iPhone Application Programming

Location & Maps

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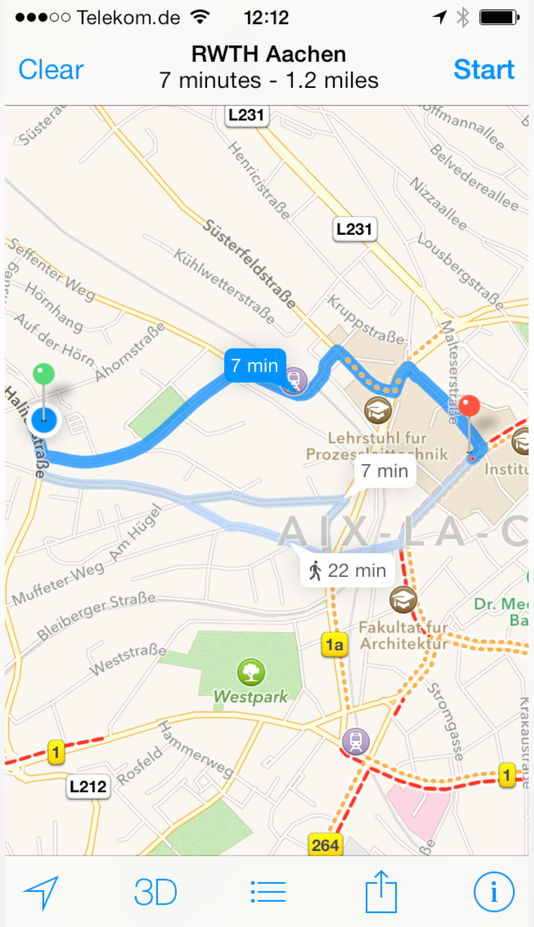
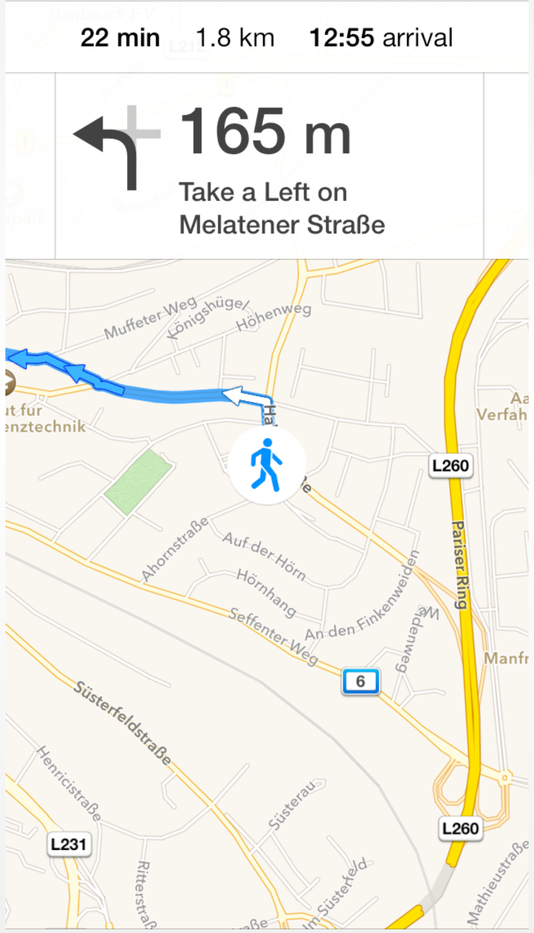
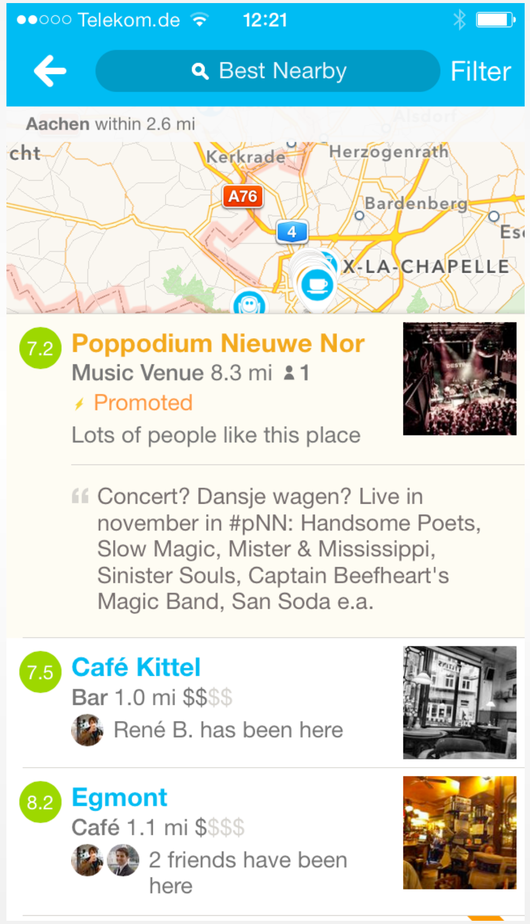
WS 2015/16
http://hci.rwth-aachen.de/iphone

Why Use Locations & Maps?







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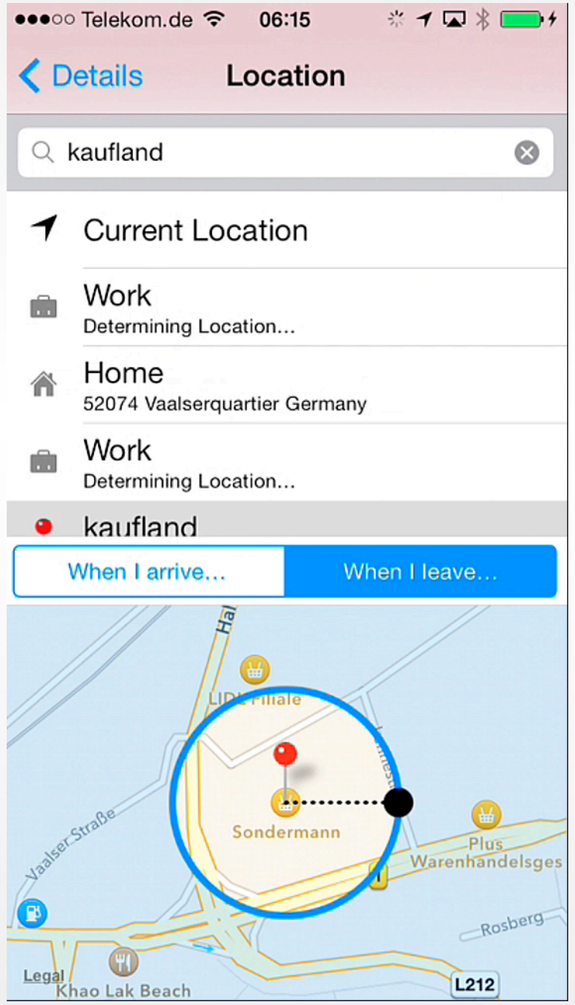
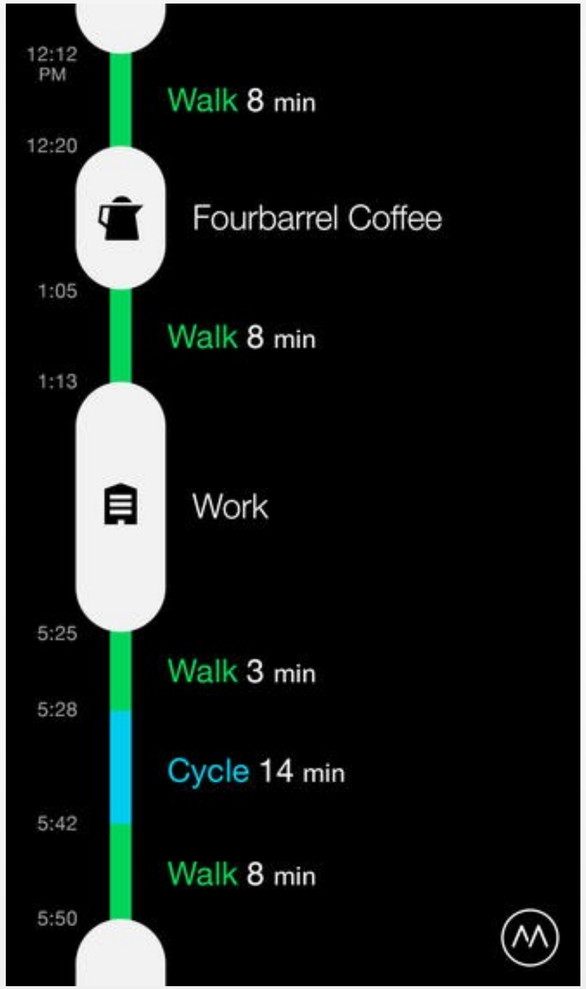
Why Use Locations & Maps?





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Core Location

- Determine where you are
- Geocoding

Map Kit

- Showing where you are
- Search and routing

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Core Location

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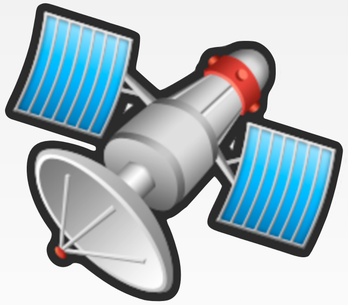
Technology



more precise

faster

consume more energy

Region monitoring

Ranging

: iBeacon (limited range, needs beacons)

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Location Monitoring

Foreground App	Background App
iBeacon ranging	
iBeacon region monitoring	
Continuous location updates and Single location request (9)	
Outdoor region monitoring	
Visit monitoring (8)	
Significant location changes	

more precise

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Overview of Core Location Usage

Your App

Core Location

request user permission →

check if the location update available →

register for the updates →

delegate called for each update ←

stop updating →

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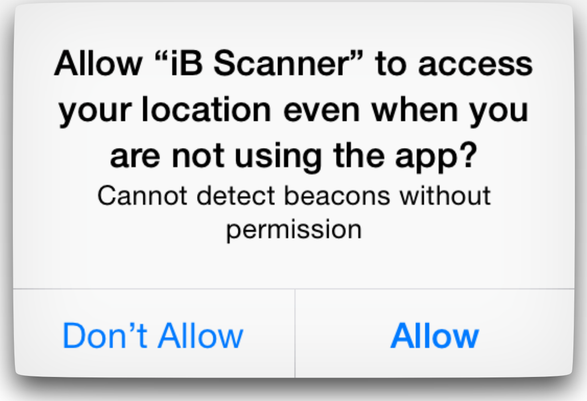
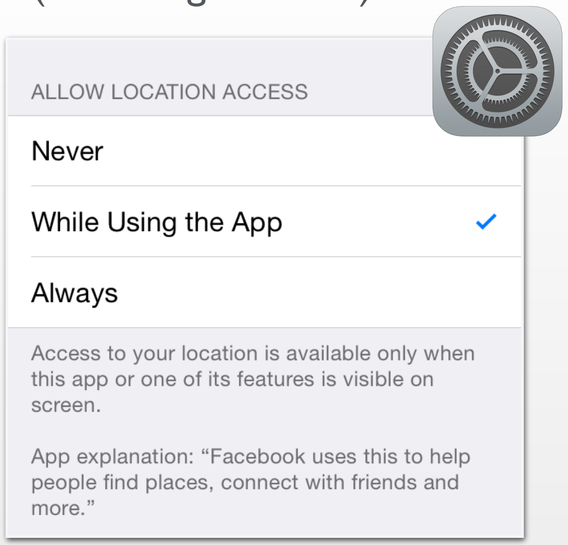
Authorization



- Enable users to control their privacy
- Two types
  - `WhenInUse:` Typical scenario including background continuous update (Encouraged mode)
  - `Always:` Anything that can launch your app
    - Region monitoring
    - Significant location changes
    - Visits



Requesting Authorization

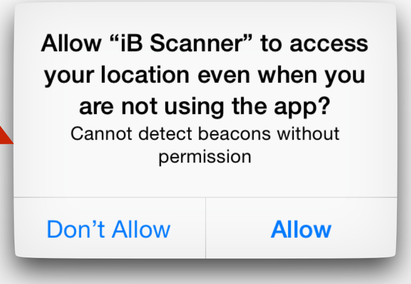
```
let locationManager = CLLocationManager()

locationManager.requestWhenInUseAuthorization()
// OR
locationManager.requestAlwaysAuthorization()
```

Before using location data

```
NSLocationWhenInUseUsageDescription
OR
NSLocationAlwaysUsageDescription
```

“Cannot detect beacons without permission”

Info.plist



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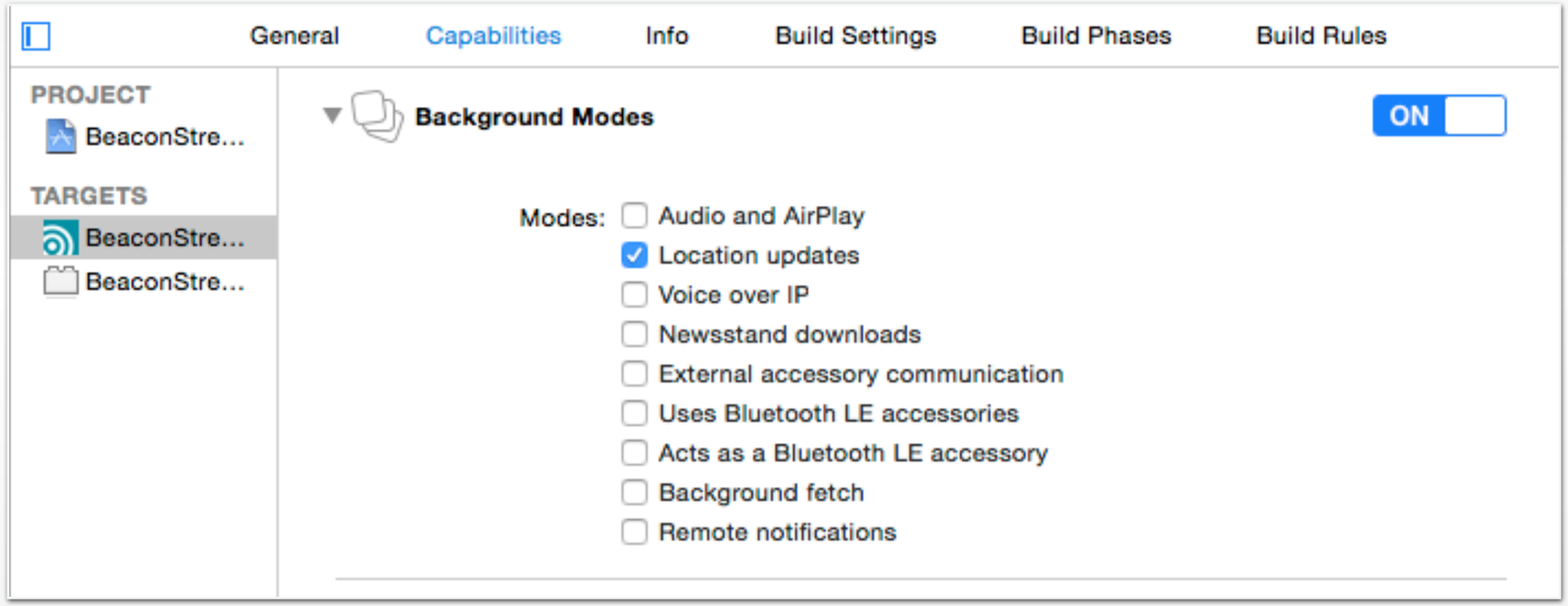
Background Mode

- Background mode allows apps to access location updates even when they are not in the foreground




```
if UIApplication.sharedApplication().backgroundRefreshStatus == .Available
```

Issues With Background Mode

- Background mode can be **dangerous**
  - User might not notice the app is running
  - App could drain battery
- Background mode **lacks a more fine-level control**
  - Currently, you either have background mode for an app or not
  - We may need to toggle background mode depending on app state

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allowsBackgroundLocationUpdates

- A property of CLLocationManager that controls the state of background mode for location updates
- Default value: **false**
  - If your app needs location updates in background mode, you need to set this to true!

Check for Availability

```
CLLocationManager.locationServicesEnabled()
CLLocationManager.headingAvailable()
CLLocationManager.isMonitoringAvailableForClass(CLCircularRegion)
CLLocationManager.isMonitoringAvailableForClass(CLBeaconRegion)
CLLocationManager.isRangingAvailable()
```

- Reasons why location services are not available
  - User disabled the services in the settings app
  - Authorization to use the services denied for your app
  - Airplane mode
- Check every time you before you register for the location update

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Getting Location Data (1)

```
// Get a reference to the Location Manager
let locationManager = CLLocationManager()

// -- viewDidLoad() --

// Set ourselves as the delegate (CLLocationManagerDelegate)
self.locationManager.delegate = self

// Request authorization from the user
if CLLocationManager.authorizationStatus() == .NotDetermined {
    self.locationManager.requestWhenInUseAuthorization()
} else if CLLocationManager.authorizationStatus() != .AuthorizedWhenInUse {
    UIApplication.sharedApplication().openURL(NSURL(string: UIApplicationOpenSettingsURLString)!)
}


// Respond to changes in authorization
func locationManager(manager: CLLocationManager,
     didChangeAuthorizationStatus status: CLAuthorizationStatus) {
    …
}
```

Getting Location Data (2)

```
if CLLocationManager.locationServicesEnabled() {
    self.locationManager.startUpdatingLocation()
}

#pragma mark CLLocationManagerDelegate methods

func locationManager(manager: CLLocationManager,
    didUpdateToLocation newLocation: CLLocation,
    fromLocation oldLocation: CLLocation) {

    print(“newLocation: ", newLocation)
}

func locationManager(manager: CLLocationManager,
    didFailWithError error: NSError) {

    print(“Error: ", error)
}
```

Issues with Continuous Location Updates

- First few location updates are *inaccurate*
- Requires a lot of steps
  - Start tracking
  - Implement delegate
  - Monitor the location updates to figure out the best update (e.g., by sampling previous points)
  - Stop tracking

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requestLocation

- Automatically: starts location updates, monitors updates to find the update with the desired accuracy, and stops location updates
- Uses *desiredAccuracy* property
- *locationManager:didUpdateLocations* is called **once** with the desired location update
- **Note:** Cannot be used alongside continuous location updates!
  - If you use both, continuous location updates takes precedence.

CLLocation Object

- coordinate (lat, long)
- altitude (m)
- horizontalAccuracy (m) and verticalAccuracy (m)
- timestamp (NSDate)
- description (string)
- course (degree) and speed (m/s)
- floor (floor number; when available)
- distanceFromLocation:(_ location: CLLocation) (m)

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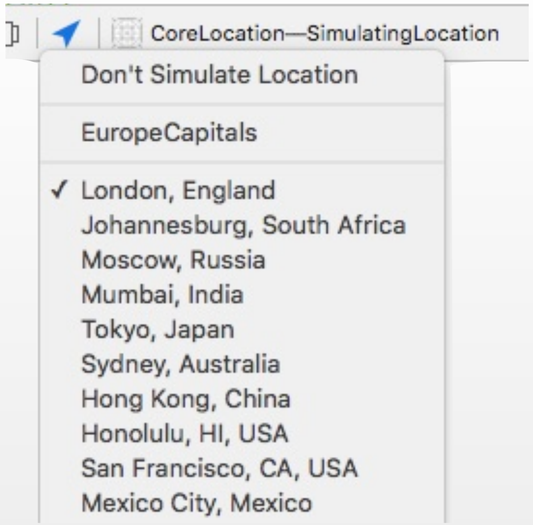
Demo: Simulating Location



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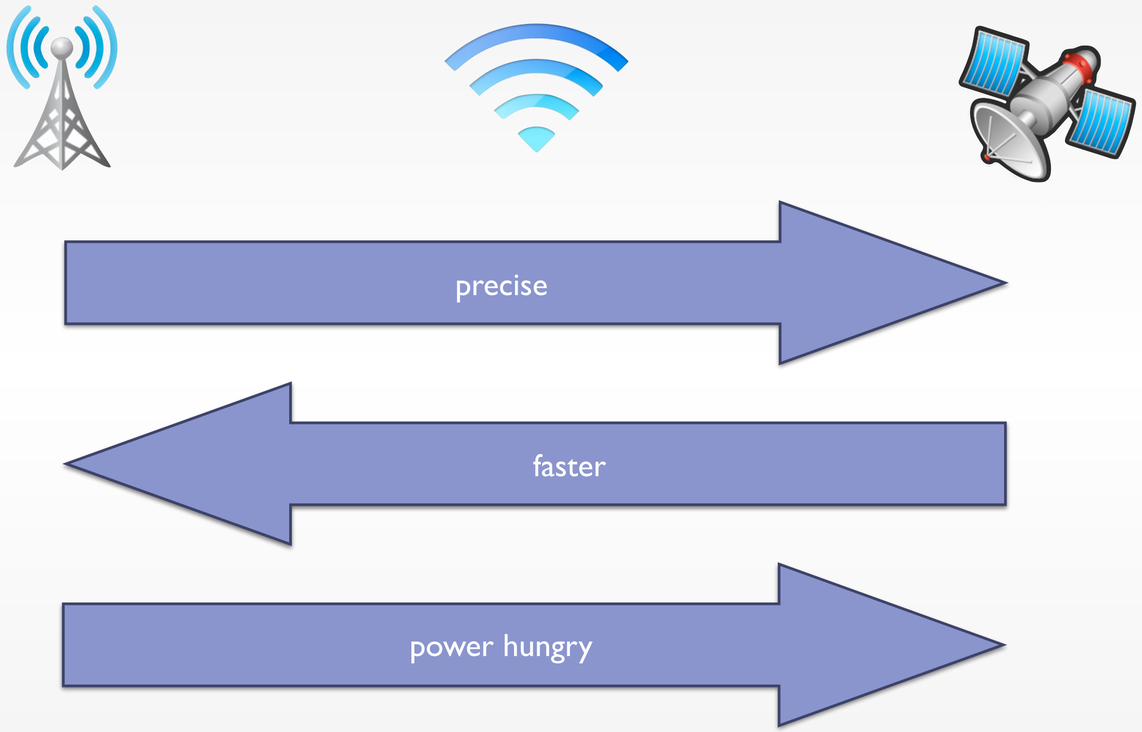
GPX Format

- Open-source
- XML based
- Can be used to describe
  - *waypoints*
  - *tracks*
  - *routes*

```
<wpt lon="6.0713038444518999" lat="50.7894134521484020">
    <ele>205.0</ele>
    <time>2013-06-02T07:51:00.000Z</time>
</wpt>
<wpt lon="6.0709676742553702" lat="50.7893638610839986">
    <ele>202.0</ele>
    <time>2013-06-02T07:51:05.000Z</time>
</wpt>
```

Location Manager Settings

- Desired accuracy
  - Best for navigation
  - Best
  - Nearest ten meters
  - Hundred meters
  - Kilometer
  - Three kilometers
- Distance Filter
  - The minimum distance a device must move laterally before an update event is generated.



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Significant Location Changes

Always

```
self.locationManager.startMonitoringSignificantLocationChanges()

self.locationManager.stopMonitoringSignificantLocationChanges()


#pragma mark CLLocationManagerDelegate methods

func locationManager(manager: CLLocationManager,
    didUpdateToLocation newLocation: CLLocation,
    fromLocation oldLocation: CLLocation) {

    print(“newLocation: ", newLocation)
}

func locationManager(manager: CLLocationManager,
    didFailWithError error: NSError) {

    print(“Error: ", error)
}
```


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Monitoring Regions

Always

- Monitor user's position and fires when user crosses the boundary of a defined geographic region
- System launches your app in the background
- **Circular** regions (GPS) or **iBeacon** regions (Bluetooth LE)

Monitoring Regions

```
func registerRegionWithOrigin(origin: CLLocationCoordinate2D,
    radius rad: CLLocationDistance,
    andIdentifier id: String) -> Bool {

    // Check if region monitoring service is available
    if !CLLocationManager.isMonitoringAvailableForClass(CLCircularRegion) {
        return false
    }

    // Make sure the radius is not more than the maximum monitorable value
    let radius = min(rad, self.locationManager.maximumRegionMonitoringDistance)

    // Create a circular region
    let region = CLCircularRegion.init(center: origin, radius: radius, identifier: id)

    // Specify when to notify
    region.notifyOnEntry = true
    region.notifyOnExit = false

    // Start monitoring the region
    self.locationManager.startMonitoringForRegion(region)

    return true;
}
```

CLLocationManager Delegate

```
func locationManager(manager: CLLocationManager,
    didEnterRegion region: CLRegion)

func locationManager(manager: CLLocationManager,
    didExitRegion region: CLRegion)

func locationManager(manager: CLLocationManager,
    monitoringDidFailForRegion region: CLRegion?,
    withError error: NSError)

func locationManager(manager: CLLocationManager,
    didDetermineState state: CLRegionState,
    forRegion region: CLRegion)
```

iBeacon Region Monitoring

```
func registerBeaconRegionWithUUID(UUID: NSUUID,
    AndIdentifier id: String) -> Bool {

    // Check if region monitoring service is available
    if !CLLocationManager.isMonitoringAvailableForClass(CLBeaconRegion) {
        return false
    }

    // Create a beacon region
    let region = CLBeaconRegion.init(proximityUUID: UUID, identifier: id)

    // Specify when to notify
    region.notifyOnEntry = true
    region.notifyOnExit = true

    // Start monitoring the region
    self.locationManager.startMonitoringForRegion(region)

    return true
}

func locationManager(manager: CLLocationManager, didEnterRegion region: CLRegion)

func locationManager(manager: CLLocationManager, didExitRegion region: CLRegion)
```


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Ranging with iBeacons

```
if !CLLocationManager.isRangingAvailable() {
    return false
}

self.locationManager.startRangingBeaconsInRegion(region)

// Delegate methods
func locationManager(manager: CLLocationManager,
    didRangeBeacons beacons: [CLBeacon],
    inRegion region: CLBeaconRegion) {

    let aBeacon = beacons[0]

    print("RSSI: ", aBeacon.rssi) // in Decibels
    print("Proximity: ", aBeacon.proximity) // CLProximityUnknown, CLProximityImmediate,
                                                CLProximityNear, CLProximityFar
    print("Accuracy:  ", aBeacon.accuracy) // in meters
}

func locationManager(manager: CLLocationManager,
    rangingBeaconsDidFailForRegion region: CLBeaconRegion,
    withError error: NSError)
```

Fine-grained Positioning with RSSI

- Received Signal Strength Indicator
- High level of uncertainty
- Influencing factors
  - Obstructions: iPhone case, physical environment (e.g., walls, doors), users' body, …
  - Radio noise
- Using RSSI from one beacon: Inconsistent due to signal noise
- Use RSSI from multiple iBeacons + classification algorithm
  - E.g., Support Vector Machine (libsvm)
  - See Brunato, Mauro, and Roberto Battiti. "**Statistical learning theory for location fingerprinting in wireless LANs.**" Computer Networks 47.6 (2005): 825-845.

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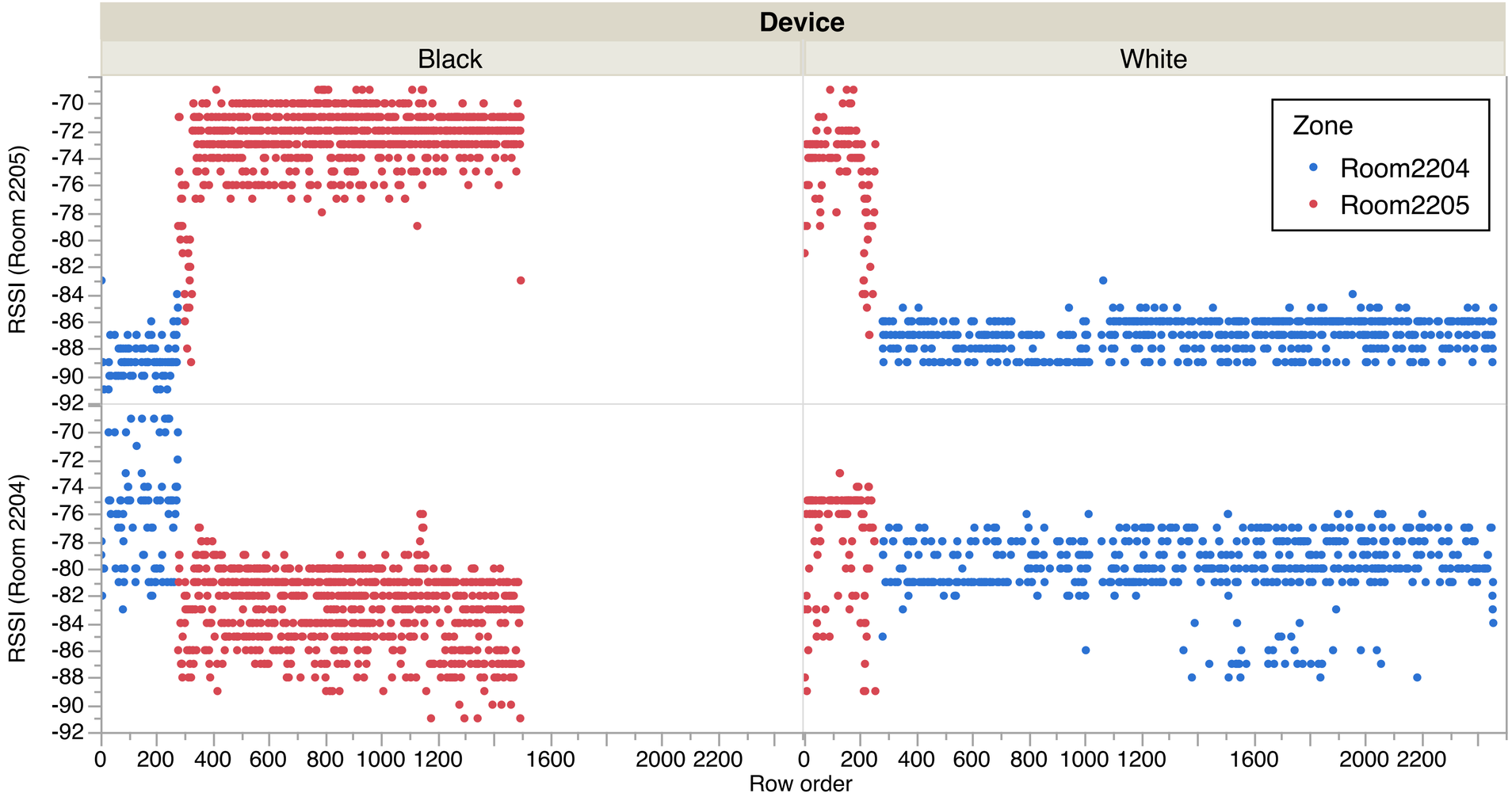
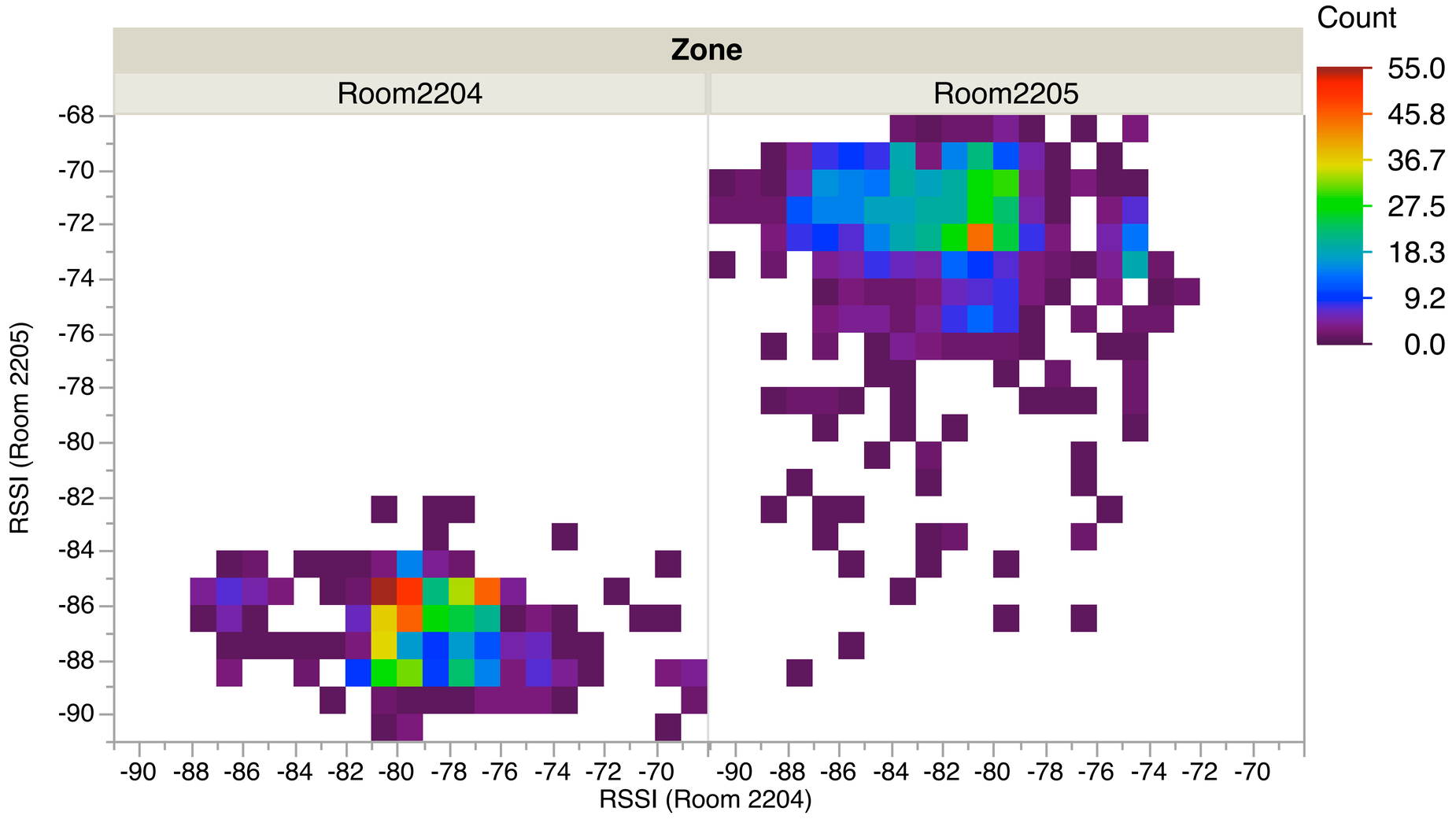
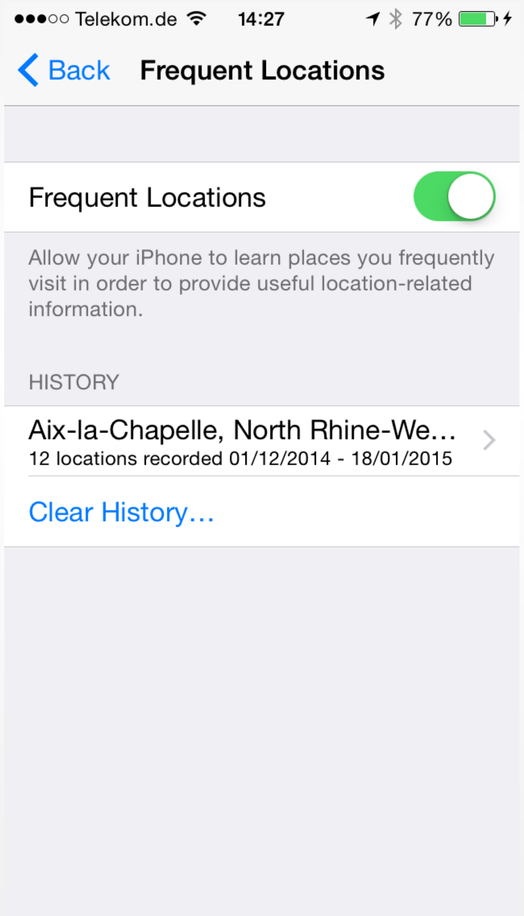
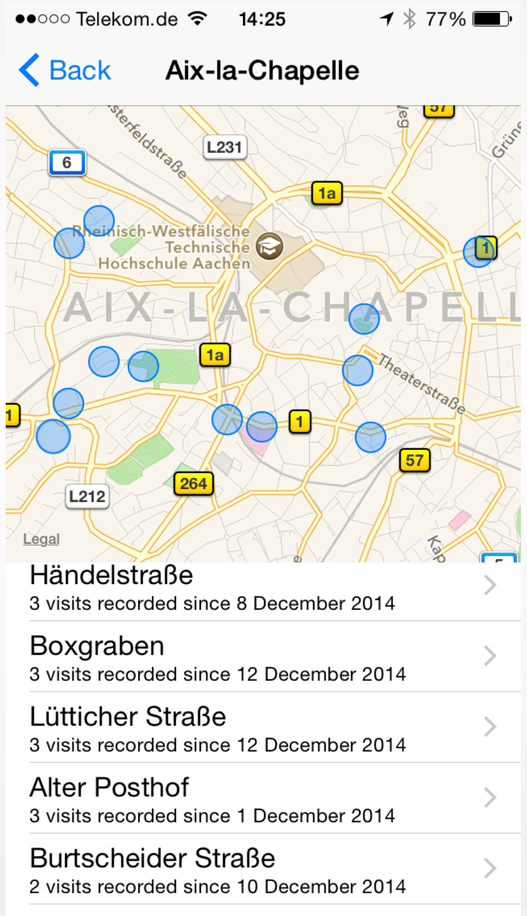

Device
Black
White
Zone
Room2204
Room2205
RSSI (Room 2205)
RSSI (Room 2204)
-70
-72
-74
-76
-78
-80
-82
-84
-86
-88
-90
-92
0
200
400
600
800
1000
1200
1600
2000
2200
Row order


Zone
Room2204
Room2205
Count
55.0
45.8
36.7
27.5
18.3
9.2
0.0
RSSI (Room 2205)
-68
-70
-72
-74
-76
-78
-80
-82
-84
-86
-88
-90
-90 -88 -86 -84 -82 -80 -78 -76 -74 -72 -70
-90 -88 -86 -84 -82 -80 -78 -76 -74 -72 -70
RSSI (Room 2204)

Monitoring Visits

- Characteristics
  - Place & time are recognized by iOS
    - Your app cannot specify the places
    - Can be disabled by the user
  - Imprecise location
  - Delayed event delivery
  - Low energy consumption
- Applications
  - Check-in apps
  - Journal apps





Monitoring Visits

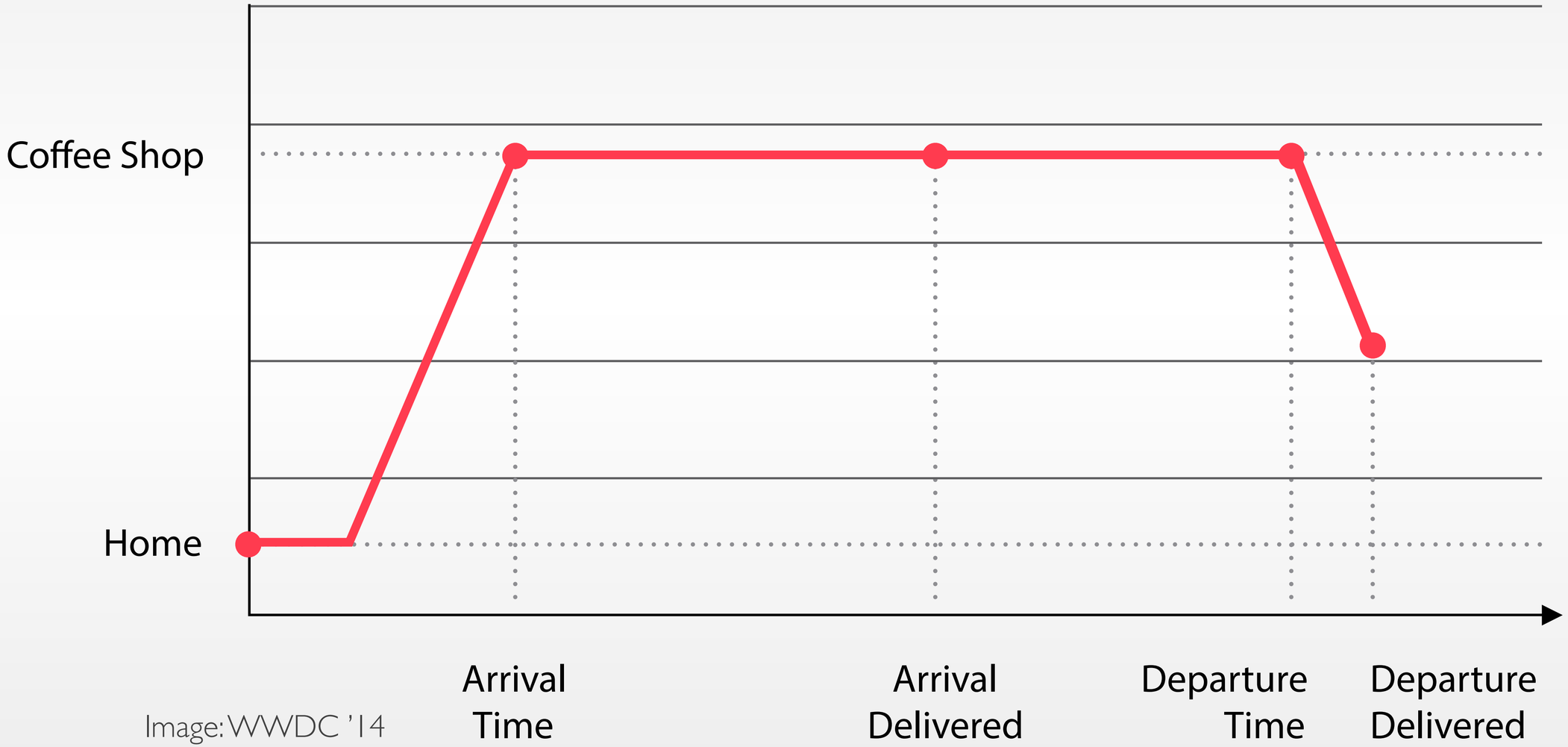


Image: WWDC '14

Monitoring Visits

Always

```
// Start monitoring
self.locationManager.startMonitoringVisits()


// The delegate method is called on arrival/departure
func locationManager(manager: CLLocationManager, didVisit visit: CLVisit) {
    print("Coordinate: ", visit.coordinate)
    print("Horizontal accuracy: ", visit.horizontalAccuracy)
    print("Arrival: ", visit.arrivalDate)
    print("Departure: ", visit.departureDate)
}


// Stop monitoring
self.locationManager.stopMonitoringVisits()
```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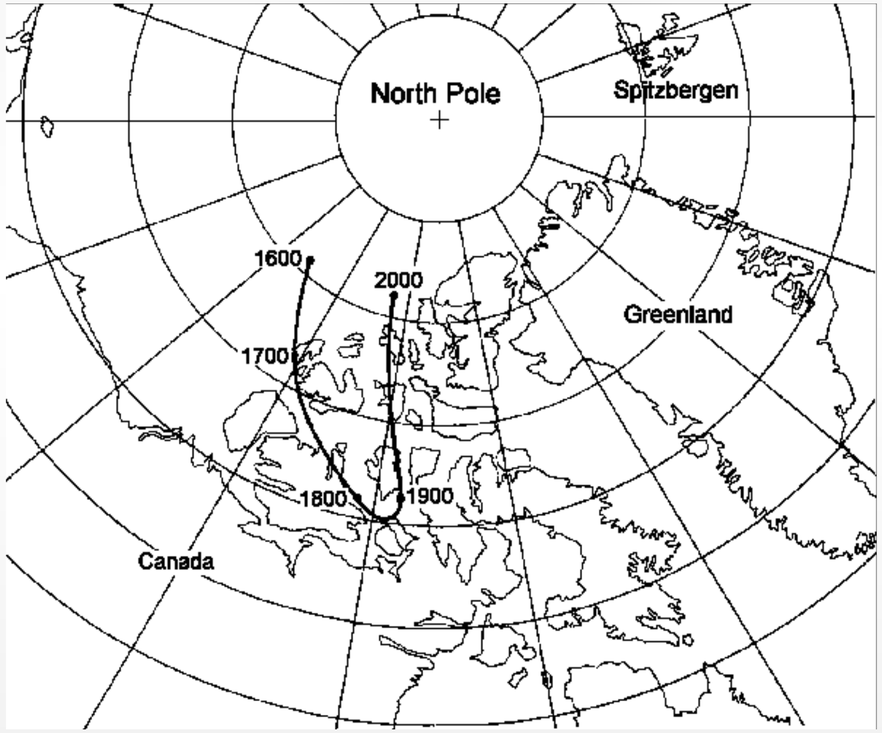
Heading Information

- Magnetic north & (geographic) true north
- Magnetic north uses integrated magnetometer
- True north requires GPS-Hardware



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Getting Heading

```
func startUpdatingHeading() {

    // Set as delegate
    self.locationManager.delegate = self

    self.locationManager.startUpdatingLocation()

    // If heading service is available, start updating
    if CLLocationManager.headingAvailable() {
        self.locationManager.headingFilter = 0 // The minimum angular change required to
                                                  generate new heading events
        self.locationManager.startUpdatingHeading()
    }
}
```

CLLocation Manager Delegate

```
var heading = CLLocationDirection()

// Delegate method
func locationManager(manager: CLLocationManager,
    didUpdateHeading newHeading: CLHeading) {

    // Return if the headingAccuracy value is invalid (=> both magneticHeading and
    true Heading are invalid)
    if newHeading.headingAccuracy < 0 {
      return
    }

    // Check if trueHeading is valid (e.g., not valid when location updates are off)
    if newHeading.trueHeading > 0 {
      self.heading = newHeading.trueHeading
    } else {
      self.heading = newHeading.magneticHeading // Magnetic heading is valid if
headingAccuracy > 0
    }
  }
```

Saving Battery Power

- Turn off location services when not used
- Use the significant location change service whenever possible
- Use low-resolution accuracy values
  - Unless doing so would impair your application
- Turn off location services if the accuracy does not increase
- Defer location updates when the app is in background
  - Updates are then batch-processed

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Overview of Core Location Usage

Your App

Core Location

request user permission →

check if the location update available →

register for the updates →

delegate calls for each update ←

stop updating →

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MapKit

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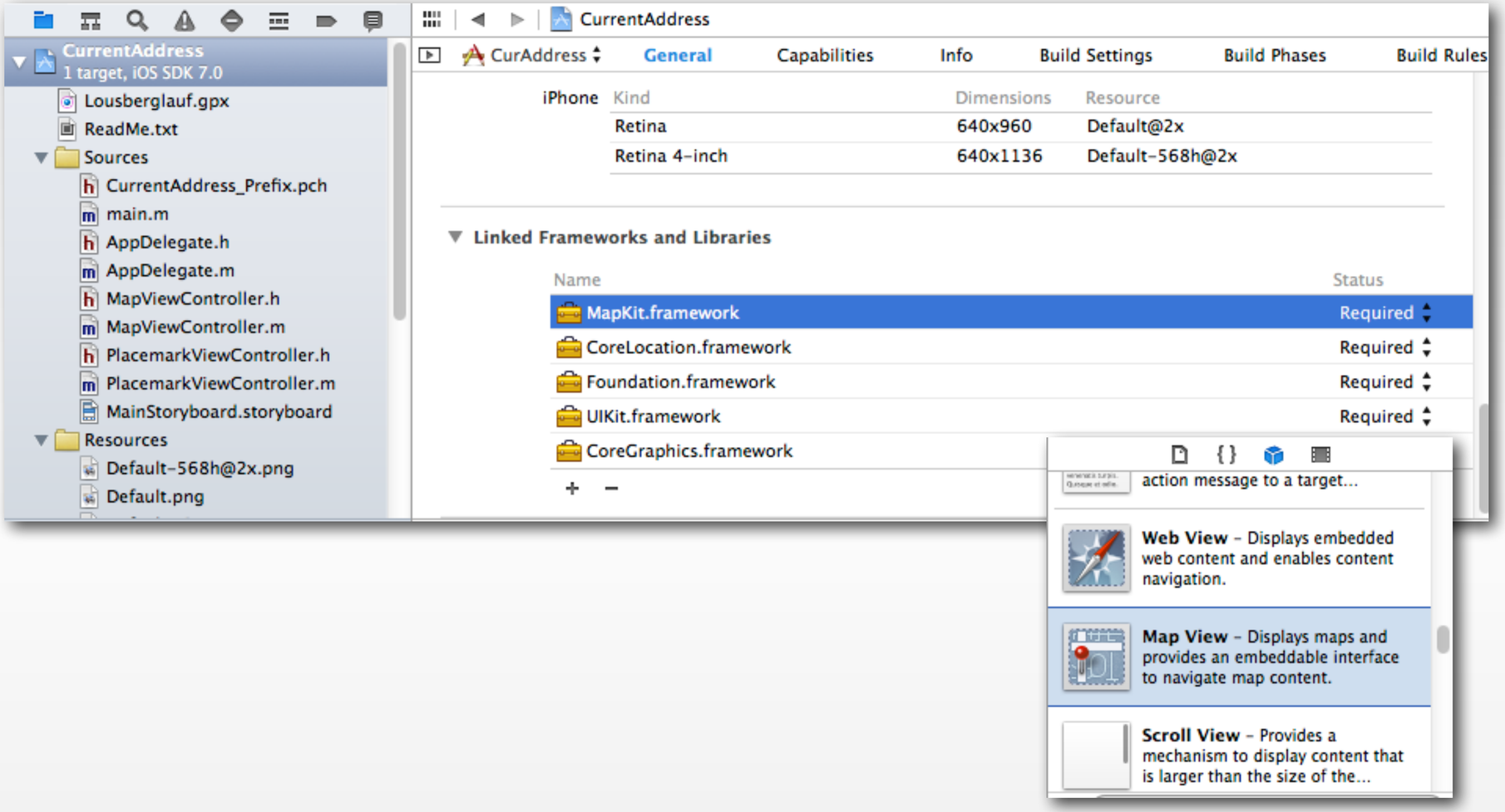
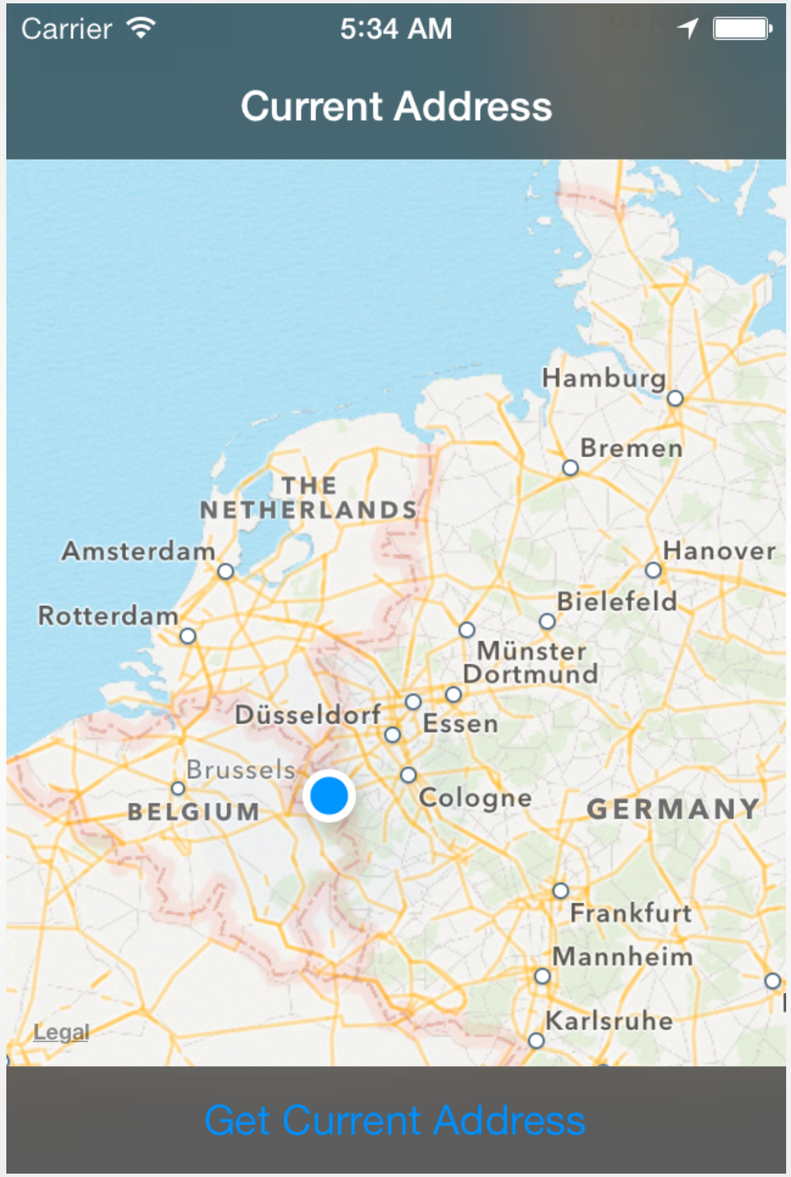

CurrentAddress
1 target, iOS SDK 7.0
Lousberglauf.gpx
ReadMe.txt
Sources
CurrentAddress_Prefix.pch
main.m
AppDelegate.h
AppDelegate.m
MapViewController.h
MapViewController.m
PlacemarkViewController.h
PlacemarkViewController.m
MainStoryboard.storyboard
Resources
Default-568h@2x.png
Default.png
CurrentAddress
CurAddress
General
Capabilities
Info
Build Settings
Build Phases
Build Rules
iPhone
Kind
Dimensions
Resource
Retina
640x960
Default@2x
Retina 4-inch
640x1136
Default-568h@2x
Linked Frameworks and Libraries
Name
Status
MapKit.framework
Required
CoreLocation.framework
Required
Foundation.framework
Required
UIKit.framework
Required
CoreGraphics.framework
action message to a target...
Web View – Displays embedded web content and enables content navigation.
Map View – Displays maps and provides an embeddable interface to navigate map content.
Scroll View – Provides a mechanism to display content that is larger than the size of the...

MKMapView

- MKMapViewDelegate
- User location
- User heading
- Annotations, overlays



Map Geometry

- Mercator projection
- Useful for navigation
- Lines of constant course
- Distorts areas far from the equator

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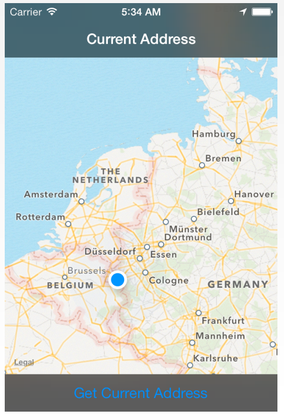
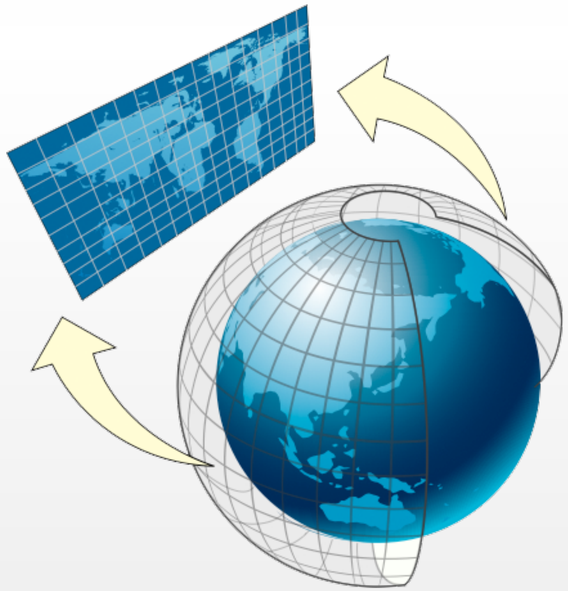
MapKit Unit

- Screen Points (x,y)
  - CGPoint
  - CGSize
  - CGRect
- Map points (x,y)
  - MKMapPoint
  - MKMapSize
  - MKMapRect
- Map coordinates (lat, long)
  - CLLocationCoordinate2D
  - MKCoordinateSpan
  - MKCoordinateRegion





Unit Conversion

Convert from	Convert to	Routines
Map coordinates	Screen Points	`convertCoordinate: toPointToView: (MKMapView)` `convertRegion: toRectToView: (MKMapView)`
Map coordinates	Map points	`MKMapPointForCoordinate (MapKit)`
Map Points	Map coordinates	`MKCoordinateForMapPoint (MapKit)` `MKCoordinateRegionForMapRect (MapKit)`
Map Points	Screen Points	`pointForMapPoint: (MKOverlayRenderer)` `rectForMapRect: (MKOverlayRenderer)`
Screen Points	Map coordinates	`convertPoint: toCoordinateFromView: (MKMapView)` `convertRect: toRegionFromView: (MKMapView)`
Screen Points	Map points	`mapPointForPoint: (MKOverlayRenderer)` `mapRectForRect: (MKOverlayRenderer)`

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Using Maps (1)

```
// (Optional) tell mapView to show user location
self.mapView.showsUserLocation = true // Uses CoreLocation to find the user's
                                         position


// Set the type of map
self.mapView.mapType = MKMapType.Satellite // Standard, Satellite, Hybrid, Flyover


// Create a coordinate of the Eiffel Tower
let EiffelTower = CLLocationCoordinate2D(latitude: 48.858093, longitude: 2.294694)


// Show an area of 400m X 400m around the Eiffel Tower
self.mapView.region = MKCoordinateRegionMakeWithDistance(EiffelTower, 400, 400)
```

Using Maps (2)

```
@IBAction func moveMap(sender: AnyObject) {
    // Get the current center
    var mapCenter = self.mapView.centerCoordinate

    // Move it to the left by half the width of the frame
    mapCenter = self.mapView.convertPoint(CGPointMake(1,
            self.mapView.frame.size.height/2.0),
        toCoordinateFromView: self.mapView)

    // Make the transition animated
    self.mapView.setCenterCoordinate(mapCenter,
        animated: true)
  }
```


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Using Maps (3)

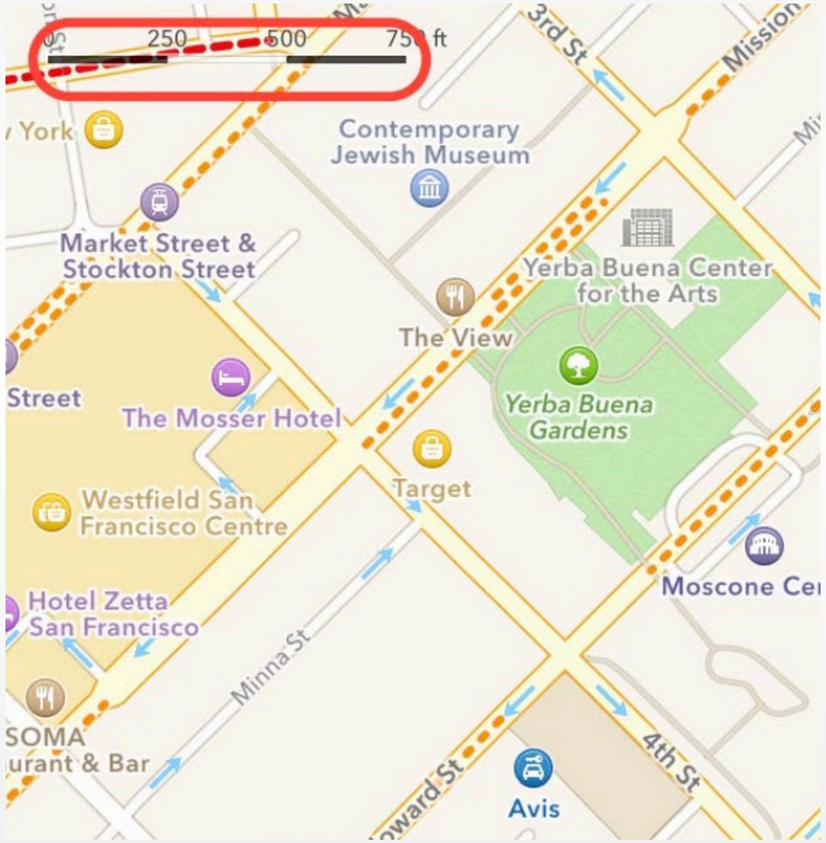
```
@IBAction func zoomIn(sender: AnyObject) {
    // Get the area currently displayed by the mapView
    var region = self.mapView.region

    // Change the span of the region
    region.span.latitudeDelta *= 0.5
    region.span.longitudeDelta *= 0.5

    // Set region with animation
    self.mapView.setRegion(region, animated: true)
}
```

Map Customizations

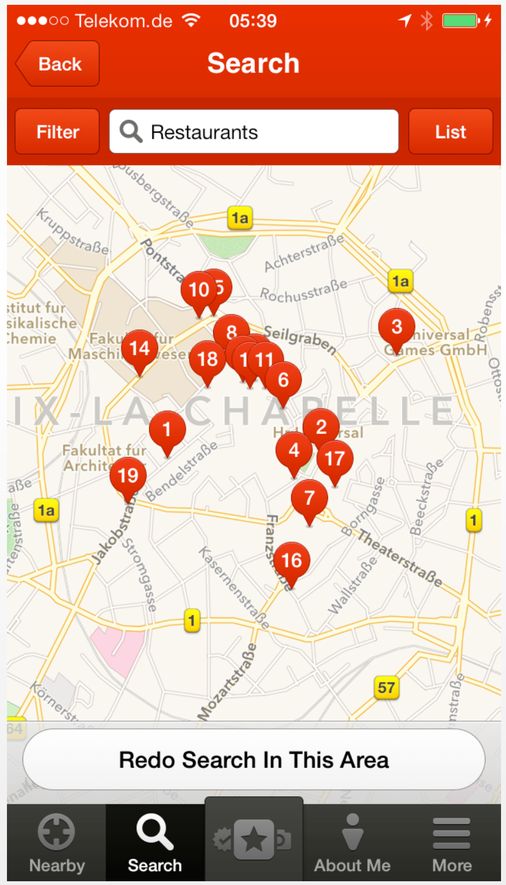
- Properties that you can for your mapView
  - showsUserLocation
  - showsPointsOfInterest
  - showsBuildings
  - showsTraffic
  - showsScale
  - showsCompass

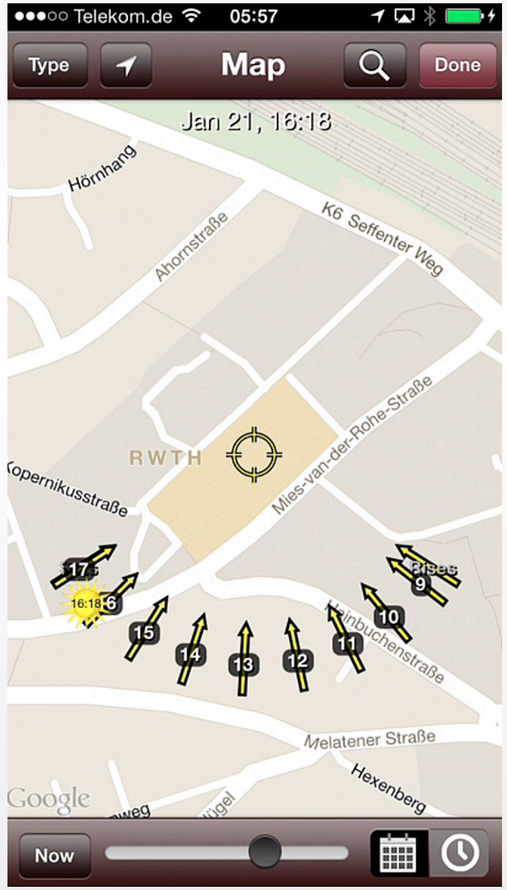


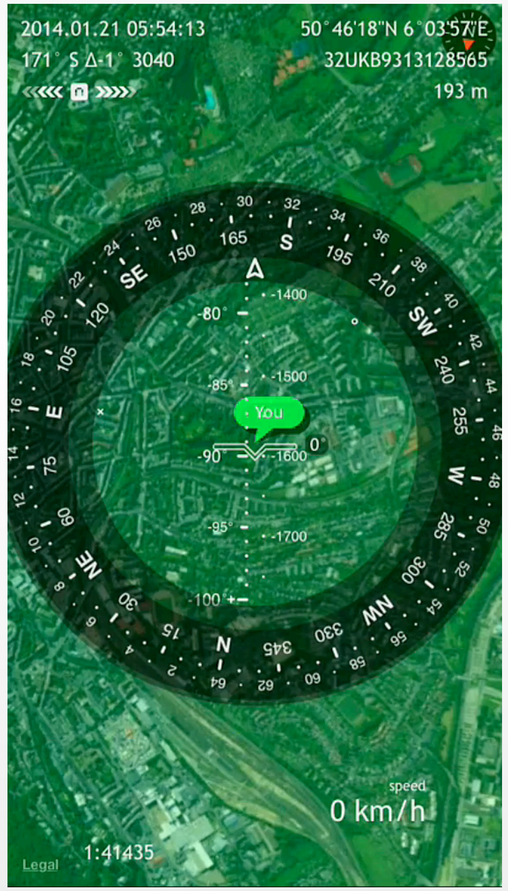
WWDC '15

Adding Annotations

- Custom class implements the `MKAnnotation` protocol







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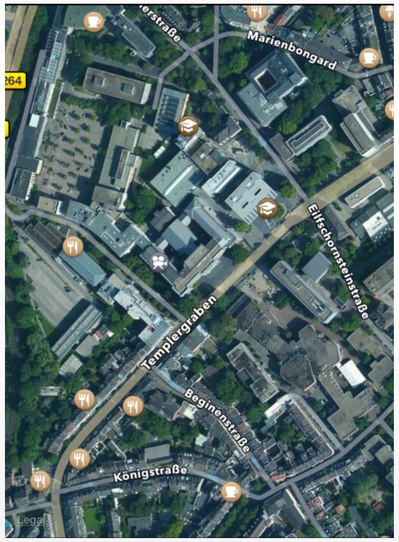
Overview of MapKit Usage

<<Protocol>>
MKAnnotation

<<Protocol>>
MKOverlay

create models →

← request view/renderer for an annotation/overlay



MKAnnotationView

provide a view →

MKMapView

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Annotations

Create annotation object(s)

MKPointAnnotation

<<Protocol>>
MKAnnotation

MKPinAnnotationView

MKAnnotationView

Define annotation view

Implement delegate method

mapView:viewForAnnotation

addAnnotation:

Add annotation to map view

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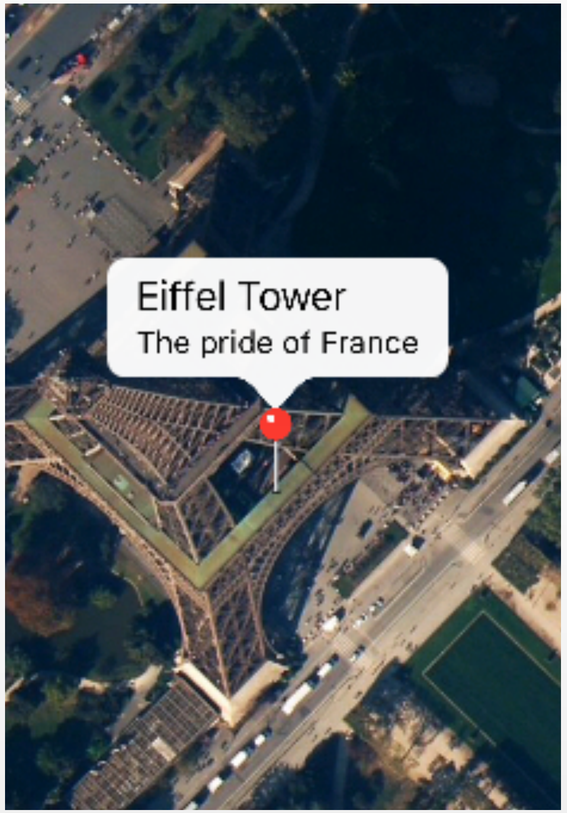
Point Annotation (Standard Pin Annotation)

```
let pointAnnotation = MKPointAnnotation()

pointAnnotation.coordinate = EiffelTower
pointAnnotation.title = "Eiffel Tower"
pointAnnotation.subtitle = "The pride of France"

self.mapView.addAnnotation(pointAnnotation)
```



Custom Pin Annotation (1)

```
@IBAction func createCustomPointAnnotation(sender: AnyObject) {
    // Create location with coordinates
    let InformatikZentrum = CLLocationCoordinate2D(latitude: 50.779419, longitude:
6.059010)

    // Make a point annotation
    let customPointAnnotation = MKPointAnnotation()

    // Set values
    customPointAnnotation.coordinate = InformatikZentrum

    // Add to mapView
    self.mapView.addAnnotation(customPointAnnotation)
}
```

Custom Pin Annotation (2)

```
func mapView(mapView: MKMapView,
    viewForAnnotation annotation: MKAnnotation) -> MKAnnotationView? {

    if annotation.title! == "Computer Science Building" {
        // Create a MKPinAnnotationView
        let aView = MKPinAnnotationView.init(annotation: annotation,
    reuseIdentifier: "InformatikZentrum")

        aView.pinTintColor = UIColor.blueColor() // Also: redPinColor, greenPinColor,
                                                 purplePinColor
        aView.animatesDrop = true // Animate the pin being dropped

        return aView
    }

    return nil
}
```

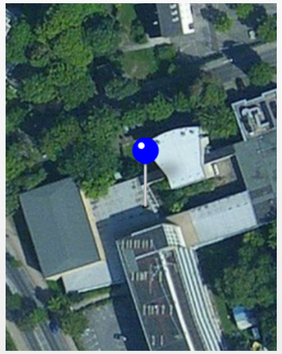


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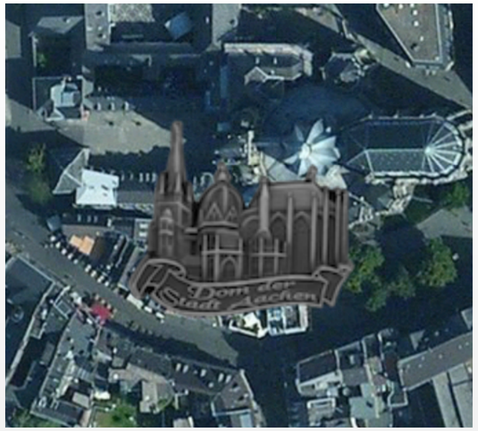
Image Annotation (1)

```
@IBAction func createImageAnnotation(sender: AnyObject) {
    // Create a location with coordinates
    let AachenerDom = CLLocationCoordinate2D(latitude: 50.774783, longitude: 6.083920)

    // Create an annotation
    let imageAnnotation = MKPointAnnotation()

    // Set coordinate
    imageAnnotation.coordinate = AachenerDom

    // Add to mapView
    self.mapView.addAnnotation(imageAnnotation)
}
```

Image Annotation (2)

```
func mapView(mapView: MKMapView,
    viewForAnnotation annotation: MKAnnotation) -> MKAnnotationView? {

      if annotation.title! == "Aachener Dom" {
        // Create a MKAnnotationView
        let aView = MKAnnotationView.init(annotation: annotation,
            reuseIdentifier: "AachenerDom")

        // Set image and offset
        aView.image = UIImage.init(named: "dom")
        aView.centerOffset = CGPoint.init(x: -50, y: 50)

        // Return the view
        return aView
    }

    return nil
}
```



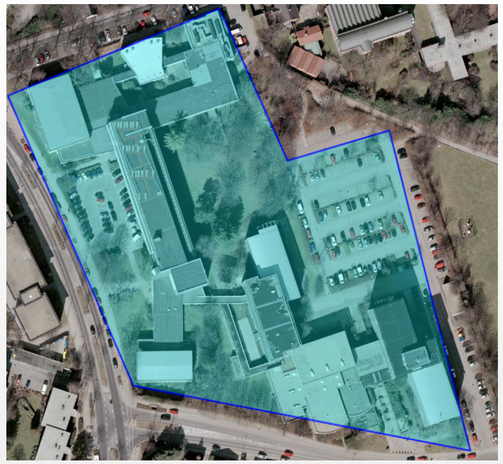
Demo: Annotations

Overlays

```
// Define an overlay that covers the CS building.
var points: [CLLocationCoordinate2D] = [CLLocationCoordinate2D]()

points.append(CLLocationCoordinate2DMake(50.779396749979426, 6.058316230773926))
points.append(CLLocationCoordinate2DMake(50.77815527465925, 6.059163808822632))
points.append(CLLocationCoordinate2DMake(50.77787712539619, 6.061438322067261))
points.append(CLLocationCoordinate2DMake(50.779247503323184,6.060891151428223))
points.append(CLLocationCoordinate2DMake(50.7791186081004, 6.06020450592041))
points.append(CLLocationCoordinate2DMake(50.77976986453611, 6.059743165969849))

let csBuilding = MKPolygon(coordinates: &points, count: 6)
csBuilding.title = "CS Building”;

self.mapView.addOverlay(csBuilding, level: MKOverlayLevel.AboveRoads)
```

Overlay Renderer

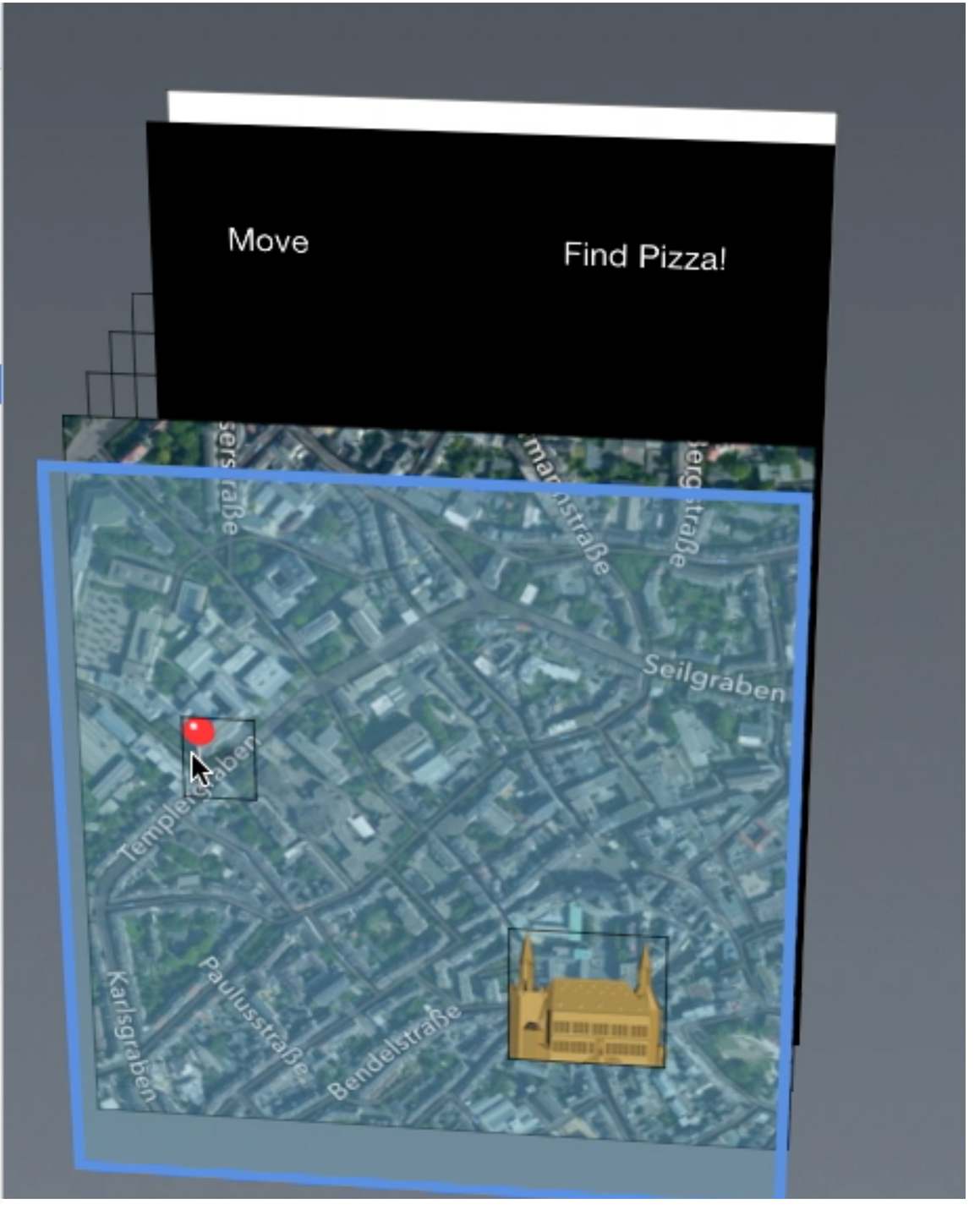
```
func mapView(mapView: MKMapView,
    rendererForOverlay overlay: MKOverlay) -> MKOverlayRenderer {

    // Create a renderer
    var renderer = MKOverlayRenderer()

    let cyan = UIColor.cyanColor().colorWithAlphaComponent(0.3)
    let blue = UIColor.blueColor().colorWithAlphaComponent(0.8)

    if overlay.title! == "CS Building" {
      let csRenderer = MKPolygonRenderer(overlay: overlay)

      csRenderer.fillColor = cyan
      csRenderer.strokeColor = blue

      csRenderer.lineWidth = 2
      renderer = csRenderer
    }

    return renderer
  }
```

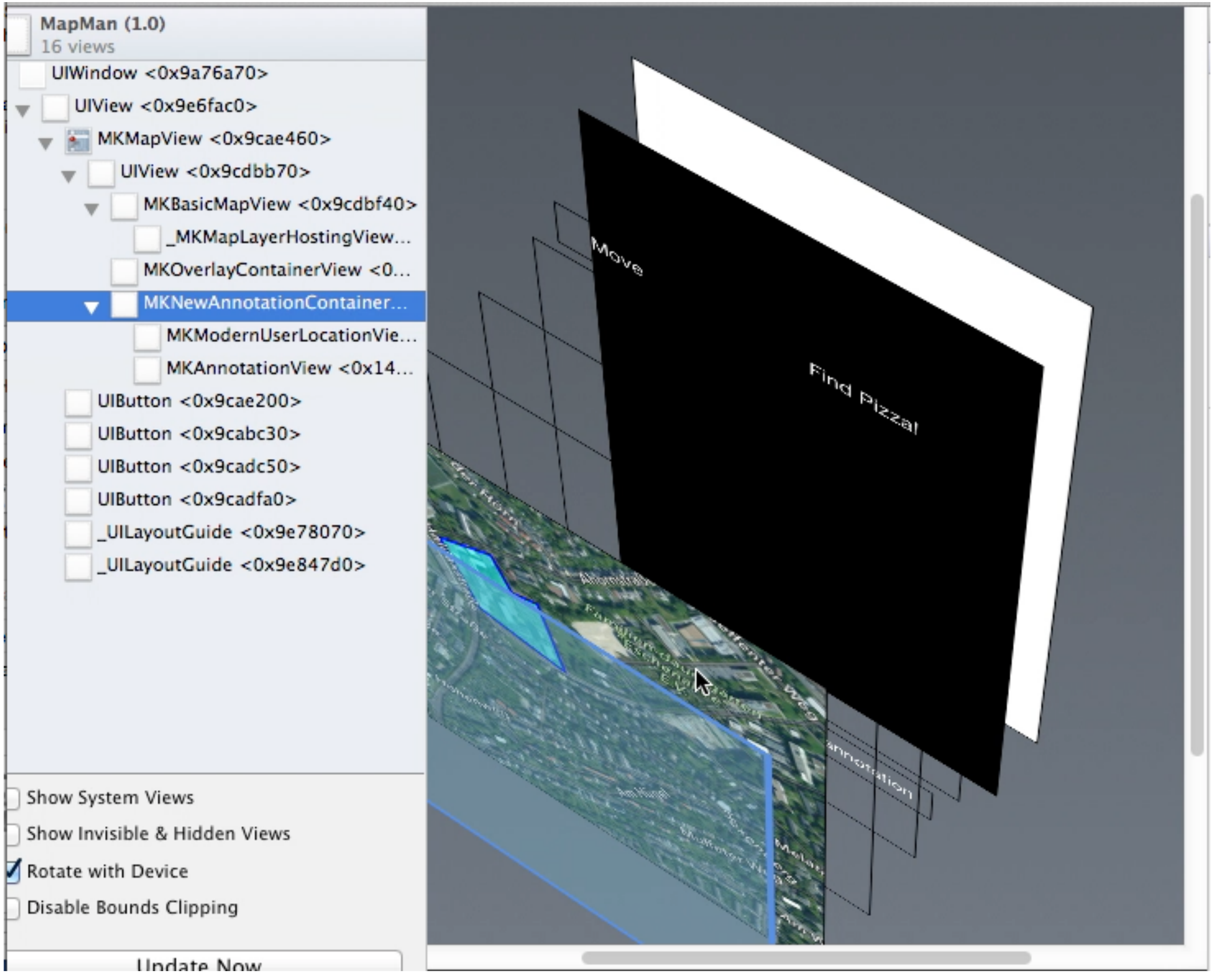


MapMan (1.0)
16 views

- UIWindow <0x9a76a70>
- UIView <0x9e6fac0>
  - MKMapView <0x9cae460>
    - UIView <0x9cdbb70>
      - MKBasicMapView <0x9cdbf40>
        - _MKMapLayerHostingView...
        - MKOverlayContainerView <0...
        - MKNewAnnotationContainer...
          - MKModernUserLocationVie...
          - MKAnnotationView <0x14...
    - UIButton <0x9cae200>
    - UIButton <0x9cabc30>
    - UIButton <0x9cadc50>
    - UIButton <0x9cadfa0>
    - _UILayoutGuide <0x9e78070>
    - _UILayoutGuide <0x9e847d0>

- [ ] Show System Views
- [ ] Show Invisible & Hidden Views
- [x] Rotate with Device
- [ ] Disable Bounds Clipping

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_UILayoutGuide <0x9e847d0>
Show System Views
Show Invisible & Hidden Views
Rotate with Device
Disable Bounds Clipping
Update Now
Move
Find Pizza!

Overview of MapKit Usage

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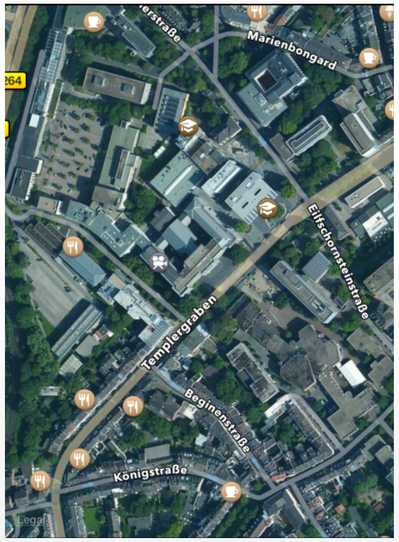
MKAnnotation

<<Protocol>>
MKOverlay

create models →

← request view/renderer for an annotation/overlay



MKAnnotationView

provide a view →

MKMapView

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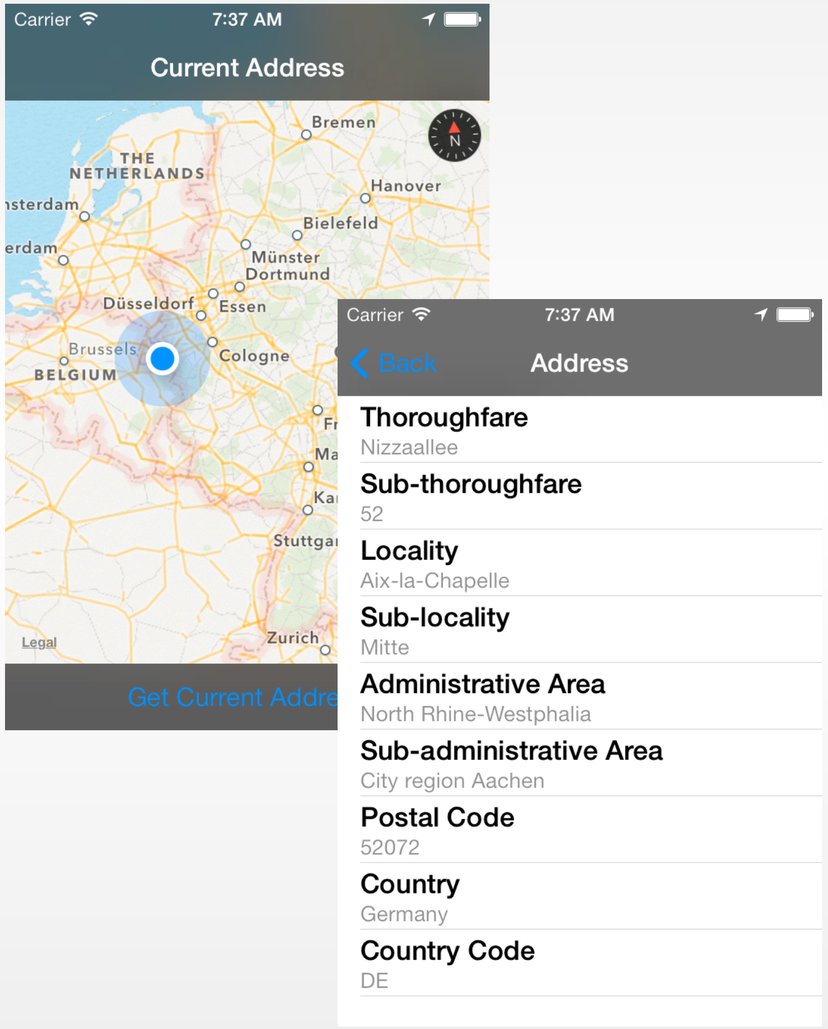
Geocoding

- Convert address to coordinates (*forward geocoding*)
- Convert coordinates to address (*reverse geocoding*)
- Address: more user-friendly than coordinates
- CLGeocoder
  - Limited resources
  - Requires live network connection



Reverse Geocoding

```
self.geocoder.reverseGeocodeLocation(CLLocation(latitude: 48.858592, longitude: 2.294481),
completionHandler: {
      (placemarks, error) in
        let placemark = placemarks![0]

        print("thoroughfare: ", placemark.thoroughfare!) // Street address
        print("subThroughfare: ", placemark.subThoroughfare!) // Additional street-level
information
        print("locality: ", placemark.locality!) // City
        print("subLocality: ", placemark.subLocality!) // Additional city-level information
        print("administrativeArea: ", placemark.administrativeArea!) // State or Province
        print("subAdministrativeArea: ", placemark.subAdministrativeArea!) // Additional state-
level information
        print("postalCode: ", placemark.postalCode!)
        print("country: ", placemark.country!)
        print("ISOcountryCode: ", placemark.ISOcountryCode!) // Abbreviated country name
        print("timeZone: ", placemark.timeZone!) // Timezone of the location
    })
}
```

Output:

```
thoroughfare:  Avenue Anatole France
subThroughfare:  5
locality:  Paris
subLocality:  Tour Eiffel-Champs de Mars
administrativeArea:  Île-de-France
subAdministrativeArea:  Paris
postalCode:  75007
…
```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Natural Language Search

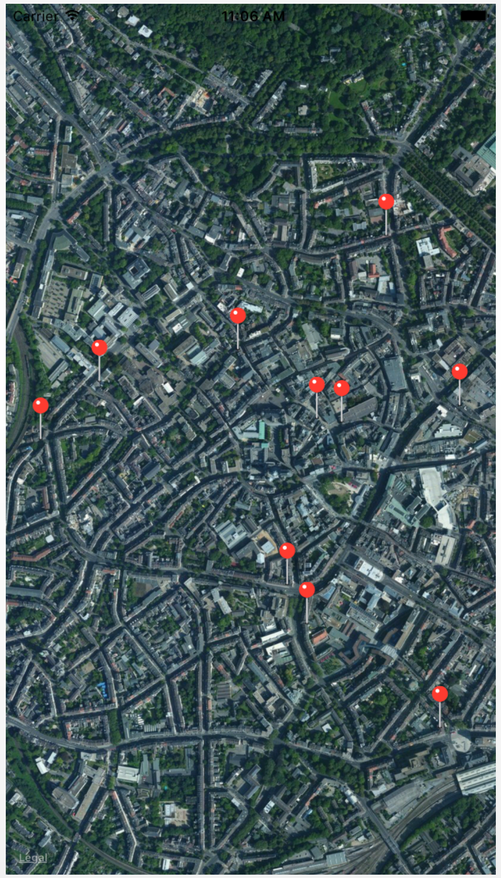
```
func findPizza() {
    // Make a request object
    let request = MKLocalSearchRequest()
    request.naturalLanguageQuery = "Pizza"
    request.region = self.mapView.region

    // Make a search object
    let search = MKLocalSearch(request: request)

    // Search and handle the response
    search.startWithCompletionHandler({
        (response, error) in
        var placemarks = [MKPlacemark]()

        // Store the retrieved map items in an array
        for item in (response?.mapItems)! {
            placemarks.append(item.placemark)
        }

        // Display the annotations
        self.mapView.showAnnotations(placemarks, animated: false)
    })
}
```



Demo: Find Pizza

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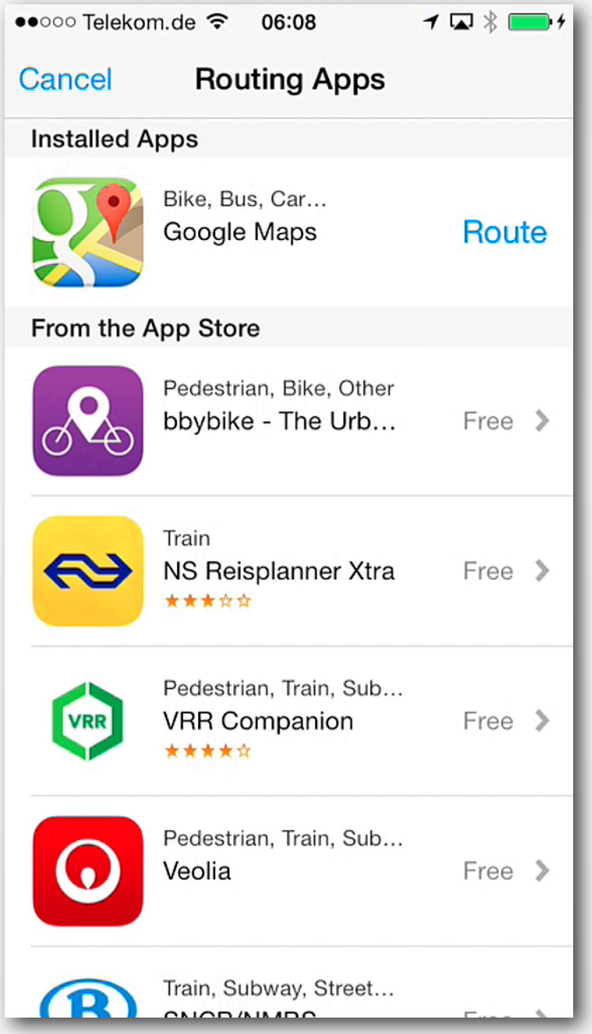
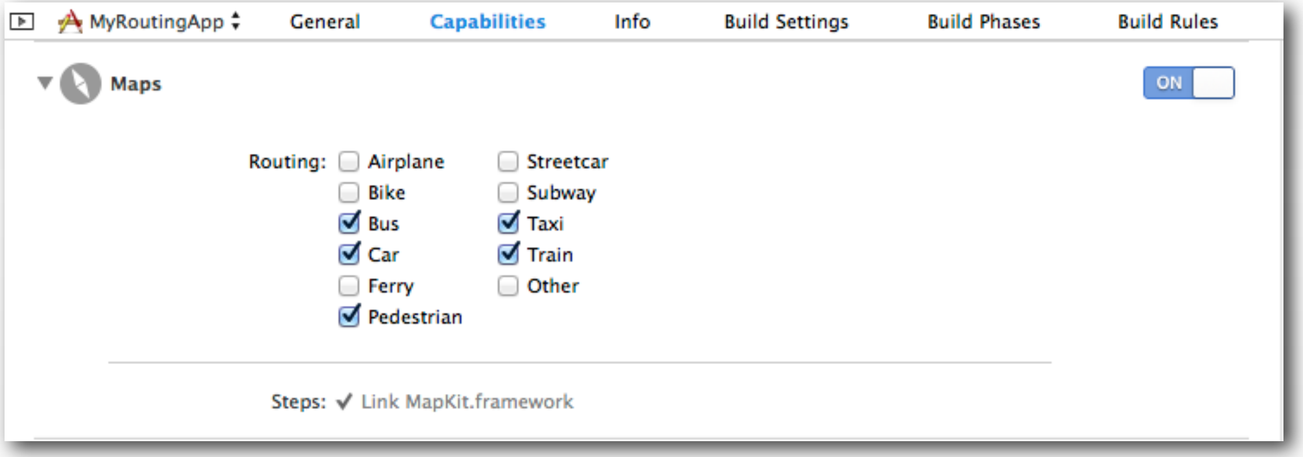
Integrating with iOS Routing





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MapKit

GoogleMaps

OpenStreetMap

Map Image Data

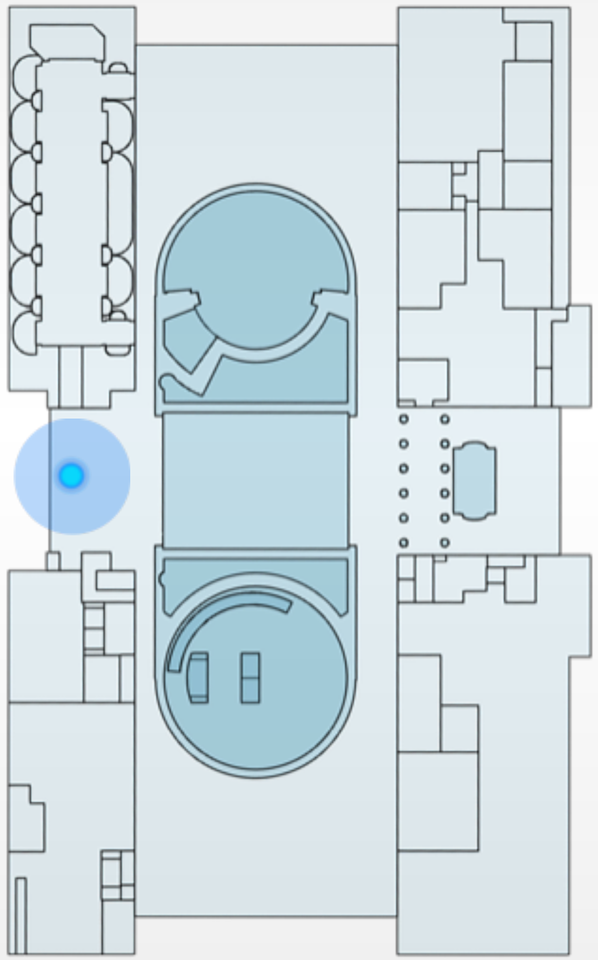
Semantic Data

Offline Caching

https://developers.google.com/maps/documentation/ios/
http://wiki.openstreetmap.org/wiki/Develop

Indoor Positioning

- Provide context information
  - Indoor maps, way finding
  - Interactive museum exhibits
- Combined cellular, GPS, wifi, and motion sensor
- Only a few locations supported so far
  - California Academy of Sciences
  - The Westfield San Francisco Center
  - The Mineta San Jose Airport
- Apple Maps Connect Program is working with venue owner
- Update from WWDC 2015: A cleaner API



Summary

- Core Location: determining location, processing location data
- Map Kit: Visualize location

- Reading Assignment:
  - Location Awareness Programming Guide
  - What's New in Core Location WWDC15
  - What's New in MapKit WWDC15