Vrije Universiteit Brussel

Loosely-coupled Distributed Reactive Programming in Mobile Ad Hoc Networks

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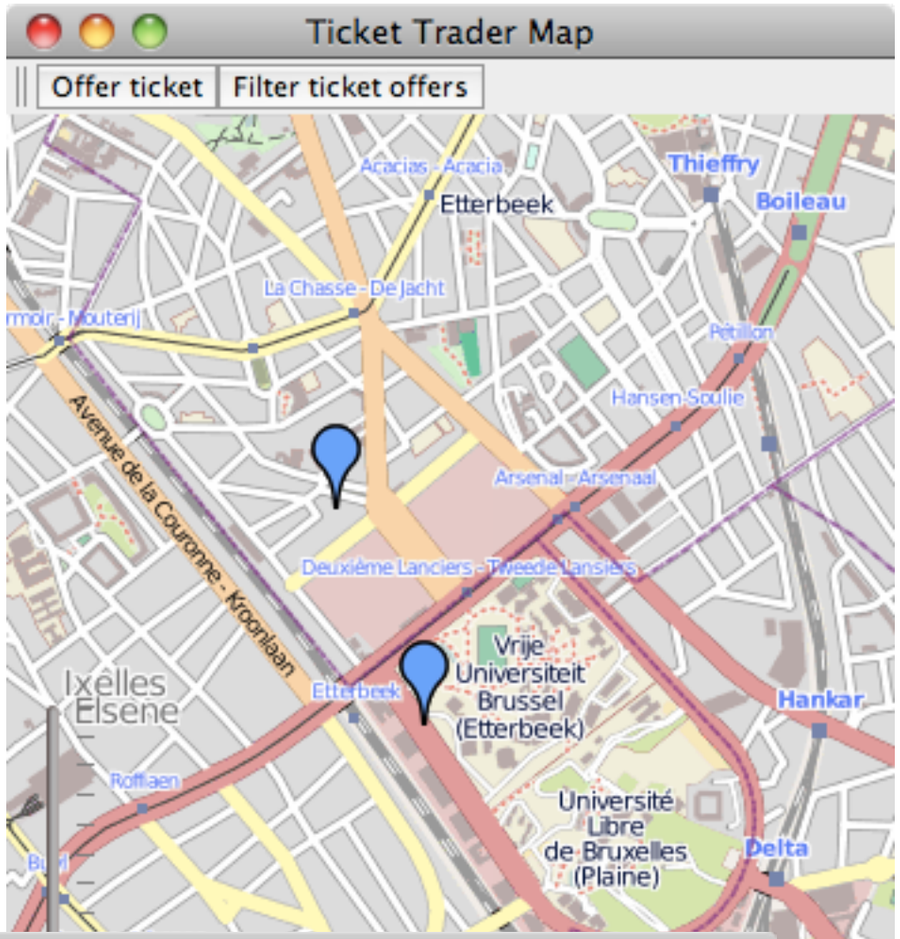
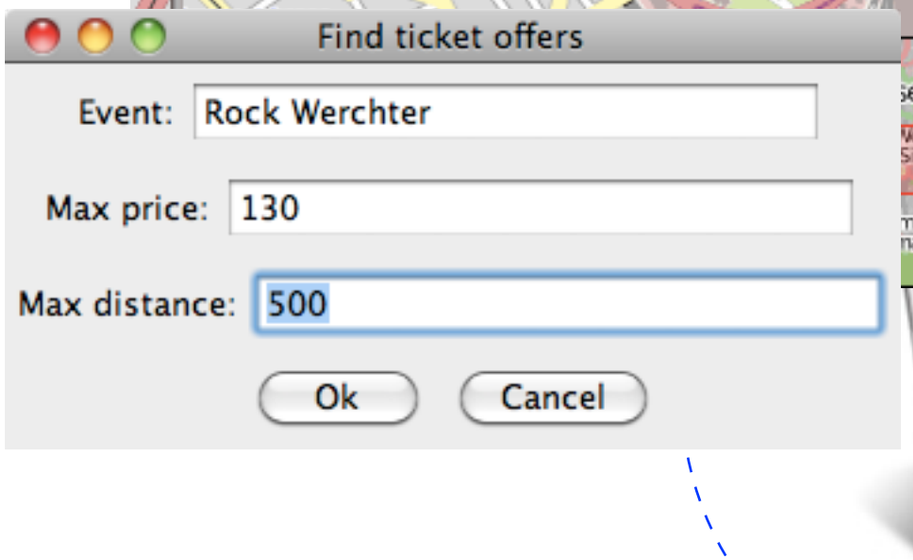
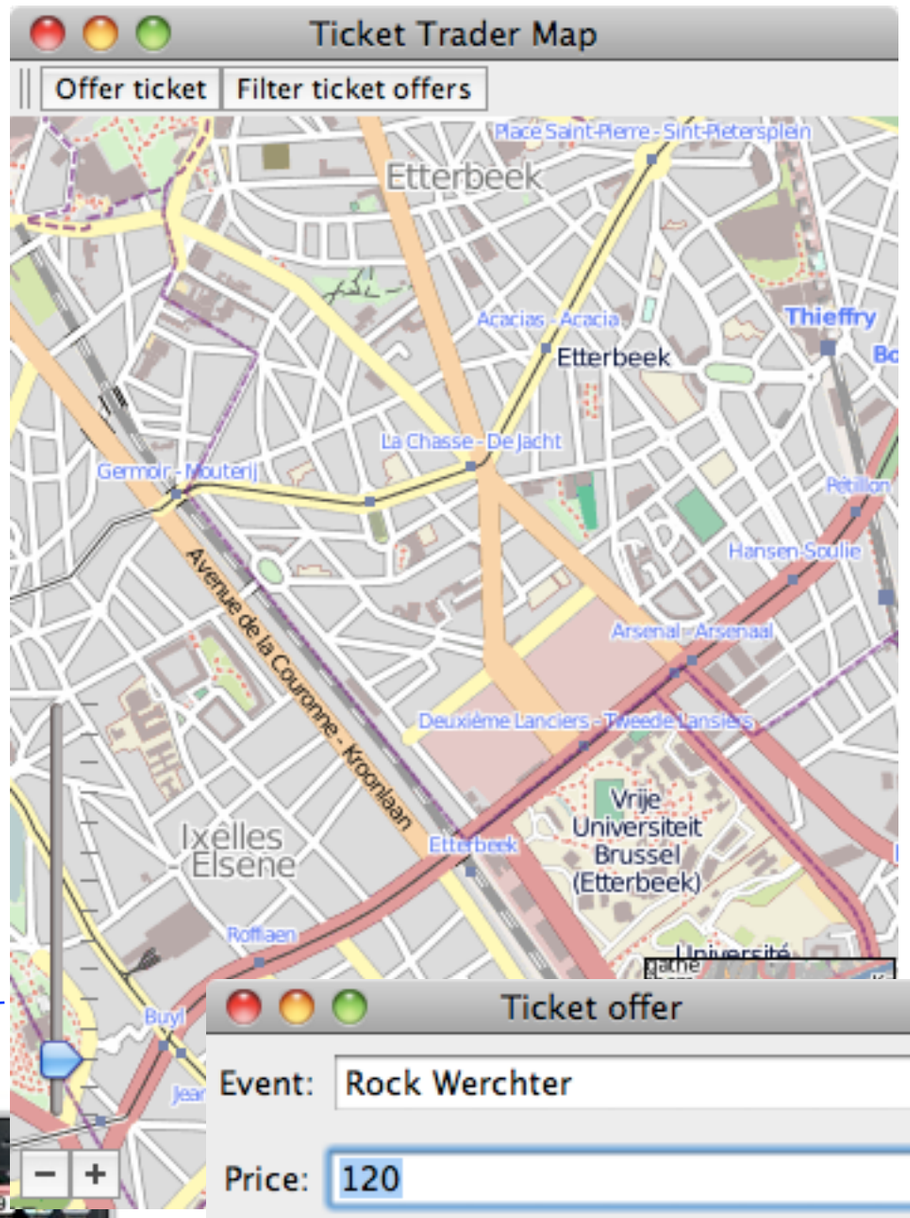
The mobile ticket trader application

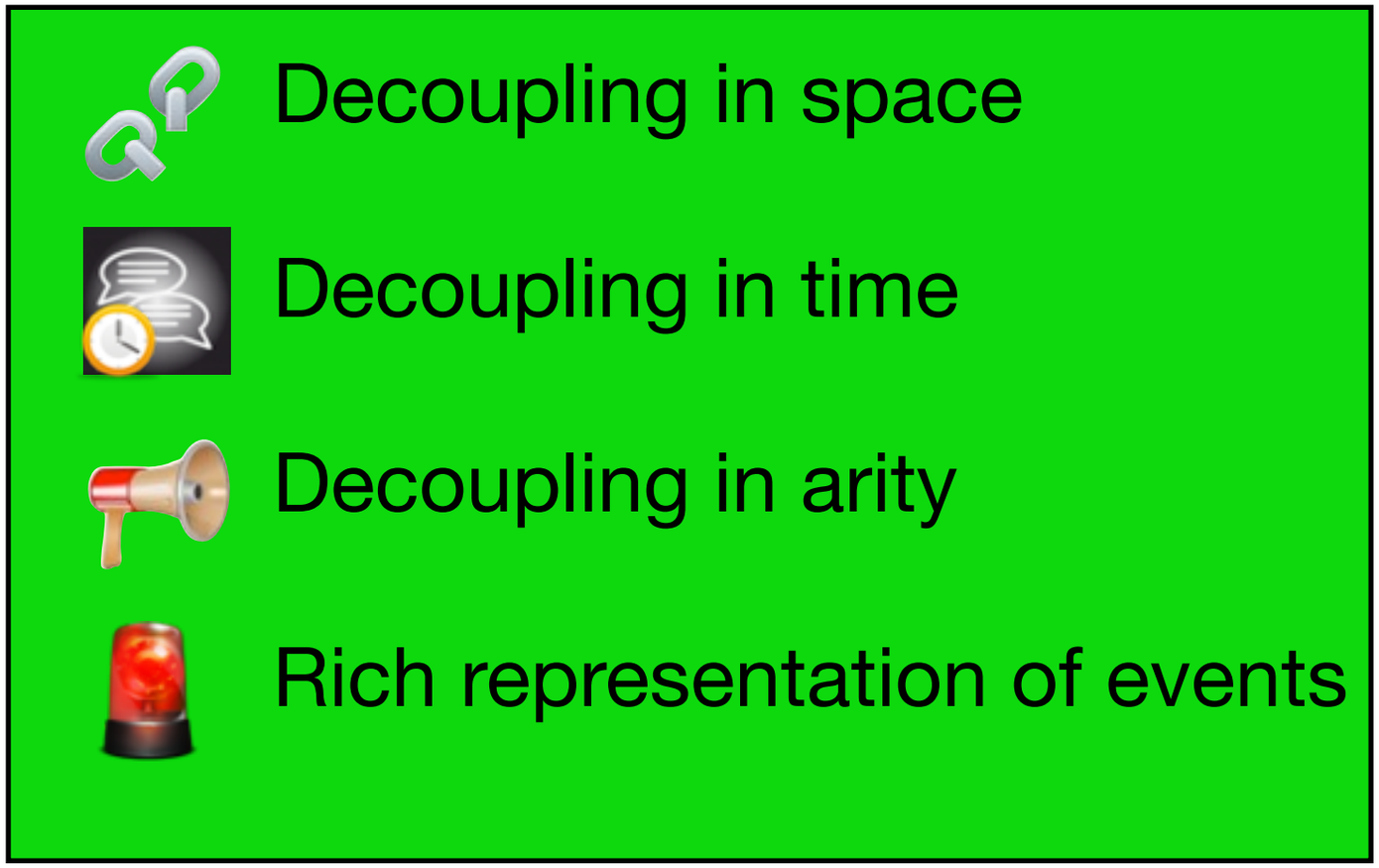




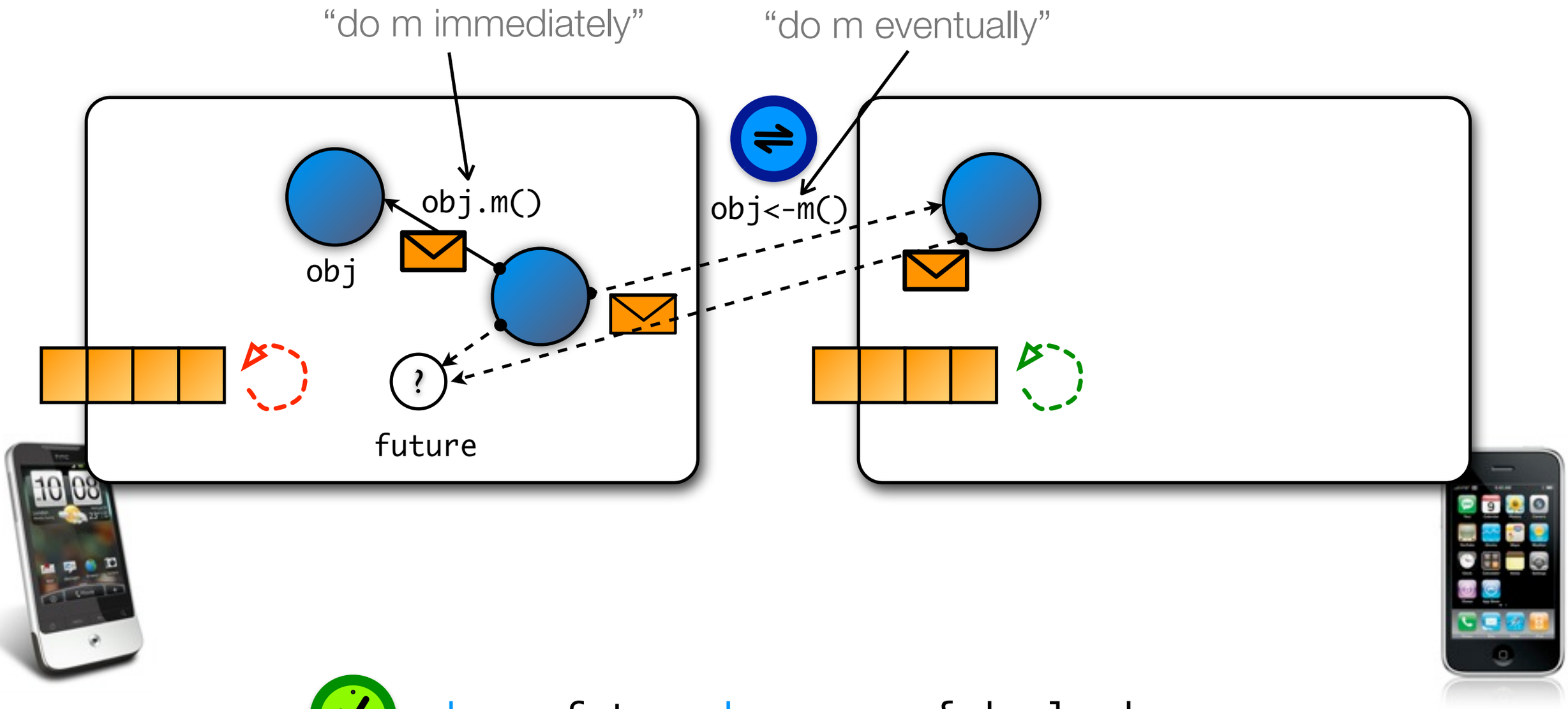


Pervasive Computing and Mobile Ad Hoc Networks

Ambient-oriented Programming in AmbientTalk

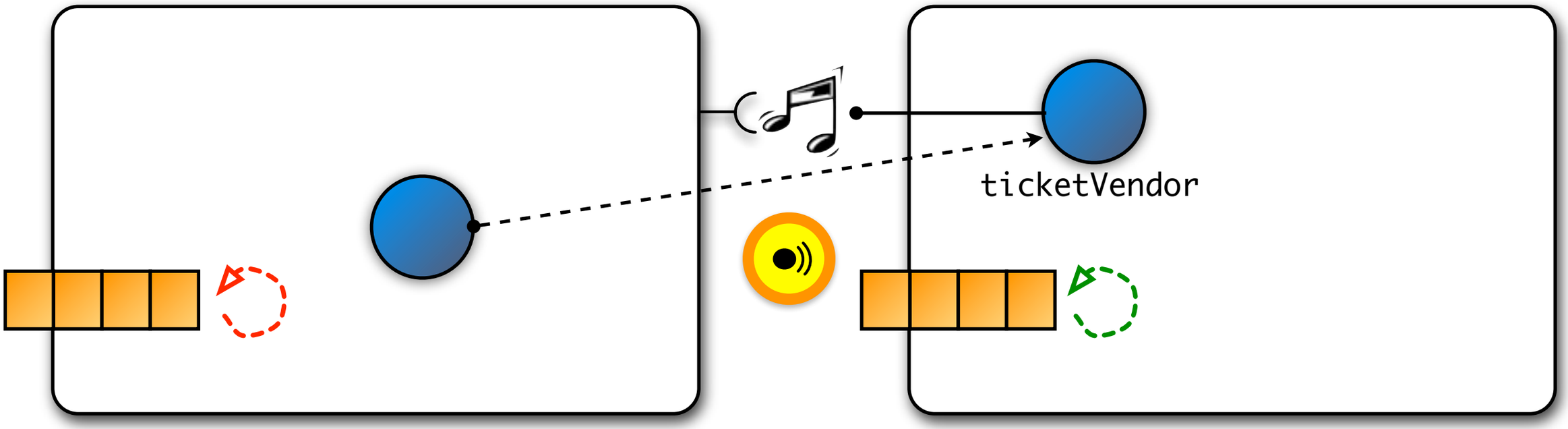


Event Loop Concurrency in AmbientTalk




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

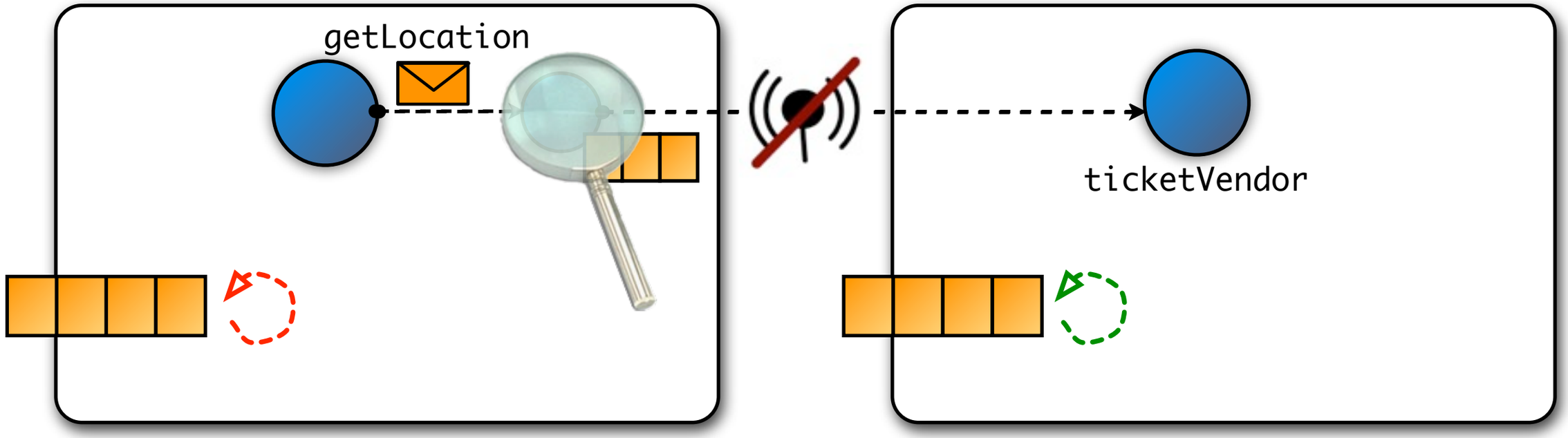
Publishing & discovering objects by topic




```
deftype TicketVendor
```

```
deftype TicketVendor
  export: ticketVendor as: TicketVendor
whenever: TicketVendor discovered: { |ticketVendor|
  // React on ticketVendor appearance
  when: ticketVendor disconnected: {
    // React on disappearance
  }
  when: ticketVendor reconnected: {
    // React on reappearance
  }}
```

Asynchronous communication




```
when: TicketVendor discovered: { |ticketVendor|
  when: ticketVendor<-getLocation()@Due(timeout) becomes: { |loc|
    // Update user interface with the location
  } catch: TimeoutException using: { |e|
    // Remove ticket offer from user interface
  }
}
```

The Ticket Trader Application

Event	Signaling	Reacting
New ticket trader connected	Automatic notification by AmbientTalk	`whenever:discovered:`
Ticket trader disconnected	Automatic notification by AmbientTalk	`when:disconnected:`
Ticket trader reconnected	Automatic notification by AmbientTalk	`when:reconnected:`
New ticket for sale	`notifyTicketForSale` asynchronous message	`notifyTicketForSale` callback
Price of ticket changed	`notifyPriceChanged` asynchronous message	`notifyPriceChanged` callback
Location of ticket trader changed	`notifyLocationChanged` asynchronous message	`notifyLocationChanged` callback
Own location changed	GPS abstraction invokes callback with new coordinates	Callback registered on GPS abstraction

*main.at

```
1
2
3 def seconds := jlobby.edu.vub.at.signals.natives.NATSeconds.instance();
4
5 system.println(seconds);
6
7
8
9
10
```

Problems | Javadoc | Declaration | Search | LogCat

Android

Save and Launch

Select resources to save:

main.at

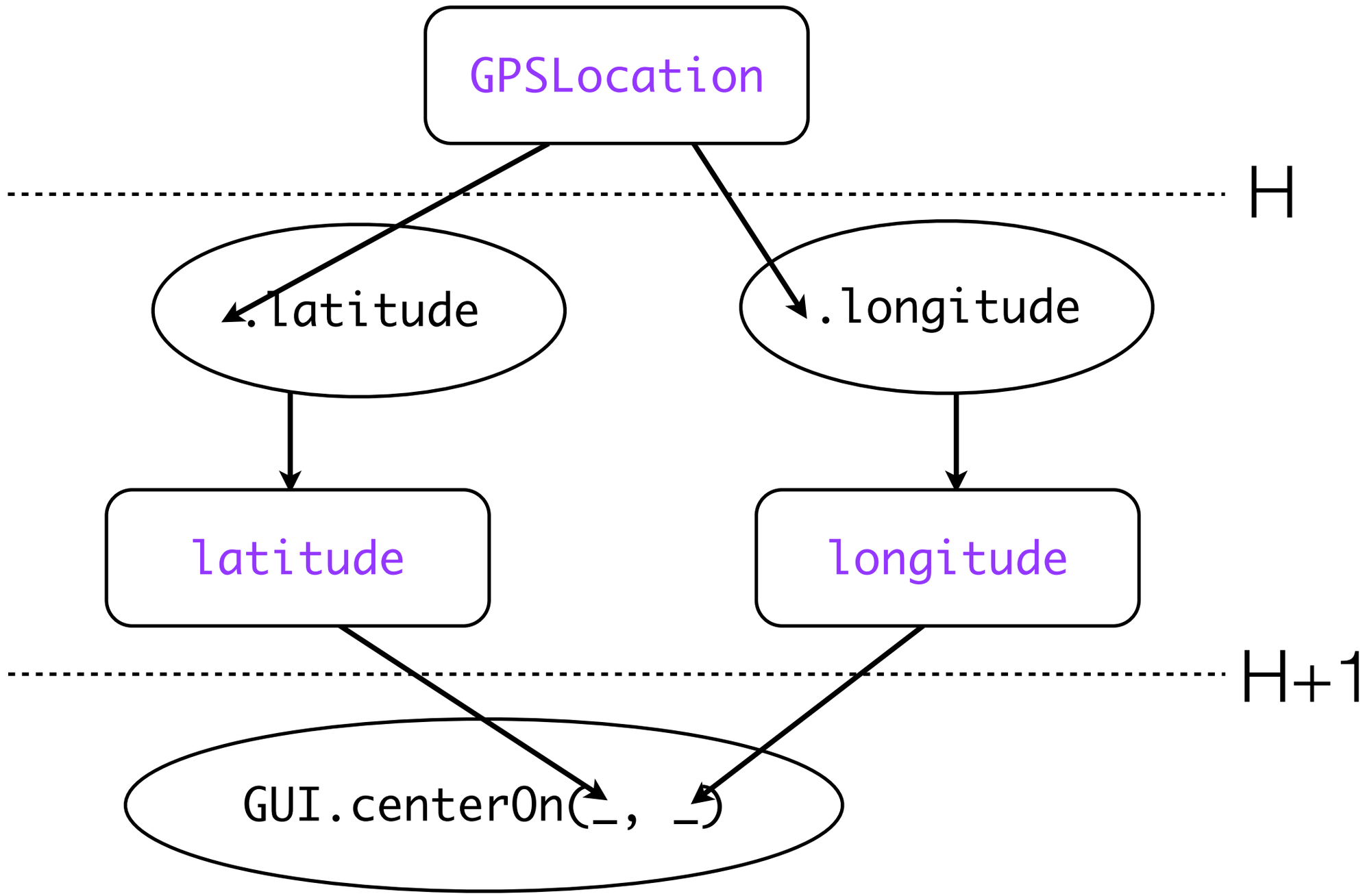
Select All | Deselect All

Always save resources before launching

Cancel | OK

Reactive Programming in AmbientTalk/R

```
GUI.centerOn(GPSLocation.latitude, GPSLocation.longitude);
```

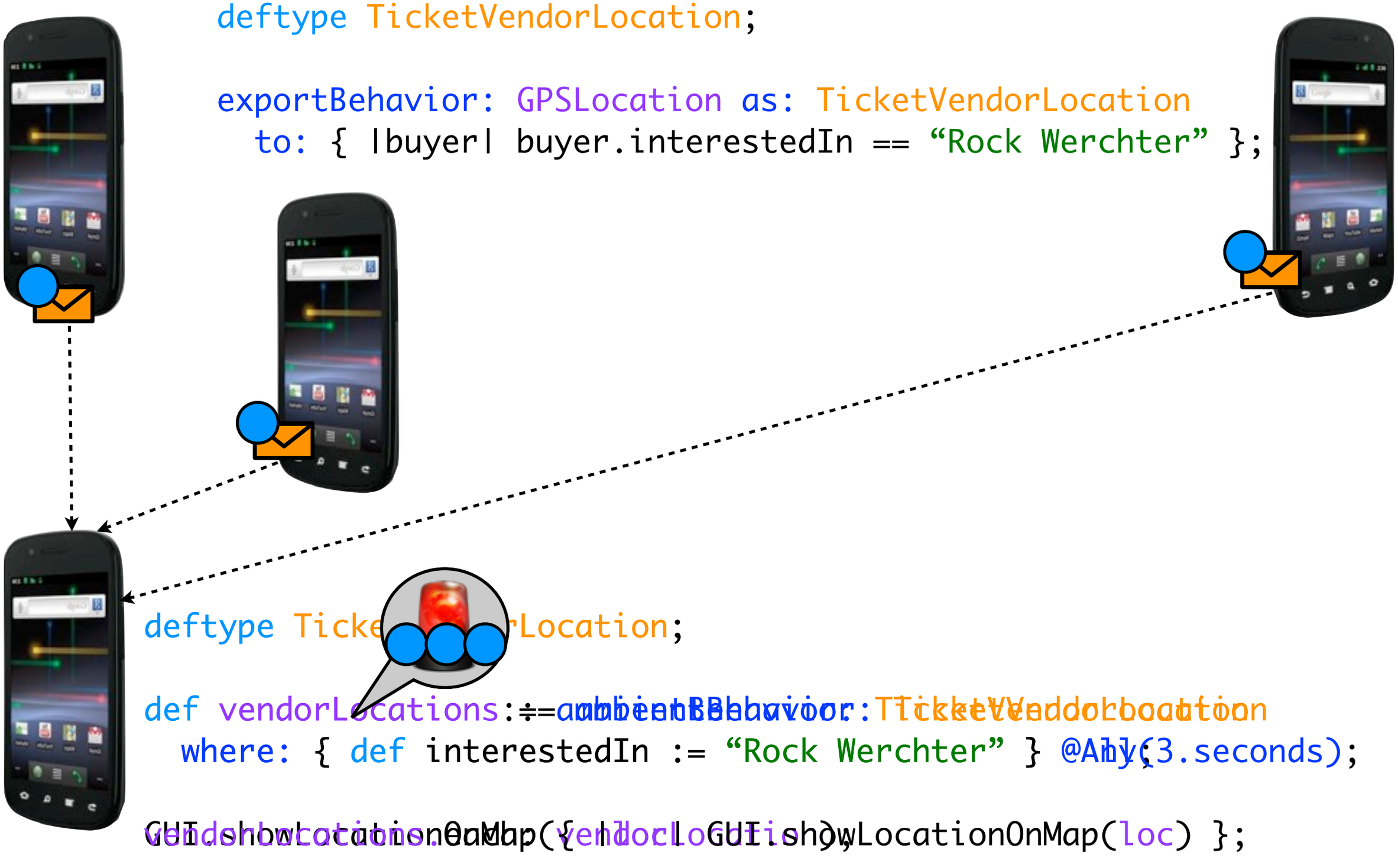


Reactive Objects 

```
def Coordinate := isolate: {
  def latitude := 0;
  def longitude := 0;

  def distanceTo(anotherCoordinate) {
    // Compute via Haversine formula
  };

  def @Mutator update(newLatitude, newLongitude) {
    latitude := newLatitude;
    longitude := newLongitude;
  };
};

def GPSLocation := makeReactive(Coordinate.new());

GPS.addLocationObserver: { |lat, lon|
  GPSLocation.update(lat, lon)
};
```

GPSLocation

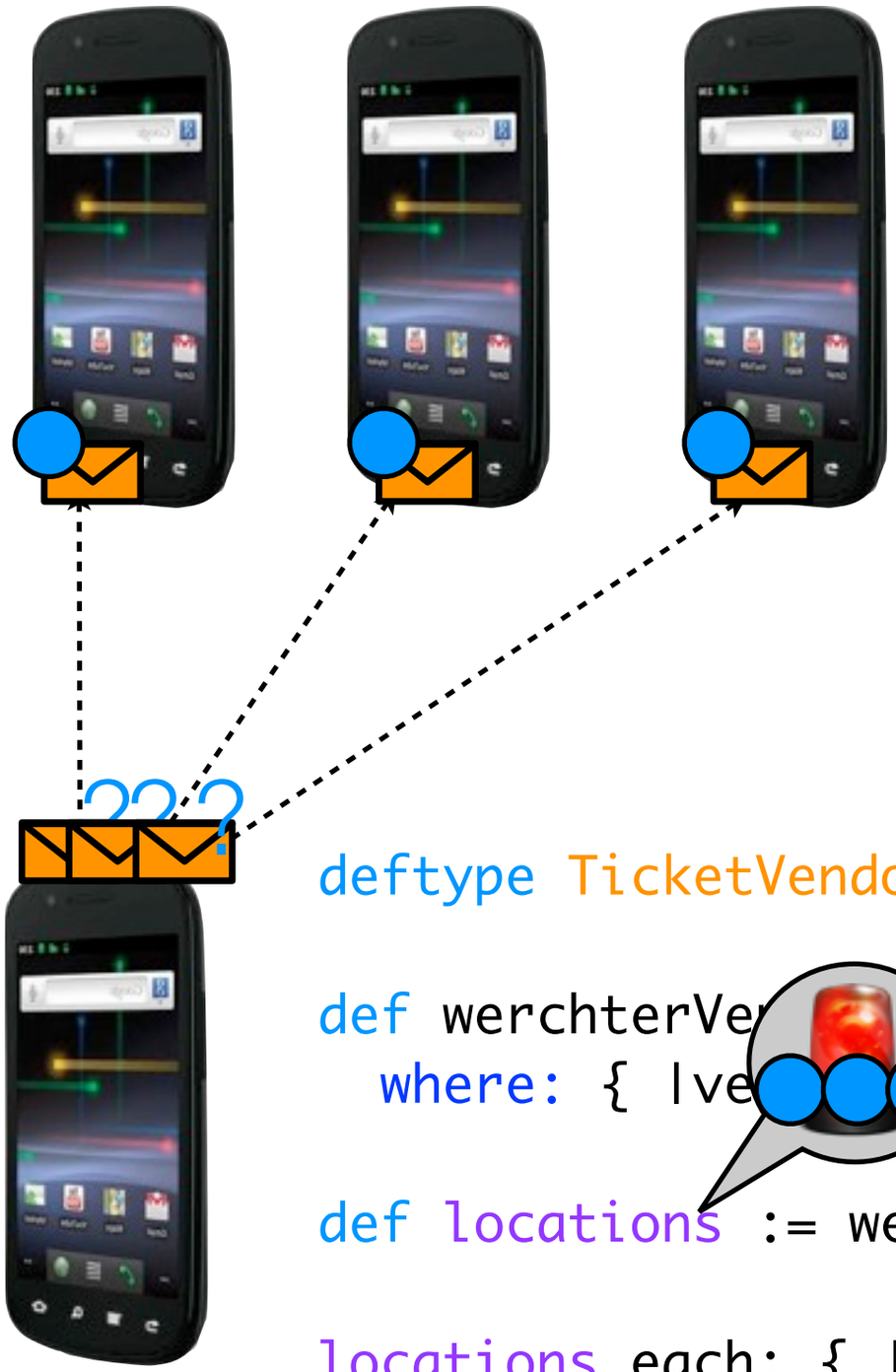
Ambient Behaviors



```
deftype TicketVendorLocation;

exportBehavior: GPSLocation as: TicketVendorLocation
  to: { |buyer| buyer.interestedIn == “Rock Werchter” };
```

```
deftype TicketVendorLocation;

def vendorLocations := ambientBehavior: TicketVendorLocation
  where: { def interestedIn := “Rock Werchter” } @Any(3.seconds);

vendorLocations.onEach: { |loc| GUI.showLocationOnMap(loc) };
```

Reactive Queries



```
deftype TicketVendor;

export: ticketVendor as: TicketVendor
  with: { def event := “Rock Werchter” };
```

```
deftype TicketVendor;

def werchterVe      := ambient: TicketVendor
  where: { |ve      vendor.event == “Rock Werchter” };

def locations := werchterVendors<-getLocation()@Refresh(3.seconds);

locations.each: { |loc| GUI.showLocationOnMap(loc) };
```

Evaluation

```
ef ticketVendor := object: {

  def clients := HashSet.new();
  def ticketOffers := HashSet.new();

  whenever: TicketClient discovered: { |client|
      clients.add(client);
      when: client disconnected: {
          clients.remove(client);
      };
      when: client reconnected: {
          clients.add(client);
      };
  };

  def offerTicket(ticketOffer) {
      clients.each: { |client| client<-notifyTicketForSale(ticketOffer) };
  };

  def changeTicketPrice(ticketOffer, newPrice) {
      ticketOffer.price := newPrice;
      clients.each: { |client| client<-notifyPriceChanged(ticketOffer) };
  };

      GPSLocation.addChangeListener({ |newLocation|
      ticketOffers.each: { |offer|
          offer.location := newLocation;
          clients.each: { |client| client<-notifyLocationChanged(offer) };
      };
  });

  def forceNotifyLocationChanged(client) {
      ticketOffers.each: { |offer| client<-notifyLocationChanged(offer) };
  };

xport: ticketVendor as: TicketVendor;
```

```
def interestingOffers := HashSet.new();

whenever: TicketVendor discovered: { |vendor|
    allVendors.add(vendor);
    when: vendor disconnected: {
        allVendors.remove(vendor);
    };
    when: vendor reconnected: {
        allVendors.add(vendor);
    };
};

def isInterestingOffer(ticketOffer) {
    ((ticketOffer.eventName == event).and:
        { ticketOffer.price <= maxPrice }).and:
            { myLocation.distanceTo(ticketOffer.location) }
        };

def notifyTicketForSale(ticketOffer) {
    if: isInterestingOffer(ticketOffer) then: {
        interestingOffers.add(ticketOffer);
        GUI.showTicketOffersOnMap(interestingTicketOffers);
    };
};

def notifyPriceChanged(ticketOffer) {
    if: isInterestingOffer(ticketOffer) then: {
        interestingOffers.add(ticketOffer);
    } else: {
        interestingOffers.remove(ticketOffer);
    };
    GUI.showTicketOffersOnMap(interestingTicketOffers);
};

def notifyLocationChanged(ticketOffer) {
    if: isInterestingOffer(ticketOffer) then: {
        interestingOffers.add(ticketOffer);
    } else: {
        interestingOffers.remove(ticketOffer);
    };
    GUI.showTicketOffersOnMap(interestingTicketOffers);
};

    GPSLocation.addChangeListener({ |newLocation|
    allVendors.each: { |vendor| vendor<-forceNotifyLocationChanged(sel
});
```

Limitations and Future Work

- AmbientTalk/R yields a higher computational overhead than plain AmbientTalk.

- Event message order preservation not guaranteed on very fine-grained levels over different communication partners.

- No timing guarantees.

- Event consumers can only create and cancel their distributed dependencies: they cannot limit the number of propagated events.