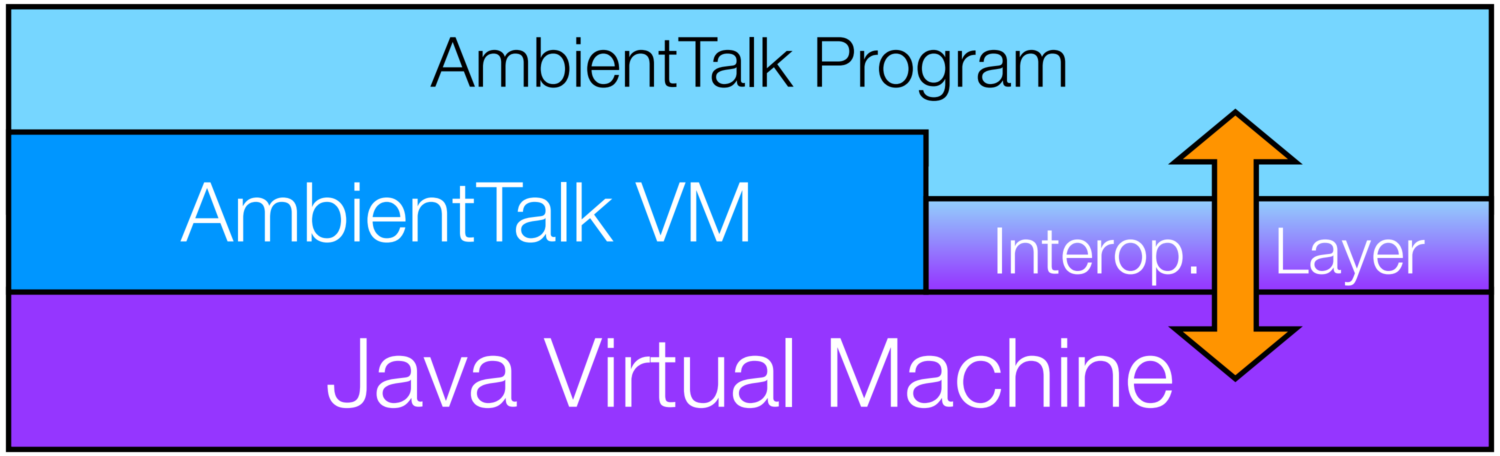
Event Notifications

```
when: type discovered: { |obj| ... }      whenever: type discovered: { |obj| ... }

when: obj disconnected: { ... }           whenever: obj disconnected: { ... }

when: obj reconnected: { ... }            whenever: obj reconnected: { ... }

when: obj expired: { ... }
```

Synchronisation

```
when: 5.minutes elapsed: { ... }          whenever: 5.minutes elapsed: { ... }

when: future becomes: { |result| ... }
```

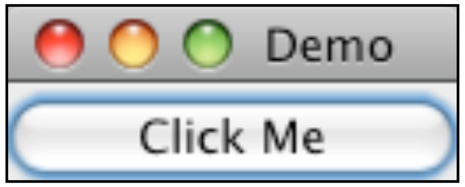
Language Interoperability



- Scripting language on top of the JVM, cfr. JRuby, Jython, Groovy, ...
- AmbientTalk can use Java libraries, Java can use AmbientTalk scripts

Batteries Included

```
def Button := jlobby.java.awt.Button;
def button := Button.new(“Click Me”);
button.addActionListener(object: {
  def actionPerformed(actionEvent) {
    println(“button clicked”);
  }
});
button.setVisible(true);
```



Reflection

- AmbientTalk code can introspect and change behavior of objects and actors

```
def makeSong(artist, title) {
  object: {
    def printArtist() {
      if: (artist == nil) then: {
        “unknown artist”;
      } else: {
        artist;
      }
    }
  }
}

def song := makeSong(“U2”, “One”);
song.printArtist();
```

Reflection

- AmbientTalk code can introspect and change behavior of objects and actors

```
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      } else: {
        artist;
      }
    }
  }
}

def song := makeSong(“U2”, “One”);
song.printArtist();
```

```
def mirrorOnSong := (reflect: song);

mirrorOnSong.invoke(song,
  createInvocation(`printArtist, []));

mirrorOnSong.listSlots();

mirrorOnSong.addSlot(slot);

...
```

Implementation

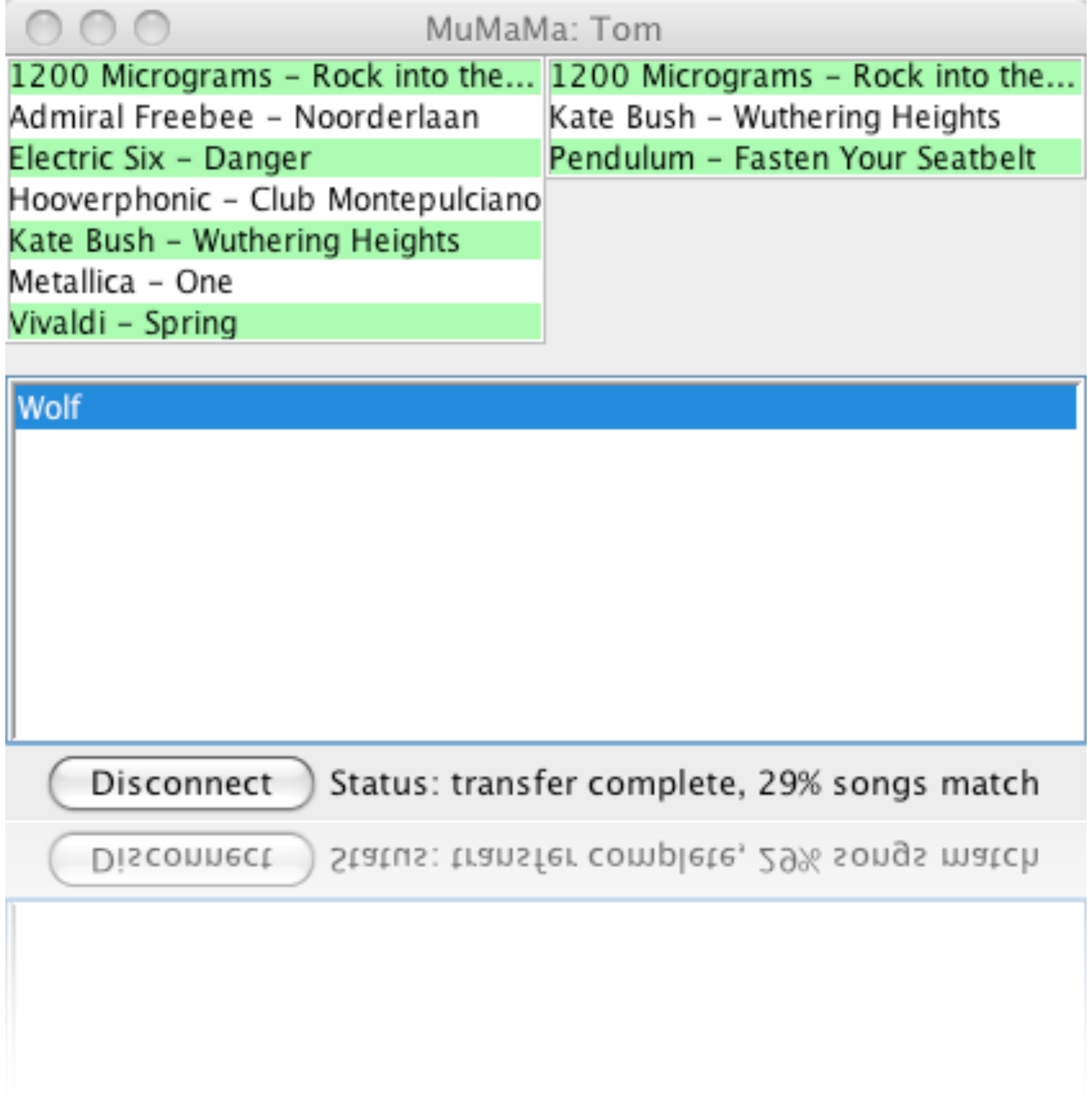
- Interactive interpreter
- ± 17.000 SLOC of Java
- UDP & TCP/IP over WLAN
- Runs on top of J2ME/CDC
  - QTek 9090 SmartPhones
  - HTC Touch Cruise SmartPhones
  - iPhone [in progress]
  - Android G1 [in progress]

Experiments

Demo Applications

Case: Musical Match Maker

- Demo



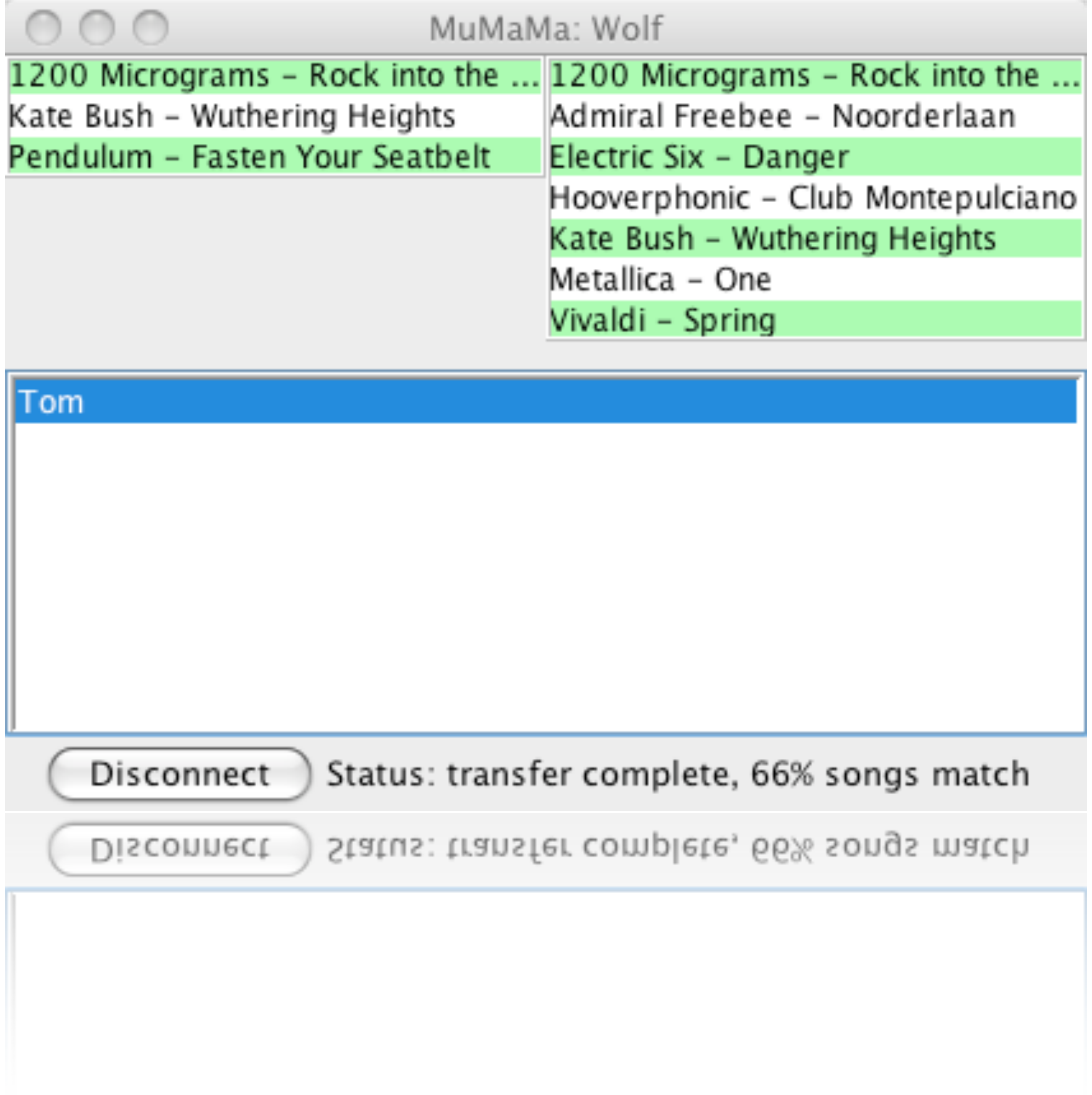
MuMaMa: Tom

1200 Micrograms - Rock into the...
Admiral Freebee - Noorderlaan
Electric Six - Danger
Hooverphonic - Club Montepulciano
Kate Bush - Wuthering Heights
Metallica - One
Vivaldi - Spring

1200 Micrograms - Rock into the...
Kate Bush - Wuthering Heights
Pendulum - Fasten Your Seatbelt

Wolf

Status: transfer complete, 29% songs match



MuMaMa: Wolf

1200 Micrograms - Rock into the ...
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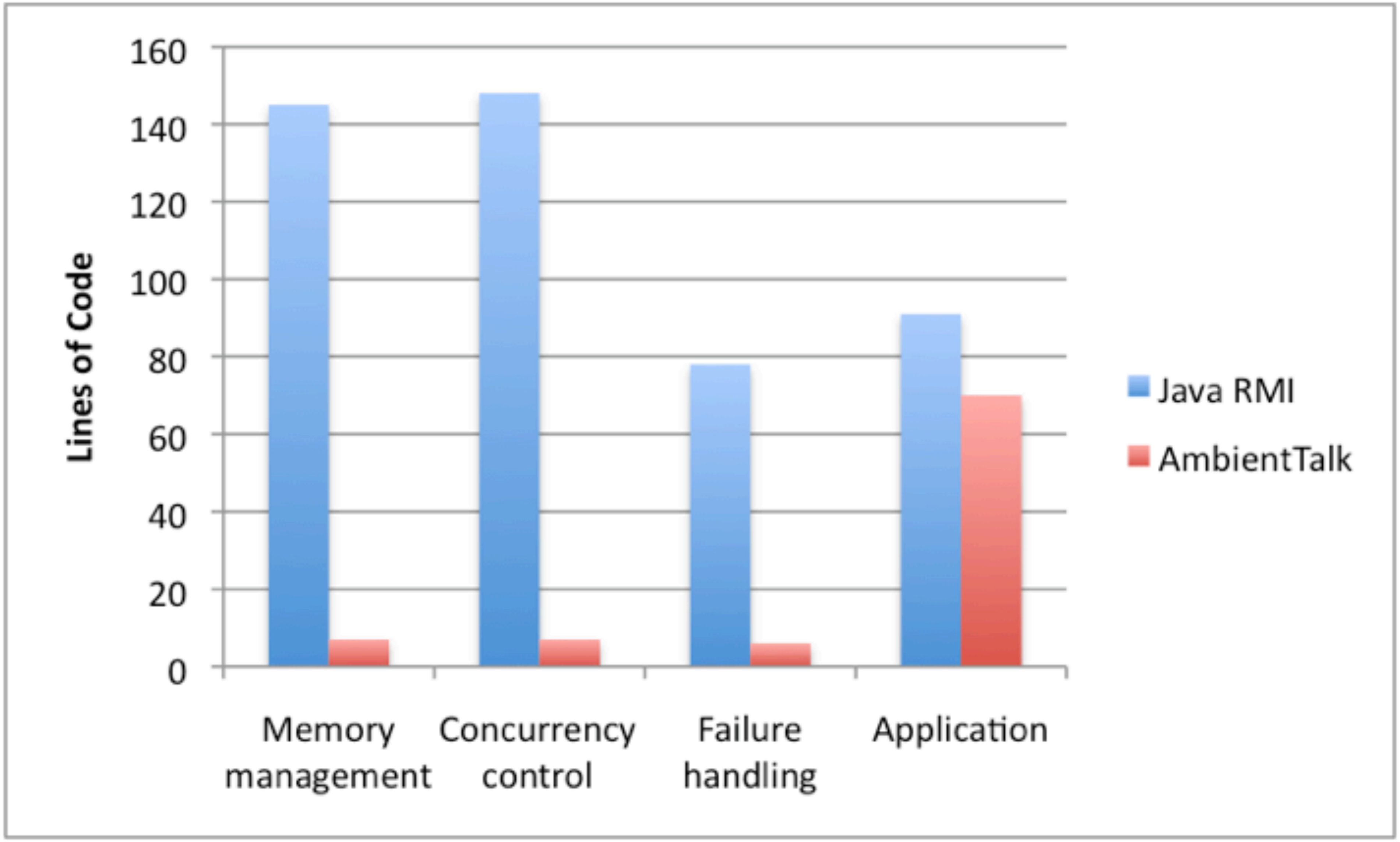
1200 Micrograms - Rock into the ...
Admiral Freebee - Noorderlaan
Electric Six - Danger
Hooverphonic - Club Montepulciano
Kate Bush - Wuthering Heights
Metallica - One
Vivaldi - Spring

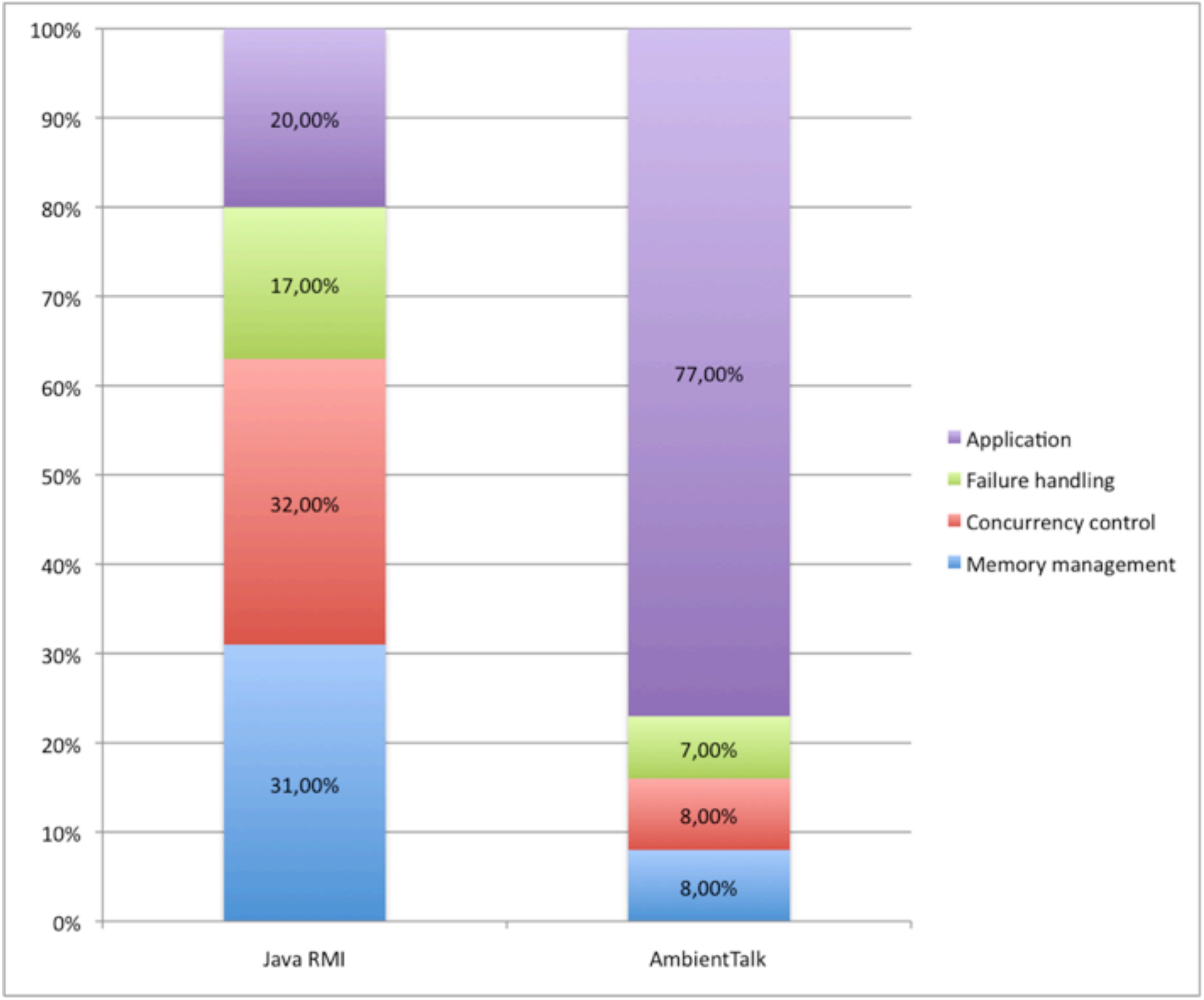
Tom

Status: transfer complete, 66% songs match

Experimental Results



Experimental Results

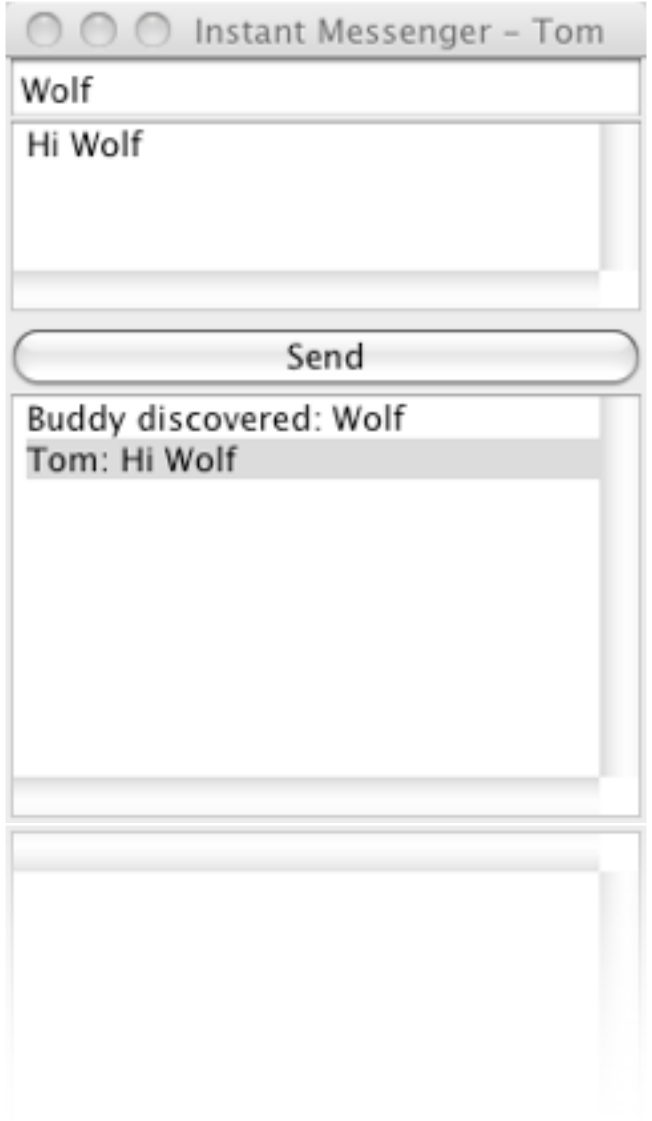


Causes

- Explicit encoding of
  - buffered, asynchronous communication using threads
  - remote messages using objects
  - timeouts using timer threads
  - event notifications (lease expiration & renewal, calls & callbacks) using listeners + event loop threads
- Java RMI does not deal with service discovery

Case: Instant Messenger

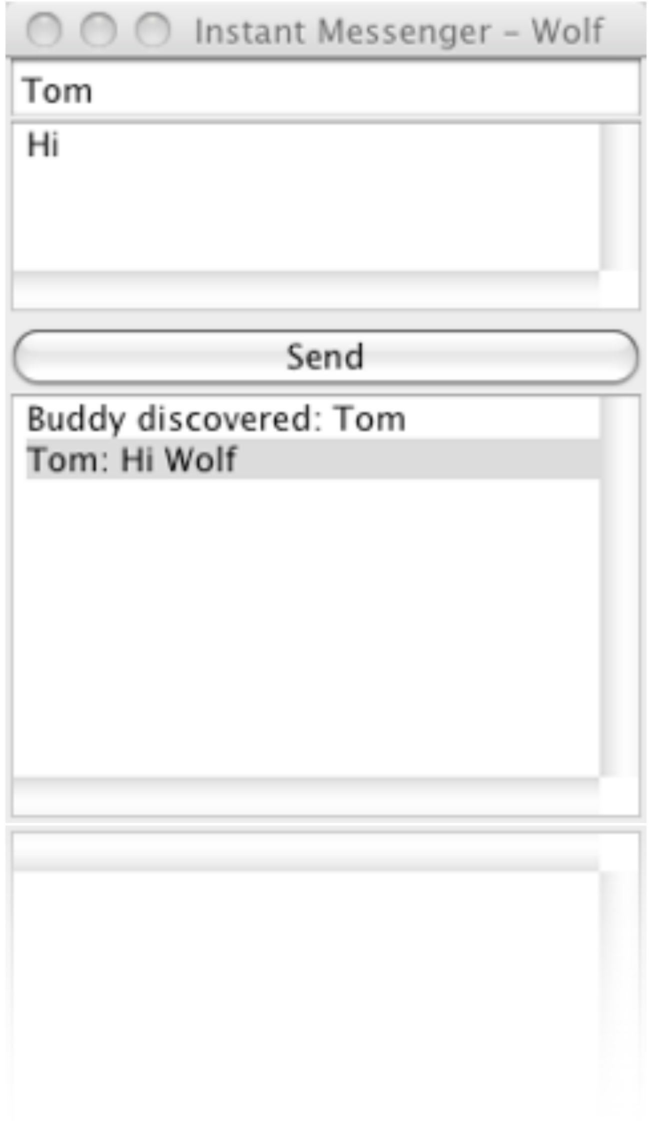
- Demo



Wolf

Hi Wolf

Buddy discovered: Wolf
Tom: Hi Wolf

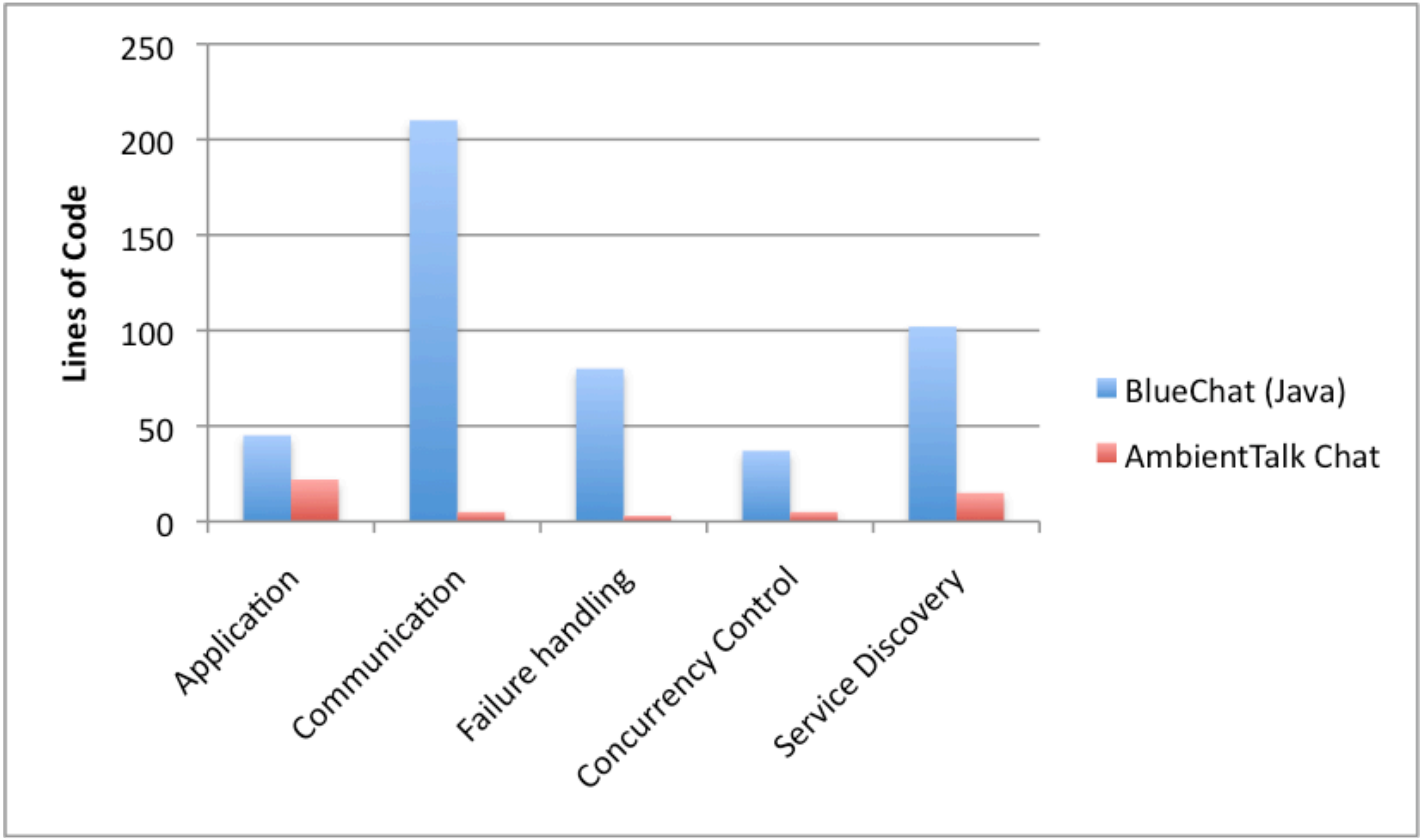


Tom

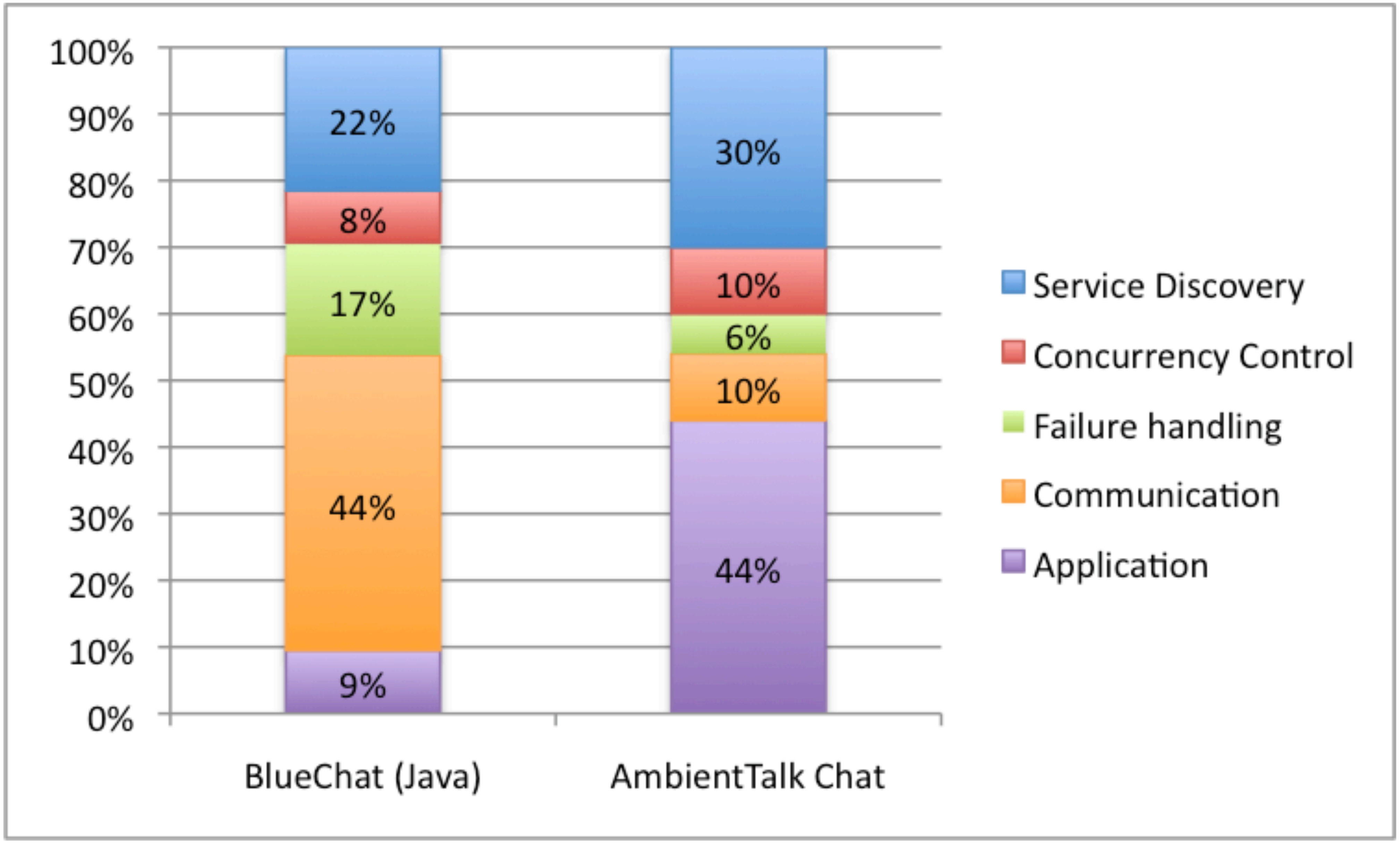
Hi

Buddy discovered: Tom
Tom: Hi Wolf

Chat: Java vs AmbientTalk (LoC)



Chat: Java vs AmbientTalk (%)



A simple application but...

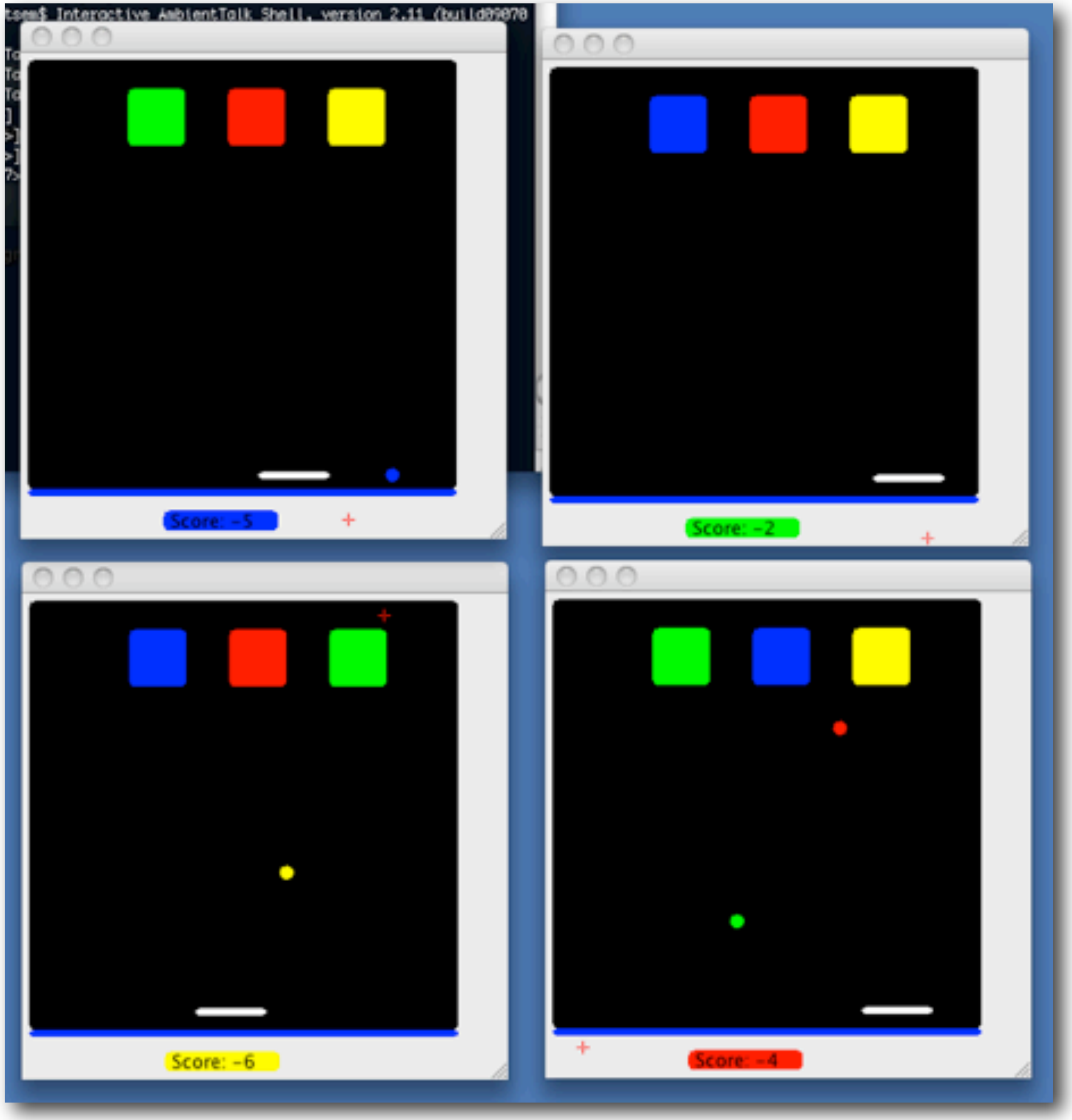
... we do not need to explicitly manage:

- threads & locks
- low-level socket connections
- stubs, skeletons
- name server or lookup service
- timeouts, leasing

AmbientMorphic

- Implementation of the Morphic UI framework from Self

- Demo: PortalPong



```
tsem$ Interactive AmbientTalk Shell, version 2.11 (build09070
```

Conclusion

- Mobile ad hoc networks:
- Ambient-oriented programming:
- AmbientTalk:
  - Scripting language on top of the JVM
  - Reactive, event-driven programs
- Applications: chat, match maker, multiplayer game

Conclusion

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Conclusion

- Mobile ad hoc networks: Zero Infrastructure Volatile Connections
- Ambient-oriented programming: Peer-to-peer Tolerate disconnections
- AmbientTalk:
  - Scripting language on top of the JVM
  - Reactive, event-driven programs
- Applications: chat, match maker, multiplayer game

Don’t program the hardware of the future with the software of the past

AMBIENTTALK

http://prog.vub.ac.be/amop