CSC 491 / 391 Mobile Application Development for iOS II

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Outline

- Asynchronous calls
- Singleton design pattern
  - Access levels
- Lazy loading
- Parsing JSON data
- CocoaPods

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Asynchronous & Lazy Loading

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Synchronous Calls vs. Asynchronous Calls

- Synchronous calls
  - Blocking calls. Wait for tasks to complete.
  - Execution on the same or a different thread.
  - Return upon completion.
- Asynchronous calls
  - Non-blocking calls. Return immediately.
  - Execution on a different tread.
  - Call back upon completion
    - Commonly in Swift, *completion blocks*

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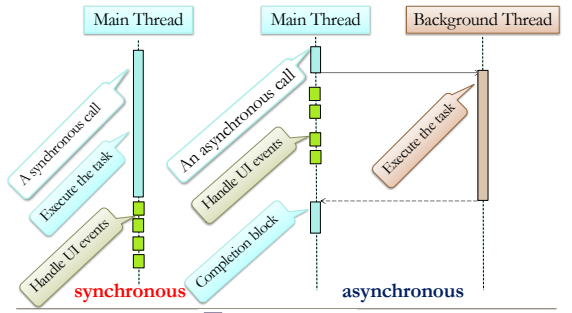
Synchronous vs. Asynchronous



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An ITunes RSS Reader with a Single Entry

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An ITunes RSS Reader – the First Iteration

- Access iTune data, e.g., top paid apps
- (Asynchronous) HTTP request
  - Data returned in XML or JSON
- Parse JSON
- Handle errors

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Failable Initializers

- An initializer that may fail
  - Declared as `init?(…)`
  - Return `nil` when initialization fails
  - The result is an optional value
- Example:

```
class Car {
    let model: String
    init?(_ model: String) {
        if model.isEmpty {
            return nil
        }
        self.model = model
    }
}

let myCar = Car("Tesla 3S")
myCar?.model
let anotherCar = Car("")
anotherCar?.model
```

The type is `Car?`

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Handle HTTP Requests

```
let feed = "http://ax.itunes.apple.com/…/limit=1/json"
…
guard let feedURL = URL(string: feed)
    else { … return }
let request = URLRequest(url: feedURL)
let session = URLSession.shared
session.dataTask(with: request) {
       data, response, error in
    Process the data received from the request
}.resume()
```

The request URL

A failable initializer

The shared instance, singleton

An asynchronous call

A completion handler of the asynchronous call, as a closure

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URL Session

- Load and manage the contents of a URL
  - Download or upload data
  - Manage cookies, caching, credentials, and authentication
- Natively supported URL schemes
  - File Transfer Protocol – ftp://
  - Hypertext Transfer Protocol – http:// https://
  - Local file URLs – file:///
  - Data URLs – data://

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Using an URL Session

- Create one or more *sessions*
  - A shared session, singleton, handle basic requests
  - Other sessions, customizable and configurable
    - *Default, Ephemeral,* and *Background* sessions
- Create tasks in a session
  - *Data* tasks, short, interactive, send/receive data
  - *Upload* and *Download* tasks, background processing
- Each task starts in a *suspended* state.
  - Call `resume()` to begin receiving/sending data

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JSON

- **JSON** (JavaScript Object Notation)
- A lightweight data-interchange format
- Widely used and supported
- Compared to XML
  - More compact, less verbose, and more readable
  - Faster to parse
  - Limited data types

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Examples of JSON Data

An Array

```
[
   "Hello world!",
   2021,
   true
]
```

A Dictionary

```
{
  "name": "Caffè Macs",
  "coordinates": {
    "lat": 37.330576,
    "lng": -122.029739
  },
  "menu": [
     "breakfast",
     "lunch",
     "dinner"
  ]
}
```

A Dictionary in a Dictionary

An Array in a Dictionary

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JSON Serialization

- Class `JSONSerialization`
  - Converts JSON data into Swift data types:
    - `Dictionary`, `Array`, `String`, `Number`, and `Bool`, etc.
- Extracting values from JSON
  - Dictionary: `[String:Any]`
  - Array: `[Any]`
  - Values: `String` `Number` `Bool`
- JSON data can be non-uniform
  - Optional downcasting is often necessary

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Non-Specific Types

- Two special types to represent values and objects of non-specific types

  `Any`
  - an instance of any type, including class, struct, enum, and closure types.

  `AnyObject`
  - an instance of any class or closure type.
- Not classes, but protocols
- Use specific types whenever possible

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Process JSON Data

- Deserialize JSON data

```
let json = try? JSONSerialization.jsonObject(
                                with: data, options: [])
```

- When the root is a dictionary

```
if let dictionary = json as? [String: Any] { … }
```

- When the root is an array

```
if let array = json as? [Any] { … }
```

- Extract the data descending the tree, one level at a time
- May encounter various types of anomalies in data
  - missing keys
  - invalid values

```
enum SerializationError: Error {
    case missing(String)
    case invalid(String, Any)
}
```

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Receiving Data from URL Session

```
session.dataTask(with: request) { data, response, error in
    guard error == nil else {
        print(error!.localizedDescription); return
    }
    guard let data = data else { return }
    do {
        …
    } catch SerializationError.missing(let msg) {
        print("Missing \(msg)")
    } catch SerializationError.invalid(let msg, let data) {
        print("Invalid \(msg): \(data)")
    } catch let error as NSError {
        print(error.localizedDescription)
    }
}.resume()
```

An NSError

Parse JSON data

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JSON Data from iTunes

```
{ "feed": {
    "author": { ... },
    "name": { ... },
    "entry": {
        "im:artist": { "attributes": { "href": "https://…/…" },
                       "label": "Mojang"},
        "im:contentType": { … },
        "im:image": [
            { "attributes": { "height": 53 }, "label": "http://….png" },
            { "attributes": { "height": 75 }, "label": "http://….png" },
            { "attributes": { "height": 100 }, "label": "http://….png" }
        ],
        "im:name": { "label": "Minecraft: Pocket Edition" }
    }
  },
  ...
}
```

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Parsing JSON Data

```
if let json = try JSONSerialization.jsonObject(with: data!, options: [])
                    as? [String:Any] {
    guard let feed = json["feed"] as? [String:Any] else {
        throw SerializationError.missing("feed")
    }
    guard let entry = feed["entry"] as? [String:Any] else {
        throw SerializationError.missing("entry")
    }
    guard let nameEntry = entry["im:name"] as? [String:Any] else {
        throw SerializationError.missing("im:name")
    }
    guard let artistEntry = entry["im:artist"] as? [String:Any] else {
        throw SerializationError.missing("im:artist")
    }
    guard let imageArray = entry["im:image"] as? [Any] else {
        throw SerializationError.missing("im:image")
    }
    …
```

{ "feed": … }

{ "entry": … }

{
"im:name": …
"im:artist": …
"im:image": …
}

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Parsing & Displaying Data

```
if let json = try JSONSerialization.jsonObject() as? [String:Any] {
    guard let feed = …
    guard let entry = …
    guard let nameEntry = …
    guard let artistEntry = …
    guard let imageArray = …
    if let title = nameEntry["label"] as? String,
       let artist = artistEntry["label"] as? String {
        DispatchQueue.main.async {
            self.titleLabel.text = title
            self.artistLabel.text = artist
        }
        if let imageEntry = imageArray.last as? [String:Any],
           let imageURL = imageEntry["label"] as? String,
           let url = URL(string:imageURL) {
            self.loadImage(from: url, in: self.imageView)
        }
    }
}
```

{ "label": "…" }

{ "label": "…" }

[{…} {…} …]

{ "label": "…" }

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Loading Image

- A second asynchronous call

```
func loadImage(from URL: Foundation.URL,
               in imageView: UIImageView) {
    let request = URLRequest(url: URL)
    URLSession.shared.dataTask(with: request) {
            data, response, error in
        if let imageData = data {
            let image = UIImage(data: imageData)
            DispatchQueue.main.async {
                imageView.image = image
            }
        }
    }.resume()
}
```

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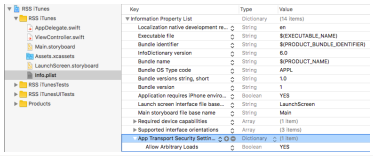
App Transport Security (ATS)

- Require secure network connections over HTTPS
  - Improves user security and privacy
- Add a new entry in your app's `Info.plist` file
  - `Allow Arbitrary Loads: YES`



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Design Pattern – Singleton

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The Singleton Pattern

- One of the most common design patterns
- To ensure a unique instance, i.e., shared instance, for the entire application.
  - No way to create a second instance, intentionally or accidentally
  - Accessing the shared instance is thread-safe.
- Lazy initialization
  - Initialized when the instance is first accessed

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The Singleton Pattern

```
class MySingleton {

    static let sharedInstance = MySingleton()

    private init() {}

    var data: String = "foo"
    // other members …
}

let myinstance = MySingleton.sharedInstance
print(myinstance.data)
```

The shared instance

Initialization of static and global variables are *lazy* and *atomic*

The initializer is not accessible outside the class

The instance initialized here

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Swift Access Control

- Access levels are defined in terms of the various levels of units of your code,
  - *Modules:* a single unit of distribution
    - Typically consists of multiple source files.
    - A simple project usually consists of a single model.
  - *Source files:* a file containing Swift source code.
    - May contain definitions of multiple classes, functions, etc.
  - *Scopes:* a section of source code within a single source file delimited by a matching pair of { and }.
    - E.g., the definition of a single class.

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Access Levels

- `open` – accessible anywhere
  - Only applicable to classes and class members
  - Subclassing and overriding allowed anywhere.
- `public` – accessible anywhere
  - Subclassing allowed only within its own module
- `internal` – accessible only within its own module
  - The default access level
- `fileprivate` – accessible only within its own file
- `private` – accessible only within the enclosing scope of its definition, and *extensions in the same file*

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An ITunes RSS Reader with Multiple Entries

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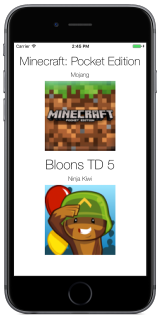
The Second Iteration – Loading Multiple Entries

- Two entries
- Loading an array from JSON data



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The UI and the Outlets

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Parsing JSON Data

```
let feed = "http://ax.itunes.apple.com/…/limit=2/json"
…
if let json = try JSONSerialization.jsonObject() as? [String:Any] {
  guard let feed = json["feed"] as? [String:Any] else { throw … }
  guard let entries = feed["entry"] as? [Any] else {throw … }
  for (i, e) in entries.enumerated() {
    if let entry = e as? [String:Any] {
      guard let nameEntry = entry["im:name"] as? [String:Any] else {…}
      guard let artistEntry = entry["im:artist"] as? [String:Any] else {…}
      guard let imageArray = entry["im:image"] as? [Any] else {…}
      if let title = nameEntry["label"] as? String,
         let artist = artistEntry["label"] as? String {
        DispatchQueue.main.async {
            self.titleLabels[i].text = title
            self.artistLabels[i].text = artist
        }
        …
```

{ "feed": … }

{ "entry": … }

[{…} {…}]

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Parsing JSON Data

```
if let json = try JSONSerialization.jsonObject() as? [String:Any] {
  guard let feed = …
  guard let entry = …
  for (i, e) in entries.enumerated() {
    if let entry = e as? [String:Any] {
      guard let nameEntry = entry["im:name"] as? [String:Any] else {…}
      guard let artistEntry = entry["im:artist"] as? [String:Any] else {…}
      guard let imageArray = entry["im:image"] as? [Any] else {…}
      if let title = nameEntry["label"] as? String,
         let artist = artistEntry["label"] as? String {
        …
        if let imageEntry = imageArray.last as? [String:Any],
           let imageURL = imageEntry["label"] as? String,
           let url = URL(string:imageURL) {
            self.loadImage(from: url, in: self.imageViews[i])
        }
      }
    }
  }
}
```

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An ITunes RSS Reader with a Lazy Loading Table

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Lazy Loading

- Load resource only when it is needed, e.g., becomes visible
- Use asynchronous calls to perform time-consuming loading tasks
  - Avoid blocking the main thread
  - Keep UI responsive
- Improve perceived performance, and user experience (UX)
  - Quick, meaningful feedback

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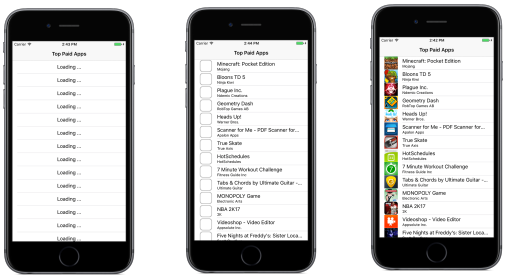
The Third Iteration – A Lazy Loading Table View

- A table view with three stages of loading



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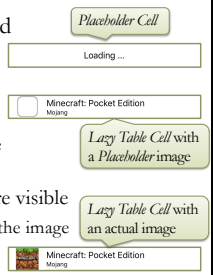
A Lazy Loading Table View

- A table view displaying iTunes data
- Lazy loading contents, on-demand
  - Initial loading
    - placeholder cells, no text, no image
  - Text only
    - when the text data is available, image displayed using a placeholder
  - Images are loaded when the cells are visible
    - replace the image placeholder when the image is available



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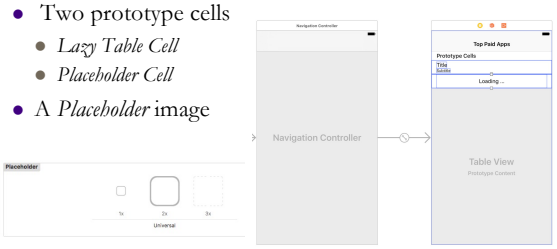
The Table View Design

- A navigation controller and a table view controller
- Two prototype cells
  - *Lazy Table Cell*
  - *Placeholder Cell*
- A *Placeholder* image



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The Table View Controller

```
let feed = "http://ax.itunes.apple.com/…/limit=75/json"

class TableViewController: UITableViewController {
    class Record {
        var title: String = ""
        var artist: String = ""
        var imageURL: URL?
        var icon: UIImage?
    }

    var dataAvailable = false
    var records: [Record] = []

    override func viewDidLoad() {
        super.viewDidLoad()
        loadData()
    }
    …
}
```

A class to stored the data for each entry

Optional type for lazy loading

No data is available initially

Start loading data when view loading is complete

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The Table View Controller

- The number of rows of the table view

```
class TableViewController: UITableViewController {
    …
    override func numberOfSections(in tableView: UITableView) -> Int {
        return 1
    }

    override func tableView(_ tableView: UITableView,
                            numberOfRowsInSection section: Int) -> Int {
        // if there's no data yet, return enough rows to fill the screen
        return dataAvailable ? records.count : 15
    }
    …
}
```

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The Initial View – No Data

- Before data loading is complete
  - Showing the *Placeholder Cells* for every row

```
class TableViewController: UITableViewController {
  override func tableView(_ tableView: UITableView,
                          cellForRowAt indexPath: IndexPath) -> UITableViewCell {
    if (dataAvailable) {
      …
    } else {
      let cell = tableView.dequeueReusableCell(
                    withIdentifier: "PlaceholderCell", for: indexPath)
      return cell
    }

  }
  …
}
```

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Loading Data without Images

```
func loadData() {
  guard let feedURL = URL(string: feed) else { return }
  let request = URLRequest(url: feedURL)
  let session = URLSession.shared
  session.dataTask(with: request) { data, response, error in
    guard error == nil else { … }
    guard let data = data else { return }
    do {
      if let json = try JSONSerialization.jsonObject(…) as? [String:Any] {
        guard let feed = json["feed"] as? [String:Any] else {…}
        guard let entries = feed["entry"] as? [Any] else {…}
        for e in entries {
          if let entry = e as? [String:Any] {
            Process the data for a single entry (the next slide)
          }
        }
    } catch … { … }
  }.resume()
}
```

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Loading Data without Images

```
for e in entries {
  if let entry = e as? [String:Any] {
    guard let nameEntry = entry["im:name"] as? [String:Any] else {…}
    guard let artistEntry = entry["im:artist"] as? [String:Any] else {…}
    guard let imageArray = entry["im:image"] as? [Any] else {…}
    if let title = nameEntry["label"] as? String,
       let artist = artistEntry["label"] as? String {
      let record = Record()
      record.title = title
      record.artist = artist
      if let imageEntry = imageArray.last as? [String:Any],
         let imageURL = imageEntry["label"] as? String {
          record.imageURL = URL(string:imageURL)
      }
      self.records.append(record)
    }
  }
}
self.dataAvailable = true
DispatchQueue.main.async{
   self.tableView.reloadData()
}
```

Only set the image URL, not the image

Data is available. Table view is reloaded with the data.

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The Table View with Data (Without Image)

- After data loading is complete

```
override func tableView(_ tableView: UITableView,
                cellForRowAt indexPath: IndexPath) -> UITableViewCell {
    if (dataAvailable) {
      let cell = tableView.dequeueReusableCell(
                  withIdentifier: "LazyTableCell", for: indexPath)
      let record = records[indexPath.row]
      cell.textLabel?.text = record.title
      cell.detailTextLabel?.text = record.artist
      if let icon = record.icon {
          cell.imageView?.image = icon
      } else {
          cell.imageView?.image = UIImage(named: "Placeholder")
          loadImage(for: record, in: cell.imageView)
      }
      return cell
    } else { … }
}
```

No image loaded yet. Use Placeholder

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Loading Images and Updating

```
func loadImage(for record: Record, in imageView: UIImageView?) {
    let request = URLRequest(url: record.imageURL!)
    URLSession.shared.dataTask(with: request) {
            data, response, error in
        if let imageData = data {
            let image = UIImage(data: imageData)
            record.icon = image
            if let imageView = imageView {
                DispatchQueue.main.async {
                    imageView.image = image
                }
            }
        }
    }.resume()
}
```

Table view will be updated when image loading is done.

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Handling Errors in Data

- Need to catch errors, recover and limit the damage

```
func loadData() {
  …
  session.dataTask(with: request) { data, response, error in
    guard error == nil else { … }
    guard let data = data else { return }
    do {
      if let json = try JSONSerialization.jsonObject(…) {
        …
      }
    } catch … { … }
  }.resume()
}
```

What happens when an error is caught?

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Handling Errors in Data

```
func loadData() {
  …
  session.dataTask(with: request) { data, response, error in
    …
    do {
      if let json = try JSONSerialization.jsonObject(…) as? [String:Any] {
        guard let feed = json["feed"] as? [String:Any] else {…}
        guard let entries = feed["entry"] as? [Any] else {…}
        for e in entries {
          do {
            if let entry = e as? [String:Any] {
              …
            }
          } catch … { … }
        }
    } catch … { … }
  }.resume()
}
```

Limit the errors in a single entry. Skip to the next entry

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Low Memory Warning

- Dispose of any resources that can be recreated

```
override func didReceiveMemoryWarning() {
    super.didReceiveMemoryWarning()
    for r in records {
        r.icon = nil
    }
}
```

Dispose all the images and retain all the records.

- A more drastic alternative

```
override func didReceiveMemoryWarning() {
    super.didReceiveMemoryWarning()
    records.removeAll(keepingCapacity: false)
    dataAvailable = false
}
```

Dispose all the data.

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Codable and JSON Parsing

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Encoding & Decoding Protocols

- The Swift standard library defines a standardized approach to data encoding and decoding.
- The *Codable* protocol

```
typealias Codable = Decodable & Encodable
```

- The *Encodable* and *Decodable* protocols

```
protocol Encodable
    func encode(to encoder: Encoder) throws
}
protocol Decodable {
    init(from decoder: Decoder) throws
}
```

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Encode and Decode Automatically

- Declare conformance to *Codable*
- Use properties that are codable
  - Most standard types are codable
    - String
    - Int
    - Double
    - Date
    - URL
    - Array
    - Dictionary
    - etc.

```
struct Student : Codable {
    var name: String
    var id: Int
    var major: Program
}

struct Program : Codable {
    var name: String
}
```

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Encode in JSON

```
let compSci = Program(name: "Computer Science");
let john = Student(name: "John Appleseed", id: 7,
                   major: compSci)

let jsonEncoder = JSONEncoder()
let jsonData = try jsonEncoder.encode(john)

let jsonString = String(data: jsonData, encoding: .utf8)
print(jsonString!)
```

Output:

```
{ "name" : "John Appleseed",
  "id" : 7,
  "major" : { "name" : "Computer Science" } }
```

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Decode from JSON

```
…
let jsonDecoder = JSONDecoder()
let student2 = try jsonDecoder.decode(Student.self,
                                      from: jsonData)
print(student2)
```

Output:

```
Student(name: "John Appleseed", id: 7,
        major: Program(name: "Computer Science"))
```

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Customize Coding Keys

- Declare a special nested enumeration named *Coding Keys*

```
struct Student : Codable {
    var name: String
    var id: Int
    var major: Program

    enum CodingKeys: String, CodingKey {
        case id = "studentId"
        case name
        case major
    }
}
```

```
{ "name" : "John Appleseed",
  "studentId" : 7,
  "major" : { "name" : "Computer Science"} }
```

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Encode and Decode Manually

- Automatic encoding and decoding assumes the structures of Swift type and JSON data coincide.
- If the structures of the Swift type and JSON data are different, you need to provide custom implementation of encode and decode logic.

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Encode Manually

```
struct Student : Encodable {
    var name: String
    var id: Int
    var major: Program
    enum CodingKeys: String, CodingKey {
        case id = "studentId"
        case name
        case major
    }
    func encode(to encoder: Encoder) throws {
        var container = encoder.container(keyedBy: CodingKeys.self)
        try container.encode(name, forKey: .name)
        try container.encode(id, forKey: .id)
        try container.encode(major.name, forKey: .major)
    }
}
```

```
{ "name" : "John Appleseed",
  "studentId" : 7,
  "major": "Computer Science" }
```

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Decode Manually

```
extension Student: Decodable {
    init(from decoder: Decoder) throws {
        let values = try decoder.container(keyedBy: CodingKeys.self)
        name = try values.decode(String.self, forKey: .name)
        id = try values.decode(Int.self, forKey: .id)
        let majorName = try values.decode(String.self,
                                          forKey: .major)
        major = Program(name: majorName)
    }
}
```

```
{ "name" : "John Appleseed",
  "studentId" : 7,
  "major": "Computer Science" }
```

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Encode More Data Types

```
struct Student : Codable {
    var name: String
    var id: Int
    var major: Program
    var minor: Program?
    var gpa: Double
    var category: Category
}
enum Category : Int, Codable {
    case Freshman, Sophomore, Junior, Senior
    case Graduate
}
let compSci = Program(name: "Computer Science");
let art = Program(name: "Art History");
let john = Student(name: "John Appleseed", id: 7,
                  major: compSci, minor: art,
                  gpa: 3.5, category: .Sophomore)
```

```
{   "name": "John Appleseed",
    "category": 1,
    "id": 7,
    "gpa": 3.5,
    "major": {
        "name": "Computer Science"
    },
    "minor": {
        "name": "Art History"
    }
}
```

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Encode Collection Types

```
struct Student : Codable {
    var name: String
    var id: Int
    var major: Program
    var minor: Program?
    var gpa: Double
    var category: Category
    var courses: [Course]
    var grades: [String:Grade]
}
```

```
struct Course: Codable {
    var code: String
    var title: String
}
enum Grade: String, Codable {
    case A, B, C, D, F
}
```

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Encode Collection Types

```
let cs101  = Course(code: "CS101",
                    title: "Intro to Swift")
let art201 = Course(code: "ART201",
                    title: "Renaissance Masterpieces")
let compSci = Program(name: "Computer Science");
let art = Program(name: "Art History");
let john = Student(name: "John Appleseed", id: 7,
                  major: compSci, minor: art,
                  gpa: 3.5, category: .Sophomore,
                  courses: [ cs101, art201],
                  grades: [ "CS101": .A, "ART201": .B])
```

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Encode Collection Types

- The JSON data

```
{
    "name": "John Appleseed",
    "category":1,
    "id":7,
    "gpa":3.5,
    "major": { "name":"Computer Science" },
    "minor": { "name":"Art History" },
    "grades": {
        "CS101": "A",
        "ART201": "B"
    },
    "courses":
    [
      { "title": "Intro to Swift",
        "code": "CS101" },
      { "title": "Renaissance Masterpieces",
        "code":"ART201"}
    ],
}
```

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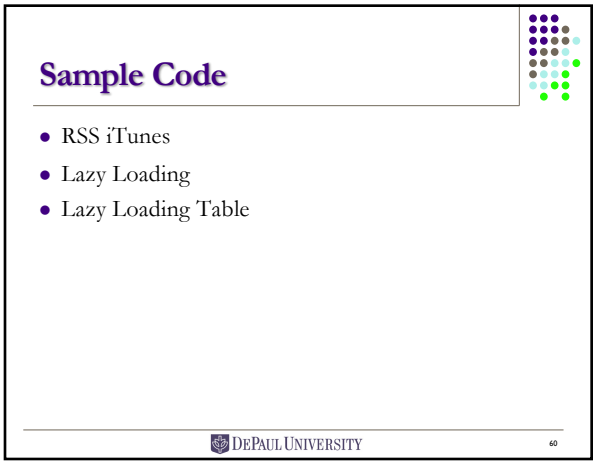
Sample Code
RSS iTunes
Lazy Loading
Lazy Loading Table
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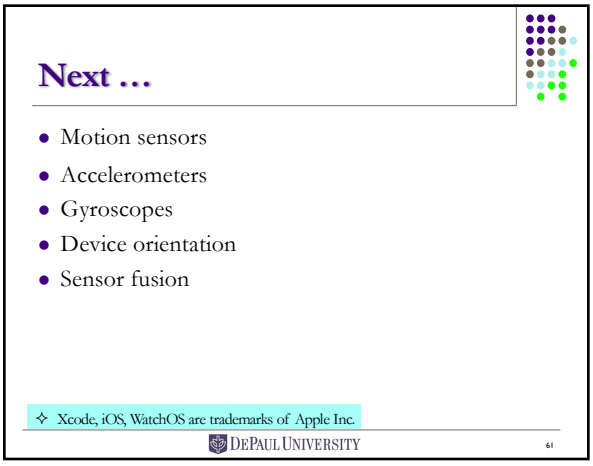
Next …
Motion sensors
Accelerometers
Gyroscopes
Device orientation
Sensor fusion
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