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**Digital Marketing Tool Analysis and Evaluation**

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## ABSTRACT OF THE THESIS

Visible Light Communication (VLC) systems impose information to the visible light, using Intensity Modulation/Direct Detection (IM/DD) communication unlike RF system, which modulates the amplitude, frequency and phase of carriers. With similarities of fiber communication, VLC is also based on IM/DD, using the transmitted signal to modulate the light intensity, illuminated from LEDs. The optical power is therefore proportional to the optical forward current of Light Emitting Diodes (LEDs). It is a short-range optical wireless communication using visible light spectrum from 380 to 780 nm, enabled by recent advances in LED technology [7]. Although, the fiber communication technology has been already mature, this technique could not be exploited in mobile communication because of harm of Infrared for health. Instead, VLC has the ability of providing us great advantages of safety, economical and high-speed transmission. Recently, a majority of papers focus on the researches, indoor and outdoor communications imposed with LEDs, which play a very important role in illumination, eventually replacing traditional incandescent and fluorescent lamps for their high energy efficiency, environmental friendliness, and long lifetime. Due to their low-cost and popularity in modern life, many scientific papers ([7]-[9]) have brought the potential methods to use white LEDs to transmit information and a Photo Diode (PD) with the sensitivity of visible spectrum is imposed to Direct Detect (DD) the data transmitted. Moreover, [6] is authored by Samsung company, where there are majority of researches, focusing on realization of VLC transmission and potential future standards. While a VLC Lab for testing and realization has been set up, financially is supported by Japan government.

This thesis studies the possible modulation and transmission that can be exploited with VLC and achievement performances by means of analytical and simulation methods, taking into account the relevant application scenario of indoor communication. The first main part provides the development background of VLC systems, the comparison of Radio Frequency (RF) and VLC systems, LED characteristic, typical wireless optical links and challenges. The second main part depicts the performance study with possible modulation methods, such as On-off Keying (OOK), Variable Pulse Position Modulation (VPPM), Color-shift Keying (CSK) from the IEEE 802.15.7 standard. The third main part, the most important section, demonstrates advanced possible modulation approaches, Optical-Orthogonal Frequency Division Multiplexing (O-OFDM), for instance Asymmetrical Clip-

ping Optical-OFDM (ACO-OFDM), DC-Biased OFDM (DCO-OFDM) and Flip-OFDM and analyze their performances theoretically. The following several parts display the details of analysis of typical optical wireless links, combat with LED non-linearity, flicker mitigation and dimming support mechanisms. Finally, the complete VLC system performance is to be comprehensively analyzed and obtained by using a novel dual chains based receiver with MATLAB<sup>®</sup> based on DCO-OFDM modulation scheme, mentioned before. The obtained performance is improved significantly compared with the usage of a single chain based receiver.

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# 1 Introduction of Digital Marketing

## 1.1 Background

Over the last decades, The role of marketing plays a critical function in generating sales, educating consumers, and building brand equity. A variety of channels, influence on consumers, and the metrics used to measure marketing has changed over the years. Exciting, new, and innovation approaches(YouTube, Facebook, LinkedIn, Instagram and so on) are displacing traditional marketing, such as newspaper, TV, radio and so on.

What is digital? Bud Caddell defines digital as a participatory layer of all medias that allow users to self-select their own experiences, and afford marketers the ability to bridge media, gain feedback, iterate their message, and collect relationships (Caddell, 2013). In other words, digital is a new way of exploring content (for users) and connecting with customers (for marketers).

The term digital marketing was first used in the 1990s [1]. In simple terms, Digital Marketing is the promoting of products over the internet or any form of electronic media. According to the Digital Marketing Institute, "Digital Marketing is the use of digital channels to promote or market products and services to targeted consumers and businesses." The digital age took off with the coming of the internet and the development of the Web 2.0 platform. Web 2.0 allowed users to interact with other users and businesses. As a result, information flow volumes including channels utilized by digital marketers increased manifold, and by 2004, internet advertising and marketing in the US alone brought in around \$ 2.9 billion. Soon, social networking sites began to emerge. MySpace was the first social networking site to arrive, soon followed by Facebook. Many companies realized all these fresh new sites popping up were beginning to open new doors of opportunities to market their products and brands. To give you a thorough understanding of what the term "Digital marketing" includes, here are the most important types of digital marketing in Figure 1.

With the fast-paced lifestyle all over the world, we have witnessed a surprisingly growth of the digital marketing in big or small company. Digital marketing opened fresh avenues for business, and signaled the beginning of a new chapter to business. Its free (most of the time), fun, casual, and diverse and shows off your creativity. With the right content, your business can easily reach thousands, if not millions of people in one hit. You can



Figure 1: What does the digital marketing consist of

not only talk directly to your customers, but your customers can talk directly to you, share their experiences of your business and your brand to provide valuable, real-time feedbacks on areas you excel in, and areas you could improve on. Besides, on most social media platforms, particularly Facebook, you can target specific groups or types of people, dependent on all sorts of factors, including: location, interests, gender, and anything else that would help you talk directly to your ideal customer. Every business is unique, and as a result, has a unique tone of voice to match, a specific way of speaking and writing about your work to engage your audience and get people invest in your products or services. Due to its casual, personal format, social media can support you to perfect your tone of voice and work out the best way of talking to your audience, about your business, to keep people engaged. As the time goes on, one of the biggest changes in human interaction is the recent proliferation of online social networks.

## 1.2 Digital Marketing Tool

As we all know, Maintaining the brand and growing the number of customer has never been more difficult, thanks to the rapid rise of online marketing and social networking. Your company needs to have an active campaign going at all times to take advantage of every opportunity available. Here are some of the most effective tools your team can use to

implement a cost effective and rewarding lead generation policy in Figure 2. Without the



Figure 2: Digital Marketing Tools

right marketing and the tools to power it, you will have a hard time achieving the hockey-stick growth everyone is longing for. Next, I will shows you some of the different types of marketing tools available, and gives examples of the leading tools in those markets.

- **Google Analytics:**

Google Analytics is a free website analytics service offered by Google that gives you insights into how users find and use your website and measure site traffic, conversions and ads performance. Meanwhile, you can track ROI(return on investment) for your online marketing. Its a huge, monstrous amount of information, generously given away for free. As a social media marketing team, you will appreciate the ease with which you can see traffic from the different networks. You can check the engaged reading time by looking at time on page. And for the real-time stats of who is on your site right now, you can

simply click on real-time – > overview.

If there is one or more pieces of data you want to see at a glance every time you login to your analytics, be sure to set it up in the dashboards area where contains multiple widgets. You can choose from widgets that show you one particular metric, a pie chart comparing metrics, a timeline of one to two metrics, or a table showing a dimension with two specific metrics. Each type of widget can also be filtered. This is great if you want to see an overview of your stats for traffic, goal completions, and other metrics of your choosing all in one place. Besides, you can learn what people are searching for on your site. Besides, you can learn what people are searching for on your site. Site Search can help you determine if people are finding what they are looking for on your site. It can also give you ideas of which pages of your content need more specific information as well as the new content you can create on your site to further engage your visitors. Last but not least, you can visualize what people click on the most by Google Analytics. You can hover over each link to see additional details and click through to more pages on your site to see more details. This can help you visually see what areas of your site are the most popular, and help you identify where people are clicking on your site. So if you have a particular link you want visitors to see, you should be sure to place it in the areas of your website that receive the most clicks.

- **Google Adwords:**

Google AdWords is Google's advertising system in which advertisers bid on certain keywords in order for their clickable ads to appear in Google's search results. Since advertisers have to pay for these clicks, this is how Google makes money from search. You can target websites or applications that are contextually matched with the keywords you want or have that specific keywords in their content. For example, you want to target articles in websites that are doing wordpress theme reviews. Then I will choose the option only to show my ads where best Wordpress themes is present in the content of the website. Similarly, you can target websites on certain topics. More interesting, you can target people based on what Google they might be interested in. Lets say that you sell Macbook Pro Accessories and know your potential customers read Macworld.com. You can tell Adwords to show ads only on this website. To make the targeting even better you can combine targeting preferences. What this means is that I can show ads to people who read Macworld.com and read articles that contain the keyword Macbook Pro Accessories.

It is essential for a modern marketer to know how to use AdWords to boost their business. Otherwise, depending on the competitiveness of the keywords you're bidding for and the relevancy of that keyword to real conversions for your company, AdWords may or may not work for your business.

- **Oracle Content Marketing:**

To remain competitive, brands have become increasingly focused on creating a higher quantity of content, while still striving to maintain quality. Unfortunately, the quantity and quality struggle is real for so many B2B(business to business) and B2C(business to customer) marketers alike. Along with finding the right people and creating a sound content strategy, there is the matter of finding the right tools to integrate with your process and help you reach your goals. Oracle Content Marketing supports custom workflows and uses custom roles for publishing, which simplifies the overwhelming process of creating, distributing, and promoting new content to drive strategic conversations for every stage of the sales cycle. Plan, craft, and communicate messages to prospects and customers to spark relevant conversations that lead to conversions.

It will empower sales conversations by providing access to marketing-approved content created and categorized by persona and stages of the sales funnel. Users can share content across major channels and even leverage "snippets" of content specific to a buyers interest to drive engagement. Besides, Oracle Content Marketing has built-in metrics essential to the overall content marketing strategy and compliment general analytics packages. These insightful reports help the marketer understand how content is performing and how to speed up content production by identifying any potential bottlenecks in the content workflow. Without metrics content efforts are becoming increasingly difficult to defend. Last but not least, The Oracle Content Marketing main analytics dashboard will give the marketer a quick look at content production while also providing traffic and conversion statistics.

- **MailChimp:**

MailChimp is a web-based email marketing service. It helps you design email newsletters, share them on social networks, integrate with services you already use, and track your results. Now it is the worlds leading marketing automation platform, and it democratize technology for small businesses, creating innovative products that empower the

customers to grow.

Most email services and Internet service providers (ISP) limit the number of emails you can send at one time. This is to prevent spamming. With a tool like MailChimp, you can send an email to an unlimited number of recipients at one time. It allows you to easily create newsletters of varying types and then provides simple options for sharing them on social networks such as Twitter or Facebook, making it your own personal platform for publishing your newsletter. Build a list of the people whom you want to market your products to, and save the list for use later on, and create custom templates for your products so that you do not have to rewrite mails again and again. Besides, It work with ISPs and corporate domains to ensure your emails are recognized as safe and approved. If there is a problem with delivery, it will attempt to re-send the email and tell you why an email might be bouncing.

More interesting, If you send an email through your personal email, you have no idea who opened it. It will help you save your drafts and formats quite easily and track your results so you can check the responses that you receive from your clients. This gives you a better idea about how you can make changes to your campaign in order to get a more positive response for your page also gives you all sorts of fun analytics on successful deliveries and open rates so you know your fans are listening.

- **SimilarWeb:**

SimilarWeb is an online competitive intelligence tool that provides traffic and marketing insights for any website. The tool provides users with a quick overview of a sites reach, ranking and user engagement. Users can search for data by entering a specific website URL or by running a category search by industry or country, where the top 50 websites are displayed. What is more, it transforms raw data into engaging and insightful website metrics, including traffic sources, organic versus paid search, social traffic, related sites, and more. In its default view (audience overview), SimilarWeb presents website traffic for the past six full months. It displays Global, US and category rank and snapshots of audience breakdowns by countries and traffic sources.

SimilarWeb offers a rich visual dashboard with a wealth of data divided into general overview and eight other metrics such as geography, referring sites, search traffic, social, display advertising, audience, similar sites and mobile apps. The free version enables comparison of up to 2 websites side by side. Besides, it will also cover the needs of

multinational and large enterprises, as it secures unobstructed multi-user access, top tier professional support and services, custom reporting, and a number of API integrations. The number of websites you can manage with it is not limited, and the company is very flexible when it comes to choosing your preferred payment method. Assistance, in brief, is accessible in any moment upon implementation.

### **1.3 Motivation**

With the dramatic developments and progresses of technologies, especially for more and more people or business are using Facebook and Instagram to attract more customers and services. This thesis fixes attention to the social network, like Facebook, Instagram, are exploited and convert into an attracted platform, in order to gain some useful data, analyse the data, predict the future directions and boost the business. In other words, there is a lot of data offered on the Facebook or Instagram platform, but you want to sort through it and identify what information is meaningful and will help you make decisions about your engagement and content strategy. So if that data is not readily available, you might want to do some manual calculations to derive the numbers you're looking for. Besides, if you have a page and aren't checking your stats, then you're missing out on a lot of useful information. While it will be easy and accurate by using Facebook built-in analytics.

Apart from being the most popular social network in the world, Facebook also provides support for developers to interact programmatically with its platform. The knowledge of APIs provides unparalleled access to the web services you use on a daily basis. For developers, this means creating applications that seamlessly integrate with services. For marketers, a basic knowledge of APIs can open doorways to growth hacking tactics. In order to analyse the data efficiently and accurately, I also focus on leveraging the Facebook Graph API to fix the more difficult problems.

Recently years, one of the big terms is visual marketing. Most of the big social media sites have made changes to increase the presence of visual content as well as improving the ease of accessing this content. And as visual content becomes more and more important, Instagram will be a means to create high quality, original content. Instagram enables you to produce photos and videos which can be shared to other social media sites as well as being embedded into your website or blog. In order to know the best posting times, when

the audience is most active, how many your gained and lost followers, which one your most popular post is, enhance your images to coincide with your branding and grow the business and the audiences. I also talk about the plain media Instagram.

As the progressing of the technology, the business and marketers need to know more information behind the audience, posts, comments and likes. Similar to Facebook, the Instagram business tool only provide us the basic data about the audience. Sometimes, it can not show everything we want to know to us automatically. So we need explore the Instagram API for the deeper and sensitive information in order to reach more audience and boost the business rapidly and efficiently.

#### **1.4 Thesis Organization**

The major contribution of this thesis is to analyse and evaluate the digital marketing tools, especially for Facebook, Instagram, hunting for the possible methods for reaching more audiences and boosting the business. During the development of this thesis, the characteristics of Facebook Graph Explorer and Instagram API console will be displayed, they play a vital role in retrieving the data and aggregating the data. From that, we also know some data how to retrieve programmingly so as to have the further knowledge about the application programming interface(API).

This thesis is organized as following: Section 1 introduces the background of digital marketing, along with some basic digital marketing tools. Besides, it will give you the rough idea about what I will discuss and which tools I use. Section 2 displays the characteristics of social media marketing API, including what the API is and how the API work related to the social networks. Section 3 demonstrates the typical Facebook platform, contains Facbook Graph API, Facebook Marketing API and Faxebook Insights Analytics to be characterized respectively. Besides, I capture the analysis results by the Facebook built in methods, which will be helpful when you want to analyse your business and reach more audiences in the future. Section 4, which includes three major aspects namely Instagram Business Tool, Instagram API and Instagram ads. After you read it, you will have a clear realization about the reason why the Instagram is more and more popular. Similarly, the built in tools will be used and you also can see the captured result of the retrieved data. The vital important two parts are Section 3 and Section 4, where you will gain the further knowlwdge about the Facebook platform and Instagram platform. In the

end, Section 9 concludes the thesis work and figures out future challenges.

## 2 Characteristics of Social Media Marketing

As we all know, social media marketing is the use of social media platforms and websites to promote a product or service. Although the terms e-marketing and digital marketing are still the dominant terms in academic, social media marketing is becoming more and more popular both among practitioners and researchers. Most social media platforms have their own built-in data analytics tools, which enable companies to track the progress, success, and engagement of ad campaigns. Companies address a range of stakeholders through social media marketing including current and potential customers, current and potential employees, journalists, bloggers, and the general public. On a strategic level, social media marketing includes the management of the implementation of a marketing campaign, governance, setting the scope (e.g. more active or passive use) and the establishment of a firm's desired social media "culture" and "tone". To use social media effectively, firms should learn to allow customers and Internet users to post user-generated content (e.g., online comments, product reviews, etc.), also known as "earned media", rather than use marketer-prepared advertising. While social media marketing is often associated with companies, as of 2016, a range of not-for-profit organizations and government organizations are engaging in social media marketing of their programs or services.

Social media can be used not only as public relations and direct marketing tools but also as communication channels targeting very specific audiences with social media influencers and social media personalities and as effective customer engagement tools. Facebook and LinkedIn are leading social media platforms where users can hyper-target their ads. Hypertargeting not only uses public profile information but also information users submit but hide from others. There are several examples of firms initiating some form of online dialogs with the public to foster relations with customers. According to Constantinides, Lorenzo and Gmez Borja (2008) "Business executives like Jonathan Swartz, President and CEO of Sun Microsystems, Steve Jobs CEO of Apple Computers, and McDonalds Vice President Bob Langert post regularly in their CEO blogs, encouraging customers to interact and freely express their feelings, ideas, suggestions, or remarks about their postings, the company or its products". Using customer influencers like popular bloggers can be a very efficient and cost-effective method to launch new products or services Narendra Modi current prime minister of India ranks only second after President Barack

Obama in a number of fans on his official Facebook page at 21.8 million and counting. Modi employed social media platforms to circumvent traditional media channels to reach out to the young and urban population of India which is estimated to be 200 million.

Social media marketing has to be focused on using these media to help achieve your marketing objectives both protecting and expanding your brand: monitoring and facilitating customers interactions, participation and sharing through digital medias to encourage positive engagement with a company and its brands leading to commercial value. Interactions may occur on a company site, social networks and other third-party sites.

## **2.1 The Generation of API**

In order to have a better understand about the social media plantform, we also need know the API well. What is API? This acronym is the driving force behind virtually all social platforms. API stands for application programming interface. For those who have never heard the term before, an API is a seamless software-to-software interface, meaning there is no user involvement during the passing of information. As its a rather complicated concept, lets break it down by looking at each of its parts. If you have a smartphone, you are well acquainted with what applications are, for example, the tools, games, social networks and other software that we use everyday. Programming is how engineers create all the software that make our lives so much easier. An interface is a common boundary shared by two applications or programs that allow both to communicate with one another. So an API is essentially a way for programmers to communicate with a certain application. In other words, when you enter credit card information to make an online purchase, the website sends your credit card information through an API to another application, which confirms that the provided information is correct. In computer programming, an application program interface (API) is a set of routines, protocols, and tools for building software applications. Basically, an API specifies how software components should interact. Additionally, APIs are used when programming graphical user interface (GUI) components. A good API makes it easier to develop a program by providing all the building blocks. A programmer then puts the blocks together.

Every time you want to access a set of data from an application, you have to call the API. But there is only a certain amount of data the application will let you access, so you have to communicate to the operator in a very specific language which is unique to each

application. To help visualize this concept, imagine an API as the middleman between a programmer and an application in Figure 3. This middleman accepts requests and, if that request is allowed, returns the data. The middleman also informs programmers about everything they can request, exactly how to ask for it and how to receive it.

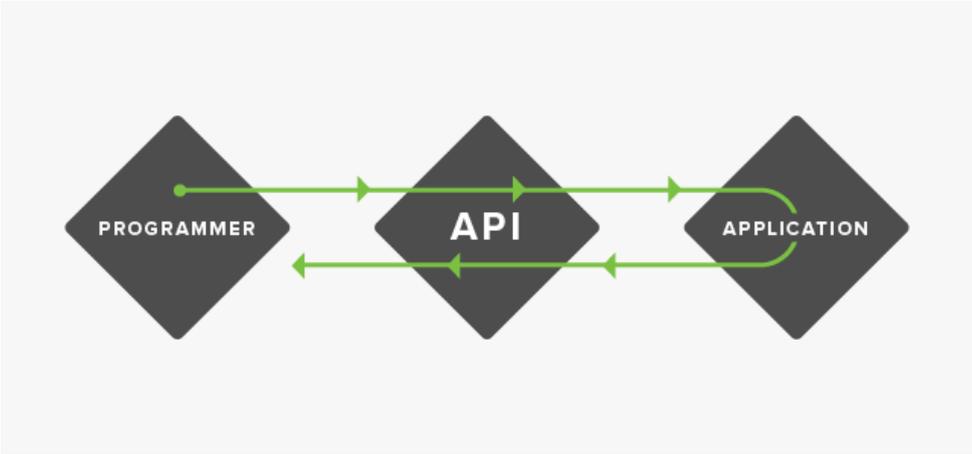


Figure 3: Visualization for the API

Now that you know what an API is, why is it so important for the business? Most companies today have several software systems like accounting, CRM(customer relationship management), sales. Giving the software the ability to work together is becoming increasingly important for both synergy and financial reasons. It also can help simplify incredibly difficult or time-consuming tasks into much easier processes. What is more, companies have also realized the possibilities APIs can provide for their customers, and have created their own tools to enhance their own systems. Facebook just launched an API that will allow users to integrate their social media advertising with their social CRM tools and simplify the advertising process. At the same time, the API ais designed to help clients automate many of the processes that were formerly done manually. Most customers will have the option to fully integrate with the systems without requiring them to log into a web browser, and will give customers complete control over their stores and the ability to create their own environment. Last but not least, with API, developers can quickly and inexpensively launch useful tools to benefit both the business and their customers. With an increasing number of businesses creating and adopting APIs into their systems, the best is yet to come.

## 2.2 Characteristics of Social Network APIs

Recently, the number of the social media platform API is attract a lot of attention and engagement among all kinds of professionals in social media and web analytics in Figure 4. However, the picture is still hazy for most of us. Social media companies like Facebook, Instagram, Twitter and LinkedIn are big believers in social network APIs. After all, when developers incorporate a particular API in their application, they are essentially extending the social network. While the most of API documentations and their technical parlance are not very easy to understand for analytics professionals.

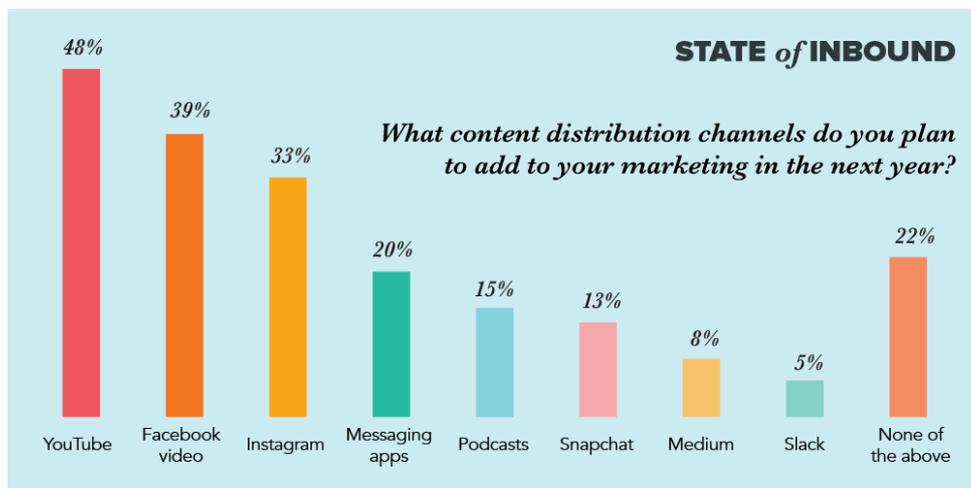


Figure 4: Social Network APIs

Social Media APIs are very important to any digital marketer who understands the wealth of information that it can provide in order to help improve the ability of your business to thrive more competitively in the online marketing industry. In the balance of this chapter, we will examine APIs for the popular Facebook and Instagram in their platform respectively. Majority of us have heard about a Facebook API application or a Twitter API application. But before I drill down to the detail of them, first I would like to take a moment to get a better sense of how social media APIs work in our day to day work around these social media platforms and what they can do for the business.

Using these social network APIs, one can programmatically access almost all of the features like the individual items that the platform offers to a user, but also the related details by other similar services. Along with that API programming enables one to customize the platform offerings to their own requirements. In other words, Social media

platforms use APIs in order to allow the development of web applications that will be suited to its own programming structure for third parties to use and integrate its service features to their own websites. Through APIs, websites can share information seamlessly. If you are fond of using social media widgets to your website, the application uses API in order to connect your website to a particular social media network and make the exchange of information smoother and convenient through the apps.

One of the most obvious problems that professionals in social media reporting and analytics have to face in their day to day job is the lack of a convenient mechanism of pulling out data and metrics for their social media assets like Twitter profiles and YouTube videos. While retrieving metrics through the GUI of individual platforms is possible, it is very manual in nature which makes it very time consuming and sometimes inaccurate as well. This is where APIs can help. Platform specific API applications can retrieve data and metrics related to these social media assets (profiles, videos, feed and so on.) in an automated manner. What this essentially means to an end user is that one can retrieve and administer data and metrics for multiple assets on a periodic basis by simply clicking a button. That is the reason why most business and developers like it so much.

With many benefits that can be extracted from social media APIs, it has become a good social media marketing practice to ensure that your business is API friendly. The influence of the social media has become a game changer in the online marketing industry. Your brand promotion should include social media APIs strategy in order to reap maximum benefits from the social media influence to the consumers.

### 3 Facebook Platform Characteristics

As time is going on, we can see that Facebook has become the world's most important personal social network. According to official statistics, there are now more than 1 billion people registered on the platform, which is one of every seven people, more than half of them are active every day on Facebook. As people spend a lot of time on Facebook, advertisers and marketers naturally want to take advantage of these audiences. As a result, Facebook is rapidly becoming an advertising and marketing platform. Indeed, the Facebook business model is based on advertising revenue. Despite the indiscriminate advertising to a total of 725 million people (the right time to see the right people to see the right advertising), the efficiency is not high. As a result, marketers are very interested in finding ways to segment Facebook users, thereby more effectively targeting ads for goods and services.

One of the key reasons people use Facebook is for purposes of impression management. Facebook users often employ verbal and nonverbal presentation of preferred brands for this purpose [2], offering marketers a convenient way to match users with products and services they are likely to find appealing. Another rich source of information is the personal data that Facebook users post in their profiles, including both demographic data and information on the person's interests and activities. But Facebook profiles also contain implicit data, such as photographs, which are mostly overlooked. Facebook users upload 350 million new images every day, providing data that marketing researchers can use to understand impression management and to design ways of targeting online ads more effectively.

I find some of the possibilities with the data extracting approach via Application Programming Interfaces (API) applied to Facebook and introduces some tools that allow researchers to generate data files in standard formats for different sections of the facebook social networking service without having to resort to manual collecting or custom programming. At the same time, I will provide a number of examples for the type of analysis it makes possible.

## 3.1 Facebook Graph API

Facebook released the first version of its Graph API in April 2010. The Graph API is the primary way to get data in and out of Facebook's social graph. It's a low-level HTTP-based API that is used to query data, post new stories, upload photos and a variety of other tasks that an app might need to do. The easiest way to understand the Graph API is to use it with the Graph API Explorer, a low-level tool you can use to query, add and remove data. It's a very handy resource to have at your fingertips while you integrate with Facebook. It lets you execute Graph API queries (PUT, GET, POST, DELETE) in the browser and examine the results: You can use one of your applications access tokens or create one on the fly with selected scopes.

The Graph API is named after the idea of the social graph that is a representation of the information on Facebook composed of nodes, edges and fields. More specifically, the nodes contain the user, photo, page and comment; the edges are the connections between page's photo and page's comments and so on; the fields are the attributes of the node, such as the birthday of the user, the name of the page. In the world of APIs, the Graph API Explorer is an interface that helps us to craft a request URL. This URL is like a command line that tells Facebook to do something on your behalf. For instance, performing a GET request to pull data from your Facebook profile. As a result, we can use the Graph API to read or publish data to the social graph.

### 3.1.1 Graph API user

A user represents a person on Facebook. The `/user-id` node returns a single user, which is used to access the user information via the Graph API. To perform operations on users with the Graph API, you need to send HTTP requests with a supported method to an endpoint that targets the users resource collection, a specific user, a navigation property of a user, or a function or action that can be called on a user. You specify the resource path differently depending on whether you are targeting the collection of all users in your tenant, an individual user, or a navigation property of a specific user. `"/me"` is a special endpoint that translates to the user ID of the person whose access token is being used to make the request. By default, not all fields in a node or edge are returned when you make a query. You can choose the fields or edges that you want returned with the `fields` query parameter. This is really useful for making your API calls more efficient and fast.

You can refer to [the url](#) for all fields of the user. In Figure 5, you will see the basic fields you want to know about the user and you also can get the php code in detail In Figure 6.

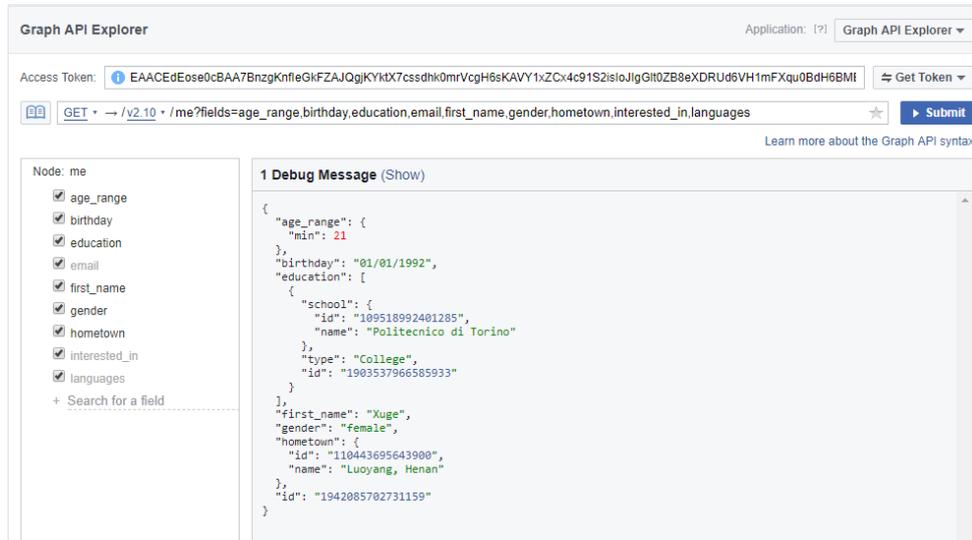


Figure 5: Result of the user fields

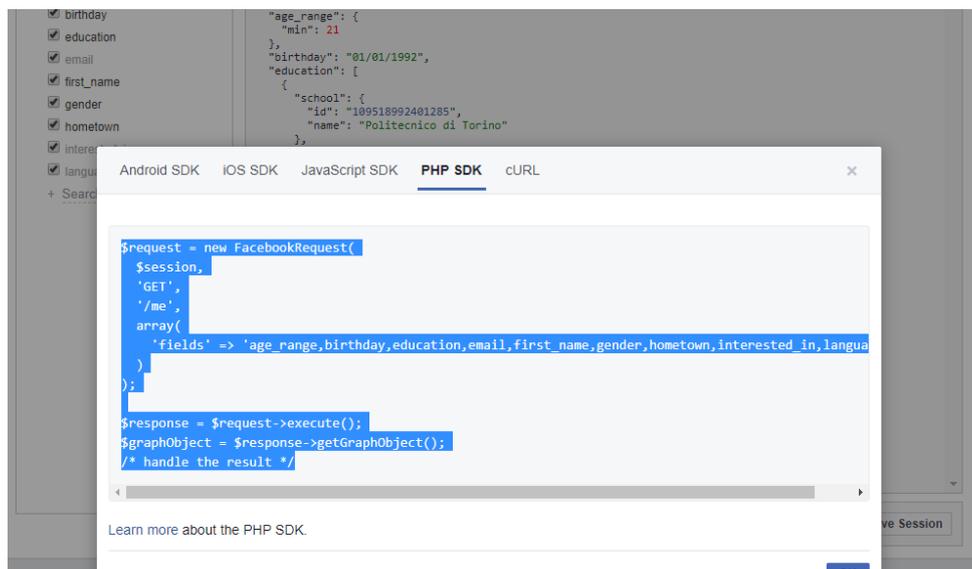


Figure 6: Code of the user fields

From the edge of the user, we can get the further information about the user. For example, reading the photos edge includes all photos a person has been tagged in. Besides, you can get the like and comment data with limitations. There is no limitation to the amount of nesting of levels that can occur here. You can also use a `.limit(n)` argument on each field or edge to restrict how many objects you want to get. Except that, When

you make an API request to a node or edge, you usually don't receive all of the results of that request in a single response. This is because some responses could contain thousands of objects so most responses are paginated by default. Cursor-based pagination is the most efficient method of paging and should always be used where it is possible. A cursor refers to a random string of characters which marks a specific item in a list of data, such as, before (This is the cursor that points to the start of the page of data that has been returned), after (This is the cursor that points to the end of the page of data that has been returned). Unless this item is deleted, the cursor will always point to the same part of the list, but will be invalidated if an item is removed. Therefore, your app shouldn't store cursors. You will see them I tell you in Figure 7 and Figure 8.

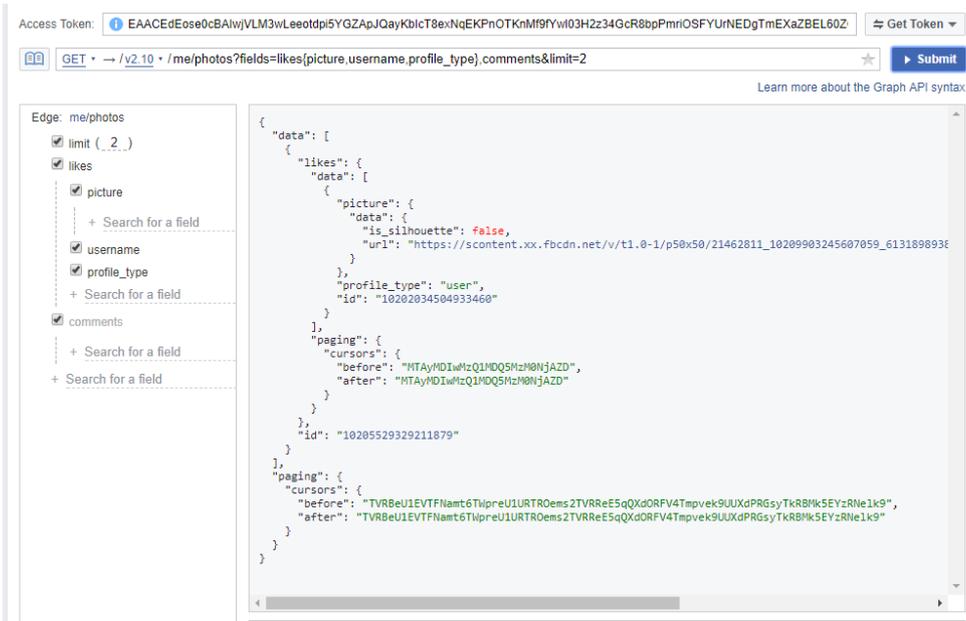


Figure 7: Result of the user edges

### 3.1.2 Graph API page

A Facebook page is a public profile created by businesses, organizations, celebrities and anyone seeking to promote themselves publicly through social media. Facebook pages work much like personal profile pages, except that they have "fans" instead of "friends." These pages are publicly visible online and often post status updates, links, events, photos and videos to their fans' news feeds and walls. What is more, Facebook pages provide a way for businesses and other organizations to interact with potential customers rather

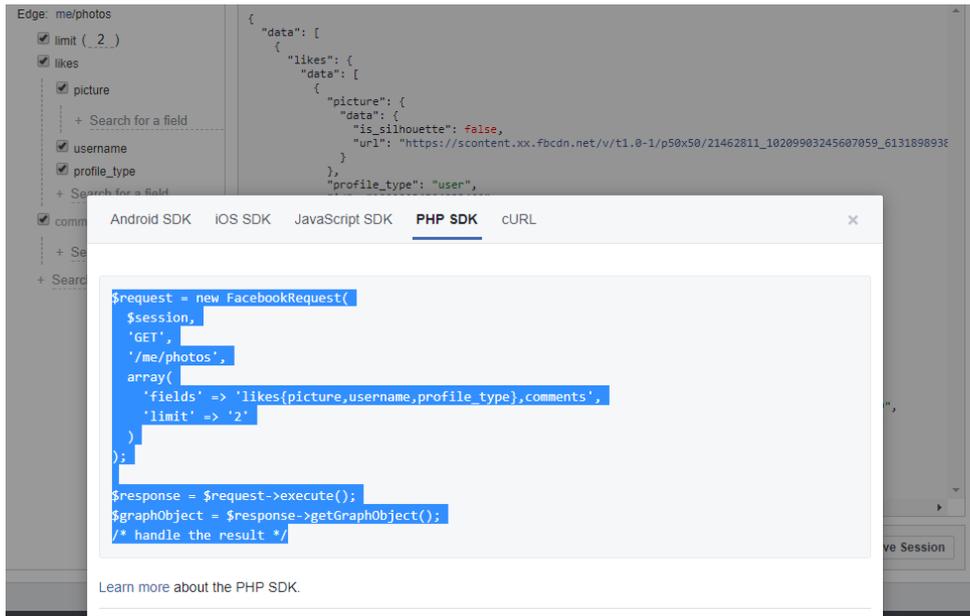


Figure 8: Code of the user edges

than just advertise to them. They also provides a simple hub of information about the page's owner.

Your Facebook Page lets you promote your business and engage with people on Facebook. When people like your Facebook Page, they can follow your Page posts to stay informed about your business. You can also use geographic and demographic insights about people who like your Page to make marketing decisions. In Figure 9, we can know the category of the page(such as product, service), locaton of the page and how many unique account likes this page so on. We can know a lot about the page metrics from the [official document](#), which is useful for us to analyse our business and potential customers in order to interact with them. Most importantly, we can retrieve which person like our picture or page by the person id rather than only know how many people like our page or picture in Figure 10, since businesses use page audience data to understand what their fans care about so as to make audience data even more meaningful for businesses.

### 3.1.3 Graph API insights

Facebook insights is a data collection to all pages on Facebook using the Graph API Explorer. This object represents a single insights metric that is tied to another particular Graph API object (such as page, post and so on). This object is returned by the following edges /page-id/insights/metric. Facebook insights can be seen by all the admins of your

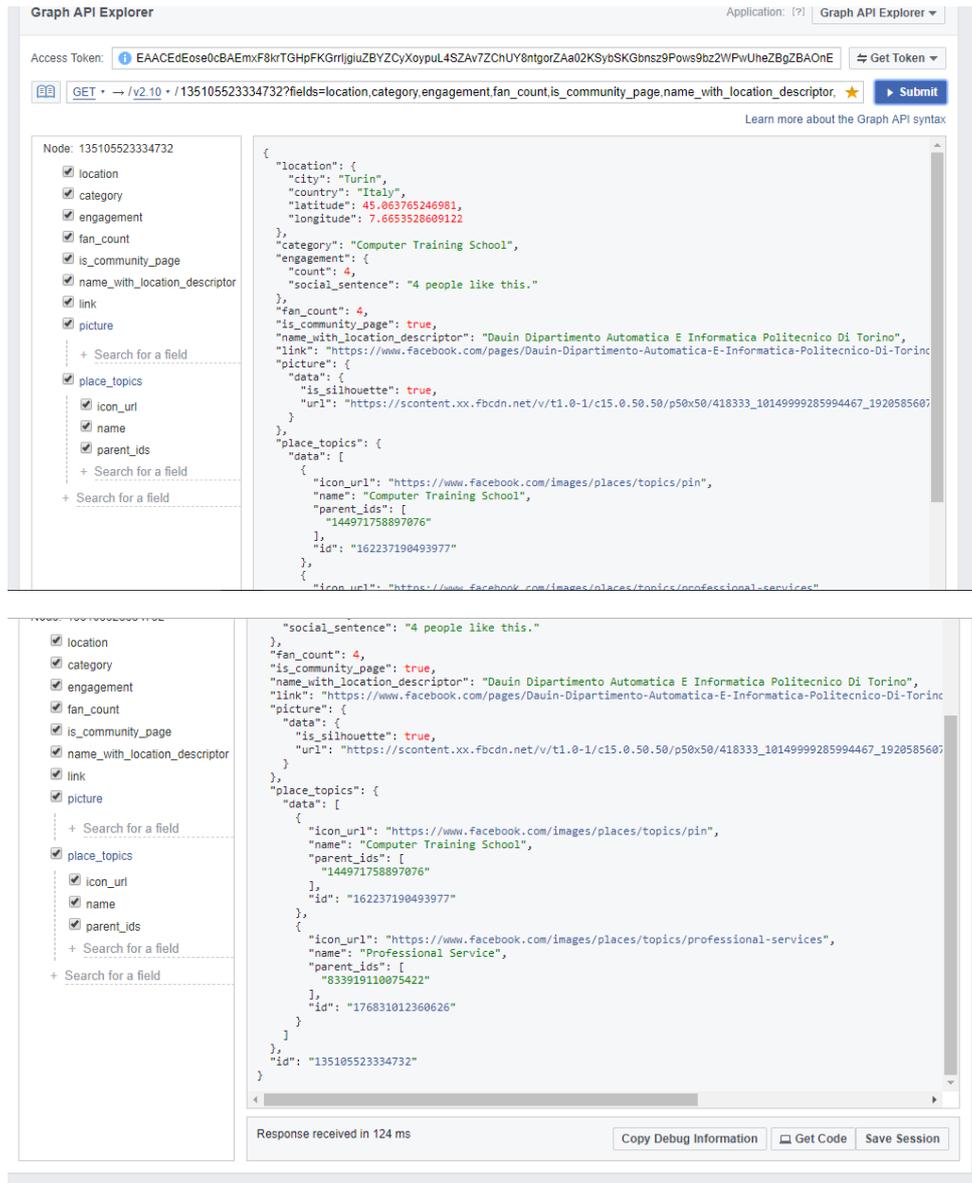


Figure 9: Basic information about one page

page and it can help you track the number of active users to better understand page performance. By using Facebook insights you'll be able to determine the best time of day to post, the best day of the week to post and what type of content is most popular. Otherwise, insights are only generated for a Facebook page that has more than 30 people that like it. What is more, the Insights API only offers two years retention. Insights data older than two years is subject to removal. If you neglect to indicate a specific metric or metrics for the endpoint, you will receive an error response like Figure 11.

With the Facebook insights you can access metrics about your Facebook page and

Access Token: EAACEdeEose0cBAMRZArKXMPK70oH5FpRjycxCMFBEuyLsEDJPCBYZBr3pDroCnFHms8bgulqntbjsISZCf7AYiVa9U! Davide-Account-Thesis

GET /v2.10 /273370079823829?fields=instagram\_business\_account,feed(likes),fan\_count,likes

Learn more about the Graph API syntax

Node: 273370079823829

- instagram\_business\_account
- feed
  - likes
  - + Search for a field
  - + Search for a field
- fan\_count
- likes
- + Search for a field
- + Search for a field

```

{
  "instagram_business_account": {
    "id": "17841402803258501"
  },
  "feed": {
    "data": [
      {
        "likes": {
          "data": [
            {
              "id": "587367474744230",
              "name": "Shuang Qi"
            },
            {
              "id": "273370079823829",
              "name": "Davide-Account-Thesis"
            }
          ]
        },
        "paging": {
          "cursors": {
            "before": "NTg3MzY3NDc0NzQ0Mjkw",
            "after": "Mjc2MzcuMdc5ODIzODI5"
          }
        }
      },
      {
        "id": "273370079823829_275015706325933"
      }
    ]
  },
  "likes": {
    "data": [
      {
        "id": "587367474744230",
        "name": "Shuang Qi"
      },
      {
        "id": "273370079823829_275015626325941"
      }
    ]
  },
  "paging": {
    "cursors": {
      "before": "Q2c4U1pXNTBYM0YxwIhKNVgzTjBiM0o1MDJsa0R5UXl0ek16Tnp8d056azRNak00TnpNkxUSXpNemt4T0RVd01L",
      "after": "Q2c4U1pXNTBYM0YxwIhKNVgzTjBiM0o1MDJsa0R5UXl0ek16Tnp8d056azRNak00TnpNkxUSXpNemt4T0RVd01L"
    }
  },
  "fan_count": 2,
  "id": "273370079823829"
}

```

Response received in 233 ms

Copy Debug Information Get Code Save Session

Figure 10: Which person like our page or picture

segmentation your audiences, which is helpful for us to boost our business and know our fans well. Some metrics are available publicly, for example, a breakdown by country of a Page's fans known as *page\_fans\_country*, which will let you know where the people who like our page or picture come from. We will see it in Figure 12. At the same time, you will take notice of the next (The Graph API endpoint that will return the next page of data. If not included, this is the last page of data. Due to how pagination works with visibility and privacy, it is possible that a page may be empty but contain a next paging link. Stop paging when the next link no longer appears) and previous (The Graph API

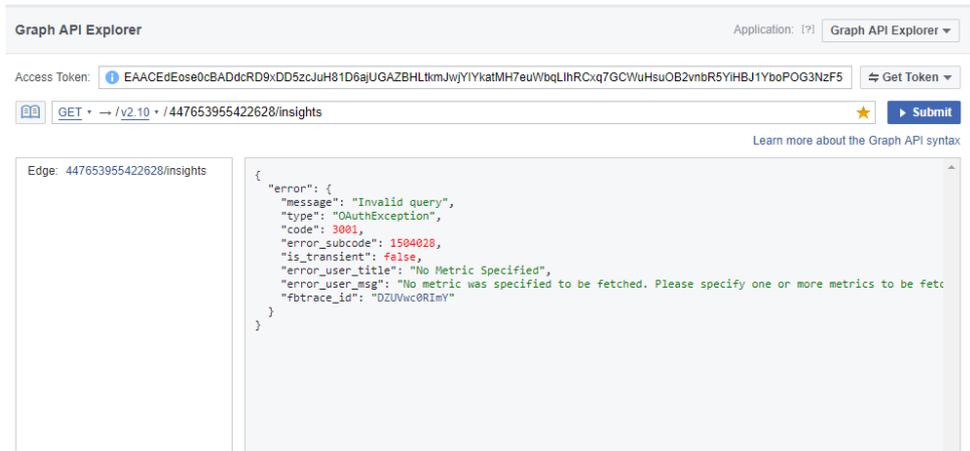


Figure 11: Error response when you miss the metric

endpoint that will return the previous page of data. If not included, this is the first page of data) in Figure 13. And you can access these public metrics for all pages using any access token. While most of the metrics are private. One example is the total number of impressions made by people who saw content associated with your page. To access such data someone needs to grant you the *read\_insights* permission. Once granted, you can retrieve metrics for all pages owned by this person. If you are not the admin of a page, you can still read insights about a page as long as you have a Page Access Token. For a list of all available metrics, you will know them in [insights metric documentation](#).

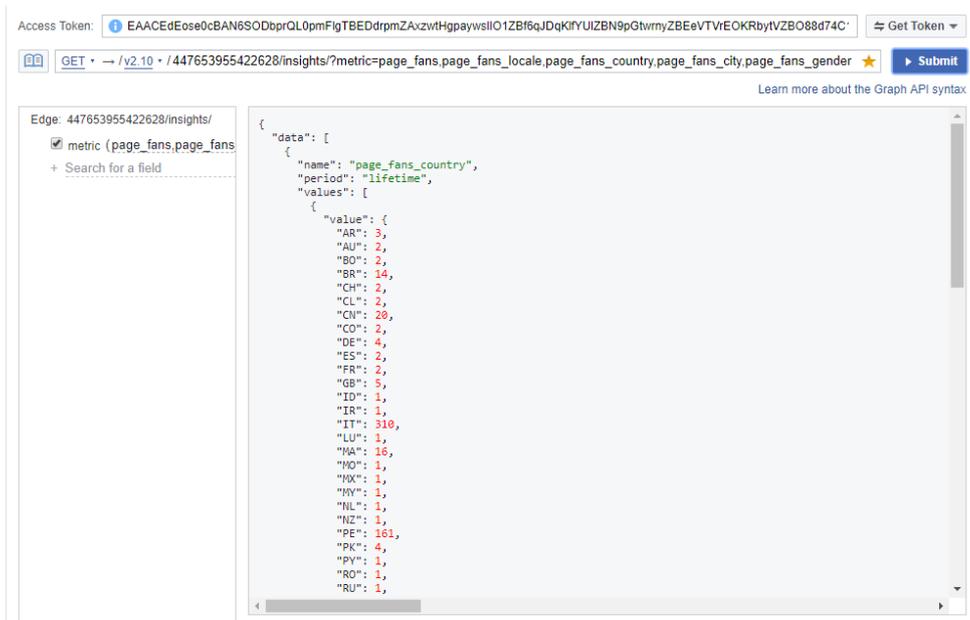


Figure 12: Segment the page fans by country

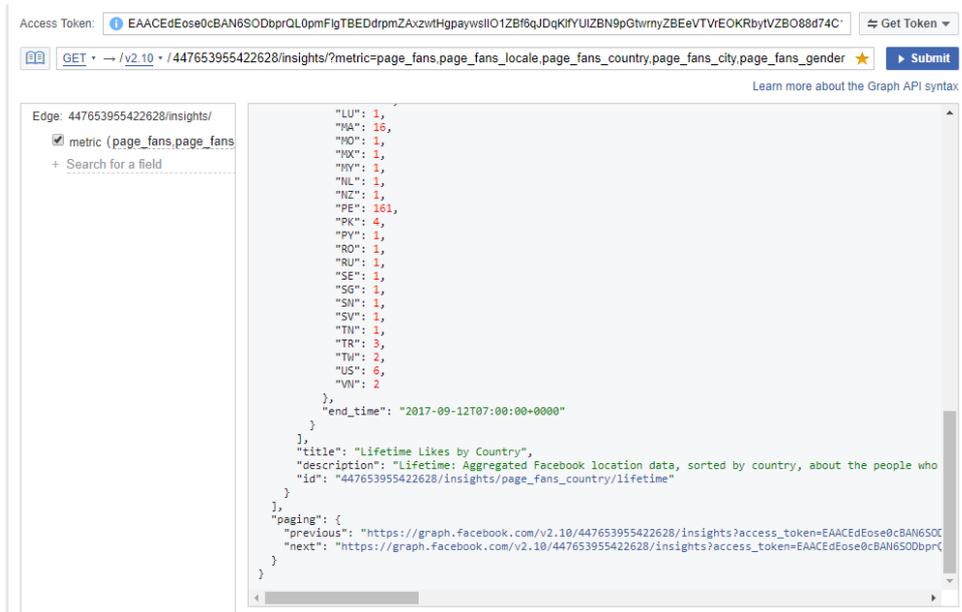


Figure 13: Segment the page fans by country

### 3.2 Facebook Marketing API

The marketing API deserves special mention because it is a powerful tool to manage Facebook ads and get ad insights through your application. The main use cases for the Marketing API are ads insights, audience management, and ads management. It works the same way as other Graph API methods. However, you need the *ads\_management* scope in order to get access to the users ads. Facebook also needs to review your app before you can publish it.

This insights edge provides a single, consistent interface to retrieve an ad's statistics, which is composed of many elements, like parameters(parameters available on this endpoint), fields(options in the fields parameter for this endpoint), breakdowns(group results from API calls), action breakdowns(understanding the response from action breakdowns), limits and best practices(explains insights API call limits, filtering and best practices) and so on, which is convenient for filter any ads object. You can request specific fields with a comma separated list in the fields parameters and aggregate or sort results at a defined object level.

As for the audience management, it mainly can help us reach the right people at the right place. But you need to specify targeting options for your such as interests, demo-

graphics, behaviors and locations. Facebook delivers your ads only to people who match the criteria you select. Starting with basic demographic and location based targeting, you typically get data to define targeting from targeting search, then specify options in targeting spec. For example, you can target males age from 20 to 24 within 10 miles of Menlo Park, CA or living in Texas or in Japan. Firstly you can get Japan's country code, then retrieve Texa's region code and Menlo Park, CA city code, last filtering the gender and age range. To get suggestions based on interest targeting, you can know the interests from someone's timeline, from pages liked or from keywords associated with pages or apps someone uses. At the same time, you can target based on digital activities, such as devices people use, past or intended purchases, and travel. More advanced, you also can intelligently target based on relationships, education, finances, and life events. They are very useful for you to target the right people at right time and place rapidly. Based on targeting, you can learn the lookalike audience, which most like your established customers. It takes several sets of people as seeds then Facebook builds an audience of similar people. You can use lookalikes for any business objective: targeting people similar your customers for fan acquisition, site registration, off-Facebook purchases, coupon claims, or simply to drive awareness of a brand. While audiences populate, you can create and run ad sets targeting the audience.

Another important thing is ads management. Firstly, we need create a new campaign and set an objective for your ad, such as link clicks, which asks people to visit your website. A campaign is the highest level organizational structure within an ad account and should represent a single objective for an advertiser, for example, to drive page post engagement. All of the objectives can be found listed within the [documentation](#). Setting objective of the campain will enforce validation on any ads added to the campaign to ensure they also have the correct objective. To read the campaigns associated with a specific account, you need to make a request to the connection of the ad account you are using. Secondly, create an ad set, which is a group of ads that share the same daily or lifetime budget, schedule, billing, optimization, and targeting data. An ad object contains all of the information necessary to display an ad on Facebook, such as the creative. After we set how long our ads will run, how much money we want to spend per day and what results we want to achieve with our ads, we can design our ads format. Finally, we can create our Facebook ads and schedule the delivery.

To be honest, learning APIs is heavy stuff. But it's well worth learning it in the end. I only tackles using APIs in social media analytics and marketing, although this barely scratches the surface of what you can do with APIs.

### **3.3 Facebook Insights Analytics**

Facebook Insights Analytics is a pretty powerful tool for those wanting to track user interactions on their Facebook page. When you dive into your Facebook insights, you'll receive a wealth of data to help you to understand more about your Facebook page, refine your Facebook page content strategy and improve engagement. With so many different data points available to measure likes, engagement, reach, and demographics, it is easier to understand how your content is resonating with your audience, how your page is growing and provide you with an awesome overview of how your Facebook strategy is performing.

#### **3.3.1 Overview of your page**

The Overview tab gives you the most important data about your page at a glance in Figure 14, including new page likes, post reach, and engagement for the last week. On the left top, you will see the default time frame is the last 28 days, but you can change the date range by clicking the date range drop-down menu. On the right top, you can also select different layouts and data format for the export file, which will affect the versions of data and analytics that are downloaded. Your layout options differ depending on which data type you choose. You can enter any section you want to know by clicking the corresponding box. In Figure 15, there is a nice overview of your most recent page posts, including the type of post (link, photo, video and so on), targeting (if you are targeting a specific audience), reach (the number of people who have seen your post), clicks, and engagement (the number of people that like, comment, and share your Facebook post) alongside the amount you spent promoting your posts using Facebook Ads.

#### **3.3.2 Basic data of page likes**

The Totals graph is interesting, as it will tell you if your fan base has grown or not in Figure 16. Facebook insights analytics tells you about the likes you've gained, but also about the likes you lost. That can be due to people not liking your page anymore, or

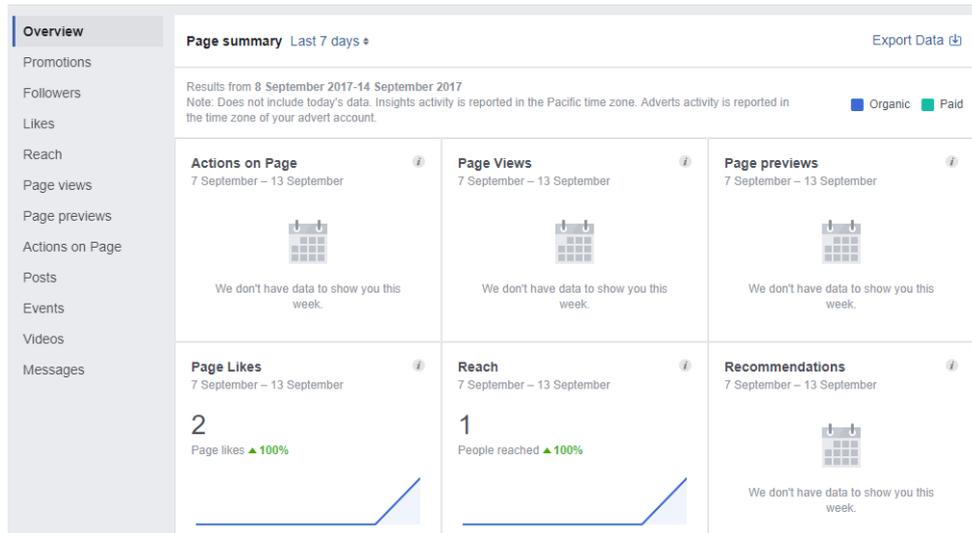


Figure 14: Overview of your page

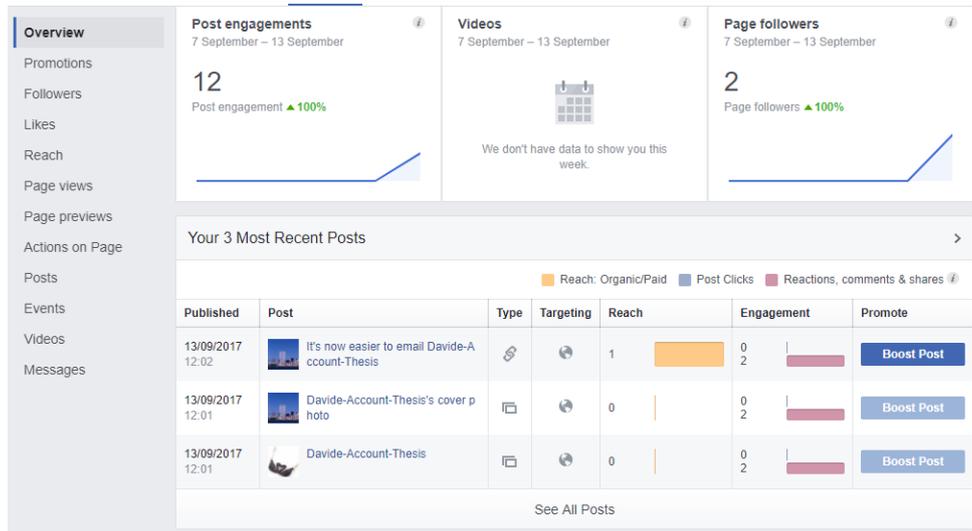


Figure 15: Overview of your page

Facebook cleaning up their database. You can use the date selector to view data from the last week, month, or quarter. As you hover over your total page likes graph, you can see the number of likes you had on a particular date.

In Figure 17, you will get a breakdown of how your likes changed on a daily basis, including unlikes, organic likes, paid likes, and net likes (total likes minus unlikes). I can recommend using Facebook ads / promoted posts on Facebook. It works. As Facebook knows a lot about you all, and Facebook ads can be targeted right into your target audi-

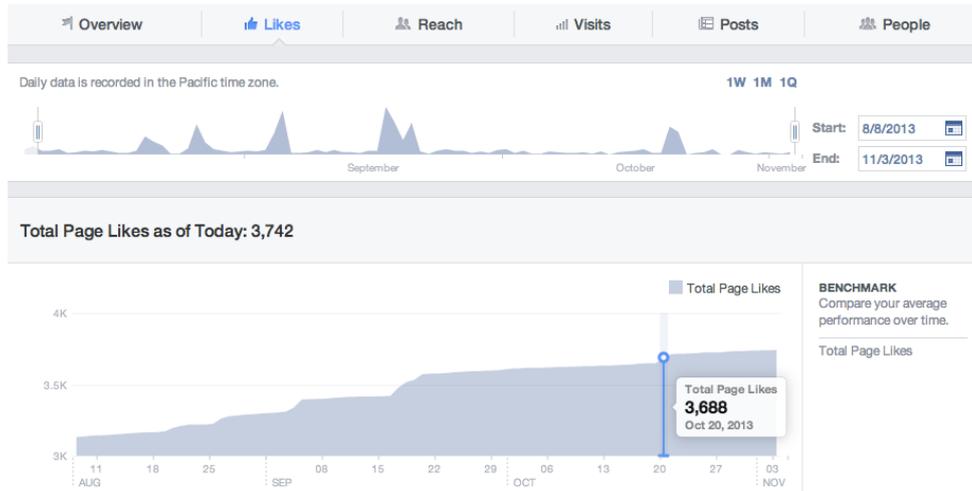


Figure 16: Total page likes as of today

ence, which can be adjusted per promotion. This will not only help you grow your likes, but it will also increase your reach for the next post!

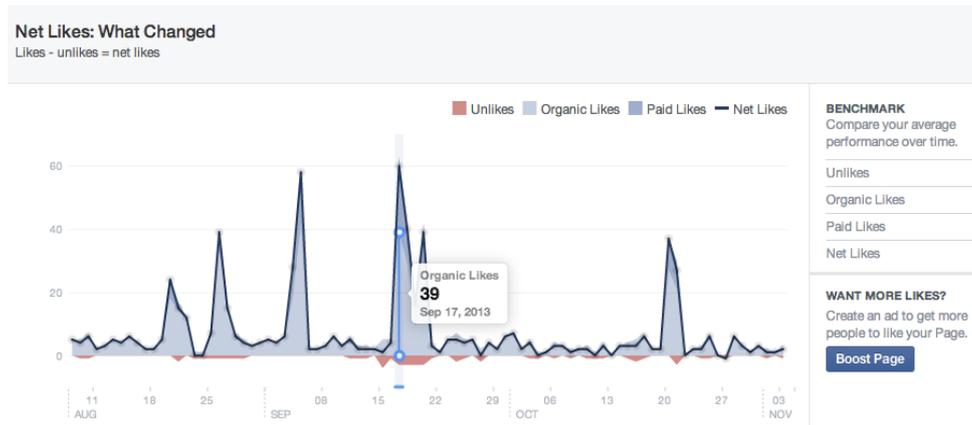


Figure 17: Net likes

On a per day basis, you also can see where your page likes come from in Figure 18. People can like your page using the like button on your page or from page suggestions, ads, and stories about others who have liked your page. This tab can help you gauge whether your page is growing at the rate you would like, and whether you are getting the most new fans from organic traffic or ads. Besides, clicking a certain day in the graph will give you a nice pop-up with numbers as well. And a lot can be filtered by clicking the legenda next to the graph, or by adjusting the date range at the top of the page.

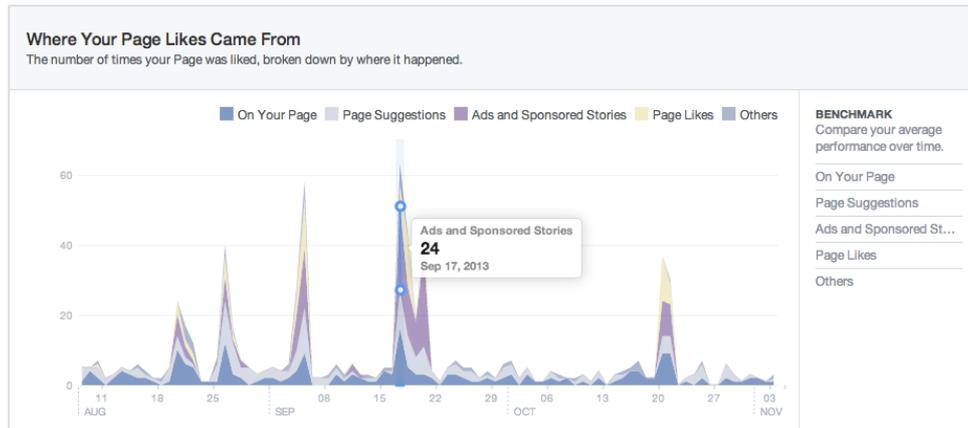


Figure 18: Where your page likes happened

### 3.3.3 Related data about page reaches

Reach is one of the more ubiquitous terms of measurement that many social media marketers struggle with. In the reach section, we find similar graphs and numbers. You can see the organic reach compared to the paid reach, showing you which types of posts are doing best and bringing in views. Where likes is about the click itself, reach is about the number of people that might have seen your post. Might have, as opening a page with your post below the fold and no scroll action, still seems to count as a view. The section is about post reach and engagement and there is one extra interesting graph: an overview of hide, report as spam, and unlikes actions, which are considered as negative feedback. They are ways users tell Facebook that they don't want to see a page's posts. Facebook will accordingly show those posts to fewer people. As you'd want to keep these negative feedback low or zero, it's great to monitor this graph.

I can show you one example. In Figure 19, I boosted Our Basic SEO training post and that triggered a lot of impressions and engagement. It also caused an increase in the number of posts that were hidden from timelines in Figure 20. Luckily, this might have caused just one person to unlike our page. If you post once per day, this will give you a nice overview of what type of posts to avoid or adjust to your audience. If your promoted post gets hidden, that doesn't matter as much as a sudden increase in dislikes. Of course, promoted posts tend to surface quite often, and I might have hidden a few of your own promoted posts as well. No hard feelings.

Active Posts from October 13, 2015

Impressions: Organic / Paid Post Clicks Likes, Comments & Shares

Published	Post	Type	Targeting	Impressions	Engagement	Promote
10/12/2015 10:53 am	 Our Basic SEO training is available NOW, check it out: <a href="https://yoast.com/basic-seo-training-of-yaost-">https://yoast.com/basic-seo-training-of-yaost-</a>			104.7K 	676  216 	<input type="button" value="Boosted"/>
10/11/2015 5:20 pm	 Tomorrow is the day! Our Basic SEO training is coming! In this video, Joost, Marieke and Jaro expl			137 	2  1 	<input type="button" value="Boost Post"/>
10/08/2015 4:13 pm	 We're counting the days until the launch of our Basic SEO training: only 5 days to go! The Basic SE			84 	0  0 	<input type="button" value="Boost Post"/>
10/09/2015 4:13 pm	 Joost reviews this week's SEO news. Read about Google's push for a new web standard: Accelerat			83 	1  0 	<input type="button" value="Boost Post"/>
10/06/2015 11:47 am	 Today, we're releasing our new eBook: UX & Conversion from a holistic SEO perspective! In this eB			75 	2  0 	<input type="button" value="Boosted"/>

Figure 19: Boost the post of my page

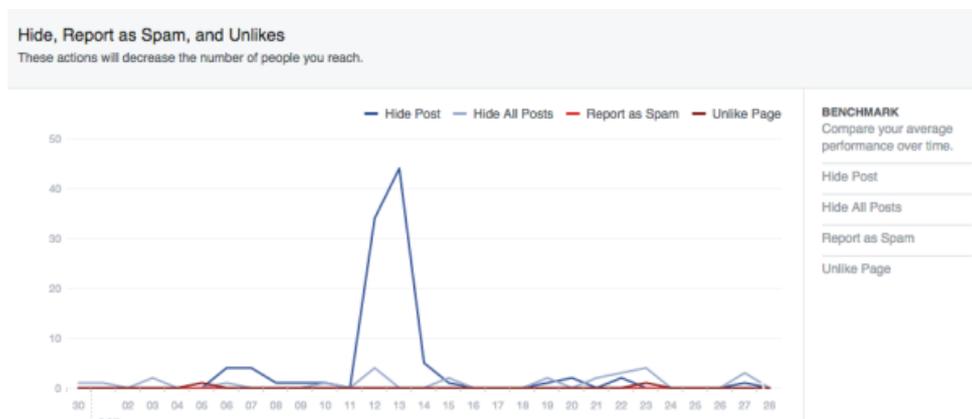


Figure 20: Hide decrease the number of people you reach

### 3.3.4 How well your posts are performing

To be honest, the post section is the one my favorite to explore, which is about your content. This area will let you break down individual posts and pieces of content to see how well they are performing. You will see two headings on this page, labeled When Your Fans Are Online and Post Types. The first one helps us recognize, based on data from one week period, when the best times for posting specific pieces of content are. This information is calculated according to the time most fans are most frequently on Facebook, information that is of obvious value to you. It starts with a nice overview of visits per hour in Figure 21. This is Pacific Time. For us, that means posting on Facebook around 2PM would be smack in the middle of our peak hour. The second one helps us evaluate the success of posts based on what kind of content they are. This shows us the top three performing types of content (such as photos, videos, or links) you shared, and the average reach and engagement associated with each. It is very convenient to analyze

what kind of posts work best for your company. You can see it in Figure 22.

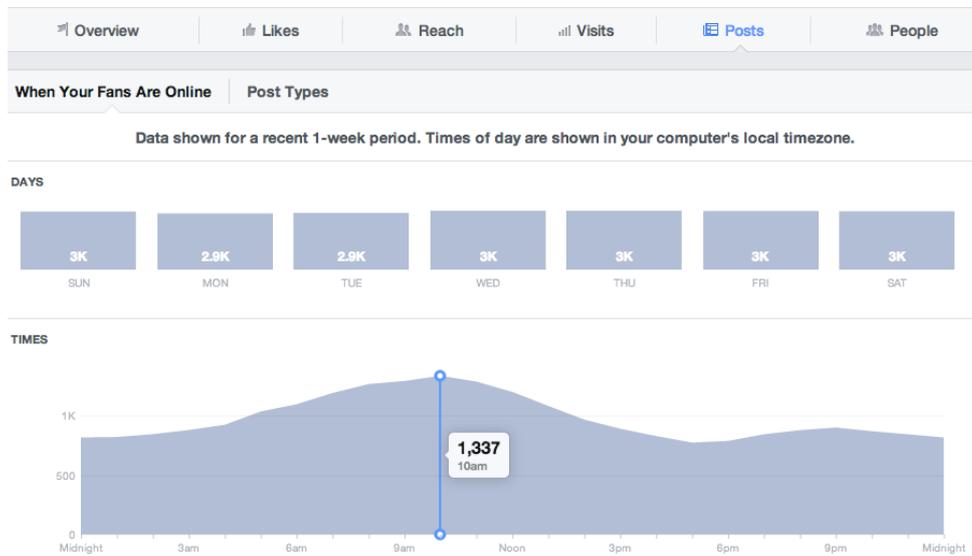


Figure 21: When your fans are online

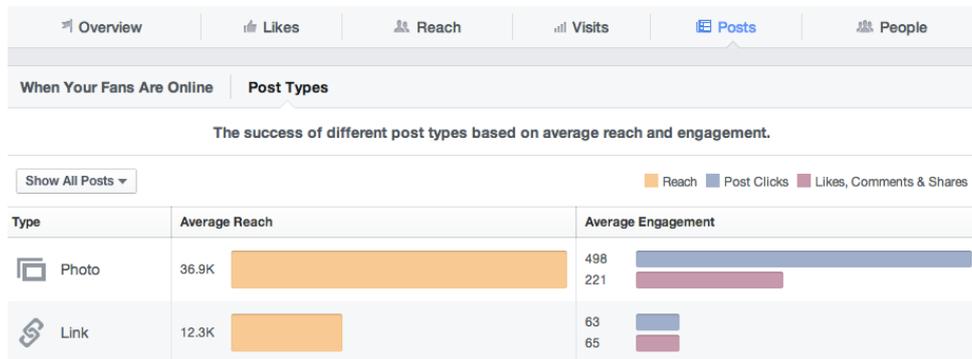


Figure 22: Post types

Beneath that, there is a more in-depth table of individual post data about the video. If you go to insights - posts - all posts published - click the video post you want to check - post details - Video, you'll find the further informations in Figure 23. How many times have you started a video in your timeline, for instance on your phone, just because you were trying to scroll? Take that into account when checking these stats. But it is nice to know the reach of a video.

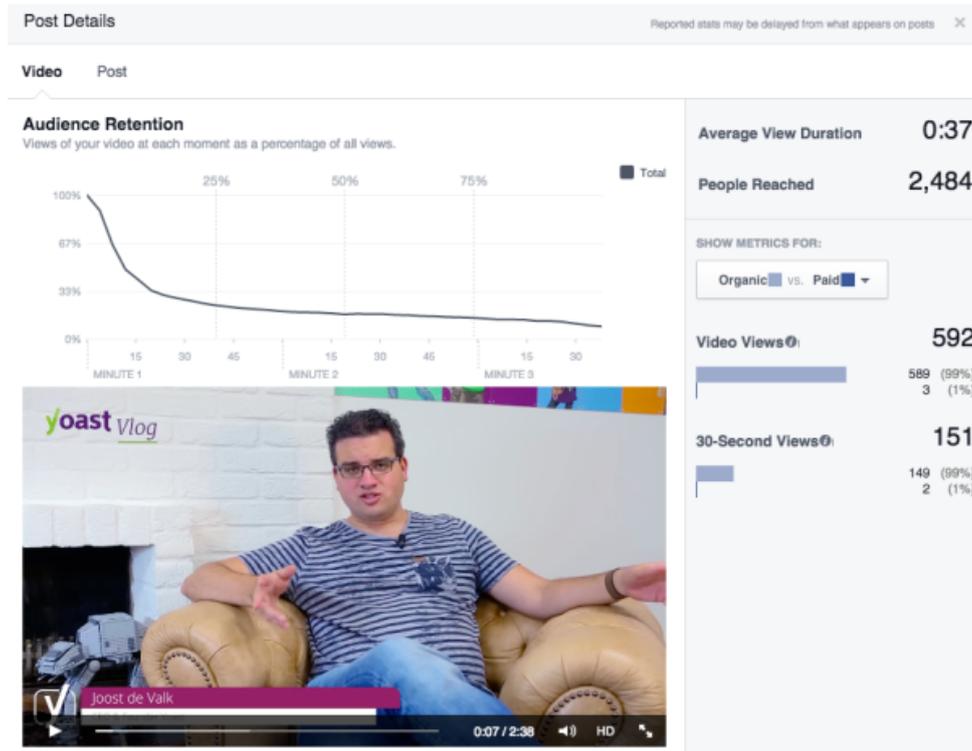


Figure 23: Detail about the video post

### 3.3.5 Actions on page

The section of actions on page allows you to understand what people do when they are on your page per day. The few actions that Facebook considered are clicking on get directions, clicking on your phone number, clicking on your website, and clicking on your action button. At the same time, the Facebook insight analytics can divide the people do these actions by city, country, device, gender and age intelligently. In general, the section is composed of total actions on page, people who clicked action button, people who clicked get directions, people who clicked phone number and people who clicked website.

Figure 24 shows you the number of actions people have taken on your page as time goes on. If you are a local business, you might be more concern about the number of times people want to get directions to your place or get your phone number. If you are an online business, you might be more concern about the number of website clicks. It depends on you.

Figure 25 shows you the number of people who took the respective actions on your page. The action button directs people who click on it to the homepage. From this graph,

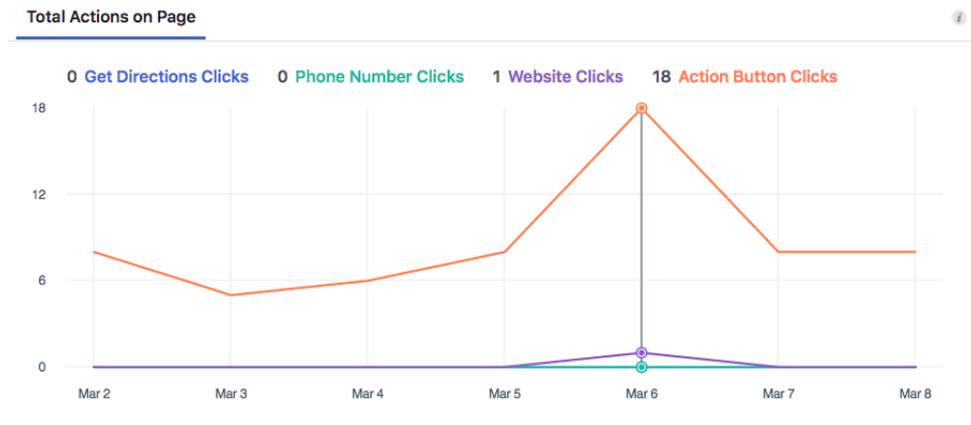


Figure 24: Total actions on the page

we can get a sense of the traffic our page drove to our homepage. Besides, we can have a clear knowledge about the people where they come from, how old they are and the gender. It is very vital to know everything behind the action.

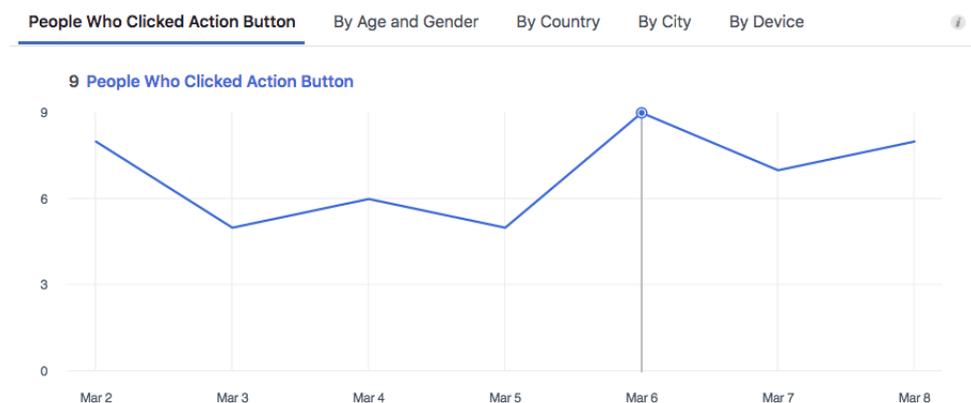


Figure 25: People who clicked action button

Except for the insights above, you will also find some other useful insights, such as followers, page views, page previews, promotion, event, messages. When you click them, you will know the features of followers are similar to likes, page views and page previews are similar to actions on page. So it is very understandable if you are familiar with one of them. As for event, it will enable you to be more data driven by providing you with key data of your events. You can find out what's working and what's not working with your event promotion. You get data such as the number of people who saw your event, the number of people who responded to your event, and the demographics of your audience,

which can inform you about the type of people who are most interested in your events. If you want to have a quick overview of your recent promotions, you can enter the promotion section. Its a great place for you to check your recent promotions while you are in your Facebook insights. Alternatively, you can use the Facebook Ads Manager, which might be more comprehensive. Last insights is the message, which shows us the performance metrics of our conversations with people on Messenger.

At the end, data analytics are useful only if the information you glean is relevant to your social media objectives. Focusing on a few key stats and using them to inform your Facebook page strategy will help you produce content your community will respond to and engage with.

## 4 Instagram Platform Characteristics

Instagram is a mobile, desktop and Internet-based photo sharing application and social networking platform that allows users to share images and videos in public or private. It was created by Kevin Systrom and Mike Krieger and was launched in October 2010 as a free mobile app for iOS operating systems. Two years later, it released the Android device version, followed by the feature limited web interface in November 2012, as well as in April 2016 and October 2016 Windows 10 Mobile and Windows 10 applications respectively. At the same time, Instagram was acquired by Facebook in April 2012, with the cash and stock of approximately 100\$ million. After the launch in 2010, Instagram quickly spread. There are one million registered users two months later, 10 million a year. As of 2017 April, eventually reached 700 million. What is more, users have uploaded more than 40 billion photos to the service until October 2015. And by June 2017, Instagram's story has more than 250 million active users. The popularity of Instagram raises an attractive community, including specialized trends, where users can publish specific types of photos on specific dates of the week, where the title is a label that represents a common topic. Instagram has received a positive evaluation of its iOS app and has been named one of the world's most influential social networks.

Instagram allows users to edit and upload photos and movies via mobile apps. Users can add titles to each post and use thematic labels and location-based geotags to index these posts and make them available to other users within the app. Each user's post will be displayed on their followers' Instagram feed, which can also be viewed by the public when using labels or geotagging tags. Users can also choose to make their profile private so that only their followers can view their posts. As with other social networking platforms, Instagram users can like, comment on others' posts, and send private messages to their friends via the Instagram Direct feature. Photos can be shared on one or more other social media sites, including Twitter, Facebook and Tumblr.

Instagram offers a wide range of digital filters that can be applied to users' photos, including photos that add retro or faded look. Other editing functions including Lux, a kind of reducing the shadow effect, make the window dim, increase the contrast, and move light tool to allow the user to adjust the brightness, contrast, saturation, sharpness, structure, straightness and tone. The manual tilting and motion sickness can also be added to the photo. Instagram also has a series of additional apps available. These applications

are boomerang, which creates custom gifs, delay videos, and layout. It creates image collages with multiple images. Once installed, these applications can be accessed directly from the Instagram application.

Instagram is not only a personal tool, but also a tool of the enterprise. Photo sharing apps offer companies the opportunity to create free business accounts to promote their brands and products. Companies with business accounts can access free interaction and display metrics. According to Instagram's website, more than a million advertisers worldwide use Instagram to share their stories and drive corporate performance. In addition, 60 percent of the people said they found new products through the app. In order to know our audiences and businesses clearly, we need to learn the Instagram tools and application programming interface basically.

#### **4.1 Instagram Business Tools**

Instagram provides tools for businesses to help customers stay in touch, switch to a business profile on Instagram, and get contact information, new features like Instagram Insights and promotion. The Instagram business tool is a key part of any Instagram marketing strategy. Without analysis, your Instagram marketing job might be a little disappointing. How do you know if your Instagram marketing strategy is going well? How do you track your Instagram performance and improve your content? The Instagram business tool is often critical to answering your questions. Through the Instagram business tool, you can get a lot of valuable data and information to learn about your brand's performance on Instagram and how to improve the results. Additionally, you'll learn about the metrics and insights available, how to get all the information for free, and how to use them to boost your Instagram marketing. In early 2016, Instagram confirmed that they were developing new business profiles to help brands and small businesses succeed on Instagram. Next we will learn and test all the features of the Instagram Business Tool together.

If you want to visit the Instagram Business Tool, firstly you need to convert your Instagram profile to the business profile. The business profile on Instagram will help your customers connect to your business. When converting to the business profile, you can add additional information about your business in your profile. For example, you can add phone numbers, email addresses, and business addresses. When you add contact

information, the contact button will appear near the top of your profile. When people want to communicate with you, they can click that button. Secondly, you need to confirm your identity through Facebook and connect your Facebook page to your business profile. Connecting to your Facebook Page, the Instagram can quickly include your page's business information in your Instagram Business Profile. For example, your Facebook page contacts and category information will be imported to the Instagram. In addition, through Facebook confirming your identity, you will be able to use Facebook ads account to promote on Instagram platform. More importantly, you need have more than 100 followers on Instagram Business Profile so as to use the tool to analyse the data. In the next section, we will see the every function the Instagram Business Tool provided one by one.

#### 4.1.1 Profile analytics

After you convert into the Business Profile, it will show you the general information about you clearly in Figure 26. In the left side picture, you can see how many post you have totally, how many followers you have totally and how many followings you have totally. Which will be useful for you to have a rough idea about your business. And most important thing is the person interested in your business can have the option to get in touch with you by the phone. After you click the chart icon in the right top, you will have the access to your Instagram Insights. In two right pictures, you'll see the changes of your followers and posts for your account in the last seven days. Additionally, you will see the section about the number of impressions, the number of reaches and the number of profile views in the last week, when you slide the section left or right.

*Followers:* The number of people following your Instagram account.

*Posts:* The number of Instagram posts you have published.

*Impressions:* The total number of all of your posts have been seen.

*Reach:* The number of unique accounts that saw any of your posts.

*Profile views:* The number of times your profile was viewed.

It is worth mentioning that there is a heart button at the bottom of each picture. When you click it, you will have the access to the information about your following and

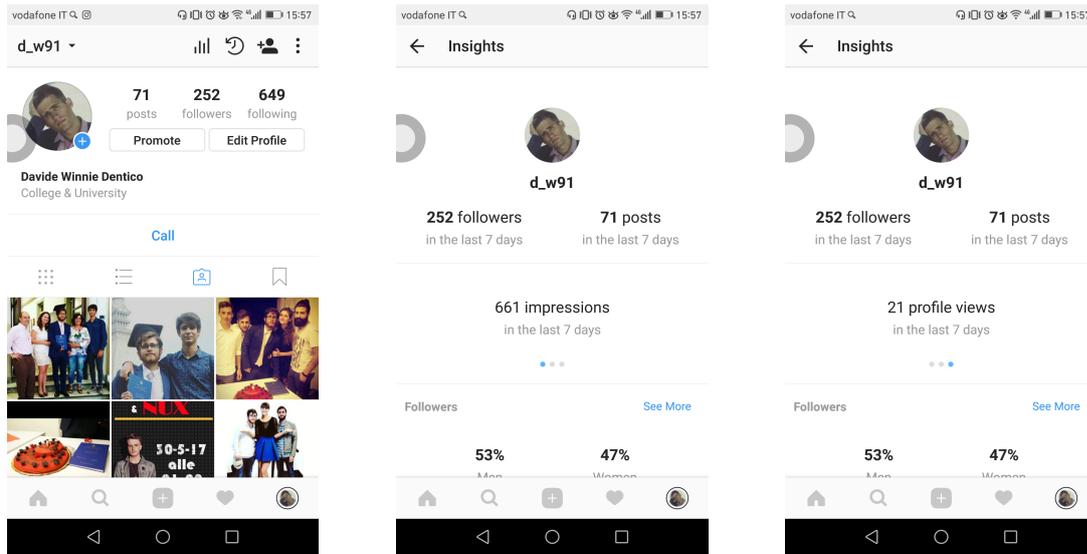


Figure 26: Your business profile

your activity including the promotion. As the Figure 27 depict, you will know your recent promotions and corresponding actions about you including the which post someone likes, when someone start following you and who is on Instagram without your following.

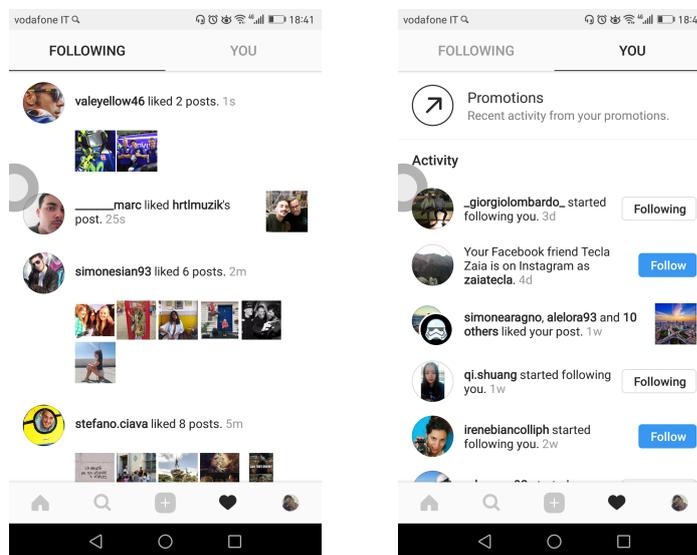


Figure 27: The activities after you click heart button

In order to make your business stand out and get more followers, you should to optimise your business profile. Firstly, your username is very vital, which is also what your users are using to find you. So you should be sure to use identifiable username in your business profile. At the same time, you should make your profile public so that it is as easy as possible for your audiences to follow you. Secondly, It is essential to add your full business

name so that the customers can recognise your business in many businesses directly. Last but not least, it is better for you to add a link to your profile in order to the followers visiting your website straightly.

#### **4.1.2 Audience insights**

The Audience Insights can help you learn more about who your followers are, when they are online more often and people interacting with your business on Instagram. For example, you will find information such as gender, age range and location. By learning more about your audience's behavior and demographics, you can create more relevant and timely content.

In Figure 28, it shows you the total number of followers, including how many new followers you got or lost in last week. Then you can view the collapse of the ratio of the male followers and the female followers on a circular chart clearly. More specifically, depending on the age of decomposition, you can view the age range of men, women, or both. According these information, you can also track interest and online buying behavior. As a result, it is helpful for you talk to your followers on this platform. Then you will view the top locations, which can be segmented by the country or even the city of your followers. With these information, it will be useful for larger brands, until a small local business to understand the basics of most users in order to help companies better determine where and when should be more pay attention. More interesting, The followers section also displays the average time of your fans are on Instagram by each hour on that day of the week.(for example, the average time on Monday if it is Monday), or you can organize them in each day of the week. Knowing when your followers are most active on Instagram can help you arrange the best post in right time.

*Gender and Age:* The gender and age distribution of your followers.

*Top locations:* The top five countries and cities where your followers are.

*Followers Hours:* The average times your followers are on Instagram on a typically day by the hour.

*Followers Days:* The days of the week when your followers are most active.

More specific, businesses can find value in different insights, while it depends on your business and your goal on Instagram. For example, some businesses may be interested

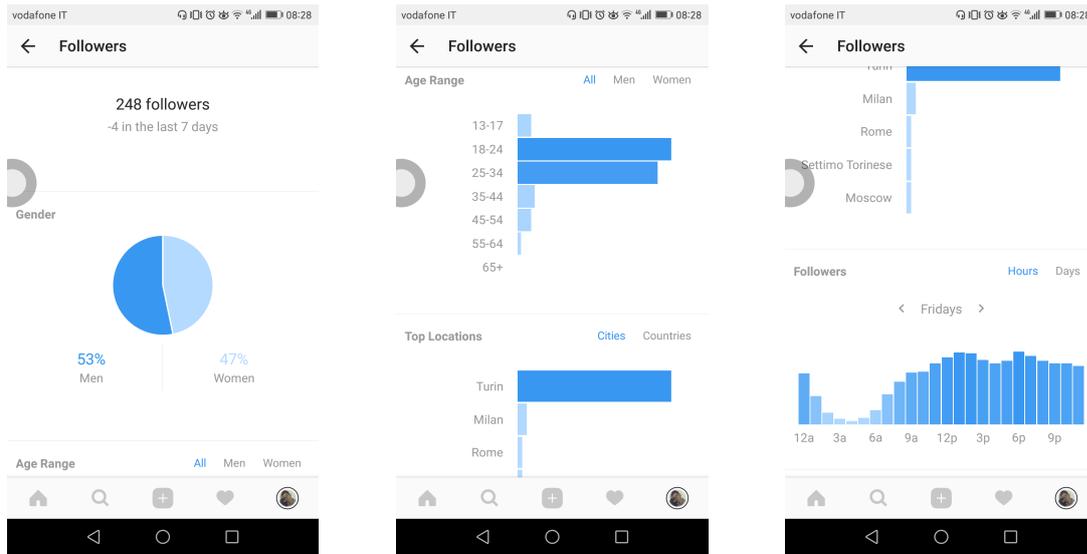


Figure 28: Demographic metrics of your followers

in learning more about the followers. If the business sees their most of audiences aged between 25 and 34, they may try to create content that is more appropriate for these audiences. Besides, it is possible that they will test different ideas to see if they can increase the number of followers between 35 and 44 years old. In other words, the division of the audiences mean that the brand needs a deeper understanding of who is the right audience, how to attract them and drive the growth.

#### 4.1.3 Instagram posts

When it comes to figuring out how to publish content to their profile to maximize the reach and engagements. The new insights will show you the most popular post on Instagram recently. This area is particularly interesting because it is not a simple chart, but as an image thumbnail of the grid with the number of impressions that post had. This will not only help you keep track of which posts are doing well, but you can view them as images. So you can better visualize the most effective content for your audience. This can also help you track the performance of your articles over time, in other words, whether your followers and others return to previous posts or just click on the new content?

In Figure 29, you will get a comprehensive overview of how well your account is performing, along with detailed information about your follower growth. In the center of the picture, you'll see the top posts section. It shows you the top posts sorted by impressions. This information is valuable because it allows you to see exactly how many people have

seen your post rather than the number of people who liked it, which will give you a more accurate engagement rate. At the same time, you can filter the insights about the post by the category of your post, the response format of your post and when you post the content. It is helpful for you to distinguish which kind of post is more popular among the audiences. Choosing the right filter criteria can actually lead to more views and engagement.

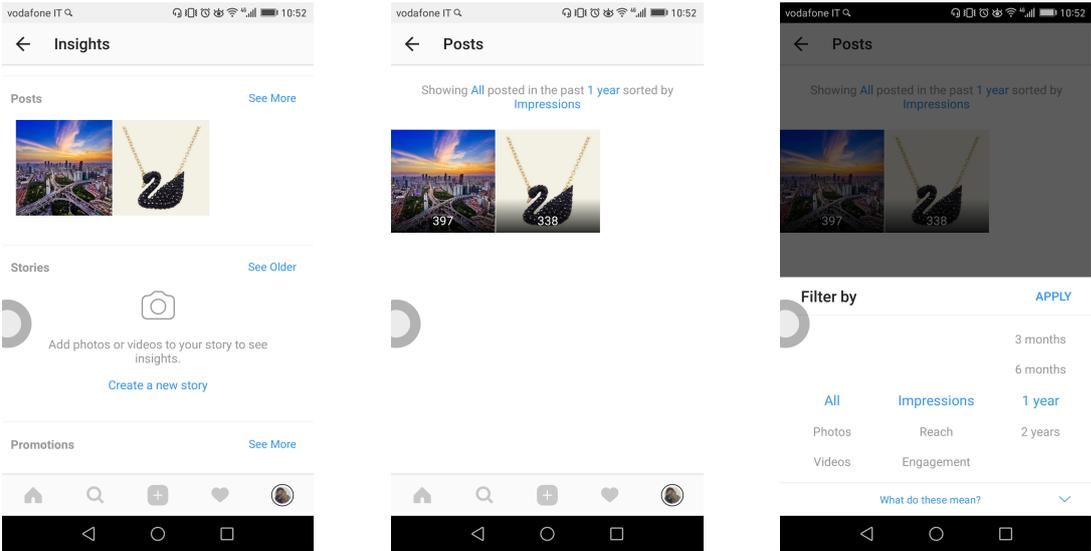


Figure 29: Status of your posts

After you tap the specific post, you can explore your post further. In Figure 30, you can see how many Instagram user commented, saved, reached and engagement with your post, especially liked in relation to how many followers you have in total. It's worth mentioning that you find someone liked your post but you are not the follower of him or she, you can follow him or she immediately in order to get more audiences. Another important thing is you can know whether the person liked your post is your follower or not by click the person link below the post. When you access his or her page, you are able to view the following status in order to acquire the basic information you want to know. Besides, when your followers like you post, the like button will give you the notification. Otherwise, the person is not your follower, the like button will not give you the notification. According to that, you also can recognise your followers from all the instagram users.

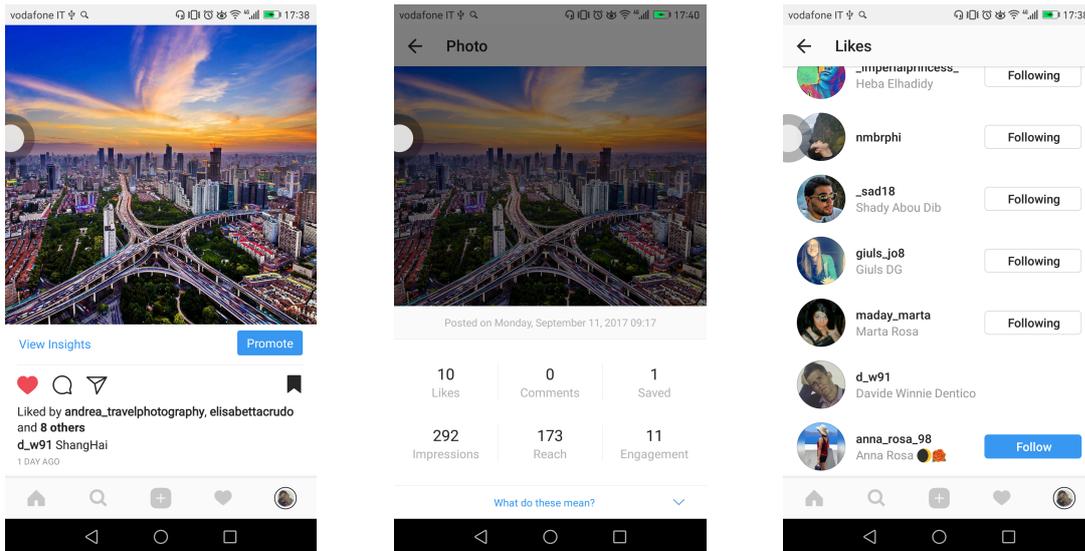


Figure 30: Who likes your post

*Impressions*: The total number of times a post has been seen.

*Reach*: The number of unique accounts that have seen your post.

*Saved*: The number of unique accounts that saved your post.

*Engagement*: The number of likes and comments on your post.

Similarly, you also need to optimise your posts for your business. For example, when you post one beautiful photo, it is better to add the location where they are taken. Since you can segment the followers by the location of the picture they like most. In addition, it is likely to attract more followers when you use more relatable and inclusive content. While it is a trick to use the filters, tags, links and hashtags to your photos so as to customize your posts. I also believe that you will use high quality photos. Even more interesting is that users with the most fans have an average of 2 to 3 photos posted per day. These data may make us say that more successful accounts tend to have higher frequencies in Table 1. Consequently, those businesses that often post on Instagram tend to see the best results.

#### 4.1.4 Instagram stories

Instagram story allows you to share all the moments of your day, not just those moments you want to keep in your profile. When you share multiple photos and videos, they show up in the form of slides. It is not necessary to worry about over-posting on

Table 1: Number of Posts Per Page in January 2015 [4]

Page Bucket	Facebook	Optical Instagram
1-1k Fans	7	8
1k-10k Fans	21	20
10k-100k Fans	47	41
100k-1m Fans	106	57
1m-10m Fans	166	90
10m Fans+	107	95

Instagram. On the contrary, you can share what you want as much as possible in a day. You can use the new way to put your story with words and drawing tools into your life. These photos and videos will disappear after 24 hours and will not available in your profile or feed.

As Figure 31 described, you'll see the stories section where you can get the general view for your Instagram stories. If you have created a story in the last 24 hours, it will appear here. Otherwise, you can click the see more link to access the insights of your older stories, which are posted in previous seven days. In order to see someone's story, you only need to click on their profile photo. Viewing your story at your own pace also can jump to another person's story by moving forward or backward. If you want to comment on what you see, you can click on Instagram directly and send a private message to that person. Your story follows your account's privacy settings. If you set your account as private, your story will only show to your followers, but you can also hide your story to anyone you do not want to see, even if they follow you.

*Exits*: The number of times someone exited your story. *Replies*: The number of replies to a particular photo or video in your story.

*Swipes Away*: The number of swipes away from this photo or video to skip to the next account's story.

*Taps Forward*: The number of taps to see the next photo or video.

*Taps Back*: The number of taps to see the previous photo or video.

Recently, some new features are add into the Instagram stories in order to make the story creative. For example, no matter what your business is or what you're going to do, you can add some context to the story with a sticker. The audience see your story

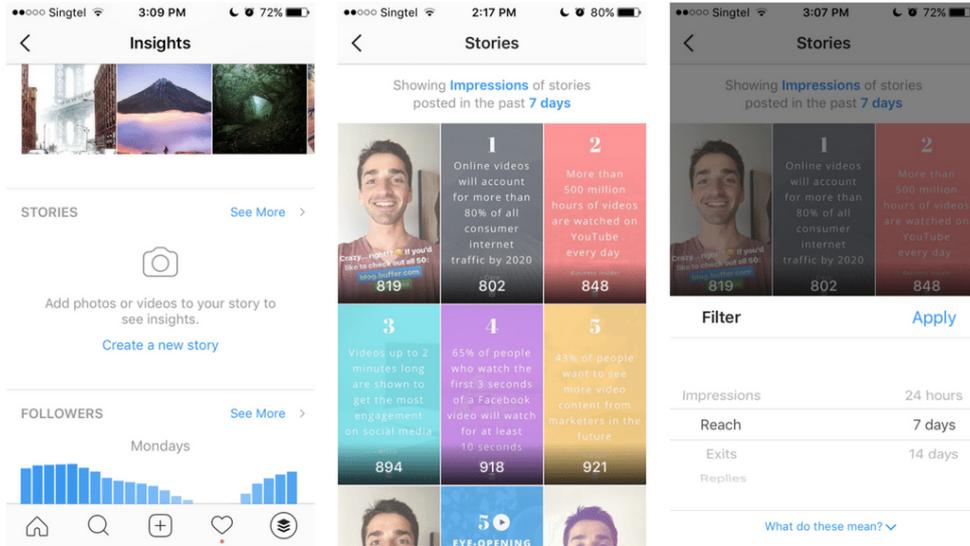


Figure 31: Insights from your stories [3]

will be able to learn more about your business by clicking the sticker. With such friendly features, more and more people will use this tool to target the audience and boost their business.

#### 4.1.5 Instagram promotions

As we all know, Instagram has published mobile ads. Users will be able to promote good posts and quickly translate them into advertisements, as well as offer suggestions based on viewers and budgets. For example, Facebook’s desktop advertising creation tool gives the access to businesses services such as uploading a targeted email address list, creating a login page pixel, or requiring more complicated reporting features. Otherwise, the advertising tool on Instagram pay more attention to the simplicity and speed. That is, because of the relationship between Instagram and Facebook, the owners of the business can use mobile tools based on Facebook and Instagram users personal information (such as gender, age, location and personal interests) to define, save and target custom audiences.

The promotion ability allows you to apply well performing posts into advertising on Instagram built in application in order to help you connect more customers. In the business mode, if you would like to promote something, you need to select the posts you have on Instagram to share and choose the audiences for your promotion. Beside, you can determine the target audiences or allow Instagram popping up the recommendations for you. We recommend creating the targeted audience based on the type of customer

you want to reach. You set the person within the audience will be qualified to see your promotion. If someone see you promotions and marks another person in the comments, the tagged people will also be able to see your promotion. After clicking on the promotion, your promotion will be reviewed in accordance with advertising policies. In general, it will takes about 60 minutes for promotion reviewing, but in some cases, the approval process may take longer. Will begin to after the promotion activities. Once approved by the review, your promotion will be run anytime you choose to advertising.

As Figure 32 depicted, you'll be able to see your active promotions. In each promotion,you can gain how many people reach your promotion website, the number of impressions your promotion received, how long the promotion last as well as how much of your budget has been spent. According to that, you can adjust your strategy of the promotion for targeting even more audiences and boosting your business. Additionally, the original version of your post promoted still exist in your business profile. The original post still can be seen in your followers sets in the feed, so you do not worry someone can not see it.

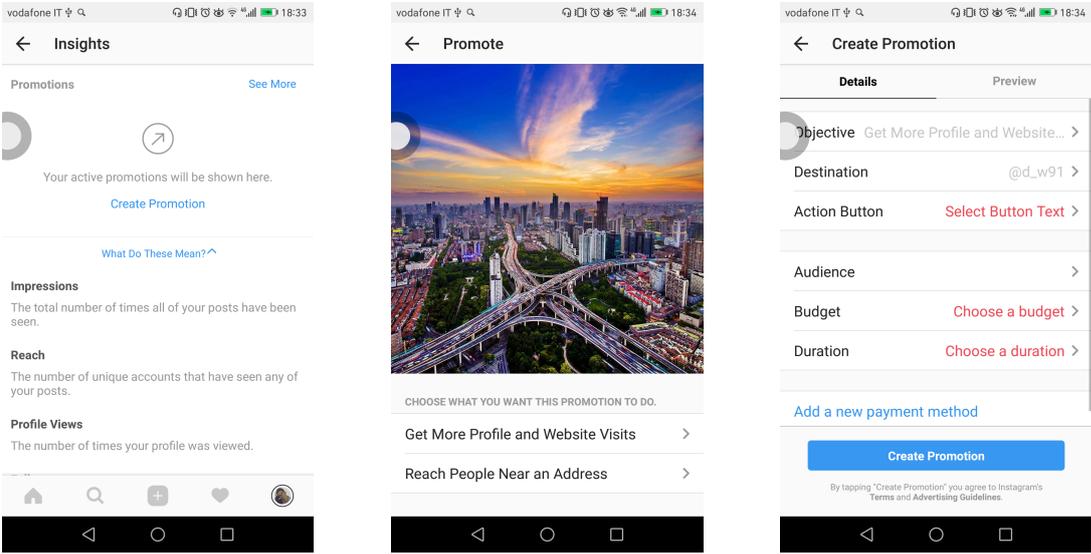


Figure 32: Status of your promotion

These metrics and insights can be accessed from Instagrams native analytics (Instagram Business Profile) instead of other analytic tools. It is extremely convenient for analyse the insights of your account or your business. If you can leverage the Instagram Business Tool well, Your business will go far on Istagram. Importantly, the posts or sto-

ries of your business should not be lost or overbearing.

## 4.2 Instagram API

Instagram has become one of the most popular photo and video sharing platforms on the web. In order to help users to further integrate the social networks into their daily lives, it has already issued a public application programming interface (API).

The Instagram API is a standard REST API that provides basic create, update, delete and read(CRUD) operations. The Instagram API permits developers to programmatically access the Instagram business account so that they can retrieve the basic insights, view comments and metadata, and manage media objects as easy as possible through custom build applications. It can be by checking the user's access token to get any Facebook page role. If the user has a role on the page and the page is linked to the Instagram business account, the user can be granted to your business account application permissions to access the data of the connected business account. For some cases, you can propose a request to pull all Instagram pictures taken in any geographic area. So that you can see who uploads your favorite local bar or bar photos to the rest of the world. Or you can request that all Instagram photos marked the cats be created every second to the real-time information of thousands of cats uploaded to Instagram. The Instagram API is based on the Graph API, so its endpoints consist of nodes, edges and fields. In addition, all endpoints can be accessed through a valid user access token with specific privileges.

### 4.2.1 Preparation for using Instagram API

Before we start using the Instagram API to develop our application, we need to understand how it works. Like many other web APIs, the Instagram API works through HTTP and expects to send HTTP requests to the specified endpoint. Upon receiving this request, the API server will use JSON subscription containing the requested data to answer queries. We can then use the server-side programming language (such as PHP) or the client toolkit (for example jQuery) to parse the data and extract the content from it so as to integrate into the web.

Similar to most API providers, we must register an Instagram account and sign up for the developer in order to start using the Instagram API. It is obviously that we need fill

in the details and accept the terms and conditions to be as a developer in Figure 33 and 34.

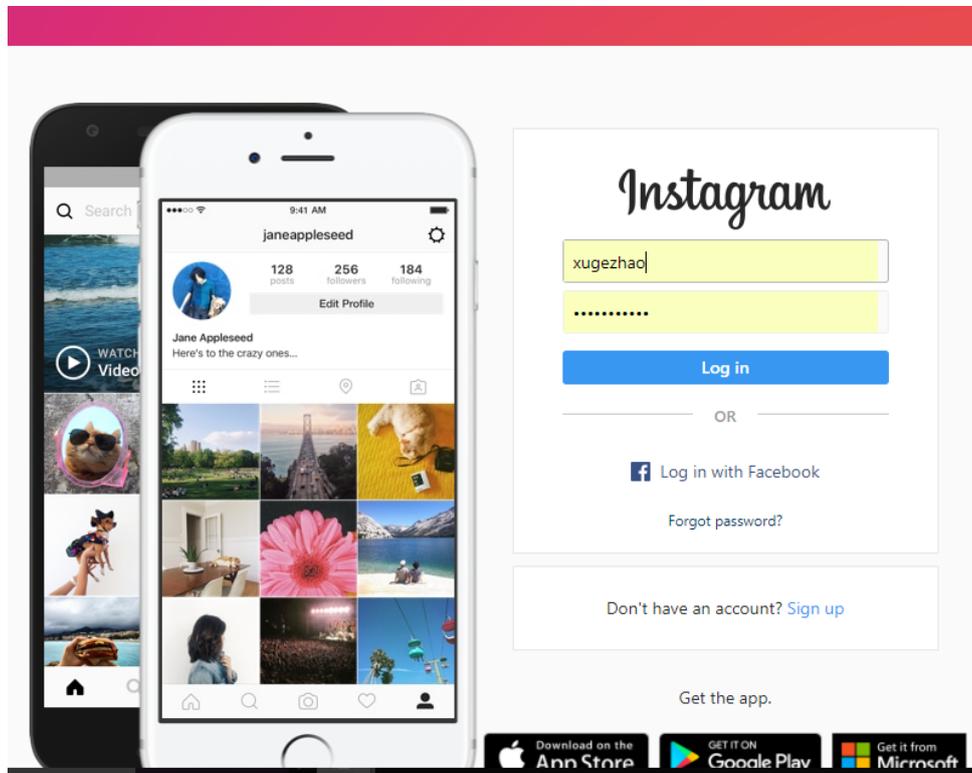


Figure 33: Log in the Instagram

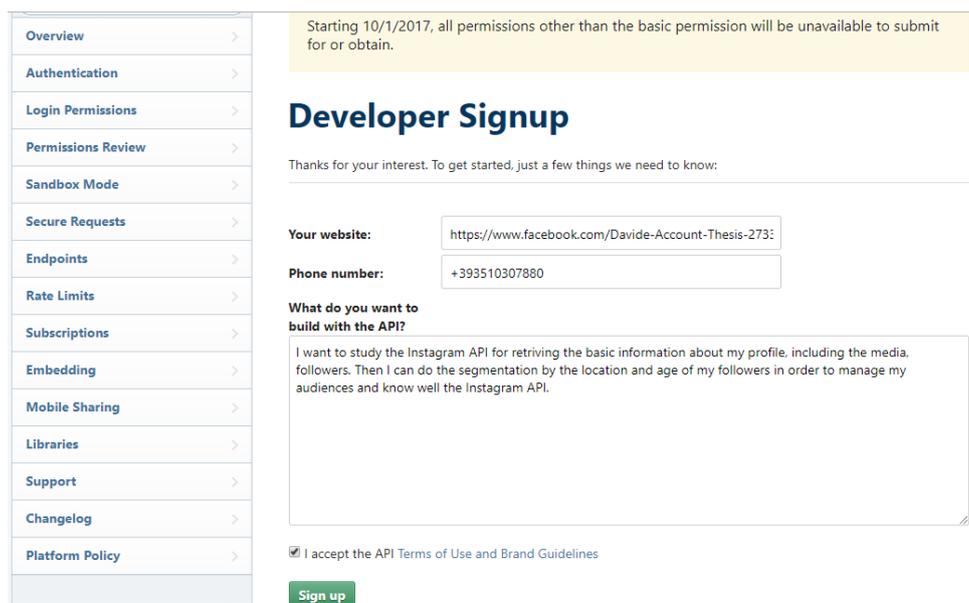


Figure 34: Register as a developer

Now, you can register your application using the manage client link as a developer. After you finish filling the details in Figure 35, it will provide you the client ID and client secret to permit you to integrate your application by implementing the OAuth dance. After we register the client application successfully, we can manage the client according to the security, permission and migration in Figure 36.

The screenshot shows the 'Register new Client ID' page. On the left is a sidebar with a search bar and a list of navigation items: Overview, Authentication, Login Permissions, Permissions Review, Sandbox Mode, Secure Requests, Endpoints, Rate Limits, Subscriptions, Embedding, Mobile Sharing, Libraries, Support, and Changelog. The main content area has a header with 'Instagram', 'Sandbox Invites', 'Manage Clients', and the user name 'xugezhao'. Below the header, there are tabs for 'Details' and 'Security'. The 'Details' tab is active, showing a form with the following fields:
 

- Application Name:** A text input field.
- Description:** A large text area.
- Company Name:** A text input field.
- Website URL:** A text input field.
- Valid redirect URIs:** A text input field with the placeholder text 'Press Enter to confirm.'
- Privacy Policy URL:** A text input field.

 A note below the Application Name field states: 'Do not use *Instagram*, *IG*, *insta* or *gram* in your app name. Make sure to adhere to the API Terms of Use and Brand Guidelines.'

Figure 35: Register a new client

The screenshot shows the 'Manage Clients' page. On the left is the same sidebar as in Figure 35. The main content area has a header with 'Manage Clients', 'Report Issue', and a green button 'Register a New Client'. Below the header, there are two client entries, each with a 'DELETE' and 'MANAGE' button:
 

green	
CLIENT INFO	
CLIENT ID	51c29df2672540c6ba810f610e7afa93
SUPPORT EMAIL	920416015@qq.com
CLIENT STATUS	Sandbox Mode
simple test	

Ayan	
CLIENT INFO	
CLIENT ID	5c2035493a1844cbb12fdb385b5eb351
SUPPORT EMAIL	zizimumu00@gmail.com
CLIENT STATUS	Sandbox Mode
A simple test	

Figure 36: Manage the client

Additionally, Instagram API requires the authentication. All requests for the API must be made through SSL (Secure Sockets Layer), especially on behalf of the user's request. Therefore, in order to verify the request, we need to use the client ID and secret to obtain the access token. In order to receive an access token, we can choose the server-side flow or implicit flow. But I choose the implicit flow here, which includes the access token as one part of the url rather than handling a code. It allows the application receive the access token simply without the server joining in, even if it is less secure. Firstly, we should direct ourself to our authorization url. For example, I use the url [https://api.instagram.com/oauth/authorize/?client\\_id=CLIENT-ID&redirect\\_uri=REDIRECT-URI&response\\_type=token](https://api.instagram.com/oauth/authorize/?client_id=CLIENT-ID&redirect_uri=REDIRECT-URI&response_type=token) to get my client access token. We should substitute the CLIENT-ID and REDIRECT-URI with our client id and valid redirect url we got above. After that, we will be asked to authorize in Figure 37. Once authenticating and authorizing of your application, you will be redirected to your redirect uri with the access token in the url fragment by the Instagram. It will be look like the Figure 38. Finally, you just need to grab the access token from the returned url fragment. More interesting, you can get the user id from the access token. In other words, the user id is the first string of numbers before the first dot. If you chooses not to authorize the application, you will receive the error response including the error reason and error description.

#### 4.2.2 Prerequisites you need to know

Each new application created on the Instagram platform is launched in sandbox mode. This is a full featured environment that authorizes you to test the API before submitting an application for review. Sandbox mode is ideal for developers who want to explore the API platform, even if they are new on the Instagram platform. In order to help you develop and test your application, they are real Instagram data for the users and media in the sandbox mode. However, there are also some limitations for the application in the sandbox mode.

Because the model is suitable for development, the application in sandboxed mode is invisible to the general public and can only be displayed by no more than 10 authorized sandbox users. The application Only can be tested and validated by these users. If

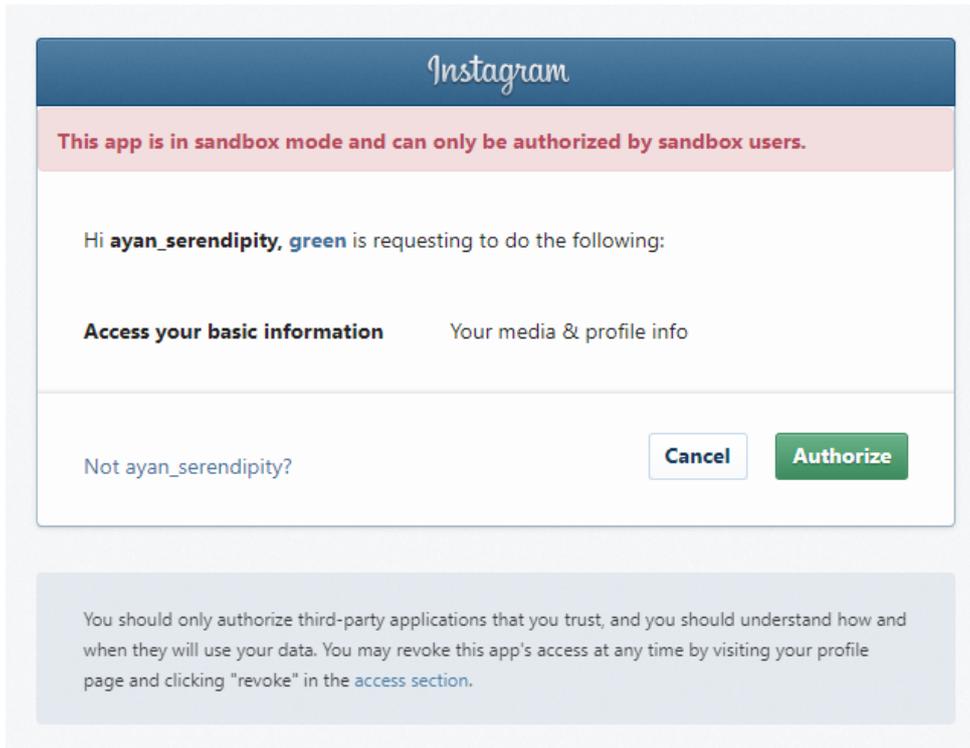


Figure 37: Authorize the client

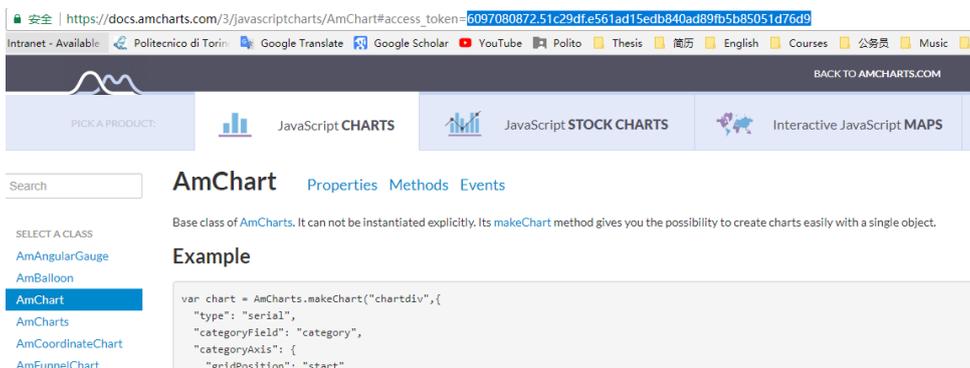


Figure 38: Retrieve your access token

you want to manage the list of sandbox users for a given application, you can go to the sandbox button in Figure 39. At that point, you can add or remove sandbox users for your application, which can accommodate up to 10 users. Please note that the application's administrator is always a sandbox user, so you can add at most nine sandbox users effectively. When users are added to the list and accept the invitation, they will be exactly becoming a sandbox user. It is really convenient to go to the developer's website and click the sandbox invitation button to accept the invitation. Besides, the user can accept or reject invitations, or can stop sandbox users of a given application on the

sandbox invitation page. At the same time, the users can be at most five application sandbox users. It is impossible to invite one user that is already 5 test users.

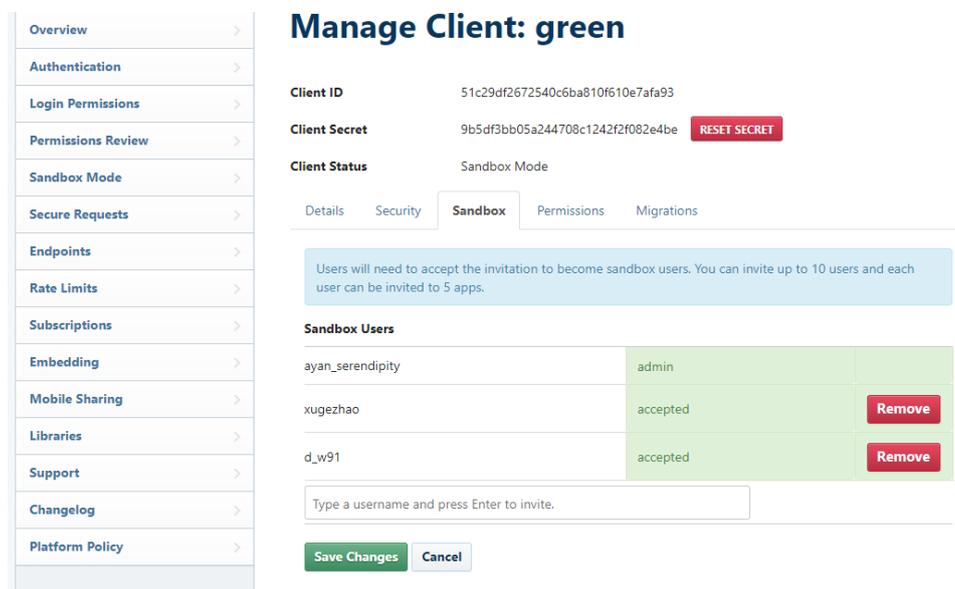


Figure 39: Manage the sandbox users

Sandbox users who are other Instagram users are invited to the client by us. Why do we need to do that? The main reason is that the application can access their media data in addition to our own. Let me give you one example, if you have the request `/users/user-id/` to the user endpoint and user id is a sandbox user, you will get a normal API response about the user information. However, if the user id is not a sandbox user, the Instagram platform will show `APINotFound` error. In addition, another restriction is that no more than 20 recent media can be seen from each sandbox user. For example, when we query the endpoint `/tags/tag-name/media/recent`, it will response the media with the given label. But it will only return the media that belongs to your sandbox user, limiting to the last 20 of each user, rather than returning any media from the sandbox users.

All rate limits in a sliding 1 hour window are individually controlled for each access token on the Instagram platform. The rate limits of live application are higher than those in sandboxed mode, which is the another restriction for the application in sandbox mode. However, it is enough for you to test the Instagram API.

To exit the sandbox mode, you need to submit your application for review. If your application belongs to an approved use case and is approved, it will start automatically.

At this stage, any Instagram user can authorize the application, but you can only access the permissions granted by you during the audit. If you need to have more access, you can submit the review again and you already have the previous granted permissions.

The OAuth 2.0 protocol is used by the Instagram API for simple valid authentication and authorization. The OAuth 2.0 specification permits you to specify the scope parameter of access that you want to request from the user. By default, there are basic access rights for all approved applications. However, if you are going to require the extended access, such as reading public content, likes, comments, or managing friendships, it is necessary for you to specify these scopes in the authorization request. It is compulsory to submit the application for review for people that want to use these extended permissions. You should only request scope you needed when you authorize. If you try to execute a request using an unauthorized access token for that scope, you will receive an `OAuthPermissionsException` API error response. If you need additional scope in the future, you can instruct the user to grant an authorized URL with an additional scope.

#### **4.2.3 Instagram Endpoints for users and likes**

It is known that the API is an entity that represents an external resource that can accept and respond to a protected resource request generated by the client. After getting the access token, you can now start making requests to the API endpoints. There are many different endpoints provided by the Instagram API, for example, the users, relationships, media, likes, tags, comments and locations. Some endpoints can only be accessed by providing the access token as a request parameter, however, other endpoints need to use the scope to acquire the extended data. All endpoints located at `api.instagram.com` can only be accessed through the https with the access token. You can use the same access token to retrieve the API's resources without having to verify it again until it expires. Additionally, each API has a number of defined permissions. It is allowed that a portion of defined permissions are requested by the client, when executing the authorization process and including it as part of the scope request parameter in the access token.

The users endpoint provides us many methods to access the information about the user. For example, we can get the information about a certain user, before we do that, we can search that user id by the user name in the browser. In addition, we can easily look up the most recent media of the user and know which one is liked by the user. Sometimes,

when we query these resources, we need to provide the access token as well as other related parameters.

As an example, we are going to retrieve the information of the user that owns one access token. Figure 40 displays the request url and the response will be depicted in Figure 41. The response contains the data, meta and pagination three main parts. The part of the data will list the content you requested. Here, it will show the basic information about the user, including user id, bio, profile picture and so on. The meta portion is used to convey additional information about the response. If everything goes well, it will show you a code value 200. While it will return you one error message with code value 400 when your request has some problems. Sometimes, if you would like to access more data, you can invoke the next url in the pagination part.

```
https://api.instagram.com/v1/users/self/?access_token=6097080872.51c29df.e561ad15edb840ad89fb5b85051d76d9
```

Figure 40: Request url for the endpoint /users/self

```
{
  "data": {
    "id": "6097080872",
    "username": "ayan_serendipity",
    "profile_picture": "https://scontent.cdninstagram.com/t51.2885-19/s150x150/21980292_918928378256013_3543509320991768576_n.jpg",
    "full_name": "Yuan Li",
    "bio": "",
    "website": "",
    "is_business": false,
    "counts": {
      "media": 0,
      "follows": 2,
      "followed_by": 4
    }
  },
  "meta": {
    "code": 200
  }
}
```

Figure 41: Response for the endpoint /users/self

Another case is that we can get the user id matched with the user name we want to know. It is extremely helpful for us to acquire the basic information of the specific user we need to know. You can request the data of the user name jack through the url in Figure 42. However, you receive the error message in Figure 43 instead of the list of users matched the query in Figure 44. Since your application is not authorized with the public

content scope, when you get the access token. In order to have the public content scope, you need to submit your application for review by Instagram and specify the scope in the authorization request.

```
https://api.instagram.com/v1/users/search?q=jack&access_token=6097080872.51c29df.e561ad15edb840ad89fb5b85051d76d9
```

Figure 42: Request url for the endpoint /users/search

```
{
  "meta": {
    "code": 400,
    "error_type": "OAuthPermissionsException",
    "error_message": "This request requires scope=public_content, but this access token is not authorized with this scope. The user must re-authorize your application with scope=public_content to be granted this permissions."
  }
}
```

Figure 43: Error response for the endpoint /users/search

```
{
  "data": [
    {
      "username": "jack",
      "first_name": "Jack",
      "profile_picture": "http://distillery.s3.amazonaws.com/profiles/profile_66_75sq.jpg",
      "id": "66",
      "last_name": "Dorsey"
    },
    {
      "username": "sammyjack",
      "first_name": "Sammy",
      "profile_picture": "http://distillery.s3.amazonaws.com/profiles/profile_29648_75sq_1294520029.jpg",
      "id": "29648",
      "last_name": "Jack"
    },
    {
      "username": "jacktidy",
      "first_name": "Jack",
      "profile_picture": "http://distillery.s3.amazonaws.com/profiles/profile_13096_75sq_1286441317.jpg",
      "id": "13096",
      "last_name": "Tiddy"
    }
  ]
}
```

Figure 44: Correct response for the endpoint /users/search

At the same time, you can retrieve the list of recent media liked by the owner of the

access token. It is convenient to use the url in Figure 45. Besides, you can specify the max like id parameter to return the liked media before this id and the count parameter to return how many meida you want. You can see the all kind of data about your liked media, including the videos and images in Figure 46.

```
https://api.instagram.com/v1/users/self/media/liked?access_token=6097080872.51c29df.e561ad15edb840ad89fb5b85051d76d9
```

Figure 45: Request url for the endpoint /users/self/media/liked

```
{
  "data": [{
    "location": {
      "id": "833",
      "latitude": 37.77956816727314,
      "longitude": -122.41387367248539,
      "name": "Civic Center BART"
    },
    "comments": {
      "count": 16
    },
    "caption": null,
    "link": "http://instagr.am/p/BXsFz/",
    "likes": {
      "count": 190
    },
    "created_time": "1296748524",
    "images": {
      "low_resolution": {
        "url": "http://distillery.s3.amazonaws.com/
media/2011/02/03/efc502667a554329b52d9a6bab35b24a_6.jpg",
        "width": 306,
        "height": 306
      },
      "thumbnail": {
```

#### 4.2.4 Instagram Endpoints for relationships

It is widely known if we would like to access the information about our relationships, we need to request the relationship endpoint like Figure 47. But it is necessary to add the extend permissions, containing the follower list scope to read the list of followers and followed-by users and the relationships scope to follow and unfollow accounts on a users behalf. As Figure 48 depicted, we can get the list information of my followers, including the follower id. In addition to retrieve the basic information about the user's relationships, it is also possible for you to modify the relationships between the current authenticated user and the target user using the post method. Do not forget to specify

```

      "standard_resolution": {
        "url": "http://distillery.s3.amazonaws.com/
media/2011/02/03/efc502667a554329b52d9a6bab35b24a_7.jpg",
        "width": 612,
        "height": 612
      }
    },
    "type": "image",
    "users_in_photo": [],
    "filter": "Earlybird",
    "tags": [],
    "id": "22987123",
    "user": {
      "username": "kevin",
      "full_name": "Kevin S",
      "profile_picture": "http://distillery.s3.amazonaws.com/
profiles/profile_3_75sq_1295574122.jpg",
      "id": "3"
    }
  },
  {
    "videos": {
      "low_resolution": {
        "url": "http://
distilleryvesper9-13.ak.instagram.com/090d06dad9cd11e2aa0912313817975d_102
        "width": 480,

```

```

    {
      "videos": {
        "low_resolution": {
          "url": "http://
distilleryvesper9-13.ak.instagram.com/090d06dad9cd11e2aa0912313817975d_102
          "width": 480,
          "height": 480
        },
        "standard_resolution": {
          "url": "http://
distilleryvesper9-13.ak.instagram.com/090d06dad9cd11e2aa0912313817975d_101
          "width": 640,
          "height": 640
        },
        "comments": {
          "count": 2
        },
        "caption": null,
        "likes": {
          "count": 1
        },
        "link": "http://instagr.am/p/D/",
        "created_time": "1279340983",
        "images": {
          "low_resolution": {
            "url": "http://

```

Figure 46: Response for the endpoint /users/self/media/liked

the action parameter which contains the follow, unfollow, approve and ignore four types, when you perform the relationship on the endpoint. What is more, we need to know two terms in the relationship response, which are the outgoing status and incoming status.

The former means your relationship to the user, which can be the follows, requested and none. While the later means a user's relationship to you, which can be the followed by, requested by, blocked by you and none.

```
https://api.instagram.com/v1/users/self/followed-by?access_token=6097080872.51c29df.e561ad15edb840ad89fb5b85051d76d9
```

Figure 47: Request url for the endpoint /users/self/followed-by

```
{
  "data": [{
    "username": "kevin",
    "profile_picture": "http://images.ak.instagram.com/profiles/
profile_3_75sq_1325536697.jpg",
    "full_name": "Kevin Systrom",
    "id": "3"
  },
  {
    "username": "instagram",
    "profile_picture": "http://images.ak.instagram.com/profiles/
profile_25025320_75sq_1340929272.jpg",
    "full_name": "Instagram",
    "id": "25025320"
  }
]
```

Figure 48: Response for the endpoint /users/self/followed-by

#### 4.2.5 Instagram Endpoints for media and comments

#### 4.2.6 Instagram Endpoints for tags and locations

### 4.3 Instagram Ads

aa

## 5 Conclusion and Future Challenges

### 5.1 Conclusion

This thesis studies a complete VLC system, including the optical characteristics of LEDs and PDs, the VLC link properties and modulation scheme discussions. In details, a couple of potential transmission links, namely LoS and NLoS are discussed by both analytic and simulation methods. Regarding of its real applications, the potential noise including dark current noise, ambient light noise, quantum shot noise and clipping noise caused by inner transmitters are analyzed and modelled as AWGN noise. The main purpose of the thesis is to figure out and simulate the potential modulation schemes to be exploited into VLC transmission systems. Therefore several modulation schemes suggested in IEEE 802.15.7 Standard are discussed, OOK, VPPM and CSK included, followed by the advanced optical high speed modulation schemes, such as ACO-OFDM, DCO-OFDM and Flip-OFDM. In order to figure out their performances, the link-level simulations are done with exploitation of blocks already exploited into the 4G LTE simulator. The main contribution of this thesis is a generation of a novel VLC receiver combined with dual chains, which is different from the conventional proposed receivers with only one chain applied. The new receiver has been introduced and tested, exploiting the advanced modulation schemes described in section ???. Compared with conventional receivers, the novel receiver can mitigate the error rate dramatically with the same SINR level. It therefore can be improve the VLC system performance significantly.

### 5.2 Future Challenges

Due to the time constraint during the development of this thesis, ACO-OFDM and Flip-OFDM modulation schemes described in Section ??, have not been investigated. They could be tested with the VLC simulator in the future in order to study the corresponding system performances and do comparisons among these different schemes (i.e. DCO-OFDM, ACO-OFDM and Flip-OFDM). Besides, demos could be also generated exploiting hardware components, such as PD, LEDs and Field Programming Gate Array (FPGA) to test the VLC system based on these advanced modulation techniques in real scenarios. Meanwhile, the dimming techniques can be implemented and tested according to the available techniques ,described in Section ??.

The VLC techniques can not only be deployed in indoor environment, but also for outdoor applications, such as Underwater Wireless Sensor Network (UWSN), applications of VLC in an outdoor open space scenario and security check based on VLC instead of X-ray. For instance, more and more researches have been done to study the application underwater, working with Wireless Sensor Network (WSN) due to its high accuracy. Moreover, a further interesting research and development topic is the application of VLC for indoor navigation and localization, particularly in large buildings like hospitals, railway stations, or shopping malls. While GPS signals are not always available indoors and radio fails due to rich multipath propagation. Obtaining indoor location information by means of light sources may be an attractive solution.

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