$$c - a = (1 - q)(d - a) \tag{1}$$

Which states that c shall be located so that it is $q(d-a)$ left from d. In other words, c shall be the point next to the upper endpoint of the new interval. From the construction we know two further equations:

$$c - a = q(b - a)$$

(in accordance how we have chosen c in the first step)

$$d - a = (1 - q)(b - a)$$

(in accordance how we have chosen d in the first step) Using this in (1) gives

$$q(b - a) = (1 - q)^2(b - a)$$

or after canceling out $b - a$, just

$$q = (1 - q)^2$$

This equation can be solved for q and yields a solution of

$$q = \frac{3}{2} - \frac{\sqrt{5}}{2}$$

lying within $(0, 1)$.