JSON

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[Document subtitle]

Contents

[Problem statement 4](#_Toc420251814)

[Problem (and why)? 4](#_Toc420251815)

[Plan 4](#_Toc420251816)

[Problems 5](#_Toc420251817)

[Implementing security requires lots of setup time and money 5](#_Toc420251818)

[Serializing and desterilizing between Swift objects to JSON results in lots of redundant code 5](#_Toc420251819)

[Setting up REST Web Api Urls in the front end for your different models results in a lot of redundant code 6](#_Toc420251820)

[.NET Date formatting inconsistencies 6](#_Toc420251821)

[Research 8](#_Toc420251822)

[Methods 8](#_Toc420251823)

[Principles 8](#_Toc420251824)

[Number of lines of code 8](#_Toc420251825)

[DRY 8](#_Toc420251826)

[DAMP 9](#_Toc420251827)

[REST API 9](#_Toc420251828)

[URL Format 10](#_Toc420251829)

[Request Verbs 10](#_Toc420251830)

[Most used variable types in programming 11](#_Toc420251831)

[Testing 11](#_Toc420251832)

[Compression 12](#_Toc420251833)

[Lossy compression 12](#_Toc420251834)

[Lossless compression 12](#_Toc420251835)

[Lossy vs lossless 13](#_Toc420251836)

[Compression algorithms 13](#_Toc420251837)

[Approaches 14](#_Toc420251838)

[Testing 15](#_Toc420251839)

[Encoding 17](#_Toc420251840)

[Encryption 18](#_Toc420251841)

[Symmetric 18](#_Toc420251842)

[Asymmetric 18](#_Toc420251843)

[HTTPS 19](#_Toc420251844)

[Data consumption & Latency 19](#_Toc420251845)

[Findings 20](#_Toc420251846)

[Encoding 20](#_Toc420251847)

[Types 20](#_Toc420251848)

[Data consumption 20](#_Toc420251849)

[Order (Encryption/compression) 21](#_Toc420251850)

[Other solutions 22](#_Toc420251851)

[JSON format 22](#_Toc420251852)

[JSON stream 24](#_Toc420251853)

[Data formats 24](#_Toc420251854)

[Research Findings 25](#_Toc420251855)

[JSON format 25](#_Toc420251856)

[Product 27](#_Toc420251857)

[Overview 27](#_Toc420251858)

[JSON format 27](#_Toc420251859)

[Compression 28](#_Toc420251860)

[Encryption 28](#_Toc420251861)

[Backend library (C#) 28](#_Toc420251862)

[Features 28](#_Toc420251863)

[Installation 28](#_Toc420251864)

[Usage 28](#_Toc420251865)

[How it works 30](#_Toc420251866)

[Internal dependencies 32](#_Toc420251867)

[External dependencies 32](#_Toc420251868)

[Frontend library (Swift) 34](#_Toc420251869)

[Features 34](#_Toc420251870)

[Installation 34](#_Toc420251871)

[Usage 34](#_Toc420251872)

[How it works 41](#_Toc420251873)

[JsonRequest 44](#_Toc420251874)

[CompresJsonRequest 46](#_Toc420251875)

[CompresJSONObject 48](#_Toc420251876)

[External dependencies 49](#_Toc420251877)

[Configuration 50](#_Toc420251878)

[Backend configuration 50](#_Toc420251879)

[Frontend configuration 50](#_Toc420251880)

[Testing 51](#_Toc420251881)

[Environment 51](#_Toc420251882)

[MySql Database 51](#_Toc420251883)

[Analysis 51](#_Toc420251884)

[Discussion 51](#_Toc420251885)

[Compromises 51](#_Toc420251886)

[Conclusion 52](#_Toc420251887)

[References 54](#_Toc420251888)

# Problem statement

## Problem (and why)?

JSON is a widely used data transport mechanism, but there are issues with security and bandwidth consumption. JSON is usually carried over HTTP, which is easily intercepted by standard sniffing software.

Mobile devices don't always have high data allowances and often have slow connections. The JSON format is not as efficient as it could be, given that it does not compress the data in any way. As a result of this some mobile applications can seem slow and unresponsive.

It is also a cumbersome process to research and develop your own optimizations and security while developing a product, as it requires extra time and effort. As a result of this, JSON requests are often left in the current format and open to misuse.

## Plan

I plan to look into the best possible technologies, libraries, and methods to optimize the JSON format while considering both security and data consumption. I plan to explore the possibility of a security implementation on HTTP requests without using HTTPS.

I then plan to develop an open source C# and Swift framework to communicate with each other via this format. I aim to make it as easy as possible for a future developer to install this library on both the server and the frontend, and make them as intuitive as possible. This may result in some compromises having to be made, which will be done so while prioritizing the ease of use for a future developer and functionality.

## Assumptions

Security is often deprioritized due to lack of time

A secure solution costs money

No optimized JSON format exists

Why im doing this project:

I have these assumptions:

* Security is often deprioritized due to time and money investment needed
* The JSON format uses more data than neccesary

## JSON

JSON stands for JavaScript Object Notation. It is a “human-readable” format to transport objects which consist of key/value attribute pairs. It often referred to as a “fat free alternative to XML”. XML (Extensible Mark-up Language) is a preceding data format which looks very similar to HTML, consisting of tags.

In this project I have decided to focus on JSON as it is more modern than XML and can send the same data using less data. It does this by requiring less characters to define each key/value.

## Problems

### Implementing security requires lots of setup time and money

JSON response and HTTP requests made between a server and a frontend send all their data in plain text, and can be easily intercepted by an unwanted third party.

It might send some parameters to the server for user verification:

Username: *Alex*

**Password**: secretpassword

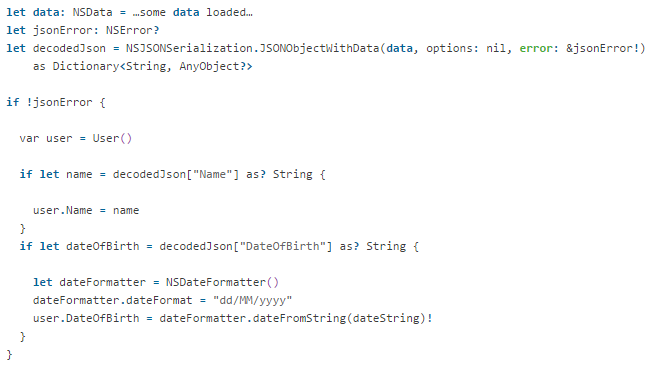
If this was intercepted, a hacker could very easily get your credentials. Security is important, but because of the investment needed, it can sometimes be forgotten or deprioritized.

### Serializing and desterilizing between Swift objects to JSON results in lots of redundant code

iOS programming is very object orientated. When you make a request for external data via the internet, you will most likely want to extract the values, and map them to a Swift class instance. Unfortunately there is quite a tedious set of steps to implement this.

When you receive an HTTP request, anything inside the HTTP body is read into swift as “NSData” which is an integrated class in Swift containing the raw data.

This data has to then be converted into a dictionary, checked for errors, and then each key needs to be manually unpacked and binded to an instance of the target class. Date formatting requires date formatters to convert strings into dates. This example shows mapping two properties from JSON to an instance of “User”, the end result is quite messy:



This process has to be done on every JSON request and is different for every class. A lot of this seems to be unnecessary work as the key names are very often exactly the same as the property names in your class, and you rarely expect date strings to be formatted differently in different requests. As a result of this it seems like this processes can be improved.

### Web API URL Redundancy

Setting up Web API URL’s in the front end for your different models results in a lot of redundant code. The URL’s seem to be very similar to each other, and follow a specific format. When you make data requests, you are often retyping the resource domain and the database table key for each request.

### .NET Date formatting inconsistencies

.NET JsonResult and Web Api result formats dates differently. You might want to mix API controllers with separate methods from MVC5 controllers. The inconsistent date formatting is an inconvenience.

|  |  |
| --- | --- |
| **Web API 2 Controller: IHttpActionResult** | **MVC5 Controller: ActionResult** |
|  |  |
|  |  |

# 

# Research

To complete this project I need to do some research to find out possible solutions to the outlined problems.

I need to explore:

* Different methods of securing and reducing data during internet transport
* The norms for REST Web Api’s
* Best library installation practices
* Whether or not any other similar solutions exist that tackle similar problems

## Methods

For the research I plan to use a combination of online research and manual testing. The testing will include installing and setting up testing environment in a web page, as well as testing different libraries and analysing their performance.

Literature review??

Assumptions

## Principles

The foundation for this project is based on some coding principles

### Separation of concerns

Different aspects of code functionality should be managed by separate, clearly distinguished sections of code. This means separating business logic, UI and data requests etc. Mixing up too these can create very messy and hard-to-read code. For example, changes to the user interface should not require changes to the business logic.

MVC (Model, View, Controller) is a common example of separation of concerns. It is a pattern used in a number of frameworks including .NET C# and Swift which will be used in this project. It separates the UI logic (View) from the main functionality of the app (Controller) and the data source (Model).

HTML5 in web design is another example, separating HTML from CSS and JavaScript. HTML is used to define the elements on a web page, CSS defines the styling and positioning, while JavaScript handles how it interacts with user input.

### Number of lines of code

It is very important to consider the lines of code something takes. It helps the readability, allowing future developers to decipher what is happening in the code as well as reducing the application size.

I am going to consider this in my comparisons of different libraries and code snippets for this project, prioritizing a smaller code base where possible.

### DRY[[1]](#footnote-1)

DRY stands for Don’t Repeat Yourself. The principle is that you shouldn’t repeat code where you it can be avoided.

The reasoning for this is that redundant code requires any changes in the code to be mirrored in all the places they have been put. This is both time consuming, and increases the possibility of type errors.

There are many constructs in most programming languages to allow for this, including loops, classes, functions etc. A practical implementation of DRY programming would make use of these and side off code into functions or base classes. By using inheritance from base classes, you put as much code as you can into the base class, meaning that all classes which inherit from the base class have access to its methods and properties. I am also going to consider the use of utility classes.

### **DAMP**[[2]](#footnote-2)

DAMP stands for “Descriptive and Meaningful Phrases”. This is a complimentary principle to DRY to try and prevent you from being too “DRY”. The idea is that sometimes it can be preferred to have some redundant code, instead of having one method which tries to cover multiple scenarios for example. It prefers legibility over pure effectiveness. If you side off too much logic into separate functions, a developer trying to read your code could end up having to follow a long chain of functions and loose the overview of the context.

### KISS

Standing for “Keep it simple, stupid”, KISS

## REST API[[3]](#footnote-3)

I aim to create a class to handle communication between an object and a Web API on the frontend. For this to function properly it must follow the accepted REST API standards. I am going to find out what standards exist and how to best implement them. I also need to make sure that the server side library will not interfere with a normal REST API implementation.

API stands for “Application Programming Interface”. It is a web resource, providing the ability to read and write data to an online database. It is controlled by the server, and is setup to only allow certain tasks to be performed from an external source.

REST is short for Representational State Transfer. It sends a data representation for part of the server state as a response to a request made via the HTTP protocol. REST itself is an architecture with some set rules to how it should be setup.

Together, a REST API is a controlled architecture for creating a controlled web interface for allowing external sources to gain access to a data source. Mobile apps often draw from multiple API’s and can display the results inside the native UI.

An HTTP request contains:

* **Resource:** The web address (URL)
* **Request Verbs:** Themethod of sending data to the same URL which can be interpreted by the server (GET/POST/PUT/DELETE/PATCH)
* **Request headers:** Additional information needed, could be authentication.
* **Request body:** The container for request data.
* **Response body:** The container for response data.
* **Response status codes:** All requests have a status code which represents whether or not the request was successful or not. An incorrect URL will always provide status code 404 (Not Found) for example, but you can also set the status code from the backend.

### URL Format

A typical URL has three main components. The base, resource identifier and ID.

The server domain is usually the base for all requests, while including the path to the Web API resource (e.g. “api” folder/route) e.g. “<http://www.mysite.com/api>”. The resource identifier is used to identify which resource is going to be read or written to. Typically this would be a table in a database e.g. **“Users”.** The ID usually points to the primary key for a database which is a unique identifier for a database record. This ensures the API is will not update the wrong record.

These components are then formatted: *domain* / *resource Identifier* / *ID*

e.g. “<http://www.mysite.com/api/Users/5>”

### Request Verbs

The HTTP Methods (Verbs) are to be used like this:

|  |  |
| --- | --- |
| Method | Action |
| GET | Get |
| POST | Insert |
| PUT | Update |
| DELETE | Delete |
| PATCH | Update from included fields only |

Examples of how to format REST URL’s:

|  |  |  |
| --- | --- | --- |
| Method | Resource | Response |
| GET | /Users | A list of users |
| GET | /Users/4829 | User with id of 4829 |
| POST | /Users | Confirmation of creation |
| PUT | /Users/3 | Confirmation of update |
| DELETE | /Users/194 | Confirmation of deletion |

## Most used variable types in programming

(for object mapper)

## Testing

#### Tools

##### Wireshark

##### Google Chrome

## Compression[[4]](#footnote-4)

I am going to research which types of compression exist, which is the most effective and how much data it will save on different JSON requests. I will also look for existing libraries for both C# and Swift to achieve this.

Compression is a method used to reduce the size of files, to allow for faster transfer over the internet as well as taking up less storage space.

I am going to use a combination of desktop research and manual testing using some network tools to measure the data size of a request using different compression techniques.

### Lossy compression

Lossy compression removes information from the original data to reduce its size. A good example of this is an MP3 file. It gradually starts removing information for sounds in the high frequencies, starting with those outside the frequency range for human hearing,

It can however be compressed further, and the more you compress it, the “muddier” it starts to sound as the compression starts to remove some of the higher frequencies which are audible to humans.

As data is removed during the compression process, the original cannot be decompressed again.

### Lossless compression

Lossless compression reduces the size of the data without while allowing it to be restored to its full original state. Lossless compression removes redundancy by looking for patterns, using various mathematical tricks before applying a “code” to represent the original information. This representation takes up less space than the original data.

E.g.

“mmmmmmmmmmYYYY” could be represented as: “m10Y4”

### Lossy vs lossless

Lossy compression is not appropriate for JSON optimization as it implies the loss of information which will make the JSON requests incomplete. Lossless compression however could be used.

### Compression algorithms

There are two main methods of compression which are accepted by HTTP standards.

#### Deflate

The deflate algorithm is a combination of LZ77 and Huffman coding. LZ77 is an algorithm which was published in the 1970’s and was a starting point for many other compression algorithms. Describe Huffman coding

#### GZip[[5]](#footnote-5)

GZip is a file format based on the deflate algorithm but contains extra headers such as timestamp, original file name and a CRC-32[[6]](#footnote-6) checksum. The checksum is used to verify the accuracy of the decompressed output. It also allows the compressed result to be saved to a file and can be opened in common compression software such as WinZip.

As a result of this extra data, the output is larger than a standard deflate compression.

### Approaches

#### Content-encoding

HTTP has a standard which allows you to define your compression preference via an HTTP header: “Content-Encoding”. It accepts one of two compression types: “gzip” and “deflate”.

It allows you to read the headers from an MVC action filter, and then compress the entire request. The request can then be decompressed on the other client (a web browser does this automatically), and the data can then be used normally.

This screenshot shows the same request made with different headers:

1. No extra headers
2. “Content-Encoding”: “gzip”
3. “Content-Encoding”: “deflate”
4. No extra headers – HTTP body compressed using deflate manually



I found that this method of compression was extremely efficient, reducing a 38.4kb request to 2.9kb. It even produced smaller requests than manually compressing using the same compression technique. (request 4). I believe that this is due to compression of the entire request, including headers etc.

It was also a very simple process to implement, requiring only two lines of code. The first of which is simply a header declaration for the benefit of letting the client know which compression algorithm was used. A modern web browser is able to recognise the header “content-encoding” and de-compress it automatically without having to code anything.

The compression itself is achieved by adding a compression filter to the response:



Although providing some implementation advantages, there is a problem with this using content encoding due a lack of control for the ordering of encryption and compression to maximize efficiency. This compression is the final wrapper for the request, and cannot be tampered with afterwards.

As my findings showed that encryption should be done after compression, this method is not appropriate for this project.

#### Manual compression/decompression

Compressing manually basically implies the compression of data inside the HTTP Body of the request. This means that the data is compressed, but the request headers aren’t. The compression is done in the backend before being sent across the network. The compression has to be compressed and decompressed manually using C# methods.

### Testing

For testing, I decided to run some requests from a web browser, use Google Chrome’s networking tools to read the size of each request, and then look for trends with the resulting data.

I tested a number of different JSON strings of varying lengths by compressing them with both compression algorithms and comparing them to the original string data length (in bytes). The results of this are shown in the graphs below:

The best compression method I found was LZ77. This outperformed the GZip algorithm every single time. Compression seems to be more effective, for the more data you have that needs to compression on what appears to be a direct correlation.

There is also a minimum string length needed for compression to be useful at all, because below this threshold it actually increases the data size. I found that any response below 103 bytes will be better off not compressed.

Overall I found that compression was extremely effective on any decent sized JSON response.

## Encryption

There are different types of encryption with varying data overhead as well as security. I am going to find out which methods are available, and appropriate for a JSON response.

### Symmetric

Symmetric encryption requires a secret key to be exchanged between the sender and receiver. This key is the same for both parties, and is used to both encrypt and decrypt the message.

This requires the secret key to be hardcoded on both server and client. This may have security implications as it only takes one phone to be hacked, gaining access to the source code to potentially compromise every user of the app’s security.

### Asymmetric

Asymmetric encryption works slightly differently. It uses a combination of private and public keys.

The sender can encrypt a message using the receiver’s public key. The receiver can then decrypt this using his own private key. It is also possible for the sender to sign the message using their private key. The sender is then able to verify the sender.

The receiver's public key cannot be used to decrypt the message so does not need to be kept secret and can be sent un-securely to the sender.

The benefit of Asymmetric encryption as it would be possible to verify the sender on both the server and frontend. This means that it will be much harder for a hacker to fake requests.

It is also possible to increase the security from a single key algorithm via the use of a SALT or IV. This adds a randomly generated aspect to the encryption. It generates a random key, separate from the encryption key, which is used as part of the encryption process. This key is then appended somewhere inside the finished product. The receiver knows where to find the SALT/IV, extracts it and uses that value in the decryption. This is not absolutely secure, but does make it harder, as the encrypted value for the same value will be different each time.

### HTTPS

HTTPS is a protocol which enhances the security of web communication. It encrypts and decrypts HTTP requests between the web server and client.

The security works by initializing a connection with a handshake using very secure symmetric encryption. Once each party has verified the integrity of each other, a less secure symmetric key is negotiated for subsequent requests. This allows for faster performance for all requests in that session, after the initial handshake.

HTTPS requires a digital certificate to be installed on the web server. This certificate has be bought form a certificate authority, and renewed annually. It also requires another port (443) to be opened to allow the traffic through. It adds cost to the running costs as well as requiring time to setup. This is often a big dis-incentive, especially for some smaller businesses.

If security is your main priority, you can’t really get any better than HTTPS. It is a very effective security method which accounts for most common hack types. It encrypts the whole request, masking the target URL aswell as all its headers and content.

It is often neglected however, due to extra cost and setup processes, often resulting in leaving all communication including passwords, credit card information etc. open for anyone to hack easily.

The key benefits to HTTPS are:

* Very secure initial handshake
* Entire request is encrypted (including headers and URL)

### Data consumption & Latency[[7]](#footnote-7)

Encrypting data increases the size of the data, the main problem being in the initial request where the initial handshake takes place. This is a comparatively slow process

#### Reduce encryption overhead

It might be a good idea to not encrypt the entire response, but maybe only some of it. If the keys to encrypt were specified as part of the request, only these fields would be encrypted, reducing the encryption overhead.

### Hashing[[8]](#footnote-8)

Hashing data completely transforms data into something else. It is an irreversible process and does not contain the original data. You can hash an entire program to a small hash signature. This is often done on software to allow the possibility of checking if the program is the original copy, and not a modified version.

When hashing a string for example, even with one character different, the end result is completely different:



Hashing the same data however, always produces the same result. This is very commonly used in password security. Instead of storing the user’s actual password, they store a hashed version of it, and try to re-create the hash when they enter their login credentials. That way the password isn’t transported over the web, or stored in a database.

### Findings

While HTTPS is definitely the most secure option, it has its cost and setup time drawbacks. Symmetric and Asymmetric encryption both have their uses in different scenarios. For the purpose of this project I am going to concentrate on Symmetric encryption. Although there are more secure encryption methods available, it is simpler to implement and requires less data traffic.

Asymmetric encryption could be used to simulate an HTTPS handshake to agree on a symmetric encryption key, but it doesn’t make sense to try to emulate HTTPS as it will never be as well tested as HTTPS itself. If more security is needed, this library may not be suitable and HTTPS should be used instead.

Some of the benefits from HTTPS communication however could be adopted however including masking target URL and encrypting response data. I am going to try and consider as many of the benefits of HTTPS as possible.

Hashing is not appropriate for this project at all, because it is a requirement that the data can be retrieved after transport, of which is impossible with a hashed value. Hashing is instead a completely separate topic which should be tackled “per-project”.

## Encoding[[9]](#footnote-9)

After testing, I found that after a string has been compressed or encrypted, it needs to then be encoded afterwards. This is because the compressed string doesn’t transport properly through POST forms, and the decompressor throws an error.

**e.g.** "-??\t?0\fW???QZ?h???F??\r\"???\"{????n???8|b0?0??z???G???oJ\b??~?s??^”

There are many types of encoding methods but I am going to use Base64[[10]](#footnote-10) because it is a well-established and widely used encoding algorithm. This is important because it needs to be easily and accurately decoded on multiple platforms. Both C# and Swift have built-in Base64 encoding and decoding methods so it seems appropriate to utilize this.

Base64 encoding is used to transform it into a transportable string that looks something like: “LT8/XHQ/MFxmVz8/P1FaP2g/Pz9GPz9cclwifz8/P1wiez8/Pz9uPz8/OHxiMD8wPz96Pz8/Rz8/P29KXGI/P34/cz8/XuKAnQ==”

It is much easier to transport as it only uses a small set of characters[[11]](#footnote-11), all of which can be transported through HTTP requests safely, including:

ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789+/

Base64 encoded strings while unreadable to a human, are easily decoded again. The purpose is not to secure data but simply to ease the transportation of data. Using this encoding does however increase the data consumption by 33%. While this seems like a drawback, it is a necessary cost.

## Order (Encryption/compression)

The final output will have been affected by compression, encryption. I am going to try to find out whether or not the order of when these methods are done will affect the data size of the output.

The following tests compare two sets of data of varying size, with two methods. The first method is encryption before compression and the second is compression before encryption. Both show the data size after each step.

Test1: (array of 2 JSON objects)

Original: 725 bytes

|  |  |
| --- | --- |
| Method 1 | Method 2 |
| AES 256 Encrypted output: 1024 | Compression output: 182 |
| Compression output: 1064 | AES 256 Encryption output: 344 |
| Output: 1064 bytes | Output: 344 bytes |

Test2: (array of 1000 JSON objects)

Original: 79673  bytes

|  |  |
| --- | --- |
| Method 1 | Method 2 |
| AES 256 Encrypted output: 106240 | LZ77 Compression output: 7264 |
| LZ77 Compression output: 89912 | AES 256 Encryption output: 9688 |
| Output: 89912 bytes | Output: 9688 bytes |

As you can see, the ordering makes a huge difference. This is because the compressor has a much easier time finding patterns in the original string, than an encrypted string. Once a string has been encrypted, it is essentially nonsense and looks like a completely random set of characters.

By compressing first, you are able to make the most of the compression algorithms, before encrypting the final result which is a must smaller string. This reduces data size as well as the processing time it takes to encrypt the larger response.

## Other solutions

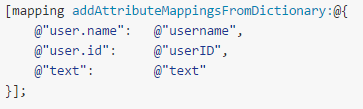
### Object mapping:

I am going do some desktop research to see if there other object mapping (from JSON to Swift objects) solutions out there, and analyse them.

##### RestKit

<https://github.com/RestKit/RestKit/wiki/Object-mapping>

This is an Objective-C library which allows you to map JSON responses to classes. It requires however, a mapping attribute to be set for every single key, even if the property key matches the JSON key.



Also, according to the documentation the library contains up to 25 different classes. This definitely goes against the DAMP and lines of code principle by over complicating the class structure and seemingly more code than necessary.

conc:

There are other object mapping solutions availabl

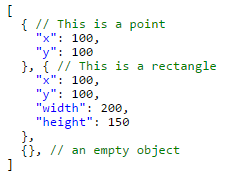
### JSON format

The compression algorithms simply compresses the result, looking for patterns. But it might be possible to optimize the JSON format completely, reducing the amount of data before sending it to the compressor.

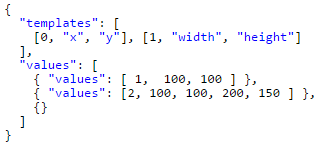
<http://web-resource-optimization.blogspot.dk/2011/06/json-compression-algorithms.html>

#### CJSON

In an array of objects, the JSON keys are repeated multiple times. The basic principle with CJSON is to remove the keys from the JSON responses, and use template maps to know which values belong to which keys.

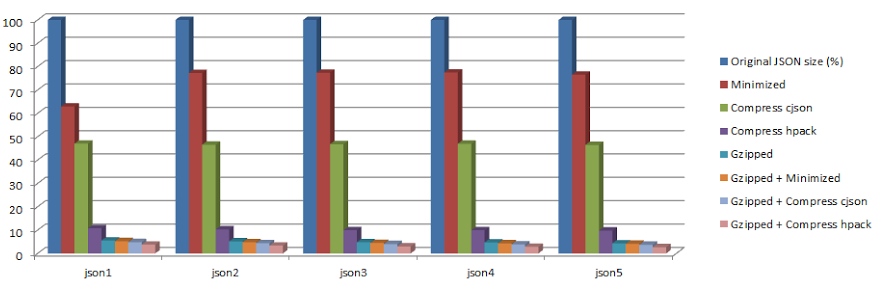


Using the CJSON algorithm, this could be represented as:



Object definitions are transported as arrays of values instead of key/value dictionaries. The templates are part of the response and include an “id” which is the first number of the array. E.g. [1, “width”, “height”] – has template id of 1. The first value in the values array points to the template id. This allows it to be unpacked on the otherside.

According to the source, it can drastically reduce data size:



CJSON seemed like a very promising algorithm for further compression, although there didn’t seem to be a .NET library available. It could ultimately be ported to C#.

#### HPack

<https://github.com/WebReflection/json.hpack>

<https://github.com/WebReflection/JSONH>

<https://github.com/WebReflection/json.hpack/wiki>

HPack is a data compressor which claims to be able to reduce the data by up to 70%. It takes the compression a step further by removing an obvious split between the objects. It is similar to CJSON as it also uses templates for each object.



It can also setup enum values for repeating values for further optimizations



In this case, gender is setup two accept one of two values “Male” or “Female”, set inside an array. They can then be referenced in notation as 0 or 1, representing their position in the array.

#### Taking it further

I think that the HPack algorithm could be utilized in this project as it seems to have all the benefits from CJSON (reducing keys from the response as templates) as well as other optimizations. It could however be improved.

Each object doesn’t actually need to be encased in curly or square brackets because the beginning and end of each object can be deduced by the number of properties in the each object definition.

Using the template



[“Alex”, “23”, “Male”, 1], [“Tom”, “25”, “Male”, 5] could be represented as:

[“Alex”, “23”, “Male”, 1, “Tom”, “25”, “Male”, 5]

HPack also sends the templates in every request. I suggest the possibility of sending the template once, storing it in memory on the frontend device and using that to decode the data.

You could send a header in the HTTP request, asking for the template if it needs it. The response would then be smaller for all but the first one. I would suggest a method to specify an expiry date for the cached template or a way to manually refresh the template. This would have to be carefully thought out because you might end up in the situation where your response doesn’t match the cached template if you have updated your database model, after release for example. A new format could also be created, combining CJSON with HPack to further decrease unnecessary characters using templates as well as merging responses into a single array of values.

## Library management

### Swift

#### Cocoapods [[12]](#footnote-12)

CocoaPods is the most popular library manager for iOS and OSX projects which originated with Objective-C. It has only recently been updated to support Swift frameworks, and now allows you package your library as a “pod” and integrate it easily into any project.

By using Cocoapods you gain some advantages over simply dragging and dropping the files into your project.

* Maintenance: The code has a central base. If you have multiple projects all using different versions of your library, it can be very difficult to maintain which files have the latest code. It also dissuades you from editing the library code from inside your project as they are added as read-only.
* Version control: You can specify “latest”, or use a specific version. In some apps you might want to lock the version number, after it has been tested so you can ensure that the app performs as it should.
* Updates: Updates can be downloaded very easily by simply typing “pod update” in the terminal, from your project folder.
* Dependencies: Often, your code has its own dependencies. You can specify those in your CocoaPod config file. When your pod is installed, it will then automatically download its dependencies.

CocoaPods are a very effective way to manage external libraries. They are well documented[[13]](#footnote-13) and widely used throughout iOS and OSX development.

### .NET

#### Class libraries

In Visual studio, you can setup a class library. You can then package all your classes into a useable DLL which can be referenced from another project. This will also make it harder to make edits to the class library code base which will provide the same benefits as for the Swift CocoaPods.

#### NuGet

A feature of the Visual Studio IDE are the NuGet packages. You are able to browse and install third party libraries from inside Visual Studio. It handles all the downloading of the files, updating and organization of the references.

You can publish your DLL as a NuGet package and make it searchable from the IDE.

## Research Findings

As a result of the research I was able to compose a list of the optimal configuration, and a base for starting the build phase of the product.

### Optimal settings

|  |  |
| --- | --- |
| **Compression** | DEFLATE (LZ77) |
| **Encryption** | AES |
| **Encoding** | Base64 |
| **JSON format** | Standard JSON |
| **Swift Library** | CocoaPod |
| **C# Library** | Class library |

### Plan for product

### Other considerations

#### Latency

To achieve the best results, a number of things will need to be considered and tested, including data size as well as the processing time of compression and encryption algorithms. The benefits of compression become obsolete if the total time of the request doesn’t get reduced due to a processing overhead.

# Product

The product consists of a server side and a client side library. Its purpose is two provide a framework for communicating to and from a Web API while ensuring an optimized transport of data which handles both security and compression.

The main aim is for the product is to be easy to install, and as easy as possible for a future developer to use. This means considering the installation and updating of the frameworks as well as the number of lines of code and DRY principles.

It also tries to be as unobtrusive as possible. This means that you can apply this framework to an existing .NET Web API and Swift project without having to make any big changes.

## Overview

### JSON format

The JSON format for a response is normal valid JSON which can would pass any JSON validator.

A sample request looks like this (while in transport):

{    
   **"data"**:"U2FsdGVkX1/Q0adIWkeHud7buJ797pcaO4V1Accxe0/Ox+e4votw8"  
}

The string inside the data parameter is its own JSON string (also valid JSON) which has been compressed and encrypted using the settings defined by the user (explained later on). This can be processed on the front end and the normal JSON extracted.

The processed JSON is completely valid JSON although has been “percentage escaped” with a backslash to allow it to sit inside a string:

{ \”Name\” : \”Alex\” }

In a request to the server, the data parameter is parsed to the server as a normal HTTP body parameter. This allows these values to be easily retrieved again by the server.

### Compression

### Encryption

Salt/IV random every time – every response diff

## Backend library (C#)

### Features

The backend library includes the following features:

* Automatic compression and encryption of data via action filters.
* Mask URL routes with encryption
* The ability to continue using built in MVC and Web API 2 methods as normal
* Add easily to an existing project.

### Installation

The library is installed by dragging and dropping the folder into your project. You must then ensure you have a reference to the namespace in any files which you wish to access features from the library.

using CompresJSON;

### Usage

The processing is applied to a normal MVC or Web API 2 Controller via action filters. The action filters can be applied to a single “JsonResult”, “ActionResult” or “IHttpActionResult” providing it returns a “JsonResult” instance.



It can also be applied to the controller itself. This method reduces lines of code, but all actions from the controller are required to return a JsonRequest object to avoid this interfering with any other existing action results.



The developer has control over whether they want to process an incoming request, outgoing request or both. For the purpose of communicating between client and server, it is necessary to process both the incoming and outgoing data.

If the method does not receive any data, you can just add one action filter:



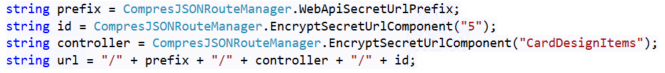
By using action filters, the library doesn’t require any large changes to the existing code, and is very easy to implement:

SHOW FULL EXAMPLE OF ACITONRESULT

#### Masked route

A masked route allows you to encrypt components of the URL to mask the contents of the data. This is to prevent a hacker from being able to gain information about the context of the request. E.g. if it was a request to login, and the URL looked like: “/api/login”, a hacker would expect “username” and “password” as parameters somewhere in the data.

To demonstrate the masked route, this is a URL which points to the URL: **/api/CardDesignItems/5.** Secret routes must start with the secret prefix. The prefix is necessary to distinguish from the default route.





This produces the following:

[/VTJGc2RHVmtYMSs2MEZvbGlxL3BjVDZrU3JIbnRCcStacm1nV094WmNxcz0=/VTJGc2RHVmtYMSs1U1FMYnZlWXFRNFdDQWg0SHhhaXBMZEhYKzd0VjBNYz0=/VTJGc2RHVmtYMTg2Sk5XOVFaczJmL3VtZDZ3bjBWenErdkdoWmxOM3B2WT0](http://localhost:22058/VTJGc2RHVmtYMSs2MEZvbGlxL3BjVDZrU3JIbnRCcStacm1nV094WmNxcz0=/VTJGc2RHVmtYMSs1U1FMYnZlWXFRNFdDQWg0SHhhaXBMZEhYKzd0VjBNYz0=/VTJGc2RHVmtYMTg2Sk5XOVFaczJmL3VtZDZ3bjBWenErdkdoWmxOM3B2WT0)=

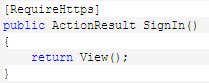
To achieve this behaviour the routes need to be added.

### How it works

#### Action filters[[14]](#footnote-14)

An action filter is a class which provides the ability to run code before and after an ActionResult on a MVC Controller executes. They are very powerful classes which have access to a lot of different information about the current context including route parameters and information about the connection etc.

This allows you to add logic to decide whether or not to allow a client access to that action result. This might be an action filter that requires an authorization header present, or an HTTPS connection. You can check for all these values here. They are applied to an action result via square bracket notation. The following example is a view in an MVC website which will only allow access through a secure HTTPS connection.

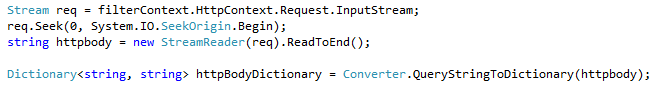


The action filters in this project are used to manipulate the incoming and outgoing data, converting normal parameters into a single processed string.

To access the context before the action result has been executed you can override the method: “onActionExecuting”:



This method is used to process the incoming data sent in a POST from the client for example. We are expecting data inside one parameter called “data”. Before we can access this we need to access the HTTP body which contains all the post values:



This code retrieves the HTTP body as a string, and converts it to a useable dictionary. The data can then be accessed from the dictionary using the key: “data”.

It can then process the data inside that parameter, and convert it into another dictionary containing the original values sent in the request.



The value “dict” now contains the original values. However in MVC, you usually expect the parameters to be mapped to an object automatically by the time your ActionResult code executes:



As we are not posting the parameters directly, we need to do some extra work to restore this behaviour. Without this, the user object will be empty, creating unpredictable behaviour.

From the action filter it is possible to retrieve the expected parameters from action result, along with its type.



E.g. Using the “LookAtUser” example, this variable will now contain one key called “user” and type: “User”.

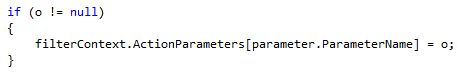
The type is stored as a string so you can use Reflection to create an instance of an object using the string type description.



The object’s properties are then populated using another method “toObject” which is able to parse values from a dictionary into the object.



This object is now ready to pass into the Action Parameters dictionary which is what is passed to the action result parameters.



#### Custom routes

The default Web API route looks like this:



This is able to map segments of the URL into accessible values. In the case of controller and id, these help the program decide which action result, on which controller to execute.

#### Compressor

#### Encryptor

### Third party dependencies

* Jint
* CrytoJS (CS library)

## Frontend library (Swift)

### Features

The frontend library includes the following features:

* Automatic compression and encryption of data
* Automatic generation of standard Web API URL’s
* Automatic JSON to object mapping
* Automatic object to JSON mapping
* Methods to execute all CRUD functions.

### Installation

This library can be installed via CocoaPods[[15]](#footnote-15). CocoaPods is a dependency manager for Swift and Objective-C libraries. The “pod” can be installed by adding this line to your Podfile:

pod "ABToolKit", :git => 'https://github.com/a1exb1/ABToolKit-pod.git'

The pod contains the code files for all internal dependencies, as well as references to external dependencies. After running “pod install” in the command line, the library is downloaded alongside all its dependencies and integrated into the project as a framework.

To use a framework you must import it to any code files where you wish to use it:



### Usage

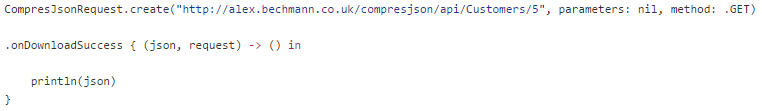
#### Making a request

A request can be made using the create method on the **CompresJsonRequest** class.

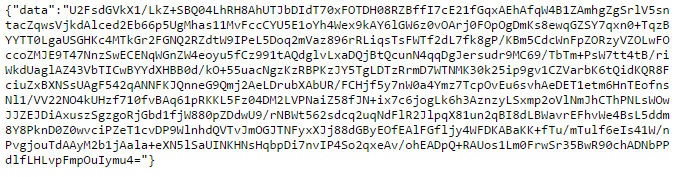


This will execute but will not run any code on completion.

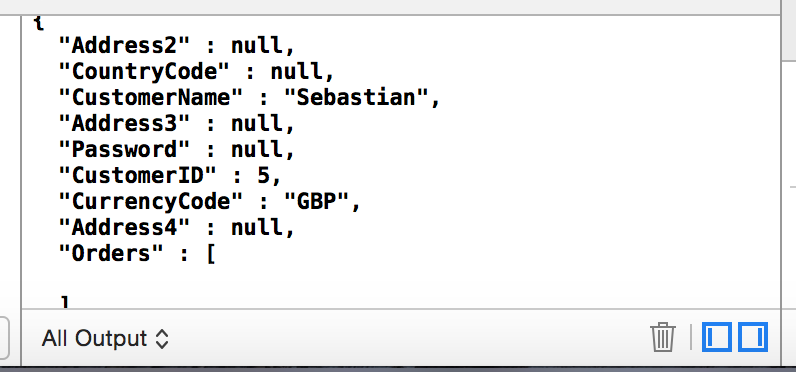
You can add code in the callback by adding a handler (e.g. onDownloadSuccess):



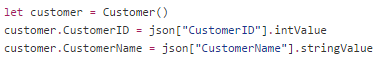
This will convert the processed JSON from the response:



Into normal JSON and print it to the console:

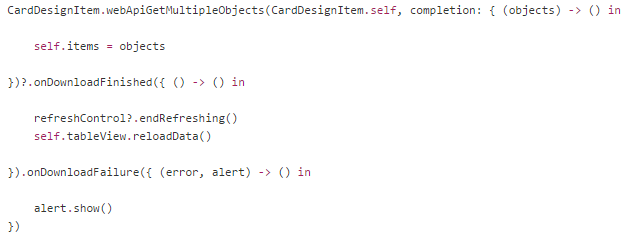


The values could then be unpacked using SwiftyJSON syntax:



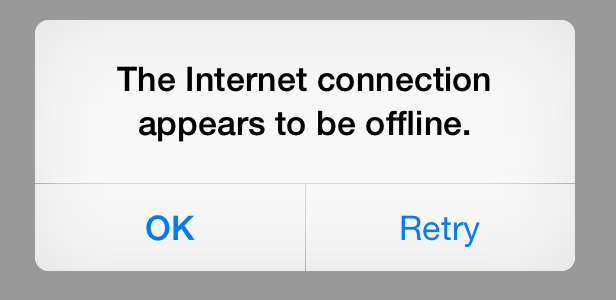
#### Multiple handlers

You can add “onDownloadSuccess”, “onDownloadFailed”, and “onDownloadFinished” handlers in any order.



* **“onDownloadSuccess”** gives you access to the JSON response.
* **“onDownloadFinished”** is useful for cleaning up the UI (e.g. hiding loader animations) regardless of whether the request failed or not.
* **“onDownloadFailed”** provides you with a pre-setup UIAlert containing the error message and a retry button. You can edit the message manually via the alert object, or use this code space to generate your own error handling.

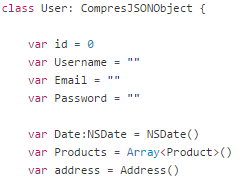
Activating “alert.show()” will bring up an alert box like this:



#### JSON Mapping

Mapping JSON parameters to objects manually (as seen above) involves a lot of redundant code and can be time consuming if you have many complex models. Your models can be setup to handle this automatically.

Your model must inherit from “CompresJSONObject” instead of “NSObject”. You can use a pre-existing object class, and just replace the inheritance class. The class properties are setup in the usual way:



You can now use a class method on your object to instantiate a new instance and map the properties directly from a JSON object (providing your class properties match the JSON keys):



In swift a “class” method is the same as a “static” method in C#, meaning it can be executed without requiring an instance of that class.

If the properties do not match, you can use “registerKey” function to map a JSON key to a property key. The delegate method “registerClassesForJsonMapping()” is called just before it does the mapping. You can set your mapping preferences here and add any logic if you require it.

If you had the property:



You can map the JSON paramter “FontID” to this property. Once this is defined it will do everything for you automatically:



You might also have embedded types within your JSON response. This could be an address object or a list of products.

You can register a class to a parameter. It will detect automatically if the response is an array or single object and automatically map all the properties. “Address.self” and “Product.self” refer to user defined swift classes. (Including JSON key parameter if necessary). When it maps to the class, it will use the defined mappings setup from inside each of those classes.



You might also have a date, formatted as a string. You can choose to use the global default for the date format, or define it per key. To use the global default you would have to set first, this should be done in the AppDelegate.



It is important to make sure that this format is accurate because otherwise the date formatter will through an exception, and the app will crash. Once this is set, dates can be registered to property keys:



If you need to specify the format you can do so. You can also use the DateFormat enum helper, or write it yourself.

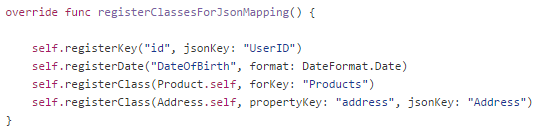




This example shows how these methods can be combined to map a JSON response to a cl[[16]](#footnote-16)ass.

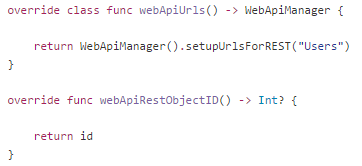
|  |  |
| --- | --- |
| If your model looked like this: | And the JSON you were expecting looked like this: |
|  |  |

You would put the following into the “registerClassesForJsonMapping” method:



Automating the REST URL’s

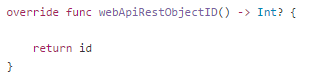
The REST URL’s are managed within the “WebApiManager” class. A set of RESTful routing URLs can be setup by overriding the “webApiUrls()” function:



The Web Api Manager takes the domain from the global defaults which is setup inside the AppDelegate, unless overridden.



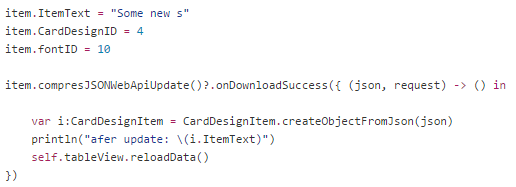
The “webApiRFestObjectID” function is fired whenever the Web Api manager needs the object’s unique identifier. It should be setup to return whichever value should identify the object. This example returns the property “id” from the User class:



The function “setupUrlsForREST” with the argument “Users” will generate these URL’s when called from the following swift methods:

|  |  |  |  |
| --- | --- | --- | --- |
| Swift method | Action | Method | URL |
| User.webApiUrls().getMultipleUrl() | Get multiple | GET | <http://topik.ustwo.com/Users> |
| User.webApiUrls().getUrl(5) | Get | GET | <http://topik.ustwo.com/Users/5> |
| User.webApiUrls().insertUrl() | Insert | POST | <http://topik.ustwo.com/Users> |
| User.webApiUrls().updateUrl(9) | Update | PUT | <http://topik.ustwo.com/Users/9> |
| User.webApiUrls().deleteUrl(122) | Delete | DELETE | <http://topik.ustwo.com/Users/122> |

These URL’s can be accessed to send your own requests, or you can use the in-built CRUD methods on the CompresJSONObject class. You can change the values via the swift objects as you would normally, and then all the “compresJSONWebApiUpdate” method to send the data to the Web API. This object returns the CompresJSONRequest so you can chain the code handlers in the same way as a normal CompresJsonRequest.



### How it works

#### JSONObject

The JSONObject class is derived from “NSObject” which is the base for all classes in swift. It contains a number of methods to convert to and from JSON and dictionary objects, aswell as handling the Web API CRUD methods.

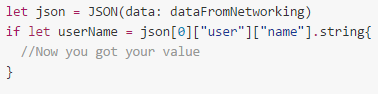
##### Converting from JSON

###### SwiftyJSON[[17]](#footnote-17) (Dependency)

SwiftyJSON is a library which is used to handle extraction of data from a JSON response. Any JSON string can be converted into a “SwiftyJSON” object using the class “JSON”. It contains the information inside an instance of this class and has some advantages over using a normal String/AnyObject dictionary.

It tackles the issues defined in the problem statement with mapping JSON data to a dictionaries, and reading its values. SwiftyJSON allows you to safely read the values without throwing a crash if something is missing. This behaviour is optional so you can decide if you would like a crash or not if keys are accessed without values present in the JSON string.

You can bypass serialization code shown in the example (page x) with:



If you use .string to access the value, the program will crash if it does not find a value there. In the example above that problem is tackled by wrapping it around an “if let[[18]](#footnote-18)” statement. You can replace this with .stringValue to return an empty string in the same scenario, also preventing a crash:



###### Mapping

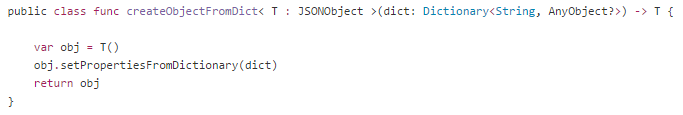
SwiftyJSON is used at this stage, only to convert a JSON string (or NSData) into a useable String/AnyObject dictionary.



This method has a parameter “T” for the type, which is part of a generic function[[19]](#footnote-19). The parameter is parsed indirectly, by getting the type from whichever class it was fired from.

E.g. If you invoke it from the class “User”, T will be of type “User”. This allows you to gain information about the class (if fired from a derived class) from the base class. This extra information includes access to the properties which are used in the object mapping. This means the same code can set the values of whatever properties are included in the derived class.

The JSONObject class method “createObjectFromJson” expects a JSON object as the parameter, converts it to a dictionary, and fires the “createObjectFromDict” method.



createObjectFromDict creates and returns an instance of the class after firing “setPropertiesFromDict”, which handles the mapping to the object.



The first thing this method does is fire the delegate method: “registerClassesForJsonMapping”. This fires the method defined in the Swift class (if overridden), to get all the information needed to start mapping.



As the method is aware of the class type, it can access the class properties. It then loops through “keysWithTypes”, a method which returns an array of objects containing the each property as a string value, as well as its type description.



With this information it’s able to use the jsonKey to access the dictionary it received from the JSON, and retrieve the correct value. If the jsonKey is not specifically set, it is simply the same as the propertyKey.



The function “setValue”, a built in NSObject method, can then be fired using the propertyKey. It allows you set values to a property via a string representation of the property.



It also does some processing on the value if necessary. For example, if you specified in your class that it expects a date for that jsonKey, it will convert the string into an NSDate object using your defined date format, before firing “setValue”.



##### Converting to JSON

It can also reverse this process. This is needed when you want to convert a Swift object into key/value pairs to send as parameters to a Web API for inserting or updating information.



It loops through all the properties names via the “keys” method and extracts the value from the object using “valueForKey” which is a built-in NSObject method. It sets the value to the return value “dict” using the defined jsonKey. This means that the parameter used will be the same for posting data as it is for reading it.



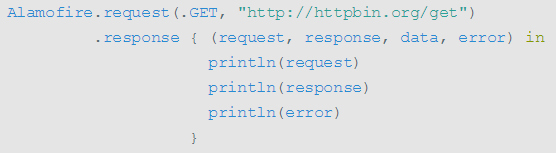
##### Web API Manager

### JsonRequest

#### Alamofire

JsonRequest is built on top of Alamofire which handles the actual HTTP request. It is a very powerful library which can handle HTTP requests as well as file upload/downloads etc.

It makes it easy to send a request, specifying the HTTPMethod via an enum, and handle the response data and error messages.



#### HTTP Requests

JsonRequest was developed to utilize the functionality of Alamofire but improve the markup and build in some extra features.

##### Method chaining

When you make a request, you usually need to handle a successful request, a failed request and when it finished. You would often have a response parameter to the function, in which you pass a “closure”. A closure is a piece of code which you pass in, and can execute from inside that function.

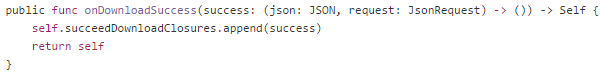
The closure would provide you with a space to handle response data and error objects, requiring you to manually check if the error was nil, before continuing.



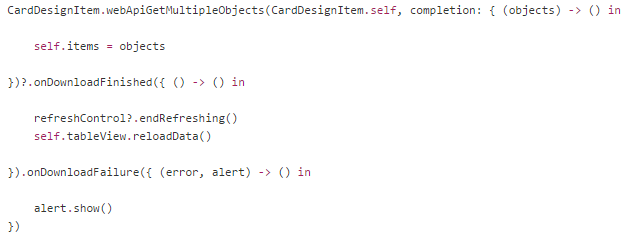
You could get around this by having multiple closures for success and for error, but then you need a third for finished. You need a finished closure to tidy up the UI (e.g. hide animated loaders) regardless of whether the request was successful or not. This starts to make the code look untidy.

I tackled this by implementing “method chaining”. This allows you to subscribe to as many events as possible by chaining response handlers:

To implement this, the methods “onDownloadSuccess”, “onDownloadFinished” and “onDownloadFailed” methods all return the JsonRequest instance, and save the closure inside the class:



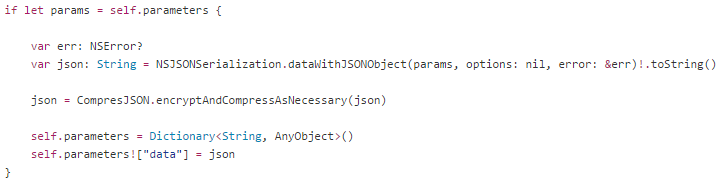
This allows you to do the following (Using the same example from earlier):



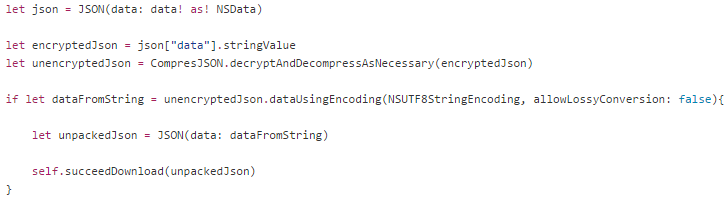
### CompresJsonRequest

This class inherits from “JsonRequest”, but has some of the methods overridden in order to extend the functionality. When the HTTP request is executed in a “CompresJsonRequest”, it overrides the passed parameters, serializes them into a JSON string and processes that string with the necessary encryption & compression.

It then sends just one parameter “data” in the actual request, and puts the processed string inside here. This is now in a format that the backend will understand.

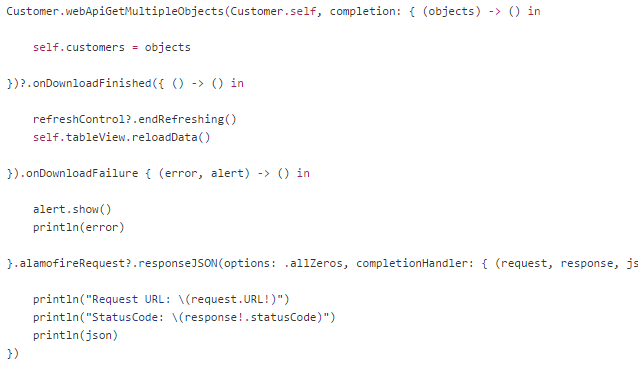


It also adds some logic to the request before it fires the callbacks, to decrypt/decompress the data:



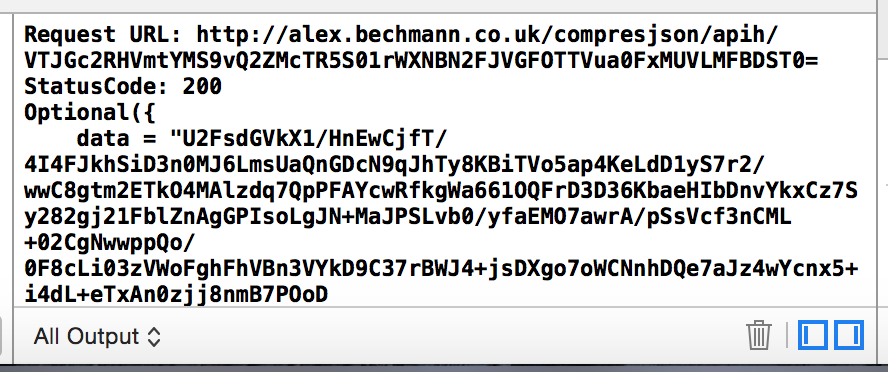
It reads from the “data” property of the response, processes the data inside that string, and converts that string value into a JSON object before firing the callback.

You can access the underlying Alamofire request via the property: “alamofireRequest” on a JsonRequest, and continue the method chain:



By accessing the Alamofire request object directly, you are able to inspect the actual values and URL’s being used in the HTTP request, including status code, headers, parameters, data size etc.

E.g. the above code outputs the following to the console:



This shows you that it is accessing the Web API using an encrypted route and the raw data string from the response.

### CompresJSONObject

This is derived from JSONObject and its purpose is to extend the functionality in order to communicate with the Web API while utilizing the compression and encryption methods from the CompresJsonRequest class. It overrides all the “factory” methods and Web API CRUD methods. It does this to ensure that those methods fire a “CompresJsonRequest”, instead of a “JsonRequest”. By using a CompresJsonRequest, everything stays the same except that it transports the data in the compressed/encrypted state.

Due to the fact that a CompresJSONRequest returns the unpacked JSON, you can easily switch between using a JSONObject and a compresJSONObject simply by changing which class your object inherits from. This is possible because they both take in the same parameters, and return the same values.

Dependencies: Alamofire

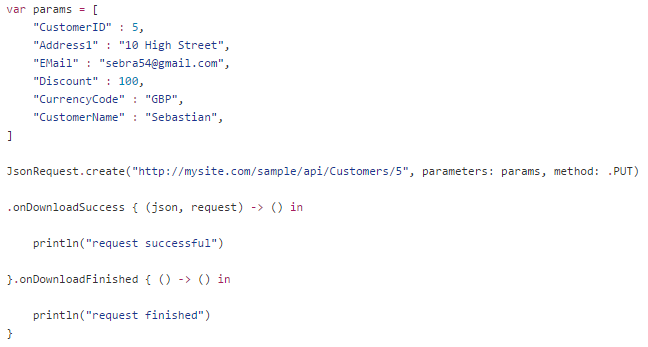
compresJSon request

javascriptanalyzer

cocoapods

Compressor

* JavaScriptAnalyzer
* Compressor
* Encryptor



* WebApiManager

### External dependencies

* SwiftyJSON
* CryptoJS

## Configuration

Both libraries feature ways to configure the settings. These settings include the symmetric encryption key, as well as Boolean variables for whether or not to encrypt, compress, or do both. This settings step is important because the server settings have to match the client side settings in order to correctly process the data it sends and receives. Both libraries have settings and are implemented similarly on each.

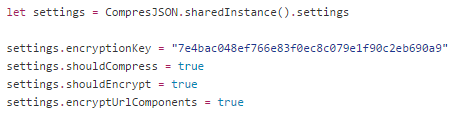
### Backend configuration

The configuration settings are static variables which mean you cannot change these from inside code, but by editing the source of the page via an IDE.



### Frontend configuration

In the frontend, the settings instance is a global variable which is configured in the “AppDelegate” file. This file is the first thing to run whenever the app is launched.



As the frontend isn’t stateless like the server, it can save global variables in memory and allow access to them from anywhere in the code.

The “encryptUrlComponents” variable toggles the encrypted routing option. This setting does not need to be on the backend, although if it is set to true, the routes must have been setup in the global.asax file.

## Testing

### Environment

To test the traffic and effectively measure whether data consumption with and without the use of this library I have setup an environment which is using real data and hosted on a web server.

both



Compres only



### MySql Database

The database is a copy of a real world database from another project. The database contains user and order data.

Diagram?

# Analysis

Analysis of encryption method – limitations e.g. doesn’t encrypt headers

Use of JavaScript opens it up to any platform

Works in browser

Wrong compression method

# Discussion

Doesn’t follow rest 100% yet – caching, auth headers, json/xml output

## Compromises

I had numerous problems finding libraries for both compression and encryption which would produce the same results on both the server (C#) and the client (Swift/Objective-C). It was not feasible to create my own implementation of the algorithms due to a lack of time. This was an issue because I was not able to gain enough control of the libraries I found, to match the settings and they were producing different results, making communication impossible.

From my research, I found that the most effective compression was using DEFLATE. However I was not able to find a library for both server and client side which produced the same results. So I had to use a compromise, in the form of a GZIP implementation and a library called LZString. LZString is pure JavaScript and is able to run on both the server and client using JavaScript.

LZString is quite a slow implementation due to the dependency on JINT (to run JavaScript in .NET) so I was able to get GZip partially implemented, in the browser only and was able to decompress the data from the server. GZip is very slightly larger than LZString but by an extremely small margin (roughly 2 bytes).

Criticize method

Data doesn’t need to be human readable – e.g. json – could use another format

# Conclusion

Focusing on functionality not speed

Perspective:

What u could have done differently

Future plans

Analysis

* Is it worth it? Does it work?
* Encryption key stored on server + client device

The purpose of the testing is to compare the response time and data size of requests of different sizes, in order to measure the effectiveness of the implementation. I setup a test page in a web browser which

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<http://xss.tkch.dk/aes.php>

deflate, gzip, x-gzip, identity

compress – UNIX "compress" program method (historic; deprecated in most applications and replaced by gzip or deflate)

deflate – compression based on the deflate algorithm (described in RFC 1951), wrapped inside the zlib data format (RFC 1950);

exi – W3C Efficient XML Interchange

gzip – GNU zip format (described in RFC 1952). This method is the most broadly supported as of March 2011.[5]

identity – No transformation is used. This is the default value for content coding.

pack200-gzip – Network Transfer Format for Java Archives[6]

encrypt analysis:

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<https://www.simple-talk.com/dotnet/asp.net/attribute-routing-in-web-api-v2/>

<http://automagical.rationalmind.net/2009/02/12/aes-interoperability-between-net-and-iphone/>

!!

<http://automagical.rationalmind.net/2009/02/12/aes-interoperability-between-net-and-iphone/>

compression dependency:

<https://github.com/dankogai/js-base64>

<http://ayende.com/blog/163425/json-packing-text-based-formats-and-other-stuff-that-come-to-mind-at-5-am>

“human readable” dooesnt need to be

todo product:

clean c# lib

c# handle dates

decrypt/encrypt – add base64

shouldDecrypt (capital s)

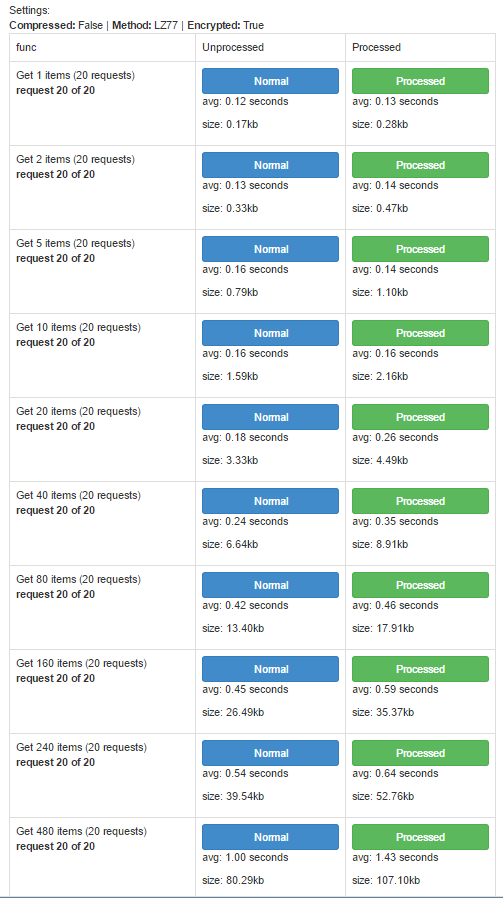
web api verbs

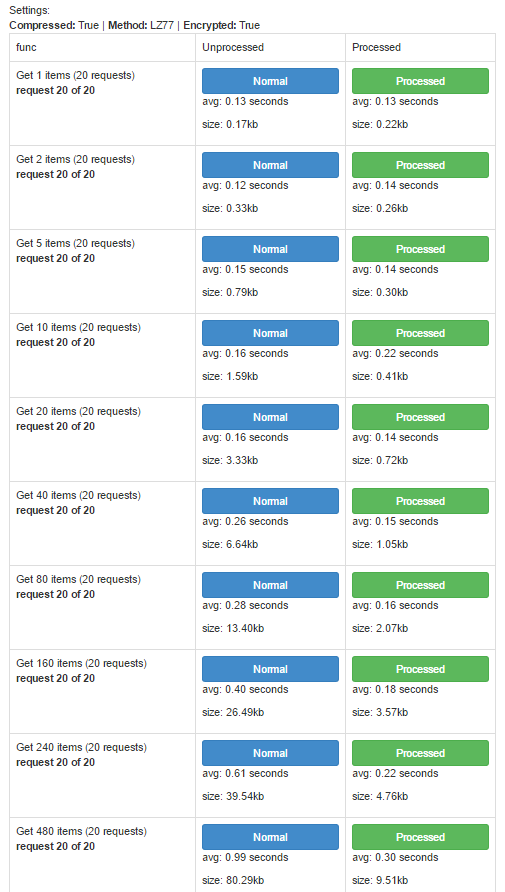
<http://micheltriana.com/2013/09/30/http-verbs-in-a-rest-web-api/>

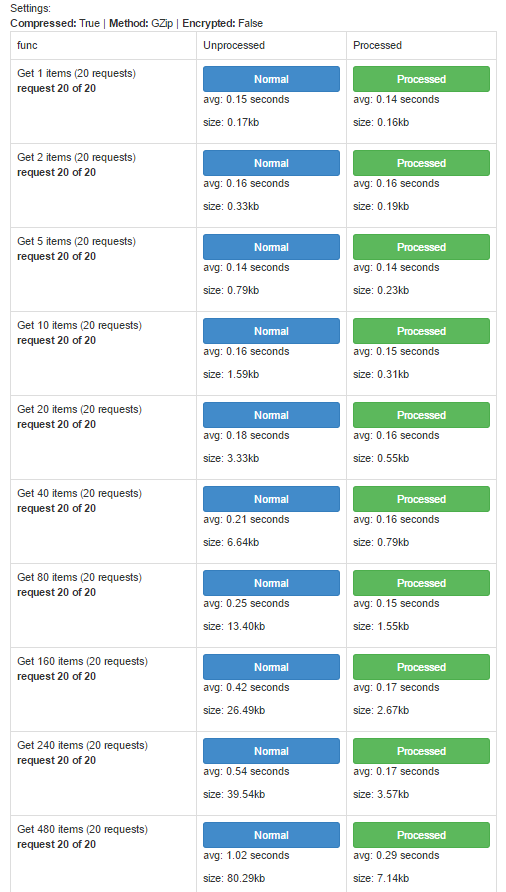


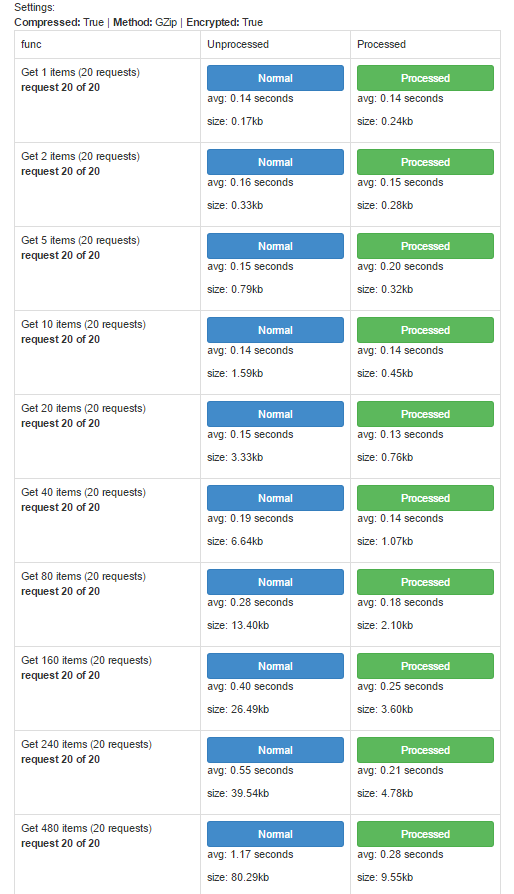
Lz77

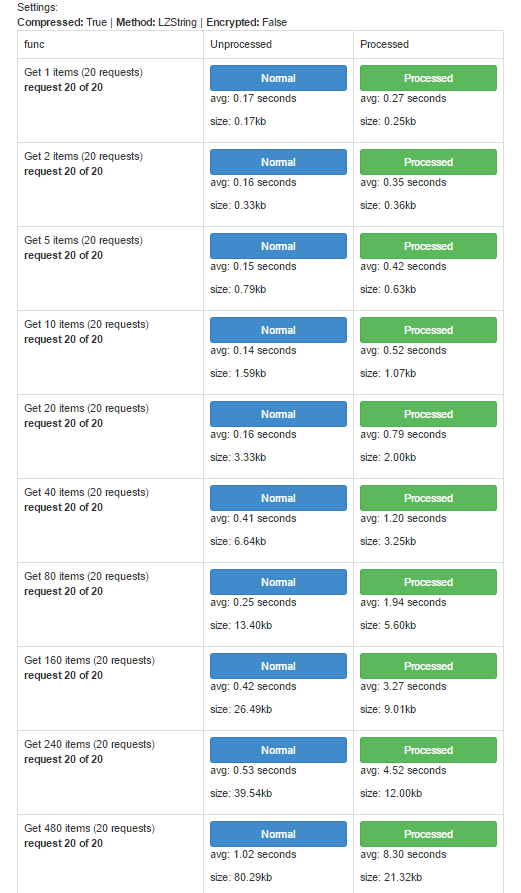


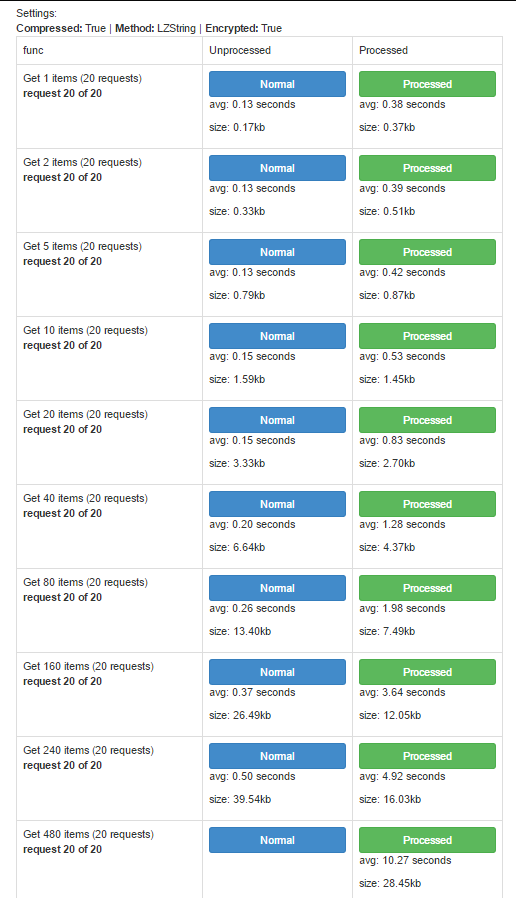












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2. <http://simplythetest.tumblr.com/post/93114654620/keep-your-test-code-damp> [↑](#footnote-ref-2)
3. (Microsoft, 2015) [↑](#footnote-ref-3)
4. (Pot, 2012) [↑](#footnote-ref-4)
5. (Wikipedia (GZip), n.d.) [↑](#footnote-ref-5)
6. (Wikipedia (Cyclic redundancy check), n.d.) [↑](#footnote-ref-6)
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