Array push javascript performance

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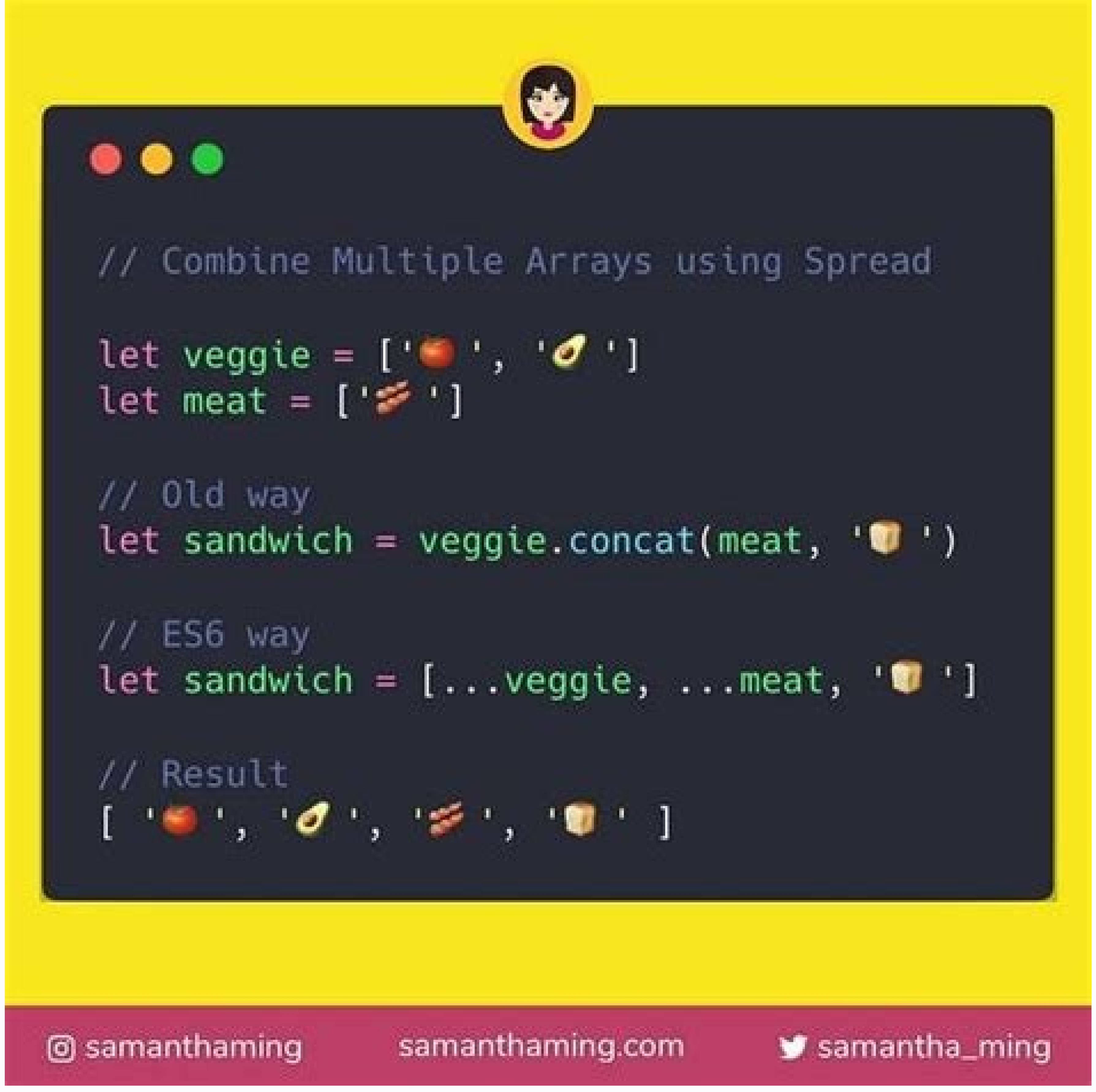

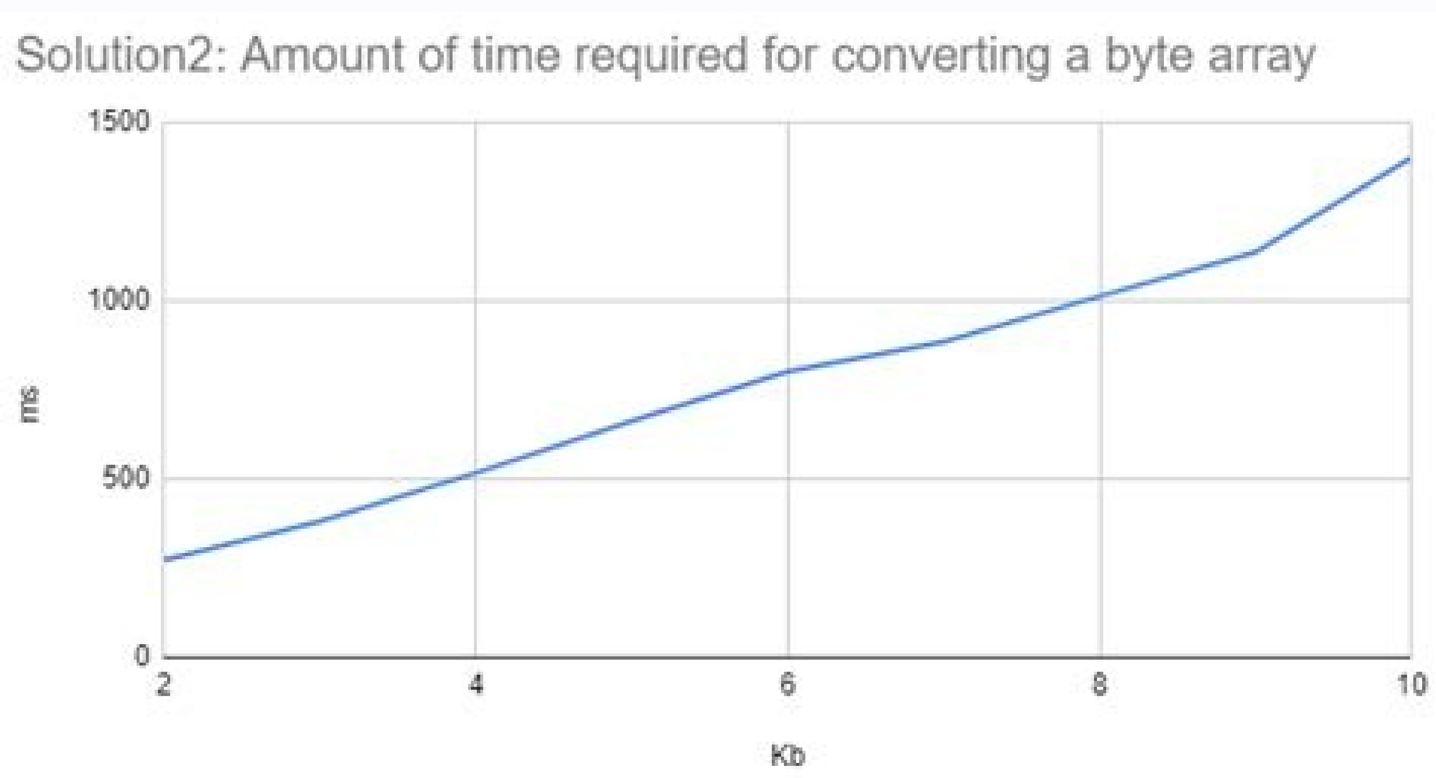

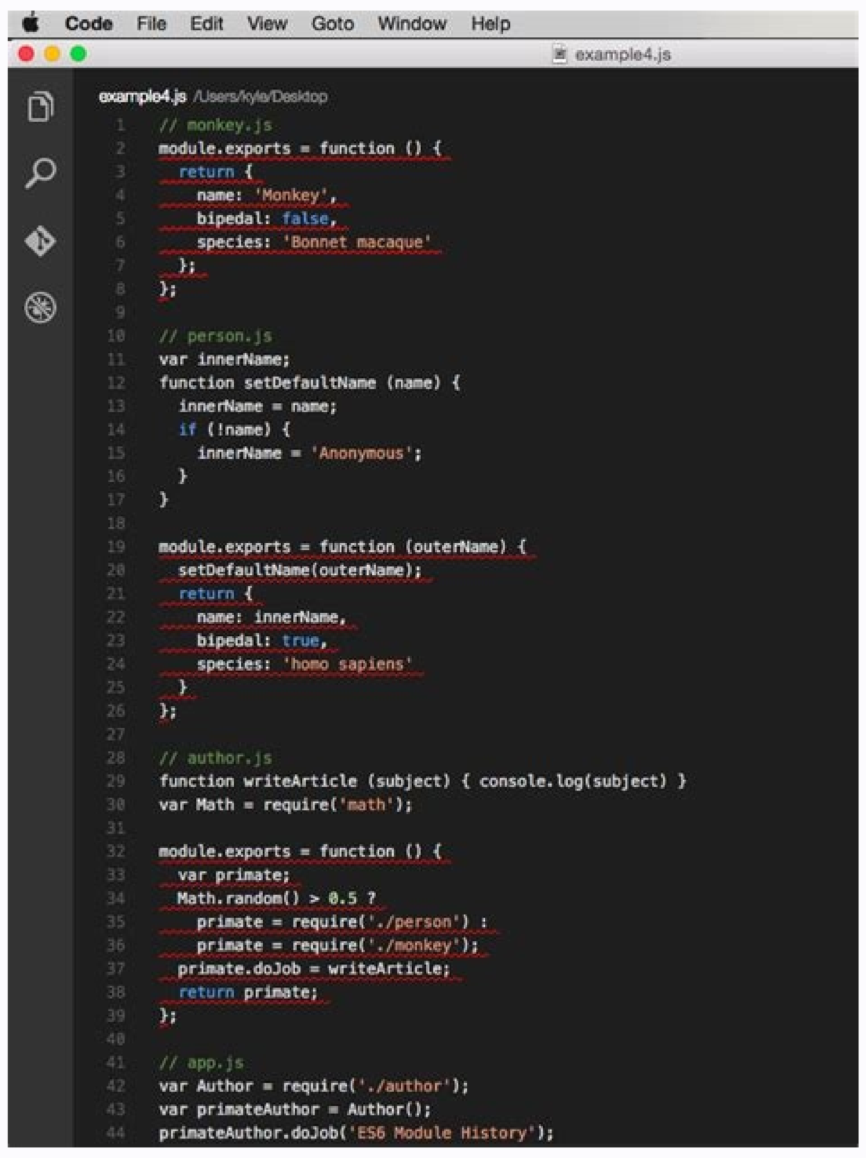

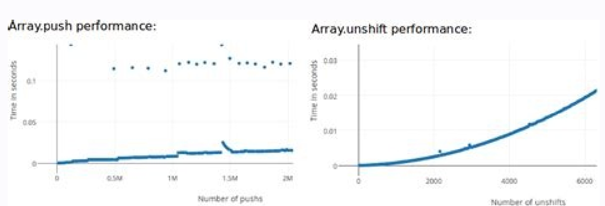

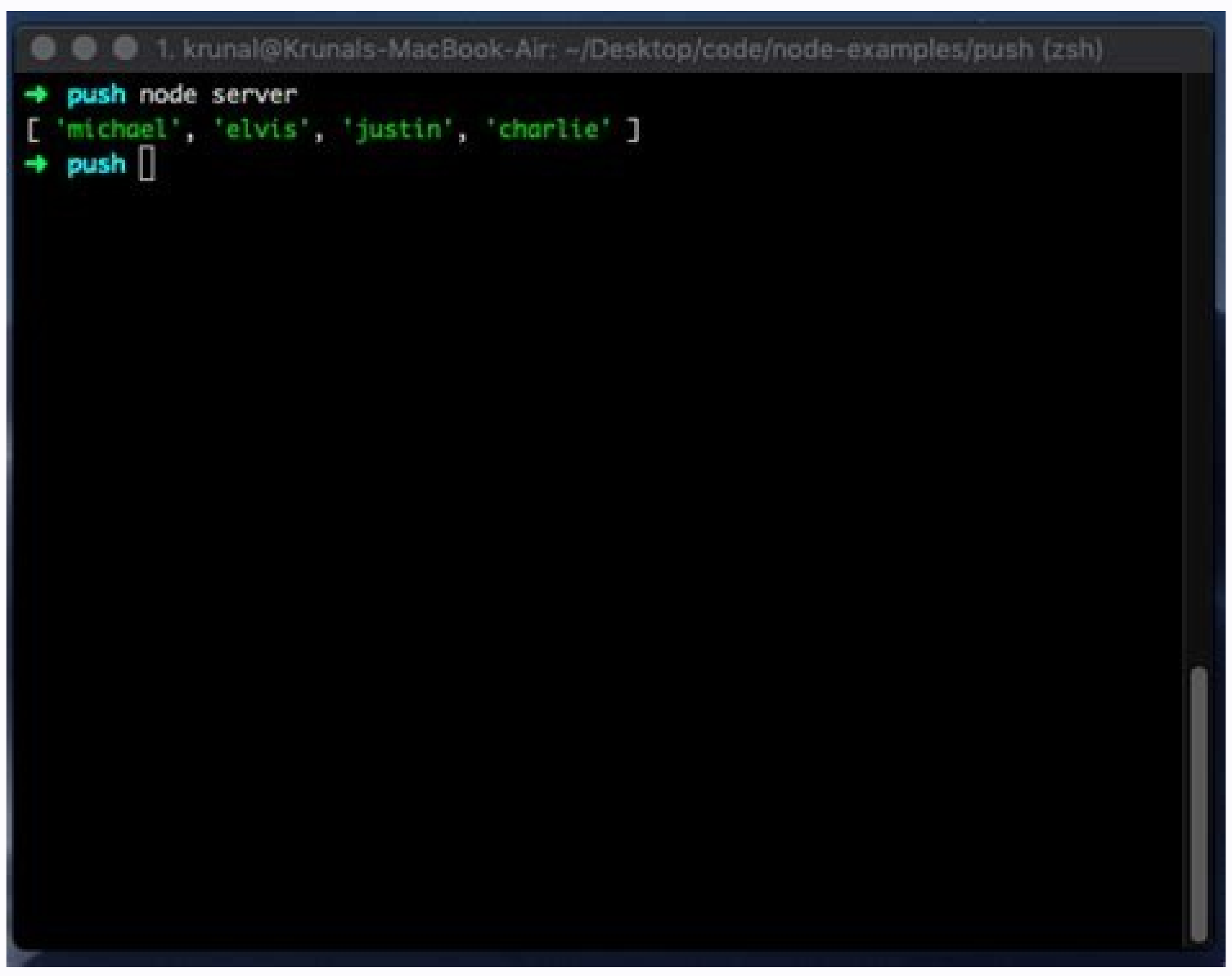

Javascript array push pop performance. Javascript array push vs index performance. Javascript array push performance. Javascript array push vs pop. Javascript array push vs unshift performance. Javascript array push vs shift. Javascript array concat vs push performance.

This is a short response I wrote to a question on /r/javascript. The user who asked it was curious whether there would be any performance difference between adding elements to a JavaScript array by calling push, or manually adding a new object to an array by making a call like myArray[myArray.length] = obj. Let's take a look at the ECMAScript specification to see what it says. In the case of Array.prototype.push, the JS runtime must first call toObject on the argument passed to push. It must also do a bit of work to handle the case where more than one item was passed to push, since you are allowed to make a call like this: abc.push(1,2,3). After from calling toObject and checking how many arguments were provided, it then goes through each one and does a regular property set call, which ends doing the same as myArray[myArray.length] = obj. If you're only adding one thing to your array, you may as well call push, since it is easier to read and the toObject call and args length check is going to make an immeasurably small difference to execution time. If you're adding multiple things to your array, then call myArray.push(...things). because when you do that, the JS engine's compiled C++ will handle all of the iteration, instead of thunking back and forth between native code and JavaScript if you're looping through yourself and calling push every time. In reality, with all of the optimization and JITing that modern JS engines do, looping through yourself probably isn't all that much slower than passing everything to pushat once. I haven't tested this to verify, though. Related Latest run results: Run details: (Test run date: 2 months ago) User agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10.15; rv:100.0) Gecko/20100101 Firefox/100.0 Browser/OS: Firefox 100 on Mac OS X 10.15 View result in a separate tab Test name Executions per second Concat 2297.0 Ops/sec Push 25841460.0 Ops/sec Spread syntax 0.3 Ops/sec Because the .push() is a function call and the other is direct assignment. Direct assignment is always faster. Remember that in javascript, arrays are objects like everything else. This means you can assign properties directly to them. In the special case of arrays, they have a built-in length property that gets update behind the scenes (and lots of other optimizations under the hood, but that's not important right now). In a regular object, you can do this but its not an array: var x = { 0: 'a', 1: 'b', 2: 'c' }; However, since arrays and hashes are both objects, this is equivalent. var x = ['a', 'b', 'c']; Since x is an array in the second case, length is automatically calculated and available. to understand this, there needs to be some knowledge about how a Stack (in JavaScript, an Array) is designed in computer science and is represented within your RAM/memory. If you create a Stack(an Array), essentially you are telling the system to allocate a space in memory for a stack that eventually can grow. Now, everytime you add to that Stack (with push), it adds to the end of that stack. Eventually the system sees that the Stack isn't going to be big enough, so it allocates a new space in memory at oldstack.length*1.5-1 and copies the old information to the new space. This is the reason for the jumps/jitters in your graph for push that otherwise look flat/linear. This behavior is also the reason why you always should initialize an Array/Stack with a predefined size (if you know it) with var a=new Array(1000) so that the system doesn't need to "newly allocate memory and copy over". Considering unshift, it seems very similar to push. It just adds it to the start of the list, right? But as dismissive this difference seems, its very big! As explained with push, eventually there is a "allocate memory and copy over" when size runs out. With unshift, it wants to add something to the start. But there is already something there. So it would have to move the element at position N to position N+1, N1 to N1+1, N2 to N2+1 etc. Because that is very inefficient, it actually just newly allocates memory, adds the new Element and then copies over the oldstack to the newstack. This is the reason your graph has more an quadratic or even a slight exponential look to it. To conclude; push adds to the end and rarely needs reallocate memory+copy over. unshift adds to the start and always needs to reallocate memory and copy data over /edit: regarding your questions why this isn't solved with a "moving index" is the problem when you use unshift and push interchangeably, you would need multiple "moving indexes" and intensive computing to figure out where that element at index 2 actually resides in memory. But the idea behind a Stack is to have O(1) complexity. There are many other datastructures that have such properties (and more features) but at a tradeoff for speed, memory usage, etc. Some of these datastructures are Vector, a Double-Linked-List, SkipList or even a Binary Search Tree depending on your requirements Here is a good resource explaining datastructures and some differences/advancements between them const MAX_BLOCK_SIZE = 65535; export function appendArrayInPlace(dest: T[], source: T[]) { let offset = 0; let itemsLeft = source.length; if (itemsLeft 0) { const pushCount = Math.min(MAX_BLOCK_SIZE, itemsLeft); const subSource = source.slice(offset, offset + pushCount); dest.push.apply(dest, subSource); itemsLeft -= pushCount; offset += pushCount; } } return dest;} If you are merging arrays with thousands of elements across, you can shave off seconds from the process by using arr1.push(...arr2) instead of arr1 = arr1.concat(arr2). If you really to go faster, you might even want to write your own implementation to merge arrays. Wait a minute... how long does it take to merge 15,000 arrays with .concat... Recently, we had a user complaining of a major slowdown in the execution of their UI tests on UI-licious. Each I.click I.fill I.see command which usually takes ~1 second to complete (post-processing e.g. taking screenshots) now took over 40 seconds to complete , so test suites that usually completed under 20 minutes took hours instead and was severely limiting their deployment process. It didn't take long for me to set up timers to narrow down out which part of the code was causing the slowdown, but I was pretty surprised when I found the culprit: Array's .concat method. In order to allow tests to be written using simple commands like I.click("Login") instead of CSS or XPATH selectors I.click("#login-btn"), UI-licious works using dynamic code analysis to analyse the DOM tree to determine what and how to test your website based on semantics, accessibility attributes, and popular but non-standard patterns. The .concat operations was being used to flatten the DOM tree for analysis, but worked very poorly when the DOM tree was very large and very deep, which happened when our user recently pushed an update to their application that caused their pages to bloat significantly (that's another performance issue on their side, but it's another topic). It took 6 seconds to merge 15,000 arrays that each had an average size of 5 elements with .concat. What? 6 seconds... For 15,000 arrays with the average size of 5 elements? That's not a lot data. Why is it so slow? Are there faster ways to merge arrays? Benchmark comparisons So I started researching (by that, I mean googling) benchmarks for .concat compared to other methods to merge arrays in Javascript. It turns out the fastest method to merge arrays is to use .push which accepts n arguments: // Push contents of arr2 to arr1 arr1.push(arr2[0], arr2[1], arr2[3], ..., arr2[n]) // Since my arrays are not fixed in size, I used `apply` instead Array.prototype.push.apply(arr1, arr2) And it is faster by leaps in comparison. How fast? I ran a few performance benchmarks on my own to see for myself. Lo and behold, here's the difference on Chrome: Link to the test on JsPerf To merge arrays of size 10 for 10,000 times, .concat performs at 0.40 ops/sec, while .push performs at 378 ops/sec. push is 945x faster than concat! This difference might not be linear, but it is already is already significant at this small scale. And on Firefox, here's the results: Firefox's SpiderMonkey Javascript engine is generally slower compared to Chrome's V8 engine, but .push still comes out top, at 2260x faster. This one change to our code fixed the entire slowdown problem. .push vs. .concat for 2 arrays with 50,000 elements each But ok, what if you are not merging 10,000 size-10 arrays, but 2 giant arrays with 50000 elements each instead? Here's the the results on Chrome along with results: Link to the test on JsPerf .push is still faster than .concat, but a factor of 9. Not as dramatic as 945x slower, but still dang slow. Prettier syntax with rest spread If you find Array.prototype.push.apply(arr1, arr2) verbose, you can use a simple variant using the rest spread ES6 syntax: The performance difference between Array.prototype.push.apply(arr1, arr2) and arr1.push(...arr2) is negligable. But why is Array.concat so slow? It lot of it has to do with the Javascript engine, but I don't know the exact answer, so I asked my buddy @picocreator , the co-creator of GPU.js, as he had spent a fair bit of time digging around the V8 source code before. @picocreator 's also lent me his sweet gaming PC which he used to benchmark GPU.js to run the JsPerf tests because my MacBook didn't have the memory to even perform .concat with two size-50000 arrays. Apparently the answer has a lot to do with the fact that .concat creates a new array while .push modifies the first array. The additional work .concat does to add the elements from the first array to the returned array is the main reason for the slowdown. Me: "What? Really? That's it? But by that much? No way!" @picocreator : "Serious, just try writing some naive implementations of .concat vs .push then!" So I tried writing some naive implementations of .concat and .push. Several in fact, plus a comparison with lodash's _.concat: Link to the test on JsPerf Naive implementation 1 Let's talk about the first set of naive implementation: Naive implementation of .concat // Create result array var arr3 = [] // Add Array 1 for(var i = 0; i < arr1Length; i++){ arr3[i] = arr1[i] } // Add Array 2 for(var i = 0; i < arr2Length; i++){ arr3[arr1Length + i] = arr2[i] } Naive implementation of .push for(var i = 0; i < arr2Length; i++){ arr1[arr1Length + i] = arr2[i] } As you can see, the only difference between the two is that the .push implementation modifies the first array directly. Results of vanilla methods: .concat : 75 ops/sec .push: 793 ops/sec (10x faster) Results of naive implementation 1 .concat : 536 ops/sec .push : 11,104 ops/sec (20x faster) It turns that my DIY concat and push is faster than the vanilla implementations... But here we can see that simply creating a new result array and copying the content of the first array over slows down the process significantly. Naive implementation 2 (Preallocate size of the final array) We can further improve the naive implementations by preallocating the size of the array before adding the elements, and this makes a huge difference. Naive implementation of .concat with pre-allocation // Create result array with preallocated size var arr3 = Array(arr1Length + arr2Length) // Add Array 1 for(var i = 0; i < arr1Length; i++){ arr3[i] = arr1[i] } // Add Array 2 for(var i = 0; i < arr2Length; i++){ arr3[arr1Length + i] = arr2[i] } Naive implementation of .push with pre-allocation // Pre allocate size arr1.length = arr1Length + arr2Length // Add arr2 items to arr1 for(var i = 0; i < arr2Length; i++){ arr1[arr1Length + i] = arr2[i] } Results of naive implementation 1 .concat : 536 ops/sec .push : 11,104 ops/sec (20x faster) Results of naive implementation 2 .concat : 1,578 ops/sec .push : 18,996 ops/sec (12x faster) Preallocating the size of the final array improves the performance by 2-3 times for each method. .push array vs. .push elements individually Ok, what if we just .push elements individually? Is that faster than Array.prototype.push.apply(arr1, arr2) for(var i = 0; i < arr2Length; i++){ arr1.push(arr2[i]) } Results .push entire array: 793 ops/sec .push elements individually: 735 ops/sec (slower) So doing .push on individual elements is slower than doing .push on the entire array. Makes sense. Conclusion: Why .push is faster .concat In conclusion, it is true that the main reason why concat is so much slower than .push is simply that it creates a new array and does the additional work to copy the first array over. That said, now there's another mystery to me... Another mystery Why are the vanilla implementations so much slower than the naive implementations?I asked for @picocreator 's help again. We took a look at lodash's _.concat implementation for some hints as to what else is vanilla .concat doing under the hood, as it is comparable in performance (lodash's is slightly faster). It turns out that because according to the vanilla's .concat's specs, the method is overloaded, and supports two signatures: Values to append as n number of arguments, e.g. [1,2].concat(3,4,5) The array to append itself, e.g. [1,2].concat([3,4,5]) You can even do both like this: [1,2].concat(3,4,[5,6]) Lodash also handles both overloaded signatures, and to do so, lodash puts all the arguments into an array, and flattens it. It make sense if you are passing in several arrays as arguments. But when passed an array to append, it doesn't just use the array as it is, it copies that into another array, and then flattens it. ... ok... Definitely could be more optimised. And this is why you might want to DIY your own merge array implementation. Also, it's just my and @picocreator 's theory of how vanilla .concat works under the hood based on Lodash's source code and his slightly outdated knowledge of the V8 source code. You can read the lodash's source code at your leisure here. Additional Notes The tests are done with Arrays that only contain Integers. Javascript engines are known to perform faster with Typed Arrays. The results are expected to be slower if you have objects in the arrays. Here are the specs for the PC used to run the benchmarks: Why are we doing such large array operations during UI-licious tests anyway? Under the hood, the UI-licious test engine scans the DOM tree of the target application, evaluating the semantics, accessible attributes and other common patterns to determine what is the target element and how to test it. This is so that we can make sure tests can be written as simple as this: // Lets go to dev.to I.goTo(" ") // Fill up search I.fill("Search", "uilicious") I.pressEnter() // I should see myself or my co-founder I.see("Shi Ling") I.see("Eugene Cheah") Without the use of CSS or XPATH selectors, so that the tests can be more readable, less sensitive to changes in the UI, and easier to maintain. ATTENTION: Public service announcement - Please keep your DOM count low! Unfortunately, there's a trend of DOM trees growing excessively large these days because people are building more and more complex and dynamic applications with modern front-end frameworks. It's a double-edge sword, frameworks allow us to develop faster, folks often forget how much bloat frameworks add. I sometimes cringe at the number of elements that are just there to wrap other elements when inspecting the source code of various websites. If you want to find out whether your website has too many DOM nodes, you can run a Lighthouse audit. According to Google, the optimal DOM tree is: Less than 1500 nodes Depth size of less than 32 levels A parent node has less than 60 children A quick audit on the Dev.to feed shows that the DOM tree size is pretty good: Total count of 941 nodes Max. depth of 14 Max number of child elements at 49 Not bad!

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