

WordPress on AWS: a Communication Framework

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Abstract

Every organization needs to communicate with its audience, and social media is an attractive and inexpensive way to maintain dialogic communication. About 1/3 of the Internet web pages are powered by WordPress, and about a million companies have moved their IT infrastructure to the AWS cloud. Together, AWS and WordPress offer an attractive, effective and inexpensive way for companies, both large and small, to maintain their presence on the web.

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1 Introduction

This paper summarizes a course titled *Online Communication and Society*, taught at California State University Channel Islands with code COMP 347. This class starts from the following premise:

you have been hired by a company with a small Communication budget, but ambitious plans. You have been tasked with setting up an effective web presence; in this role you have to combine both your CS/IT skills, as well as your Communication savvy. The decision has been made to deploy the web page as WordPress hosted on Amazon Web Services (AWS), integrated with social media, as well as robust Analytics to measure the effectiveness of your communication campaigns.

This paper, which reflects the content of the course, covers how to accomplish this mission.

The material is aimed a junior (3rd year) students in Computer Science and IT, but it covers all the content from the beginning, and thus it is accessible to Business and Communication students as well. Of course, the more Computer Science / IT maturity a student has, the more they will be able to draw out of this important and topical material.

1.1 The Cloud with AWS

As discussed in [1], the Cloud is a new paradigm of computing. What we mean by “The Cloud” is a way of provisioning IT services that involves accessing them through the Internet, where they are reachable *on-demand* in a *pay-as-you-go* manner. There are various providers of Cloud services, where the top three are Amazon Web Services (AWS) with the largest market share, followed by Microsoft Azure and Google Cloud.

What is attractive about The Cloud is that a business can deploy a state of the art online presence without making capital investments, that is purchasing hardware, “rack-stack-cool-power” a data center, and hire an IT department. The cloud’s “pay-as-you-go” model scales according to need, and therefore a business does not have to provision for peak usage.

AWS ([1]) works well with universities as it has a well developed academic interface, in the form of *AWS Academy* and *AWS Educate*, as well as its significant dominance of the cloud market, which works to the advantage of graduating students, in search of a job, who have AWS expertise. About a million companies use AWS, including giants such as Netflix and Dropbox, as well as start-ups and non-profits.

This paper describes how to build a scalable, flexible and fault-tolerant web site using the WordPress application running on the AWS cloud platform. In itself, building a web site is not difficult; but it is another matter to build a web site that *scales*, i.e., is able to serve a fluctuating number of visitors, *flexible*, can be quickly and easily updated with content and in fact works as a *Content Management System* (CMS), and is *fault-tolerant*, i.e., when something breaks, and something always breaks, it is still able to perform its function adequately.

It is possible to use free AWS Educate accounts to learn and practice all that is presented in this paper. Those who wish to turn that knowledge into practice can save their *Infrastructure as Code* (IaC), a great advantage of the Cloud, and port it as a json or yaml file to another environment.

1.2 WordPress

WordPress (WP) is a free and open-source *Content Management System* (CMS) based on PHP and MySQL. It includes a *plugin architecture* and a *template system*. While WP is often associated with blogging, it supports other types of web content including traditional mailing lists and forums,

media galleries, and online stores. WP is by far the most used CMS by websites, as can be seen here [2].

As WP is written in PHP and MySQL, familiarity with those two languages can help with a deeper customization of your site, but it is not required to understand and implement the material discussed in this paper. Also, even without knowledge of PHP, but with some familiarity of programming and scripting, it is possible to make tweaks to the WP code. To give an example of this, consider this case: when a WP page is password protected the title shows as “Protected: Title of the page.” The word “Protected” can be confusing to some, and the WP administrator may wish to change it to something else, e.g., “Password Protected: Title of the page.” To accomplish that, simply go to the file `wp-includes/post-template.php` and replace the first line given below with the second:

```
$prepend = __( 'Protected: %s' );  
$prepend = __( 'Password Protected: %s' );
```

In the author’s current version of WP¹, this is line 127 in `post-template.php`. This example was put here to illustrate that deeper customization of WP can be accomplished with little experience with PHP. That said, PHP makes up over 80% of all server-side code out there, and it is not too difficult to pick up, and hence a web site administrator is encouraged to learn it.

In order to host WP, you will need to be running an EC2 instance, which is a virtual machine in the cloud, with a setup that is called a “LAMP” (an acronym for Linux, Apache, MySQL and PHP). This will be explained in Section 3.1. Once you have an EC2 instance with LAMP, you will download WP to it, and proceed from there as outlined in Section 3.2. Note that WP is free (the software, that is), and you can download it to your machine (`wget https://wordpress.org/latest.tar.gz`) and examine at will before doing an actual installation in the cloud.

Note that it is also possible to host a WP blog on wordpress.com; this is a paid service, as it provides a host machine and ability to register a domain, as well as the WP installation. It is a managed service, i.e., *Software as a Service* (SaaS), whereas in this paper we examine a *Platform as a Service* (PaaS) installation. Finally, check [3, 4] for more information on PaaS installations of WP on AWS, and in particular the `yaml` template for deploying WP on AWS in [5].

¹Version 5.4

2 Working online

Many professionals work from home these days, a trend accelerated by the COVID-19 crisis, when most of the nation was working from home in order to practice “social isolation.” It is fundamental for remote work (and study) to be well versed in the tools that enable it. Note that these tools are deployed in the Cloud, and hence this course will in fact have the added benefit of teaching students how to work productively in an online environment. In this section we are going to examine the tools used in this online course, which are also the pre-eminent tools used in the workforce.

Slack and Microsoft Teams are the top work-place messaging systems. Both applications group workers into “channels,” and offer wide integration with other tools, such as, GitHub, Dropbox and Dropbox Paper, Google Drive, and many others, as well as teleconferencing. They support *Markdown* which is a lightweight markup language with a plain-text formatting syntax. In Markdown one can specify bold-face or italics text with simple tags, such as `*bold*` and `_italics_`. See [6] and [7] for more background on workplace communication.

StackOverflow is where coders go to learn, share knowledge and build their careers. It has more than 50 million visitors each month, and it is divided into numerous communities defined by topics, such as “Theoretical Computer Science” [8], “Ask Ubuntu” [9] and “ \TeX – \LaTeX ” [10] to name just a few from the 15,000 communities.

StackOverflow requires a certain etiquette, such as clarity of questions, and reproducibility of issues described (in sufficient detail). Read [11] on how to ask a good question, and [12] on how to write a good answer. A companion to the CSUCI StackOverflow site is a LinkedIn group on all matters AWS Cloud that is concerned with jobs, careers and networking in the area of AWS Cloud Computing [13].

3 Building WP on AWS

In this section we describe the backend work, where you provision an AWS virtual server, called an EC2 instance, where EC2 abbreviates “Elastic Cloud Compute,” and set up a LAMP stack on it that is needed to have a web server, and finally a WP installation on top of that.

Keep in mind that there are automated ways to install WP on AWS, as

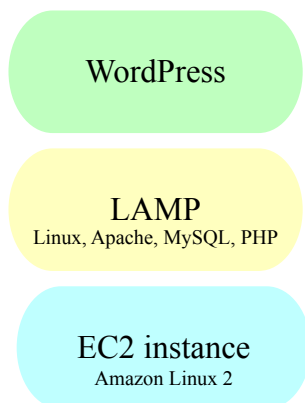


Figure 1: WP stack

for example with AWS Lightsail ([14]), or Bitnami’s public AMIs with WP ([15]). However, it is important for the purpose of this course to be able to build WP from scratch, as this gives invaluable insights into the stack, as well as more flexibility in configuring it.

3.1 EC2 with LAMP

First launch an *Amazon Linux 2 AMI* EC2 instance; detailed instructions are given in [16]. For the *instance type*, it is recommended that you select “General purpose” `t2.micro`, which is “free tier eligible,” and while it is not a powerful server, it is enough for the purpose of the exercise. Note that *instance type* can always be updated later to more powerful specs, if required.

Once your Amazon Linux 2 EC2 instance is up and running, the next step is to install on it a LAMP stack. “LAMP” here stands for Linux, the Operating System of the instance, Apache web server, MariaDB (which is a community-developed fork of MySQL) and PHP. Follow the instructions here: [17]. Note that these LAMP instructions are meant for the specified AMI: Amazon Linux 2.

3.1.1 Create an image

Once the EC2 server with LAMP has been built, it should be saved as an *image* before moving on to the next section (Section 3.2). This way, if some-

thing goes wrong during the WP setup, the process can be restarted from this point, rather than from scratch. This is a transformational lesson of cloud computing: infrastructure should be treated as code, *infrastructure as code*, and the user should not be afraid to delete, start anew, and in general approach the infrastructure as if it were a script.

In order to launch a template, select the desired EC2 instance in the console, select “Actions” and then select “Create Image.” This image will be placed in “IMAGES” in the left margin menu, under “AMIs.” Now, you can launch a fully fledged EC2 server with LAMP from that image. The ID of the AMI will be of this form: `ami-0a1b2c3d4e5f6g7h8`, and it is unique, and it can be shared with others.

3.2 WP

In this section you will learn how to set up WP on your EC2 instance with LAMP, as provisioned in Section 3.1. The set up included installation and configuration, as well as securing the WP; security is a foundational concern — for example, you do not want hackers to deface your company’s web page and thereby send a message to the community that you are an easy target and thus not to be trusted. In order to set up WP, follow these instructions: [18].

Once again an image should be created at this point as described in Section 3.1.1, so that the user will also have an EC2 server instance with LAMP and a fresh installation of WP.

4 Social Media integration

Social media is no panacea in terms of generating engagement with ones’ stakeholders. In fact, two decades into a wide-spread usage of social media, we see that it is not all good. See for example the following articles: [19, 7, 20], and the recently published book by Hasson, *The Manipulators*, [21], which shows that purveyors of social media are prone to use it to further their own agendas.

Yet, social media can be wielded successfully to amplify the message of a company. At the very least, it can be used to advertise a post on various platforms; of course, the success of this strategy depends on an earlier success in bringing a receptive audience to those platforms in the first place.

In the following three sections we are going to show the technical side of automating the notification about posts on three social media platforms: Twitter, LinkedIn and Slack. In all cases this is done with APIs, Application Programming Interfaces, which are the glue that hold the Cloud together.

4.1 Twitter

Twitter integration automates tweeting a message about a post. That message can be customized in WP in the final stages of publishing a post, but in general the tweet will include a title to the post, and a link to the post itself. Authors often modify the tweet by using key #’s (*hashtags*) and @’s (*mentions*) in order to draw more viewers.

There are various ways to accomplish twitter integration; for example the Jetpack plugin has this integration built in (it still has to be customized and API tokens generated). We are going to install Jetpack in Section 5, but integration can also be done with a lightweight plugin such as “WP to Twitter.” It is lightweight when compared to Jetpack, as Jetpack has a lot of functionality. A *plugin* is a software bundle that can be install in WP to expand its functionality. Examples of popular plugins are “Akismet Anti-Spam,” which protects WP comments from spam, and Jetpack itself. More information, as well as a download, of “WP to Twitter” can be found here: [22].

Whether using Jetpack or “WP to Twitter,” there are three steps in a typical twitter integration: First, apply to upgrade your Twitter account to a developer account; the Twitter Developer account allows you to access Twitter’s API, which is needed to automate tweets when posting, and it is free. Second, download and install “WP to Twitter” plugin from its page ([22]). Third, configure the plugin: “WP to Twitter” is very well documented and walks the user through the installation. As a valuable tip for the the installation, make sure that the tokens are generated and entered correctly.

4.2 LinkedIn

LinkedIn is a professional networking site, designed to make business connections, share resumes and find jobs. Just like Twitter and Facebook it allows members to post, comment and like. It has two types of posts: a short post message in the style of Twitter or Facebook, and a longer post called an *article*.

Just as in the case of Twitter integration discussed in the previous section, LinkedIn integration is achieved through plugins; the integration is included in Jetpack, but it can also be established with “WP LinkedIn Auto Publish,” which can be accessed here [23].

4.3 Slack

WP Slack is achieved through an RSS application in Slack. RSS, which stands for *Real Simple Syndication*, is a web feed that allows applications to access updates to a website in a standard way. It allows to have news aggregators in one place; for example, <https://wordpress.com/read> allows one to follow various other blogs in one place, precisely through RSS. Slack integration allows to choose the channel where the posts will be forwarded.

5 Measuring effectiveness

In this section we are going to consider how to measure the effectiveness of our online presence. We are going to deploy two tools; both of them can be installed as plugins in WP, but both require setting up an online account:

- **Jetpack**, site: [24], and plugin: [25]
- **Google Analytics**, site: [26], and plugin: [27]

Jetpack is a comprehensive plugin that includes security protections, backup, malware scanning, and Analytics. It is the creation of a company named *Automattic*, which is known for running WP.com (a self-hosting site) and contributions to the WP software. Jetpack is able to measure the performance of each blog post and each page individually.

Google Analytics provides a comprehensive view of the performance of the entire WP site. It does not have a breakdown by post and page as Jetpack, but on the other hand it offers a lot of parameters that Google with its vast Analytics experience can offer. For example, *bounce rate*, which gives the percentage of sessions where the viewer looks at a page, but has no other interaction with it; *average session duration*, number of *sessions* and number of *sessions per user*, where a session is a concrete period during which a user is engaged with a web site. For example, the higher the number of sessions per user, the more returning — rather than new — users are engaged. The following YouTube video: [28] is a simple introduction to Google Analytics.



Figure 2: Google Analytics front page for <https://prof.msoltys.com>

6 Maintenance

6.1 Backups

It is irresponsible to build a WP site without a well understood backup procedure in place. If you are running a professional production version of WP, you should discuss with management two parameters related to backups: *Recovery Point Objective* (PRO) and *Recovery Time Objective* (RTO).

The RPO depends on how much data is your company willing to lose (i.e., frequency of backups), and the RTO depends on how long is your company

willing to wait to recover from a catastrophic failure.

In order to meet the RPO and RTO, whatever they may be, two types of backups are recommended. One is to do periodic snapshots of the EC2 instance and attached EBS volumes, as the site can be recovered from such a snapshot very quickly. Still, it has to be decided how many such snapshots to keep (what if the last ten have been affected by the same ransomware?) and how frequently to make them; the decisions will have an associated storage price.

Another type of backup is to copy files from the WP installation into S3, for example using `aws s3 sync` ([29]). Here S3 versioning might be useful, but a decision has to be made as to how many version to keep, and at which point — if ever — to move them for very cheap storage to Glacier. The copying can be scheduled with `crontab` ([30]), by putting the command:

```
aws s3 sync /var/www/html/ s3://<bucket-name>
```

inside a shell file and invoking it at regular times from `crontab`. Note that for the EC2 instance to have access to the S3 bucket, it is important that it assume a role with the following permission attached: `AmazonS3FullAccess`. Of course, granting this permission violates the best practice of granting “minimal permission needed to do the job.” The permission could be weakened with a bespoke policy that grants access only to the particular S3 bucket.

6.2 Scripts

As the size and complexity of a system under your administration grows, it is crucial to automate service managements with scripts. AWS has a host of command line utilities that help with that: AWS Serverless Application Model (AWS SAM) Local, AWS Tools for PowerShell, AWS Amplify, as well as of course the AWS CLI (v2 recommended over v1; see [31]). To the AWS script tools we also add the following three convenient utilities: Makefile, Bash (or your favorite shell-script; for example, in macOS Catalina the default shell is `zsh`), and a WP CLI called WP-CLI ([32]).

There are certain files on your WP that change (i.e., are updated) frequently. A resume in the “About Me” page would be a good example. Instead of uploading multiple versions of this file, it is convenient to quickly update it as it changes locally. Here is an [example of a Makefile](#) that can be used for that. In that example we use `scp` (secure copy) to upload the new version; note that this will typically ask for a password. In order to automate that,

the user can export their public `id_rsa.pub` from the local machine to the EC2 instance running WP and append it to the file `.ssh/authorized_keys` there. If the local `.ssh` folder does not contain the file `id_rsa.pub`, it can be easily generate with the command `ssh-keygen`. See [33] for more details. Also note that automating the ssh access to the EC2 instance running your WP is a good idea in general, as it will help with management of the instance (e.g., running `sudo yum update` frequently to update the system). A best practice in this case is to ensure that the Security Group that controls the ssh access to the machine is configured to allow access from few select IPs, for example home IP and office IP. It should definitely not be `0.0.0.0/0,:::0`, i.e., open to the world.

Here is an example of a [Bash script](#) that is used to update a WP site, so that new plugin, themes, and the WP core itself, can all be updated automatically by running this script, which we call `genupdate.sh`. Note that the script also updates the `wp-cli` utility itself, keeping a copy of the older version just in case the update breaks any current configuration.

If you are running several WP sites, or simply want to streamline the maintenance of your WP site(s), you should consider using `wp-cli` which will speed up maintenance and plugin/theme installation/maintenance considerably. Finally, there are documents which are often updated and then uploaded to your WP site. We will show how to stream line this as well. WP-CLI is a WP Command Line Interface ([32]).

6.3 Security

This is a comprehensive reference on AWS security: [34]. Note that document [17] we followed for building a LAMP stack in Section 3.1, has a “Step 3: Secure the Database Server.” That is an important component of the setup, and if you have not completed that step already, now would be a good time to do so. If your WP installation has been hacked, you may find this article helpful: [35], where the author points out that WP’ popularity makes it a huge target, and that the login page (for administrative maintenance) and the plugin directories are especially vulnerable to attack.

6.4 Cost

Start by visiting the billing dashboard in the AWS Console, as well as [36]. It is absolutely crucial, especially at the beginning of hosting your WP site

on the AWS Cloud infrastructure, to set up billing alarms that notify the administrator, using AWS Simple Notification Services (SNS), that certain cost thresholds have been reached. This will help you avoid surprises in your monthly billing, as well as facilitate trouble-shooting and optimizing your setup. See here for a comprehensive list of cost tools: [37].

6.5 Performance

The basic setup discussed so far, depending slightly on which type you selected in Section 3.1 (`t2.micro` was suggested), can carry a website with a few simultaneous users, say 20. But if you are serving an audience of a million users, with, say, up to 10,000 simultaneous connections to your site, you will need something more powerful.

Enter *load balancers* ([38]), *auto-scaling* ([39]), CloudFront ([40]), *fault-tolerance* and *Transport Layer Security* (TLS) for encrypted (HTTPS) connections to your website. You may also want to give your server a unique domain name, in which case you will need to work with Route 53 ([41]). See the Appendix section “Other Deliverables” to implement the above.

7 Acknowledgements

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A Deliverables

This section contains sample assignments, called “deliverables”, based on the material in the paper.

1. **Deliverable:** Sections 1 and 2. Log into Slack and StackOverflow. Post a comment in Slack. Throughout the course, you will be responsible for participating on Slack, and posting 2 *good* questions on StackOverflow, and 4 *good* answers on StackOverflow. Note that the StackOverflow activity should be spread throughout the course, i.e., it should not be all done for the first deliverable. Submit a link to your

Slack comment, as well as a PDF of your updated resume and a text file containing an “About Me” page — you will be putting both as your initial content on your WordPress blog.

2. **Deliverable:** Section 3. Build an EC2 Amazon Linux 2 server with Wordpress installed and secured on it, by following closely the instructions cited in the article. This will be a good opportunity to post on StackOverflow as you encounter — and deal with — technical difficulties. Submit a text file containing the AMI Ids of both your “EC2 with LAMP,” and your “EC2 with LAMP and WordPress.” Also submit two links: one to your “About Me” page, and one to your CV (on your blog).
3. **Deliverable:** Section 4. Integrate your WordPress site with social media, in particular with Twitter and LinkedIn. This means that you will set up APIs (Application Processing Interface) for both Twitter and LinkedIn (which means that you must have active accounts with both. Create them, if you do not; you can always close them after the course is over). Now write a post and publish it on your blog, and it should automatically post on Twitter and LinkedIn. Submit three links: a link to your post; a link to the corresponding tweet; and a link to the corresponding LinkedIn post.
4. **Deliverable:** Section 5. Install Jetpack (free version) and Google Analytics in order to measure the effectiveness of your online campaign. Conduct an experiment to measure engagement; for example, write a post and observe using Jetpack and Google Analytics what kind of traction it is getting. Submit a one page write up (as a PDF) on your experiment. Part of your experiment should be to determine who is your audience; in Google Analytics you can see *Demographics*, *Geolocation*, *Technology*, etc.; use those datapoints to construct a narrative about your audience.
5. **Deliverable:** Section 6 and 7. Set up a well designed backup of your site; as explained in Section 6.2, use snapshots, S3 and crontab to accomplish this. Once you are complete, you should estimate the total monthly cost of your WordPress setup, including everything (not just the cost of the backups) in that analysis. Set up a billing alarm that

notifies you by email when the costs have reached 50% of your estimated monthly expenses, and then again when the costs have reached 100% and 150%. Describe your backup and cost analysis in a two-page document.

B Advanced Deliverables

6. **Deliverable:** Section 6.3. Deploy the following scripts: `wp-cli` to maintain, especially update, your WP installation. Set up seamless ssh-ing into your EC2 instance with `ssh-keygen` and allow only select ssh traffic (port 22) to your EC2 via its Security Group. The HTTP(S) traffic (ports 80 and 443) should be open to the world (i.e., 0.0.0.0/0).
7. **Deliverable:** Using Route53, as well as Load Balancers, set up a domain name for your EC2 instance (note that this will require a small payment, and may not be doable with an “AWS Educate” account), and using Load Balancers set up an SSL/TLS connection to your instance by generating a Certificate using AWS Certificate Manager. What is the advantage of having the load balancer encrypt and decrypt SSL/TSL traffic, and communicating internally via HTTP with your instance? In fact, allowing SSL/TLS connections to your EC2 instance is crucial in order to allow secure administration of your site.
8. **Deliverable:** Section 6.1. Suppose that your site is getting a lot of traction, and you need to accommodate the higher traffic. In order to do that, implement the following change: instead of hosting the MySQL DB on your EC2 instance, launch an AWS RDS (Relational Database Service), and move the DB there ([42]). Make sure that you make the appropriate changes in `wp-config.php` where, for example, you will need to change the `localhost` in `define('DB_HOST', 'localhost');` with the hostname of your new RDS DB. The next deliverable is a continuation of this one.
9. **Deliverable:** Suppose that a lot more media than you expected, both audio and video, is uploaded to your WP site, and you are running out of the provisioned capacity on your EBS volume. Since you realized that EBS storage can get expensive, you decide to actually shrink the

EBS volume so it only holds the EC2 instance OS and the WP installation, but the `wp-content/uploads` page is going to reside in an S3 bucket; how would you do that? With this new setup, can you now have a load balancer, and an auto-scaling group that spawns new EC2 instances that are replicas of the current EC2 instance, and shuts them down as needed?

10. **Deliverable:** WP releases its software frequently ([43]) and you are going to implement a Blue/Green deployment (see [44, pg 26]) strategy to update your site without downtime. In order to do that, you are going to have two target groups, the *Blue Group* and the *Green Group*, or put another way, two environments, the *Blue Environment* and the *Green Environment*. When a new update is released (checking for updates could be done with `crontab` and the WP CLI `wp core update`), and when an update is available, it is deployed into the Blue Environment, which now becomes Green, and the old Green becomes Blue, and the Blue environment is kept idle in case a rollback is needed.

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