DFS
DVFS

Adapted from Rajeev Subramaniam's Spring '16 CS6810 course (University of Utah)

28 Jan 2019

Aftab Hussain
University of California, Irvine
Basic idea of DFS and DVFS
We need to improve the performance of the processor: i.e., reduce its power and energy consumption.

two techniques to so:

**Dynamic Frequency Scaling** - change frequency of processor

**Dynamic Voltage and Frequency Scaling** - change V and f of processor during runtime

both impacts the *power consumption* and *time* of the processor
Example of how DFS and DVFS changes power and time of processor.
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W + Leakage Power : 25 W
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W  +  Leakage Power : 25 W

Let's say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns  
(cycle time = 1 / frequency)
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W + Leakage Power : 25 W

Let's say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns (cycle time = 1 / frequency)
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W  +  Leakage Power : 25 W

Let's say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns  

(cycle time = 1 / frequency)

Applying DFS,

Change frequency to 0.5 GHz

So new cycle time = 2 ns
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W + Leakage Power : 25 W

Let's say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns (cycle time = 1 / frequency)

Applying DFS,

> Change frequency to 0.5 GHz
> So new cycle time = 2 ns

Note

> Each circuit has been designed to complete within 1 ns.
> So now, each circuit has enough time to finish the task assigned to it.
> Say a processor consumes 100 W and takes 100 s to finish a given task.

> 100 -----> Dynamic Power : 75 W + Leakage Power : 25 W

> Let's say frequency of the processor is 1 GHz.

> Therefore, cycle time = 1 ns (cycle time = 1 / frequency)

Applying DFS,

> Change frequency to 0.5 GHz
> So new cycle time = 2 ns

Note
> Decreasing the frequency is ok.
> Increasing the frequency is not an option -- because it would then be assigning a new task to a circuit before it could finish.
Say a processor consumes 100 W and takes 100 s to finish a given task.

> 100 -----> Dynamic Power : 75 W  +  Leakage Power : 25 W

Let’s say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns  
(cycle time = 1 / frequency)

Applying DFS,

> Change frequency to 0.5 GHz
> So new cycle time = 2 ns

What is the,

New Execution Time?
New Energy Consumption?
New Power Consumption?
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W + Leakage Power : 25 W

Let's say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns (cycle time = 1 / frequency)

Applying DFS,

Change frequency to 0.5 GHz
So new cycle time = 2 ns

**Two relations**

*Dynamic Power α Voltage^2 x Frequency*

*Leakage Power α Voltage x Leakage Current*
> Say a processor consumes 100 W and takes 100 s to finish a given task.

> 100 -----> Dynamic Power : 75 W  +  Leakage Power : 25 W

> Let’s say frequency of the processor is 1 GHz.

> Therefore, cycle time = 1 ns (cycle time = 1 / frequency)

Applying DFS,

> Change frequency to 0.5 GHz

> So new cycle time = 2 ns

Two relations

*Dynamic Power* ∝ Voltage^2 x Frequency

*Leakage Power* ∝ Voltage x Leakage Current
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W  +  Leakage Power : 25 W

Let's say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns  (cycle time = 1 / frequency)

Applying DFS,

Change frequency to 0.5 GHz
So new cycle time = 2 ns

Assumption

Program is entirely CPU-bound.

In reality, programs may be memory bound. Memory is not affected by CPU speed.
Program is entirely CPU-bound.

In reality, programs may be memory bound. Memory is not affected by CPU speed.
> Program is entirely CPU-bound.

> In reality, programs may be memory bound. Memory is not affected by CPU speed.
Program is entirely CPU-bound.

In reality, programs may be memory bound. Memory is not affected by CPU speed.
Program is entirely CPU-bound.

In reality, programs may be memory bound. Memory is not affected by CPU speed.
A memory bound program

If this example program was memory-bound the total time taken would have been less than 200s.

Assumption

> Program is entirely CPU-bound.

> In reality, programs may be memory bound. Memory is not affected by CPU speed.
Summarizing DFS,

> Reducing frequency can significantly reduce power.

> Reducing frequency may not necessarily reduce energy due to a (possibly linear) increase in execution time.
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W + Leakage Power : 25 W

Let's say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns  
\(\text{cycle time} = \frac{1}{\text{frequency}}\)

Supply voltage is 1 V.
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W + Leakage Power : 25 W

Let's say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns (cycle time = 1 / frequency)

Supply voltage is 1 V.

Applying DVFS,

Change supply voltage to 0.9 V
Also need to reduce frequency, because circuit delay increases if V decreases.
Say a processor consumes 100 W and takes 100 s to finish a given task.

100 -----> Dynamic Power : 75 W  +  Leakage Power : 25 W

Let’s say frequency of the processor is 1 GHz.

Therefore, cycle time = 1 ns   (cycle time = 1 / frequency)

Supply voltage is 1 V.

Applying DVFS,

- Change supply voltage to 0.9 V
- Also need to reduce frequency, because circuit delay increases if V decreases.
Problem 3 on Rajeev’s Slides (Slide nos. 10, 11)
Thank you