Developing Applications for iOS

Lecture 9:
iDevice Capabilities

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Content

- Core Location: GPS + Compass
- Accelerometer
- Map Kit

Core Location

Framework for managing location and heading

- No user-interface.

Basic object is `CLLocation`

- It has many properties: `coordinate`, `altitude`, `floor`, `speed`, `horizontal/verticalAccuracy`, `timestamp`, `course`.
- Where (approximately) is this location?

```
var coordinate: CLLocationCoordinate2D { get }

struct CLLocationCoordinate2D
{
	var latitude: CLLocationDegrees // a double
	var longitude: CLLocationDegrees // a double
}

var altitude: CLLocationDistance { get }
```

A negative value means “below sea level”.

Core Location

- How close to that latitude/longitude is the actual location?

```
var horizontalAccuracy: CLLocationAccuracy { get }
var verticalAccuracy: CLLocationAccuracy { get }
```

- Both are measured in meters. A negative value means the `coordinate` or `altitude` (respectively) is invalid.
- The accuracy depends on the hardware. You can specify the desired accuracy of the device location:

```
kCLLocationAccuracyBestForNavigation
kCLLocationAccuracyBest
kCLLocationAccuracyNearestTenMeters
kCLLocationAccuracyHundredMeters
kCLLocationAccuracyKilometer
kCLLocationAccuracyThreeKilometers
```

- The phone should be plugged in to power source when the desired accuracy is `kCLLocationAccuracyBestForNavigation`.
- The more accuracy you request, the more battery will be used.

Core Location

The iDevice does its best given a specified accuracy request

- GPS (very accurate, lots of power).
- Wi-Fi node database lookup (more accurate, more power).
- Cellular tower triangulation (not very accurate, but low power).

Speed

```
var speed: CLLocationSpeed { get }
```

- Measured in meters/second.
- Note that the speed is instantaneous (not average speed).
- Generally it’s useful as “advisory information” when you are in a vehicle.
- A negative value means “speed is invalid”.

Core Location

Course

```
var course: CLLocationDirection { get }
```

- Values are measured in degrees starting at due north and continuing clockwise around the compass. Thus, North is 0 degrees, East is 90 degrees, and so on.
- Not all devices can deliver this information. A negative value means “direction is invalid”.

Time Stamp

```
var timestamp: Date { get }
```

- Pay attention to these since locations will be delivered on an inconsistent time basis.

Distance (in meters) between `CLLocations`

```
func distance(from location: CLLocation)
              -> CLLocationDistance
```

Core Location

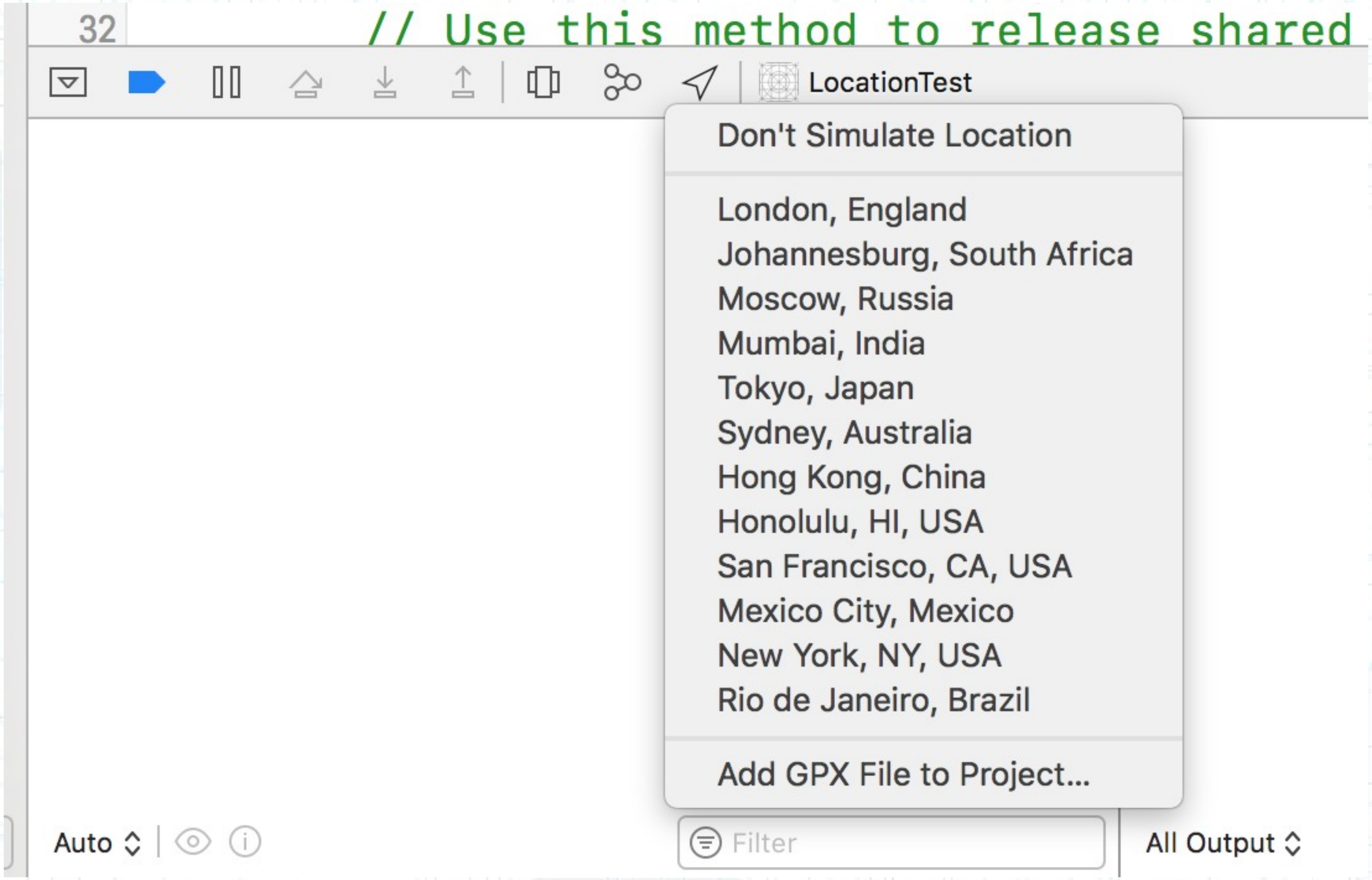
How do you get a `CLLocation`?

- Always from a `CLLocationManager` (sent to you via its `delegate`) when you are interested in the device location.
- Can also use initializer when you are interested in a different location:

```
init(latitude: CLLocationDegrees,
     longitude: CLLocationDegrees)
```

Core Location

- The device location can be tested in the iOS Simulator from Xcode.



```
// Use this method to release shared
```

CLLocationManager

`CLLocationManager`

- General approach to using it:

1. Always request authorization to use location services and check to see whether the desired services are available as described in Requesting Permission to Use Location Services.

2. Create an instance of the `CLLocationManager` class and store a strong reference to it somewhere in your app.

3. Keeping a strong reference to the location manager object is required until all tasks involving that object are complete.

4. Assign a custom object to the delegate property. This object must conform to the `CLLocationManagerDelegate` protocol.

5. Configure any additional properties relevant to the desired service.

6. Call the appropriate start method to begin the delivery of events.

CLLocationManager

- The use of location services requires user authorization:

1. When your application first tries to use location monitoring, user will be asked if it’s okay to do so. Setup one these two keys in your project’s Info.plist:

```
NSLocationWhenInUseUsageDescription

NSLocationAlwaysUsageDescription
```

2. Call the `authorizationStatus()` class method to get the current authorization status for your app.

If the authorization status is `restricted` or `denied`, your app is not permitted to use location services and you should abort your attempt to use them.

3. If the authorization status was `notDetermined`, call one of the following methods to request the appropriate type of authorization from the user:

```
func requestWhenInUseAuthorization()

func requestAlwaysAuthorization()
```

CLLocationManager

Kinds of location monitoring

- Accuracy-based continuous updates.
- Updates only when significant changes in location occur.
- Region-based updates.
- Heading monitoring.
- Proximity to beacons updates.

CLLocationManager

Checking to see what your hardware can do

- Has the user enabled location services in Settings?

```
class func locationServicesEnabled() -> Bool
```

- Can this hardware provide heading info (compass)?

```
class func headingAvailable() -> Bool
```

- Can get events for significant location changes (requires a cellular radio)?

```
class func significantLocationChangeMonitoringAvailable()
        -> Bool
```

- Is region monitoring available?

```
class func isMonitoringAvailable(for regionClass:
        AnyClass) -> Bool
```

- Does the device support ranging of Bluetooth beacons?

```
class func isRangingAvailable() -> Bool
```

CLLocationManager

Getting the information from the CLLocationManager

- You can just ask the CLLocationManager for the location or heading, but usually we don’t.
- Instead, we let it update us when the location changes (enough) via its delegate.

CLLocationManager

Accuracy-based continuous location monitoring

- Always set the desired accuracy as low as possible:

```
var desiredAccuracy: CLLocationAccuracy { get set }
```

- Only changes in location of at least this distance (in meters) will fire a location update to you:

```
var distanceFilter: CLLocationDistance { get set }
```

Use the value `kCLDistanceFilterNone` to be notified of all movements. This is also the default value.

Starting and stopping the monitoring

```
func startUpdatingLocation()

func stopUpdatingLocation()
```

- Be sure to turn updating off when your application is not going to consume the changes!

CLLocationManagerDelegate

Get notified via the CLLocationManager's delegate

- The CLLocationManagerDelegate methods that give location updates are:

```
func locationManager(_ manager: CLLocationManager,
                     didUpdateTo newLocation: CLLocation,
                     from oldLocation: CLLocation)

func locationManager(_ manager: CLLocationManager,
               didUpdateLocations locations: [CLLocation])
```

- Because it can take several seconds to return an initial location, the location manager typically delivers the previously cached location data immediately.
- It delivers more up-to-date location data as it becomes available.
- Therefore it is always a good idea to check the timestamp of any location object before taking any actions.

Heading

Heading monitoring

- Only changes in heading of at least this many degrees will fire a location update to you:

```
var headingFilter: CLLocationDegrees { get set }
```

- Heading of “zero degrees” is the heading of the “top” of the device.
- With the next property, you can change that “top” (for example, `.landscapeLeft`, `.faceDown`):

```
var headingOrientation: CLDeviceOrientation { get set }
```

Start the monitoring

```
func startUpdatingHeading()
```

```
func stopUpdatingHeading()
```

- Be sure to turn updating off when your application is not going to consume the changes!

CLLocationManagerDelegate

Get notified via the `CLLocationManager`'s `delegate`

```
func locationManager(_ manager: CLLocationManager,
                     didUpdateHeading newHeading: CLHeading)
```

Error reporting to the `delegate`

```
func locationManager(_ manager: CLLocationManager,
                     didFailWithError error: Error)
```

- Not always a fatal thing, but pay attention to this delegate method.
- The `CLError.locationUnknown` error is likely temporary, keep waiting (for a while at least).
- If the user denies your application's use of the location service, this method reports a `CLError.denied` error. Upon receiving such an error, you should stop the location service.
- If the heading could not be determined because of strong interference from nearby magnetic fields, this method will return a `CLError.headingFailure`. Keep waiting then.

Heading

`CLHeading`

- There are two types of heading (because the Earth's North Pole is not exactly the magnetic north):

```
var magneticHeading: CLLocationDirection { get }
var trueHeading: CLLocationDirection { get }
```

- Negative values mean “this heading is unreliable” (i.e. don’t use it).
- You won’t get `trueHeading` if location services are turned off (e.g. by the user).

```
var headingAccuracy: CLLocationDirection { get }
```

- Basically how far off the magnetic heading might be from actual magnetic north (in degrees).
- A negative value means “this heading is not valid”.

```
var timestamp: Date { get }
```

Heading

Heading calibration user-interface

- Automatically put on screen by iOS, but can be prevented by the CLLocationManager's delegate:

```
func locationManagerShouldDisplayHeadingCalibration(_
     manager: CLLocationManager) -> Bool
```

- Or dismissed (maybe after a timer or something) using CLLocationManager instance method:

```
func dismissHeadingCalibrationDisplay()
```

Significant Location Changes

Significant location change monitoring in `CLLocationManager`

- “Significant” is not strictly defined. Think vehicles, not walking. Likely uses cell towers.

```
func startMonitoringSignificantLocationChanges()
func stopMonitoringSignificantLocationChanges()
```

- Be sure to turn updating off when your application is not going to consume the changes!
- You get notified via the `CLLocationManager`’s `delegate`. Same as for accuracy-based updating if your application is running.

Significant Location Changes

This service works even if your application is not running

- Or is in the background (we haven’t talked about multitasking yet).
- You will get launched and your application delegate will receive the message `application(didFinishLaunchingWithOptions:)` with an options dictionary that will contain this key (it indicates that the application was launched in response to an incoming location event):

```
UIApplicationLaunchOptionsKey.location
```

- You should use this as a signal to create and configure a new `CLLocationManager`. Get the latest location via:

```
var location: CLLocation? { get }
```

- Or start location services again. Upon doing so, your delegate receives the corresponding location data.
- If you are running in the background, don’t take too long (a few seconds)!

Region-based Monitoring

Region-based location monitoring in `CLLocationManager`

```
func startMonitoring(for region: CLRegion)

func stopMonitoring(for region: CLRegion)
```

Get notified via the `CLLocationManager`’s `delegate`

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

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

func locationManager(_ manager: CLLocationManager,
                     monitoringDidFailFor region: CLRegion?,
                     withError error: Error)
```

Region-based Monitoring

Works even if your application is not running!

- In exactly the same way as “significant location change” monitoring.
- The regions in this property are shared by all instances of the `CLLocationManager` class in your application:

```
var monitoredRegions: Set<CLRegion> { get }
```

- The set of monitored regions persists across application termination/launch.
- You cannot add regions to this property directly.
- Instead, you must register regions by calling:

```
func startMonitoring(for region: CLRegion)
```

Region-based Monitoring

`CLRegion`

- `CLRegions` are tracked by name (identifier) because they survive application termination/relaunch.
- The CLRegion class defines an abstract area that can be tracked. In iOS, you do not create instances of this class directly; instead, you instantiate subclasses that define specific types of regions.
- You can configure which notifications shoud be generated:

```
var notifyOnEntry/Exit: Bool { get set }
```

Regions (currently) require large location changes to fire

- Probably based on same technology as “significant location change” monitoring.
- Likely both of these “fire” when a new cell tower is detected.
- Definitely they would not use GPS (that would be very expensive power-wise).

Region-based Monitoring

Region monitoring size limit

- This property defines the largest boundary distance allowed from a region’s center point:

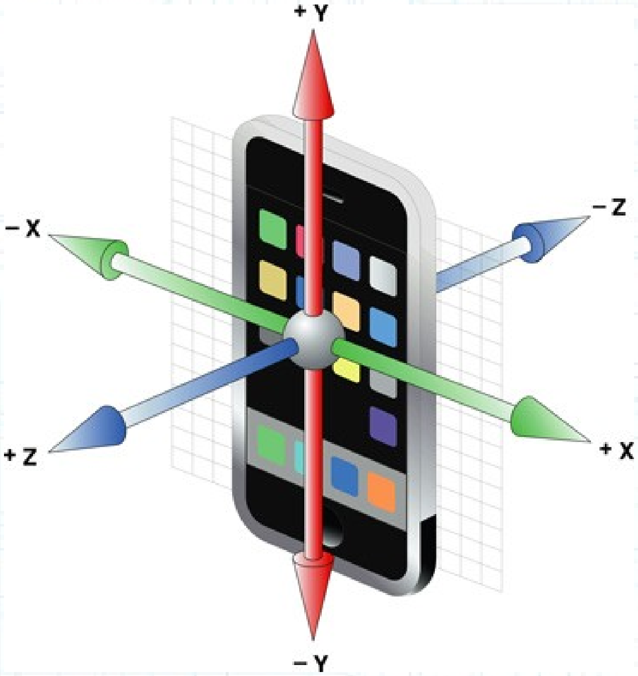
```
var maximumRegionMonitoringDistance: CLLocationDistance { get }
```

- Attempting to monitor a region larger than this (radius in meters) will generate a `CLError.regionMonitoringFailure` error (which will be sent via the delegate method mentioned on a previous slide).
- If this property returns a negative value, then region monitoring is not working.

Accelerometer

`CMMotionManager`

- The `CMMotionManager` class is the gateway to the motion services provided by iOS. These services provide an app with accelerometer data, rotation-rate data, magnetometer data, and other device-motion data.
- As a device moves, its hardware reports linear acceleration changes along the primary x, y, z axes in three-dimensional space.
- The device accelerometer reports values for each axis in units of G-force.
- You can use this data to detect both the current orientation of the device (relative to the ground) and any instantaneous changes to that orientation.



Accelerometer

How to get accelerometer data

- You create a `CMMotionManager` object:

```
var motionManager = CMMotionManager()
```

- Specify the interval at which you want to receive events:

```
var accelerometerUpdateInterval: TimeInterval { get set }
```

This property is measured in seconds. You may also change this property while the manager gives updates.

- To start/stop accelerometer updates use the following methods:

```
func startAccelerometerUpdates()
func stopAccelerometerUpdates()
```

- This time, there is **NO** delegate. To get data from the accelerometer use the following property:

```
var accelerometerData: CMAccelerometerData? { get }
```

Accelerometer

- The following code will also handle accelerometer updates. This is more elegant, but it requires advanced Swift knowledge (we already discussed about closures):

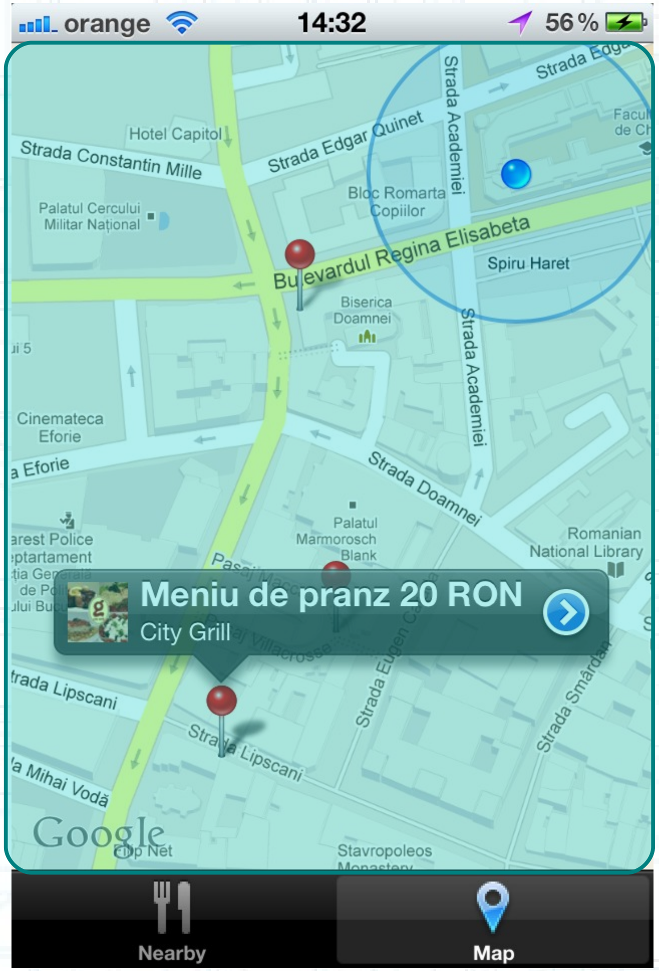
```
self.motionManager?.startAccelerometerUpdates(to:
   OperationQueue(),
   withHandler: {
      [unowned self] (accelerometerData, error) in

      if error == nil
      {
        self.rollX = (accelerometerData?.acceleration.x)! *
           kFilterFactor + self.rollX * (1.0 - kFilterFactor)
        self.rollY = (accelerometerData?.acceleration.y)! *
           kFilterFactor + self.rollY * (1.0 - kFilterFactor)
      }
   })
```

- `kFilterFactor` is a constant between 0 and 1 defined in your code somewhere. Actually a value near 0.1 is a good option.
- And `rollX`, `rollY` are properties of the `self` object:

```
var rollX: UIAccelerationValue = 0
```

Map Kit

`MKMapView` displays a map

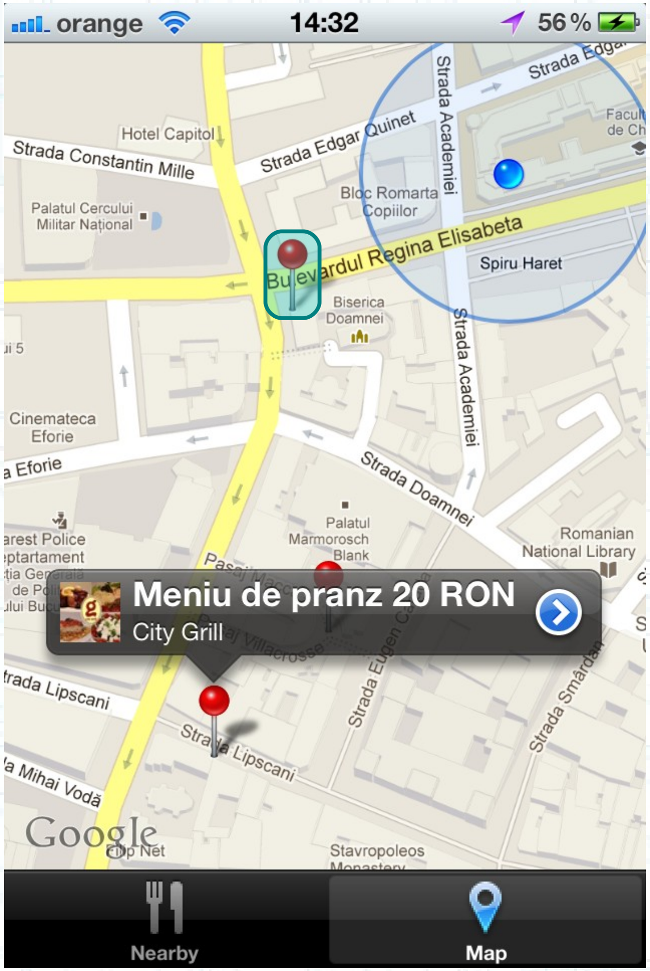


Map Kit

`MKMapView` displays a map

The map can have annotations on it

- Each annotation is simply a `coordinate`, a `title` and a `subtitle`. They are displayed using an `MKAnnotationView` (`MKPinAnnotationView` shown here).



Map Kit

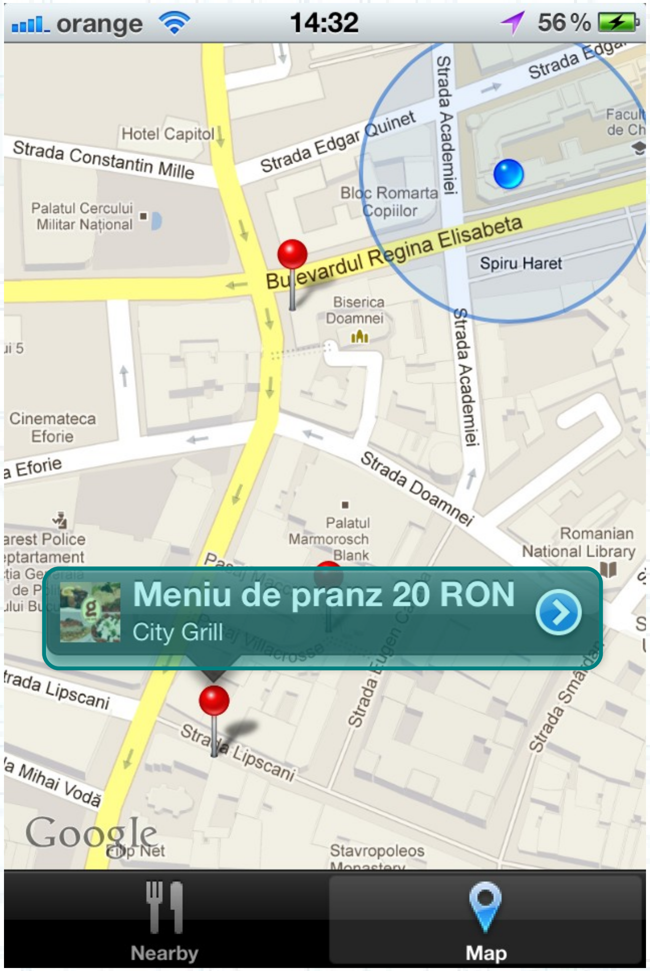
`MKMapView` displays a map

The map can have annotations on it

- Each annotation is simply a `coordinate`, a `title` and a `subtitle`. They are displayed using an `MKAnnotationView` (`MKPinAnnotationView` shown here).

Annotations can have a callout

- It appears when the annotation view is tapped. By default just shows the `title` and `subtitle`. But you can add left and right accessory views.
- In this example, left is a `UIImageView`, right is a detail disclosure `UIButton` (`UIButtonTypeDetailDisclosure`).



MKMapView

- Create with `init` or drag from Object Library in Interface Builder.
- Displays an array of objects which implement `MKAnnotation`:

```
var annotations: [MKAnnotation] { get }
```

- `MKAnnotation` protocol:

```
protocol MKAnnotation: NSObjectProtocol
{
    var coordinate: CLLocationCoordinate2D { get }
    optional var title: String? { get }
    optional var subtitle: String? { get }
}
```

MKAnnotation

Note that the `annotations` property is readonly

```
var annotations: [MKAnnotation] { get }
```

- Must add/remove annotations explicitly:

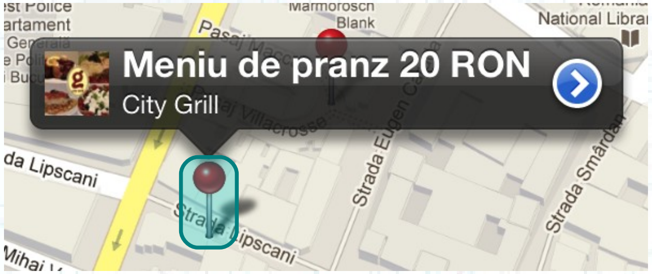
```
func addAnnotation(_ annotation: MKAnnotation)
func addAnnotations(_ annotations: [MKAnnotation])
func removeAnnotation(_ annotation: MKAnnotation)
func removeAnnotations(_ annotations: [MKAnnotation])
```

Generally a good idea to add all your annotations up-front

- Allows the `MKMapView` to be efficient about how it displays them.
- Annotations are light-weight, but annotation views are not.
- `MKMapView` reuses annotation views similar to how `UITableView` reuses cells. Usually, we end up using only a few annotation views.

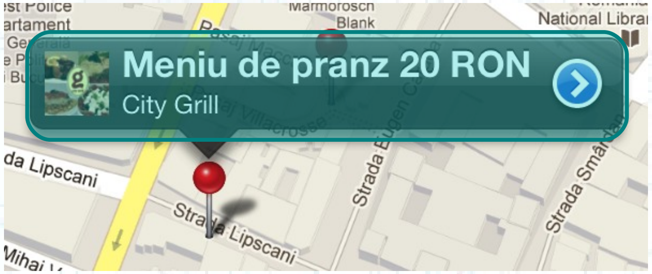
MKAnnotation

What do annotations look like on the map?



- By default they look like a pin.
- Annotations are drawn using an `MKAnnotationView` subclass.
- The default one is `MKPinAnnotationView` (which is why they look like pins).
- You can create your own or set properties on existing `MKAnnotationViews` to modify the look.

MKAnnotation



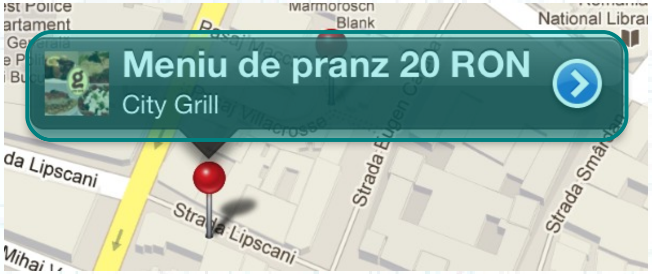
What do annotations look like on the map?

- By default they look like a pin.
- Annotations are drawn using an `MKAnnotationView` subclass.
- The default one is `MKPinAnnotationView` (which is why they look like pins).
- You can create your own or set properties on existing `MKAnnotationViews` to modify the look.

What happens when you touch on an annotation (e.g. the pin)?

- Depends on the `MKAnnotationView` that is associated with the annotation (more on this later).
- By default, nothing happens, but if `canShowCallout` is `true` in the `MKAnnotationView`, then a little box will appear showing the annotation's `title` and `subtitle`. And this little box (the callout) can be enhanced with `left/rightCalloutAccessoryViews`.

MKAnnotation



- The following delegate method is also called when you touch on an annotation:

```
func mapView(_ mapView: MKMapView,
             didSelect view: MKAnnotationView)
```

- This is a great place to set up the `MKAnnotationView's` callout accessory views lazily.
- For example, you might want to wait until this method is called to download an image to show.

MKAnnotationView

How are MKAnnotationViews created and associated with annotations?

- Very similar to UITableViewCells in a UITableView. Implement the following MKMapViewDelegate method (if not implemented, returns a pin view):

```
func mapView(_ mapView: MKMapView,
     viewFor annotation: MKAnnotation) -> MKAnnotationView?
{
   var p = mapView.dequeueReusableAnnotationView(withIdentifier:"P")

   if p == nil
   {
      p = MKPinAnnotationView(annotation: annotation,
                              reuseIdentifier: "P")
   }

   p?.canShowCallout = true
   // build pinView’s callout accessory views here

   p?.annotation = annotation // this can happen twice

   /* Maybe load up accessory views here (if not too expensive)?
    * Or reset them and wait until
    * mapView:didSelectAnnotationView: to load actual data. */
   return p
}
```

MKAnnotationView

Interesting properties

- The annotation should be treated as if it is readonly:

```
var annotation: MKAnnotation? { get set }
```

- The pin itself can be replaced with another image:

```
var image: UIImage? { get set }
```

- Left and right callout accessory views:

```
var leftCalloutAccessoryView: UIView? { get set }
// maybe a UIImageView

var rightCalloutAccessoryView: UIView? { get set }
// maybe a detail disclosure UIButton
```

- Set this to `false` to ignore touch events (no delegate method, no callout):

```
var isEnabled: Bool { get set }
```

MKAnnotationView

Interesting properties

- Where the `image` (pin) should be relative to the coordinate point of the associated `annotation`:

```
var centerOffset: CGPoint { get set }
```

- Where the callout view should be relative to the top-center point of the annotation view:

```
var calloutOffset: CGPoint { get set }
```

When this property is set to (0, 0), the anchor point of the callout bubble is placed on the top-center point of the annotation view’s frame.

- Users can drag annotations. Only works if the associated `annotation` implements `setCoordinate` and this property is set to `true`:

```
var isDraggable: Bool { get set }
```

MKAnnotationView

- If you set one of the callout accessory views to a UIControl, for example:

```
pinView?.rightCalloutAccessoryView = UIButton(type:
                                        .detailDisclosure)
```

- Then the following MKMapViewDelegate method will get called when the accessory view is touched:

```
func mapView(_ mapView: MKMapView,
     annotationView view: MKAnnotationView,
     calloutAccessoryControlTapped control: UIControl)
```

MKAnnotationView

Using mapView(didSelect:) to load up callout accessories

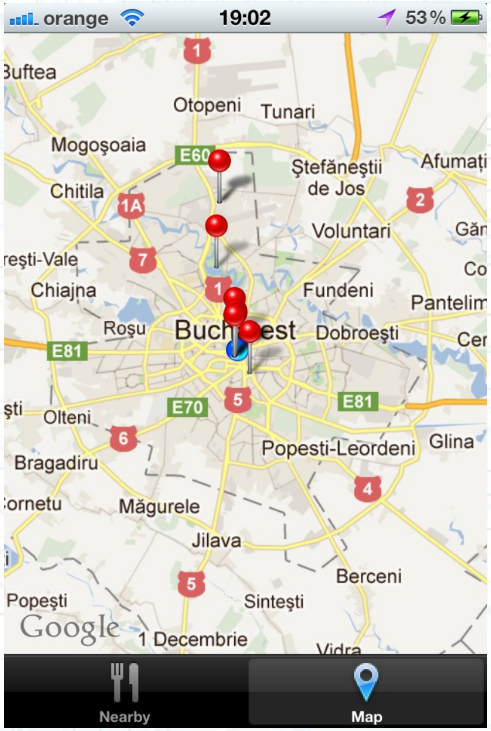
- Example: Using a downloaded thumbnail image for leftCalloutAccessoryView.
- Create a UIImageView. Assign it to leftCalloutAccessoryView in mapView(viewFor:).
- Reset the UIImageView’s image to nil there as well.
- Then load the image on demand like this:

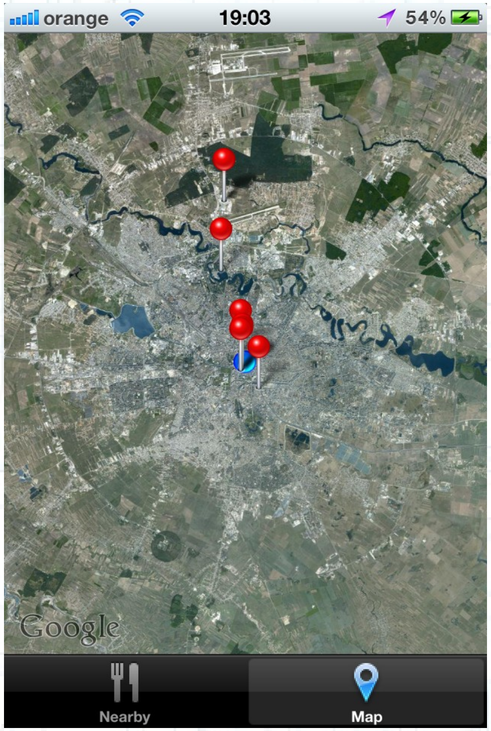
```
func mapView(_ mapView: MKMapView,
             didSelect view: MKAnnotationView)
{
   if view.leftCalloutAccessoryView is UIImageView
   {
      let imageView = view.leftCalloutAccessoryView as!
                      UIImageView
      imageView.image = UIImage(named: "thumb")
   }
}
```

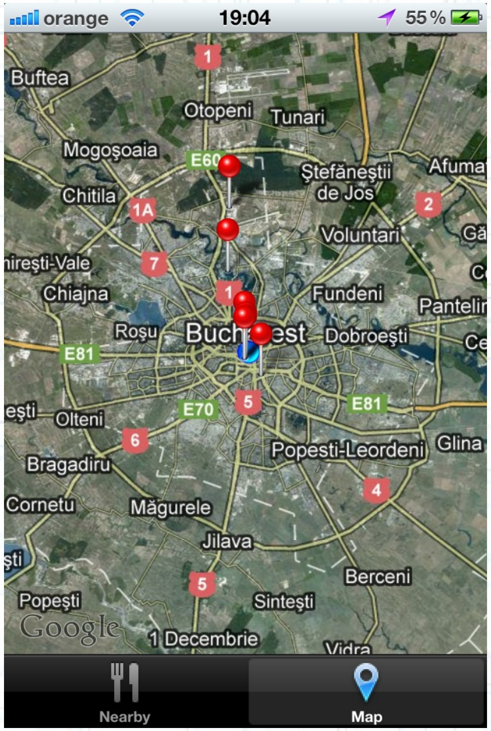
MKMapView

- Configuring the map view’s display type:

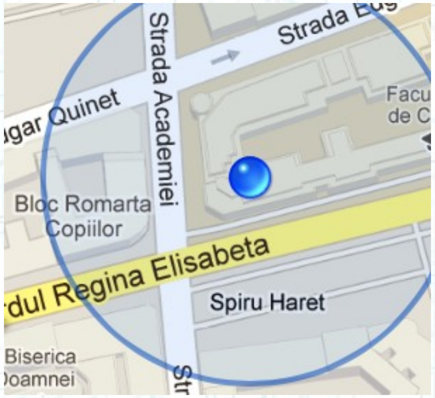
```
var mapType: MKMapType { get set }
 .standard,             .satellite,            .hybrid
```







MKMapView



- Showing the user’s current location:

```
var showsUserLocation: Bool { get set }
var isUserLocationVisible: Bool { get }
var userLocation: MKUserLocation { get }
```

`MKUserLocation` is an object which conforms to `MKAnnotation` which holds the user’s location.

- Restricting the user’s interaction with the map:

```
var isZoomEnabled: Bool { get set }
var isScrollEnabled: Bool { get set }
```

MKMapView

- Controlling the region the map is displaying:

```
var region: MKCoordinateRegion { get set }
struct MKCoordinateRegion
{
   var center: CLLocationCoordinate2D
   var span: MKCoordinateSpan
}
struct MKCoordinateSpan
{
   var latitudeDelta: CLLocationDegrees
   var longitudeDelta: CLLocationDegrees
}
func setRegion(_ region: MKCoordinateRegion,
               animated: Bool)
```

- Can also set the center point only:

```
var centerCoordinate: CLLocationCoordinate2D { get set }
func setCenter(_ coordinate: CLLocationCoordinate2D,
               animated: Bool)
```

MKMapView

Map loading notifications

- Remember that the maps are downloaded from the Internet.
- These methods are called whenever a new group of map tiles need to be downloaded from the server (whenever you expose portions of the map by panning or zooming the content):

```
func mapViewWillStartLoadingMap(_ mapView: MKMapView)

func mapViewDidFinishLoadingMap(_ mapView: MKMapView)

func mapViewDidFailLoadingMap(_ mapView: MKMapView,
                               withError error: Error)
```

Lots of functions to convert points, regions, rects, etc.

- Take a look over the documentation.
- Examples:

`MKMapRectContainsPoint`, `MKMapPointForCoordinate`, etc.

Overlays

Overlays

- Mechanism is similar to annotations (uses `MKOverlayView` instead of `MKAnnotationView`).

```
func add(_ overlay: MKOverlay,
         level: MKOverlayLevel)
func addOverlays(_ overlays: [MKOverlay])
func remove(_ overlay: MKOverlay)
func removeOverlays(_ overlays: [MKOverlay])
```

`MKOverlay` protocol

- Protocol which includes `MKAnnotation` plus these:

```
var boundingMapRect: MKMapRect { get }
```

```
func intersects(_ mapRect: MKMapRect) -> Bool
// optional method, uses boundingMapRect otherwise
```

- Overlays are associated with `MKOverlayViews` via delegate (just like annotations are associated with `MKAnnotationViews`):

```
func mapView(_ mapView: MKMapView,
             rendererFor overlay: MKOverlay)
             -> MKOverlayRenderer
```

MKOverlayView

- MKOverlayRenderer subclasses must be able to draw the overlay:

```
func draw(_ mapRect: MKMapRect,
          zoomScale: MKZoomScale,
          in context: CGContext)
```

- This is not quite like drawRect() (because you'll notice that you are provided the context).
- But you will still use CoreGraphics to draw (this method must be thread-safe, by the way).
- Also notice that the rectangle to draw is in map coordinates, not view coordinates.
- Converting to/from map points/rects from/to view coordinates:

```
func point(for mapPoint: MKMapPoint) -> CGPoint
func mapPoint(for point: CGPoint) -> MKMapPoint
func rect(for mapRect: MKMapRect) -> CGRect
func mapRect(for rect: CGRect) -> MKMapRect
```

Next Time

Managing and Storing Data:

- Property Lists
- Archiving Objects
- Filesystem Storing
- SQLite
- Closures (recap)
- Grand Central Dispatch
- URL Requests