Measuring time between frames to achieve a constant speed on screen, even when the frame rate changes

METHOD 1 - USING THE JAVASCRIPT DATE OBJECT

Now, we just modify the example from the previous lesson by adding a *time-based animation*. Here we use the "standard JavaScript" way for measuring time, using the Date JavaScript object:

```
        var time = new Date().getTime();
```

The `getTime()` method returns the number of milliseconds elapsed between midnight of January 1, 1970, and now. This is the number of milliseconds elapsed since the Unix epoch (!).

There is a variant, as we could have called:

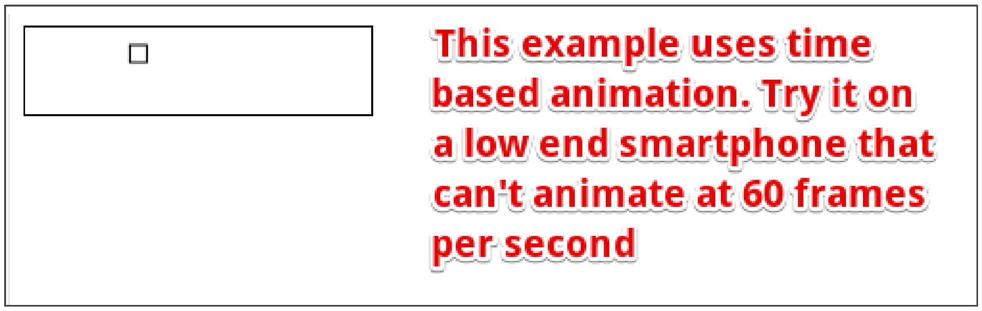
```
        var time = Date.now();
```

So, if we measure the time at the beginning of each animation loop, and store it, we can then compute the delta of the time elapsed between two consecutive loops.

We then apply some simple maths to compute the number of pixels we need to move the shape to achieve a given speed (in pixels/s).

First example that uses time based animation: the bouncing square

Online example at JSBin:


This example uses time based animation. Try it on a low end smartphone that can't animate at 60 frames per second

Source code from the example:

```
<!DOCTYPE html>
<html lang="en">
<head>
  <meta charset=utf-8 />
  <title>Move rectangle using time based animation</title>
  <script>
    var canvas, ctx;
    var width, height;
    var x, y, incX; // incX is the distance from the previously
drawn
                    // rectangle to the new one
    var speedX; // speedX is the target speed of the rectangle, in
pixels/s
    // for time based animation
    var now, delta;
    var then = new Date().getTime();
    // Called after the DOM is ready (page loaded)
    function init() {
      // Init the different variables
      canvas = document.querySelector("#mycanvas");
      ctx = canvas.getContext('2d');
      width = canvas.width;
      height = canvas.height;
      x=10; y = 10;
      // Target speed in pixels/second, try with high values,
1000, 2000...
      speedX = 200;
      // Start animation
     animationLoop();
   }
   function animationLoop() {
     // Measure time
     now = new Date().getTime();

     // How long between the current frame and the previous one?
     delta = now - then;
     //console.log(delta);
     // Compute the displacement in x (in pixels) in function of
the time elapsed and
     // in function of the wanted speed
     incX = calcDistanceToMove(delta, speedX);
     // an animation involves: 1) clear canvas and 2) draw shapes,
     // 3) move shapes, 4) recall the loop with
requestAnimationFrame
```

```
         // clear canvas
         ctx.clearRect(0, 0, width, height);
         ctx.strokeRect(x, y, 10, 10);
51.
         // move rectangle
         x += incX;
         // check collision on left or right
         if((x+10 >= width) || (x <= 0)) {
            // cancel move + inverse speed
            x -= incX;
            speedX = -speedX;
         }
61.
         // Store time
         then = now;
         requestAnimationFrame(animationLoop);
     }
     // We want the rectangle to move at a speed given in
    pixels/second
     // (there are 60 frames in a second)
72.  // If we are really running at 60 frames/s, the delay between
73.  // frames should be 1/60
     // = 16.66 ms, so the number of pixels to move = (speed *
    del)/1000.
     // If the delay is twice as
     // long, the formula works: let's move the rectangle for twice as
    long!
     var calcDistanceToMove = function(delta, speed) {
         return (speed * delta) / 1000;
     }
     </script>
    </head>
84. <body onload="init();">
     <canvas id="mycanvas" width="200" height="50" style="border: 2px solid
    black"></canvas>
    </body>
    </html>
```

In this example, we just added a few lines of code for measuring the time and computing the time elapsed between two consecutive frames (see *line 38*).

Normally, `requestAnimationFrame(callback)` tries to call the callback function every 16.66 ms (this corresponds to 60 frames/s)... *but this is never exactly the case*. If you do a `console.log(delta)` in the animation loop, you will see that even on a very powerful computer, the delta is "very close" to 16.6666 ms, but 99% of the time it will be slightly different.

The function `calcDistanceToMove(delta, speed)` takes two parameters: 1) the time elapsed in ms, and 2) the target speed in pixels/s.

Try this example on a smartphone, use this link: http://jsbin.com/jeribi to run the JSBin example in stand alone mode. Normally you should see no difference in speed, but it may look a bit jerky on a low end smartphone or on a slow computer. This is the correct behavior.

Or you can try the next example that fakes a complex animation loop that could take a long time to draw a frame...

A fake example that spends a lot of time in the animation loop, compare with the previous example

Try it on JsBin:

We added a long loop in the middle of the animation loop. This time the animation should be very jerky, however, notice that the apparent speed of the square is the same as in the previous example: the animation adapts itself!

```
function animationLoop() {
   // Measure time
  now = new Date().getTime();

  // How long between the current frame and the previous one ?
  delta = now - then;
  //console.log(delta);
  // Compute the displacement in x (in pixels) in function of the
time elapsed and
  // in function of the wanted speed
  incX = calcDistanceToMove(delta, speedX);
  // an animation is : 1) clear canvas and 2) draw shapes,
  // 3) move shapes, 4) recall the loop with requestAnimationFrame
  // clear canvas
  ctx.clearRect(0, 0, width, height);
  for(var i = 0; i < 50000000; i++) {
    // just to slow down the animation
  }
  ctx.strokeRect(x, y, 10, 10);
  // move rectangle
  x += incX;
```

```
    // check collision on left or right
    if((x+10 >= width) || (x <= 0)) {
     // cancel move + inverse speed
     x -= incX;
     speedX = -speedX;
    }
    // Store time
    then = now;
    requestAnimationFrame(animationLoop);
   }
```

METHOD 2 - USING THE NEW HTML5 HIGH RESOLUTION TIMER

Since the beginning of HTML5, game developers, musicians, and others have asked for a sub-millisecond timer in order to avoid some glitches that may occur with the regular JavaScript timer. This API is called the "high resolution time API".

This API is very simple to use - just do:

```
var time = performance.now();
```

... to get a sub-millisecond time. It is similar to Date.now() except that the accuracy is much higher and that the result is not exactly the same. The value returned is a floating point number, not an integer value!

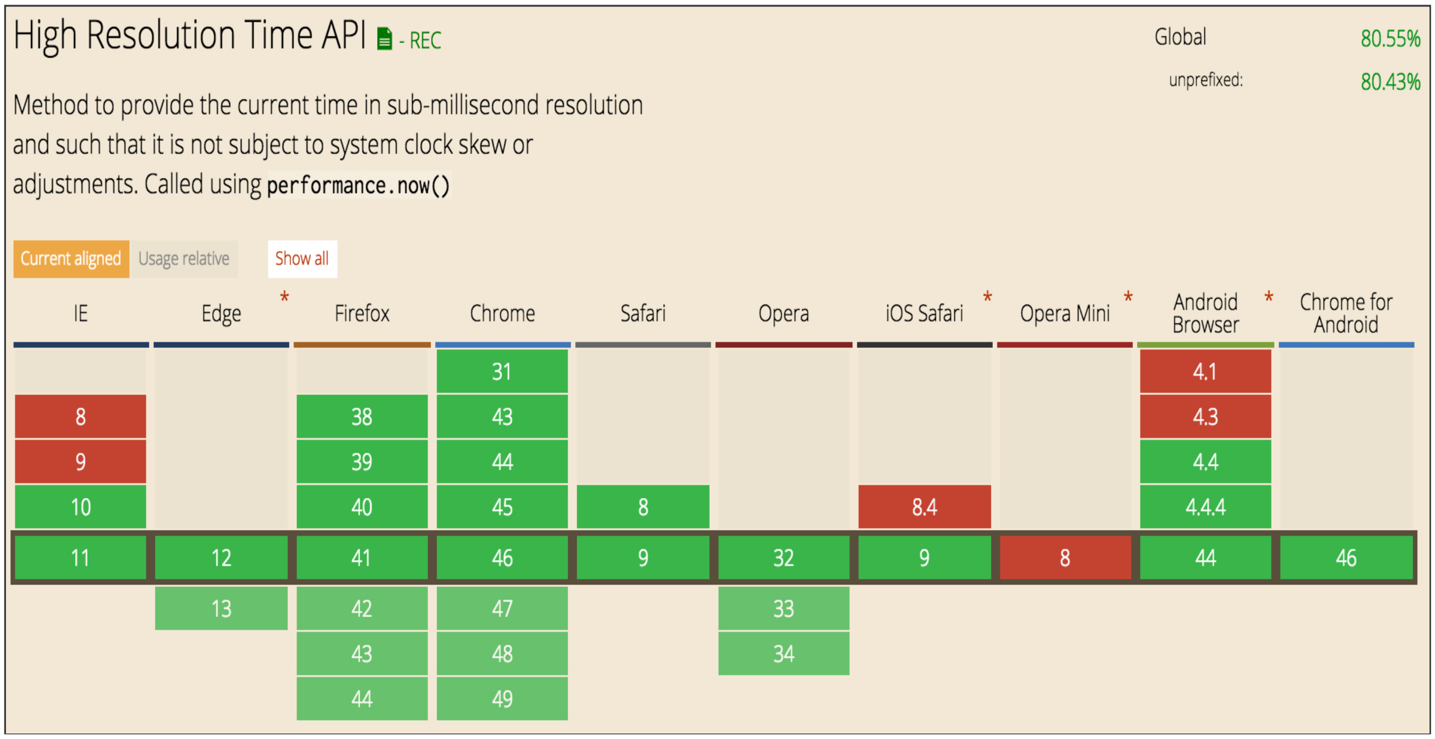
From this article that explains the high resolution time API: "*The only method exposed is `now()`, which returns a DOMHighResTimeStamp representing the current time in milliseconds. The timestamp is very accurate, with precision to a thousandth of a millisecond. Please note that while `Date.now()` returns the number of milliseconds elapsed since 1 January 1970 00:00:00 UTC, `performance.now()` returns the number of milliseconds, with microseconds in the fractional part, from performance.timing.navigationStart(), the start of navigation of the document, to the `performance.now()` call. Another important difference between `Date.now()` and `performance.now()` is that the latter is monotonically increasing, so the difference between two calls will never be negative.*"

To sum up:

- `performance.now()` returns the time since the load of the document (it is called a `DOMHighResTimeStamp`), with a sub ms accuracy, as a floating point value, with very high accuracy.

- `Date.now()` returns the number of ms since the Unix epoch, as an integer value.

Support for this API is good as of November 2015 (check an up to date version) :



High Resolution Time API - REC

Global 80.55%
unprefixed: 80.43%

Method to provide the current time in sub-millisecond resolution and such that it is not subject to system clock skew or adjustments. Called using `performance.now()`

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
			🟩 31					🟥 4.1	
🟥 8		🟩 38	🟩 43					🟥 4.3	
🟥 9		🟩 39	🟩 44					🟩 4.4	
🟩 10		🟩 40	🟩 45	🟩 8		🟥 8.4		🟩 4.4.4	
🟩 11	🟩 12	🟩 41	🟩 46	🟩 9	🟩 32	🟩 9	🟥 8	🟩 44	🟩 46
	🟩 13	🟩 42	🟩 47		🟩 33				
		🟩 43	🟩 48		🟩 34				
		🟩 44	🟩 49						

Here is a version on JSBin of the previous example with the bouncing rectangle, that uses the high resolution timer.

Source code of the example:

```
 ...
 <script>
   ...
   var speedX; // speedX is the target speed of the rectangle in
pixels/s
   // for time based animation
   var now, delta;
   **// High resolution timer**
   **var then = performance.now();**

   // Called after the DOM is ready (page loaded)
   function init() {
     ...
   }
   function animationLoop() {
     **// Measure time, with high resolution timer**
     now = performance.now();

     // How long between the current frame and the previous one?
    delta = now - then;
    //console.log(delta);
    // Compute the displacement in x (in pixels) in function
    // of the time elapsed and
    // in function of the wanted speed
    incX = calcDistanceToMove(delta, speedX);
    //console.log("dist = " + incX);
    // an animation involves: 1) clear canvas and 2) draw shapes,
    // 3) move shapes, 4) recall the loop with
requestAnimationFrame
    // clear canvas
   ctx.clearRect(0, 0, width, height);
   ctx.strokeRect(x, y, 10, 10);
   // move rectangle
   x += incX;
   // check collision on left or right
   if((x+10 >= width) || (x <= 0)) {
      // cancel move + inverse speed
      x -= incX;
      speedX = -speedX;
   }
   // Store time
   then = now;
   // call the animation loop again
   requestAnimationFrame(animationLoop);
 }
 ...
 </script>
```

Only two lines have changed but the accuracy is much higher, if you try to uncomment the `console.log(...)` calls in the main loop. You will see the difference.

METHOD 3 - USING THE OPTIONAL TIMESTAMP PARAMETER OF THE CALLBACK FUNCTION OF`REQUESTANIMATIONFRAME`

This is the recommended method!

There is an optional parameter that is passed to the callback function called by `requestAnimationFrame`: a timestamp!

The requestAnimationFrame API specification says that this timestamp corresponds to the time elapsed since the page has been loaded.

It is similar to the value sent by the high resolution timer using `performance.now()`.

Here is a running example of the animated rectangle, that uses this timestamp parameter.

Online example at JSBin:

Source code of the example:

```
<!DOCTYPE html>
<html lang="en">
<head>
<meta charset=utf-8 />
<title>Time based animation using the parameter of the
requestAnimationFrame callback</title>
 <script>
   var canvas, ctx;
   var width, height;
   var x, y, incX; // incX is the distance from the previously drawn
rectangle
                  // to the new one
   var speedX;     // speedX is the target speed of the rectangle in
pixels/s
   // for time based animation
   var now, delta=0;
   // High resolution timer
   var oldTime = 0;
   // Called after the DOM is ready (page loaded)
   function init() {
     // init the different variables
     canvas = document.querySelector("#mycanvas");
     ctx = canvas.getContext('2d');
     width = canvas.width;
     height = canvas.height;
     x=10; y = 10;
     // Target speed in pixels/second, try with high values, 1000,
2000...
     speedX = 200;
```

```
      // Start animation
      requestAnimationFrame(animationLoop);
    }
    function animationLoop(currentTime) {
      // How long between the current frame and the previous one?
      delta = currentTime - oldTime;
      // Compute the displacement in x (in pixels) in function of the
time elapsed and
      // in function of the wanted speed
      incX = calcDistanceToMove(delta, speedX);
      // clear canvas
      ctx.clearRect(0, 0, width, height);
      ctx.strokeRect(x, y, 10, 10);

      // move rectangle
      x += incX;
      // check collision on left or right
      if(((x+10) > width) || (x < 0)) {
        // inverse speed
        x -= incX;
        speedX = -speedX;
      }

      // Store time
      oldTime = currentTime;
      // asks for next frame
      requestAnimationFrame(animationLoop);
    }
    var calcDistanceToMove = function(delta, speed) {
      return (speed * delta) / 1000;
    }
 </script>
</head>
<body onload="init();">
 <canvas id="mycanvas" width="200" height="50" style="border: 2px solid
black"></canvas>
</body>
</html>
```