Technical Report 2000-10-01
Internetworking and Media Communications Research Laboratories
Department of Math & Computer Science, Kent State University
http://medianet.kent.edu/technicalreports.html

PERFORMANCE PROFILE OF MPEG-2 TRANSCODING WITH MOTION VECTOR REUSE MECHANISM

Darsan Patel and Wansik Oh

Technical Report TR2000-10-01

Internetworking and Media Communications Research Laboratories
Department of Math & Computer Science
Kent State University, 233 MSB, Kent, OH 44242

Last Revised January 31, 2001

1 OVERVIEW

The bi-cofigurable Active Video Transcoder (AVT) developed at Kent MEDIANET can perform rate transform of MPEG-2 video in two modes—the **full logic** and **motion vector reuse** mode. The later avoids motion vector recomputation. This document contains result of profile performance test of the system AVT version S-mvX-Pv27. This document just presents the time performance result.

2 TABLE OF CONTENTS:

3 INTRODUCTION:

The project carried out different experiments on the transcoder by keeping the motion_estimation bypass ON and OFF to study the effect of motion_estimation bypass on the execution time of the transcoder and on the behavior of the transcoder.

Behavior of the transcoder was deduced from the graphs obtained from the profiling of the transcoder by keeping motion_estimation bypass OFF and ON with respect to certain functions of the transcoder.

4 METHODOLOGY:

To study the effect of motion_estimation bypass, we begun by taking images of different sizes having different M and same N and also vice versa, where in technicality M is the distance between two B frames in a sequence of frames for an image and N is the distance between two I frames in a sequence of frames for an image.

Creation of the images with different sizes with different M and N and vice versa was done by using the software named"" which allows the necessary parameters to be set before encoding the image.

After creating these images we ran each of the samples (images) through transcoder by setting the N and M to match the N and M set during encoding the samples to achieve the correct behavior of the transcoder.

For the profiling of the functions of the transcoder, we chose a unix in_built profiling tool called gprof.This profiler was enabled for ENCODER and DECODER separately for keeping the motion_estimation bypass OFF and ON for each of the graphs.

After creating profiling files for each of the samples keeping motion_estimation OFF and ON, we studied the profiling of the various functions of the encoder and decoder separately and chose the functions making significant impact on the execution time of the transcoder for constructing the graphs.

The functions chosen of the Decoder were:

- **REF_IDCT**
- **FORM_COMPONENT_PREDICTION**
- **ADD_BLOCK**
- **SATURATE**
- **OTHER FUNCTIONS OF THE DECODER**

The other functions of the decoder were the remaining functions of the decoder. Since there were many functions, we planned to depict the total time comprised of the time taken by the above mentioned significant functions and the remaining functions.

The functioned were categorized as significant based on the time taken by each function.

The functions chosen for the Encoder were:

- **FDCT**
- **INTRA**
- **NON_INTRA**
- **IDCT**
- **DCT**
- **MOTION_ESTIMATION**
- **PUTMETHODS**

- **OTHER FUNCTIONS OF THE ENCODER**

The other functions of the encoder were the remaining functions of the encoder.Since there were many functions , we planned to depict the total time comprised of the time taken by the above mentioned significant functions and the remaining functions.

The functioned were categorized as significant based on the time taken by each function.

5 GRAPHS PLOTTED

We constructed graphs as categorized as below:

- **Graphs for images with different M and same N.**

No.of frames in the image are 50.

The following samples were used in this case:

File size	176x120	352x240	704x480
NxM	18x2	18x2	18x2
NxM	18x3	18x3	18x3
NxM	18x6	18x6	18x6
NxM	18x9	18x9	18x9

As we can see, 12 samples were generated for profiling purposes keeping the N = 18 same and for all the samples keeping BYPASS OFF and ON the following graphs were generated.

- **Combined graph for time per routine**
- **Combined graph for time per frame**
- **Decoder graph for time per routine**
- **Decoder graph for time per frame**
- **Encoder graph for time per routine**
- **Combined graph for change ratio**

- **Graphs for images with different N and same M.**

No.of frames used are 100 in this case.
The following samples were used in this case:

FILE SIZE	352x240	704x480
MXN	12X3	12X3
MXN	24X3	24X3
MXN	6X3	6X3

- **Combined graph for time per routine**
- **Combined graph for time per frame**

- **Decoder graph for time per routine**
- **Decoder graph for time per frame**
- **Encoder graph for time per routine**
- **Encoder graph for time per frame.**

- **Combined graph for change ratio**

6 OBSERVATIONS

Lets discuss what each of the graph for images with different M and same N.
No.of frames are 50

6.1 Combined Graph (time per routine): (Ref. FIGURE .1 in APPENDICES).

Graph shows time taken per function in the encoder and decoder.The legend part of the graph has a line which separates decoder functions from the encoder functions.The horizontal axis shows the various samples in bypass ON and OFF alternatively for all the 3 different frame sizes which are indicated by the vertical lines in the graph.Each of the function is color coded and can be identified with the help of the legend.

Inferences:

- As we can see the total time taken with Bypass is ON is smaller than that with Bypass OFF which matches with the Theoritical conclusion.
- As we can see that the decoder function Ref_Idct takes the most of the decoder total time.
- Also we can see that the time taken by Intra function (i.e intra coding) when bypass is ON is less as compared to when bypass is OFF and also the time taken by non_intra function(non_intracoding) is more when bypass is ON and less when bypass is OFF.
- Also the time taken by motion_estimation routine when bypass is OFF is quite large and hence contributes majorly to the total execution time of the encoder and hence the transcoder.

6.2 Combined Graph(time per frame): (Ref. FIGURE .2 in APPENDICES).

This graph is obtained by dividing the each of the time values of the previous graph with the no.of frames used(which is 50 in this case).

We can deduce the total time per frame for the transcoder from the graph which has the same characteristics as of the previous graph.

6.3 Decoder Graph(time per routine): (Ref. FIGURE .3 in APPENDICES).

It displays the decoder part of the first graph and hence has the inferences same as drawn for the first graph for the decoder.

6.4 Decoder Graph(time per frame): (Ref. FIGURE .4 in APPENDICES).

It displays the decoder part of the second graph and hence has the same characteristics and inferences as drawn for the second graph.

6.5 Encoder Graph(time per routine): (Ref. FIGURE .5 in APPENDICES).

It displays the encoder part of the first graph.

6.6 Encoder Graph(time per frame): (Ref. FIGURE .6 in APPENDICES).

It displayes the encoder part of the second graph.

6.7 Combined graph for change ratio: (Ref. FIGURE .7 in APPENDICES).

This graph depicts

$$\text{Ratio} = \frac{\text{values when bypass OFF}}{\text{Values when bypass ON}}$$

As we can see from the graph that the ratio for the function motion_estimation is not there since the values will be 0 for bypass ON.

Lets discuss what each of the graph depicts for images with different N and same M:
No.of frames for the images are 100 frames.

6.8 Combined Graph (time per routine): (Ref. FIGURE .8 in APPENDICES).

Graph shows time taken per function in the encoder and decoder.The legend part of the graph has a line which separates decoder functions from the encoder functions.The horizontal axis shows the various samples in bypass ON and OFF alternatively for all the 3 different frame sizes which are indicated by the vertical lines in the graph.Each of the function is color coded and can be identified with the help of the legend.

Inferences:

- As we can see the total time taken with Bypass is ON is smaller than that with Bypass OFF which matches with the Theoritical conclusion.
- As we can see that the decoder function Ref_Idct takes the most of the decoder total time.
- Also we can see that the time taken by Intra function (i.e intra coding) when bypass is ON is less as compared to when bypass is OFF and also the time taken by non_intra function(non_intracoding) is more when bypass is ON and less when bypass is OFF.
- Also the time taken by motion_estimation routine when bypass is OFF is quite large and hence contributes majorly to the total execution time of the encoder and hence the transcoder.

6.9 Combined Graph(time per frame): (Ref. FIGURE .9 in APPENDICES).

This graph is obtained by dividing the each of the time values of the previous graph with the no.of frames used(which is 100 in this case).

We can deduce the total time per frame for the transcoder from the graph which has the same characteristics as of the previous graph.

6.10 Decoder Graph(time per routine): (Ref. FIGURE .10 in APPENDICES).

It displays the decoder part of the first graph and hence has the inferences same as drawn for the first graph for the decoder.

6.11 Decoder Graph(time per frame): (Ref. FIGURE .11 in APPENDICES).

It displays the decoder part of the second graph and hence has the same characteristics and inferences as drawn for the second graph.

6.12 Encoder Graph(time per routine): (Ref. FIGURE .12 in APPENDICES).

It displays the encoder part of the first graph.

6.13 Encoder Graph(time per frame): (Ref. FIGURE .13 in APPENDICES).

It displayes the encoder part of the second graph.

6.14 Combined graph for change ratio: (Ref. FIGURE .14 in APPENDICES).

This graph depicts

$$\text{Ratio} = \frac{\text{values when bypass OFF}}{\text{Values when bypass ON}}$$

As we can see from the graph that the ratio for the function motion_estimation is not there since the values will be 0 for bypass ON.

7 PROPOSITIONS:

From the graphs we can observe that the function other than motion_esimation in the ENCODER which takes time is FDCT and in the DECODER the function is REF_IDCT.

Hence these are the functions which needs to be OPTIMISED.

8 APPENDICES: ALL GRAPHS

FIG.1

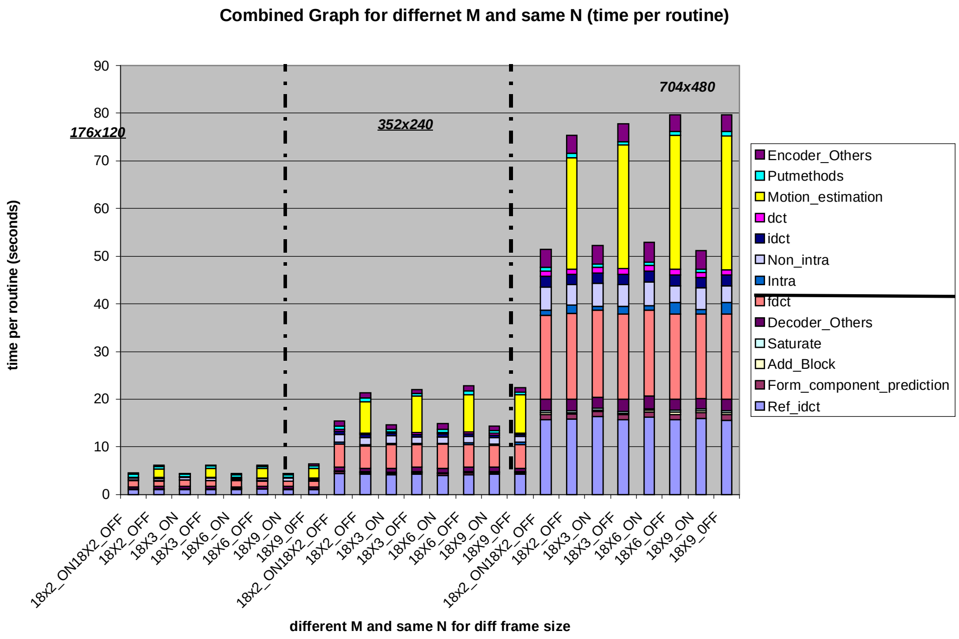


FIG.2

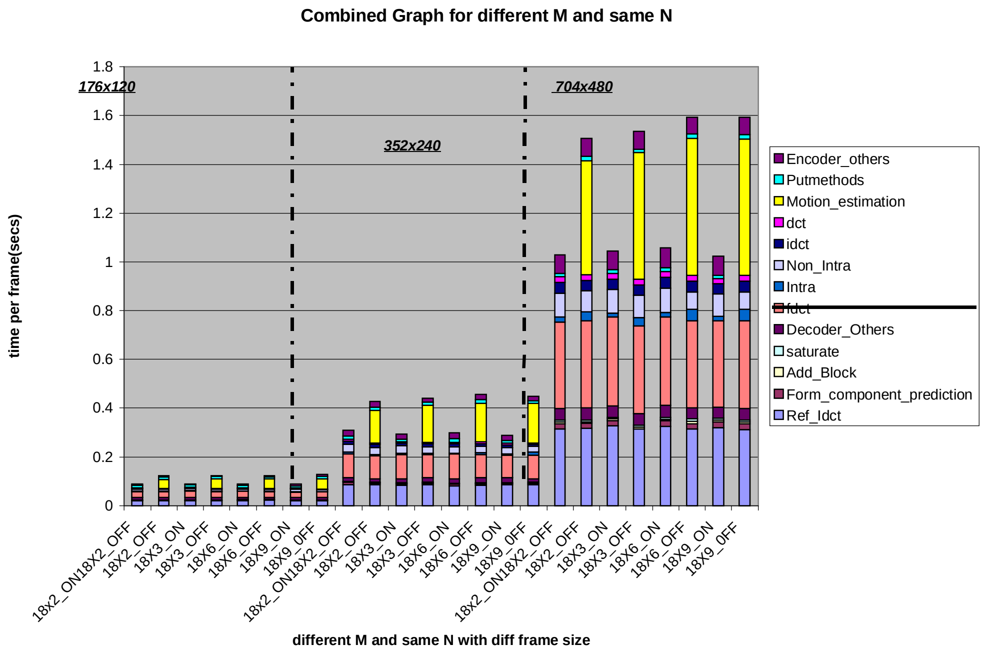


FIG.3

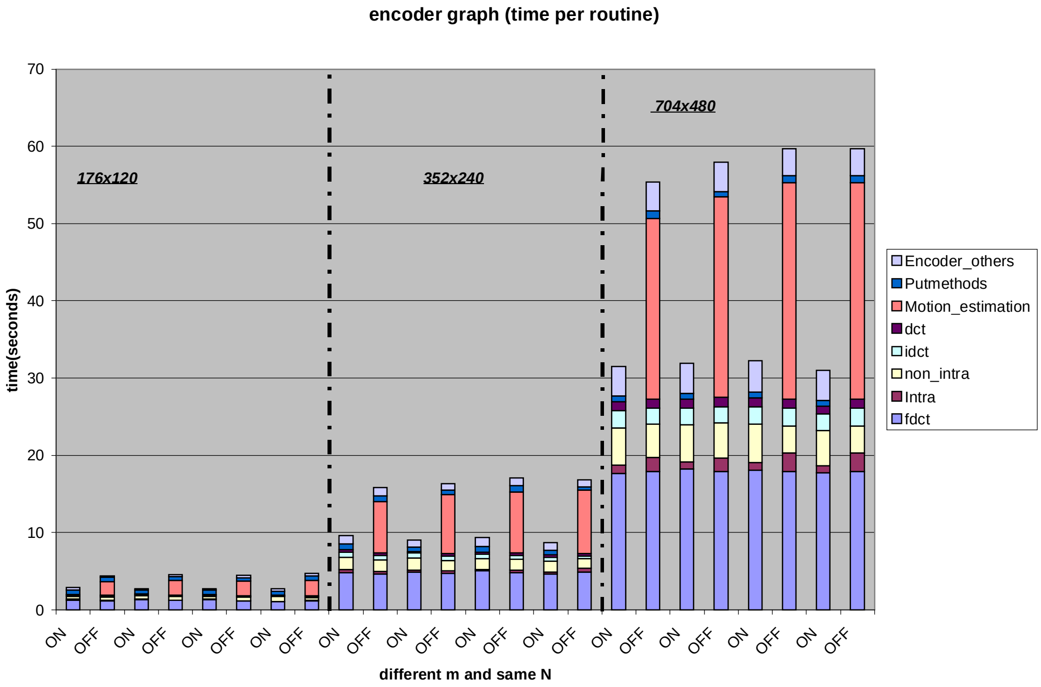

encoder graph (time per routine)
time(seconds)
70
60
50
40
30
20
10
0
176x120
352x240
704x480
Encoder_others
Putmethods
Motion_estimation
dct
idct
non_intra
Intra
fdct
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
different m and same N

FIG.4

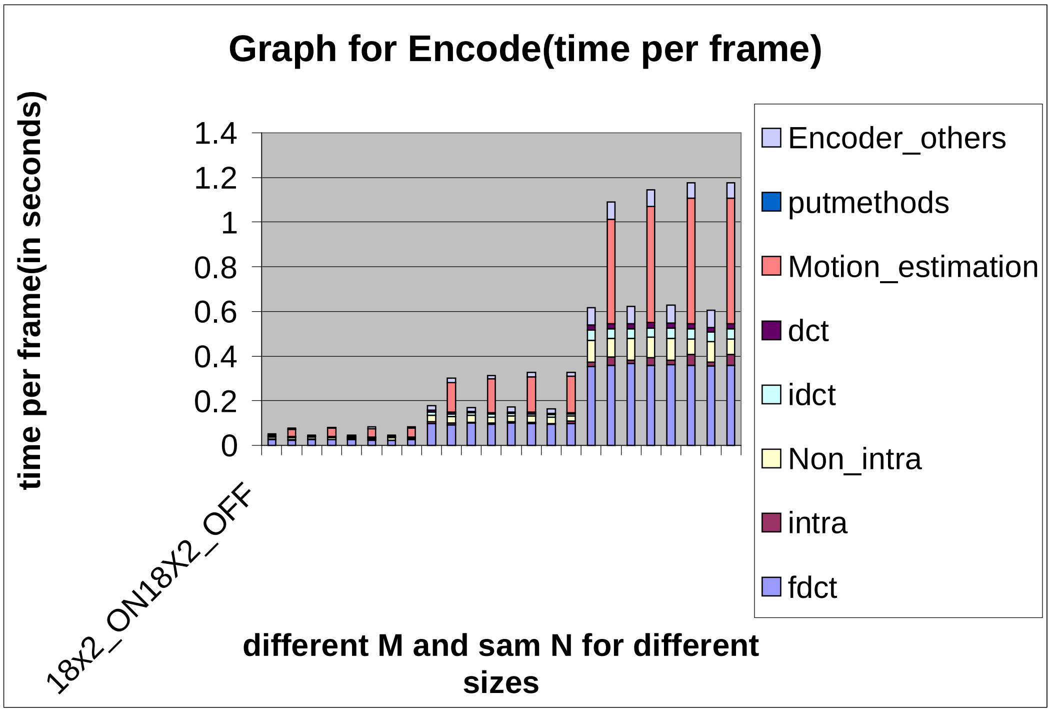

Graph for Encode(time per frame)
time per frame(in seconds)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
18x2_ON18X2_OFF
different M and sam N for different sizes
Encoder_others
putmethods
Motion_estimation
dct
idct
Non_intra
intra
fdct

FIG.5

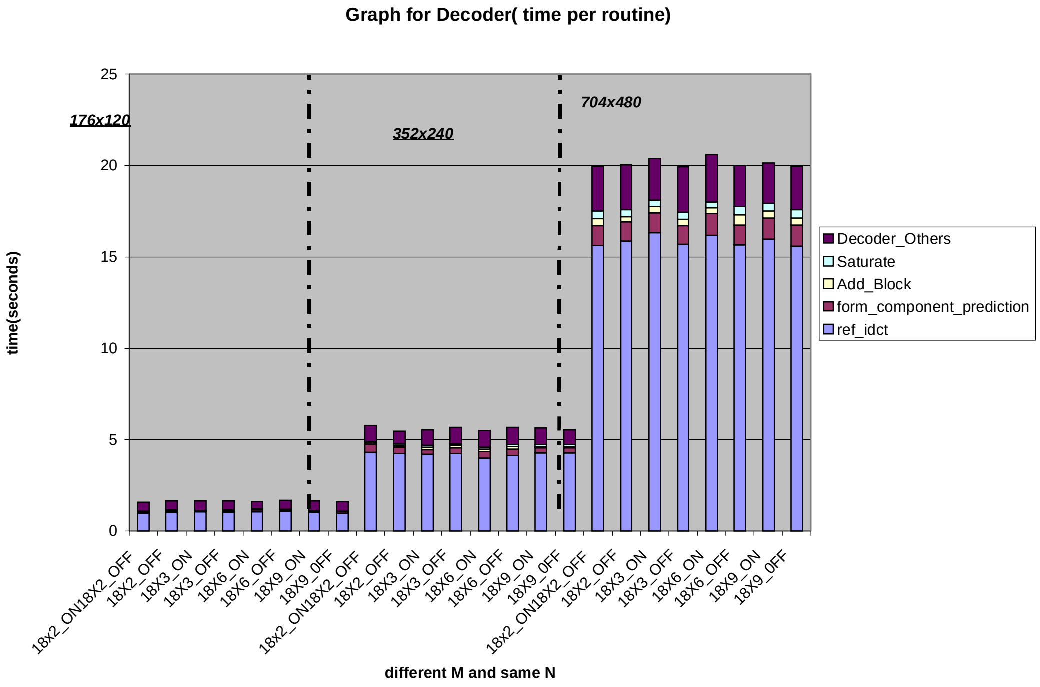

Graph for Decoder(time per routine)
176x120
352x240
704x480
time(seconds)
0
5
10
15
20
25
Decoder_Others
Saturate
Add_Block
form_component_prediction
ref_idct
18x2_ON18X2_OFF
18X2_OFF
18X3_ON
18X3_OFF
18X6_ON
18X6_OFF
18X9_ON
18X9_OFF
18x2_ON18X2_OFF
18X2_OFF
18X3_ON
18X3_OFF
18X6_ON
18X6_OFF
18X9_ON
18X9_OFF
18x2_ON18X2_OFF
18X2_OFF
18X3_ON
18X3_OFF
18X6_ON
18X6_OFF
18X9_ON
18X9_OFF
different M and same N

FIG.6

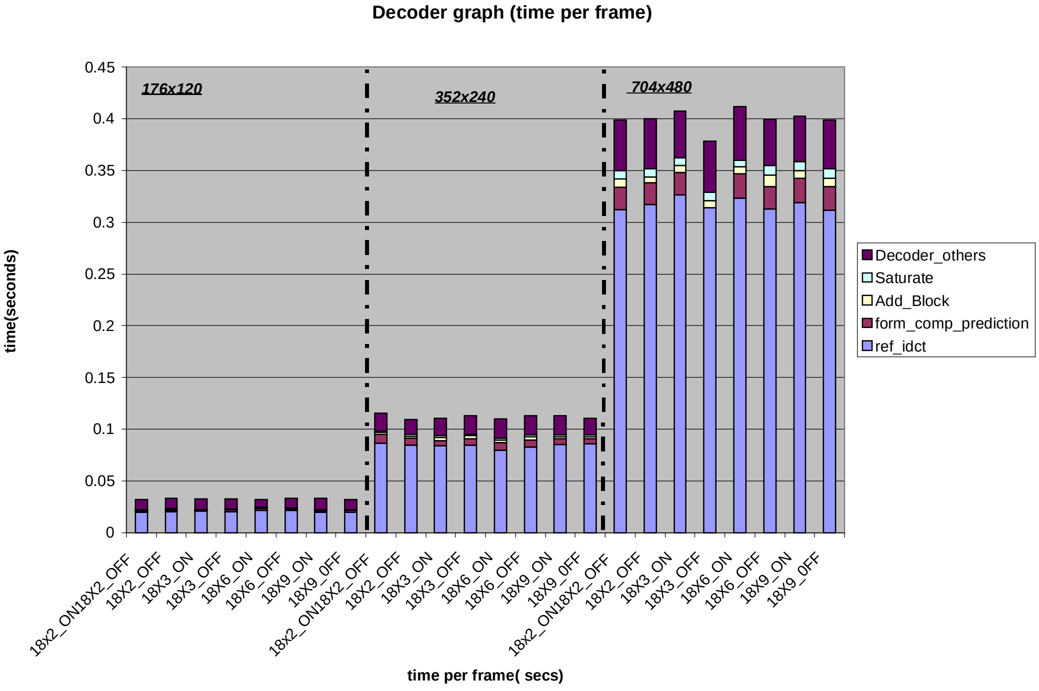

Decoder graph (time per frame)
176x120
352x240
704x480
time(seconds)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Decoder_others
Saturate
Add_Block
form_comp_prediction
ref_idct
18x2_ON18X2_OFF
18X2_OFF
18X3_ON
18X3_OFF
18X6_ON
18X6_OFF
18X9_ON
18X9_OFF
18x2_ON18X2_OFF
18X2_OFF
18X3_ON
18X3_OFF
18X6_ON
18X6_OFF
18X9_ON
18X9_OFF
18x2_ON18X2_OFF
18X2_OFF
18X3_ON
18X3_OFF
18X6_ON
18X6_OFF
18X9_ON
18X9_OFF
time per frame(secs)

FIG.7

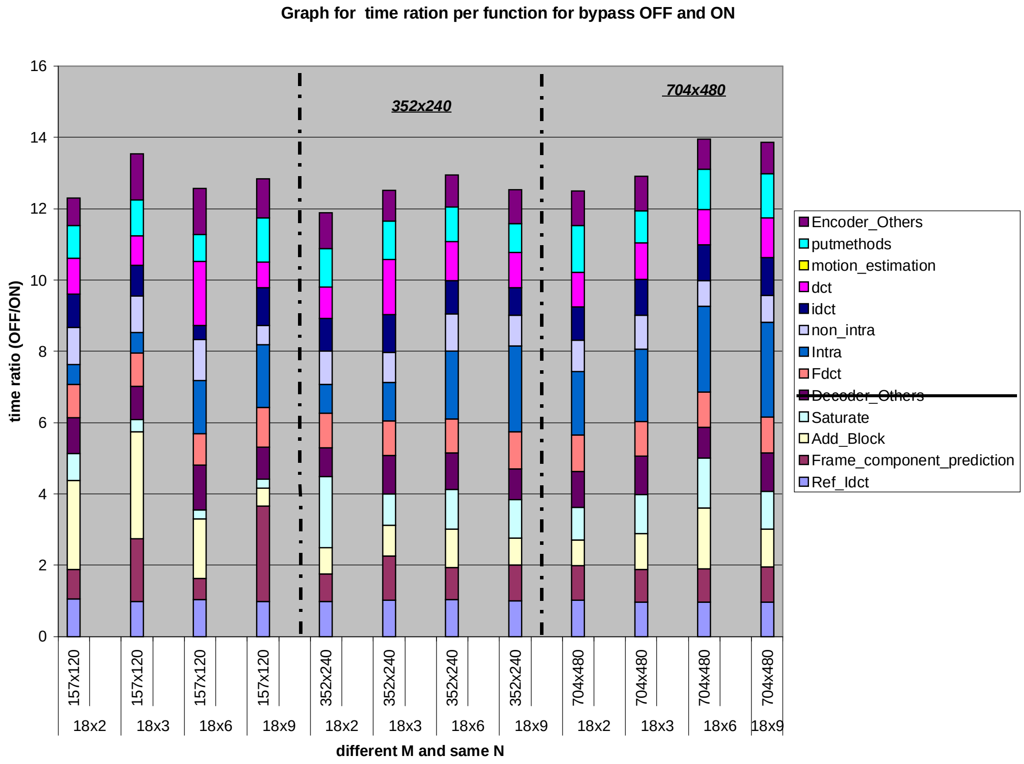

Graph for time ration per function for bypass OFF and ON
time ratio (OFF/ON)
0
2
4
6
8
10
12
14
16
352x240
704x480
157x120
157x120
157x120
157x120
352x240
352x240
352x240
352x240
704x480
704x480
704x480
704x480
18x2
18x3
18x6
18x9
18x2
18x3
18x6
18x9
18x2
18x3
18x6
18x9
different M and same N
Encoder_Others
putmethods
motion_estimation
dct
idct
non_intra
Intra
Fdct
Decoder_Others
Saturate
Add_Block
Frame_component_prediction
Ref_Idct

FIG.8

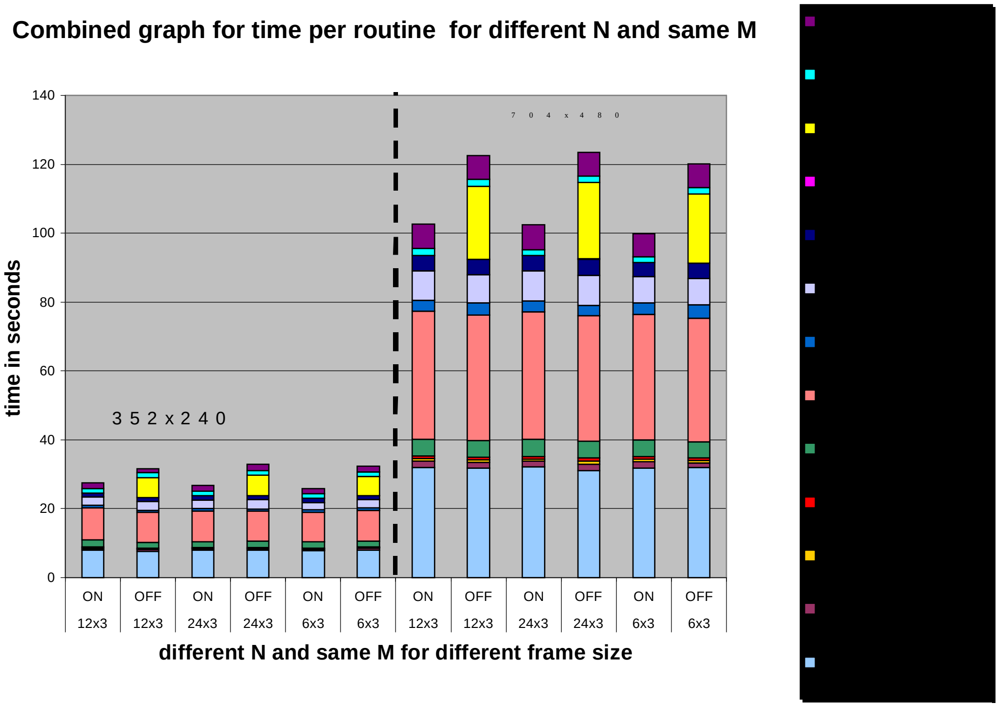

Combined graph for time per routine for different N and same M
time in seconds
0
20
40
60
80
100
120
140
704x480
352x240
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
12x3
12x3
24x3
24x3
6x3
6x3
12x3
12x3
24x3
24x3
6x3
6x3
different N and same M for different frame size

FIG.9

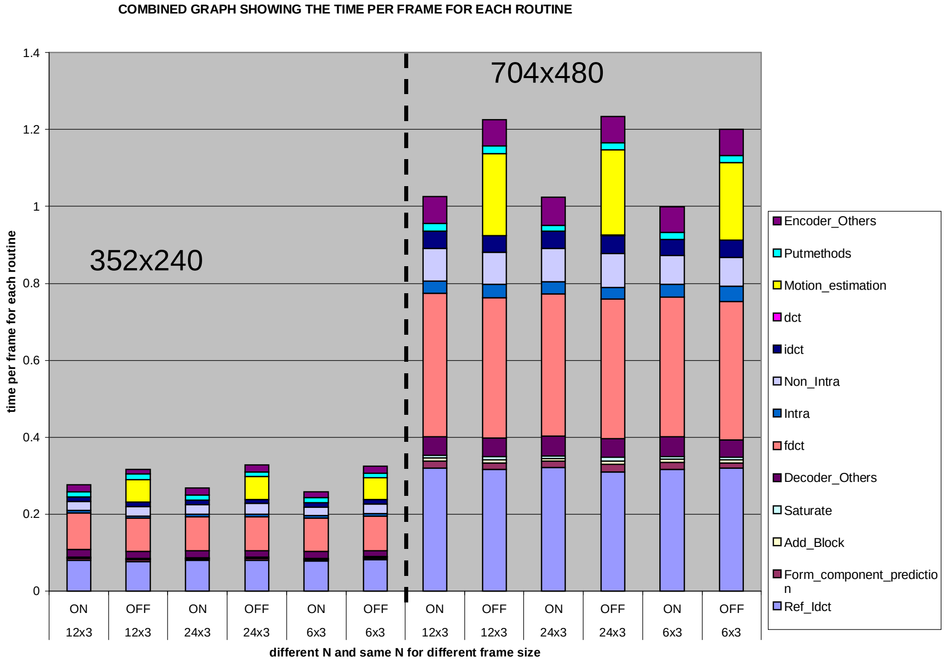
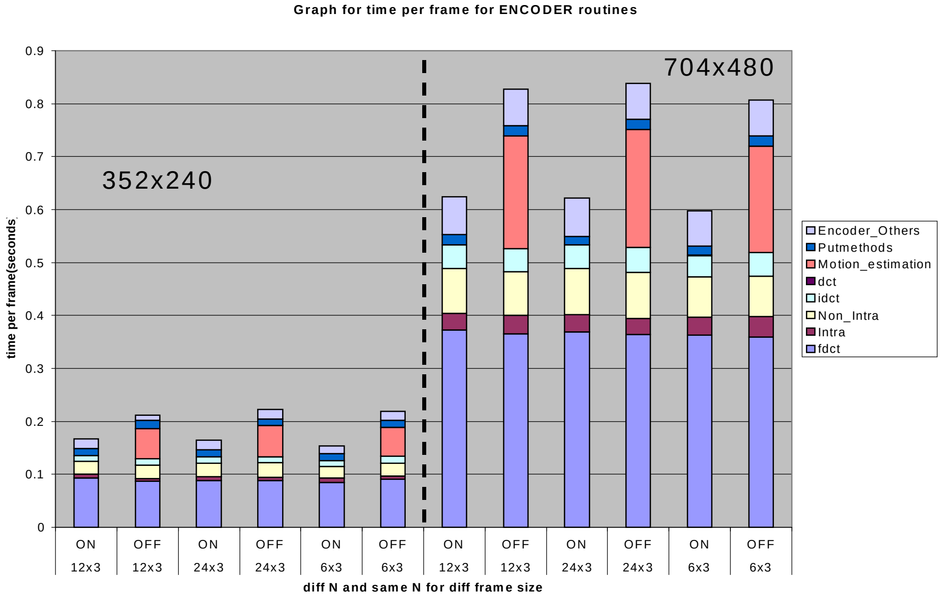

COMBINED GRAPH SHOWING THE TIME PER FRAME FOR EACH ROUTINE
time per frame for each routine
1.4
1.2
1
0.8
0.6
0.4
0.2
0
352x240
704x480
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
different N and same N for different frame size
Encoder_Others
Putmethods
Motion_estimation
dct
idct
Non_Intra
Intra
fdct
Decoder_Others
Saturate
Add_Block
Form_component_prediction
Ref_Idct

FIG.10


Graph for time per frame for ENCODER routines
time per frame(seconds)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
352x240
704x480
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
diff N and same N for diff frame size
Encoder_Others
Putmethods
Motion_estimation
dct
idct
Non_Intra
Intra
fdct

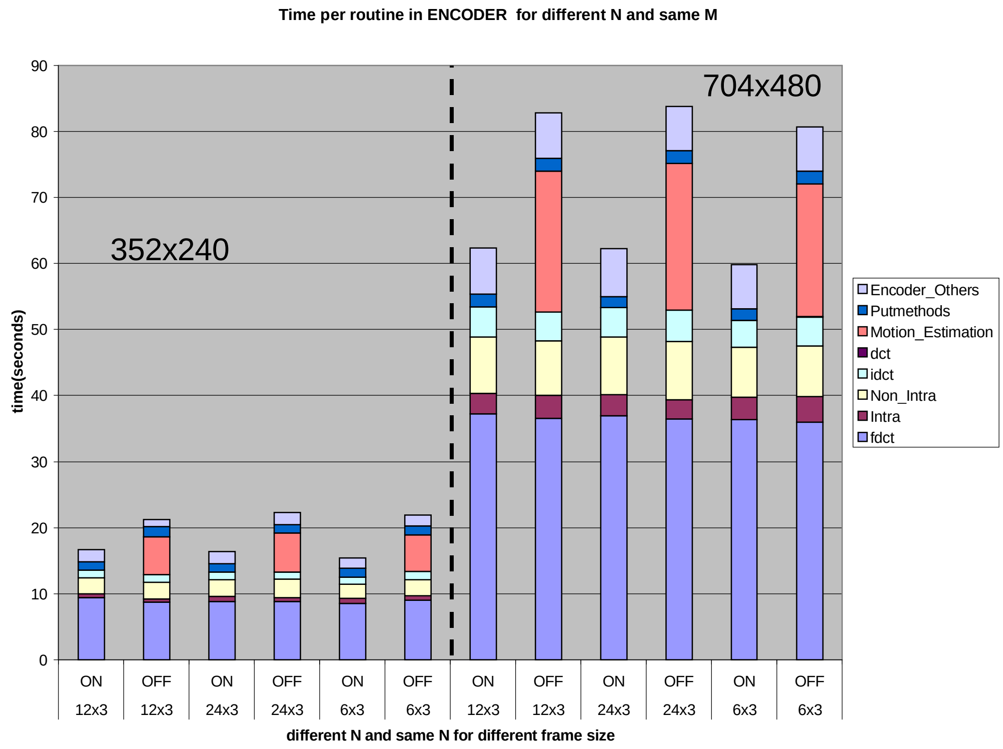

Time per routine in ENCODER for different N and same M
time(seconds)
0
10
20
30
40
50
60
70
80
90
352x240
704x480
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
different N and same N for different frame size
Encoder_Others
Putmethods
Motion_Estimation
dct
idct
Non_Intra
Intra
fdct

FIG.11

FIG.12

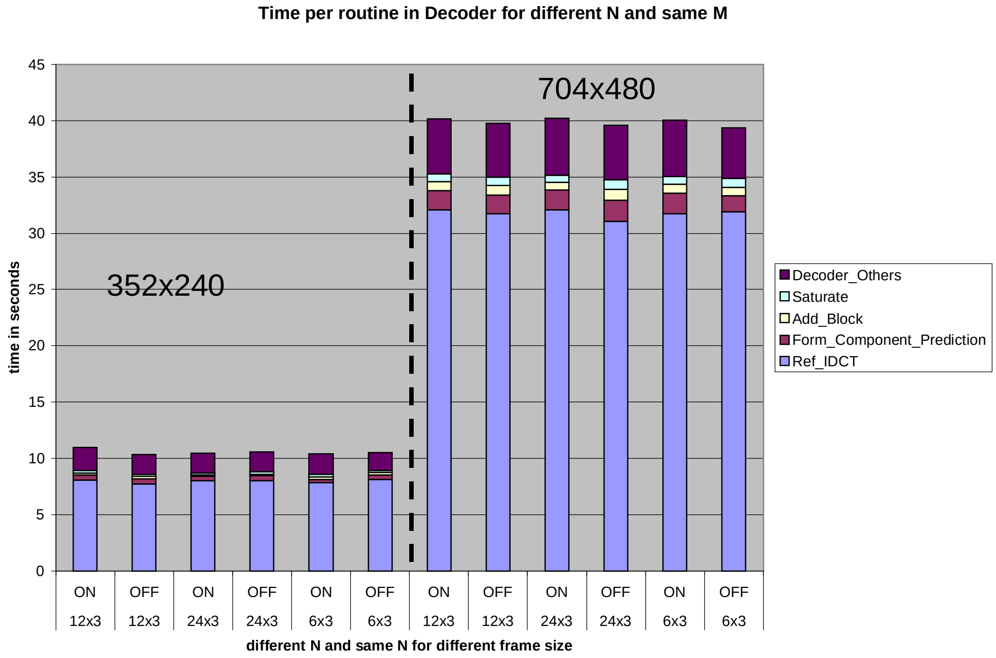

Time per routine in Decoder for different N and same M
time in seconds
0
5
10
15
20
25
30
35
40
45
352x240
704x480
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
different N and same N for different frame size
Decoder_Others
Saturate
Add_Block
Form_Component_Prediction
Ref_IDCT

FIG.13

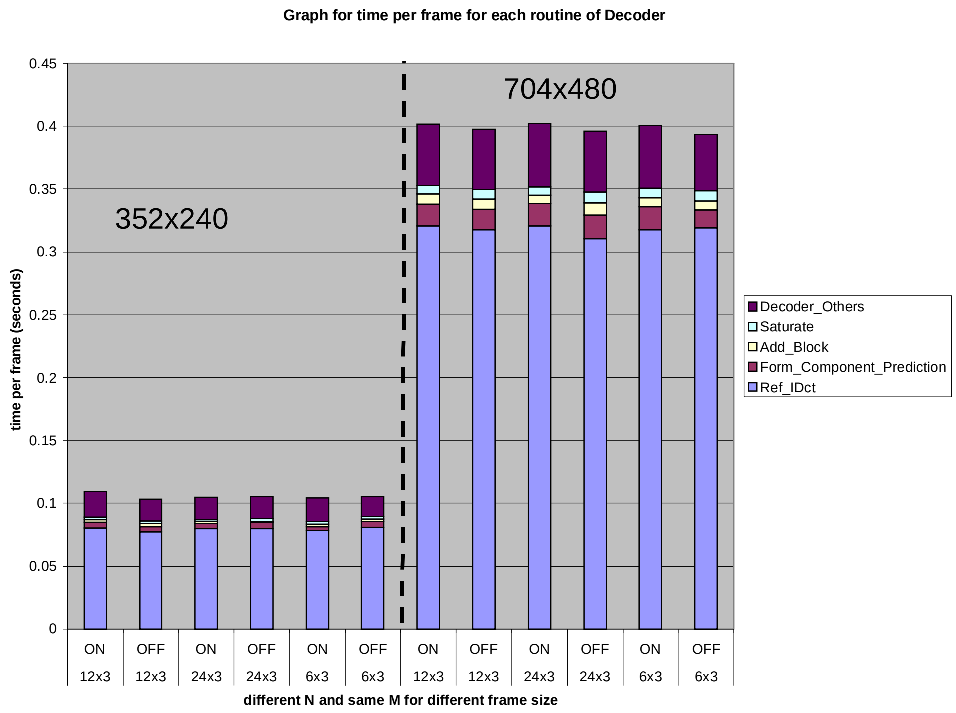
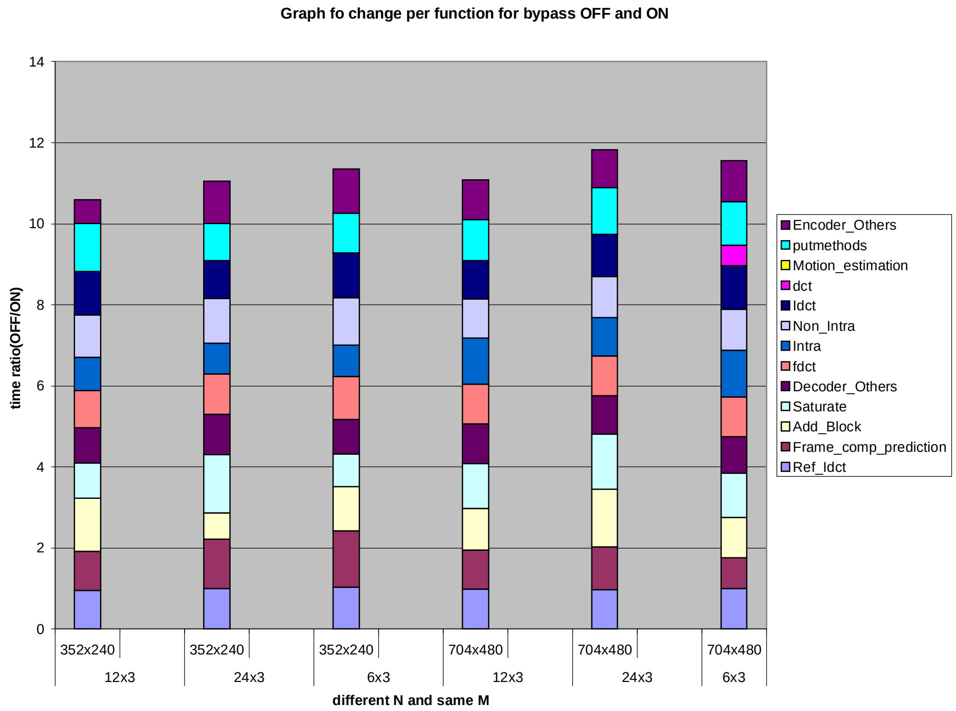

Graph for time per frame for each routine of Decoder
time per frame (seconds)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
352x240
704x480
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
ON 12x3
OFF 12x3
ON 24x3
OFF 24x3
ON 6x3
OFF 6x3
different N and same M for different frame size
Decoder_Others
Saturate
Add_Block
Form_Component_Prediction
Ref_IDct

FIG.14


Graph fo change per function for bypass OFF and ON
time ratio(OFF/ON)
0
2
4
6
8
10
12
14
352x240 12x3
352x240 24x3
352x240 6x3
704x480 12x3
704x480 24x3
704x480 6x3
different N and same M
Encoder_Others
putmethods
Motion_estimation
dct
Idct
Non_Intra
Intra
fdct
Decoder_Others
Saturate
Add_Block
Frame_comp_prediction
Ref_Idct