Stanford CS193p

Developing Applications for iPhone 4, iPod Touch, & iPad

Fall 2010

Today

- Core Location
  Framework for specifying locations on the planet
- MapKit
  Graphical toolkit for displaying locations on the planet

Core Location

- Framework for managing location and heading
  No user-interface.

- Basic object is `CLLocation`

- Where (approximately) is the location?

```
@property (readonly) CLLocationCoordinate2D coordinate;
typedef {
    CLLocationDegrees latitude;
    CLLocationDegrees longitude;
} CLLocationCoordinate2D;
```

```
@property (readonly) CLLocationDistance altitude;  // meters
```

A negative value means "below sea level."

Core Location

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

```
@property (readonly) CLLocationAccuracy horizontalAccuracy;   // in meters
@property (readonly) CLLocationAccuracy verticalAccuracy;   // in meters
```

  A negative value means the `coordinate` or `altitude` (respectively) is invalid.

```
kCLLocationAccuracyBestForNavigation;   // phone should be plugged in to power source
kCLLocationAccuracyBest;
kCLLocationAccuracyNearestTenMeters;
kCLLocationAccuracyHundredMeters;
kCLLocationAccuracyKilometer;
kCLLocationAccuracyThreeKilometers;
```

- The more accuracy you request, the more battery will be used
- Device "does its best" given a specified accuracy request

  Cellular tower triangulation (not very accurate, but low power)
  WiFi node database lookup (more accurate, more power)
  GPS (very accurate, lots of power)

Core Location

- Speed

  `@property (readonly) CLLocationSpeed speed;` // in meters/second

  Note that the speed is <u>instantaneous</u> (not average speed).

  Generally it's useful as "advisory information" when you are in a vehicle.

  A negative value means "speed is invalid."

- Course

  `@property (readonly) CLLocationDirection course;   // in degrees, 0 is north, clockwise`

  Not all devices can deliver this information.

  A negative value means "course is invalid."

- Time stamp

  `@property (readonly) NSDate *timestamp;`

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

- Distance between `CLLocations`

  `- (CLLocationDistance)distanceFromLocation:(CLLocation *)otherLocation;` // in meters

Core Location

- How do you get a `CLLocation`?

  Almost always from a `CLLocationManager` (sent to you via its `delegate`).
  Note that none of this works in the simulator, so this stuff can only be tested on a device.

- `CLLocationManager`

  General approach to using it:
  1. Check to see if the hardware you are on/user supports the kind of location updating you want.
  2. Create a `CLLocationManager` instance and set a `delegate` to receive updates.
  3. Configure the manager according to what kind of location updating you want.
  4. Start the manager monitoring for location changes.

- Kinds of location monitoring

  Accuracy-based continual updates.
  Updates only when "significant" changes in location occur.
  Region-based updates.
  Heading monitoring.

Core Location

Checking to see what your hardware can do

```
+ (BOOL)locationServicesEnabled;   // has the user enabled location monitoring in their Settings?
+ (BOOL)headingAvailable;           // can this hardware provide heading info (compass)?
+ (BOOL)significantLocationChangeMonitoringAvailable;   // currently only if device has cellular
+ (BOOL)regionMonitoringAvailable;   // only certain iOS4 devices
+ (BOOL)regionMonitoringEnabled;   // by the user in Settings
```

Purpose

When your application first tries to use location monitoring, user will be asked if it's okay to do so.
You can provide a string which describes your app's purpose in using the location services.

```
@property (copy) NSString *purpose;
```

If the user denies you, the appropriate method above will return `NO`.

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.

Core Location

- Accuracy-based continuous location monitoring

  `@property CLLocationAccuracy desiredAccuracy;` // always set this as low as possible

  `@property CLLocationDistance distanceFilter;`

  Only changes in location of at least this distance will fire a location update to you.

- Start the monitoring

  `- (void)startUpdatingLocation;`

  `- (void)stopUpdatingLocation;`

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

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

```
- (void)locationManager:(CLLocationManager *)manager
    didUpdateToLocation:(CLLocation *)newLocation
           fromLocation:(CLLocation *)oldLocation;
```

Core Location

- Heading monitoring

  `@property CLLocationDegrees headingFilter;`

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

  `@property CLHeadingOrientation headingOrientation;`

  Heading of "zero degrees" is the heading of the "top" of the device.
  With this property, you can change that "top" (e.g. `CLDeviceOrientationLandscapeLeft`).

- Start the monitoring

  `- (void)startUpdatingHeading;`

  `- (void)stopUpdatingHeading;`

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

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

```
- (void)locationManager:(CLLocationManager *)manager
       didUpdateHeading:(CLHeading *)newHeading;
```

Core Location

- `CLHeading`

  ```
  @property (readonly) CLLocationDirection magneticHeading;
  @property (readonly) CLLocationDirection trueHeading;
  ```
  Negative values mean "this heading is unreliable" (i.e. don't use it).
  You will only get `magneticHeading` if location services are turned off (e.g. by the user).

  `@property (readonly) CLLocationDirection headingAccuracy;` // in degrees
  Basically how far off the magnetic heading might be from actual magnetic north.
  A negative value means "this heading is not valid."

  `@property (readonly) NSDate *timestamp;`

- Heading calibration user-interface

  Automatically put up, but can be prevented by `CLLocationManager delegate`
  `- (BOOL)locationManagerShouldDisplayHeadingCalibration:(CLLocationManager *)manager;`
  Or dismissed (maybe after a timer or something) using `CLLocationManager` instance method
  `- (void)dismissHeadingCalibrationDisplay;`

Core Location

- Error reporting to the delegate

```
- (void)locationManager:(CLLocationManager *)manager
        didFailWithError:(NSError *)error;
```

Not always a terrible thing, so pay attention.

```
kCLErrorLocationUnknown   // likely temporary, keep waiting (for a while at least)
kCLErrorDenied            // user refused to allow your application to receive updates
kCLErrorHeadingFailure    // too much local magnetic interference, keep waiting
```

Core Location

- Significant location change monitoring in `CLLocationManager`

  "Significant" is not strictly defined. Think vehicles, not walking. Likely uses cell towers.
  ```
  - (void)startMonitoringSignificantLocationChanges;
  - (void)stopMonitoringSignificantLocationChanges;
  ```
  Be sure to turn updating off when your application is not going to consume the changes!

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

  Same as for accuracy-based updating if your application is running.

- Works even if your application is not running!

  Or in the background (we haven't talked about multitasking yet).
  You will get launched and `application:didFinishLaunchingWithOptions:` dictionary will contain `UIApplicationLaunchOptionsLocationKey`

  Create a `CLLocationManager` (if you don't have one), then get the latest location via
  ```
  @property (readonly) CLLocation *location;
  ```
  If you are running in the background, don't take too long (a few seconds)!

Core Location

- Region-based location monitoring in CLLocationManager

```
- (void)startMonitoringForRegion:(CLRegion *) desiredAccuracy:(CLLocationAccuracy);
- (void)stopMonitoringForRegion:(CLRegion *);
```

- Get notified via the CLLocationManager's delegate

```
- (void)locationManager:(CLLocationManager *)manager didEnterRegion:(CLRegion *)region;
- (void)locationManager:(CLLocationManager *)manager didExitRegion:(CLRegion *)region;

   - (void)locationManager:(CLLocationManager *)manager
monitoringDidFailForRegion:(CLRegion *)region
                 withError:(NSError *)error;
```

- Works even if your application is not running!

In exactly the same way as "significant location change" monitoring.
The set of monitored regions persists across application termination/launch.
`@property (readonly) NSSet *monitoredRegions;` // CLLocation property

Core Location

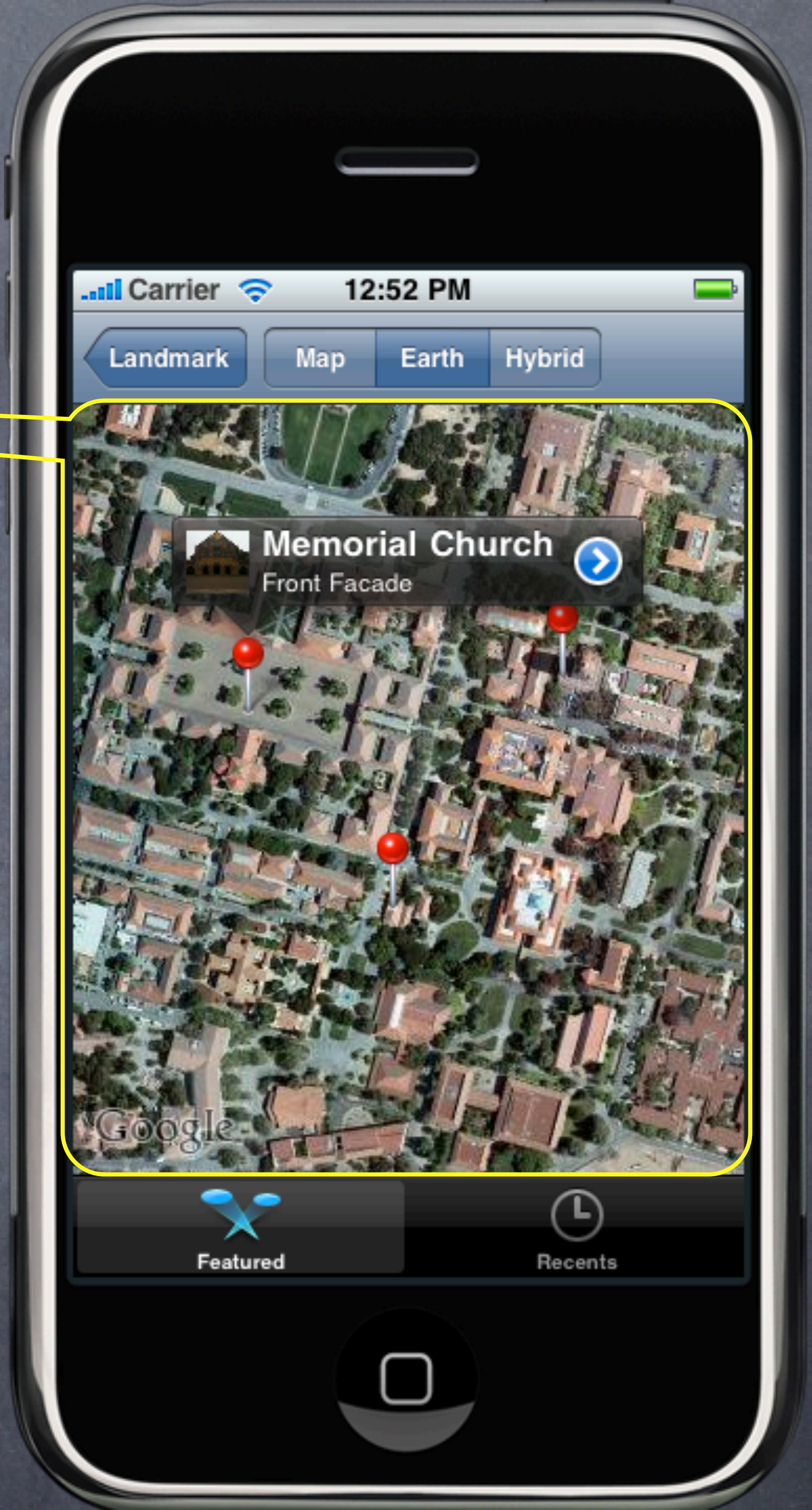
- CLRegions are tracked by name
  Because they survive application termination/relaunch.
- Regions (currently) require large location changes to fire
  Probably based on same technology as "significant location change" monitoring.
  Likely both of these "fire" when a new cell tower is detected.
  Definitely they would not use GPS (very expensive power-wise).
- Region monitoring size limit

```
@property (readonly) CLLocationDistance maximumRegionMonitoringDistance;
```

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

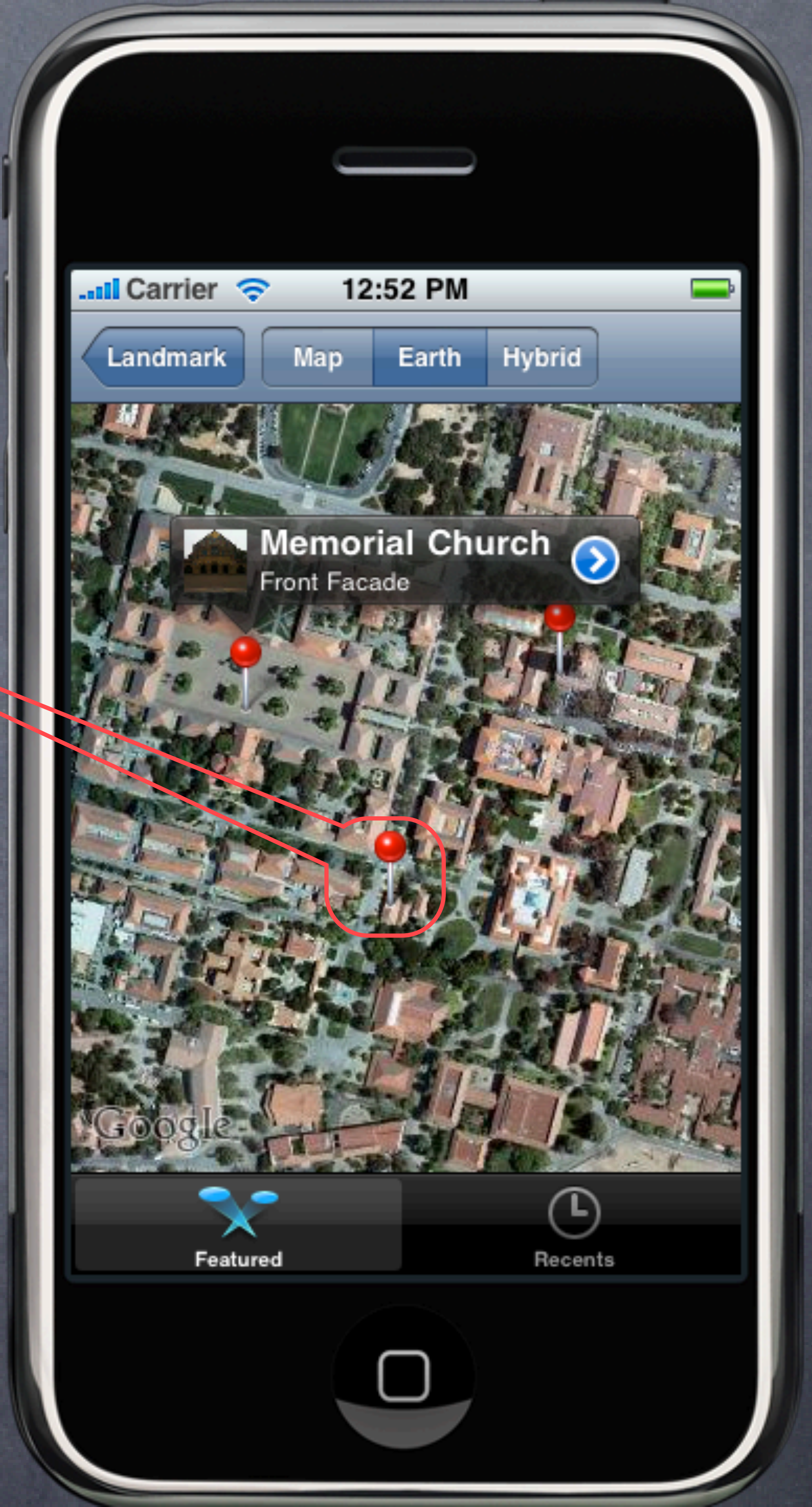
Map Kit

- Displays a map



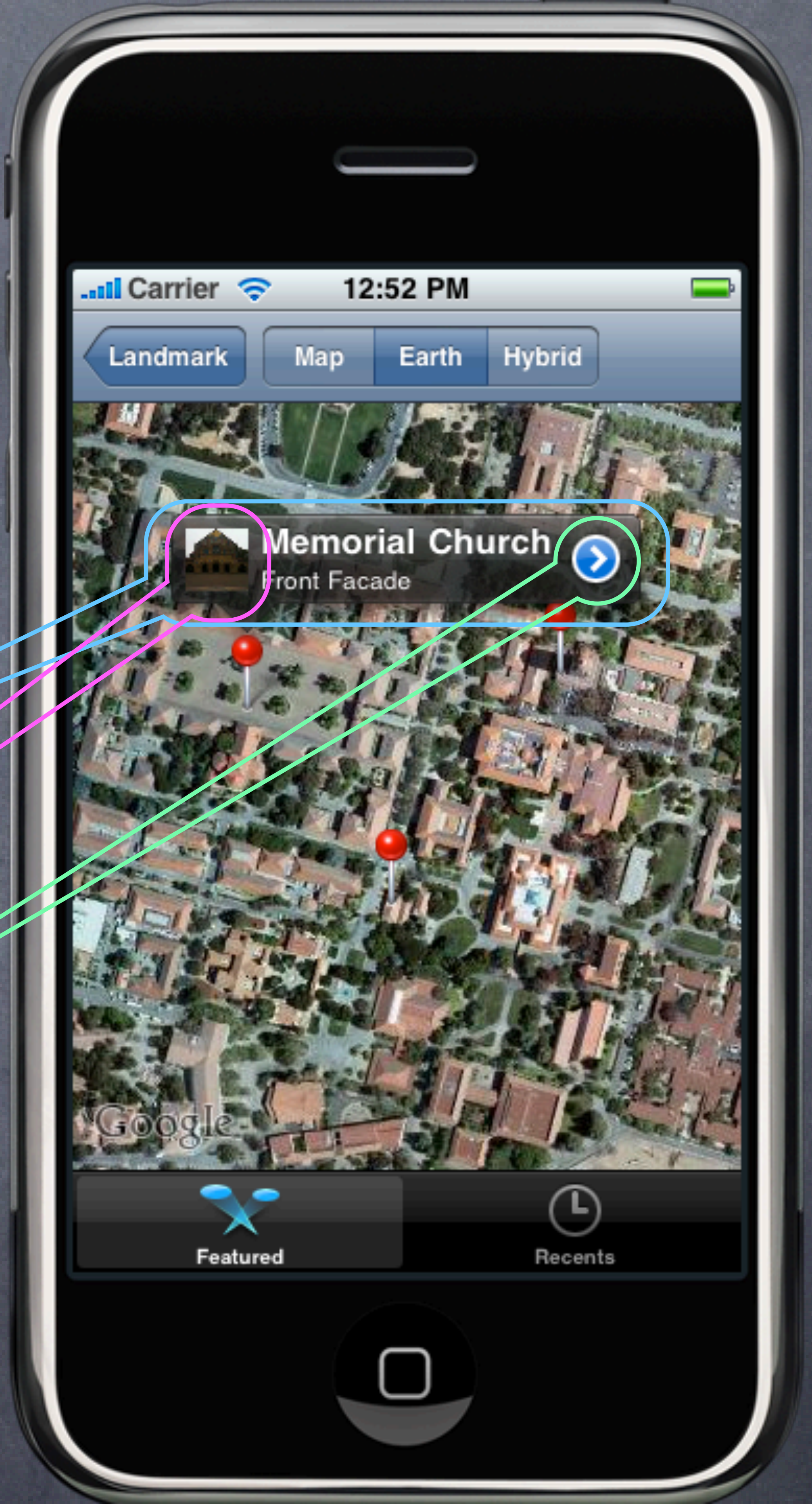
Map Kit

- Displays a map
- The map can have annotations on it
  Each annotation is just a coordinate with a title and subtitle. They are displayed using an MKAnnotationView (MKPinAnnotationView shown here).



Map Kit

- Displays a map
- The map can have annotations on it
  Each annotation is just a coordinate with a `title` and `subtitle`. They are displayed using an `MKAnnotationView` (`MKPinAnnotationView` shown here).
- Annotations can have a callout associated with them (shown when clicked)
  By default, it just shows the `title` and `subtitle`, but you can add accessory views to the left and right (in this case, `UIImageView` on left, `UIButton` (of type `UIButtonTypeDetailDisclosure`) on right).



MKMapView

- Create with alloc/init or drag from Library in IB
- Displays an array of objects which implement MKAnnotation

```
@property (readonly) id <MKAnnotation> annotations;
```

- MKAnnotation

```
@protocol MKAnnotation <NSObject>
@property (readonly) CLLocationCoordinate2D coordinate;
@optional
@property (readonly) NSString *title;
@property (readonly) NSString *subtitle;
@end

typedef {
    CLLocationDegrees latitude;
    CLLocationDegrees longitude;
} CLLocationCoordinate2D;
```

MKAnnotation

- Note that `annotations` property is `readonly`

  Must add/remove annotations explicitly

```
- (void)addAnnotation:(id <MKAnnotation>)annotation;
- (void)addAnnotations:(NSArray *)annotations;
- (void)removeAnnotation:(id <MKAnnotation>)annotation;
- (void)removeAnnotations:(NSArray *)annotations;
```

- If you have a lot of annotations, limit to (at least) visible ones

  `MKMapView`'s `delegate` method similar to `viewDidAppear:` in a view controller

```
- (void)mapView:(MKMapView *)sender regionDidChangeAnimated:(BOOL)animated;
```

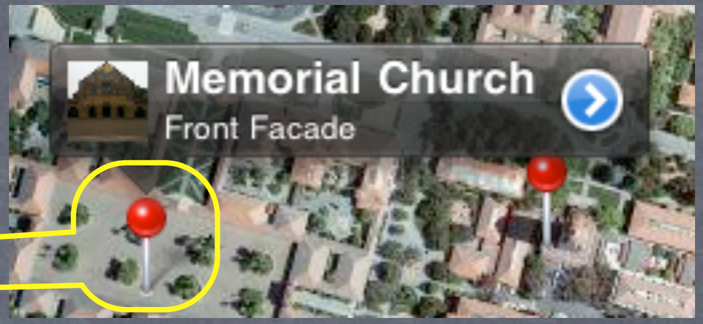
  Also a "will" version, but be careful because it is called repeatedly on scroll!

```
- (void)mapView:(MKMapView *)sender regionWillChangeAnimated:(BOOL)animated;
```

```
@property (readonly) MKMapRect visibleRect;   // where in the world is visible on the map
```

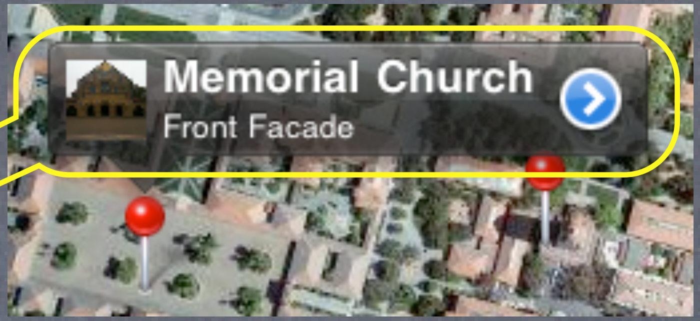
```
MKMapPoint annotationPoint = MKMapPointForCoordinate(annotation.coordinate);
if (MKMapRectContainsPoint(mapView.visibleRect, annotationPoint)) { ... }
```

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



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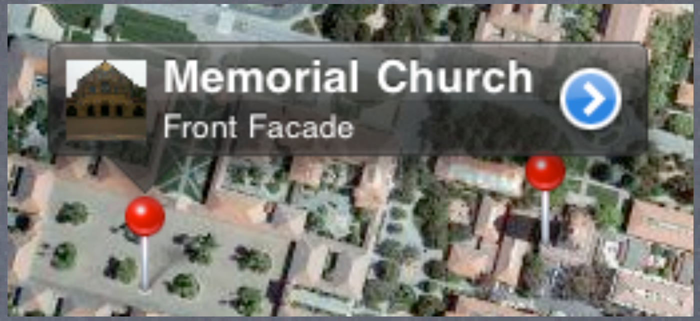
- What happens when you click on an annotation?
  - Depends on the MKAnnotationView that is associated with the annotation (more on this later).
  - By default, nothing happens, but if canShowCallout is YES in the MKAnnotationView, then
    a little box will appear showing the annotation's title and subtitle.
  - This little box can be enhanced with left and right accessory views.

  The following delegate method is also called...

  ```
  - (void)mapView:(MKMapView *)sender didSelectAnnotationView:(MKAnnotationView *)aView;
  ```

  You can either just do what you want here (e.g. push a view controller), or, if canShowCallout, ...
  You can prepare the MKAnnotationView to display its little box.

MKAnnotation



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  You can prepare the `MKAnnotationView` to display its little box.

MKAnnotationView

- How are MKAnnotationViews created & associated w/annotations?

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

```
- (MKAnnotationView *)mapView:(MKMapView *)sender
            viewForAnnotation:(id <MKAnnotation>)annotation
{
    MKAnnotationView *aView = [sender dequeueReusableAnnotationViewWithIdentifier:IDENT];
    if (!aView) {
        aView = [[[MKPinAnnotationView alloc] initWithAnnotation:annotation
                                                  reuseIdentifier:IDENT] autorelease];
        // set canShowCallout to YES and build aView's callout accessory views here
    }
    aView.annotation = annotation;
    // maybe load up accessory views and/or title/subtitle here
    // or reset them and wait until mapView:didSelectAnnotationView: to load actual data
    return aView;
}
```

  You can see why you might want to only show visible annotations (to keep view count low)

MKAnnotationView

- MKAnnotationView

  Interesting properties

  ```
  @property (retain) id <MKAnnotation> annotation;   // the annotation; treat as if readonly
  @property (retain) UIImage *image;   // instead of the pin, for example
  @property (retain) UIView *leftCalloutAccessoryView;   // maybe a UIImageView
  @property (retain) UIView *rightCalloutAccessoryView;   // maybe a "disclosure" UIButton
  @property BOOL enabled;   // NO means it ignores touch events, no delegate method, no callout
  @property CGPoint centerOffset;   // where the "head of the pin" is relative to image
  @property BOOL draggable;   // only works if the annotation implements setCoordinate:
  ```

- If you set one of the callout accessory views to a UIControl

  The following MKMapViewDelegate method will get called when the accessory view is touched ...

  ```
              - (void)mapView:(MKMapView *)sender
               annotationView:(MKAnnotationView *)aView
  calloutAccessoryControlTapped:(UIControl *)control;
  ```

  Very common:

  ```
  aView.rightCalloutAccessoryView = [UIButton buttonWithType:UIButtonTypeDetailDisclosure];
  ```

MKAnnotationView

- Using didSelectAnnotationView: to load up callout accessories

  Example … downloaded thumbnail image in leftCalloutAccessoryView.
  Create the UIImageView and assign it to leftCalloutAccessoryView in mapView:viewForAnnotation:.
  Reset the UIImageView's image to nil there as well.
  Then load the image on demand in mapView:didSelectAnnotationView: …

```
- (void)mapView:(MKMapView *)sender didSelectAnnotationView:(MKAnnotationView *)aView
{
    if ([aView.leftCalloutAccessoryView isKindOfClass:[UIImageView class]]) {
        UIImageView *imageView = (UIImageView *)aView.leftCalloutAccessoryView;
        dispatch_queue_t downloader = dispatch_queue_create("callout downloader", NULL);
        dispatch_async(downloader, ^{
            UIImage *theImage = ...;  // download theImage here
            dispatch_async(dispatch_get_main_queue(), ^{ imageView.image = theImage; });
        });
        dispatch_release(downloader);
}
```

MKMapView

- Overlays

  Similar mechanism to annotations (uses `MKOverlayView` instead of `MKAnnotationView`).

  ```
  - (void)addOverlay:(id <MKOverlay>)overlay;       // also addOverlays:(NSArray *)
  - (void)removeOverlay:(id <MKOverlay>)overlay;    // also removeOverlays:(NSArray *)
  ```

- `MKOverlay`

  Protocol which includes `MKAnnotation` plus ...

  ```
  @property (readonly) MKMapRect boundingMapRect;
  - (BOOL)intersectsMapRect:(MKMapRect)mapRect; // optional, uses boundingMapRect otherwise
  ```

- Overlays are associated with `MKOverlayViews` via `delegate`

  Just like annotations are associated with `MKAnnotationViews` ...

  ```
  - (MKOverlayView *)mapView:(MKMapView *)sender viewForOverlay:(id <MKOverlay>)overlay;
  ```

MKOverlayView

- MKOverlayView subclasses must be able to draw the overlay

```
- (void)drawMapRect:(MKMapRect)mapRect
          zoomScale:(MKZoomScale)zoomScale
          inContext:(CGContextRef)context;
```

  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

```
- (MKMapPoint)mapPointForPoint:(CGPoint)point;
- (MKMapRect)mapRectForRect:(CGRect)rect;
- (CGPoint)pointForMapPoint:(MKMapPoint)mapPoint;
- (CGRect)rectForMapRect:(MKMapRect)mapRect;
```

MKMapView

- Configuring the map view's display type

```
@property MKMapType mapType;
MKMapTypeStandard, MKMapTypeSatellite, MKMapTypeHybrid;
```

- Showing the user's current location

```
@property BOOL showsUserLocation;
@property (readonly) BOOL isUserLocationVisible;
@property (readonly) MKUserLocation *userLocation;
```

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

- Restricting the user's interaction with the map

```
@property BOOL zoomEnabled;
@property BOOL scrollEnabled;
```

MKMapView

- Controlling the region the map is displaying

```
@property MKCoordinateRegion region;
typedef struct {
    CLLocationCoordinate2D center;
    MKCoordinateSpan span;
} MKCoordinateRegion;
typedef struct {
    CLLocationDegrees latitudeDelta;
    CLLocationDegrees longitudeDelta;
}
- (void)setRegion:(MKCoordinateRegion)region animated:(BOOL)animated; // animated version
```

- Can also set the center point only

```
@property CLLocationCoordinate2D centerCoordinate;
- (void)setCenterCoordinate:(CLLocationCoordinate2D)center animated:(BOOL)animated;
```

MKMapView

- Converting to/from latitude/longitude from/to view coordinates

```
- (CGPoint)convertCoordinate:(CLLocationCoordinate2D)coord toPointToView:(UIView *)view;
- (CLLocationCoordinate2D)convertPoint:(CGPoint)point toCoordinateFromView:(UIView *)view;
- (CGRect)convertRegion:(MKCoordinateRegion)region toRectToView:(UIView *)view;
- (MKCoordinateRegion)convertRect:(CGRect)rect toRegionFromView:(UIView *)view;
```

  The view must be in the same window as the `MKMapView` (or `nil` which means window coordinates).

- Map loading notifications

  Remember that the maps are downloaded from Google earth.

```
- (void)mapViewWillStartLoadingMap:(MKMapView *)sender;
- (void)mapViewDidFinishLoadingMap:(MKMapView *)sender;
- (void)mapViewDidFailLoadingMap:(MKMapView *)sender withError:(NSError *)error;
```

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

  See documentation, e.g. `MKMapRectContainsPoint`, `MKMapPointForCoordinate`, etc.

Coming Up

- Demo

  Add a map of photographer locations to Shutterbug.
  We'll use a "representative photo" (i.e. random photo) to determine the photographer's location.
  Add new attributes to Photo class for latitude and longitude (and thumbnailURL, time permitting).
  Add button to PhotographerViewController to switch table view to map view and back.
  Map view will push a list of photos by that photographer just like the table view does.