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By AFP - Agence France Presse June 29, 2020 Order Reprints Print Article English Premier League table after Tuesday's match (played, won, drawn, lost, goals for, goals against, points): Liverpool 31 28 2 1 70 21 86 -- champions Man City 31 20 3 8 77 33 63 Leicester 31 16 7 8 59 29 55 Chelsea 31 16 6 9 55 41 54 -----  
----- Man Utd 32 14 10 8 51 31 52 ----- Wolves 32 13 13 6 45 34 52 Tottenham 31 12 9 10 50 41 45 Burnley 32 13 6 13 36 45 45 Sheff Utd 31 11 11 9 30 31 44 Arsenal 31 10 13 8 43 41 43 Crystal Palace 32 11 9 12 28 37 42 Everton 31 11 8 12 38 46 41 Southampton 32 12 4  
16 41 55 40 Newcastle 31 10 9 12 29 42 39 Brighton 32 7 12 13 34 44 33 Watford 32 6 10 16 29 49 28 West Ham 31 7 6 18 35 54 27 ----- Bournemouth 31 7 6 18 29 50 27 Aston Villa 32 7 6 19 36 60 27 Norwich 31 5 6 20 25 56 21 Notes -- Top four qualify for Champions League (Manchester  
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how you interact with the site, and to show advertisements that are targeted to your interests. You can find out more about our use, change your default settings, and withdraw your consent at any time with effect for the future by visiting Cookies Settings, which can also be found in the footer of the site. In this article, I'm going to demonstrate  
performance differences between two ways of iterating over the records in a MySQL database table with millions of records. In a high volume analytics system, tables with millions of records are quite common and iterating over the full table or a subset of these tables becomes often necessary—whether it's to perform computations, run a migration,  
or create parallelized background jobs on the records. At AirPR, we have many database tables with 100s of millions of records, and it becomes important to write efficient code for iterations because there is often an order of magnitude difference between a good and not-so-good approach. Find Each Method The standard approach provided natively  
by ActiveRecord is the find\_eachmethod. For the purposes of this exercise, I created anemployees table to which I added about 5 million rows of data<sup>1</sup>. There is also a salaries table with the following columns that stores the salaries of those employees across different time ranges. This table contains about 3 million records. Let us measure the  
performance of iterating through this table using find\_each DEFAULT\_BATCH\_SIZE = 1000 time = Benchmark.realtime doEmployee.select(:emp\_no, :first\_name, :last\_name).find\_each(batch\_size: DEFAULT\_BATCH\_SIZE) do |employee|endend=> 100.6963519999990 The underlying queries that ActiveRecord makes look like this: Employee Load  
(2.1ms) SELECT `employees`.`emp\_no`,`employees`.`first\_name`,`employees`.`last\_name` FROM `employees` ORDER BY `employees`.`emp\_no` ASC LIMIT 1000Employee Load (1.9ms) SELECT `employees`.`emp\_no`,`employees`.`first\_name`,`employees`.`last\_name` FROM `employees` WHERE (`employees`.`emp\_no` > 11000) ORDER BY  
`employees`.`emp\_no` ASC LIMIT 1000Employee Load (1.8ms) SELECT `employees`.`emp\_no`,`employees`.`first\_name`,`employees`.`last\_name` FROM `employees` WHERE (`employees`.`emp\_no` > 5127997) ORDER BY `employees`.`emp\_no` ASC LIMIT 1000 Notice how ActiveRecord keeps track of theidfrom the previous iteration and uses it in a where condition in the next one. This is called value based pagination and is generally the preferred approach for  
pagination (over other methods like offset based pagination)<sup>2</sup>. ID Iterator Method I propose we try a different iterating technique now: time = Benchmark.realtime dofirst\_id = Employee.first.idlast\_id = Employee.last.id(first\_id..last\_id).step(DEFAULT\_BATCH\_SIZE).each do |value|Employee.where(:employees.emp\ no >= ?, value).  
where(:employees.emp\ no < ?, value + DEFAULT\_BATCH\_SIZE).order(:employees.emp\ no ASC`).select(:emp\ no, :first\ name, :last\ name).each do |employee|end endend=> 101.34066200000234 In this method, we divvy up the total number of rows into batches using where conditions on the primary key to iterate through all the records in the  
table. Notice how the performance is practically the same between the two methods. This is how the underlying queries look: Employee Load (1.1ms) SELECT `employees` \* FROM `employees` ORDER BY `employees`.`emp\_no` ASC LIMIT 1Employee Load (1.1ms) SELECT `employees` \* FROM `employees` ORDER BY `employees`.`emp\_no` DESC  
LIMIT 1Employee Load (1.5ms) SELECT `employees`.`emp\_no`,`employees`.`first\_name`,`employees`.`last\_name` FROM `employees` WHERE (employees.emp\_no > 10001) AND (employees.emp\_no 11001) AND (employees.emp\_no = 5128001) AND (employees.emp\_no < 5129001) This approach works best if the ids are in order because the  
iteration wouldn't have to iterate & skip a lot of missing records in that case<sup>3</sup>. Iterating with joins Now, let's compare performance of these two methods when we add some more complexity to the query. In this new scenario, say, we want to iterate through all employees whose salary was above 80,000 at any point during their employment with the  
company. The find\_each method would look something like this: time = Benchmark.realtime doEmployee.select(:emp\_no, :first\_name, :last\_name).joins(:salaries).where(:salary > 80000).find\_each(batch\_size: DEFAULT\_BATCH\_SIZE) do |employee|endend=> 1181.770457000006 On the other hand, the id iterator method for performing the same  
operation results in an order of magnitude improvement in performance. time = Benchmark.realtime dofirst\_id = Employee.first.idlast\_id = Employee.last.id(first\_id..last\_id).step(DEFAULT\_BATCH\_SIZE).each do |value|Employee.where(:employees.emp\_no >= ?, value).where(:employees.emp\_no < ?, value +  
DEFAULT\_BATCH\_SIZE).joins(:salaries).where(:salary > 80000').order(:employees.emp\_no ASC').select(:emp\_no, :first\_name, :last\_name).each do |employee|end endend=> 72.756777999998084 The above results indicate that using the find\_each approach results in a much worse performance<sup>4</sup>. The ID iterator approach is about 15x faster than naive  
find\_each. The reason for this becomes clear when you inspect the queries that are made by the two approaches. The find\_each method makes this type of query: SELECT `employees`.`emp\_no`,`employees`.`first\_name`,`employees`.`last\_name` FROM `employees` INNER JOIN `salaries` ON `salaries`.`emp\_no` = `employees`.`emp\_no` WHERE  
(salary > 80000) ORDER BY `employees`.`emp\_no` ASC LIMIT 1000 An EXPLAIN on this query reveals the following: 1 SIMPLE salaries ALL salary,emp\_no NULL NULL NULL 2837536 Using where; Using temporary; Using filesort1 SIMPLE employees eq\_ref PRIMARY PRIMARY 4 employees.salaries emp\_no 1 Using indexwhich indicates that  
neither the index on salary nor the index on emp\_no is being used to filter the salaries table. The id iterator method makes this type of query: SELECT An EXPLAIN on this query shows that the query optimizer uses the index on emp\_no in the salaries table. 1 SIMPLE salaries range salary,emp\_no emp\_no 4 NULL 1 Using index condition; Using  
where1 SIMPLE employees eq\_ref PRIMARY PRIMARY 4 employees.salaries emp\_no 1 Using indexwhich reveals why the find\_each method is so much slower than the iterator method. TL;DR The lesson here is always use EXPLAINs to understand what the MySQL query optimizer actually does so that you can create the most optimized queries<sup>5</sup>.  
Based on analyzing the results of the EXPLAIN, a decision can be made on which approach needs to be taken for iterations on large tables. JOINS on large tables usually results in poor performance, so it's best to avoid them. Try to use JOINS only when the result set has been narrowed down significantly through the use of an index based condition  
one of the tables. Try to make the best use of indices for queries in general. Use queries that results in the MySQL query optimizer choosing to use indices that are available in the table. Add indices to the table that may help speed up queries while understanding the trade-offs in terms of write performance degradation<sup>6</sup>. Avoid running select \*,  
instead select only the columns that are necessary for your operation. This will reduce the amount of data that needs to be sent especially when there are many TEXT columns in the table. The query optimizer might take different paths depending on a variety of factors, the same query might take a different path on a server with larger resources  
because, say, an index might fit into the memory. This will result in drastic differences in performances. It is best to assume the worst in these situations and write queries that don't rely on large indices to be kept in memory. The easiest way to see the queries that ActiveRecord generates would be to turn on DEBUG logging. It is recommended to  
turn this on in development so you can catch performance issues early.ActiveRecord::Base.logger = Logger.new(STDOUT) Alternatively, you can use to\_sql on an ActiveRecord::Relation to see beforehand what query it's going to make. Employee.where(:gender = 'M').to\_sql<sup>7</sup> I started out from this sample dataset, and deleted everything but the  
employees and salaries table. And then I duplicated records in the employees table to reach 5 million rows.<sup>8</sup> This link has a good comparison of the value based vs Offset based pagination.<sup>9</sup> If AUTO\_INCREMENT option is turned on for the primary key, the records are automatically in incremental order.<sup>4</sup> The performance degrades even more on  
larger tables. When you reach 100s of millions of rows, it becomes even more important to understand the underlying queries because it might result in 100x or 1000x difference.<sup>8</sup> Take the time to read (and master) the official MySQL documentation on EXPLAIN output format, so its clear what's good and what's not good.<sup>6</sup> This link has a good  
description on the performance impact of creating indices. It's important to understand that writes on a table with a lot of indices will be slower, so use them wisely.







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