Introduction

Introduction

This book is for anyone looking to learn about push notifications on the web.

I started working on web push when Chrome first added support. There have been quite a few changes since then but the API's have stabilised across Chrome and Firefox so it's the perfect time for people to learn about push on the web.

This site / book covers everything I've learnt and will be updated with anything new I learn in the future.

If you spot mistakes, code errors or simple typos please raise issues or contribute on Github where this content lives.

To track updates of this content follow the Releases on Github, which also has an RSS feed.

Finally, a massive thank you to all the contributors who have helped with this book.

How Push Works

Before getting into the API, let's look at push from a highlevel, start to finish. Then as we step through individual topics or API's later on, you'll have an idea of how and why it's important.

The three key steps to implementing push are:

1. Adding the client side logic to subscribe a user to push (i.e. the JavaScript and UI in your web app that registers a user to push messages).
2. The API call from your back-end / application that triggers a push message to a user's device.
3. The service worker JavaScript file that will receive a "push event" when the push arrives on the device. It's in this JavaScript that you'll be able to show a notification.

Let's look at what each of these steps entails in a little more detail.

Step 1: Client Side

The first step is to "subscribe" a user to push messaging.

Subscribing a user requires two things. First, getting **permission** from the user to send them push messages. Second, getting a `PushSubscription` from the browser.

A `PushSubscription` contains all the information we need to send a push message to a particular user. You can "kind of" think of this as an ID for that user's device.

This is all done in JavaScript with the Push API.

Before subscribing a user you'll need to generate a set of "application server keys", which we'll cover later on.

The application server keys, also known as VAPID keys, are unique to your server. They allow a push service to know which application server subscribed a user and ensure that it's the same server triggering the push messages to that user.

Once you've subscribed the user and have a `PushSubscription`, you'll need to send the `PushSubscription` details to your backend / server. On your server, you'll save this subscription to a database and use it to send a push message to that user.

Figure 1: Make sure you send the PushSubscription to your backend.

Step 2: Send a Push Message

When you want to send a push message to your users you need to make an API call to a push service. This API call would include what data to send, who to send the message to and any criteria about how the push service should send the message. Normally this API call is done from your server.

Some questions you might be asking yourself:

- Who and what is the push service?

- What does the API look like? Is it JSON, XML, something else?
- What can the API do?

Who and What is the Push Service?

A push service receives a network request, validates it and delivers a push message to the appropriate browser. If the browser is offline, the message is queued until the the browser comes online.

Each browser can use any push service they want, it's something developers have no control over. This isn't a problem because every push service expects the **same** API call. Meaning you don't have to care who the push service is. You just need to make sure that your API call is valid.

To get the appropriate URL to trigger a push message (i.e. the URL for the push service) you just need to look at the `endpoint` value in a `PushSubscription`.

Below is an example of the values you'll get from a **PushSubscription**:

```
{
  "endpoint": "https://random-push-service.com/some-kind-of-unique-id-1234/v2/",
  "keys": {
    "p256dh" : "BNcRdreALRFXTkOOUHK1EtK2wtaz5Ry4YfYCA_0QTpQtUbVlUls0VJXg7A8u-Ts1XbjhazAkj7I9
    "auth"   : "tBHItJI5svbpez7KI4CCXg=="
  }
}
```

The **endpoint** in this case is *https://random-push-service.com/some-kind-of-unique-id-1234/v2/*. The push service would be 'random-push-service.com' and each endpoint is unique to a user, indicated with 'some-kind-of-unique-id-1234'. As you start working with push you'll notice this pattern.

The **keys** in the subscription will be covered later on.

What does the API look like?

I mentioned that every web push service expects the same API call. That API is the **Web Push Protocol**.

It's an IETF standard that defines how you make an API call to a push service.

The API call requires certain headers to be set and the data to be a stream of bytes. We'll look at libraries that can perform this API call for us as well as how to do it ourselves.

What can the API do?

The API provides a way to send a message to a user, with / without data, and provides instructions of *how* to send the message.

The data you send with a push message must be encrypted. The reason for this is that it prevents push services, who could be anyone, from being able to view the data sent with the push message. This is important given that it's the browser who decides which push service to use, which could open the door to browsers using a push service that isn't safe or secure.

When you trigger a push message, the push service will receive the API call and queue the message. This message will remain queued until the user's device comes online and the push service can deliver the messages. The instructions you can give to the push service define how the push message is queued.

The instructions include details like:

- The time-to-live for a push message. This defines how long a message should be queued before it's removed and not delivered.
- Define the urgency of the message. This is useful in case the push service is preserving the user's battery life by only delivering high priority messages.
- Give a push message a "topic" name which will replace any pending message with this new message.

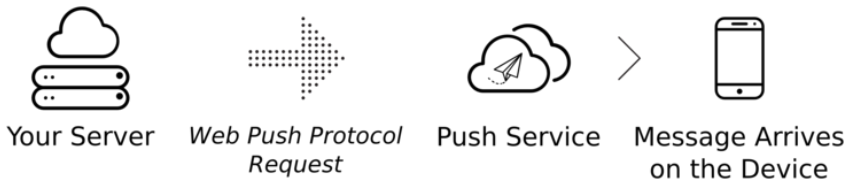


Figure 2: When your server wishes to send a push message, it makes a web push protocol request to a push service.

Step 3: Push Event on the User's Device

Once we've sent a push message, the push service will keep your message on its server until one of following events occurs:

1. The device comes online and the push service delivers the message.

2. The message expires. If this occurs the push service removes the message from its queue and it'll never be delivered.

When the push service does deliver a message, the browser will receive the message, decrypt any data and dispatch a `push` event in your service worker.

A service worker is a "special" JavaScript file. The browser can execute this JavaScript without your page being open. It can even execute this JavaScript when the browser is closed. A service worker also has API's, like push, that aren't available in the web page (i.e. API's that aren't available out of a service worker script).

It's inside the service worker's 'push' event that you can perform any background tasks. You can make analytics calls, cache pages offline and show notifications.

Figure 3: When a push message is sent from a push service to a user's device, your service worker receives a push event.

That's the whole flow for push messaging. Lets go through each step in more detail.

Subscribing a User

The first step is to get permission from the user to send them push messages and then we can get our hands on a `PushSubscription`.

The JavaScript API to do this is reasonably straight forward, so let's step through the logic flow.

Feature Detection

First we need check if the current browser actually supports push messaging. We can check if push is supported with two simple checks.

1. Check for `serviceWorker` on `navigator`.

2. Check for `PushManager` on `window`.

```
if (!('serviceWorker' in navigator)) {
  // Service Worker isn't supported on this browser, disable or hide UI.
  return;
}

if (!('PushManager' in window)) {
  // Push isn't supported on this browser, disable or hide UI.
  return;
}
```

While browser support is growing quickly for both service worker and push messaging support, it's always a good idea to feature detect for both and progressively enhance.

Register a Service Worker

With the feature detect we know that both service workers and Push are supported. The next step is to "register" our service worker.

When we register a service worker, we are telling the browser where our service worker file is. The file is still just JavaScript, but the browser will "give it access" to the service worker APIs, including push. To be more exact, the browser runs the file in a service worker environment.

To register a service worker, call `navigator.serviceWorker.register()`, passing in the path to our file. Like so:

```
function registerServiceWorker() {
  return navigator.serviceWorker.register('service-worker.js')
  .then(function(registration) {
    console.log('Service worker successfully registered.');
    return registration;
  })
  .catch(function(err) {
    console.error('Unable to register service worker.', err);
  });
}
```

This code above tells the browser that we have a service worker file and where it's located. In this case, the service worker file is at `/service-worker.js`. Behind the scenes the browser will take the following steps after calling `register()`:

1. Download the service worker file.

2. Run the JavaScript.

3. If everything ran correctly and there were no errors, the promise returned by `register()` will resolve. If there are errors of any kind, the promise will reject.

   If `register()` does reject, double check your JavaScript for typos / errors in Chrome DevTools.

When `register()` does resolve, it returns a `ServiceWorkerRegistration`. We'll use this registration to access to the PushManager API.

Requesting Permission

We've registered our service worker and are ready to subscribe the user, the next step is to get permission from the user to send them push messages.

The API for getting permission is relatively simple, the downside is that the API recently changed from taking a callback to returning a Promise. The problem with this, is that we can't tell what version of the API is implemented by the current browser, so you have to implement both and handle both.

```
function askPermission() {
  return new Promise(function(resolve, reject) {
    const permissionResult = Notification.requestPermission(function(result) {
      resolve(result);
    });

    if (permissionResult) {
      permissionResult.then(resolve, reject);
    }
  })
  .then(function(permissionResult) {
    if (permissionResult !== 'granted') {
      throw new Error('We weren\'t granted permission.');
    }
  });
}
```

In the above code, the important snippet of code is the call to `Notification.requestPermission()`. This method will display a prompt to the user:

Once the permission has been accepted / allowed, closed (i.e. clicking the cross on the pop-up), or blocked, we'll be given the result as a string: 'granted', 'default' or 'denied'.

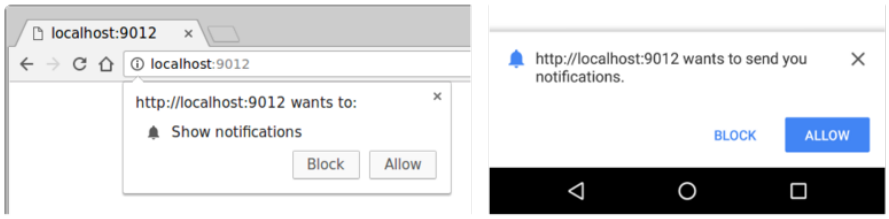


Figure 4: Permission Prompt on Desktop and Mobile Chrome.

In the sample code above, the promise returned by `askPermission()` resolves if the permission is granted, otherwise we throw an error making the promise reject.

One edge case that you need to handle is if the user clicks the 'Block' button. If this happens, your web app will not be able to ask the user for permission again. They'll have to manually "unblock" your app by changing its permission state of your web app, which is buried in a settings panel. Think carefully about how and when you ask the user for permission, because if they click block, it's not an easy way to reverse that decision.

The good news is that most users are happy to give permission as long as they *know* why the permission is being asked.

We'll look at how some popular sites ask for permission later on.

Note: You might notice that when checking what the current state of the notification permission is, a function `getNotificationPermissionState()`. This function uses the Permission API to get the permission state, falling back to `Notification.permission` if the Permission API is not supported. This is done for performance reasons. Calling `Notification.permission` locks up the main thread in Chrome and calling it repeatedly is a bad idea.

```
function getNotificationPermissionState() {
  if (navigator.permissions) {
    return navigator.permissions.query({name: 'notifications'})
    .then((result) => {
      return result.state;
    });
  }

  return new Promise((resolve) => {
    resolve(Notification.permission);
  });
}
```

Subscribe a User with PushManager

Once we have our service worker registered and we've got permission, we can subscribe a user by calling `registration.pushManager.subscribe()`.

```
function subscribeUserToPush() {
  return getSWRegistration()
  .then(function(registration) {
    const subscribeOptions = {
      userVisibleOnly: true,
      applicationServerKey: urlBase64ToUint8Array(
        'BEl62iUYgUivxIkv69yViEuiBIa-Ib9-SkvMeAtA3LFgDzkrxZJjSgSnfckjBJuBkr3qBUYIHBQFLXYp5Nk
      )
    };

    return registration.pushManager.subscribe(subscribeOptions);
  })
  .then(function(pushSubscription) {
    console.log('Received PushSubscription: ', JSON.stringify(pushSubscription));
    return pushSubscription;
  });
}
```

When calling the `subscribe()` method, we pass in an *options* object, which consists of both required and optional parameters.

Lets look at all the options we can pass in.

userVisibleOnly Options

When push was first added to browsers, there was uncertainty about whether developers should be able to send a push message and not show a notification. This is commonly referred to as silent push, due to the user not knowing that something had happened in the background.

The concern was that developers could do nasty things like track a user's location on an ongoing basis without the user knowing.

To avoid this scenario and to give spec authors time to consider how best to support this feature, the `userVisibleOnly` option was added and passing in a value of `true` is a symbolic agreement with the browser that the web app will show a notification every time a push is received (i.e. no silent push).

At the moment you **must** pass in a value of `true`. If you don't include the `userVisibleOnly` key or pass in `false` you'll get the following error:

> Chrome currently only supports the Push API for subscriptions that will result in user-visible messages. You can indicate this by calling `pushManager.subscribe({userVisibleOnly: true})` instead. See https://goo.gl/yqv4Q4 for more details.

It's currently looking like blanket silent push will never be implemented in Chrome. Instead, spec authors are exploring the notion of a budget API which will allow web apps a certain number of silent push messages based on the usage of a web app.

Firefox doesn't require `userVisibleOnly`, however Firefox does have some notion of a budget behind the scenes but there isn't much detail beyond it expiring `PushSubscription`'s if the budget it gets too low. This is most likely calculated by the number of interactions a user has with notifications displayed.

applicationServerKey Option

We briefly mentioned the notion "application server keys" in the previous section. "Application server keys" are used by a push service to identify the application subscribing a user and ensure that the same application is messaging that user.

Application server keys are a public and private key pair that are unique to your application. The private key should be kept a secret to your application and the public key can be shared freely.

The `applicationServerKey` option passed into the `subscribe()` call is the application's public key. The browser passes this onto a push service when subscribing the user, meaning the push service can tie your application's public key to the user's `PushSubscription`.

The diagram below illustrates these steps.

1. Your web app is loaded in a browser and you call `subscribe()`, passing in your public application server key.
2. The browser then makes a network request to a push service who will generate an endpoint, associate this endpoint with the applications public key and return the endpoint to the browser.
3. The browser will add this endpoint to the `PushSubscription`, which is returned via the `subscribe()` promise.

When you later want to send a push message, you'll need to create an **Authorization** header which will contain information signed with your application server's **private key**. When the push service receives a request to send a push message, it can validate this signed **Authorization** header by looking up the public key linked to the endpoint receiving the request. If the signature is valid the push service knows that it must have come from the application server with

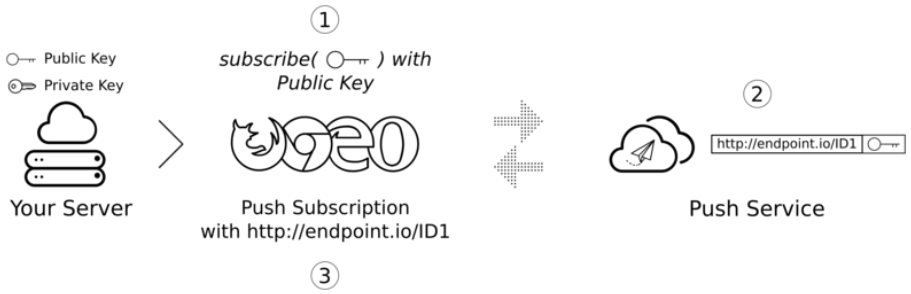


Figure 5: Illustration of the public application server key is used in subscribe method.

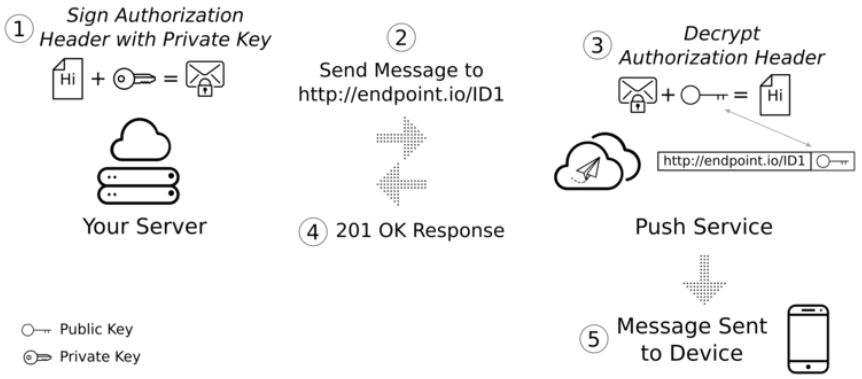


Figure 6: Illustration of how the private application server key is used when sending a message.

the **matching private key**. It's basically a security measure that prevents anyone else sending messages to an application's users.

Technically, the `applicationServerKey` is optional. However, the easiest implementation on Chrome requires it, and other browsers may require it in the future. It's optional on Firefox.

The specification that defines *what* the application server key should be is the VAPID spec. Whenever you read something referring to *"application server keys"* or *"VAPID keys"*, just remember that they are the same thing.

How to Create Application Server Keys You can create a public and private set of application server keys by visiting web-push-codelab.glitch.me or you can use the web-push command line to generate keys by doing the following:

```
$ npm install -g web-push
$ web-push generate-vapid-keys
```

You only need to create these keys once for your application, just make sure you keep the private key private. (Yeah I just said that.)

Permissions and subscribe()

There is one side effect of calling `subscribe()`. If your web app doesn't have permissions for showing notifications at the time of calling `subscribe()`, the browser will request the permissions for you. This is useful if your UI works with this flow, but if you want more control (and I think most developers will), stick to the `Notification.requestPermission()` API that we used earlier.

What is a PushSubscription?

We call `subscribe()`, pass in some options, and in return we get a promise that resolves to a `PushSubscription` resulting in some code like so:

```
function subscribeUserToPush() {
  return getSWRegistration()
  .then(function(registration) {
    const subscribeOptions = {
      userVisibleOnly: true,
      applicationServerKey: urlBase64ToUint8Array(
        'BEl62iUYgUivxIkv69yViEuiBIa-Ib9-SkvMeAtA3LFgDzkrxZJjSgSnfckjBJuBkr3qBUYIHBQFLXYp5Nk
      )
    };
```

```
    return registration.pushManager.subscribe(subscribeOptions);
  })
  .then(function(pushSubscription) {
    console.log('Received PushSubscription: ', JSON.stringify(pushSubscription));
    return pushSubscription;
  });
}
```

The `PushSubscription` object contains all the required information needed to send a push messages to that user. If you print out the contents using `JSON.stringify()`, you'll see the following:

```
{
  "endpoint": "https://some.pushservice.com/something-unique",
  "keys": {
    "p256dh": "BIPUL12DLfytvTajnryr2PRdAgXS3HGKiLqndGcJGabyhHheJYlNGCeXl1dn18gSJ1WAkAPIxr4gK
    "auth":"FPssNDTKnInHVndSTdbKFw=="
  }
}
```

The `endpoint` is the push services URL. To trigger a push message, make a POST request to this URL.

The `keys` object contains the values used to encrypt message data sent with a push message (which we'll discuss later on in this book).

Send a Subscription to Your Server

Once you have a push subscription you'll want to send it to your server. It's up to you how you do that but a tiny tip is to use `JSON.stringify()` to get all the necessary data out of the subscription object. Alternatively you can piece together the same result manually like so:

```
const subscriptionObject = {
  endpoint: pushSubscription.endpoint,
  keys: {
    p256dh: pushSubscription.getKeys('p256dh'),
    auth: pushSubscription.getKeys('auth')
  }
};

// The above is the same output as:

const subscriptionObjectToo = JSON.stringify(pushSubscription);
```

In the demo referenced throughout this book, we make a POST request to send a subscription to our node server that stores the subscription in a database.

Sending the subscription is done in the web page like so:

```
function sendSubscriptionToBackEnd(subscription) {
  return fetch('/api/save-subscription/', {
    method: 'POST',
    headers: {
      'Content-Type': 'application/json'
    },
    body: JSON.stringify(subscription)
  })
  .then(function(response) {
    if (!response.ok) {
      throw new Error('Bad status code from server.');
    }

    return response.json();
  })
  .then(function(responseData) {
    if (!(responseData.data && responseData.data.success)) {
      throw new Error('Bad response from server.');
    }
  });
}
```

The node server receives this request and saves the data to a database for use later on.

```
app.post('/api/save-subscription/', function (req, res) {
  if (!isValidSaveRequest(req, res)) {
    return;
  }

  return saveSubscriptionToDatabase(req.body)
  .then(function(subscriptionId) {
    res.setHeader('Content-Type', 'application/json');
    res.send(JSON.stringify({ data: { success: true } }));
  })
  .catch(function(err) {
    res.status(500);
    res.setHeader('Content-Type', 'application/json');
    res.send(JSON.stringify({
      error: {
        id: 'unable-to-save-subscription',
```

```
        message: 'The subscription was received but we were unable to save it to our databas
      }
    }));
  });
});
```

With the `PushSubscription` details on our server we are good to send our user a message whenever we want.

FAQs

A few common questions people have asked at this point:

> Can I change the push service a browser uses?

No. The push service is selected by the browser and as we saw with the `subscribe()` call, the browser will make network requests to the push service to retrieve the details that make up the *PushSubscription*.

> Each browser uses a different Push Service, don't they have different API's?

All push services will expect the same API.

This common API is called the Web Push Protocol and describes the network request your application will need to make to trigger a push message.

> If I subscribe a user on their desktop, are they subscribed on their phone as well?

Unfortunately not. A user must register for push on each browser they wish to receive messages on. It's also worth noting that this will require the user granting permission on each device.

Permission UX

The natural step after getting a `PushSubscription` and saving it our server is to trigger a push message, but there is one thing I flagrantly glossed over. The user experience when asking for permission from the user to send them push messages.

Sadly, very few sites give much consideration as to how they ask their user for permission, so let's take a brief aside to look at both good and bad UX.

Common Patterns

There have been a few common patterns emerging that should guide and help you when deciding what is best for your users and use case.

Value Proposition

Ask users to subscribe to push at a time when the benefit is obvious.

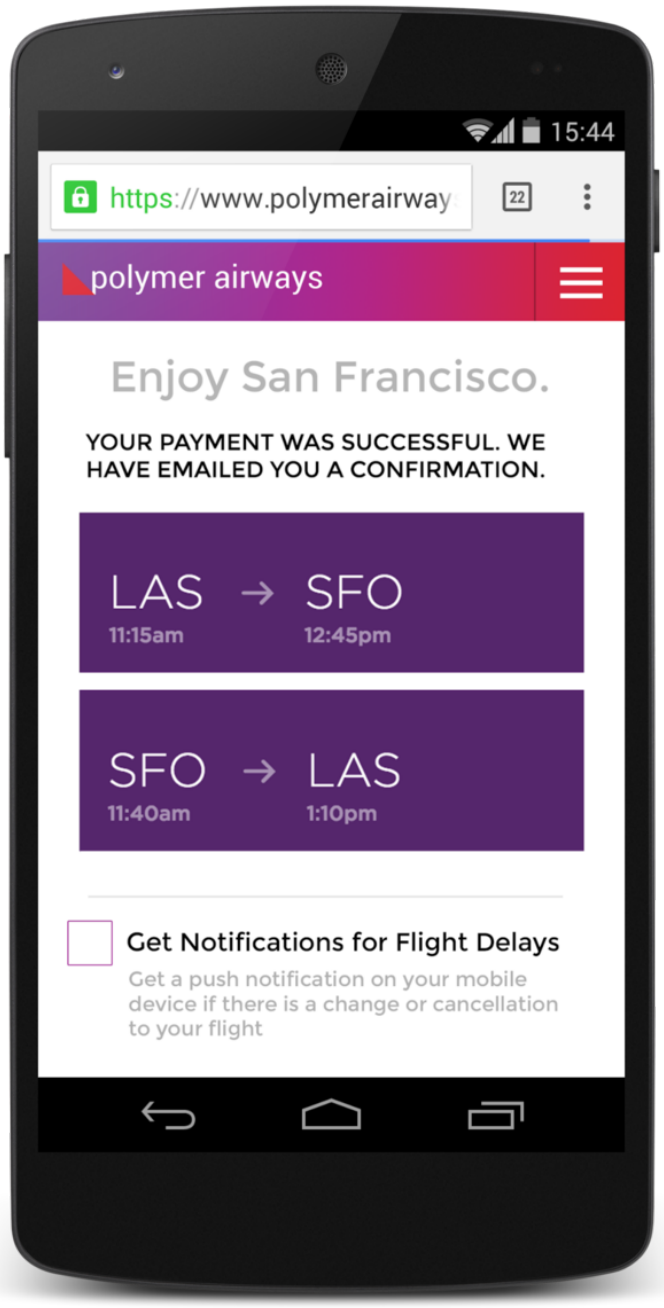
For example, a user has just bought an item on an online store and finished the checkout flow. The site can then offer updates on the delivery status.

There are a range of situations where this approach works: - A particular item is out of stock, would you like to be notified when it's next available? - This breaking news story will be regularly updated, would you like to be notified as the story develops? - You're the highest bidder, would you like to be notified if you are outbid?

These are all points where the user has invested in your service and there is a clear value proposition for them to enable push notifications.

Owen Campbell-Moore created a mock of a hypothetical airline website to demonstrate this approach.

After the user has booked a flight it asks if the user would like notifications in case of flight delays.

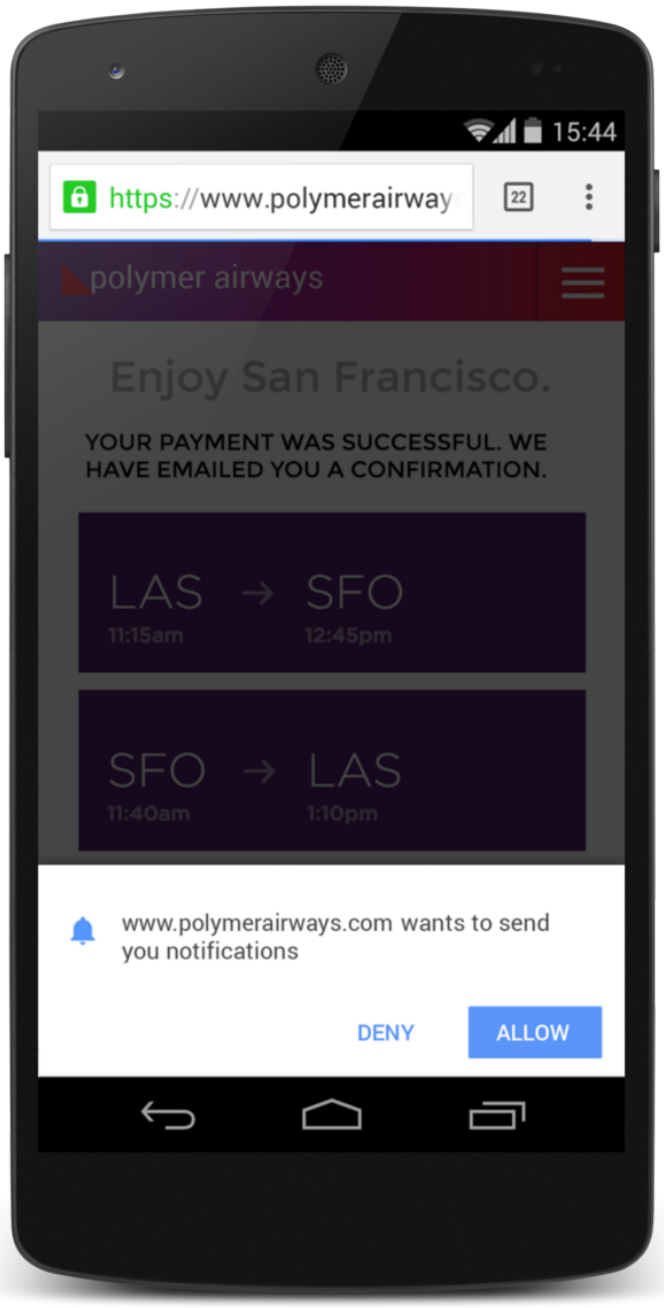

15:44
https://www.polymerairway
22
polymer airways
Enjoy San Francisco.
YOUR PAYMENT WAS SUCCESSFUL. WE HAVE EMAILED YOU A CONFIRMATION.
LAS → SFO
11:15am 12:45pm
SFO → LAS
11:40am 1:10pm
Get Notifications for Flight Delays
Get a push notification on your mobile device if there is a change or cancellation to your flight

{:

.device-image .center-image }

Note that this is a custom UI from the website.

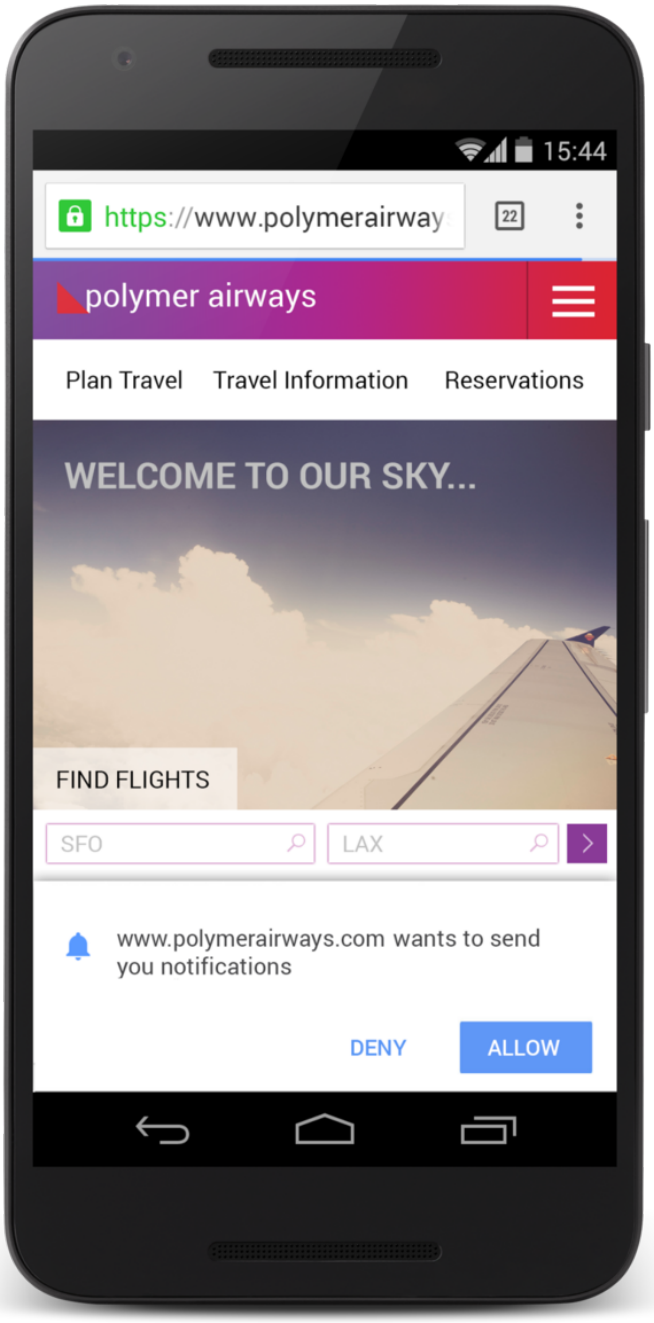
Another nice touch to Owen's demo is that if the user clicks to enable notifications, the site adds a semi-transparent overlay over the entire page when it shows the permission prompt. This draws the users attention to the permission prompt.


15:44
https://www.polymerairway
22
polymer airways
Enjoy San Francisco.
YOUR PAYMENT WAS SUCCESSFUL. WE HAVE EMAILED YOU A CONFIRMATION.
LAS → SFO
11:15am 12:45pm
SFO → LAS
11:40am 1:10pm
www.polymerairways.com wants to send you notifications
DENY
ALLOW

{:

.device-image .center-image }

The alternative to this example, the **bad UX** for asking permission, is to request permission as soon as a user lands on the airline's site.


15:44
https://www.polymerairway
22
polymer airways
Plan Travel
Travel Information
Reservations
WELCOME TO OUR SKY...
FIND FLIGHTS
SFO
LAX
www.polymerairways.com wants to send you notifications
DENY
ALLOW

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This approach provides no context as to why notifications are needed or useful to the user. The user is also blocked from achieving their original task (i.e. book a flight) by this permission prompt.

Double Permission

You may feel that your site has a clear use case for push messaging and as a result want to ask the user for permission as soon as possible.

For example instant messaging and email clients. Showing a message for a new message or email is an established user experience across a range of platforms.

For these category of apps, it's worth considering the double permission pattern.

With this approach you display a custom permission prompt in your web app which asks the user to enable notifications. By doing this the user can chose enable or disable without your website running the risk of being permanently blocked. If the user selects enable on the custom UI, display the actual permission prompt, otherwise hide your custom pop-up and ask some other time.

A good example of this is Slack. They show a prompt at the top of their page once you've signed in asking if you'd like to enable notifications.

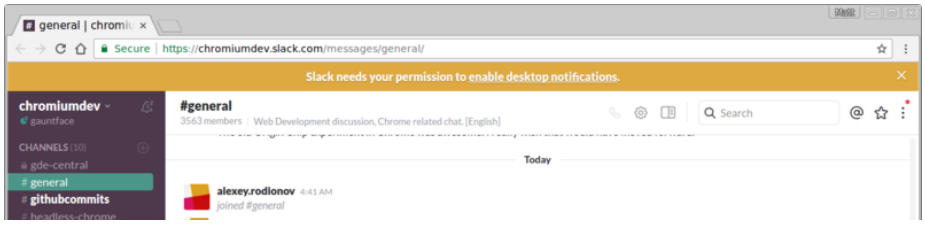


Figure 7: Example of slack.com showing custom banner for permission to show notifications.

If the user clicks accept, the actual permission prompt is shown:

I was also a big fan of Slacks first notification when you allow the permission.

Settings Panel

You can move notifications into a settings panel, giving users an easy way to enable and disable push messaging, without the need of cluttering your web app's UI.

A good example of this is Google I/O's 2016 site. When you first load up the Google I/O site, you aren't asked to do anything, the user is left to explore the site.

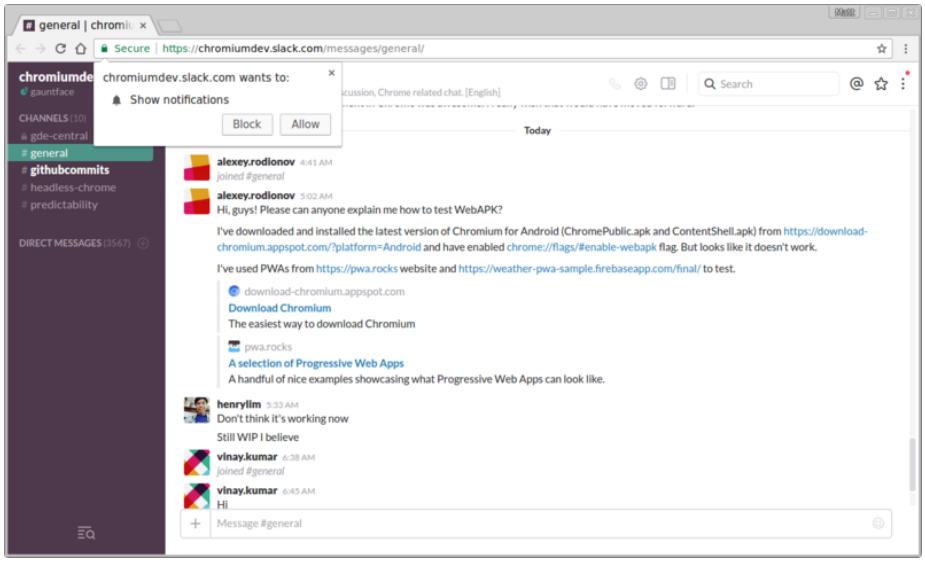


Figure 8: Actual permission prompt on slack.com.

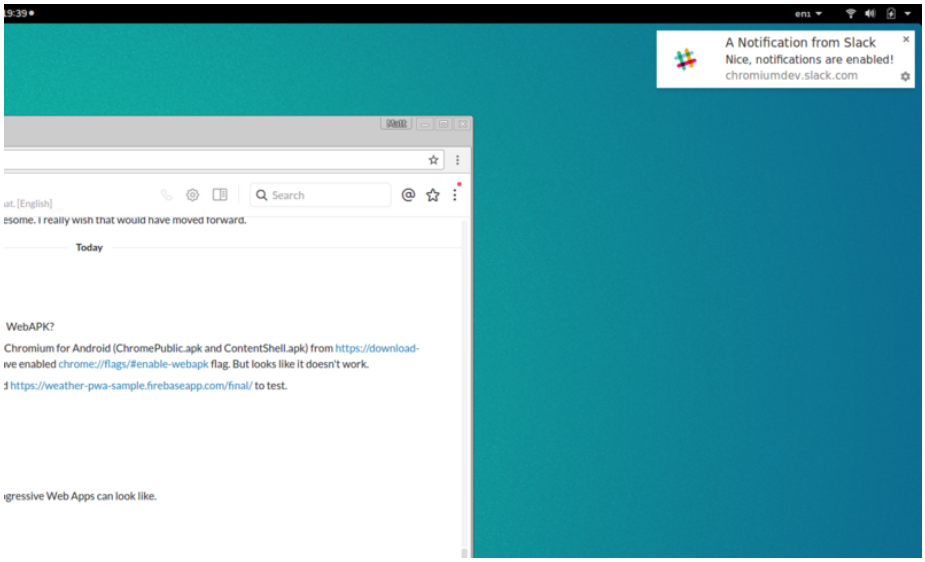
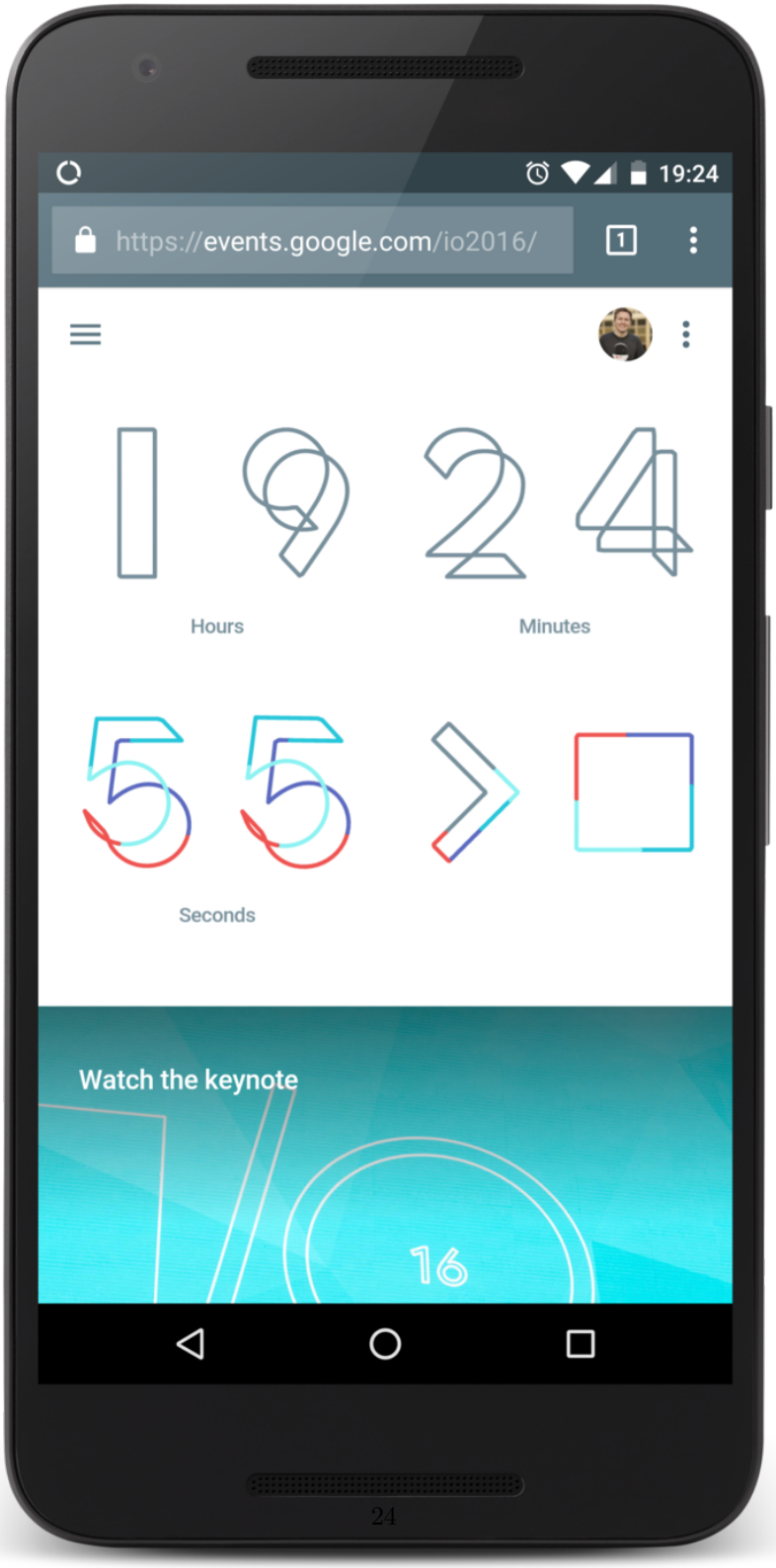


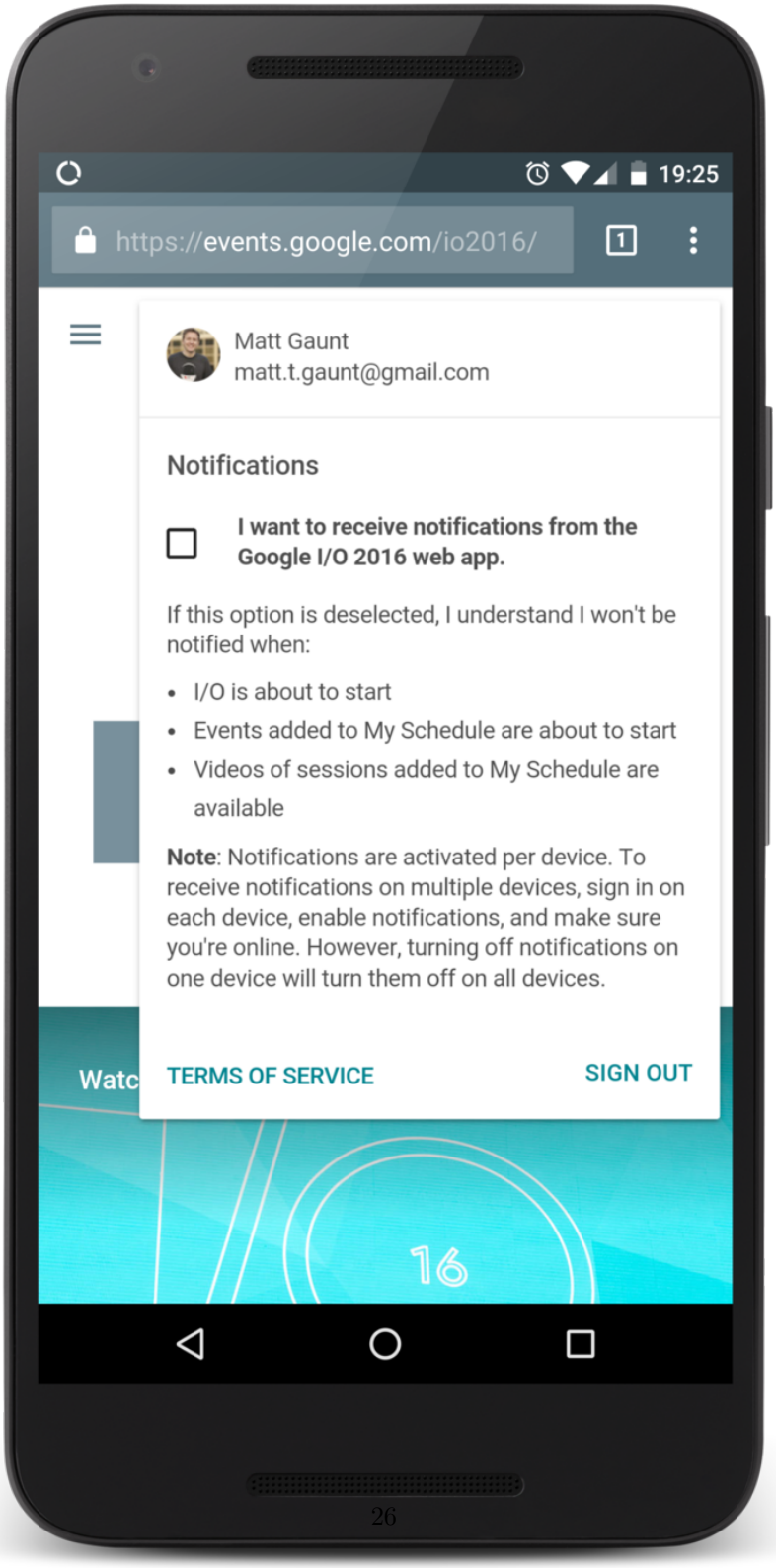
Figure 9: Cute "It's working" notification from slack.com.


19:24
https://events.google.com/io2016/
1
19
24
Hours
Minutes
55
Seconds
Watch the keynote
16

{:

.device-image .center-image }

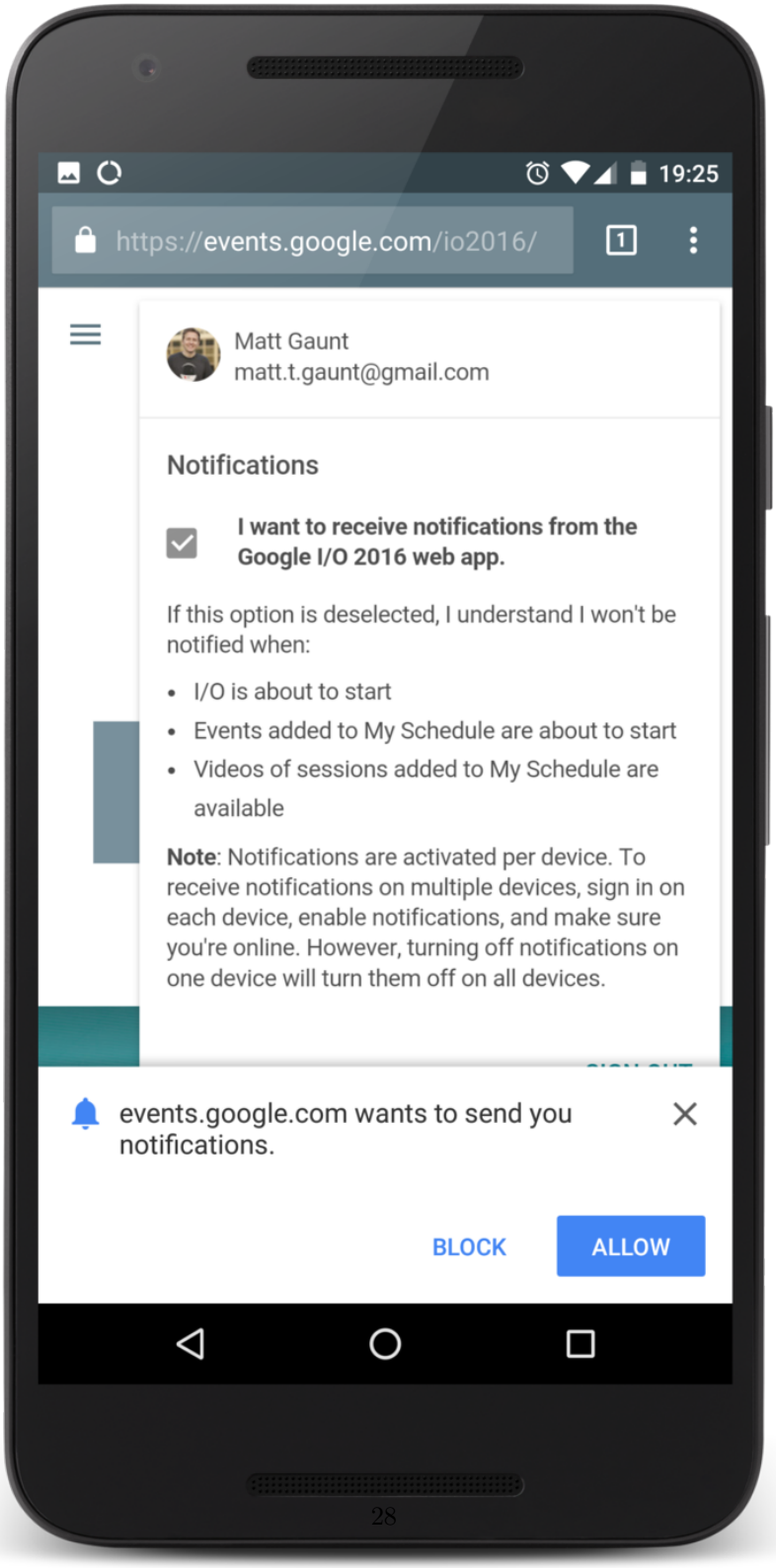
After a few visits, clicking the menu item on the right reveals a settings panel allowing the user to set up and manage notifications.


19:25
https://events.google.com/io2016/
Matt Gaunt
matt.t.gaunt@gmail.com
Notifications
I want to receive notifications from the Google I/O 2016 web app.
If this option is deselected, I understand I won't be notified when:
I/O is about to start
Events added to My Schedule are about to start
Videos of sessions added to My Schedule are available
Note: Notifications are activated per device. To receive notifications on multiple devices, sign in on each device, enable notifications, and make sure you're online. However, turning off notifications on one device will turn them off on all devices.
TERMS OF SERVICE
SIGN OUT
16

{:

.device-image .center-image }

Clicking on the checkbox displays the permission prompt. No hidden surprises.


19:25
https://events.google.com/io2016/
Matt Gaunt
matt.t.gaunt@gmail.com
Notifications
I want to receive notifications from the Google I/O 2016 web app.
If this option is deselected, I understand I won't be notified when:
I/O is about to start
Events added to My Schedule are about to start
Videos of sessions added to My Schedule are available
Note: Notifications are activated per device. To receive notifications on multiple devices, sign in on each device, enable notifications, and make sure you're online. However, turning off notifications on one device will turn them off on all devices.
events.google.com wants to send you notifications.
BLOCK
ALLOW

{:

.device-image .center-image }

After the permission has been granted the checkbox is checked and the user is good to go. The great thing about this UI is that users can enable and disable notifications from one location on the website.

Slack also does a good job at giving users control over their notifications. They offer a host of options allowing users to customise the notifications they receive.

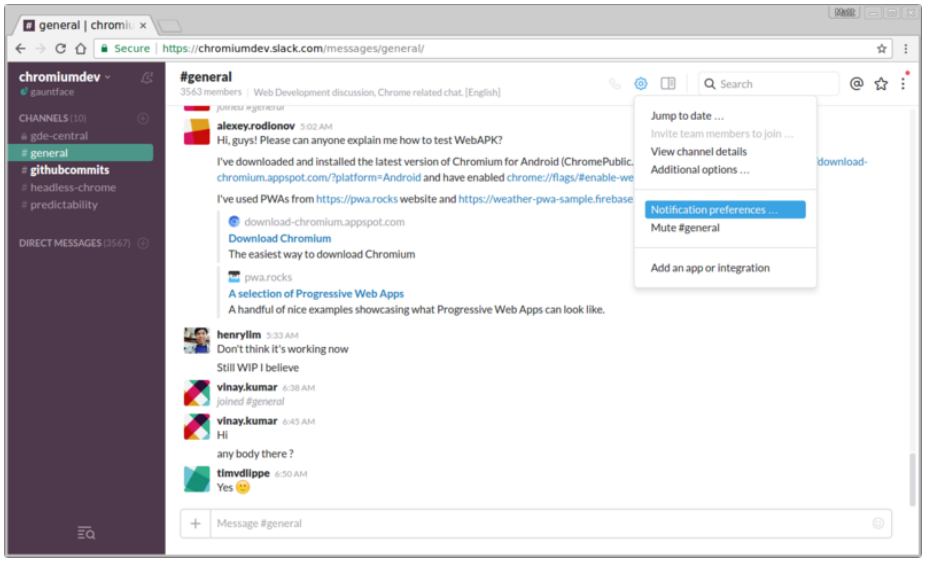


Figure 10: The notification preferences on slack.com easily found under settings drop down.

Passive Approach

One of the easiest ways to offer push to a user is to have a button or toggle switch that enables / disables push messages in a location on the page that is consistent throughout a site.

This doesn't drive users to enable push notifications, but offers a reliable and easy way for users to opt in and out of engaging with your website. For sites like blogs that might have some regular viewers as well as high bounce rates, this is a solid option as it targets regular viewers without annoying drive-by visitors.

On my personal site I have a toggle switch for push messaging in the footer.

It's fairly out of the way, but for regular visitors it should get enough attention from readers wanting to get updates. One-time visitors are completely unaffected.

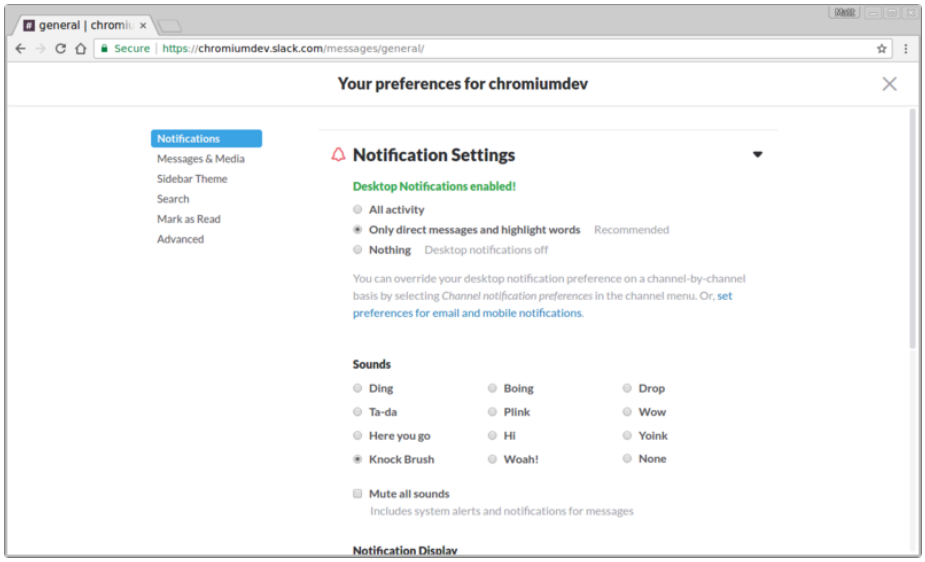


Figure 11: The settings panel for notifications on slack.com.

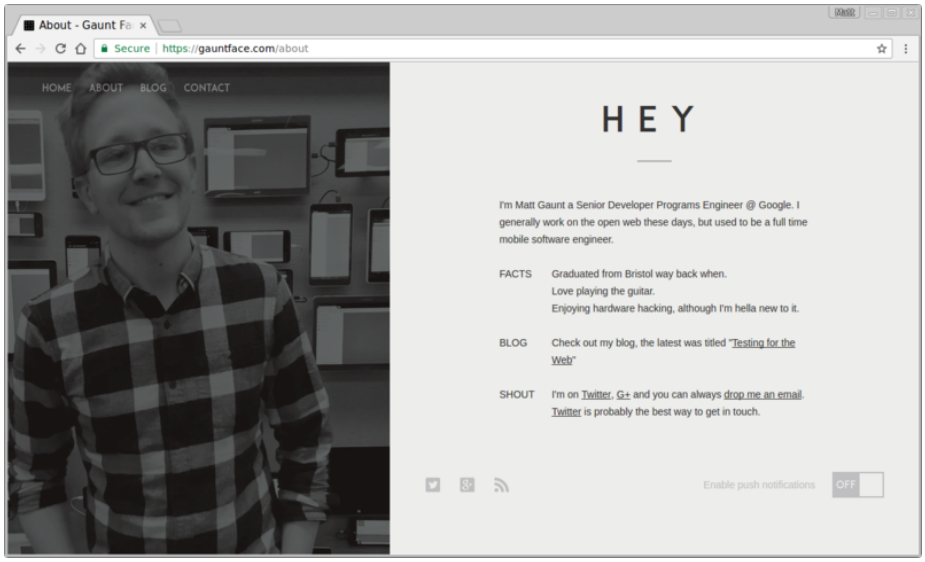


Figure 12: Example of Gauntface.com push notification toggle in footer.

If the user subscribes to push messaging, the state of the toggle switch changes and maintains state throughout the site.

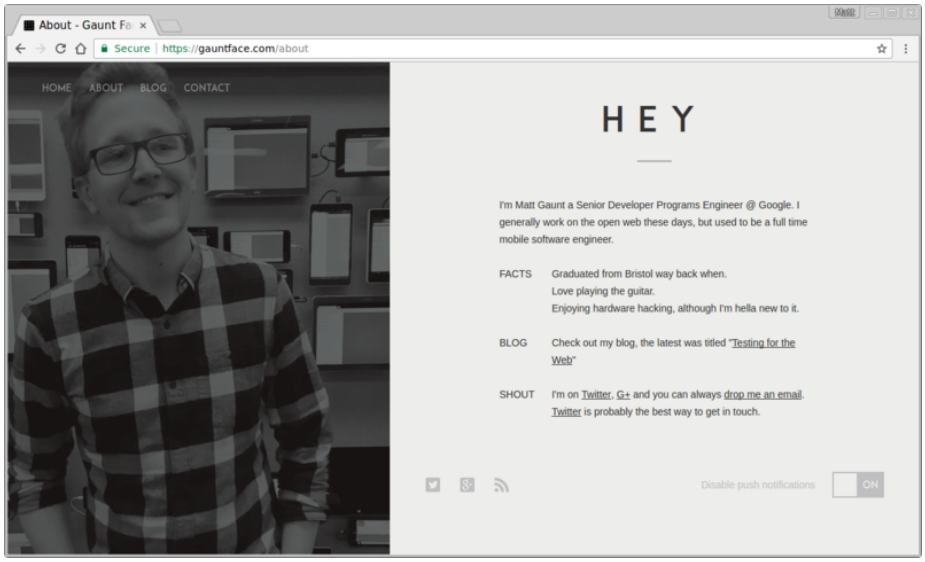


Figure 13: Example of Gauntface.com with notifications enabled.

The Bad UX

Those are some of the common practices I've noticed on the web. Sadly, there is one very common bad practice.

The worst thing you can do is instantly show the permission dialog to users as soon as they land on your site.

They have zero context on why they are being asked for a permission, they may not even know what your website is for, what it does or what it offers. Blocking permissions at this point out of frustration is not uncommon, this pop-up is getting in the way of what they are trying to do.

Remember, if the user *blocks* the permission request, your web app can't ask for permission again. To get permission after being blocked the user has to change the permission in the browsers UI and doing so is not easy, obvious or fun for the user.

No matter what, don't ask for permission as soon as the user opens your site, consider some other UI or approach that has an incentive for the user to grant permission.

Offer a Way Out

In addition to considering the UX to subscribe a user to push, **please** consider how a user should unsubscribe or opt out of push messaging.

The number of sites that ask for permission as soon as the page load and then offers no UI for disabling push notifications is astounding.

Vice News is an example of this practice. (p.s. sorry Vice for using you as an example, you were first site I recalled doing this, although I believe it's fixed now.)

When you land on Vice News you'd get the permission prompt. This isn't the end of the world, but it does offend the senses.

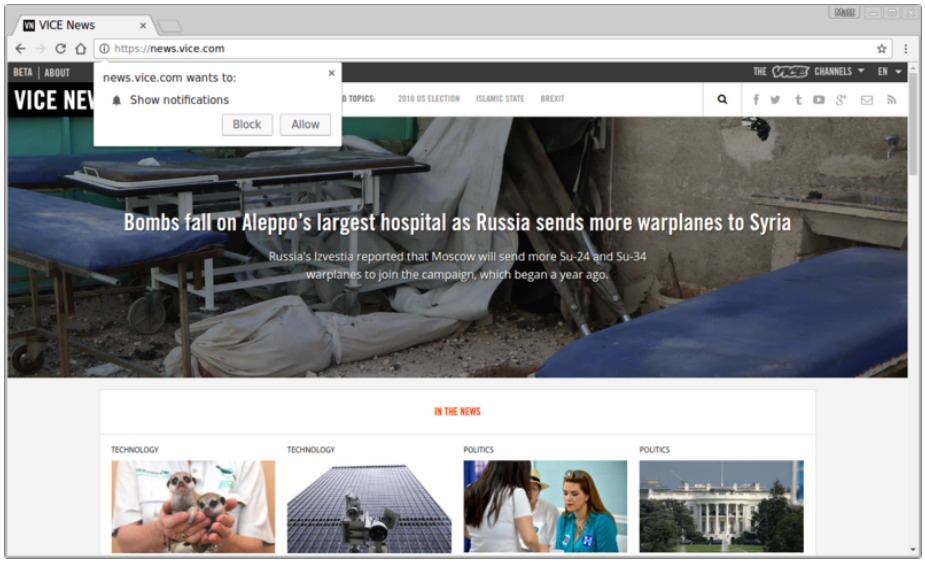


Figure 14: Vice news instantly asks for permission.

If you allow notifications, where would you go to disable them? The websites UI doesn't change at all.

This UX pushes the responsibility of notification management onto the browser, which frankly is awful in Chrome.

As a result, sites are getting users signed up, then forcing them to trial and error their way through the browser UX to disable notifications.

If you're curious what the Browser UX is for disabling push, the desktop has two options. You can visit the web page and click the padlock in the URL bar to configure permissions.

If the web page is closed, users can click the cog on a notification, which takes the user to this page in the settings of Chrome.

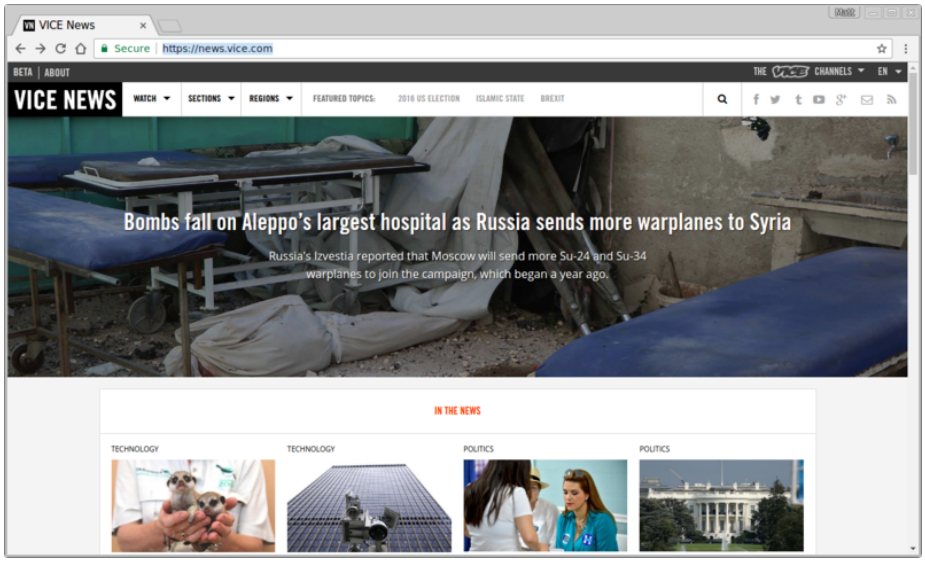


Figure 15: Vice news after granting permission.

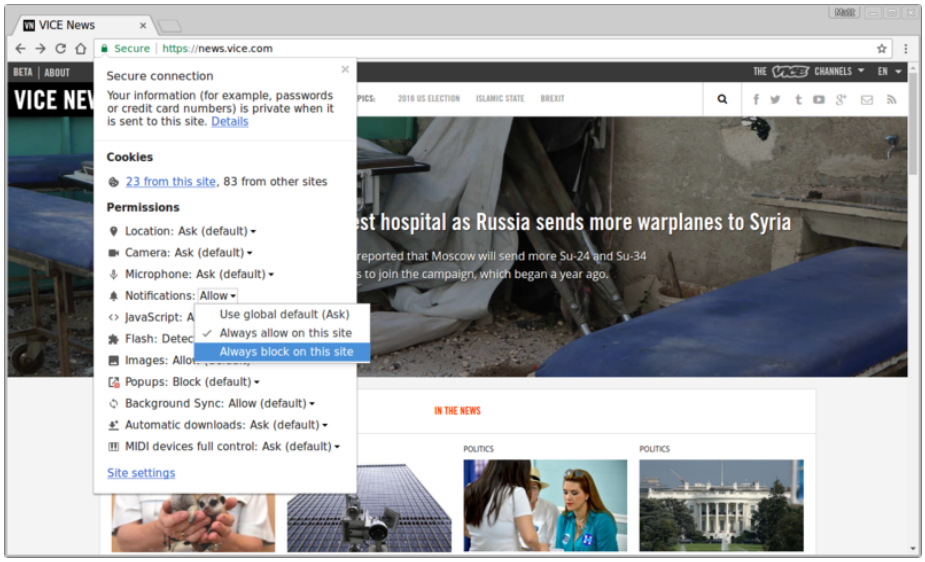


Figure 16: Chrome Notification Permissions from URL Bar.

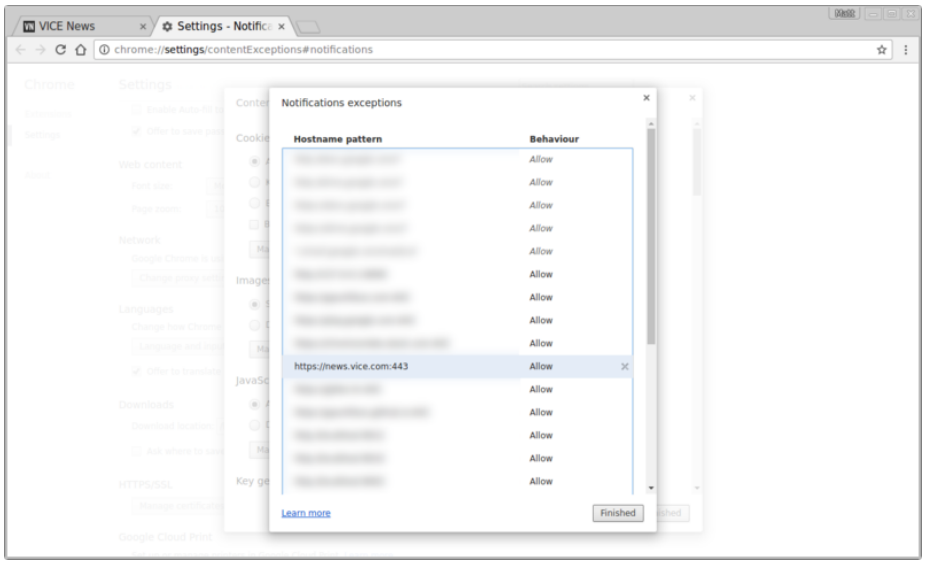


Figure 17: Chrome Notification Permissions from URL Bar.

Neither of these options are particularly pleasant for the user.

Your site should explain to your users how they can disable push. If you don't, users are likely to take the nuclear option and block permission permanently.

Sending Messages with Web Push Libraries

One of the pain points when working with web push is that trigger a push message is extremely "fiddly". To trigger a push message an application needs to make a POST request to a push service following the web push protocol. To use push across all browsers you need to use VAPID (a.k.a application server keys) which basically requires setting a header with a value proving your application can message a user. To send data with a push message, the data needs to be encrypted and specific headers added so the browser can decrypt the message correctly.

The main issue with triggering push is that if you hit a problem, it's difficult to diagnose the issue. This is improving with time and wider browser support but it's far from easy. For this reason, I strongly recommend using a library to handle the encryption, formatting and triggering of your push message.

If you really want to learn about what the libraries do and look at each closer, we'll cover it in the next section. For now, we are going to look at how to manage subscriptions and use an existing web-push library to make the push requests.

In this section we'll be using the web-push for Node library. Other languages will have differences, but they won't be too dissimilar. We are looking at Node since it's JavaScript and should be the most accessible for readers.

> **Remember**: If you want a library for a different language, checkout the web-push-libs org on Github.

We'll go through the following steps:

1. Send a subscription to our backend and save it.
2. Retrieve saved subscriptions and trigger a push message.

Saving Subscriptions

Saving and querying `PushSubscriptions` from a database will vary depending on your server side language and database choice but it might be useful to see an example of how it could be done.

In the demo web page the `PushSubscription` is sent to our backend by making a simple POST request:

```
function sendSubscriptionToBackEnd(subscription) {
  return fetch('/api/save-subscription/', {
    method: 'POST',
    headers: {
      'Content-Type': 'application/json'
    },
    body: JSON.stringify(subscription)
  })
  .then(function(response) {
    if (!response.ok) {
      throw new Error('Bad status code from server.');
    }

    return response.json();
  })
  .then(function(responseData) {
    if (!(responseData.data && responseData.data.success)) {
      throw new Error('Bad response from server.');
    }
  });
}
```

The Express server in our demo has a matching request listener for `/api/save-subscription/` endpoint:

```
app.post('/api/save-subscription/', function (req, res) {
```

In this route we validate the subscription, just to make sure the request is ok and not full of garbage:

```
const isValidSaveRequest = (req, res) => {
  // Check the request body has at least an endpoint.
  if (!req.body || !req.body.endpoint) {
    // Not a valid subscription.
    res.status(400);
    res.setHeader('Content-Type', 'application/json');
    res.send(JSON.stringify({
      error: {
        id: 'no-endpoint',
        message: 'Subscription must have an endpoint.'
      }
    }));
    return false;
  }
  return true;
};
```

> In this route we only check for an endpoint. If you **require** payload support, make sure you check for the auth and p256dh keys as well.

If the subscription is valid, we need to save it and return an appropriate JSON response:

```
  return saveSubscriptionToDatabase(req.body)
  .then(function(subscriptionId) {
    res.setHeader('Content-Type', 'application/json');
    res.send(JSON.stringify({ data: { success: true } }));
  })
  .catch(function(err) {
    res.status(500);
    res.setHeader('Content-Type', 'application/json');
    res.send(JSON.stringify({
      error: {
        id: 'unable-to-save-subscription',
        message: 'The subscription was received but we were unable to save it to our databas
      }
    }));
  });
```

This demo uses nedb to store the subscriptions, it's a simple file based database, but you could use any database you chose. We are only using this as it requires zero set-up. For production you'd want to use something more reliable (I tend to stick with good old MySQL).

```
function saveSubscriptionToDatabase(subscription) {
  return new Promise(function(resolve, reject) {
    db.insert(subscription, function(err, newDoc) {
      if (err) {
        reject(err);
        return;
      }

      resolve(newDoc._id);
    });
  });
};
```

Sending Push Messages

When it comes to sending a push message we ultimately need some event to trigger the process of sending a message to users. A common approach would be creating an admin page that let's you configure and trigger the push message. But you could create a program to run locally or any other approach that allows accessing the list of `PushSubscriptions` and running the code to trigger the push message.

Our demo has an "admin like" page that lets you trigger a push. Since it's just a demo it's a public page.

I'm going to go through each step involved in getting the demo working. These will be baby steps to everyone following along, including anyone who is new to Node.

When we discussed subscribing a user we covered adding an `applicationServerKey` to the `subscribe()` options. It's on the back end that we'll need the private key.

> Remember you can use the web-push tool to generate application server keys or use https://web-push-codelab.glitch.me to generate some application server keys. See "How to Create Application Server Keys" for more details.

In the demo these values are added to our Node app like so (boring code I know, but just want you to know there is no magic):

```
const vapidKeys = {
  publicKey: 'BEl62iUYgUivxIkv69yViEuiBIa-Ib9-SkvMeAtA3LFgDzkrxZJjSgSnfckjBJuBkr3qBUYIHBQFLX
  privateKey: 'UUxI4O8-FbRouAevSmBQ6o18hgE4nSG3qwvJTfKc-ls'
};
```

Next we need to install the `web-push` module for our Node server:

```
npm install web-push --save
```

Then in our Node script we require in the `web-push` module like so:

```
const webpush = require('web-push');
```

Now we can start to use the `web-push` module. First we need to tell the web-push module about our application server keys (remember they are also known as VAPID keys because that's the name of the spec).

```
const vapidKeys = {
  publicKey: 'BEl62iUYgUivxIkv69yViEuiBIa-Ib9-SkvMeAtA3LFgDzkrxZJjSgSnfckjBJuBkr3qBUYIHBQFLX
  privateKey: 'UUxI4O8-FbRouAevSmBQ6o18hgE4nSG3qwvJTfKc-ls'
};

webpush.setVapidDetails(
  'mailto:web-push-book@gauntface.com',
  vapidKeys.publicKey,
  vapidKeys.privateKey
);
```

We also include a "mailto:" string as well. This string needs to be either a URL or a mailto email address. This piece of information will actually be sent to web push service as part of the request to trigger a push. The reason this is done is so that if a web push service needs to get in touch, they have some information that will enable them to.

With this, the `web-push` module is ready to use, the next step is to trigger a push message.

The demo uses the pretend admin panel to trigger push messages.

Clicking the "Trigger Push Message" button will make a POST request to `/api/trigger-push-msg/` which is the signal for our backend to start send push messages, so we create the route in express for this endpoint:

```
app.post('/api/trigger-push-msg/', function (req, res) {
```

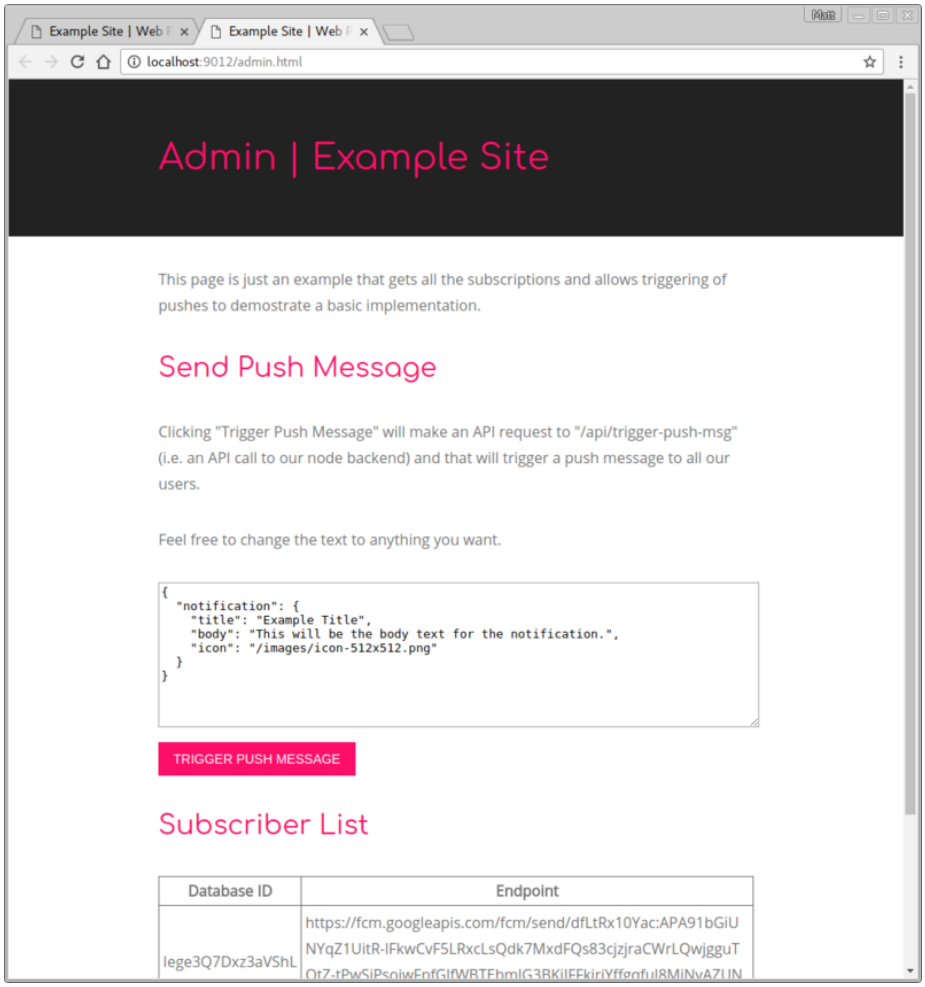


Figure 18: Screenshot of the Admin Page.

When this request is received, we grab the subscriptions from the database and for each one, we trigger a push message.

```
  return getSubscriptionsFromDatabase()
  .then(function(subscriptions) {
    let promiseChain = Promise.resolve();

    for (let i = 0; i < subscriptions.length; i++) {
      const subscription = subscriptions[i];
      promiseChain = promiseChain.then(() => {
        return triggerPushMsg(subscription, dataToSend);
      });
    }

    return promiseChain;
  })
```

The function `triggerPushMsg()` can then use the web-push library to send a message to the provided subscription.

```
const triggerPushMsg = function(subscription, dataToSend) {
  return webpush.sendNotification(subscription, dataToSend)
  .catch((err) => {
    if (err.statusCode === 410) {
      return deleteSubscriptionFromDatabase(subscription._id);
    } else {
      console.log('Subscription is no longer valid: ', err);
    }
  });
};
```

The call to `webpush.sendNotification()` will return a promise. If the message was sent successfully the promise will resolve and there is nothing we need to do. If the promise rejects, you need to examine the error as it'll inform you as to whether the PushSubscription is still valid or not.

To determine the type of error from a push service it's best to look at the status code. Error messages vary between push services and some are more helpful than others.

In this example it checks for status code '404' and '410', which are the HTTP status codes for 'Not Found' and 'Gone'. If we receive this status code, it means the subscription has expired or is no longer valid. In these scenarios we need remove the subscriptions from our database.

We'll cover some of the other status codes in the next section when we look at the web push protocol in more detail.

> If you hit problems at this stage, it's worth looking at the error logs from Firefox before Chrome. The Mozilla push service has much more helpful error messages compared to Chrome / FCM.

After looping through the subscriptions, we need to return a JSON response.

```
.then(() => {
  res.setHeader('Content-Type', 'application/json');
    res.send(JSON.stringify({ data: { success: true } }));
})
.catch(function(err) {
  res.status(500);
  res.setHeader('Content-Type', 'application/json');
  res.send(JSON.stringify({
    error: {
      id: 'unable-to-send-messages',
      message: `We were unable to send messages to all subscriptions : ` +
        `'${err.message}'`
    }
  }));
});
```

We've gone over the major implementation steps.

1. Create an API to send subscriptions from our web page to our back-end so it can save them to a database.
2. Create an API to trigger the sending of push messages (in this case an API called from the pretend admin panel).
3. Retrieve all the subscriptions from our backend and send a message to each subscription with one of the web-push libraries.

Regardless of your backend (Node, PHP, Python, …) the steps for implementing push are going to be the same.

Next up, what exactly are these web-push libraries doing for us?

The Web Push Protocol

We've seen how a library can be used to trigger push messages, but what exactly are these libraries doing?

Well, they're making network requests while ensuring such requests are the right format. The spec that defines this network request is the Web Push Protocol.

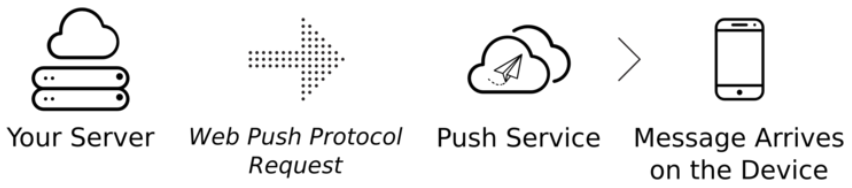


Figure 19: Diagram of sending a push message from your server to a push service.

This section outlines how the server can identify itself with application server keys and how the encrypted payload and associated data is sent.

This isn't a pretty side of web push and I'm no expert at encryption, but let's look through each piece since it's handy to know what these libraries are doing under the hood.

Application Server Keys

When we subscribe a user, we pass in an `applicationServerKey`. This key is passed to the push service and used to check that the application that subscribed the user is also the same application that is triggering push messages.

When we trigger a push message, there are a set of headers that we send that allow the push service to authenticate the application. (This is defined by the VAPID spec.)

What does all this actually mean and what exactly happens? Well these are the steps taken for application server authentication:

1. The application server signs some JSON information with it's **private application key**.
2. This signed information is sent to the push service as a header in a POST request.
3. The push service uses the stored public key it received from `pushManager.subscribe()` to check the received information is signed by the private key relating to the public key. *Remember*: The public key is the `applicationServerKey` passed into the subscribe call.
4. If the signed information is valid the push service sends the push message to the user.

An example of this flow of information is below. (Note the legend in the bottom left to indicate public and private keys.)

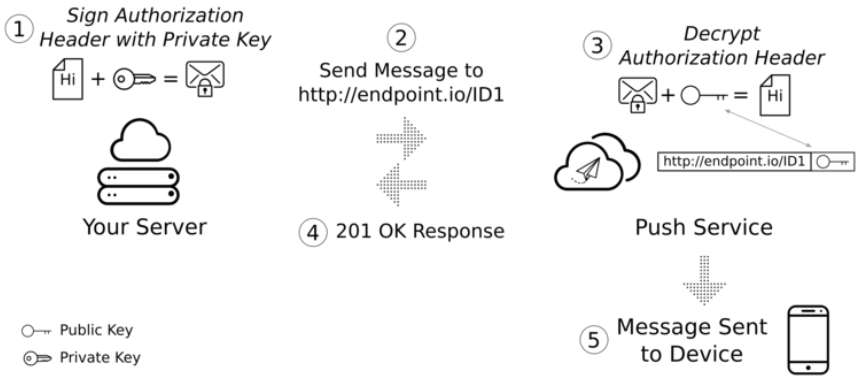


Figure 20: Illustration of how the private application server key is used when sending a message.

The "signed information" added to a header in the request is a JSON Web Token.

JSON Web Token

A JSON web token (or JWT for short) is a way of sending a message to a third party such that the receiver can validate who sent it.

When a third party receives a message, they need to get the senders public key and use it to validate the signature of the JWT. If the signature is valid then the JWT must have been signed with the matching private key so must be from the expected sender.

There are a host of libraries on https://jwt.io/ that can perform the signing for you and I'd recommend you do that where you can. For completeness, let's look at how to manually create a signed JWT.

Web Push and Signed JWTs

A signed JWT is just a string, though it can be thought of as three strings joined by dots.

The first and second strings (The JWT info and JWT data) are pieces of JSON that have been base64 encoded, meaning they're publicly readable.

The first string is information about the JWT itself, indicating which algorithm was used to create the signature.

The JWT info for web push must contain the following information:

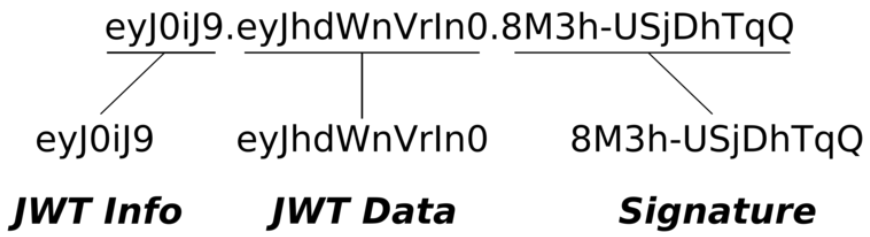


Figure 21: A illustration of the strings in a JSON Web Token

```
{
  "typ": "JWT",
  "alg": "ES256"
}
```

The second string is the JWT Data. This provides information about the sender of the JWT, who it's intended for and how long it's valid.

For web push, the data would have this format:

```
{
  "aud": "https://some-push-service.org",
  "exp": "1469618703",
  "sub": "mailto:example@web-push-book.org"
}
```

The `aud` value is the "audience", i.e. who the JWT is for. For web push the audience is the push service, so we set it to the **origin of the push service**.

The `exp` value is the expiration of the JWT, this prevent snoopers from being able to re-use a JWT if they intercept it. The expiration is a timestamp in seconds and must be no longer 24 hours.

In the Node.js library the expiration is set to `Math.floor(Date.now() / 1000) + (12 * 60 * 60)`. It's 12 hours rather than 24 hours to avoid any issues with clock differences between the sending application and the push service.

Finally, the `sub` value needs to be either a URL or a `mailto` email address. This is so that if a push service needed to reach out to sender, it can find contact info from the JWT. (This is why the web-push library needed an email address).

Just like the JWT Info, the JWT Data is encoded as a URL safe base64 string.

The third string, the signature, is the result of taking the first two strings (the JWT Info and JWT Data), joining them with a dot character, which we'll call the "unsigned token", and signing it.

The signing process requires encrypting the "unsigned token" using ES256. According to the JWT spec, ES256 is short for "ECDSA using the P-256 curve and the SHA-256 hash algorithm". Using web crypto you can create the signature like so:

```
// Utility function for UTF-8 encoding a string to an ArrayBuffer.
const utf8Encoder = new TextEncoder('utf-8');

// The unsigned token is the concatenation of the URL-safe base64 encoded
// header and body.
const unsignedToken = .....;

// Sign the |unsignedToken| using ES256 (SHA-256 over ECDSA).
const key = {
  kty: 'EC',
  crv: 'P-256',
  x: window.uint8ArrayToBase64Url(
    applicationServerKeys.publicKey.subarray(1, 33)),
  y: window.uint8ArrayToBase64Url(
    applicationServerKeys.publicKey.subarray(33, 65)),
 d: window.uint8ArrayToBase64Url(applicationServerKeys.privateKey),
};

// Sign the |unsignedToken| with the server's private key to generate
// the signature.
return crypto.subtle.importKey('jwk', key, {
  name: 'ECDSA', namedCurve: 'P-256',
}, true, ['sign'])
.then((key) => {
  return crypto.subtle.sign({
    name: 'ECDSA',
    hash: {
      name: 'SHA-256',
    },
  }, key, utf8Encoder.encode(unsignedToken));
})
.then((signature) => {
  console.log('Signature: ', signature);
});
```

A push service can validate a JWT using the public application server key to decrypt the signature and make sure the decrypted string is the same as the "unsigned token" (i.e. the first two strings in the JWT).

The signed JWT (i.e. all three strings joined by dots), is sent to the web push service as the `Authorization` header with `WebPush` prepended, like so:

```
Authorization: 'WebPush <JWT Info>.<JWT Data>.<Signature>'
```

The Web Push Protocol also states the public application server key must be sent in the `Crypto-Key` header as a URL safe base64 encoded string with `p256ecdsa=` prepended to it.

```
Crypto-Key: p256ecdsa=<URL Safe Base64 Public Application Server Key>
```

The Payload Encryption

Next let's look at how we can send a payload with a push message so that when our web app receives a push message, it can access the data it receives.

A common question that arises from any who've used other push services is why does the web push payload need to be encrypted? With native apps, push messages can send data as plain text.

Part of the beauty of web push is that because all push services use the same API (the web push protocol), developers don't have to care who the push service is. We can make a request in the right format and expect a push message to be sent. The downside of this is that developers could conceivably send messages to a push service that isn't trustworthy. By encrypting the payload, push services can't read the data thats sent. Only the browser can decrypt the information. This protects the user's data.

The encryption of the payload is defined in the Message Encryption spec.

Before we look at the specific steps to encrypt a push messages payload, we should cover some techniques that'll be used during the encryption process. (Massive H/T to Mat Scales for his excellent article on push encryption.)

ECDH and HKDF

Both ECDH and HKDF are used throughout the encryption process and offer benefits for the purpose of encrypting information.

ECDH: Elliptic Curve Diffie-Hellman Key Exchange Imagine you have two people who want to share information, Alice and Bob. Both Alice and Bob have their own public and private keys. Alice and Bob share their public keys with each other.

The useful property of keys generated with ECDH is that Alice can use her private key and Bob's public key to create secret value 'X'. Bob can do the same, taking his private key and Alice's public key to independently create the same value 'X'. This makes 'X' a shared secret and Alice and Bob only had to

share their public key. Now Bob and Alice can use 'X' to encrypt and decrypt messages between them.

ECDH, to the best of my knowledge, defines the properties of curves which allow this "feature" of making a shared secret 'X'.

This is a high level explanation of ECDH, if you want to learn more I recommend checking out this video.

In terms of code; most languages / platforms come with libraries to make it easy to generate these keys.

In node we'd do the following:

```
const keyCurve = crypto.createECDH('prime256v1');
keyCurve.generateKeys();

const publicKey = keyCurve.getPublicKey();
const privateKey = keyCurve.getPrivateKey();
```

HKDF: HMAC Based Key Deriviation Function Wikipedia has a succinct description of HKDF:

> HKDF is an HMAC based key derivation function that transforms any weak key material into cryptographically strong key material. It can be used, for example, to convert Diffie Hellman exchanged shared secrets into key material suitable for use in encryption, integrity checking or authentication.
>
> – Wikipedia

Essentially, HKDF will take input that is not particular secure and make it more secure.

The spec defining this encryption requires use of SHA-256 as our hash algorithm and the resulting keys for HKDF in web push should be no longer than 256 bits (32 bytes).

In node this could be implemented like so:

```
// Simplified HKDF, returning keys up to 32 bytes long
function hkdf(salt, ikm, info, length) {
  // Extract
  const keyHmac = crypto.createHmac('sha256', salt);
  keyHmac.update(ikm);
  const key = keyHmac.digest();

  // Expand
```

```
  const infoHmac = crypto.createHmac('sha256', key);
  infoHmac.update(info);

  // A one byte long buffer containing only 0x01
  const ONE_BUFFER = new Buffer(1).fill(1);
  infoHmac.update(ONE_BUFFER);

  return infoHmac.digest().slice(0, length);
}
```

H/T to Mat Scale's article for this example code.

This loosely covers ECDH and HKDF.

ECDH a secure way to share public keys and generate a shared secret. HKDF is a way to take insecure material and make it secure.

This will be used during the encryption of our payload. Next let's look at what we take as input and how that's encrypted.

Inputs

When we want to send a push message to a user with a payload, there are three inputs we need:

1. The payload itself.
2. The `auth` secret from the `PushSubscription`.
3. The `p256dh` key from the `PushSubscription`.

We've seen the `auth` and `p256dh` values being retreieved from a `PushSubscription` but for a quick reminder, given a subscription we'd need these values:

```
subscription.joJSON().keys.auth
subscription.joJSON().keys.p256dh

subscription.getKey('auth')
subscription.getKey('p256dh')
```

The `auth` value should be treated as a secret and not shared outside of your application.

The `p256dh` key is a public key, this is sometimes referred to as the client public key. Here we'll refer to `p256dh` as the subscription public key. The subscription public key is generated by the browser. The browser will keep the private key secret and use it for decrypting the payload.

These three values, `auth`, `p256dh` and `payload` are needed as inputs and the result of the encryption process will be the encrypted payload, a salt value and a public key used just for encrypting the data.

Salt

The salt needs to be 16 bytes of random data. In NodeJS, we'd do the following to create a salt:

```
const salt = crypto.randomBytes(16);
```

Public / Private Keys

The public and private keys should be generated using a P-256 elliptic curve, which we'd do in Node like so:

```
const localKeysCurve = crypto.createECDH('prime256v1');
localKeysCurve.generateKeys();

const localPublicKey = localKeysCurve.getPublicKey();
const localPrivateKey = localKeysCurve.getPrivateKey();
```

We'll refer to these keys as "local keys". They are used *just* for encryption and have *nothing* to do with application server keys.

With the payload, auth secret and subscription public key as inputs and with a newly generated salt and set of local keys, we are ready to actually do some encryption.

Shared Secret

The first step is to create a shared secret using the subscription public key and our new private key (remember the ECDH explanation with Alice and Bob? Just like that).

```
const sharedSecret = localKeysCurve.computeSecret(
  subscription.keys.p256dh, 'base64');
```

This is used in the next step to calculate the Pseudo Random Key (PRK).

Pseudo Random Key

The Pseudo Random Key (PRK) is the combination of the push subscription's auth secret, and the shared secret we just created.

```
const authEncBuff = new Buffer('Content-Encoding: auth\0', 'utf8');
const prk = hkdf(subscription.keys.auth, sharedSecret, authEncBuff, 32);
```

You might be wondering what the `Content-Encoding: auth\0` string is for. In short, it doesn't have a clear purpose, although browsers could decrypt an incoming message and look for the expected content-encoding. The `\0` adds a byte with a value of 0 to end of the Buffer. This is expected by browsers decrypting the message who will expect so many bytes for the content encoding, followed a byte with value 0, followed by the encrypted data.

Our Pseudo Random Key is simply running the auth, shared secret and a piece of encoding info through HKDF (i.e. making it cryptographically stronger).

Context

The "context" is a set of bytes that is used to calculate two values later on in the encryption browser. It's essentially an array of bytes containing the subscription public key and the local public key.

```
const keyLabel = new Buffer('P-256\0', 'utf8');

// Convert subscription public key into a buffer.
const subscriptionPubKey = new Buffer(subscription.keys.p256dh, 'base64');

const subscriptionPubKeyLength = new Uint8Array(2);
subscriptionPubKeyLength[0] = 0;
subscriptionPubKeyLength[1] = subscriptionPubKey.length;

const localPublicKeyLength = new Uint8Array(2);
subscriptionPubKeyLength[0] = 0;
subscriptionPubKeyLength[1] = localPublicKey.length;

const contextBuffer = Buffer.concat([
  keyLabel,
  subscriptionPubKeyLength.buffer,
  subscriptionPubKey,
  localPublicKeyLength.buffer,
  localPublicKey,
]);
```

The final context buffer is a label, the number of bytes in the subscription public key, followed by the key itself, then the number of bytes local public key, followed by the key itself.

With this context value we can use it in the creation of a nonce and a content encryption key (CEK).

Content Encryption Key and Nonce

A nonce is a value that prevents replay attacks as it should only be used once.

The content encryption key (CEK) is the key that will ultimately be used to encrypt our payload.

First we need to create the bytes of data for the nonce and CEK, which is simply a content encoding string followed by the context buffer we just calculated:

```
const nonceEncBuffer = new Buffer('Content-Encoding: nonce\0', 'utf8');
const nonceInfo = Buffer.concat([nonceEncBuffer, contextBuffer]);

const cekEncBuffer = new Buffer('Content-Encoding: aesgcm\0');
const cekInfo = Buffer.concat([cekEncBuffer, contextBuffer]);
```

This information is run through HKDF combining the salt and PRK with the nonceInfo and cekInfo:

```
// The nonce should be 12 bytes long
const nonce = hkdf(salt, prk, nonceInfo, 12);

// The CEK should be 16 bytes long
const contentEncryptionKey = hkdf(salt, prk, cekInfo, 16);
```

This gives us our nonce and content encryption key.

Perform the Encryption

Now that we have our content encryption key, we can encrypt the payload.

We create an AES128 cipher using the content encryption key as the key and the nonce is an initialization vector.

In Node this is done like so:

```
const cipher = crypto.createCipheriv(
  'id-aes128-GCM', contentEncryptionKey, nonce);
```

Before we encrypt our payload, we need to define how much padding we wish to add to the front of the payload. The reason we'd want to add padding is that it prevents the risk of eavesdroppers being able to determine "types" of messages based on the payload size.

You must add two bytes of padding to indicate the length of any additional padding.

For example, if you added no padding, you'd have two bytes with value 0, i.e. no padding exists, after these two bytes you'll be reading the payload. If you added 5 bytes of padding, the first two bytes will have a value of 5, so the consumer will then read an additional five bytes and then start reading the payload.

```
const padding = new Buffer(2 + paddingLength);
// The buffer must be only zeros, except the length
padding.fill(0);
padding.writeUInt16BE(paddingLength, 0);
```

We then run our padding and payload through this cipher.

```
const result = cipher.update(Buffer.concat(padding, payload));
cipher.final();

// Append the auth tag to the result -
// https://nodejs.org/api/crypto.html#crypto_cipher_getauthtag
const encryptedPayload = Buffer.concat([result, cipher.getAuthTag()]);
```

We now have our encrypted payload. Yay!

All that remains is to determine how this payload is sent to the push service.

Encrypted Payload Headers & Body

To send this encrypted payload to the push service we need to define a few different headers in our POST request.

Encryption Header The 'Encryption' header must contain the *salt* used for encrypting the payload.

The 16 byte salt should be base64 URL safe encoded and added to the Encryption header, like so:

```
Encryption: salt=<URL Safe Base64 Encoded Salt>
```

Crypto-Key Header We saw that the `Crypto-Key` header is used under the 'Application Server Keys' section to contain the public application server key.

This header is also used to share the local public key used to encrypt the payload.

The resulting header looks like this:

```
Crypto-Key: dh=<URL Safe Base64 Encoded Local Public Key String>; p256ecdsa=<URL Safe Base64 Enc
```

Content Type, Length & Encoding Headers The `Content-Length` header is the number of bytes in the encrypted payload. 'Content-Type' and 'Content-Encoding' headers are fixed values. This is shown below.

```
Content-Length: <Number of Bytes in Encrypted Payload>
Content-Type: 'application/octet-stream'
Content-Encoding: 'aesgcm'
```

With these headers set, we need to send the encrypted payload as the body of our request. Notice that the `Content-Type` is set to `application/octet-stream`. This is because the encrypted payload must be sent as a stream of bytes.

In NodeJS we would do this like so:

```
const pushRequest = https.request(httpsOptions, function(pushResponse) {
pushRequest.write(encryptedPayload);
pushRequest.end();
```

More Headers?

We've covered the headers used for JWT / Application Server Keys (i.e. how to identify the application with the push service) and we've covered the headers used to send an encrypted payload.

There are additional headers that push services use to alter the behavior of the sent messages. Some of these headers are required, while others are optional.

TTL Header

This is a **required header**.

`TTL` (or time to live) is an integer specifying the number of seconds you want your push message to live on the push service before it's delivered. When the `TTL` expires, the message will be removed from the push service queue and it won't be delivered.

```
TTL: <Time to live in seconds>
```

If you set a `TTL` of zero, the push service will attempt to deliver the message immediately, **but** if the device can't be reached, your message will be immediately dropped from the push service queue.

Technically a push service can reduce the `TTL` of a push message if it wants. You can tell if this has happened by examining the `TTL` header in the response from a push service.

Topic This is an **optional header**.

Topics are strings that can be used to replace a pending messages with a new message if they have matching topic names.

This is useful in scenarios where multiple messages are sent while a device is offline, and you really only want a user to see the latest message when the device is turned on.

Urgency This is an **optional header**.

Urgency indicates to the push service how important a message is to the user. This can be used by the push service to help conserve the battery life of a user's device by only waking up for important messages when battery is low.

The header value should a string value, with one of the values shown below. The default value is `normal`.

```
Urgency: <very-low | low | normal | high>
```

Everything Together

If you have further questions about how this all works you can always see how libraries trigger push messages on the web-push-libs org.

Once you have an encrypted payload, and the headers above, you just need to make a POST request to the `endpoint` in a `PushSubscription`.

So what do we do with the response to this POST request?

Response from Push Service

Once you've made a request to a push service, you need to check the status code of the response as that'll tell you whether the request was successful or not.

Status Code

Description

201

Created. The request to send a push message was received and accepted.

429

Too many requests. Meaning your application server has reached a rate limit with a push service. The push service should include a 'Retry-After' header to indicate how long before another request can be made.

400

Invalid request. This generally means one of your headers is invalid or improperly formatted.

404

Not Found. This is an indication that the subscription is expired and can't be used. In this case you should delete the `PushSubscription` and wait for the client to resubscribe the user.

410

Gone. The subscription is no longer valid and should be removed from your application server. This can be reproduced by calling `unsubscribe()` on a `PushSubscription`.

413

Payload size too large. The minimum size payload a push service must support is 4096 bytes (or 4kb).

Push Events

By this point covered subscribing a user for push sending them a message. The next step is to receive this push message on the user's device and display a notification (as well as any other work we might want to do).

The Push Event

When a message is received, it'll result in a push event being dispatched in your service worker.

The code for setting up a push event listener should be pretty similar to any other event listener you'd write in JavaScript:

```
self.addEventListener('push', function(event) {
  if (event.data) {
    console.log('This push event has data: ', event.data.text());
  } else {
    console.log('This push event has no data.');
  }
});
```

The weirdest bit of this code to most developers who are new to service workers is the `self` variable. `self` is commonly used in Web Workers, which a service worker is. `self` refers to the global scope, kind of like `window` in a web page. But for web workers and service workers, `self` refers to the the worker itself.

In the example above `self.addEventListener()` can be thought of as adding an event listener to the service worker itself.

Inside the push event example we check if there is any data and print something to the terminal.

There are other ways you can parse data from a push event:

```
// Returns string
event.data.text()

// Parses data as JSON string and returns an Object
event.data.json()

// Returns blob of data
event.data.blob()

// Returns an arrayBuffer
event.data.arrayBuffer()
```

Most people use `json()` or `text()` depending on what they are expecting from their application.

This example demonstrates how to add a push event listener and how to access data, but it's missing two very important pieces of functionality. It's not showing a notification and it's not making use of `event.waitUntil()`.

Wait Until

One of the things to understand about service workers is that you have little control over when the service worker code is going to run. The browser decides when to wake it up and when to terminate it. The only way you can tell the browser, "Hey I'm super busy doing important stuff", is to pass a promise into the `event.waitUntil()` method. With this, the browser will keep the service worker running until the promise you passed in has settled.

With push events there is an additional requirement that you must display a notification before the promise you passed in has settled.

Here's a basic example of showing a notification:

```
self.addEventListener('push', function(event) {
  const promiseChain = self.registration.showNotification('Hello, World.');

  event.waitUntil(promiseChain);
});
```

Calling `self.registration.showNotification()` is the method that displays a notification to the user and it returns a promise that will resolve once the notification has been displayed.

For the sake of keeping this example as clear as possible I've assigned this promise to a variables called `promiseChain`. This is then passed into `event.waitUntil()`. I know this is very verbose, but I've seen a number of issues that have culminated as a result of misunderstanding what should be passed into `waitUntil()` or is the result of a broken promise chains.

A more complicated example with a network request for data and tracking the push event with analytics could look like this:

```
self.addEventListener('push', function(event) {
  const analyticsPromise = pushReceivedTracking();
  const pushInfoPromise = fetch('/api/get-more-data')
    .then(function(response) {
      return response.json();
    })
    .then(function(response) {
      const title = response.data.userName + ' says...';
      const message = response.data.message;

      return self.registration.showNotification(title, {
        body: message
      });
    });

  const promiseChain = Promise.all([
    analyticsPromise,
    pushInfoPromise
  ]);

  event.waitUntil(promiseChain);
});
```

Here we are calling a function that returns a promise `pushReceivedTracking()`, which, for the sake of the example, we can pretend will make a network request to our analytics provider. We are also making a network request, getting the response and showing a notification using the responses data for the title and message of the notification.

We can ensure the service worker is kept alive while both of these tasks are done by combining these promises with `Promise.all()`. The resulting promise is passed into `event.waitUntil()` meaning the browser will wait until both promises have finished before checking that a notification has been displayed and terminating the service worker.

> **Tip:** If you ever find your promise chains confusing or a little messy I find that breaking things into functions helps to reduce complexity. I'd also recommend this blog post by Philip Walton on untangling promise chains. The main point to take away is that you should experiment with how promises can be written and chained to find a style that works for you.

The reason we should be concerned about `waitUntil()` and how to use it is that one of the most common issues developers face is that when the promise chain is incorrect or broken, Chrome will show this "default" notification:

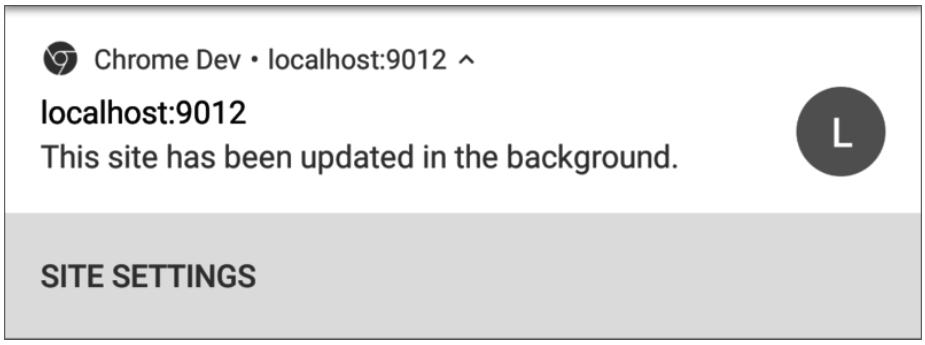


Figure 22: An Image of the default notification in Chrome

Chrome will only show the "This site has been updated in the background." notification when a push message is received and the push event in the service worker **does not** show a notification after the promise passed to `event.waitUntil()` has finished.

The main reason developers get caught out by this is that their code will often call `self.registration.showNotification()` but they **aren't** doing anything with the promise it returns. This intermittently results in the default notification being displayed. For example, we could remove the return for `self.registration.showNotification()` in the example above and we run the risk of seeing this notification.

```
self.addEventListener('push', function(event) {
  const analyticsPromise = pushReceivedTracking();
  const pushInfoPromise = fetch('/api/get-more-data')
    .then(function(response) {
      return response.json();
    })
    .then(function(response) {
      const title = response.data.userName + ' says...';
      const message = response.data.message;
```

```
      self.registration.showNotification(title, {
        body: message
      });
    });

  const promiseChain = Promise.all([
    analyticsPromise,
    pushInfoPromise
  ]);

  event.waitUntil(promiseChain);
});
```

You can see how it's an easy thing to miss.

Just remember - if you see that notification, check your promise chains and `event.waitUntil()`.

In the next section we're going to look at what we can do to style notifications and what content we can display.

Displaying a Notification

I've split up notification options into two sections, one that deals with the visual aspects (this section) and one section that explains the behavioural aspects of notifications.

The reason for this is that every developer will need to be worried about the visual aspects but the behavioural aspects you'll use will depend how you use push notifications.

All of the source code for these demo's is taken from a demo page I put together. If you want to test them out for yourself then click the button below.

Notification Demos

Visual Options

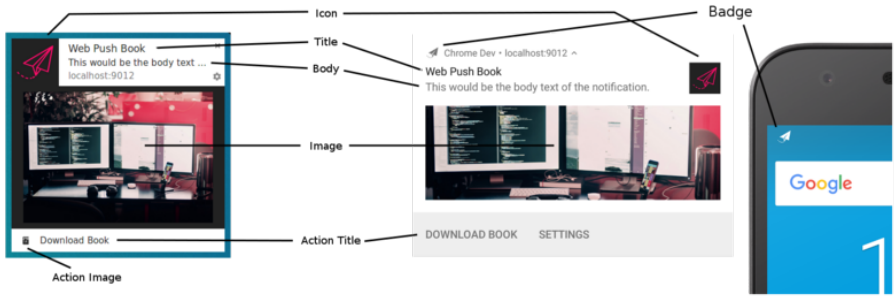
The API for showing a notification is simply:

```
<ServiceWorkerRegistration>.showNotification(<title>, <options>);
```

Where the title is a string and options can be any of the following:

```
{
  "//": "Visual Options",
  "body": "<String>",
  "icon": "<URL String>",
  "image": "<URL String>",
  "badge": "<URL String>",
  "vibrate": "<Array of Integers>",
  "sound": "<URL String>",
  "dir": "<String of 'auto' | 'ltr' | 'rtl'>",

  "//": "Behavioural Options",
  "tag": "<String>",
  "data": "<Anything>",
  "requireInteraction": "<boolean>",
  "renotify": "<Boolean>",
  "silent": "<Boolean>",

  "//": "Both Visual & Behavioural Options",
  "actions": "<Array of Strings>",

  "//": "Information Option. No visual affect.",
  "timestamp": "<Long>"
}
```

First let's look at the visual options.



{: .center-image }

Title and Body Options

The title and body options are exactly as they sound, two different pieces of text to display on the notification.

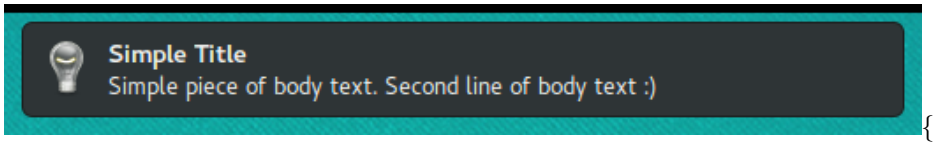
If we ran the following code:

```
const title = 'Simple Title';
const options = {
  body: 'Simple piece of body text.\nSecond line of body text :)'
};
registration.showNotification(title, options);
```

We'd get this notification on Chrome:

{:
.center-image }

On Firefox on Linux it would look like this:

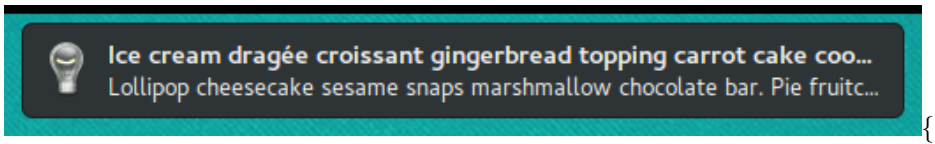


{:
.center-image }

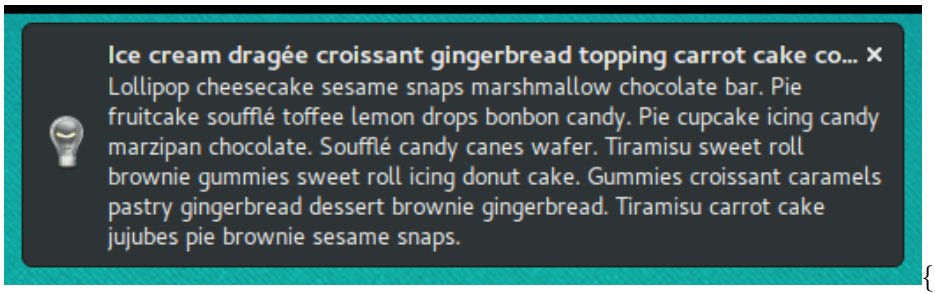
I was curious about what would happen if I added lots of text and this was the result:

{:
.center-image }

Interestingly, Firefox on Linux collapses the body text until you hover the notification, causing the notification to expand.

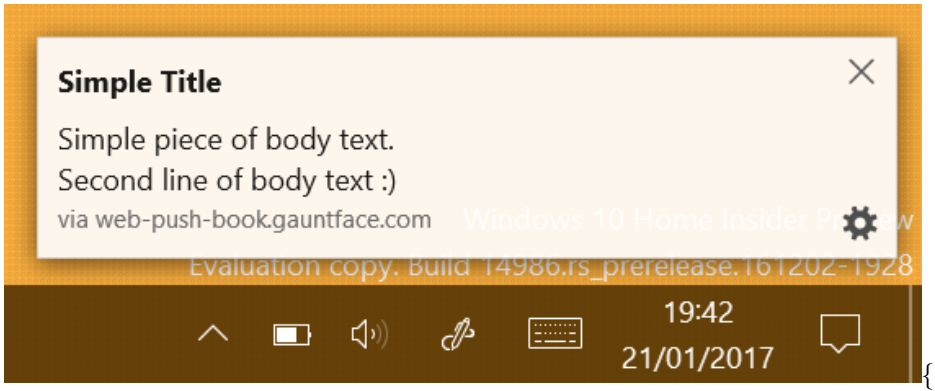


{:
.center-image }



{:
.center-image }

The reason I've included these examples is twofold. There will be differences between browsers. Just looking at text, Firefox and Chrome look and act differently. Secondly there are differences across platforms. Chrome has a custom UI for all platforms whereas Firefox uses the system notifications on my Linux machine. The same notifications on Windows with Firefox look like this:



{:
.center-image }

{: .center-image }

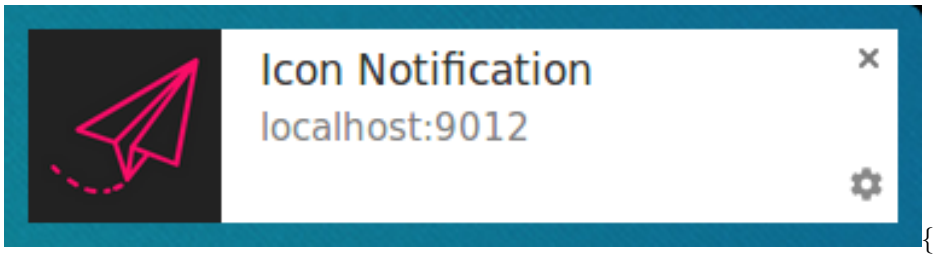
Icon

The `icon` option is essentially a small image you can show next to the title and body text.

In your code you just need to provide a URL to the image you'd like to load.

```
const title = 'Icon Notification';
const options = {
  icon: 'build/images/demos/icon-512x512.png'
};
registration.showNotification(title, options);
```

On Chrome we get this notification on Linux:



{: .center-image }

and on Firefox:

{:

.center-image }

Sadly there aren't any solid guidelines for what size image to use for an icon.

Android seems to want a 64dp image (which is 64px multiples by the device pixel ratio).

If we assume the highest pixel ratio for a device will be 3, an icon size of 192px or more is a safe bet.

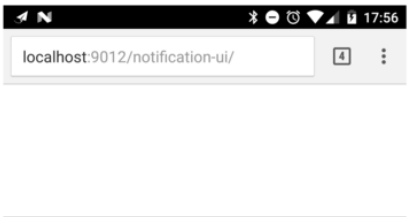
> **Note**: Some browsers may require the image be served over HTTPS. Be aware of this if you intend to use a third-party image over HTTP.

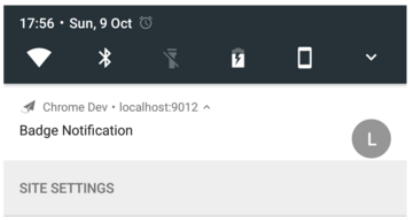
Badge

The `badge` is a small monochrome icon that is used to portray a little more information to the user about where the notification is from.

```
const title = 'Badge Notification';
const options = {
  badge: 'build/images/demos/badge-128x128.png'
};
registration.showNotification(title, options);
```

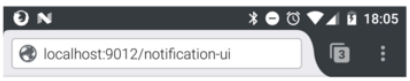
At the time of writing the badge is only used on Chrome for Android.

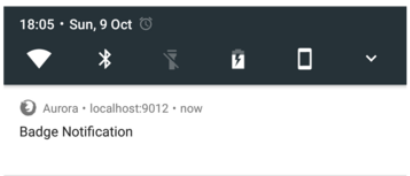




{:
.center-image }

On other browsers (or Chrome without the badge), you'll see an icon of the browser.





{:
.center-image }

As with the `icon` option, there are no real guidelines on what size to use.

Digging through Android guidelines the recommended size is 24px multiplied by the device pixel ratio.

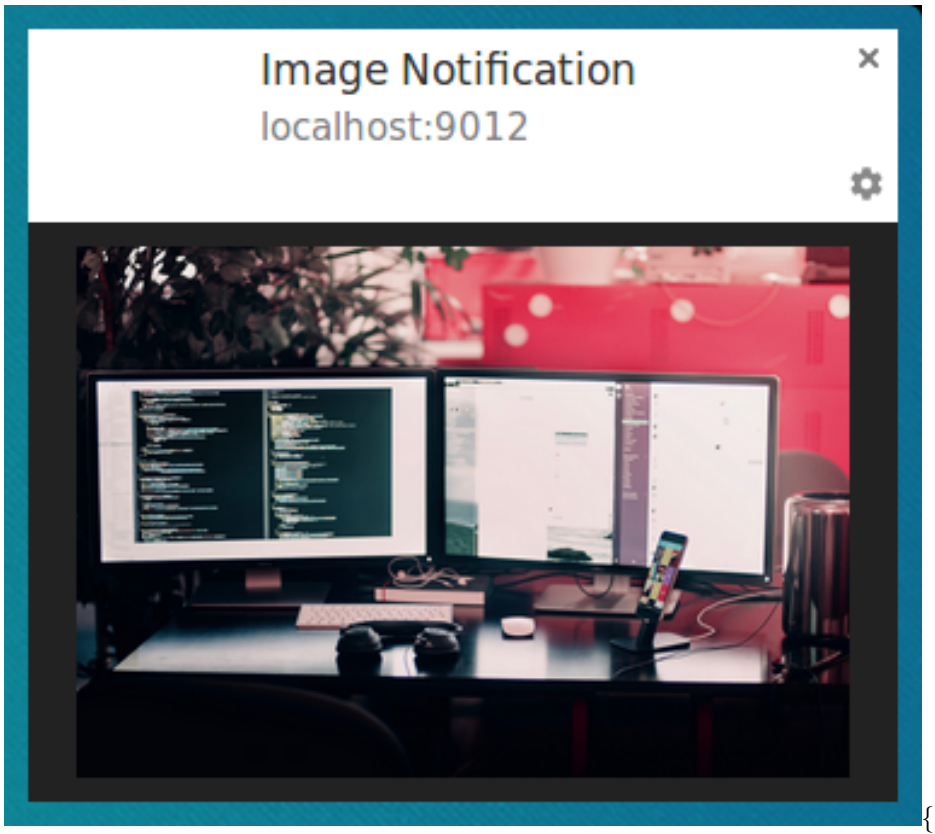
Meaning an image of 72px or more should be good (assuming a max device pixel ratio of 3).

Image

The `image` option can be used to display a larger image to the user. This is particularly useful to display a preview image to the user.

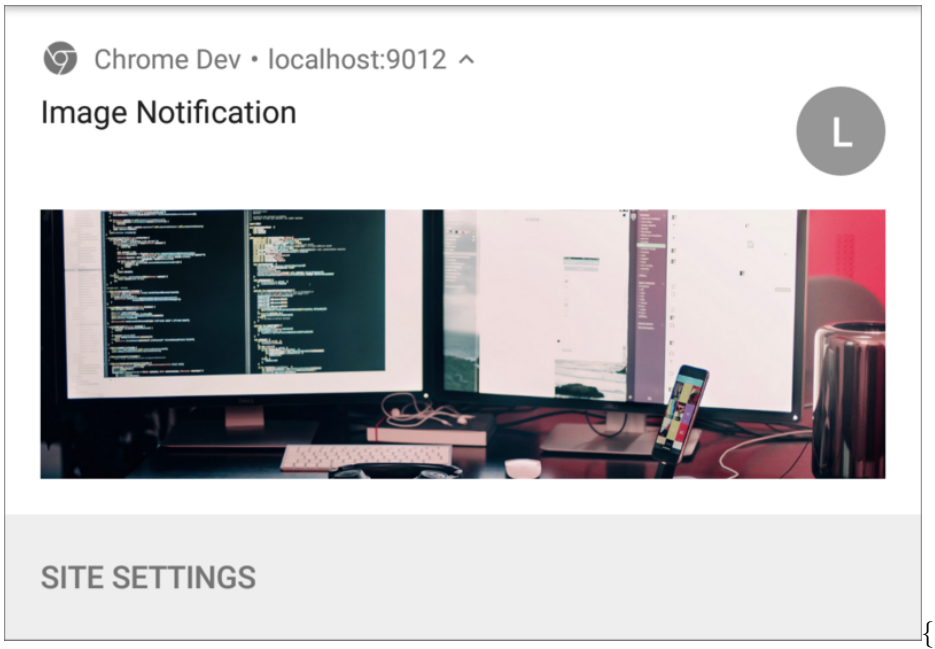
```
const title = 'Image Notification';
const options = {
  image: 'build/images/demos/unsplash-farzad-nazifi-1600x1100.jpg'
};
registration.showNotification(title, options);
```

On desktop the notification will look like this:



{:
.center-image }

On Android the cropping and ratio are different.



{: .center-image }

Given the differences in ratio between desktop and mobile it's extremely hard to suggest guidelines.

Since Chrome on desktop doesn't fill the available space and has a ratio of 4:3, perhaps the best approach is to serve an image with this ratio and allow Android to crop the image. That being said, the `image` option is still new and this behavior may change.

On Android, the only guideline width I could find is a width of 450dp.

Using this guideline, an image of width 1350px or more would be a good bet.

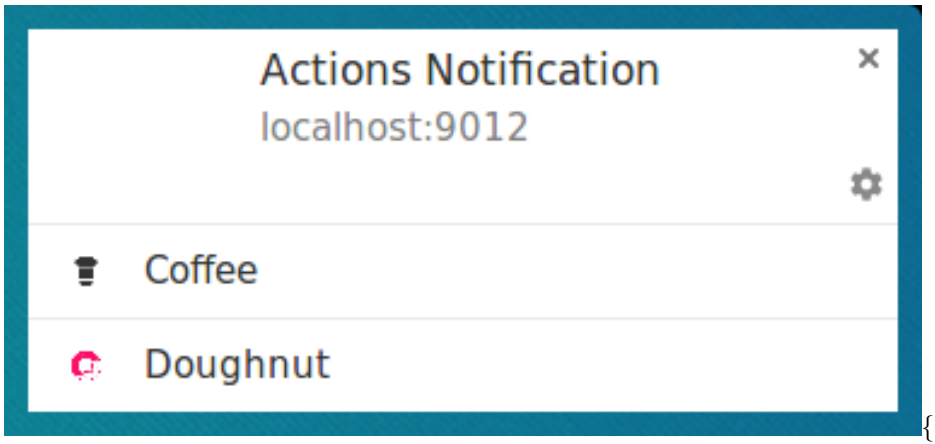
Actions

You can defined `actions` to display buttons with a notification.

```
const title = 'Actions Notification';
const options = {
  actions: [
    {
      action: 'coffee-action',
      title: 'Coffee',
      icon: 'build/images/demos/action-1-128x128.png'
    },
    {
```

```
        action: 'doughnut-action',
        title: 'Doughnut',
        icon: 'build/images/demos/action-2-128x128.png'
      },
      {
        action: 'gramophone-action',
        title: 'gramophone',
        icon: 'build/images/demos/action-3-128x128.png'
      },
      {
        action: 'atom-action',
        title: 'Atom',
        icon: 'build/images/demos/action-4-128x128.png'
      }
    ]
};

const maxVisibleActions = Notification.maxActions;
if (maxVisibleActions < 4) {
  options.body = `This notification will only display ` +
    `${maxVisibleActions} actions.`;
} else {
  options.body = `This notification can display up to ` +
    `${maxVisibleActions} actions.`;
}

registration.showNotification(title, options);
```

At the time of writing only Chrome and Opera for Android support actions.



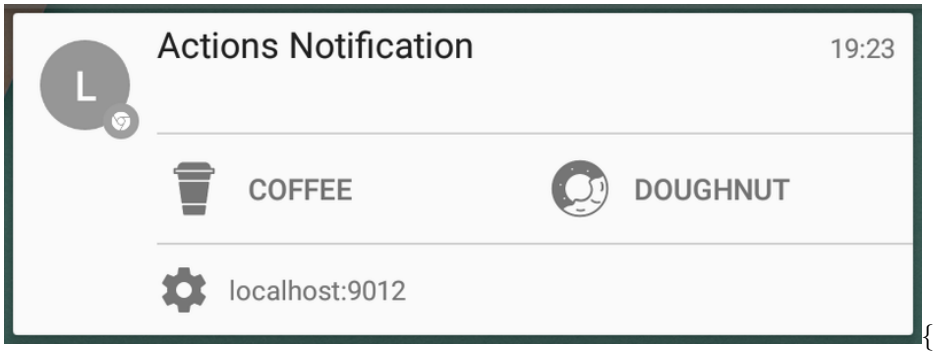
{: .center-image }

For each action you can define a title, an "action" (which is essentially an ID) and an icon. The title and icon is what you can see in the notification. The ID is used when detecting that the action button had been clicked (We'll look into this more in the next section).

In the example above I've defined 4 actions to illustrate that you can define more actions than will be displayed. If you want to know the number actions that will be displayed by the browser you can check `Notification.maxActions`, which is used in the body text in the demo.

On desktop the action button icons display their colors (See the pink doughtnut above).

On Android Marshmallow the icons are colored to match the system color scheme:



{: .center-image }

Chrome will hopefully change it's behavior on desktop to match android (i.e. apply the appropriate color scheme to make the icons match the system look and feel). In the meantime you can match Chrome's text color by making your icons have a color of "#333333"..

On Android Nougat the action icons aren't shown at all.

It's also worth calling out that that icons look crisp on Android but **not** on desktop.

The best size I could get to work on desktop Chrome was 24px x 24px. This sadly looks out of place on Android.

The best practice we can draw from these differences:

- Stick to a consistent color scheme for your icons so at least all your icons have a consistent appearance.
- Make sure they work in monochrome as some platforms may display them that way.
- Test the size and see what works for you. 128px x 128px works well on Android for me but was poor quality on desktop.

- Expect your action icons not to be displayed at all.

The Notification spec is exploring a way to define multiple sizes of icons, but it looks like it'll be some time before anything is agreed upon.

Direction

The "dir" parameter allows you to define which direction the text should be displayed, right-to-left or left-to-right.

In testing it seemed that the direction was largely determined by the text rather than this parameter. According to the spec this parameter is intended to suggest to the browser how to layout options like actions, but I saw no difference.

It's recommended to define `dir` if you can, although the browser should do the right thing according to the text supplied.

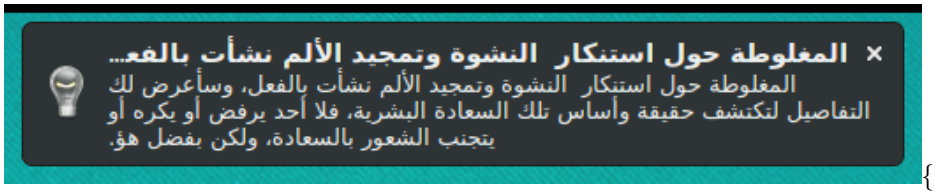
```
const title =     '
const options = {
  body:     '
  dir: 'rtl',
  actions: [{
    title:   ' 1     '1,
    action: 'action-1'
  }, {
    title:   ' 1     '2,
    action: 'action-2'
  }]
};
registration.showNotification(title, options);
```

The parameter should be set to either `auto`, `ltr` or `rtl`.

A right-to-left language used on Chrome on Linux looks like this:

{:
.center-image }

On Firefox (while hovering over the notification) you'll get this:



{:
.center-image }

Vibrate

The vibrate option allows you to define a vibration pattern that'll run when a notification is displayed, assuming the user's current settings allow for vibrations (i.e. the device isn't in silent mode).

The format of the vibrate option should be an array of numbers that describe the number of milliseconds the device should vibrate followed by the number of milliseconds the device should *not* vibrate.

```
const title = 'Vibrate Notification';
const options = {
  // Star Wars shamelessly taken from the awesome Peter Beverloo
  // https://tests.peter.sh/notification-generator/
  vibrate: [500,110,500,110,450,110,200,110,170,40,450,110,200,110,170,40,500]
};
registration.showNotification(title, options);
```

This only affects devices that support vibration.

Sound

The sound parameter allows you to define a sound to play when the notification is received.

At the time of writing no browser has support for this option.

```
const title = 'Sound Notification';
const options = {
  sound: '/demos/notification-examples/audio/notification-sound.mp3'
};
registration.showNotification(title, options);
```

Timestamp

Timestamp allows you to tell the platform the time when an event occurred that resulted in the push notification being sent.

The `timestamp` should be the number of milliseconds since 00:00:00 UTC, which is 1 January 1970 (i.e. the unix epoch).

```
const title = 'Timestamp Notification';
const options = {
  body: 'Timestamp is set to "01 Jan 2000 00:00:00".',
  timestamp: Date.parse('01 Jan 2000 00:00:00')
};
registration.showNotification(title, options);
```

UX Best Practices

The biggest UX failure I've seen with notifications is a lack of specificity in the information displayed by a notification.

You should consider why you sent the push message in the first place and make sure all of the notification options are used to help users understand why they are reading that notification.

To be honest, it's easy to see examples and think "I'll never make that mistake". But it's easier to fall into that trap than you might think.

- Don't put your website in the title or the body. Browsers include your domain in the notification so **don't duplicate it**.

Here's an example of Facebook's fallback message (you can use the DevTools 'push' button to display it yourself). Even if there is no data in the push, the important information is that there's a new notification, not "Facebook".

```
![Screenshot of Facebook's default notification](build/images/notification-screenshots/deskto
```

- Use all information you have available to you. If you send a push message because someone sent a message to a user, rather than using a title of 'New Message' and body of 'Click here to read it.' use a title of 'John just sent a new message' and set the body of the notification to part of the message.

  Here's an example from a Facebook message.

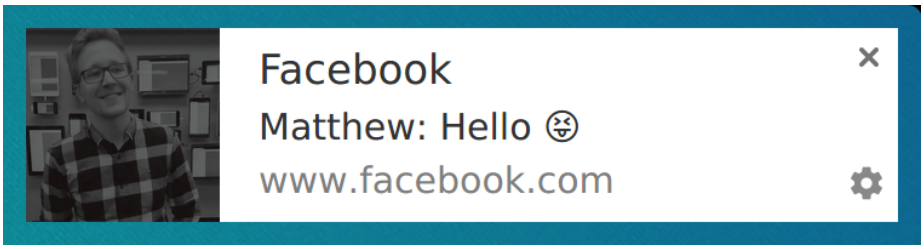


Figure 23: Screenshot of a Facebook message notification

  It contains information on who sent the message, the message content and the users profile photo, making the notification more relevant to the user.

Browsers and Feature Detection

At the time of writing there is a pretty big disparity between Chrome and Firefox in terms of feature support for notifications.

Luckily, you can detect support for notification features by looking at the Notification prototype.

Let's say we wanted to know if a browser supports notification action buttons, we'd do the following:

```
if ('actions' in Notification.prototype) {
  // Action buttons are supported.
} else {
  // Action buttons are NOT supported.
}
```

With this, we could change the notification we display to our users.

With the other options, just do the same as above, replacing 'actions' with the desired parameter name.

Notification Behaviour

So far we've looked at the options that alter the visual appearance of a notification. There are also options that alter the behaviour of notifications.

Be default, calling `showNotification()` with just visual options will have the following behaviours:

- Clicking on the notification does nothing.
- Each new notification is shown one after the other. The browser will not collapse the notifications in any way.
- The platform may play a sound or vibrate the user's devices (depending on the platform).
- On some platforms the notification will disappear after a short period of time while others will show the notification unless the user interacts with it (For example, compare notifications on Android and Desktop.)

In this section we are going to look at how we can alter these default behaviours using options alone. These are relatively easy to implement and take advantage of.

Notification Click Event

When a user clicks on a notification the default behaviour is for nothing to happen. It doesn't even close or remove the notification.

The common practice for a notification click is for it to close and perform some other logic (i.e. open a window or make some API call to the application).

To achieve this we need to add a 'notificationclick' event listener to our service worker. This will be called when ever a notification is clicked.

```
self.addEventListener('notificationclick', function(event) {
  const clickedNotification = event.notification;
  clickedNotification.close();

  // Do something as the result of the notification click
  const promiseChain = doSomething();
  event.waitUntil(promiseChain);
});
```

As you can see in this example, the notification that was clicked can be accessed via the `event.notification` parameter. From this we can access the notifications properties and methods. In this case we call its `close()` method and perform additional work.

Remember: You still need to make use of event.waitUntil() to keep the service worker running while your code is busy.

Actions

Actions allow you to give users another level of interaction with your users over just clicking the notification.

In the previous section you saw how to define actions when calling `showNotification()`:

```
const title = 'Actions Notification';
const options = {
  actions: [
    {
      action: 'coffee-action',
      title: 'Coffee',
      icon: 'build/images/demos/action-1-128x128.png'
    },
    {
      action: 'doughnut-action',
      title: 'Doughnut',
      icon: 'build/images/demos/action-2-128x128.png'
    },
    {
      action: 'gramophone-action',
      title: 'gramophone',
      icon: 'build/images/demos/action-3-128x128.png'
    },
    {
      action: 'atom-action',
      title: 'Atom',
      icon: 'build/images/demos/action-4-128x128.png'
    }
  ]
};

const maxVisibleActions = Notification.maxActions;
if (maxVisibleActions < 4) {
  options.body = `This notification will only display ` +
    `${maxVisibleActions} actions.`;
} else {
  options.body = `This notification can display up to ` +
    `${maxVisibleActions} actions.`;
}
```

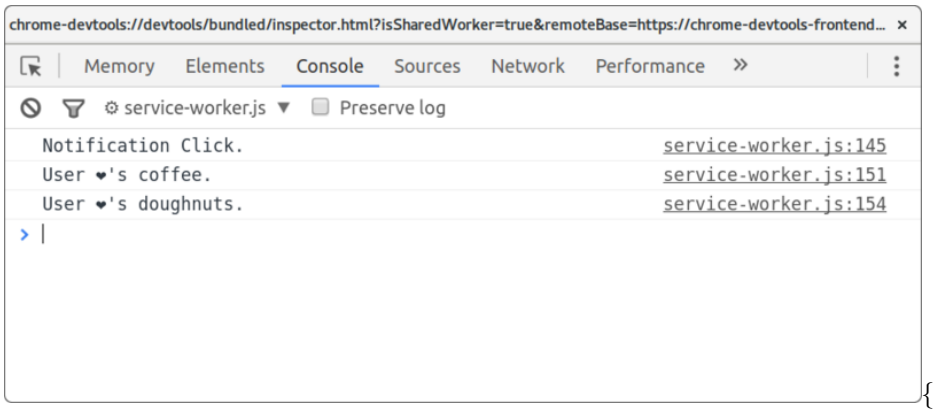
```
    registration.showNotification(title, options);
```

If the user clicks an action button, check the `event.action` value in the `noticationclick` event to tell which action button was clicked.

`event.action` will contain the `action` value set in the options. In the example above the `event.action` values would be one of the following: 'coffee-action', 'doughnut-action', 'gramophone-action' or 'atom-action'.

With this we would detect notification clicks or action clicks like so:

```
self.addEventListener('notificationclick', function(event) {
  if (!event.action) {
    // Was a normal notification click
    console.log('Notification Click.');
    return;
  }

  switch (event.action) {
    case 'coffee-action':
      console.log('User \'s coffee.');
      break;
    case 'doughnut-action':
      console.log('User \'s doughnuts.');
      break;
    case 'gramophone-action':
      console.log('User \'s music.');
      break;
    case 'atom-action':
      console.log('User \'s science.');
      break;
    default:
      console.log(`Unknown action clicked: '${event.action}'`);
      break;
  }
});
```



{: .center-image }

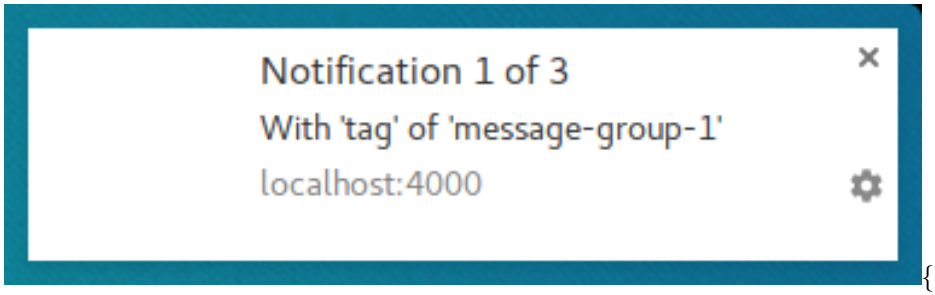
Tag

The *tag* option is a string ID that "groups" notifications together, providing an easy way to determine how multiple notifications are displayed to the user. This is easiest to explain with an example.

Let's display a notification and give it a tag, of 'message-group-1'. We'd display the notification with this code:

```
const title = 'Notification 1 of 3';
const options = {
  body: 'With \'tag\' of \'message-group-1\'',
  tag: 'message-group-1'
};
registration.showNotification(title, options);
```

Which will show our first notification.

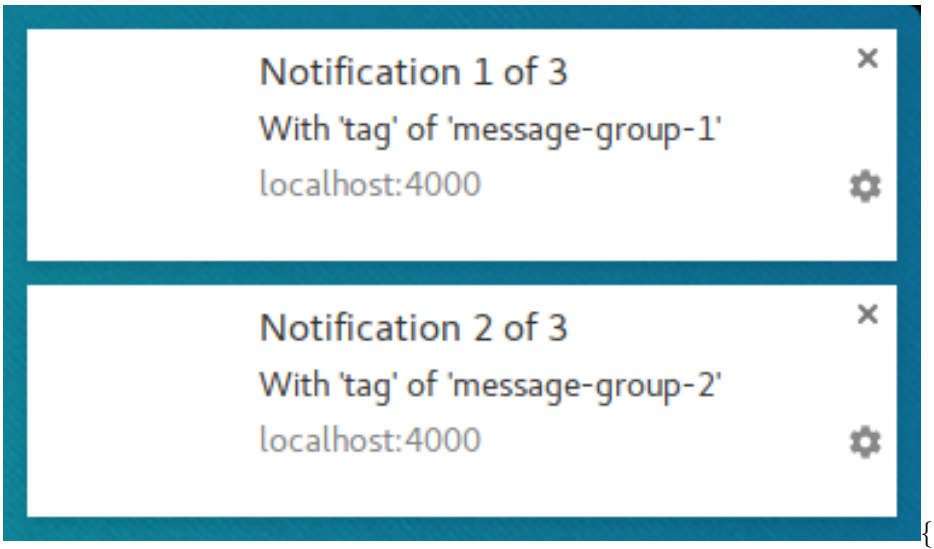


{: .center-image }

Let's display a second notification with a new tag of 'message-group-2', like so:

```
const title = 'Notification 2 of 3';
const options = {
  body: 'With \'tag\' of \'message-group-2\'',
  tag: 'message-group-2'
};
registration.showNotification(title, options);
```

This will display a second notification to the user.

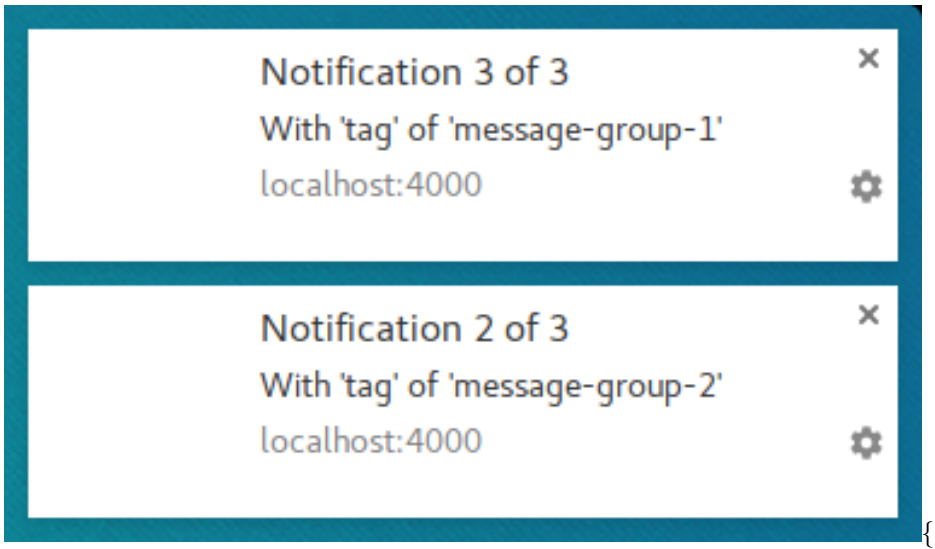


{: .center-image }

Now let's show a third notification but re-use the first tag of 'message-group-1'. Doing this will close the first notification and replace it with our new notification.

```
const title = 'Notification 3 of 3';
const options = {
  body: 'With \'tag\' of \'message-group-1\'',
  tag: 'message-group-1'
};
registration.showNotification(title, options);
```

Now we have two notifications even though `showNotification()` was called three times.



{: .center-image }

The `tag` option is simply a way of grouping messages so that any old notifications that are currently displayed will be closed if they have the same tag as a new notification.

A subtlety to using `tag` is that when it replaces a notification, it will do so *without* a sound and vibration.

This is where the `renotify` option comes in.

Renotify

This largely applies to mobile devices at the time of writing. Setting this option makes new notifications vibrate and play a system sound.

There are scenarios where you might want a replacing notification to notify the user rather than silently update. Chat applications are a good example. In this case you should set `tag` and `renotify` to true.

```
const title = 'Notification 2 of 2';
const options = {
  tag: 'renotify',
  renotify: true
};
registration.showNotification(title, options);
```

Note: If you set `renotify: true` on a notification without a tag, you'll get the following error:

```
TypeError: Failed to execute 'showNotification' on 'ServiceWorkerRegistration': Notifications
```

Silent

This option allows you to show a new notification but prevents the default behavior of vibration, sound and turning on the device's display.

This is ideal if your notifications don't require immediate attention from the user.

```
const title = 'Silent Notification';
const options = {
  silent: true
};
registration.showNotification(title, options);
```

Note: If you define both *silent* and *renotify*, silent will take precedence.

Requires Interaction

Chrome on desktop will show notifications for a set time period before hiding them. Chrome on Android doesn't have this behaviour. Notifications are displayed until the user interacts with them.

To force a notification to stay visible until the user interacts with it add the `requireInteraction` option. This will show the notification until the user dismisses or clicks your notification.

```
const title = 'Require Interaction Notification';
const options = {
  body: 'With "requireInteraction: \'true\'".',
  requireInteraction: true
};
registration.showNotification(title, options);
```

Please use this option with consideration. Showing a notification and forcing the user to stop what they are doing to dismiss your notification can be frustrating.

In the next section we are going to look at some of the common patterns used on the web for managing notifications and performing actions such as opening pages when a notification is clicked.

Common Notification Patterns

We're going to look at some common implementation patterns for web push.

This will involve using a few different API's that are available in the service worker.

Notification Close Event

In the last section we saw how we can listen for `notificationclick` events.

There is also a `notificationclose` event that is called if the user dismisses one of your notifications (i.e. rather than clicking the notification, the user clicks the cross or swipes the notification away).

This event is normally used for analytics to track user engagement with notifications.

```
self.addEventListener('notificationclose', function(event) {
  const dismissedNotification = event.notification;

  const promiseChain = notificationCloseAnalytics();
  event.waitUntil(promiseChain);
});
```

Adding Data to a Notification

When a push message is received it's common to have data that is only useful if the user has clicked the notification. For example, the URL that should be opened when a notification is clicked.

The easiest way to take data from a push event and attach it to a notification is to add a `data` parameter to the options object passed into `showNotification()`, like so:

```
    const options = {
      body: 'This notification has data attached to it that is printed ' +
        'to the console when it\'s clicked.',
      tag: 'data-notification',
      data: {
        time: new Date(Date.now()).toString(),
        message: 'Hello, World!'
      }
    };
    registration.showNotification('Notification with Data', options);
```

Inside a click handler the data can be accessed with `event.notification.data`.

```
  const notificationData = event.notification.data;
  console.log('');
  console.log('The data notification had the following parameters:');
  Object.keys(notificationData).forEach((key) => {
```

```
  console.log(`  ${key}: ${notificationData[key]}`);
});
console.log('');
```

Open a Window

One of the most common responses to a user clicking a notification is to open a window or tab to a specific URL. We can do this with the clients.openWindow() API.

In our `notificationclick` event we'd run something like this:

```
const examplePage = '/demos/notification-examples/example-page.html';
const promiseChain = clients.openWindow(examplePage);
event.waitUntil(promiseChain);
```

In the next section we'll look at how to check if the page we want to direct the user to is already open or not. This way we can focus the open tab rather than constantly opening new tabs.

Focus an Existing Window

When it's possible, we should focus a window rather than open a new window every time the user clicks a notification.

Before we look at how to achieve this, it's worth highlighting that this is **only possible for pages on your origin**. This is because we can only see open pages that belong to our site. This prevents developers from being able to see all the sites their users are viewing.

Taking the previous example, we'll alter it to see if '/demos/notification-examples/example-page.html' is already open.

```
const urlToOpen = new URL(examplePage, self.location.origin).href;

const promiseChain = clients.matchAll({
  type: 'window',
  includeUncontrolled: true
})
.then((windowClients) => {
  let matchingClient = null;

  for (let i = 0; i < windowClients.length; i++) {
    const windowClient = windowClients[i];
    if (windowClient.url === urlToOpen) {
```

```
        matchingClient = windowClient;
        break;
      }
    }

    if (matchingClient) {
      return matchingClient.focus();
    } else {
      return clients.openWindow(urlToOpen);
    }
  });

  event.waitUntil(promiseChain);
```

Let's step through the code.

First we parse our example page using the URL API. This is a neat trick I picked up from Jeff Posnick. Calling `new URL()` with the `location` object will return an absolute URL if the string passed in is relative (i.e. '/' will become 'http:///').

We make the URL absolute so we can match it against the window URL's later on.

```
  const urlToOpen = new URL(examplePage, self.location.origin).href;
```

Then we get a list of the `WindowClient` objects, which are the list of currently open tabs and windows. (Remember these are tabs for your origin only.)

```
  const promiseChain = clients.matchAll({
    type: 'window',
    includeUncontrolled: true
  })
```

The options passed into `matchAll()` inform the browser that we only want to search for "window" type clients (i.e. just look for tabs and windows and exclude web workers). `includeUncontrolled` allows us to search for all tabs from your origin that are not controlled by the current service worker, i.e. the service worker running this code. Generally, you'll always want `includeUncontrolled` to be true when calling `matchAll()`.

We capture the returned promise as `promiseChain` so that we can pass it into `event.waitUntil()` later on, keeping our service worker alive.

When the `matchAll()` promise resolves, we iterate through the returned window clients and compare their URL to the URL we want to open. If we find a match,

we need to focus that client, which will bring that window to the users attention. Focusing is done with the `matchingClient.focus()` call.

If we can't find a matching client, we open a new window, same as in the previous section.

```
.then((windowClients) => {
  let matchingClient = null;

  for (let i = 0; i < windowClients.length; i++) {
    const windowClient = windowClients[i];
    if (windowClient.url === urlToOpen) {
      matchingClient = windowClient;
      break;
    }
  }

  if (matchingClient) {
    return matchingClient.focus();
  } else {
    return clients.openWindow(urlToOpen);
  }
});
```

Note: We are returning the promise for `matchingClient.focus()` and `clients.openWindow()` so that the promises are accounted for in our promise chain.

Merging Notifications

We saw that adding a tag to a notification opts in to a behavior where any existing notification with the same tag is replaced.

You can however get more sophisticated with the collapsing of notifications using the Notifications API. Consider a chat app, where the developer might want a new notification to show a message similar to "You have two messages from Matt" rather than just showing the latest message.

You can do this, or manipulate current notifications in other ways, using the registration.getNotifications() API which gives you access to all the currently visible notifications for your web app.

Let's look at how we could use this API to implement the chat example.

In our chat app, let's assume each notification has as some data which includes a username.

First thing we'll want to do is find any open notifications for a user with a specific username. We'll get `registration.getNotifications()` and loop over them and check the `notification.data` for a specific username:

```
const promiseChain = registration.getNotifications()
.then(notifications => {
  let currentNotification;

  for(let i = 0; i < notifications.length; i++) {
    if (notifications[i].data &&
      notifications[i].data.userName === userName) {
      currentNotification = notifications[i];
    }
  }

  return currentNotification;
})
```

The next step is to replace this notification with a new notification.

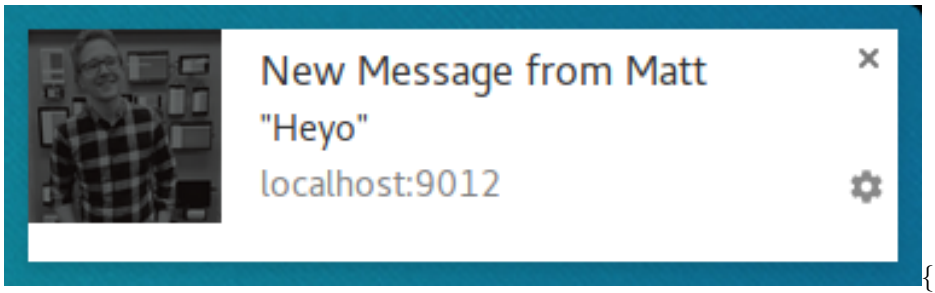
In this fake message app, we'll track the number of new messages by adding a count to our new notifications data and increment it with each new notification.

```
.then((currentNotification) => {
  let notificationTitle;
  const options = {
    icon: userIcon,
  }

  if (currentNotification) {
    // We have an open notification, let's do something with it.
    const messageCount = currentNotification.data.newMessageCount + 1;

    options.body = `You have ${messageCount} new messages from ${userName}.`;
    options.data = {
      userName: userName,
      newMessageCount: messageCount
    };
    notificationTitle = `New Messages from ${userName}`;

    // Remember to close the old notification.
    currentNotification.close();
  } else {
    options.body = `"${userMessage}"`;
    options.data = {
      userName: userName,
```

```
        newMessageCount: 1
      };
      notificationTitle = `New Message from ${userName}`;
    }

    return registration.showNotification(
      notificationTitle,
      options
    );
  });
```

If there is a notification currently display we increment the message count and set the notification title and body message accordingly. If there were no notifications, we create a new notification with a `newMessageCount` of 1.

The result is that the first message would look like this:



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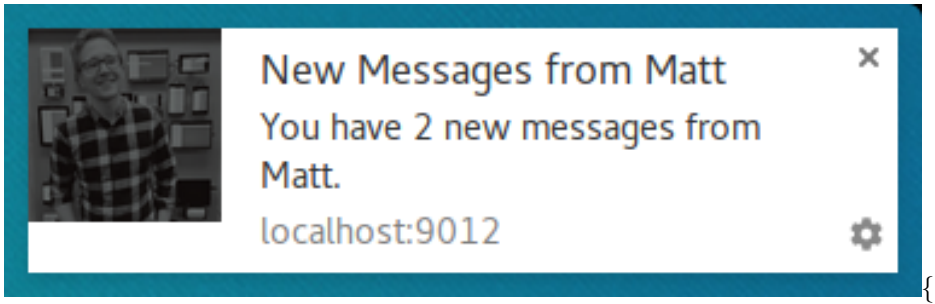
A second notification would collapse the notifications into this:



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The nice thing with this approach is that if your user witnesses the notifications appearing one over the other, it'll look and feel more cohesive than just replacing with notification with the latest message.

The Exception to the Rule

I've been stating that you **must** show a notification when you receive a push and this is true *most* of the time. The one scenario where you don't have to show a notification is when the user has your site open and focused.

Inside your push event you can check whether you need to show a notification or not by examining the window clients and looking for a focused window.

The code to getting all the windows and looking for a focused window looks like this:

```
function isClientFocused() {
  return clients.matchAll({
    type: 'window',
    includeUncontrolled: true
  })
  .then((windowClients) => {
    let clientIsFocused = false;

    for (let i = 0; i < windowClients.length; i++) {
      const windowClient = windowClients[i];
      if (windowClient.focused) {
        clientIsFocused = true;
        break;
      }
    }

    return clientIsFocused;
  });
}
```

We use clients.matchAll() to get all of our window clients and then we loop over them checking the `focused` parameter.

Inside our push event we'd use this function to decide if we need to show a notification:

```
  const promiseChain = isClientFocused()
  .then((clientIsFocused) => {
    if (clientIsFocused) {
      console.log('Don\'t need to show a notification.');
      return;

    }
```

```
  // Client isn't focused, we need to show a notification.
  return self.registration.showNotification('Had to show a notification.');
});

event.waitUntil(promiseChain);
```

Message a Page from a Push Event

We've seen that you can skip showing a notification if the user is currently on your site. But what if you still want to let the user know that an event has occurred, but a notification is too heavy handed?

One approach is to send a message from the service worker to the page, this way the web page can show a notification or update to the user informing them of the event. This is useful for situations when a subtle notification in the page is better and friendlier for the user.

Let's say we've received a push, checked that our web app is currently focused, then we can "post a message" to each open page, like so:

```
const promiseChain = isClientFocused()
.then((clientIsFocused) => {
  if (clientIsFocused) {
    windowClients.forEach((windowClient) => {
      windowClient.postMessage({
        message: 'Received a push message.',
        time: new Date().toString()
      });
    });
  } else {
    return self.registration.showNotification('No focused windows', {
      body: 'Had to show a notification instead of messaging each page.'
    });
  }
});

event.waitUntil(promiseChain);
```

In each of the pages, we listen for these messages by adding a message event listener:

```
  navigator.serviceWorker.addEventListener('message', function(event) {
    console.log('Received a message from service worker: ', event.data);
  });
```

In this message listener you could do anything you want, show a custom UI on your page or completely ignore the message.

It's also worth noting that if you don't define a message listener in your web page, the messages from the service worker will not do anything.

Cache a Page and Open Window

One scenario that is out of the scope of this book but worth discussing is that you can improve the overall UX of your web app by caching web pages you expect users to visit after clicking on your notification.

This requires having your service worker set-up to handle `fetch` events, but if you implement a `fetch` event listener, make sure you take advantage of it in your `push` event by caching the page and assets you'll need before showing your notification.

For more information check out this introduction to service workers post.

Non-Standards Browsers

Throughout this book we've been using the application server key to identify our application with push services. This is the Web Standards approach of application identification.

In older versions of Chrome (version 51 and before), Opera for Android and the Samsung Internet Browser there was a non-standards approach for identifying your application.

In these browsers they required a `gcm_sender_id` parameter to be added to a web app manifest and the value have to be a Sender ID for a Google Developer Project.

This was completely proprietary and only required since the application server key / VAPID spec had not been defined.

In this section we are going to look at how we can add support for these browsers. Please note that this isn't recommended, but if you have a large audience on any of these browsers / browser versions, you should consider this.

What is gcm_sender_id?

The "gcm_sender_id" parameter came about in the early versions of Chrome when web push was first implemented. Google had a push service called "Google Cloud Messaging", which is now called "Firebase Cloud Messaging", both of which are commonly referred to as "GCM" and "FCM" for short.

For the Chrome team to implement push they decided to use "GCM" as it was a Google controller push service that they could work with, but it had two major drawbacks.

1. GCM needed a developer account to be set up and a "Sender ID" passed to Chrome.
2. GCM used a proprietary API to trigger messages. The API required a special "Authorization" header which is an API key the developer account, this way GCM can match the API key to the sender ID.

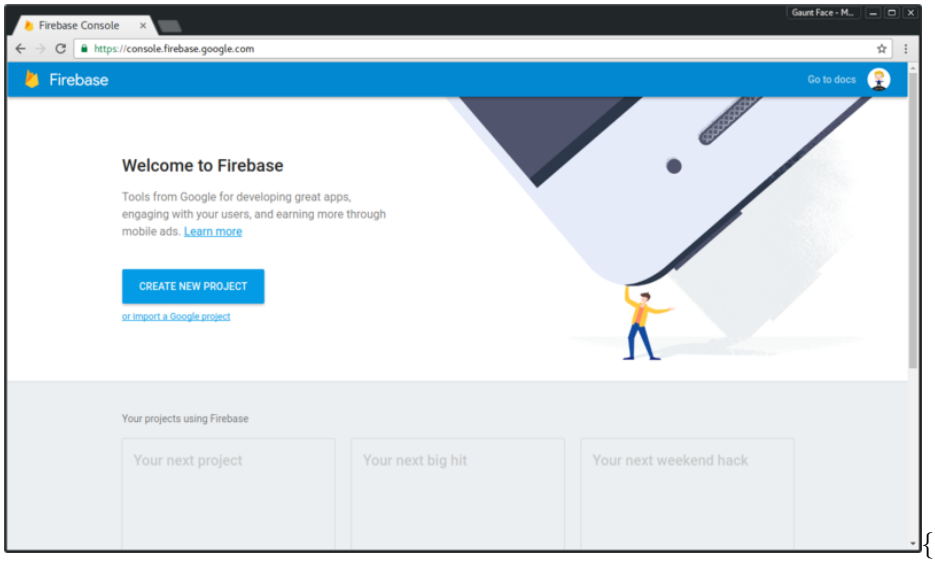
First we'll look at how to create a Firebase project to get the "Sender ID" and API key used for the "Authorization" header.

Then we'll look at adding the "gcm_sender_id" and what the API looks like to trigger a push.

Creating a Firebase Account

I briefly mentioned that Google Cloud Messaging was renamed to Firebase Cloud Messaging. For this reason we can use details from a Firebase project to work with the older GCM API. The reason we are doing this is that setting up a Firebase project is easier than an older Google Developer project.

The first step is to create a new Firebase project on https://console.firebase.google.com.



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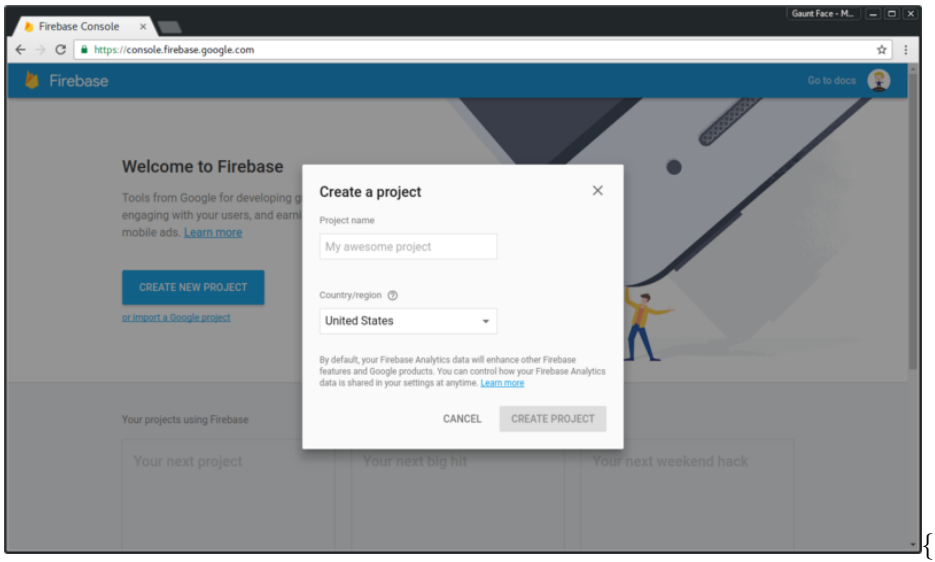
Creating a new project is simple, just fill in your project name and select your country.



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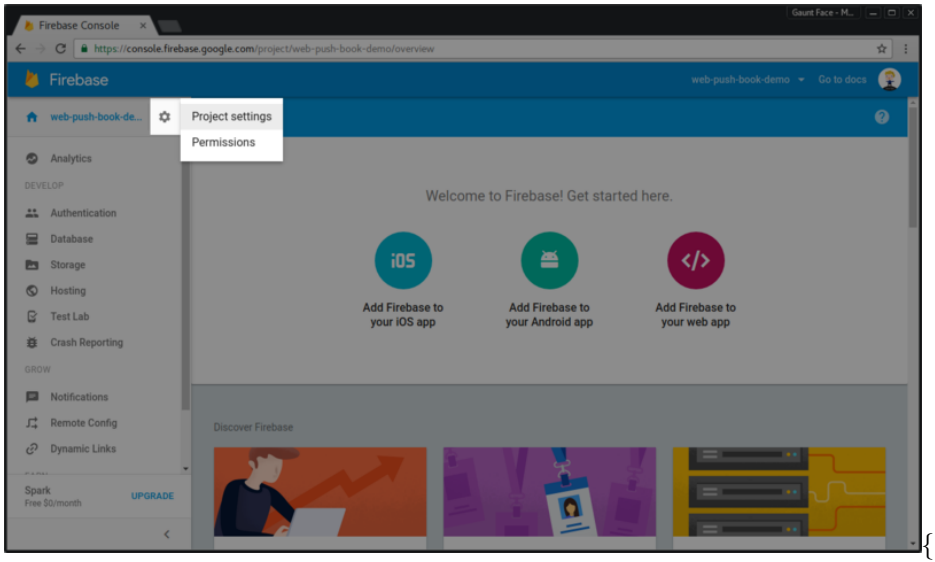
Once you've created your project, you'll find all the important push specific info in settings, which can be found by hovering / clicking the cog next to your projects name.



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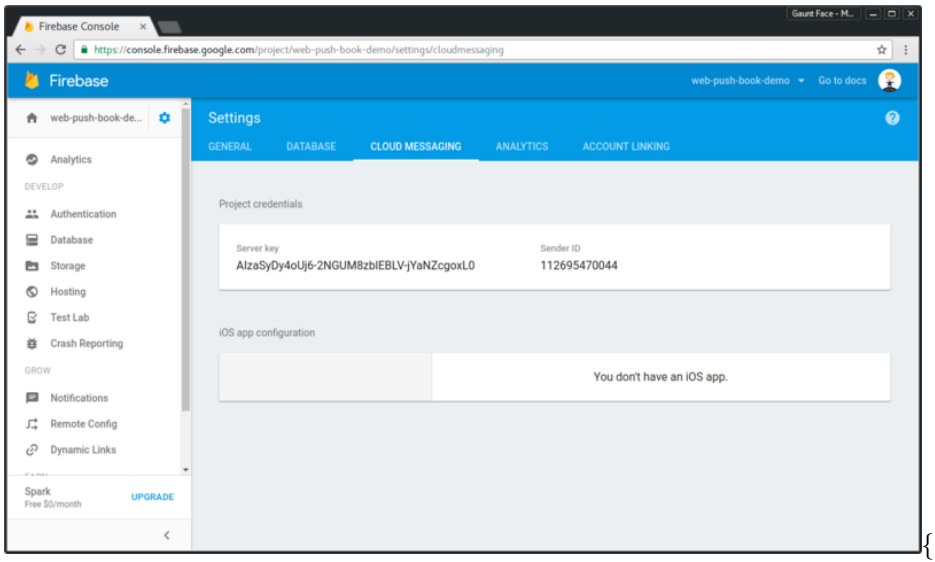
In settings, click on the "Cloud Messaging" tab and here you'll find a "Server key" and a "Sender ID". We'll need these two pieces of information shortly.



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Adding a Web App Manifest

The non-standards browsers will look for your sender ID in a web app manifest. For anyone who's new to the web app manifest, it's a JSON file that browsers can use to gain extra information about their web app. This includes meta data like your web app's name, icon, theme color and other goodies, to learn more check out the MDN docs.

For push, all we need is a JSON file with the field "gcm_sender_id" and we'll give it a value of the Sender ID from our Firebase project, like this:

```
{
  "gcm_sender_id": "547903344792"
}
```

Save this JSON as a file on your site, the demo for this site has a file called 'manifest.json' at the root of the site, i.e. '/manifest.json'.

Browsers will look for the manifest by looking for a "manifest" `link` tag in the `head` of our page.

```
<link rel="manifest" href="/manifest.json">
```

With this set up, when `subscribe()` is called, browsers that require this will retrieve the web app manifest and use the `gcm_sender_id` value to subscribe the user to "GCM".

If anything does wrong, you might receive an error like this:

```
Registration failed - no sender id provided
```

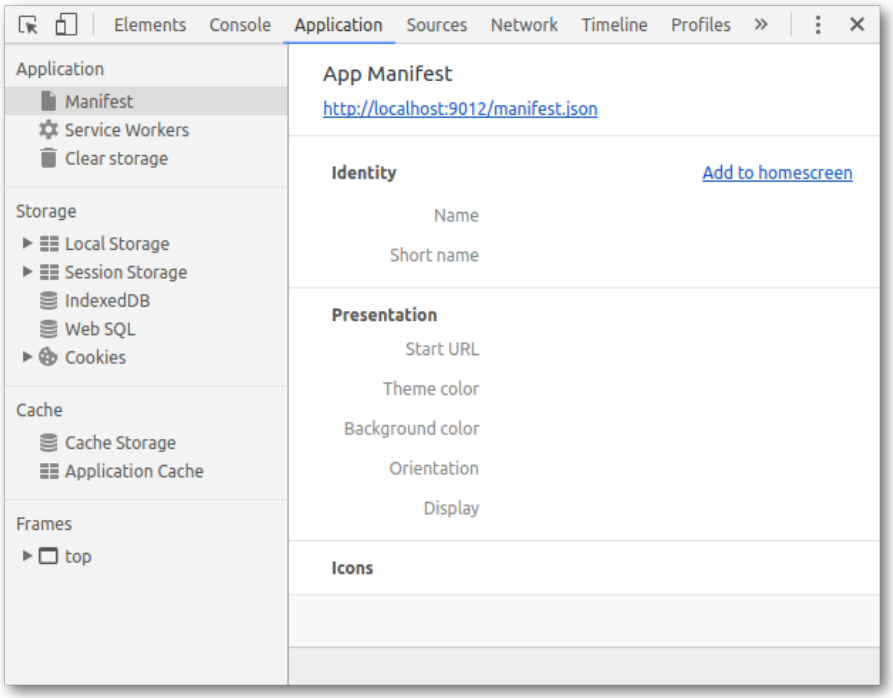
```
Registration failed - manifest empty or missing
```

```
Registration failed - gcm_sender_id not found in manifest
```

```
Failed to subscribe the user. DOMException: Registration failed - missing applicationServerKey,
```

If this happens, make sure your manifest is valid JSON and make sure you have the write sender ID value.

If you are still stumped as to what the problem could be go into Chrome DevTools, select the **Application** pane, select the **Manifest** tab and click the 'Add to homescreen' link, this will force Chrome to get the manifest and parse it. This can often give a more helpful error message if there is a problem.



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In Chrome, you can test whether your `gcm_sender_id` works or not by removing the *applicationServerKey* from your `subscribe()` options. This will result on Chrome using the `gcm_sender_id` as a fallback.

Using the Server Key

Once you've got a `PushSusbcription`, you can tell if it's using the `gcm_sender_id` from your manifest because the endpoint for the subscription will start with `https://android.googleapis.com/gcm/send/`. This is the old endpoint for GCM.

For these `PushSubscriptions`, you can still send a Web Push Protocol request, but you need to set the **Authorization** header to `key=<Server Key from Firebase Project>`.

Remember, the 'Authorization' header would normally be the signed JWT using your application server keys, you can determine which to use based on the endpoint. Most (if not all) Web Push libraries on Github will manage this for you.

The code that does this for the Node Web Library is:

```
const isGCM = subscription.endpoint.indexOf(
  'https://android.googleapis.com/gcm/send') === 0;
if (isGCM) {
  requestDetails.headers.Authorization = 'key=' + currentGCMAPIKey;
} else {
  // Add Application Server Key Details
  ...
}
```

Browser Specifics

Opera for Desktop

One thing to call out with Opera is that at the time of writing push is supported on their Android browser. On Desktop the API's are visible, but once you call subscribe, it will reject. There is no obvious way of feature detecting this sadly.

You'll need to either detect you are in Opera on desktop via user agent sniffing or simply let users go through your UI to enable push and fail at the last step.

No Payload

At the time of writing the Samsung Internet Browser doesn't support sending data with a push message (although it should do soon). This may also be the case with new browsers as they start to support web push.

This isn't necessarily a bad thing as you can make an API call when a push message is received, but for some this causes a great deal of complication. If you

fall into the bracket of requiring payload support you can feature detect payload support by checking for the existence of `getKey()` on the `PushSubscription` prototype.

```
// payloadSupport is true when supported, false otherwise.
const payloadSupport = 'getKey' in PushSubscription.prototype;
```

Conclusion

Please just remember that when you see references to GCM, it's referring to a legacy, non-standard implementation of web push and will be phased out.

Only implement this *if* you have an audience from supporting browsers that warrant use of GCM.

FAQ

Why Doesn't Push Work when the Browser is Closed?

This question crops up quite a bit, largely because there are a few scenarios that make it difficult to reason with and understand.

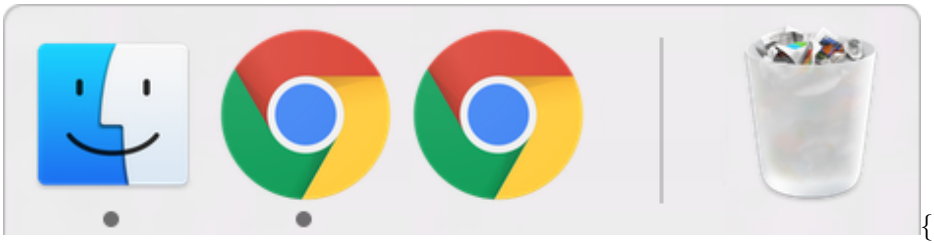
Let's start with Android. The Android OS is designed to listen for push messages and upon receiving one, wake up the appropriate Android app to handle the push message, regardless of whether the app is closed or not.

This is exactly the same with any browser on Android, the browser will be woken up when a push message is received and the browser will then wake up your service worker and dispatch the push event.

On desktop OS's, it's more nuanced and it's easiest to explain on Mac OS X because there is a visual indicator to help explain the different scenarios.

On Mac OS X, you can tell if a program is running or not by a marking under the app icon in the dock.

If you compare the two Chrome icons in the following dock, the one on the left is running, illustrated by the marking under the icon, whereas the Chrome on the right is **not running**, hence the lack of the marking underneath.

 {:

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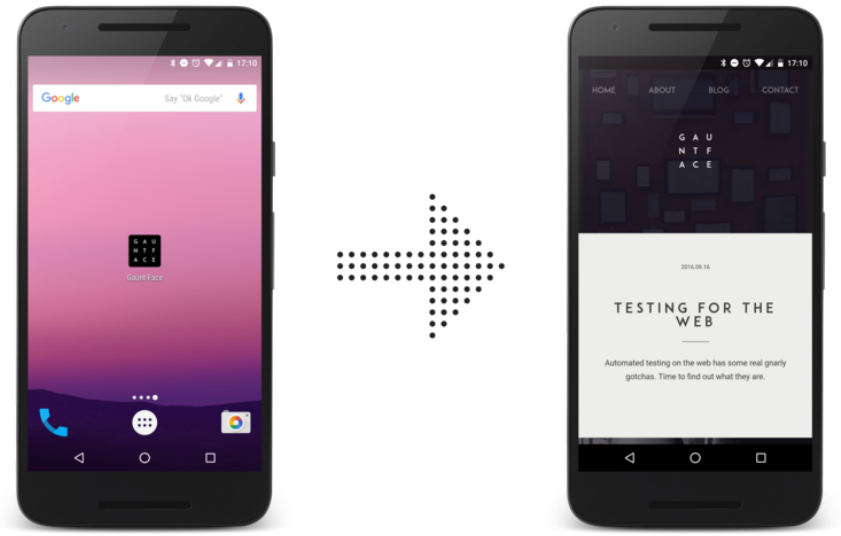
In the context of receiving push messages on desktop, you will receive messages when the browser is running, i.e. has the marking underneath the icon.

This means the browser can have no windows open, and you'll still receive the push message in your service worker, because the browser in running in the background.

The only time a push won't be received is if the browser is completely closed, i.e. not running at all (no marking). The same applies for Windows, although it's a little trickier to determine whether or not Chrome is running in the background or not.

How Do I Make My Home screen Web App Open Fullscreen from a Push?

On Chrome for Android, a web app can be added to the home screen and when the web app is opened from the home screen, it can launch in fullscreen mode without the URL bar, as shown below.



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To keep this experience consistent, developers want their clicked notifications to open their web app in fullscreen as well.

Chrome "sort of" implemented support for this, although you may find it unreliable and hard to reason with. The relevant implementation details are:

> Sites which have been added to homescreen on Android should be allowed to open in standalone mode in response to push notifications. As Chromium cannot detect what sites are on the homescreen after they have been added, the heuristic is sites which have been launched from homescreen within the last ten days will be opened in standalone from a tap on a notification. –Chrome Issue

What this means is that unless your user is visiting your site through the home screen icon fairly regularly, your notifications will open in the normal browser UI.

This issue will be worked on further.

Note: This is just the behavior of Chrome. Other browsers may behave differently. Feel free to raise an issue if you have anything you have anything to add to this discussion.

Why is this Any Better than Web Sockets?

A service worker can be brought to life when the browser window is closed. A web socket will only live as long as the browser and web page is kept open.

What is the deal with GCM, FCM, Web Push and Chrome?

This question has a number of facets to it and the easiest way to explain is to step through the history of web push and Chrome. (Don't worry, it's short.)

December 2014 When Chrome first implemented web push, Chrome used Google Cloud Messaging (GCM) to power the sending of push messages from the server to the browser.

This **was not web push**. There are a few reasons this early set-up of Chrome and GCM wasn't "real" web push.

- GCM requires developers to set up an account on the Google Developers Console.
- Chrome and GCM needed a special sender ID to be shared by a web app to be able to set up messaging correctly.
- GCM's servers accepted a custom API request that wasn't a web standard.

July 2016 In July a new feature in web push landed - Application Server Keys (or VAPID, as the spec is known). When Chrome added support for this new API, it used Firebase Cloud Messaging (also known as FCM) instead of GCM as its push service. This is important for a few reasons:

- Chrome and Application Sever Keys **do not** need any kind of project to be set up with Google or Firebase. It'll just work.
- FCM supports the *web push protocol*, which is the API that all web push services will support. This means that regardless of what push service a browser uses, you just make the same kind of request and it'll send the message.

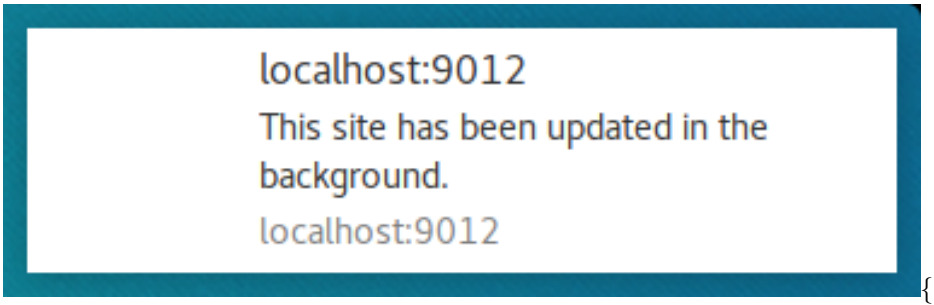
Why is it confusing today? There is a large amount of confusion now that content has been written on the topic of web push, much of which references GCM or FCM. If content references GCM, you should probably treat it as a sign that it's either old content OR it's focusing too much on Chrome. (I'm guilty of doing this in a number of old posts.)

Instead, think of web push as consisting of a browser, which uses a push service to manage sending and receiving message, where the push service will accept a "web push protocol" request. If you think in these terms, you can ignore which browser and which push service it's using and get to work.

This book has been written to focus on the standards approach of web push and purposefully ignores anything else. The *only* time you should care about this back story is if and when you want to support older versions of Chrome, Samsung Internet browser or Opera for Android, all of whom use the older GCM trick which requires supporting the proprietary GCM API. If you want to support these browsers you'll need to implement the older GCM API which is documented in the non-standrards browser section of this book here.

Why do I get the "This site has been updated in the background"?

More often than not, developers will spot a notification displayed by Chrome with the message "This site has been updated in the background", looks like this:



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Chrome will show this message if **your site fails to show a notification at the expected point in time after a push message is received**.

If you simply never show a notification, you'll get this error message if a push is received and you need to show a notification (i.e. your site isn't currently focused by the user).

One subtlety is that if you *try* to show a notification, but the promise you pass in to `event.waitUntil()` resolves **before** the notification is shown, Chrome will think you haven't shown a notification. To give you an example, consider the following code:

```
const exampleBadPromise = new Promise((resolve, reject) => {
  // Show a notification in 5 seconds.
  setTimeout(() => {
    self.registration.showNotification('Hello');
  }, 5 * 1000);

  // Resolve promise immediately will cause the "updated" notification
  resolve();
});

event.waitUntil(exampleBadPromise);
```

Notice that we are going to show a notification, but the `exampleBadPromise` will resolve before the notification is shown.

A working example would wait for the notification to display, before resolving:

```
const exampleGoodPromise = new Promise((resolve, reject) => {
  // Show a notification in 5 seconds.
  setTimeout(() => {
    self.registration.showNotification('Hello')
    .then(() => {
      // Resolve promise AFTER the notification is displayed
      resolve();
    });
  }, 5 * 1000);
});

event.waitUntil(exampleGoodPromise);
```

While this example is non-sense, it's easy to mix up a promise chain when you start making API calls with `fetch()` and attempt to perform other async tasks.

The other scenario that you may see this notification is if there is an error in your code that results in your not showing a notification. In the following example, `showNotification()` will never be called:

```
const exampleBadPromise = fetch('/api/some-api')
.then(() => {
  throw new Error('Something bad happened');
})
.then(() => {
  return self.registration.showNotification('Hello');
});

event.waitUntil(exampleBadPromise);
```

You should always provide a fallback notification to avoid the default notification:

```
const exampleGoodPromise = fetch('/api/some-api')
.then(() => {
  throw new Error('Something bad happened');
})
.then(() => {
  return self.registration.showNotification('Hello');
})
.catch(() => {
  return self.registration.showNotification('Insert generic message here :)');
});

event.waitUntil(exampleGoodPromise);
```

In short - if you see this notification, check your promise chains and make sure you are handling errors.

Firebase has a JavaScript SDK. What and Why?

For those of you who have found the Firebase web SDK and noticed is has a messaging API for JavaScript, you may be wondering how it differs from web push.

The messaging SDK (known as Firebase Cloud Messaging JS SDK) does a few tricks behind the scenes to make it easier to implement web push.

- Instead of worrying about a `PushSubscription` and its various fields, you only need to worry about an FCM Token (a string).
- Using the tokens for each user, you can use the proprietary FCM API to trigger push messages. This API doesn't require encrypting payloads. You can send a plain test payload in a POST request body.
- FCM's proprietary API supports custom features, for example FCM Topics (It works on the web too, though it's poorly documented).

- Finally FCM supports Android, iOS and web, so for some teams it is easier to work with in existing projects.

This uses web push behind the scenes, but its goal is to abstract it away.

Like I said in the previous question, if you consider web push as just a browser and push service, then you can consider the Messaging SDK in Firebase as a library to simplify implementing web push.