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Multiple Description Video Streaming Over Asymmetric Channels

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creating and sharing knowledge for telecommunications

Outline

- Introduction;
- MDSQ: Balanced and Unbalanced;
- MDC video encoder (drift compensation);
- The ρ model for MDSQ;
- U-MDC rate control for asymmetric channels;
- Simulation results;
- Conclusion.

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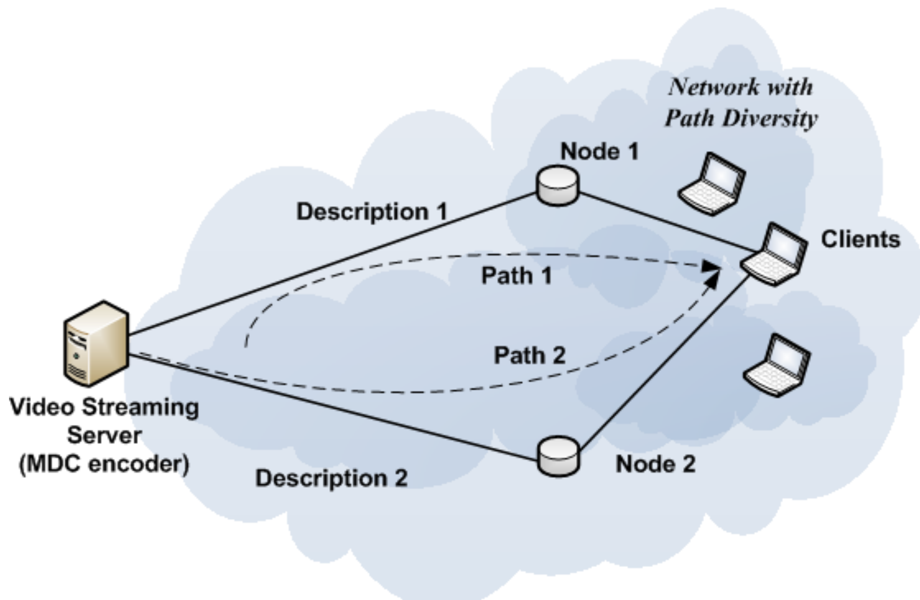
Introduction

- Current communication networks have to deal with inevitable packet loss and variable delays.
- Multiple Description Coding (MDC) has been used as an efficient approach to improve the video quality in lossy channels.
- MDC video streaming is particularly suited to networks with multiple available paths from the sender to the receiver.

MDC Context

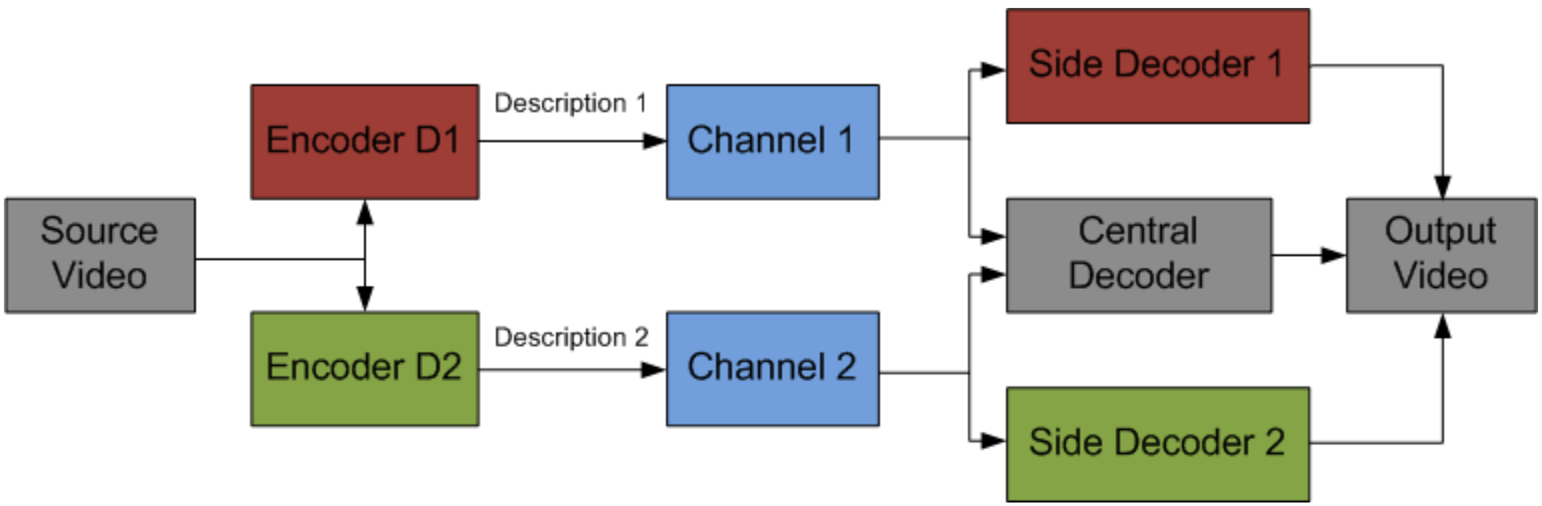
- Combination of MDC with path diversity is typically comprised of an MDC encoder, followed by multiple transmission paths to the receiver.

- MDC is robust to packet loss and/or individual channel disruption in each path → lower impact in decoded quality because of limited error propagation.



Multiple Description Coding (MDC).

- **Multiple Description Coding (MDC).**
  (a) Several descriptions (streams);
  (b) different channels;
  (c) independent decoding;
  (d) additive quality.



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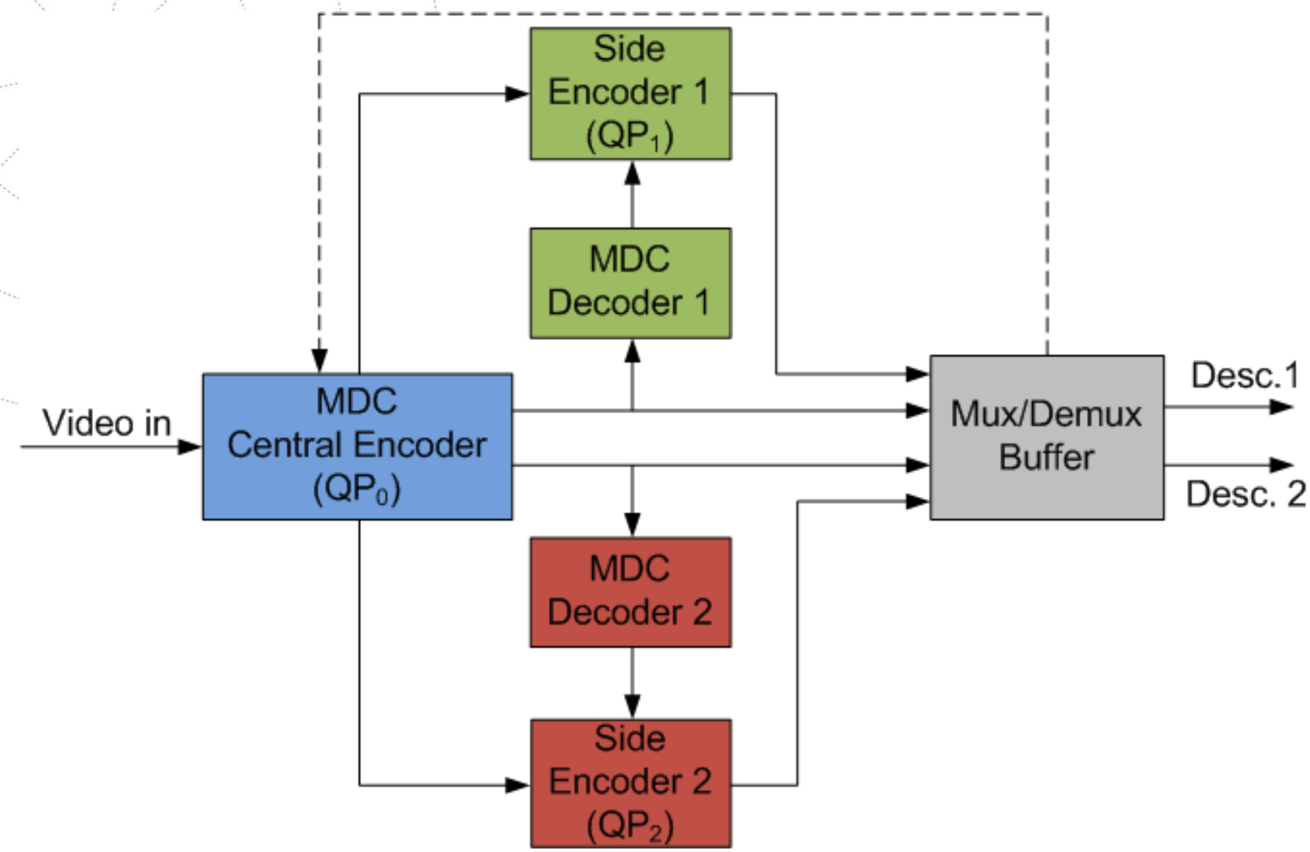
MDC with Drift Control

- Side information is used to minimize prediction mismatch at decoder.



- A single output buffer is used to accommodate for all multiplexed coded data and provide feedback information for rate control.

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Balanced Multiple Description Scalar Quantisation

- The MDSQ method is based on an index assignment operation which maps i_0 into a two dimensional coding space (i1; i2).

- The amount of redundancy is controlled by the number of diagonals of the index matrix.

i1 (Description 1) \ i2 (Description 2)	-4	-3	-2	-1	0	1	2	3	4	5
-4	-20	-16	-14							
-3	-17	-15	-12	-8						
-2	-13	-11	-10	-6	-4					
-1		-9	-7	-5	-1					
0			-3	-2	0	1	4			
1					2	5	6	8		
2					3	7	10	12	14	
3						9	11	15	16	18
4							13	17	20	...
5								19	...	...

Indices i_0

k=2

Main Diagonal

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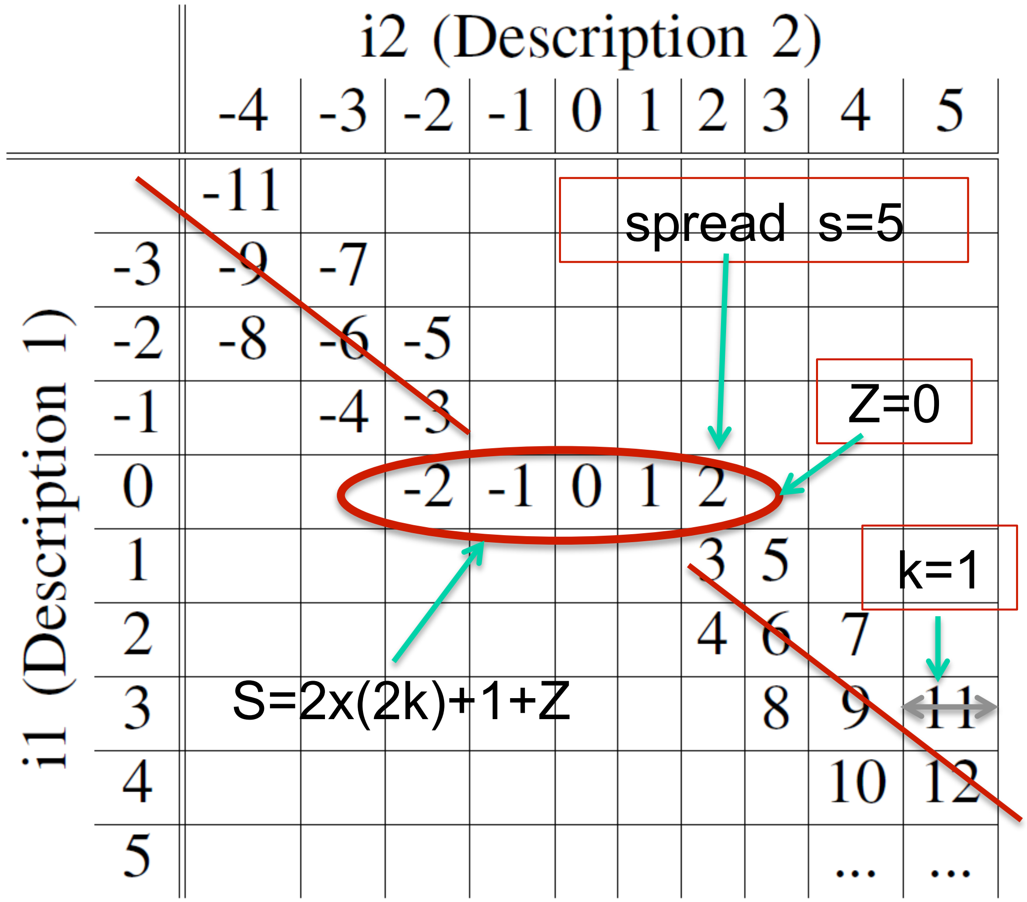
Unbalanced Multiple Description Scalar Quantisation

- The index assignment matrix is defined by k, the central index spread variation parameter Z and the spread S.



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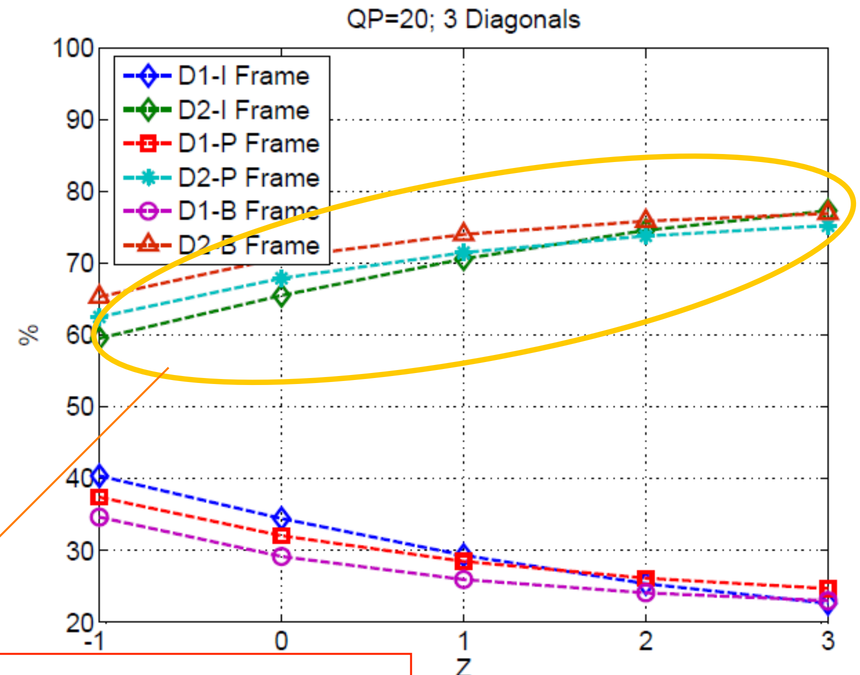
Unbalanced Multiple Description Scalar Quantisation

- The unbalanced rate percentage π1 e π2 depends on Z parameter of the index assignment table.

$$\pi_1 = \frac{R_{D1}}{R_{D1} + R_{D2}} \times 100$$

$$\pi_2 = \frac{R_{D2}}{R_{D1} + R_{D2}} \times 100$$



- A linear model relates π1 and π2 with Z:

$$\begin{cases} \pi_1(Z,t) = m_t Z + b_t, \quad -1 \leq Z \leq 3, \ t = I, P, B \\ \pi_2(Z,t) = 100 - \pi_1(Z,t) \end{cases}$$

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Rate control for U-MDC

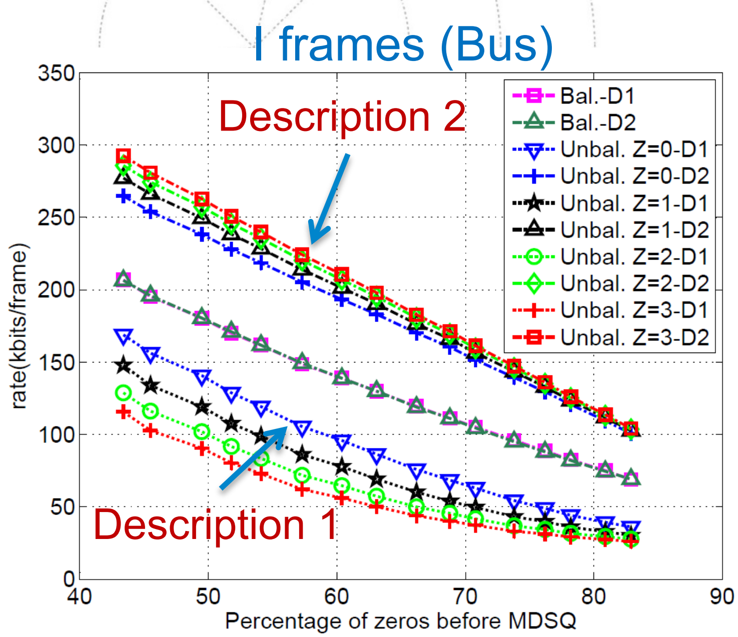
- The ρ model was extensively studied in Single Description Coding (SDC).

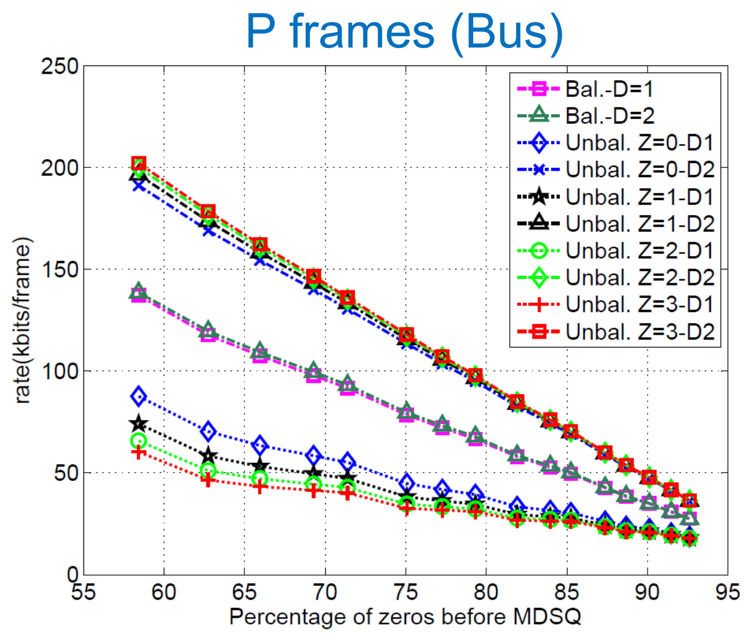
$$R(\rho) = \phi(1 - \rho)$$

- Hypothesis:

If a linear relation does not change with MDSQ, then the ρ model can be used in rate control functions for MDSQ video coding.

Rate control for U-MDC





Linear relation between the percentage of zeros before MDSQ and the rate of each individual description is maintained.

Rate control for U-MDC

1. Initialisation

- Set overall coding rate (both descriptions)
- Set buffer size
- Set default index assignment matrix

2. GOP Level

- Compute the GOP rate budget
- Set the unbalanced rate percentage

2.1 Frame

I frames

- Determine QP0 based on previous GOP;
- Set initial index assignment matrix.

P frames

- *if* the first P frame in the GOP *then* Set QP0 equal to the I frame;
  else
  a. Determine the frame target rate (both descriptions);
  b. For the main description:
  - Compute the target rate;
  - Compute ρ;
  - Determine the stepsize and set QP0 accordingly

B frames

- Determine QP0 from adjacent P frames;

- Encode both descriptions;
- Update buffer;
- Update ρ model parameter and index assignment matrix for next frame.

End of Frame Level

End of GOP Level

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Rate control for U-MDC

- **GOP Level**
  - Finds the rate budget in order to kept an appropriate buffer occupancy.
  - Set the unbalanced rate percentage.
- **Frame Level**
  - Determines the overall target rate for each frame.
  - **I frames** - Use the average central quantisation parameter QP0 used on previous GOP.
  - **B frames** - the QP0 is obtained from interpolation of neighboring anchor frames (I and P).

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Rate control for U-MDC

Frame Level

P frames: the QP0 values are obtained in two steps.

1) Target bit rate for each frame, which will be distributed among descriptions.

$$\begin{cases} T_i(j)_1 = T_i(j) * \pi_1 \\ T_i(j)_2 = T_i(j) * \pi_2 \end{cases}$$

2) Finds the QP0 for achieving the target rate of the main description.
   - The model parameter is computed as: $\phi_i = R_{i-1}/(1-\rho_{i-1})$
   - The step size δ is determined according to the percentage of zeros ρ required to produce the target rate.
   - QP0 is determined with: $QP_0 = 6 \times log_2(\frac{3\delta}{2}), 0 \leq QP_0 \leq 51.$

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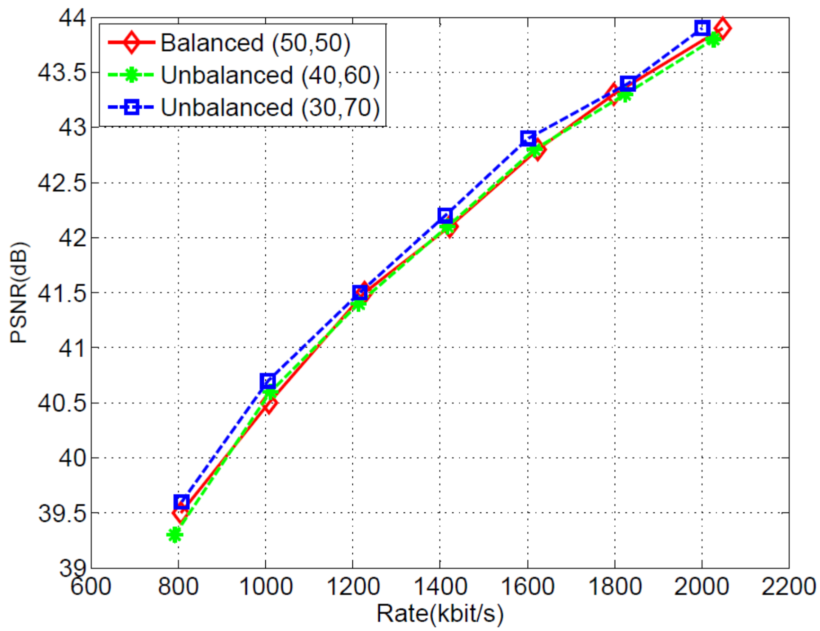
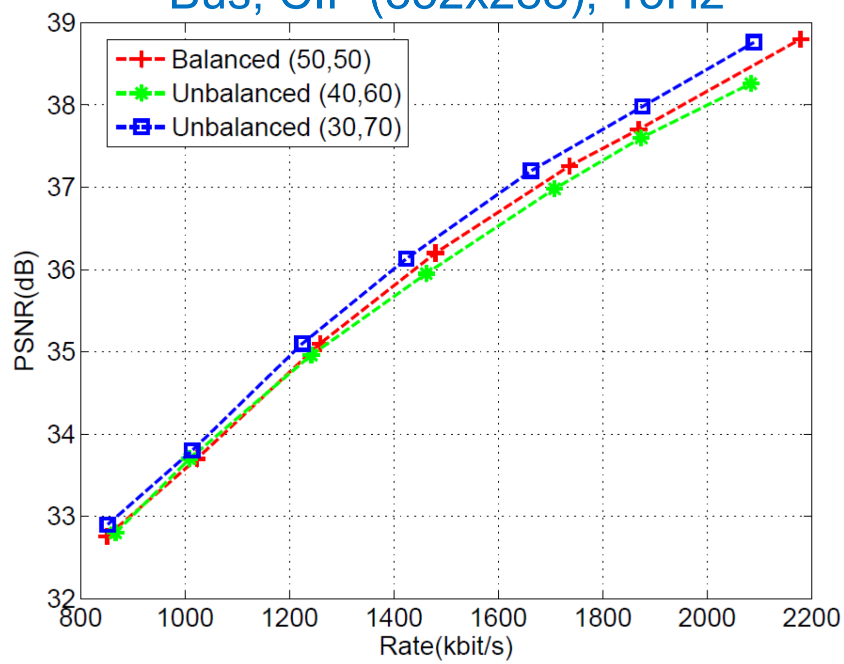
Rate control for U-MDC: R-D Performance





- The overall R-D efficiency is very close to that of balanced MDC.
- For higher rates and higher unbalanced rate percentages, the R-D efficiency of unbalanced MDC tends to outperform balanced MDC.

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Rate control for U-MDC: Accuracy

- Target deviation is around (1-6)%

806 kbit/s

792 kbit/s

808 kbit/s

RATE CONTROL ACCURACY

Seq.	Target Rate (kbit/s)	Target Bal. (π_1,π_2)=(50,50)			Target Bal. (π_1,π_2)=(40,60)			Target Bal. (π_1,π_2)=(30,70)		
		R_{D1} (kbit/s)	R_{D2} (kbit/s)	(π_1,π_2)	R_{D1} (kbit/s)	R_{D2} (kbit/s)	(π_1,π_2)	R_{D1} (kbit/s)	R_{D2} (kbit/s)	(π_1,π_2)
Foreman	800	399	407	(49,51)	303	489	(38,62)	275	533	(34,66)
	1000	501	507	(50,50)	381	630	(38,62)	328	678	(33,67)
	1200	608	619	(50,50)	447	766	(37,63)	379	837	(31,69)
	1400	704	718	(49,51)	514	903	(36,64	435	977	(31,69)
	1600	804	820	(49,51)	579	1037	(36,64)	482	1120	(30,70)
	1800	890	908	(49,51)	645	1179	(35,65)	535	1296	(29,71)
	2000	1014	1034	(49,51)	714	1313	(35,65)	565	1436	(29,71)
Bus	800	427	424	(50,50)	326	541	(38,62)	274	578	(32,68)
	1000	525	529	(50,50)	391	657	(37,63)	320	706	(31,69)
	1200	637	642	(50,50)	470	800	(37,63)	371	874	(30,70)
	1400	754	762	(50,50)	558	953	(37,63)	424	1043	(29,71
	1600	833	842	(50,50)	609	1049	(37,63)	456	1162	(28,72)
	1800	962	972	(50,50)	679	1171	(37,63)	517	1365	(27,73)
	2000	1045	1056	(50,50)	782	1334	(37,63)	565	1476	(28,72)

MDC Streaming over asymmetric channels

Channel Conditions

- Two transmission scenarios are considered:
  - i) channels with the same PLR;
  - ii) channels with different PLR.
- Channel bandwidth:
  - i) Path 1: 600 kbps; Path 2: 600 kbps;
  - ii) Path 1: 480 kbps; Path 2: 720 kbps;
  - iii) Path 1: 360 kbps; Path 2: 840 kbps;
- Average PLR between 0% and 10% (Gilbert-Elliott 2-state model).
- Average burst length of 4 packets.
- Simulated 50 times under the same network conditions.

MDC Streaming over asymmetric channels

MDC Setup

- The side information is coded using fixed quantisation parameters;
- 20% of side redundancy distributed by each description;
- Both balanced and unbalanced case use the same amount of redundancy;
- Used 10 packet per frame;

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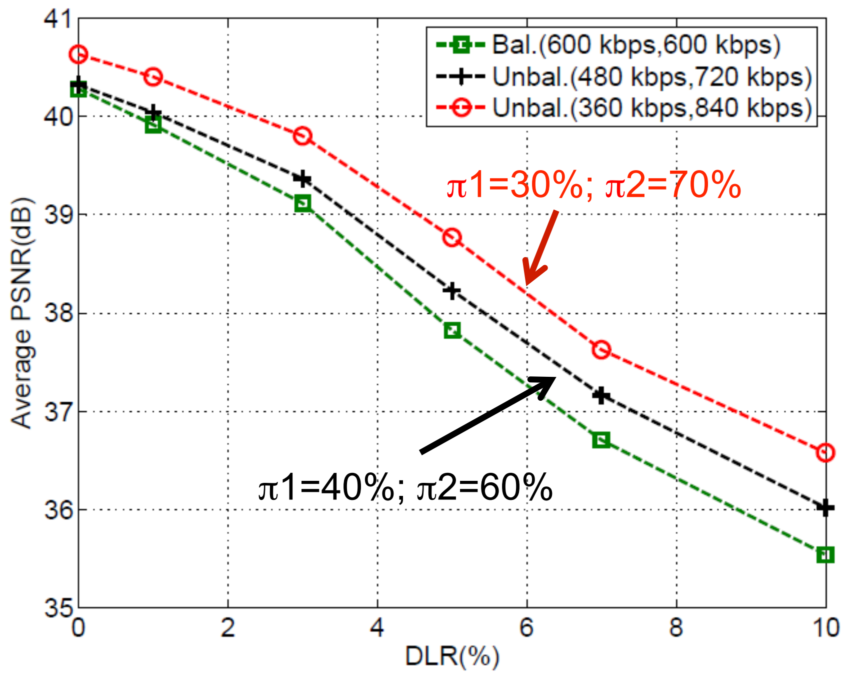
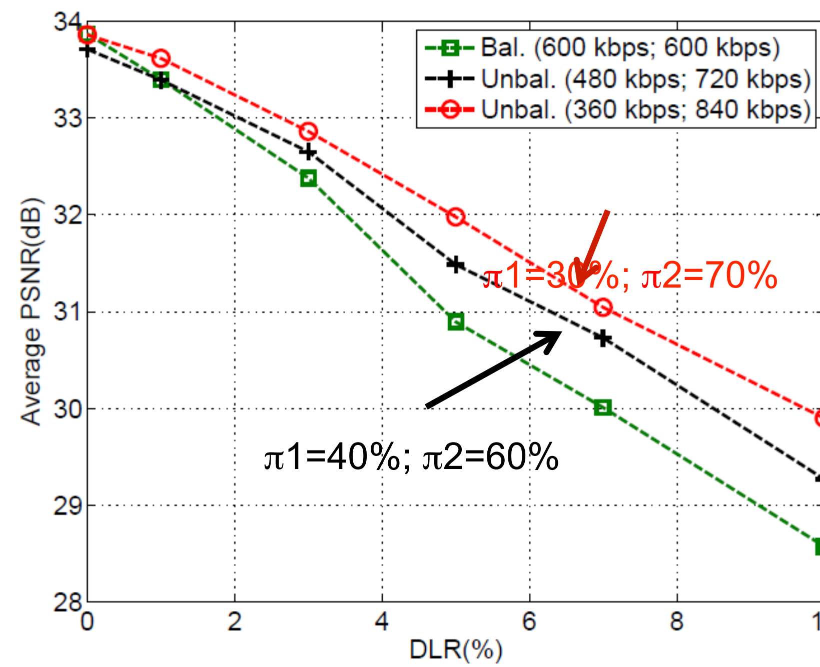
MDC Streaming over asymmetric channels

- **Channels with the same packet loss ratio**

Foreman, CIF(352x288),15Hz



Bus, CIF (352x288), 15Hz



- The performance is evaluated in function of the total data loss percentage (DLR) in both descriptions, i.e.,

$$DLR(\%) = (1 - Rx\_rate/Tx\_rate) \times 100\%.$$

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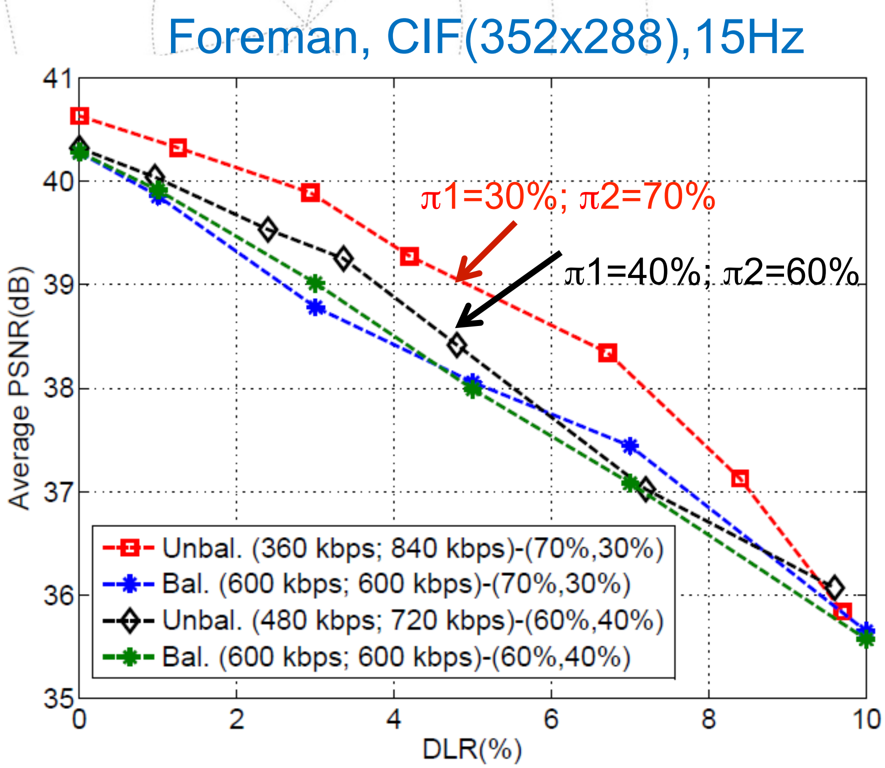
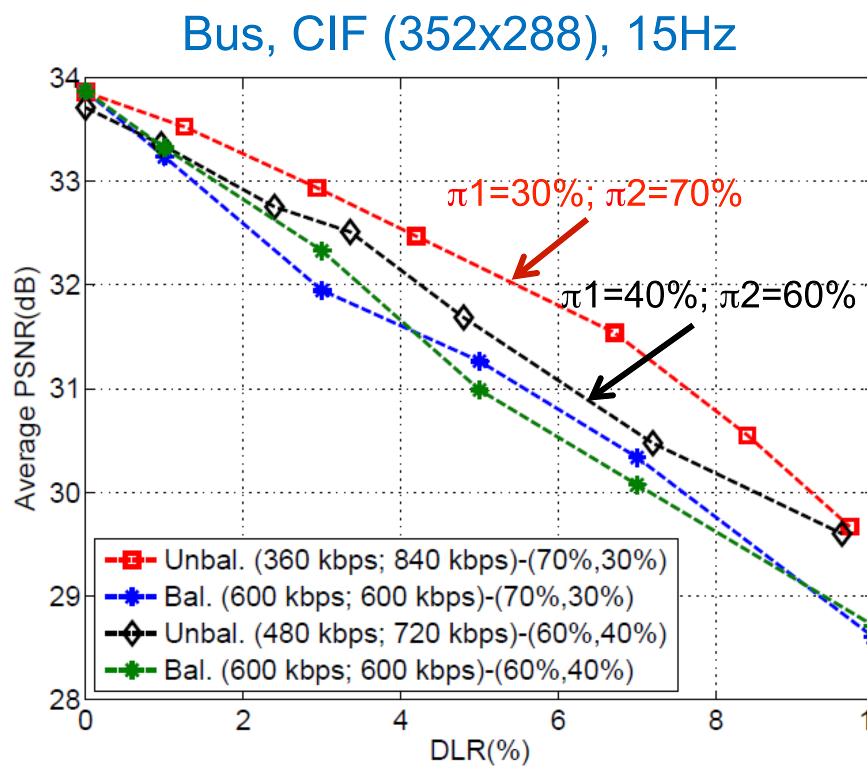
MDC Streaming over asymmetric channels

- **Channels with the different packet loss ratio**





- The DLR is the same in each corresponding description – (70%, 30%) and (60%,40%).

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Conclusions

- A new U-MDC method for asymmetric channel bandwidths was proposed;
- R-D performance of U-MDC similar to MDC;
- Improved performance over lossy channels with asymmetric bandwidths and PLR;
- Possible extension to more sophisticated multipath networking scenarios with multiple video streams transmitted through different channels with independent constraints (e.g. wireless, P2P,etc.).

THANK YOU !

Questions ?

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