Towards a Comprehensive Performance Model of Virtual Machine Live Migration

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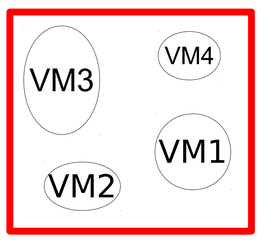
Problem Statement

Estimate migration time, downtime and network traffic accurately using parameters such as (1) VM's memory size (2) page dirtying characteristics (3) migration rate for pre-copy live migration

Need for a Performance Model



Overloaded Physical Machine

- Which VM to be migrated?
- To migrate VM2 in 10 seconds, what migration rate R should we allocate?
- **Other scenarios**: **Hardware Failure, Bug Fixing, Cloud Bursting**

Research Contribution

- Invalidated 8 existing models against 371 measured values (53 applications).

Table : Existing KVM Models

Metrics	90th %ile Error
Migration time	46%
N/W traffic	1413 MB

Table : Existing Xen Models

Metrics	90th %ile Error
Migration time	159%
N/W traffic	1839 MB

- Identified 5 parameters that are fatally ignored by existing models.

Table : Proposed Model–KVM

Metrics	90th %ile Error
Migration time	13%
N/W traffic	349 MB

Table : Proposed Model–Xen

Metrics	90th %ile Error
Migration time	19%
N/W traffic	434 MB

What Parameter Need to be Modeled?

Inputs: M $\Longrightarrow$ memory size, R $\Longrightarrow$ Migration Rate

Iteration#	KVM Transfers	Xen Transfers
$i = 1$	all **M** #pages	effective pages, $M - W_i$ #pages skipped
$i \geq 2$	all dirtied pages D_{i-1}	effective dirtied pages, $D_{i-1} - W_i$

Parameters to be modeled

- #pages dirted D_i per iteration — For both KVM and Xen.
- #pages skipped W_i per iteration — Only for Xen.

Existing Model for #Dirtied Pages D_i

$$D_i = T_i \times S$$

Key for S: Collect Dirty Bitmap Per Unit Time

Existing Computation Methods. average, exponential moving average, dirty probability, hot & cold pages, migration logs

Existing Model for #Skipped Pages W_i

$$W_i \propto D_{i-1} \qquad W_i = \beta \times M$$

Reasons for Error with Existing Models

Model for #dirtied pages failed to consider

- the #unique pages **S** dirtied per unit time.
- the #new pages S_{new} dirtied per unit time.
- the maximum writable working set size M_w.

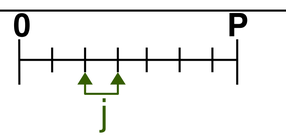
Model for #skipped pages failed to consider

- the #eligible pages E_i for skip technique.
- the impact of dirty rate **S**, S_{new} and migration rate **R**.

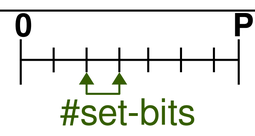
Proposed Model for #Dirtied Pages

$$D_i = \min(S + (T_i - 1) \times S_{new}, M_w)$$

Computation of S and S_{new}

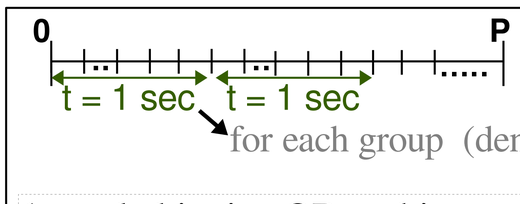


P = 10,000 msec
j = 100 msec



Dirty bitmaps are collected every j time unit

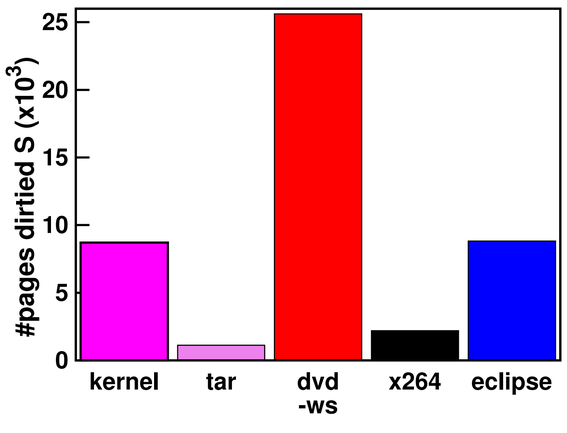
S = average #set-bits



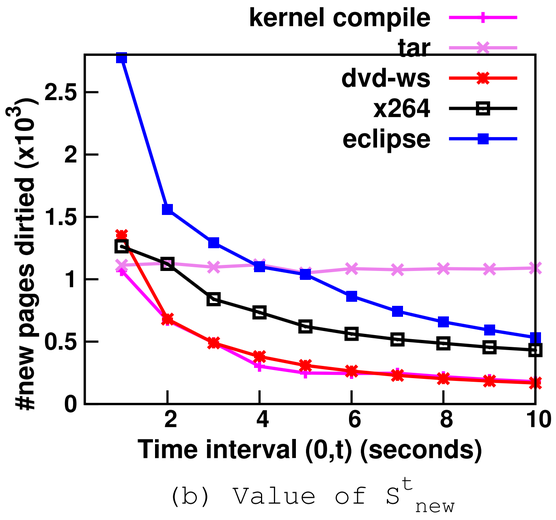
Repeat the procedure for t = 2 sec, ... P secs

1. apply bitwise-OR on bitmap one by one and count #new-set-bits
2. compute average #new set-bits per bitmap

Calculate the average of averages and assign to S^t_{new}



(a) Value of S



(b) Value of S^t_{new}

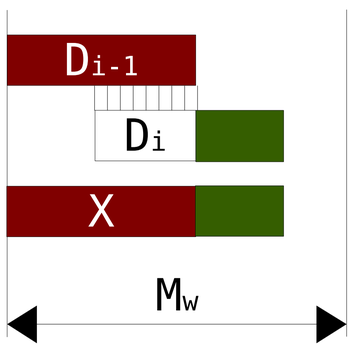
Proposed Model for #Skipped Pages

#skipped = f(#eligible_pages, dirty rate, migration rate)

$$W_i = f(E_i, S, S_{new}, R)$$

$$E_1 = D_1$$

Given D_i, D_{i-1}, T_i, T_{i-1}



X = |Union of Dirtied Pages|

X = Dirtied_Pages(T_i + T_{i-1})

E_i = (D_{i-1} + D_i) - X