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JCTVC-D108

CE6 subset A:
Bidirectional Intra Prediction

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Summary

- ## CE6 : Intra prediction improvement
  - BIP (Bidirectional Intra prediction)

- ## BIP for TMuC 0.9

- ## Experimental results compared with common anchor
  - ## Bitrate Reduction
    - I-only : 1.4% (HE), 2.0% (LC)

Bidirectional Intra Prediction (BIP)

- **Coding efficiency improvement tool for intra coding**
  - Originally proposed at Marrakech VCEG meeting (VCEG-AE14)
  - Detailed specification is shown at Geneva VCEG meeting (C181)
  - KTA software is provided at ShenZhen VCEG meeting (VCEG-AG08)
  - Experimental results based on Intra AHG in HEVC are reported (JCTVC-B042)
  - Experimental results based on TE6 are reported (JCTVC-C079)
- **Related contribution**
 - Overlapped Block Intra Prediction   (JCTVC-C193)
- **BIP**
  - Weighted average of two kinds of uni-directional prediction

Mode 0 (Vertical-Down)   Mode 3 (Diagonal-Down-Left)

$$(w[x,y] * \text{ } + (1024 - w[x, y]) * \text{ } + 512) >> 10$$

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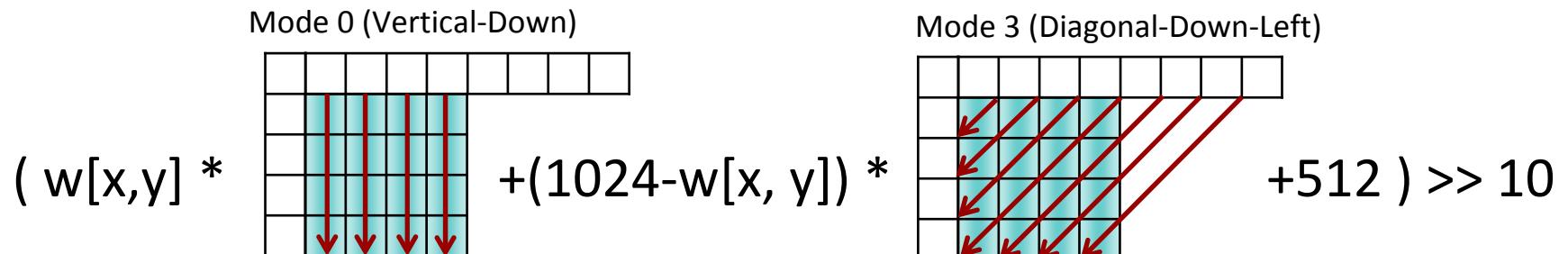
BIP based on Unidirectional Intra Prediction (UIP)

- A intra prediction mode is selected from unidirectional modes (UIP modes) and bidirectional mode (BIP modes) for each PU.

- One BIP mode is consists of two UIP modes.
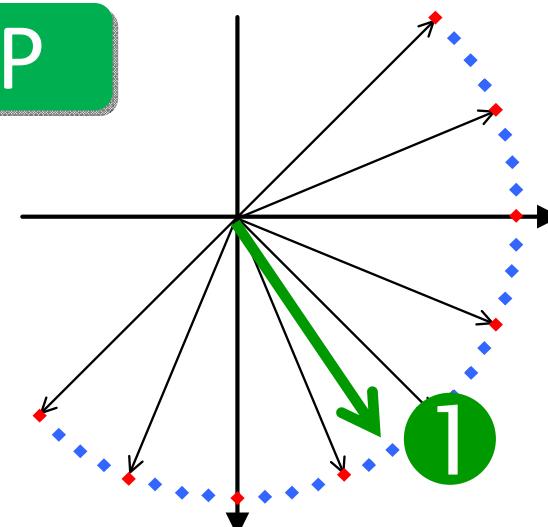
Select one prediction direction

plus...
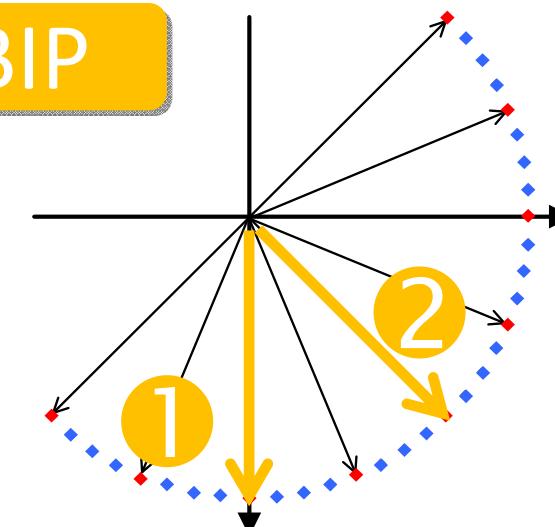
Select two prediction direction based on UIP mode

JCTVC-C079 (in Guangzhou meeting)

- **Up to 16 BIP modes on top of UIP modes.**
  - fixed combinations of UIP mode directions.

|	IntraModeL0		IntraModeL1	
0	Intra_Horizontal	0	Intra_Vertical	0
1	Intra_DC	-	Intra_Vertical	0
2	Intra_DC	-	Intra_Horizontal	0
3	Intra_Vertical	-8	Intra_Vertical	0
4	Intra_Vertical	-8	Intra_Horizontal	0
5	Intra_Vertical	-8	Intra_DC	-
6	Intra_Vertical	8	Intra_Vertical	0
7	Intra_Vertical	8	Intra_Horizontal	0
8	Intra_Vertical	8	Intra_DC	-
9	Intra_Vertical	8	Intra_Vertical	-8
10	Intra_Vertical	-4	Intra_Vertical	0
11	Intra_Vertical	-4	Intra_Horizontal	0
12	Intra_Vertical	4	Intra_Vertical	0
13	Intra_Vertical	4	Intra_Horizontal	0
14	Intra_Horizontal	4	Intra_Vertical	0
15	Intra_Horizontal	4	Intra_Horizontal	0

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Proposal

- **Up to eight BIP modes on top of UIP modes.**
  - Three fixed combinations of UIP mode directions.
  - Five implicit combinations of UIP mode directions using neighboring PUs.
    - ➔ **IBMD (Implicit bidirectional mode derivation) mode**
    - ➔ Similar in concept to C193

PU_4x4
PU_8x8
PU_16x16

	IntraModeL0		IntraModeL1	
0	Intra_Horizontal	0	Intra_Vertical	0
1	Intra_DC	-	Intra_Vertical	0
2	Intra_DC	-	Intra_Horizontal	0
3	IBMD mode 0			
4	IBMD mode 1			
5	IBMD mode 2			
6	IBMD mode 3			
7	IBMD mode 4			

PU_32x32

	IntraModeL0		IntraModeL1	
0	Intra_Horizontal	0	Intra_Vertical	0
1	IBMD mode 0			
2	IBMD mode 1			
3	IBMD mode 2			

Implicit bidirectional mode derivation (IBMD)

– IBMD modes are derived using neighboring PUs (A, B).
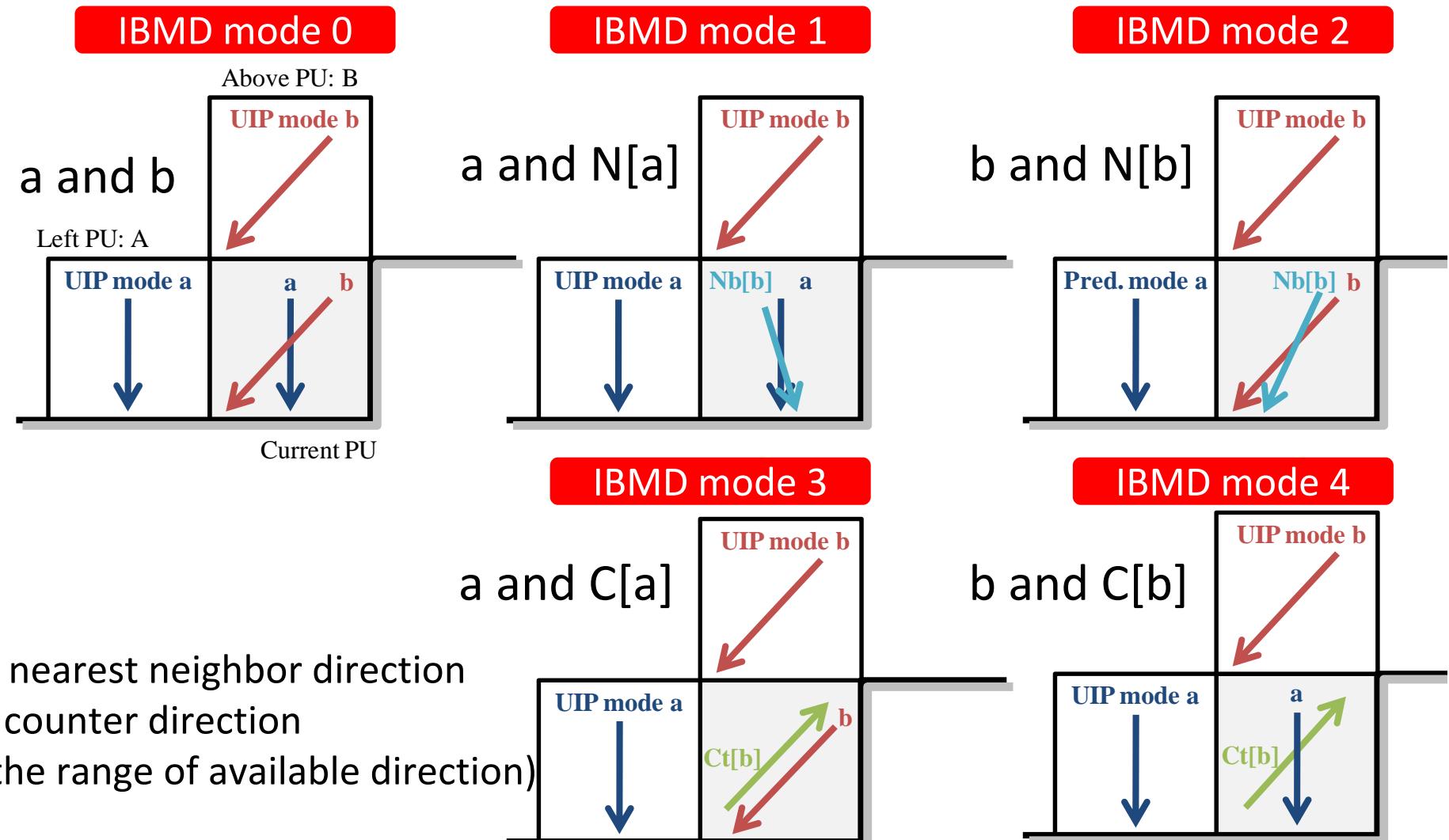
IBMD mode 0

Above PU: B

UIP mode b

a and b

Left PU: A

UIP mode a

a   b

Current PU

IBMD mode 1

UIP mode b

a and N[a]

UIP mode a   Nb[b]   a

IBMD mode 2

UIP mode b

b and N[b]

Pred. mode a   Nb[b] b

IBMD mode 3

UIP mode b

a and C[a]

UIP mode a   b

Ct[b]

IBMD mode 4

UIP mode b

b and C[b]

UIP mode a   a

Ct[b]

N[]: nearest neighbor direction
C[]: counter direction
(in the range of available direction)

Implicit bidirectional mode derivation (IBMD)

fixed combination (C079)

- All combinations cannot be used for current PU.

UIP mode **0**

1

0　**6**

3　**0**

3

1

⋮

proposal

- All combinations can be used for current PU in effect.
- Exploit spatial correlation of mode

UIP mode **15**

UIP mode **11**

BIP mode
which consists UIP mode **11** and **15**
(cannot be selected in C079)

Implicit bidirectional mode derivation (IBMD)

fixed combination (C079)

- All combinations cannot be used for current PU.

UIP mode 0

1

3 **0**

0 **6**

3

1

⋮

proposal

- All combinations can be used for current PU in effect.
- Exploit spatial correlation of mode

UIP mode 5

UIP mode 0

BIP mode
which consists UIP mode 0 and 5
(cannot be selected in C079)
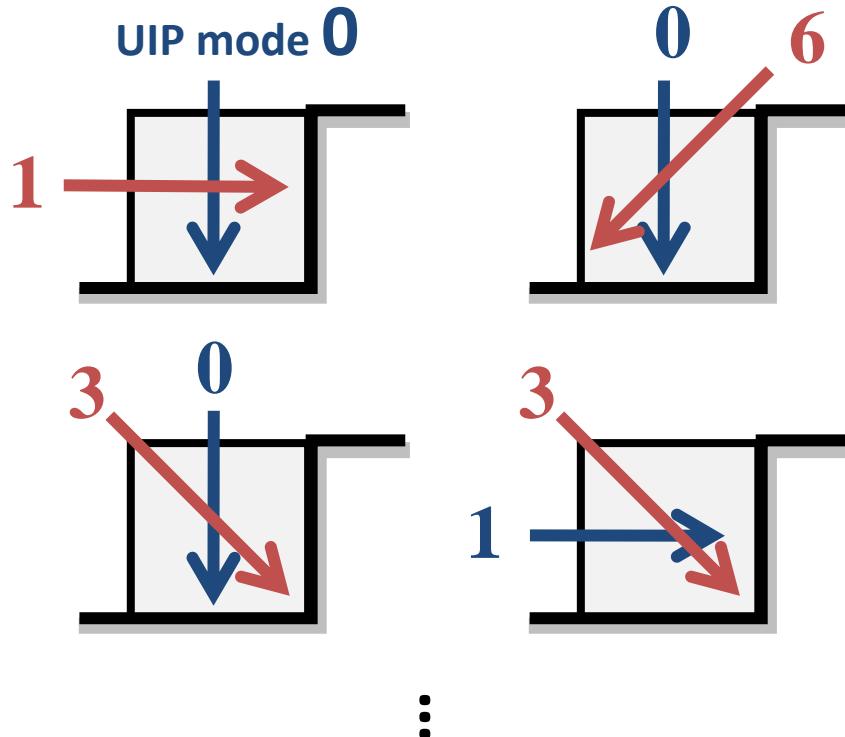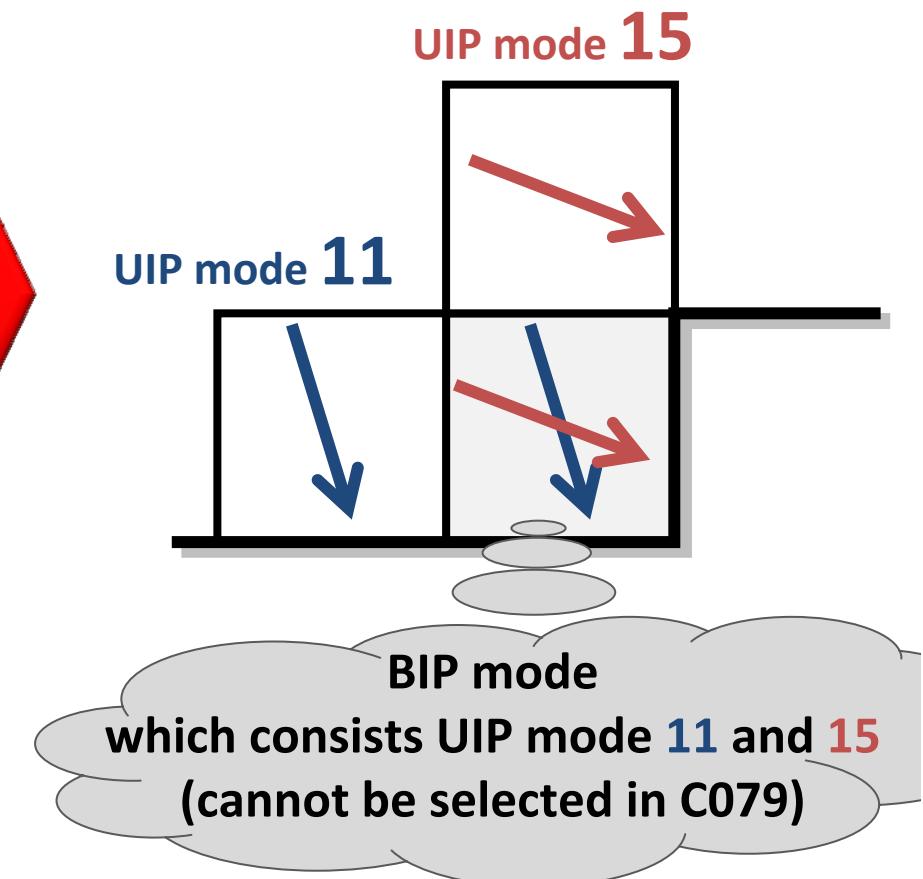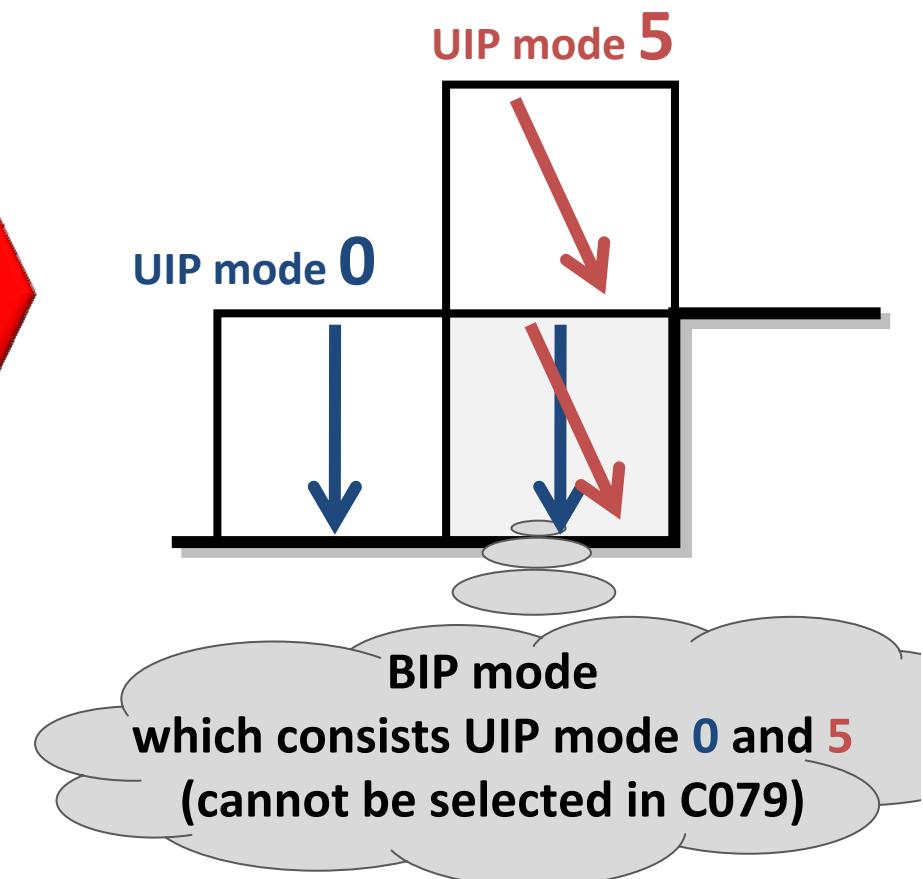
Number of intra prediction mode in proposal

- ## BIP on top of UIP
  - Add BIP modes for PU_4x4, PU_8x8, PU_16x16, PU_32x32

Number of intra prediction mode for each PU size

PuSize	Number of UIP modes (Anchor)	Number of BIP modes	Total Number of pred. modes
PU_2x2	3	0	3
PU_4x4	17	8 (5)	25
PU_8x8	34	8 (5)	42
PU_16x16	34	8 (5)	42
PU_32x32	34	4 (3)	38
PU_64x64	5	0	5
PU_128x128	5	0	5

add BIP modes

Numbers in brackets mean the number of IBMD modes

Specification of proposed intra prediction mode

- **eg. PU4x4**

| IntraPred-Mode	IntraBipred-Flag	IntraModeL0		IntraModeL1	
0	0	Intra_Vertical	0	-	-
1	0	Intra_Horizontal	0	-	-
2	0	Intra_DC	-	-	-
3	0	Intra_Vertical	-8	-	-
4	0	Intra_Vertical	-4	-	-
5	0	Intra_Vertical	+4	-	-
6	0	Intra_Vertical	+8	-	-
7	0	Intra_Horizontal	-4	-	-
8	0	Intra_Horizontal	+4	-	-
9	0	Intra_Horizontal	+8	-	-
10	0	Intra_Vertical	-6	-	-
11	0	Intra_Vertical	-2	-	-
12	0	Intra_Vertical	+2	-	-
13	0	Intra_Vertical	+6	-	-
14	0	Intra_Horizontal	-6	-	-
15	0	Intra_Horizontal	-2	-	-
16	0	Intra_Horizontal	+2	-	-
17	1	Intra_Horizontal	0	Intra_Vertical	0
18	1	Intra_DC	-	Intra_Vertical	0
19	1	Intra_DC	-	Intra_Horizontal	0
20	1	IntraPredModeAL0	-	IntraPredModeBL0	-
21	1	IntraPredModeAL0	-	Nb[IntraPredModeAL0]	-
22	1	IntraPredModeBL0	-	Nb[IntraPredModeBL0]	-
23	1	IntraPredModeAL0	-	Ct[IntraPredModeAL0]	-
24	1	IntraPredModeBL0	-	Ct[IntraPredModeBL0]	-

UIP

BIP

IBMD

- **Intra mode decision (encoder only)**

  – The fast intra mode method [5] integrated into TMuC 0.9 anchor is used in this proposal.

  – The number of candidate intra modes selected by Hadamard Transformed coefficients of residual signal (HSAD) with mode bits for each PU size is completely same as TMuC 0.9 anchor.

Eg. PU_8x8

HSAD + λBits   RD cost

Anchor: | 34 UIP | → | 9 modes | → 1 mode

Proposal: | 34 UIP + 8 BIP | → | 9 modes | → 1 mode
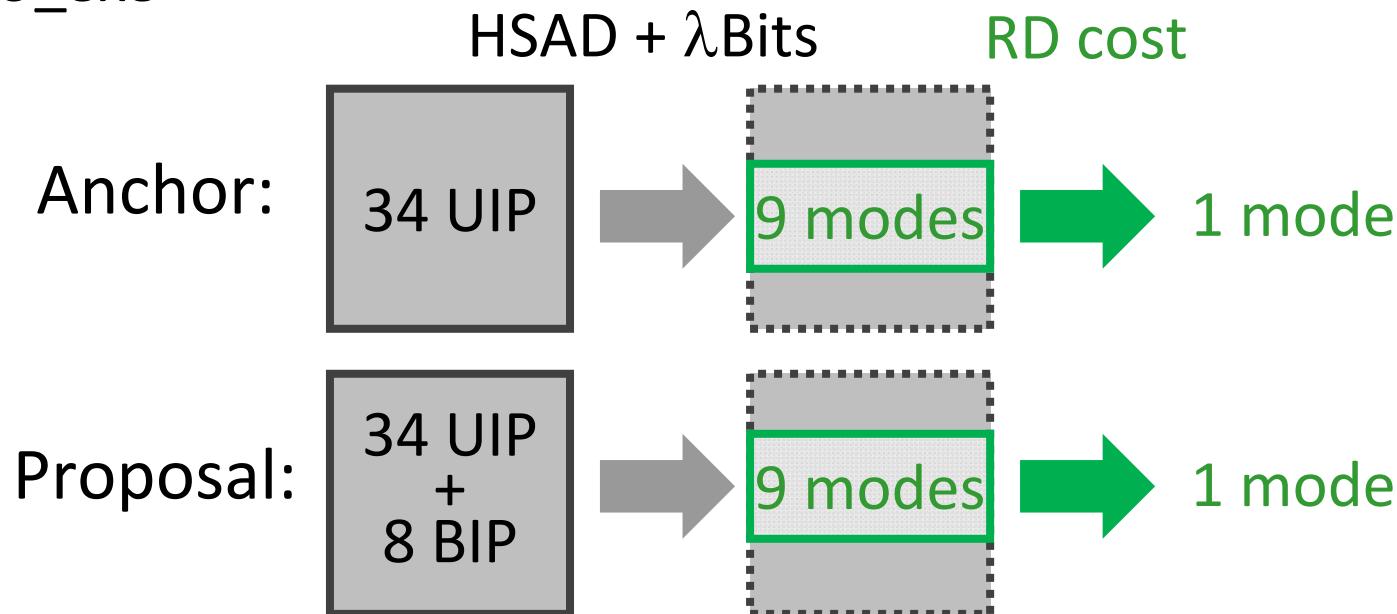
Experimental Conditions

- TMuC Software version 0.9 (HM1)
- Platform : Windows® XP 64 bits
- Complier : Visual Studio® 2008
- **Followed on CE6 common condition completely.**
- Coding structure :
  - Intra-only (high efficiency, low complexity)

		Block size and number of modes				
		4x4	8x8	16x16	32x32	64x64
CE6 Anchor	UIP	17	34	34	34	5
Proposal	UIP	17	34	34	34	5
	BIP	8	8	8	4	0

Experimental results

	Intra			Intra LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-1.6	-1.0	-1.1	-2.3	-1.7	-1.7
Class B	-1.6	-1.0	-1.1	-2.0	-1.5	-1.5
Class C	-1.4	-0.7	-0.7	-1.7	-1.1	-1.1
Class D	-1.1	-0.5	-0.5	-1.6	-0.9	-0.9
Class E	-1.7	-1.3	-1.1	-2.6	-2.2	-1.8
All	-1.4	-0.9	-0.9	-2.0	-1.4	-1.4
Enc Time[%]	107%			114%		
Dec Time1[%]	106%			110%		
Dec Time2[%]	104%			108%		

Dec Time1: the decoding time ratio without outputting the yuv file
Dec Time2: the decoding time ratio with outputting the yuv file

- The coding gain of BIP is 1.4% (for HE), 2.0% (for LC) on average .

Gain of additional UIP modes and BIP modes for **PU_4x4**
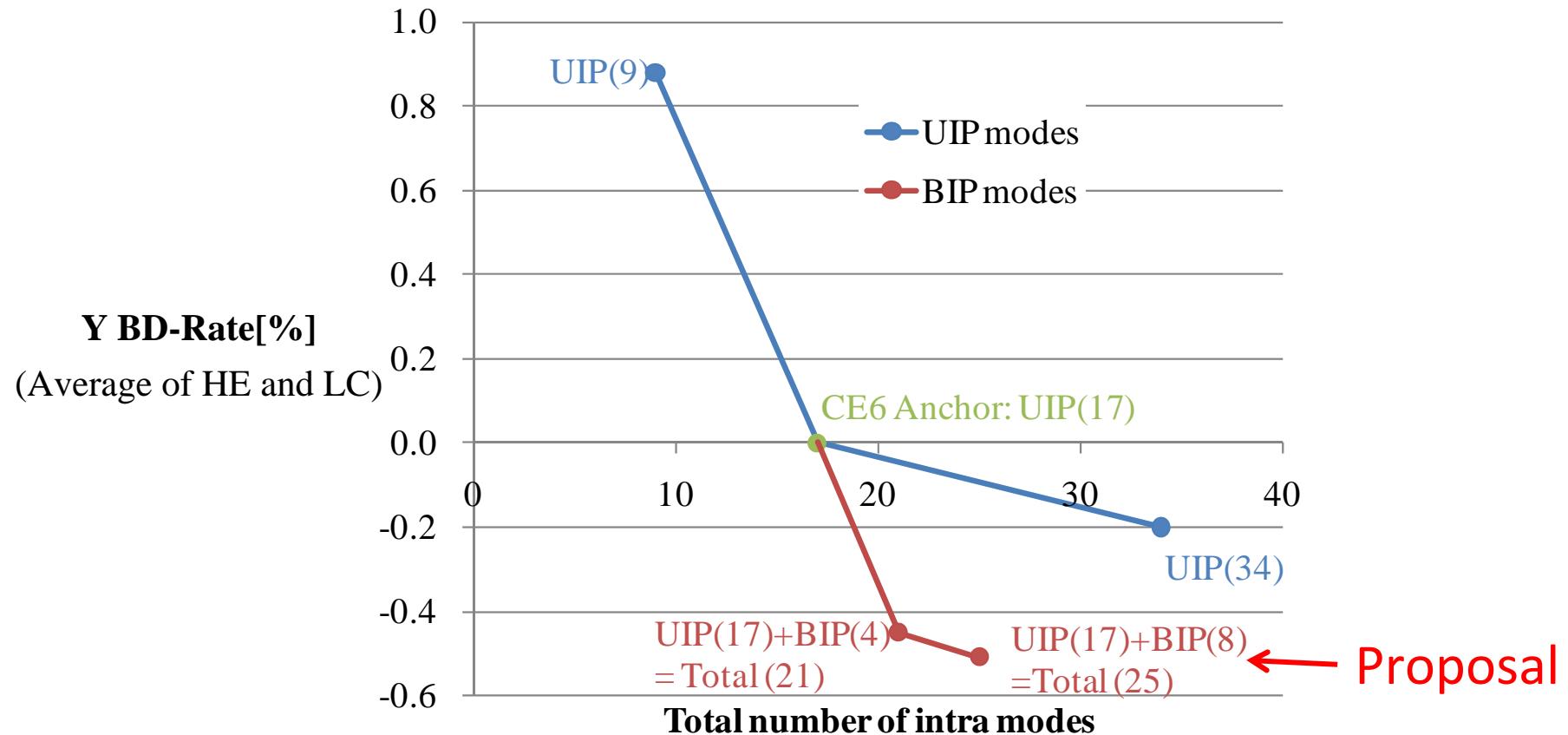
Note: The number of prediction modes for PU sizes other than the target PU size is same as TMuC 0.9 anchor

Gain of additional UIP modes and BIP modes for **PU_8x8**
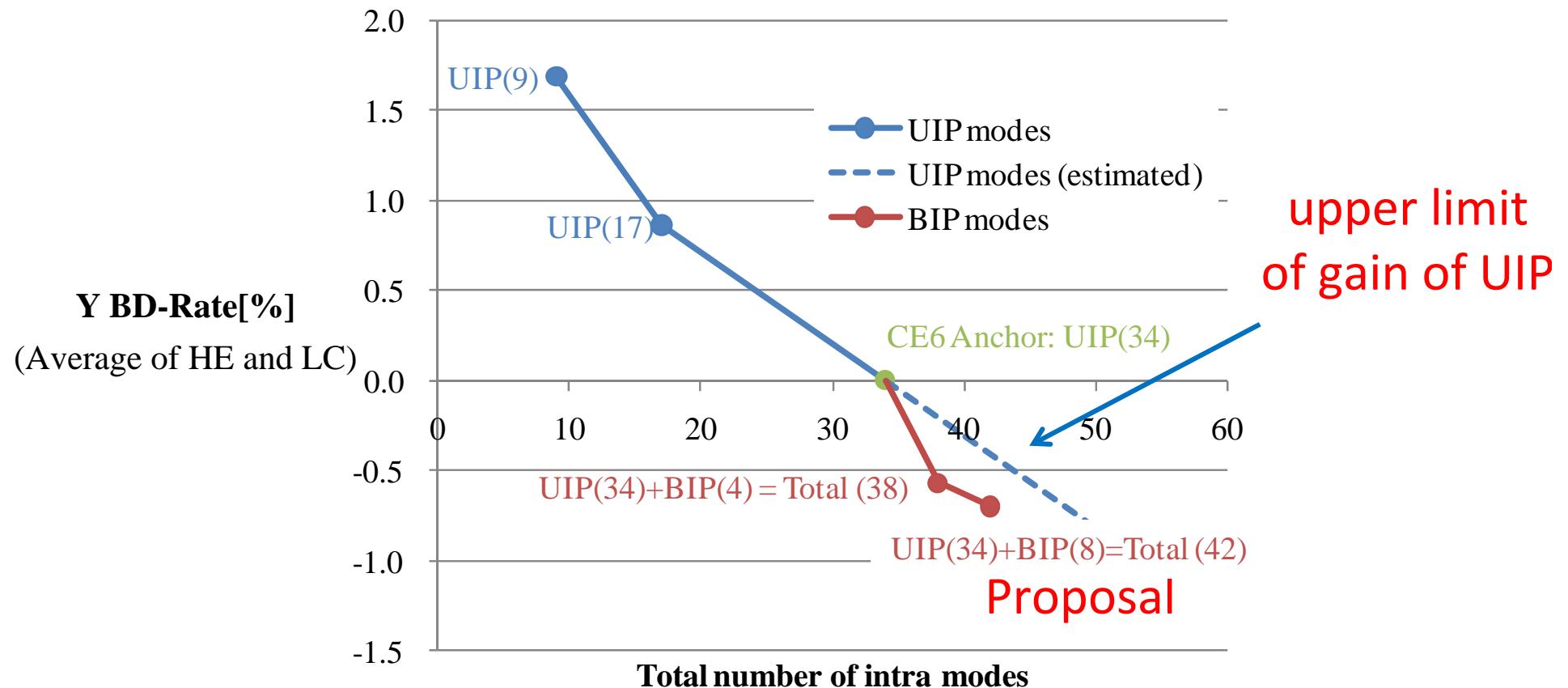
Note: The number of prediction modes for PU sizes other than the target PU size is same as TMuC 0.9 anchor

# Gain of additional UIP modes and BIP modes for **PU_16x16**

- **PU_16x16**
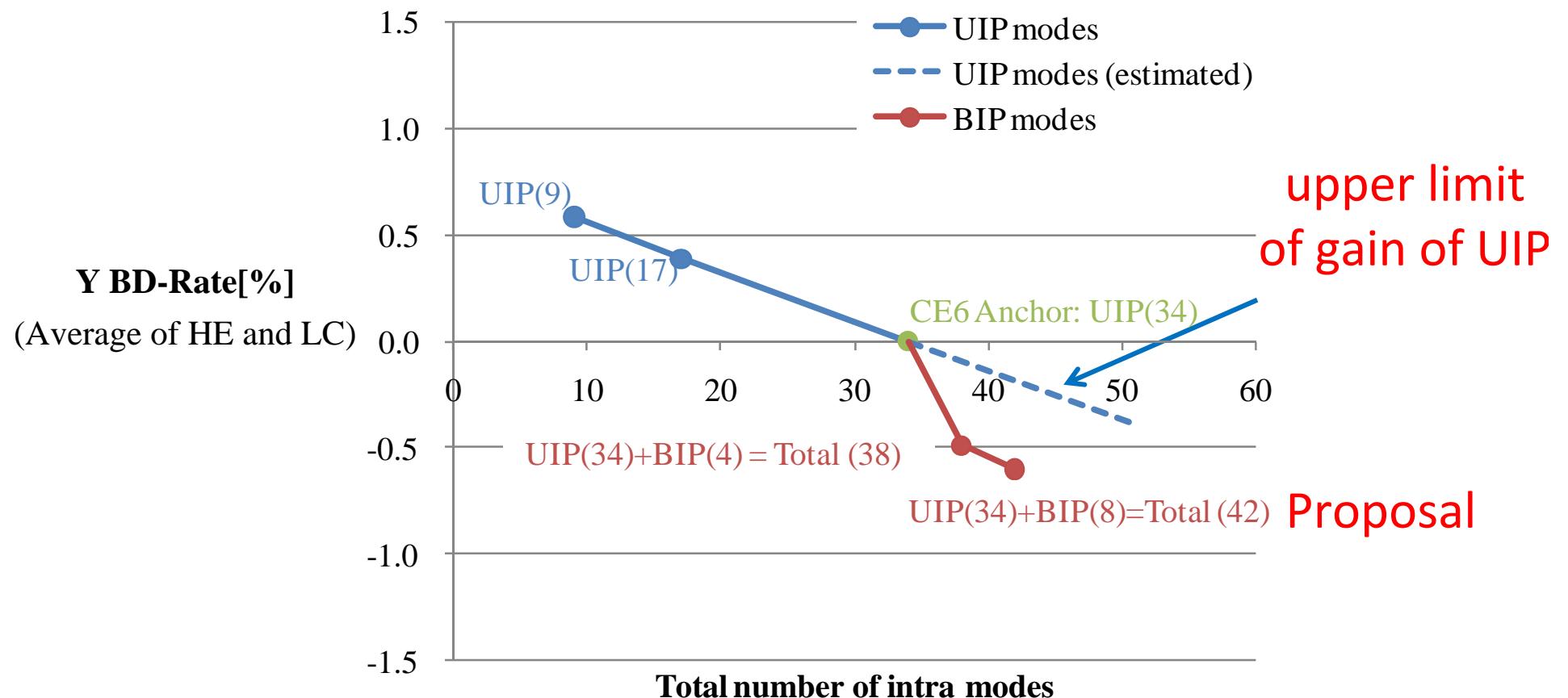
Note: The number of prediction modes for PU sizes other than the target PU size is same as TMuC 0.9 anchor

Gain of additional UIP modes and BIP modes for **PU_32x32**

- **PU_32x32**
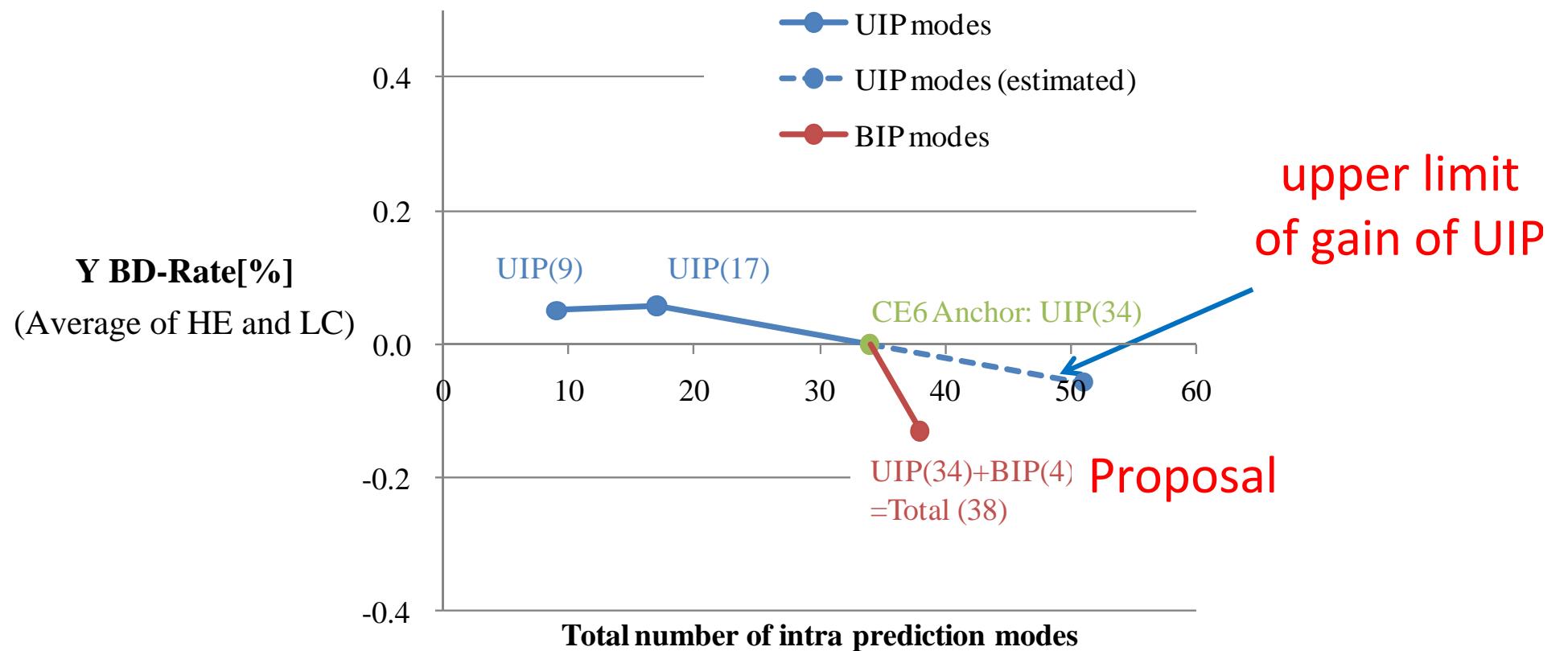
Note: The number of prediction modes for PU sizes other than the target PU size is same as TMuC 0.9 anchor

Additional results based on CE10 results

		Block size and number of modes				
		4x4	8x8	16x16	32x32	64x64
CE10	UIP	17	34	34	9	3
Proposal	UIP	17	34	34	9	3
	BIP	8	8	8	4	0

	Intra			Intra LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-1.6	-1.1	-1.2	-2.3	-1.7	-1.7
Class B	-1.6	-1.1	-1.1	-1.9	-1.5	-1.5
Class C	-1.4	-0.8	-0.7	-1.7	-1.2	-1.1
Class D	-1.1	-0.5	-0.5	-1.6	-0.9	-0.9
Class E	-1.8	-1.6	-1.2	-2.5	-2.4	-2.0
All	-1.5	-1.0	-0.9	-1.9	-1.5	-1.4
Enc Time[%]	108%			115%		
Dec Time[%]	106%			110%		

- The coding gain of BIP is 1.5% (for HE), 1.9% (for LC) on average .

Conclusion

- **Experimental results of BIP for CE6**

  - **Bitrate Reduction**
    - I-only   : 1.4% (HE), 2.0% (LC)

  - **Encoding and decoding time**
    - Not increased significantly

  - **Comparison with UIP modes**
    - The gain of additional BIP modes is higher than the one of additional UIP modes for any PU size.

- **Suggestion**

  - BIP is introduced in the HEVC test model as a tool of the coding efficiency improvement.