Lazy Loading Images and Video

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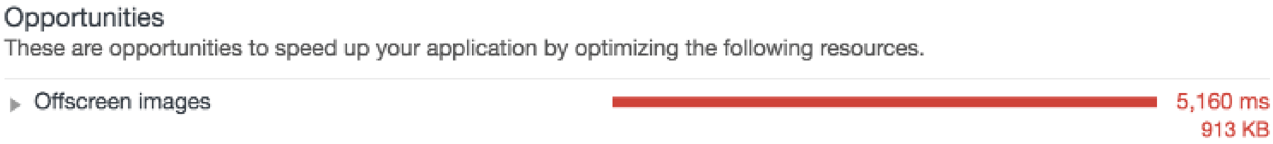
The portion of images and video in the typical payload of a website can be significant. Unfortunately, project stakeholders may be unwilling to cut any media resources from their existing applications. Such impasses are frustrating, especially when all parties involved want to improve site performance, but can't agree on how to get there. Fortunately, lazy loading is a solution that lowers initial page payload *and* load time, but doesn't skimp on content.

What is lazy loading?

Lazy loading is technique that defers loading of non-critical resources at page load time. Instead, these non-critical resources are loaded at the moment of need. Where images are concerned, "non-critical" is often synonymous with "off-screen". If you've used Lighthouse and examined some opportunities for improvement, you may have seen some guidance in this realm in the form of the Offscreen Images audit:



Opportunities

These are opportunities to speed up your application by optimizing the following resources.

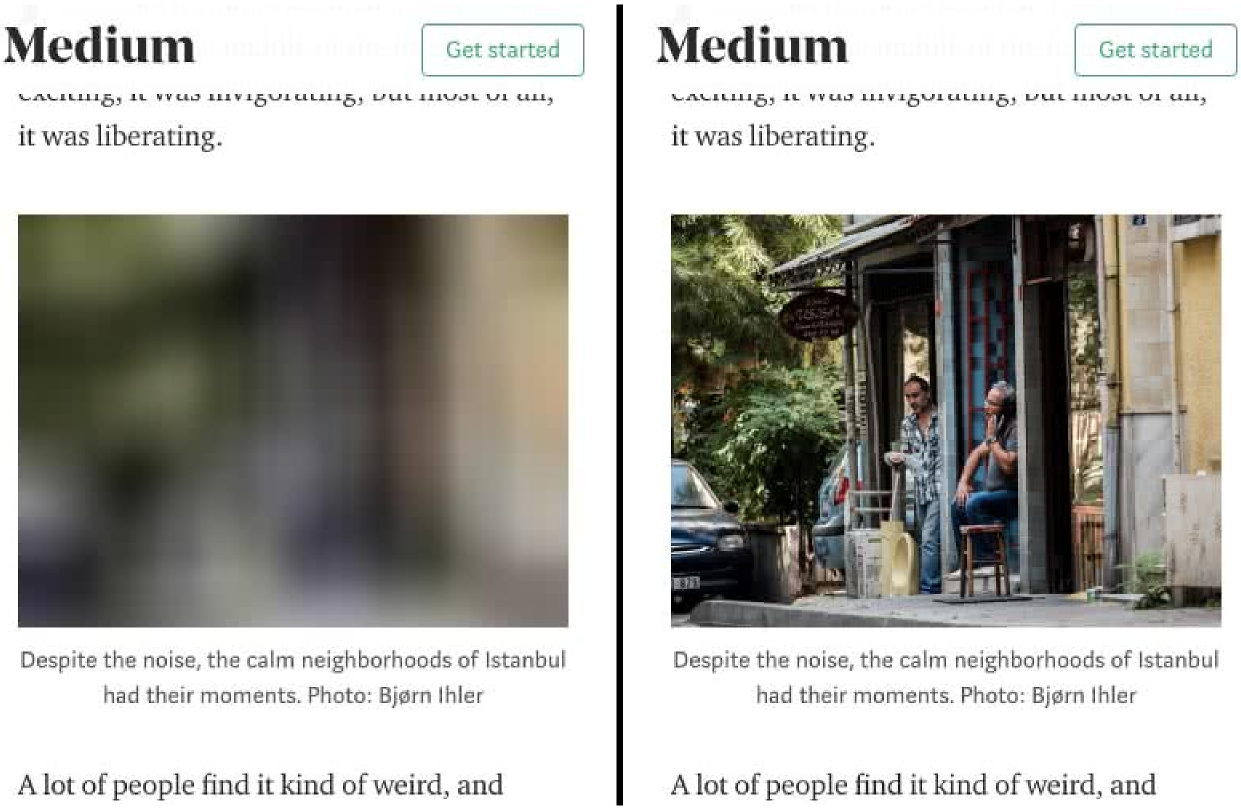
▸ Offscreen images 5,160 ms 913 KB

Figure 1. One of Lighthouse's performance audits is to identify off screen images, which are candidates for lazy loading.

You've probably already seen lazy loading in action, and it goes something like this:

- You arrive at a page, and begin to scroll as you read content.
- At some point, you scroll a placeholder image into the viewport.
- The placeholder image is suddenly replaced by the final image.

An example of image lazy loading can be found on the popular publishing platform Medium, which loads lightweight placeholder images at page load, and replaces them with lazily-loaded images as they're scrolled into the viewport.



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Despite the noise, the calm neighborhoods of Istanbul had their moments. Photo: Bjørn Ihler

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Figure 2. An example of image lazy loading in action. A placeholder image is loaded at page load (left), and when scrolled into the viewport, the final image loads at the time of need.

If you're unfamiliar with lazy loading, you might be wondering just how useful the technique is, and what its benefits are. Read on to find out!

Why lazy load images or video instead of just *loading* them?

Because it's possible you're loading stuff the user may never see. This is problematic for a couple reasons:

- It wastes data. On unmetered connections, this isn't the worst thing that could happen (although you could be using that precious bandwidth for downloading other resources that are indeed going to be seen by the user). On limited data plans, however, loading stuff the user never sees could effectively be a waste of their money.
- It wastes processing time, battery, and other system resources. After a media resource is downloaded, the browser must decode it and render its content in the viewport.

When we lazy load images and video, we reduce initial page load time, initial page weight, and system resource usage, all of which have positive impacts on performance. In this guide, we'll cover some techniques and offer guidance for lazy loading images and video, as well as a short list of some commonly used libraries.

Lazy loading images

Image lazy loading mechanisms are simple in theory, but the details are actually a bit finicky. Plus there are a couple of distinct use cases that can both benefit from lazy loading. Let's first start with lazy loading inline images in HTML.

Inline images

The most common lazy loading candidates are images as used in `<img>` elements. When we lazy load `<img>` elements, we use JavaScript to check if they're in the viewport. If they are, their `src` (and sometimes `srcset`) attributes are populated with URLs to the desired image content.

Using intersection observer

If you've written lazy loading code before, you may have accomplished your task by using event handlers such as `scroll` or `resize`. While this approach is the most compatible across browsers, modern browsers offer a more performant and efficient way to do the work of checking element visibility via the intersection observer API.

Note: Intersection observer is not supported in all browsers. If compatibility across browsers is crucial, be sure to read the next section, which shows you how to lazy load images using less performant (but more compatible!) scroll and resize event handlers.

Intersection observer is easier to use and read than code relying on various event handlers, because developers only need to register an observer to watch elements rather than writing tedious element visibility detection code. All that's left to do for the developer is to decide what to do when an element is visible. Let's assume this basic markup pattern for our lazily loaded `<img>` elements:

```
<img class="lazy" src="placeholder-image.jpg" data-src="image-to-lazy-load-
```

There are three relevant pieces of this markup we should focus on:

1. The `class` attribute, which is what we'll select the element with in JavaScript.
2. The `src` attribute, which references a placeholder image that will appear when the page first loads.
3. The `data-src` and `data-srcset` attributes, which are placeholder attributes containing the URL for the image we'll load once the element is in the viewport.

Now let's see how we can use intersection observer in JavaScript to lazy load images using this markup pattern:

```
document.addEventListener("DOMContentLoaded", function() {
  var lazyImages = [].slice.call(document.querySelectorAll("img.lazy"));

  if ("IntersectionObserver" in window) {
    let lazyImageObserver = new IntersectionObserver(function(entries, observer)
      entries.forEach(function(entry) {
        if (entry.isIntersecting) {
          let lazyImage = entry.target;
          lazyImage.src = lazyImage.dataset.src;
          lazyImage.srcset = lazyImage.dataset.srcset;
          lazyImage.classList.remove("lazy");
          lazyImageObserver.unobserve(lazyImage);
        }
      });
    });

    lazyImages.forEach(function(lazyImage) {
      lazyImageObserver.observe(lazyImage);
    });
  } else {
    // Possibly fall back to a more compatible method here
  }
});
```

On the document's `DOMContentLoaded` event, this script queries the DOM for all `<img>` elements with a class of `lazy`. If intersection observer is available, we create a new observer that runs a callback when `img.lazy` elements enter the viewport. Check out this CodePen example to see this code in action.

Note: This code makes use of an intersection observer method named **`isIntersecting`**, which is unavailable in Edge 15's intersection observer implementation. As such, the lazy loading code above (and other similar code snippets) will fail. Consult this GitHub issue for guidance on a more complete feature detection conditional.

The drawback of intersection observer, however, is that while it has good support amongst browsers, it's not universal. You'll need to polyfill browsers that don't support it, or as the above code suggests, detect if it's available and subsequently fall back to older, more compatible methods.

Using event handlers (the most compatible way)

While you *should* use intersection observer for lazy loading, your application requirements may be such that browser compatibility is critical. You *can* polyfill intersection observer support (and this would be easiest), but you could also fall back to code using `scroll`, `resize`, and possibly `orientationchange` event handlers in concert with `getBoundingClientRect` to determine whether an element is in the viewport.

Assuming the same markup pattern from before, the following JavaScript provides the lazy loading functionality:

```
document.addEventListener("DOMContentLoaded", function() {
  let lazyImages = [].slice.call(document.querySelectorAll("img.lazy"));
  let active = false;

  const lazyLoad = function() {
    if (active === false) {
      active = true;

      setTimeout(function() {
        lazyImages.forEach(function(lazyImage) {
          if ((lazyImage.getBoundingClientRect().top <= window.innerHeight && laz
            lazyImage.src = lazyImage.dataset.src;
            lazyImage.srcset = lazyImage.dataset.srcset;
            lazyImage.classList.remove("lazy");

            lazyImages = lazyImages.filter(function(image) {
              return image !== lazyImage;
            });

            if (lazyImages.length === 0) {
              document.removeEventListener("scroll", lazyLoad);
              window.removeEventListener("resize", lazyLoad);
              window.removeEventListener("orientationchange", lazyLoad);
            }
          }
        });

        active = false;
      }, 200);
    }
  };

  document.addEventListener("scroll", lazyLoad);
  window.addEventListener("resize", lazyLoad);
  window.addEventListener("orientationchange", lazyLoad);
});
```

This code uses `getBoundingClientRect` in a `scroll` event handler to check if any of `img.lazy` elements are in the viewport. A `setTimeout` call is used to delay processing, and an `active` variable contains the processing state which is used to throttle function calls. As images are lazy loaded, they're removed from the elements array. When the elements array reaches a `length` of `0`, the scroll event handler code is removed. See this code in action in this CodePen example.

While this code works in pretty much any browser, it has potential performance issues in that repetitive `setTimeout` calls can be wasteful, even if the code within them is throttled. In this example, a check is being run every 200 milliseconds on document scroll or window resize regardless of whether there's an image in the viewport or not. Plus, the tedious work of tracking how many elements are left to lazy load and unbinding the scroll event handler are left to the developer.

Simply put: Use intersection observer wherever possible, and fall back to event handlers if the widest possible compatibility is a critical application requirement.

Images in CSS

While `<img>` tags are the most common way of using images on web pages, images can also be invoked via the CSS `background-image` property (and other properties). Unlike `<img>` elements which load regardless of their visibility, image loading behavior in CSS is done with more speculation. When the document and CSS object models and render tree are built, the browser examines how CSS is applied to a document before requesting external resources. If the browser has determined a CSS rule involving an external resource doesn't apply to the document as it's currently constructed, the browser doesn't request it.

This speculative behavior can be used to defer the loading of images in CSS by using JavaScript to determine when an element is within the viewport, and subsequently applying a class to that element that applies styling invoking a background image. This causes the image to be downloaded at the time of need instead of at initial load. For example, let's take an element that contains a large hero background image:

```
<div class="lazy-background">
  <h1>Here's a hero heading to get your attention!</h1>
  <p>Here's hero copy to convince you to buy a thing!</p>
  <a href="/buy-a-thing">Buy a thing!</a>
</div>
```

The `div.lazy-background` element would normally contain the hero background image invoked by some CSS. In this lazy loading example, however, we can isolate the `div.lazy-`

background element's **background-image** property via a **visible** class that we'll add to the element when it's in the viewport:

```
.lazy-background {
  background-image: url("hero-placeholder.jpg"); /* Placeholder image */
}

.lazy-background.visible {
  background-image: url("hero.jpg"); /* The final image */
}
```

From here, we'll use JavaScript to check if the element is in the viewport (with intersection observer!), and add the **visible** class to the **div.lazy-background** element at that time, which loads the image:

```
document.addEventListener("DOMContentLoaded", function() {
  var lazyBackgrounds = [].slice.call(document.querySelectorAll(".lazy-background

  if ("IntersectionObserver" in window) {
    let lazyBackgroundObserver = new IntersectionObserver(function(entries, obser
      entries.forEach(function(entry) {
        if (entry.isIntersecting) {
          entry.target.classList.add("visible");
          lazyBackgroundObserver.unobserve(entry.target);
        }
      });
    });

    lazyBackgrounds.forEach(function(lazyBackground) {
      lazyBackgroundObserver.observe(lazyBackground);
    });
  }
});
```

As indicated earlier, you'll want to make sure you provide a fallback or a polyfill for intersection observer since not all browsers currently support it. Check out this CodePen demo to see this code in action.

Lazy loading video

As with image elements, we can also lazy load video. When we load video in normal circumstances, we do so using the **<video>** element (although an alternate method using

`<img>` has emerged with limited implementation). *How* we lazy load `<video>` depends on the use case, though. Let's discuss a couple of scenarios that each require a different solution.

For video that doesn't autoplay

For videos where playback is initiated by the user (i.e., videos that *don't* autoplay), specifying the `preload` attribute on the `<video>` element may be desirable:

```
<video controls preload="none" poster="one-does-not-simply-placeholder.jpg"
  <source src="one-does-not-simply.webm" type="video/webm">
  <source src="one-does-not-simply.mp4" type="video/mp4">
</video>
```

Here, we use a `preload` attribute with a value of `none` to prevent browsers from preloading *any* video data. To occupy the space, we use the `poster` attribute to give the `<video>` element a placeholder. The reason for this is that default behaviors for loading video can vary from browser to browser:

- In Chrome, the default for `preload` used to be `auto`, but as of Chrome 64, it now defaults to `metadata`. Even so, on the desktop version of Chrome, a portion of the video may be preloaded using the `Content-Range` header. Firefox, Edge and Internet Explorer 11 behave similarly.
- As with Chrome on desktop, 11.0 desktop versions of Safari will preload a range of the video. In version 11.2 (currently Safari's Tech Preview version), only the video metadata is preloaded. In Safari on iOS, videos are never preloaded.
- When Data Saver mode is enabled, `preload` defaults to `none`.

Because browser default behaviors with regard to `preload` are not set in stone, being explicit is probably your best bet. In this cases where the user initiates playback, using `preload="none"` is the easiest way to defer loading of video on all platforms. The `preload` attribute isn't the only way to defer the loading of video content. *Fast Playback with Video Preload* may give you some ideas and insight into working with video playback in JavaScript.

Unfortunately, it doesn't prove useful when we want to use video in place of animated GIFs, which we'll cover next.

For video acting as an animated GIF replacement

While animated GIFs enjoy wide use, they're subpar to video equivalents in a number of ways, particularly in output file size. Animated GIFs can stretch into the range of several megabytes of data. Videos of similar visual quality tend to be far smaller.

Using the **`<video>`** element as a replacement for animated GIF is not as straightforward as the **`<img>`** element. Inherent in animated GIFs are these three behaviors:

1. They play automatically when loaded.
2. They loop continuously (though that's not always the case).
3. They don't have an audio track.

Achieving this with the **`<video>`** element looks something like this:

```
<video autoplay muted loop playsinline>
  <source src="one-does-not-simply.webm" type="video/webm">
  <source src="one-does-not-simply.mp4" type="video/mp4">
</video>
```

The **`autoplay`**, **`muted`**, and **`loop`** attributes are self-explanatory. **`playsinline`** is necessary for autoplaying to occur in iOS. Now we have a serviceable video-as-GIF replacement that works across platforms. But how to go about lazy loading it? Chrome will lazy load video for you, but you can't count on all browsers to provide this optimized behavior. Depending on your audience and application requirements, you may need to take matters into your own hands. To start, modify your **`<video>`** markup accordingly:

```
<video autoplay muted loop playsinline width="610" height="254" poster="one
  <source data-src="one-does-not-simply.webm" type="video/webm">
  <source data-src="one-does-not-simply.mp4" type="video/mp4">
</video>
```

You'll notice the addition of the **`poster`** attribute, which lets you specify a placeholder to occupy the **`<video>`** element's space until the video is lazy loaded. As with our **`<img>`** lazy loading examples from before, we stash the video URL in the **`data-src`** attribute on each **`<source>`** element. From there, we'll use some JavaScript similar to the earlier intersection observer-based image lazy loading examples:

```
document.addEventListener("DOMContentLoaded", function() {
  var lazyVideos = [].slice.call(document.querySelectorAll("video.lazy"));

  if ("IntersectionObserver" in window) {
    var lazyVideoObserver = new IntersectionObserver(function(entries, observer)
      entries.forEach(function(video) {
        if (video.isIntersecting) {
          for (var source in video.target.children) {
            var videoSource = video.target.children[source];
            if (typeof videoSource.tagName === "string" && videoSource.tagName ==
              videoSource.src = videoSource.dataset.src;
            }
          }

          video.target.load();
          video.target.classList.remove("lazy");
          lazyVideoObserver.unobserve(video.target);
        }
      });
    });

    lazyVideos.forEach(function(lazyVideo) {
      lazyVideoObserver.observe(lazyVideo);
    });
  }
});
```

When we lazy load a **`<video>`** element, we need to iterate through all of the child **`<source>`** elements and flip their **`data-src`** attributes to **`src`** attributes. Once we've done that, we need to trigger loading of the video by calling the element's **`load`** method, after which the media will begin playing automatically per the **`autoplay`** attribute.

Using this method, we have a video solution that emulates animated GIF behavior, but doesn't incur the same intensive data usage as animated GIFs do, and we get to lazy load that content.

Lazy loading libraries

If you're not so concerned about *how* lazy loading works under the hood and just want to pick a library and go (and there's no shame in that!), there's plenty of options to choose from. Many libraries use a markup pattern similar to the ones demonstrated in this guide. Here are some lazy loading libraries you may find useful:

- lazysizes is a full-featured lazy loading library that lazy loads images and iframes. The pattern it uses is quite similar to the code examples shown here in that it automatically binds to a **`lazyload`** class on **`<img>`** elements, and requires you to specify image URLs in **`data-src`** and/or **`data-srcset`** attributes, the contents of which are swapped into **`src`** and/or **`srcset`** attributes, respectively. It uses intersection observer (which you can polyfill), and can be extended with a number of plugins to do things like lazy load video.
- lozad.js is a super lightweight option that uses intersection observer only. As such, it's highly performant, but will need to be polyfilled before you can use it on older

browsers.

- blazy is another such option that bills itself as a lightweight lazy loader (weighing in at 1.4 KB). As with lazysizes, it doesn't need any third party utilities to load, and works for IE7+. Unfortunately, it doesn't use intersection observer.
- yall.js is a library I wrote that uses IntersectionObserver and falls back to event handlers. It's compatible with IE11 and major browsers.
- If you're seeking a React-specific lazy loading library, you might consider react-lazyload. While it doesn't use intersection observer, it *does* provide a familiar method of lazy loading images for those accustomed to developing applications with React.

Each of these lazy loading libraries is well documented, with plenty of markup patterns for your various lazy loading endeavors. If you're not one to tinker, grab a library and go. It will take the least amount of effort.

What can go wrong

While lazy loading images and video have positive and measurable performance benefits, it's not a task to be taken lightly. If you get it wrong, there could be unintended consequences. As such, it's important to keep the following concerns in mind:

Mind the fold

It may be tempting to lazy load every single media resource on the page with JavaScript, but you need to resist this temptation. Anything resting above the fold shouldn't be lazy loaded. Such resources should be considered critical assets, and thus should be loaded normally.

The primary argument for loading critical media resources the usual way in lieu of lazy loading is that lazy loading delays the loading of those resources until after the DOM is interactive when scripts have finished loading and begin execution. For images below the fold, this is fine, but it would be faster to load critical resources above the fold with a standard `<img>` element.

Of course, where the fold lies is not so clear these days when websites are viewed on so many screens of varying sizes. What lies above the fold on a laptop may well lie *below* it on mobile devices. There's no bulletproof advice for addressing this optimally in every situation. You'll need to conduct an inventory of your page's critical assets, and load those images in typical fashion.

Additionally, you may not want to be so strict about the fold line as the threshold for triggering lazy loading. It may be more ideal for your purposes to establish a buffer zone some distance below the fold so that images begin loading well before the user scrolls them into the viewport. For example, The intersection observer API allows you to specify a `rootMargin` property in an options object when you create a new `IntersectionObserver` instance. This effectively gives elements a buffer, which triggers lazy loading behavior before the element is in the viewport:

```
let lazyImageObserver = new IntersectionObserver(function(entries, observer,
  // Lazy loading image code goes here
}, {
  rootMargin: "0px 0px 256px 0px"
});
```

If the value for `rootMargin` looks similar to values you'd specify for a CSS `margin` property, that's because it is! In this case, we're broadening the bottom margin of the observing element (the browser viewport by default, but this can be changed to a specific element using the `root` property) by 256 pixels. That means the callback function will execute when an image element is within 256 pixels of the viewport, meaning that the image will begin to load before the user actually sees it.

To achieve this same effect using scroll event handling code, simply adjust your `getBoundingClientRect` check to include a buffer, and you'll get the same effect in browsers that don't support intersection observer.

Layout shifting and placeholders

Lazy loading media can cause shifting in the layout if placeholders aren't used. These changes can be disorienting for users and trigger expensive DOM layout operations that consume system resources and contribute to jank. At a minimum, consider using a solid color placeholder occupying the same dimensions as the target image, or techniques such as LQIP or SQIP that hint at the content of a media item before it loads.

For `<img>` tags, `src` should initially point to a placeholder until that attribute is updated with the final image URL. Use the `poster` attribute in a `<video>` element to point to a placeholder image. Additionally, use `width` and `height` attributes on both `<img>` and `<video>` tags. This ensures that transitioning from placeholders to final images won't change the rendered size of the element as media loads.

Image decoding delays

Loading large images in JavaScript and dropping them into the DOM can tie up the main thread, causing the user interface to be unresponsive for a short period of time while decoding occurs. Asynchronously decoding images using the `decode` method prior to inserting them into the DOM can cut down on this sort of jank, but beware: It's not available everywhere yet, and it adds complexity to lazy loading logic. If you want to use it, you'll need to check for it. Below shows how you might use `Image.decode()` with a fallback:

```
var newImage = new Image();
newImage.src = "my-awesome-image.jpg";

if ("decode" in newImage) {
  // Fancy decoding logic
  newImage.decode().then(function() {
    imageContainer.appendChild(newImage);
  });
} else {
  // Regular image load
  imageContainer.appendChild(newImage);
}
```

Check out this CodePen link to see code similar to this example in action. If most of your images are fairly small, this may not do much for you, but it can certainly help cut down on jank when lazy loading large images and inserting them into the DOM.

When stuff doesn't load

Sometimes media resources will fail to load for one reason or another and errors occur. When might this happen? It depends, but here's one hypothetical scenario for you: You have an HTML caching policy for a short period of time (e.g., five minutes), and the user visits the site *or* a user has a left a stale tab open for a long period of time (e.g., several hours) and comes back to read your content. At some point in this process, a redeployment occurs. During this deployment, an image resource's name changes due to hash-based versioning, or is removed altogether. By the time the user lazy loads the image, the resource is unavailable, and thus fails.

While these are relatively rare occurrences, it may behoove you to have a backup plan if lazy loading fails. For images, such a solution may look something like this:

```
var newImage = new Image();
newImage.src = "my-awesome-image.jpg";

newImage.onerror = function(){
  // Decide what to do on error
};
newImage.onload = function(){
  // Load the image
};
```

What you decide to do in the event of an error depends on your application. For example, you could replace the image placeholder area with a button that allows the user to attempt to load the image again, or simply display an error message in the image placeholder area.

Other scenarios could arise as well. Whatever you do, it's never a bad idea to signal to the user when an error has occurred, and possibly give them an action to take if something goes awry.

JavaScript availability

It shouldn't be assumed that JavaScript is always available. If you're going to lazy load images, consider offering `<noscript>` markup that will show images in case JavaScript is unavailable. The simplest possible fallback example involves using `<noscript>` elements to serve images if JavaScript is turned off:

```
<!-- An image that eventually gets lazy loaded by JavaScript -->
<img class="lazy" src="placeholder-image.jpg" data-src="image-to-lazy-load.jpg" a
<!-- An image that is shown if JavaScript is turned off -->
<noscript>
  <img src="image-to-lazy-load.jpg" alt="I'm an image!">
</noscript>
```

If JavaScript is turned off, users will see *both* the placeholder image and the image contained with the `<noscript>` elements. To get around this, we can place a class of `no-js` on the `<html>` tag like so:

```
<html class="no-js">
```

Then we place one line of inline script in the `<head>` before any style sheets are requested via `<link>` tags that removes the `no-js` class from the `<html>` element if JavaScript is on:

```
<script>document.documentElement.classList.remove("no-js");</script>
```

Finally, we can use some CSS to simply hide elements with a class of lazy when JavaScript is unavailable like so:

```
.no-js .lazy {
  display: none;
}
```

This doesn't prevent placeholder images from loading, but the outcome is more desirable. People with JavaScript turned off get something more than placeholder images, which is better than placeholders and no meaningful image content at all.

Conclusion

Used with care, lazy loading images and video can seriously lower the initial load time and page payloads on your site. Users won't incur unnecessary network activity and processing costs of media resources they may never see, but they can still view those resources if they want.

As far as performance improvement techniques go, lazy loading is reasonably uncontroversial. If you have a lot of inline imagery in your site, it's a perfectly fine way to cut down on unnecessary downloads. Your site's users and project stakeholders will appreciate it!

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