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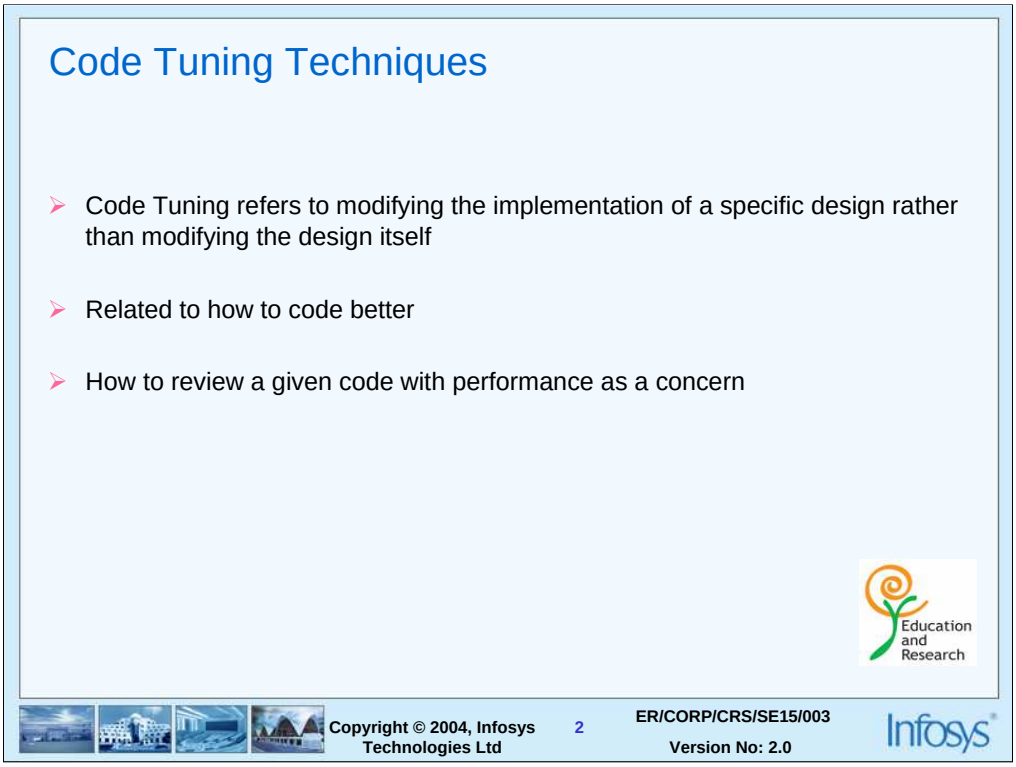
Analysis of Algorithms

Unit 2 - Code Tuning Techniques

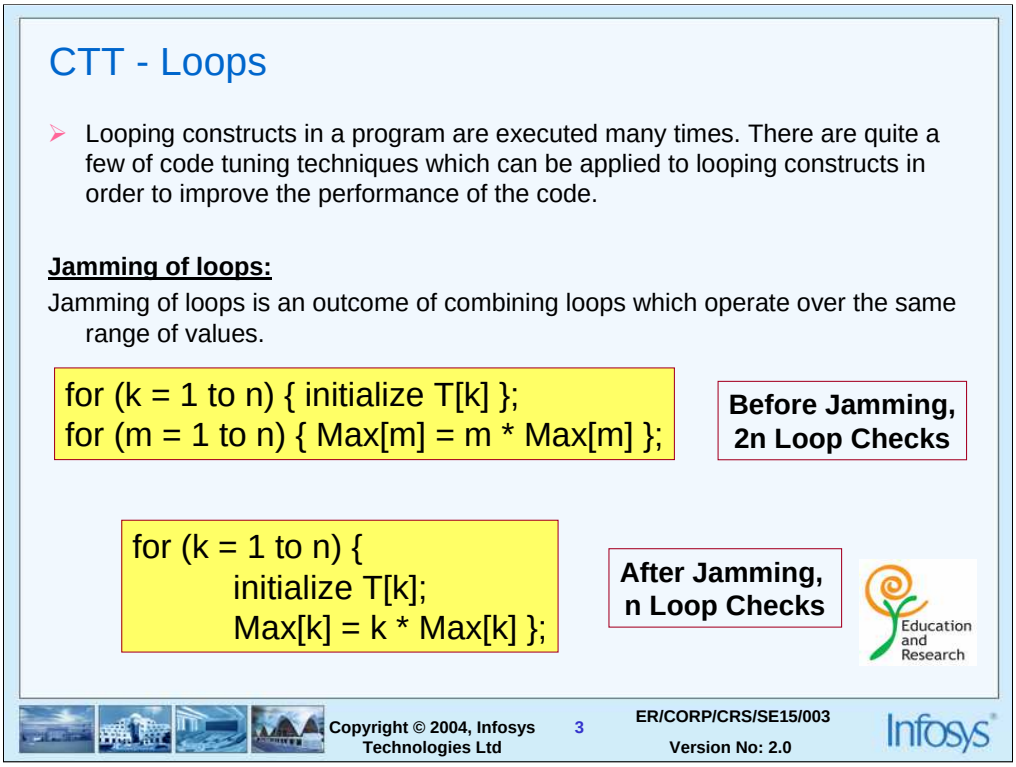
Education and Research



Code Tuning Techniques (CTT):

- Used to write better code
- Needs better understanding of the programming language and its compiler
- Removes un-necessary portion of code
- Is equivalent of code optimization at Higher Language Level

In this chapter we will study some of the CTT that can be applied to looping constructs, logic expressions, type conversions and other expressions in a program.



Jamming of loops can be applied to other similar examples like finding the maximum and minimum, from a given set of elements, in one loop. In the above example, we have highlighted the fact that boundary checks in a loop are expensive. Loops which operate over different ranges cannot be jammed. We could face problems with jamming of loops if at a later stage the range for two jammed loops change!

CTT – Loops (Contd…)

Unswitching of Loops:

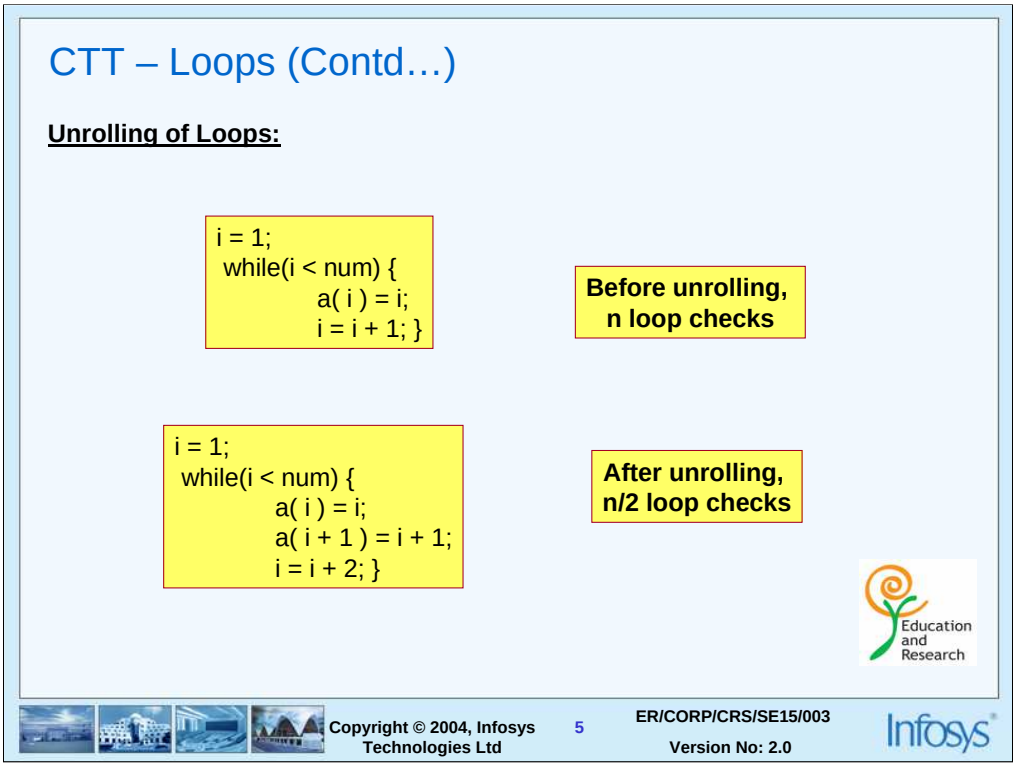
Unswitch loops that contain if tests, if the results of these tests do not change inside the loop

This is most suited for 1997-98 since the earlier budget had highest slab of 40% and the new proposal was with slab = 30% but the budget was not passed because of instability in the govt.

```
for (I=0; i<noofemployees; I++)
        {if budgetpassed = YES
        .....
        else
        .....
        }
```

Move the if condition outside the loop

Switching basically refers to making a decision (using a selectional construct) inside a loop every time the loop is executed. If the result of the selectional statement does not change inside the loop then it makes more sense to unswitch the loop by making the decision outside the loop. In such cases the loop is turned inside out by putting the loop inside the selectional construct. The basic idea in unswitching is to minimize / remove unnecessary computation inside a looping construct.



Unrolling of loops reduces the amount of housekeeping done in loops. As shown in the example above the loop is rewritten (unrolled) so that the number of loop checks are reduced. If the number, *num*, is odd then the assignment statement for *a(num)* has to be done outside the loop.

A word of caution. Unrolling of loops helps in reducing the time taken by the code to execute but it affects the quality and readability of the code.

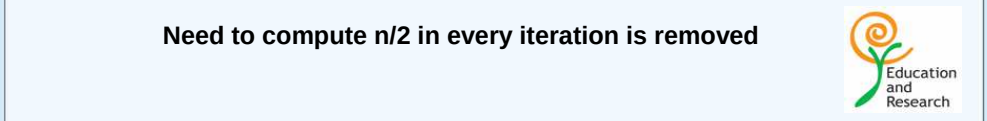
CTT – Loops (Contd…)

Minimize work performed inside loops:

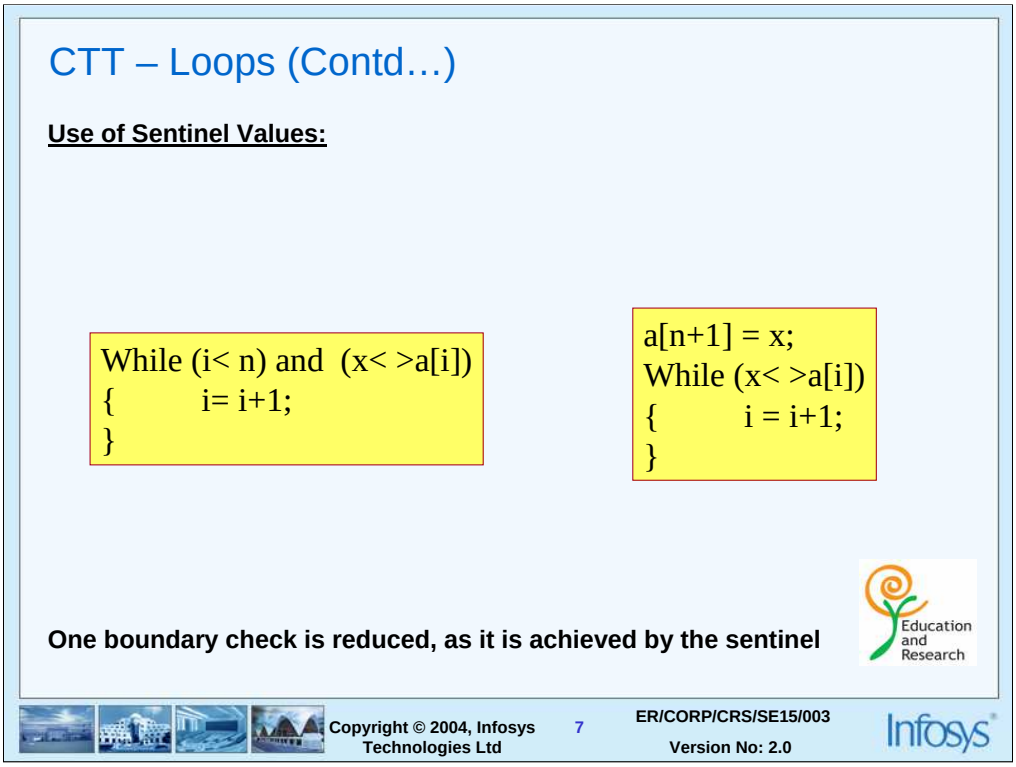
```
For (i = 1 to n/2)
{
…
}
```

```
n_2 = n/2;
For (i = 1 to n_2)
{
…
}
```

Need to compute n/2 in every iteration is removed



To minimize the work performed inside a loop, we need to move the constant expression evaluation and function calls outside the loop.



Sentinel values can be used in a search loop which looks for an element in an array. If the required size of the array is 10, declare it as 11. In all search operation, use the 11th position to store the element to be searched.

CTT – Loops (Contd…)

Reduce the strength of operations performed inside loops:

All operations which do not depend on loop variant may be moved outside loops

```
for (i  = 1 to Num ) {
commission ( i ) = i * Revenue * BaseCommission * Discount
}
```

```
Commission = Revenue * BaseCommission * Discount
for ( i = 1 to Num ) {
commission ( i ) = i * Commission
}
```

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Strength reduction in a loop refers to replacing the operations such as multiplication by cheaper operations like addition.

CTT – Logic

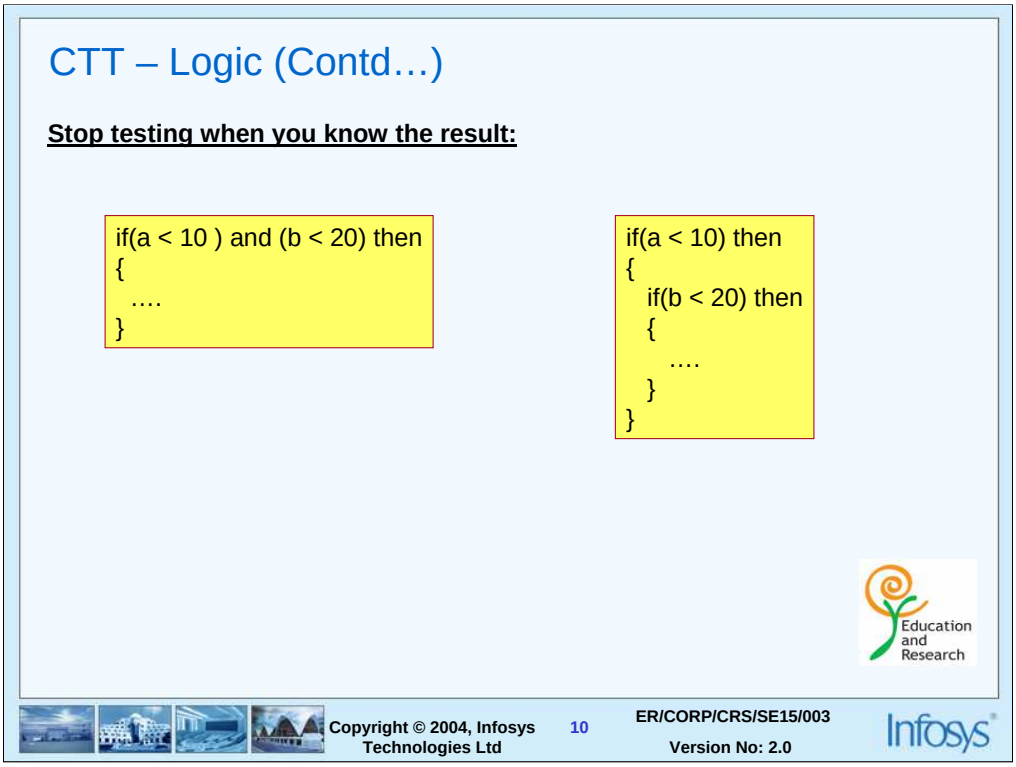
Order tests in case statements by frequency:

```
read (empNo)
case Grade(empNo) of
1: {….}
2: {….}
3: {….}
….
7: {….}
endcase
```

```
read (empNo)
case Grade(empNo) of
7: { ….}
5: {….}
6: {….}
….
1: {….}
endcase
```

Every time, the more frequent, Grade 7 is encountered, the code executes faster

This code tuning technique can be applied to *if-then-else* statement also!



In the example above it makes more sense to stop testing for *b < 20* when ever *a is not less than 10*. Some of the programming languages support this kind of evaluation which is known as ***short circuit evaluation***. Else we need to re-write the code as shown above.

CTT – Data Transformations

Minimize array references:

If the same array element is repeatedly referred to inside a loop, then move it outside the loop

```
for (a=0; a < 5; a++)
{
  for (b =0; b < 10; b++)
  {
     total[b] = total[b] * sum[a];
  }
```

```
for (a=0; a < 5; a++)
{
  sum_now = sum[a];
  for (b =0; b < 10; b++)
  {
     total[b] = total[b] * sum_now;
  }
```

Data Transformations:

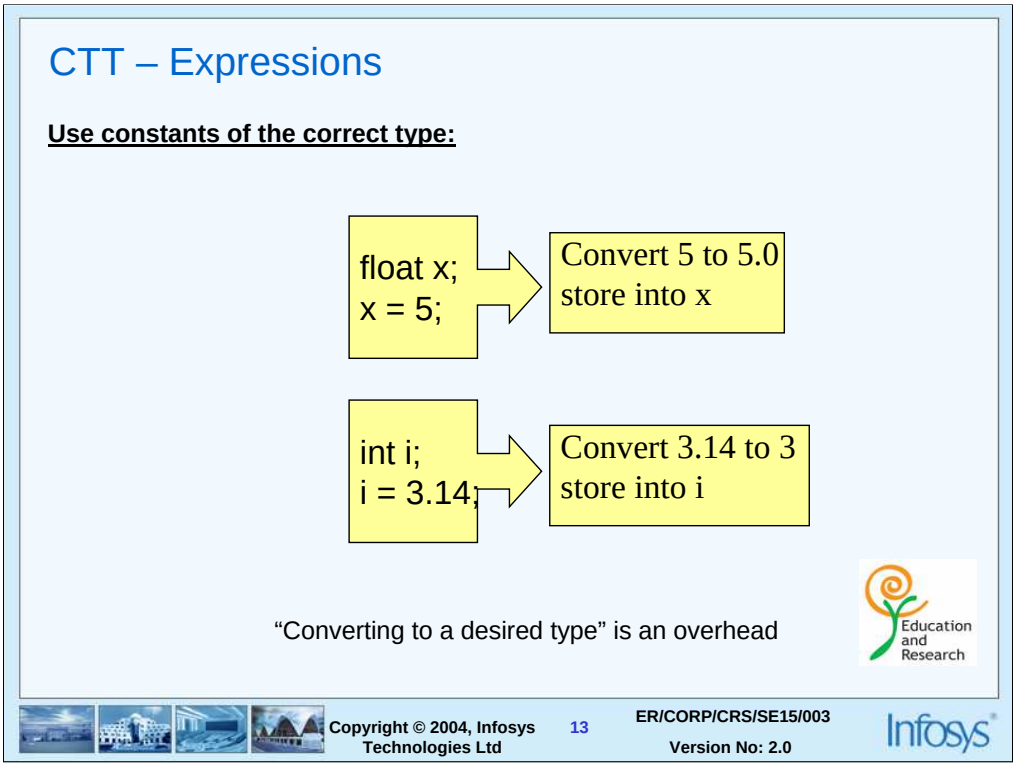
•This code tuning technique aim at making small changes to the data structures in a code so that the performance of the code increases.

•In the above mentioned example, we see that the sum[a] does not change in the second loop and it is constantly referred to in the inner loop. This array reference can be minimized by moving it outside the inner loop as shown in the example.

CTT – Data Transformations (Contd…)

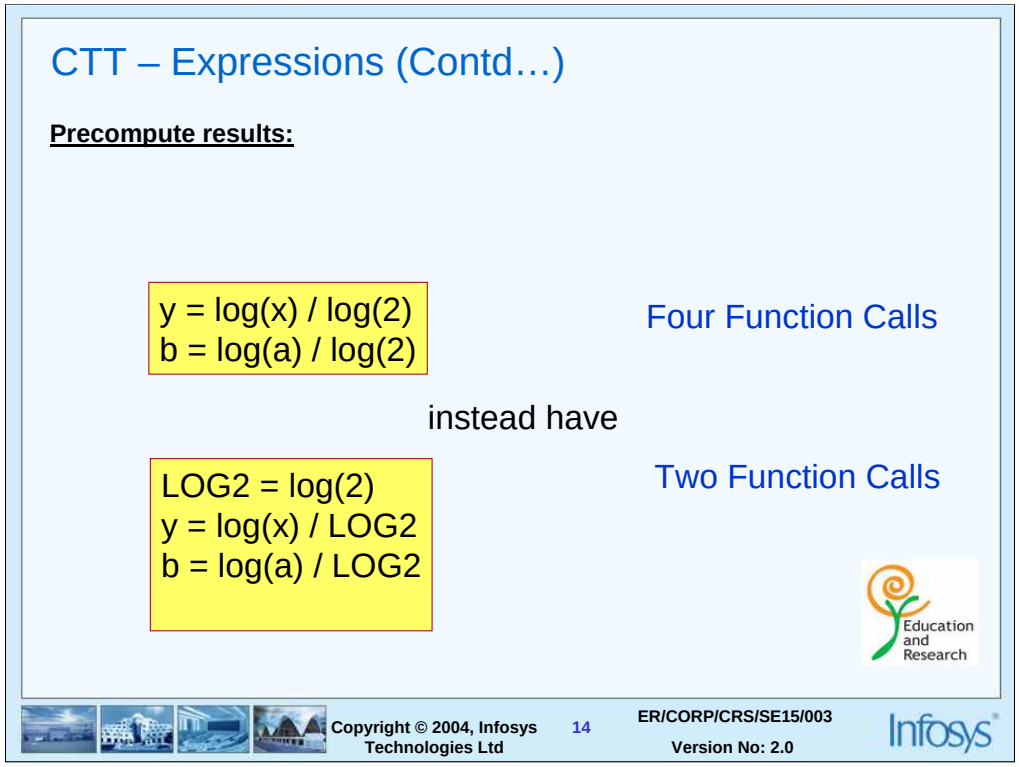
Augment data structures with indexes:

For example we can add an index to the linear linked list data structure. This index helps in speeding up the search operation in a linked list which is other wise strictly linear.



Expressions:

- This section deals with the code tuning techniques that could be applied to the mathematical and logical expressions in a program so as to improve the efficiency of the code.
- Type conversions though done by the compiler are a costly overhead which can be avoided where ever possible, by the programmers.



Log(x) is function call for a given value of x. Log(2) is log of a constant. Hence it will be advisable to calculate the Log of a constant value and store it in a variable. This will reduce unnecessary computation of Log of a constant at run time.

Also when a particular result is used many times, then it advisable to precompute this result and store it so that when ever required a look up can be done. For example the result of a tax-saving calculation formula can be put in a lookup table.

If the time taken for a look up is more than the actual computation then the purpose of precomputation is defeated.

CTT – Expressions (Contd…)

Exploit Algebraic Identities:

- Algebraic identities can be used to replace costlier operations by cheaper ones
  - Whenever we need to find whether $\sqrt{x} < \sqrt{y}$, we can use the algebraic identity which says $\sqrt{x} < \sqrt{y}$ only when $x < y$. So it is enough to check if $x < y$ in this case.
  - ***not (A or B)*** is cheaper than ***not A and not B***

CTT – Expressions (Contd…)

Strength Reduction in Expressions:

- Strength reduction refers to replacing costlier operations by cheaper ones. This can be achieved by:
  - Replacing multiplication with addition
  - Replacing exponentiation with multiplication…
  - $Ax^3 + Bx^2 + Cx + D$ is better computed as $((Ax + B)x + C)x + D$

CTT – Expressions (Contd…)

Be Wary of System Routines:

- System Routines, like the math routines, provided accuracy which is more often wasted. If we do not need the level of accuracy as provided by the math routines then it makes sense for us to write the piece of code for the same. For example the math routine which computes ***log(x)*** provides the result in a floating point number whereas most of the times we might be interested only in the integral part.

Summary

- Code Tuning Techniques for Loops
- Code Tuning Techniques for logic
- Code Tuning Techniques for Data Transformations
- Code Tuning Techniques for Expressions

In this chapter we had studied the Code Tuning Techniques:

•Which can be applied to looping constructs.

•Which covers the logic of the program

•Which aims at the modifying the implementation of data structures in a code

•Which deals with the mathematical and logical expressions in a code

Thank You!