# Rate-control algorithms testing by using video source model

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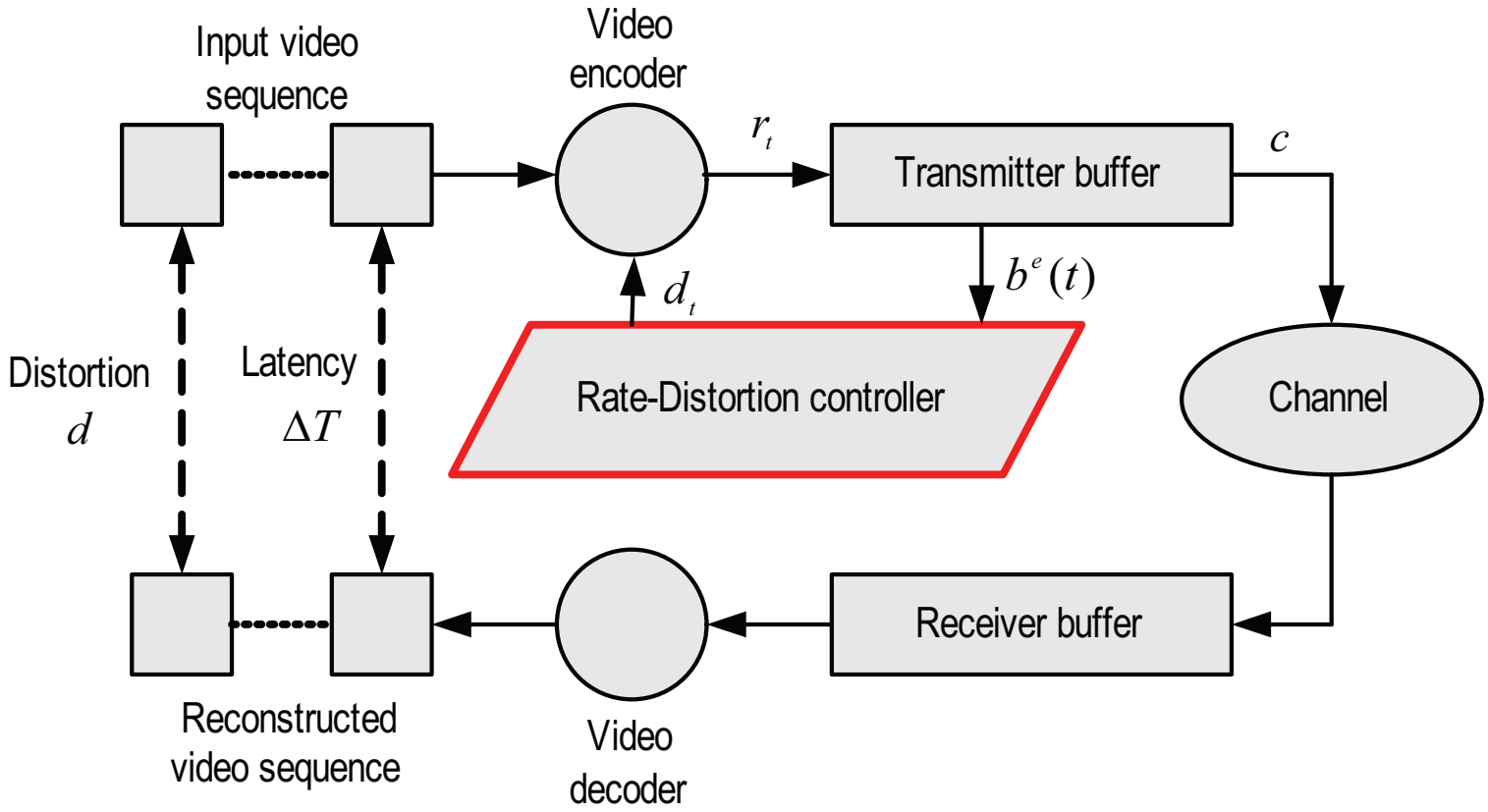
# Real-time video compression and transmission system




$$b^e(t) = \max\{0, b^e(t-1) - c\} + r_t. \quad (1)$$

# Real-time video compression and transmission system

Disadvantages of the traditional testing of rate-control algorithms:

- Long time for testing
- Short length of video sequence
- Small set of test video sequences

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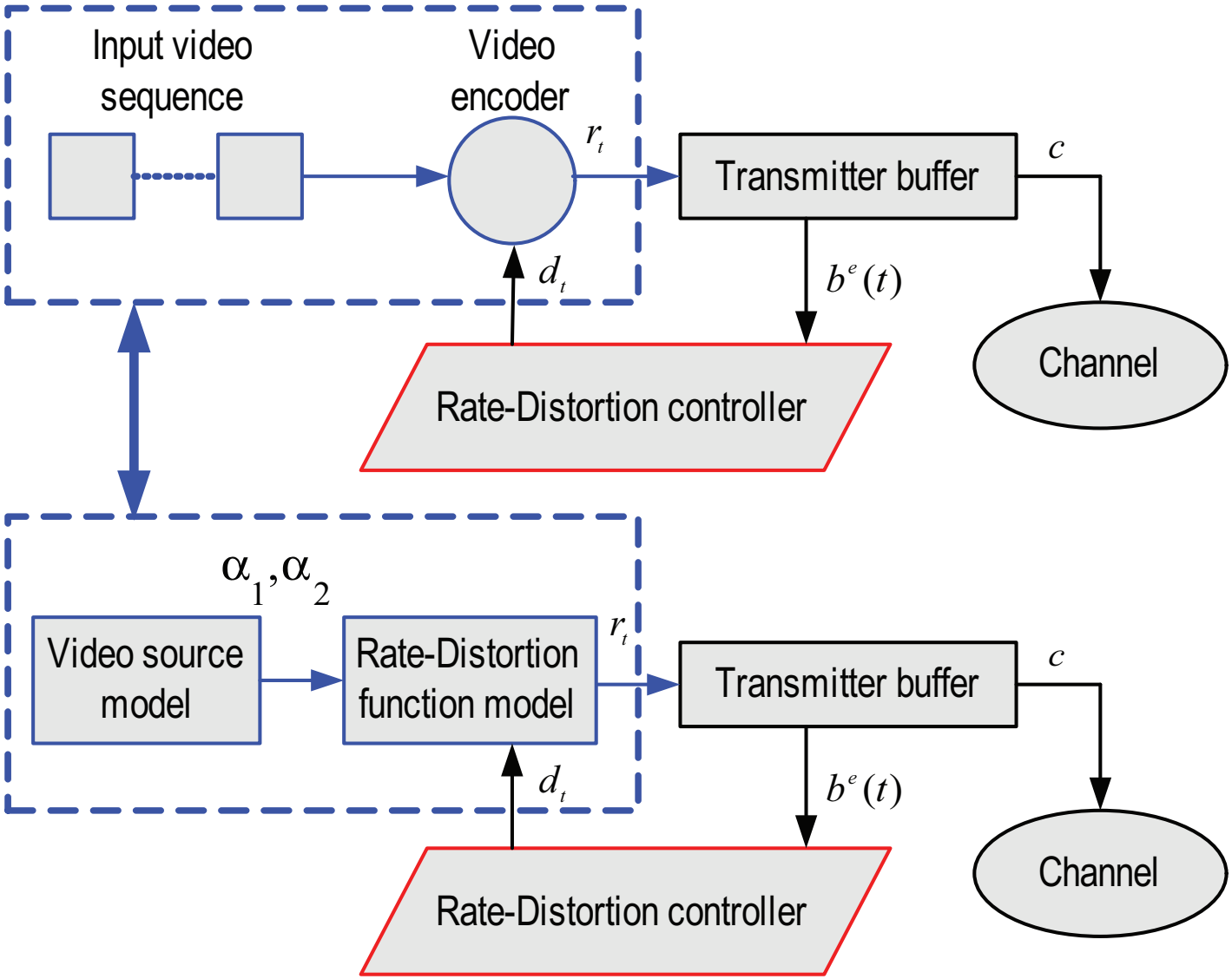

# Video source model description

Model assumptions:

- **Encoder memory restriction**
  - the whole memory of the encoder is much smaller than the number of bits for one frame of video sequence
  - only intra-encoder is valid (without motion-compensation)
  - input video frame is divided into a lot of tiles
- **Three probable tile types** (three source states $s \in \{1, 2, 3\}$)
  - tile with computer graphic ($s = 1$)
  - tile of mixed type ($s = 2$)
  - natural (photographic) tile ($s = 3$)
- **Two-parametric $(\alpha_1, \alpha_2)$ rate-distortion function model**
- **Encoder is the function** of the distortion $d$, rate $r$ and $(\alpha_1, \alpha_2)$
  - $r = f(d, \alpha_1, \alpha_2)$
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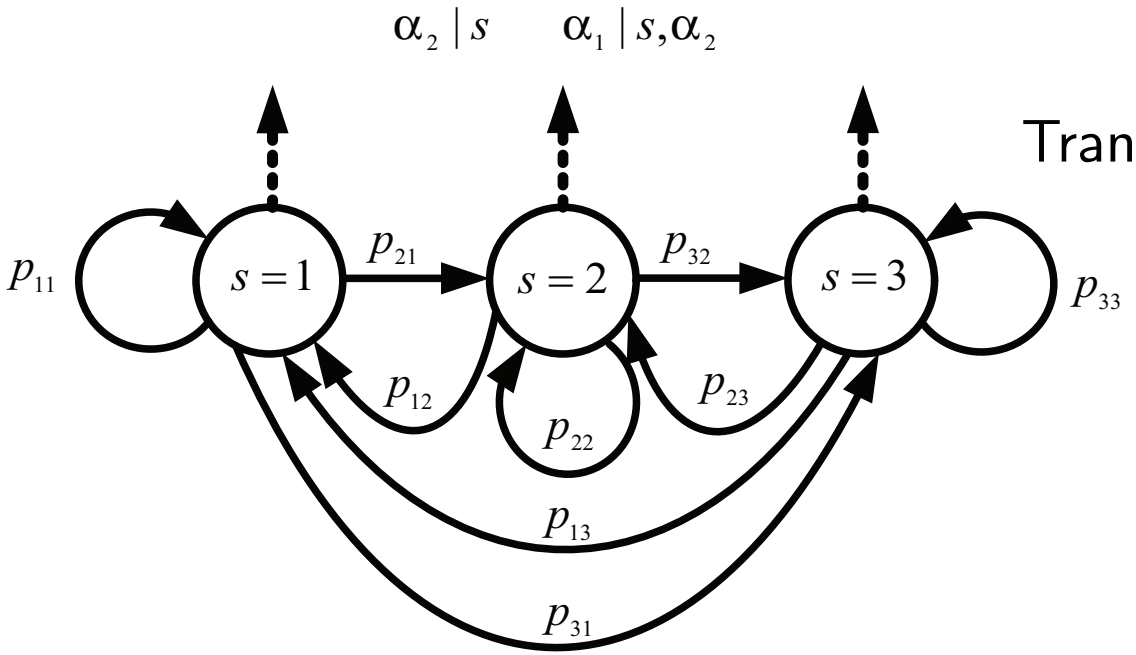
# Video source model construction

## Source state detection and transition probability matrix calculation




Transition probability matrix $P_s$:

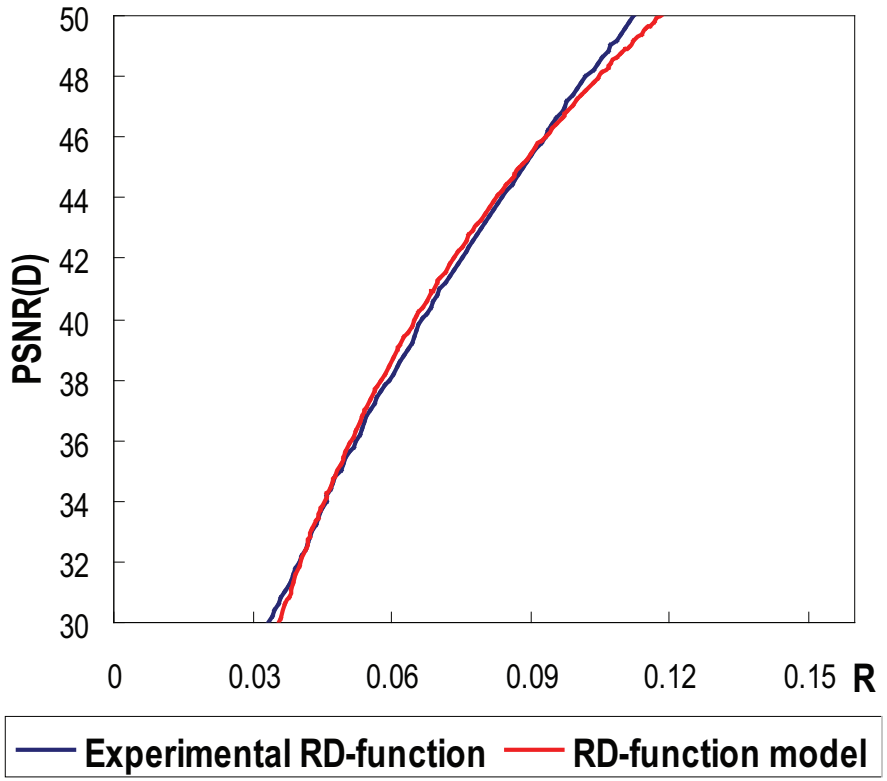
$$P_s = \begin{pmatrix} p_{11} p_{12} p_{13} \\ p_{21} p_{22} p_{23} \\ p_{31} p_{32} p_{33} \end{pmatrix}$$

For classification of image tile types it is proposed to use lossless tile compression with different number of wavelet decomposition levels[1].

[1] R. R. Coifman and M. V. Wickerhauser, "Entropy-based algorithms for best basis selection", *IEEE Transactions on Information Theory*, vol. 38, pp. 713–718, 1992.

# Video source model construction

## Calculation of parameters $(\alpha_1, \alpha_2)$ of rate-distortion function model




It is proposed to use the follow rate-distortion function model[2]

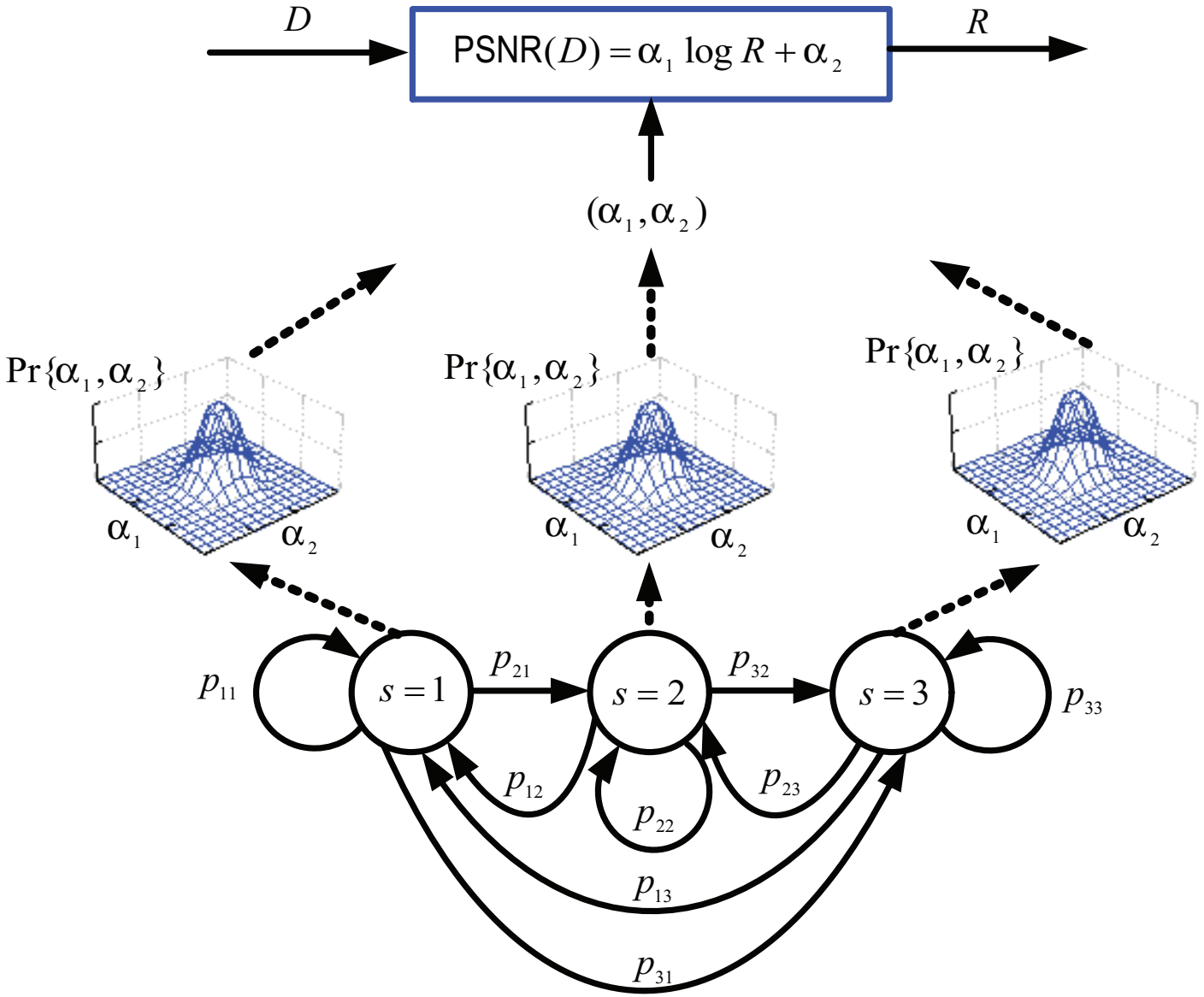
$$\mathtt{PSNR}(D) = \alpha_1 \cdot \log R + \alpha_2.$$

To define parameters $\alpha_1$ and $\alpha_2$ for each image tile:

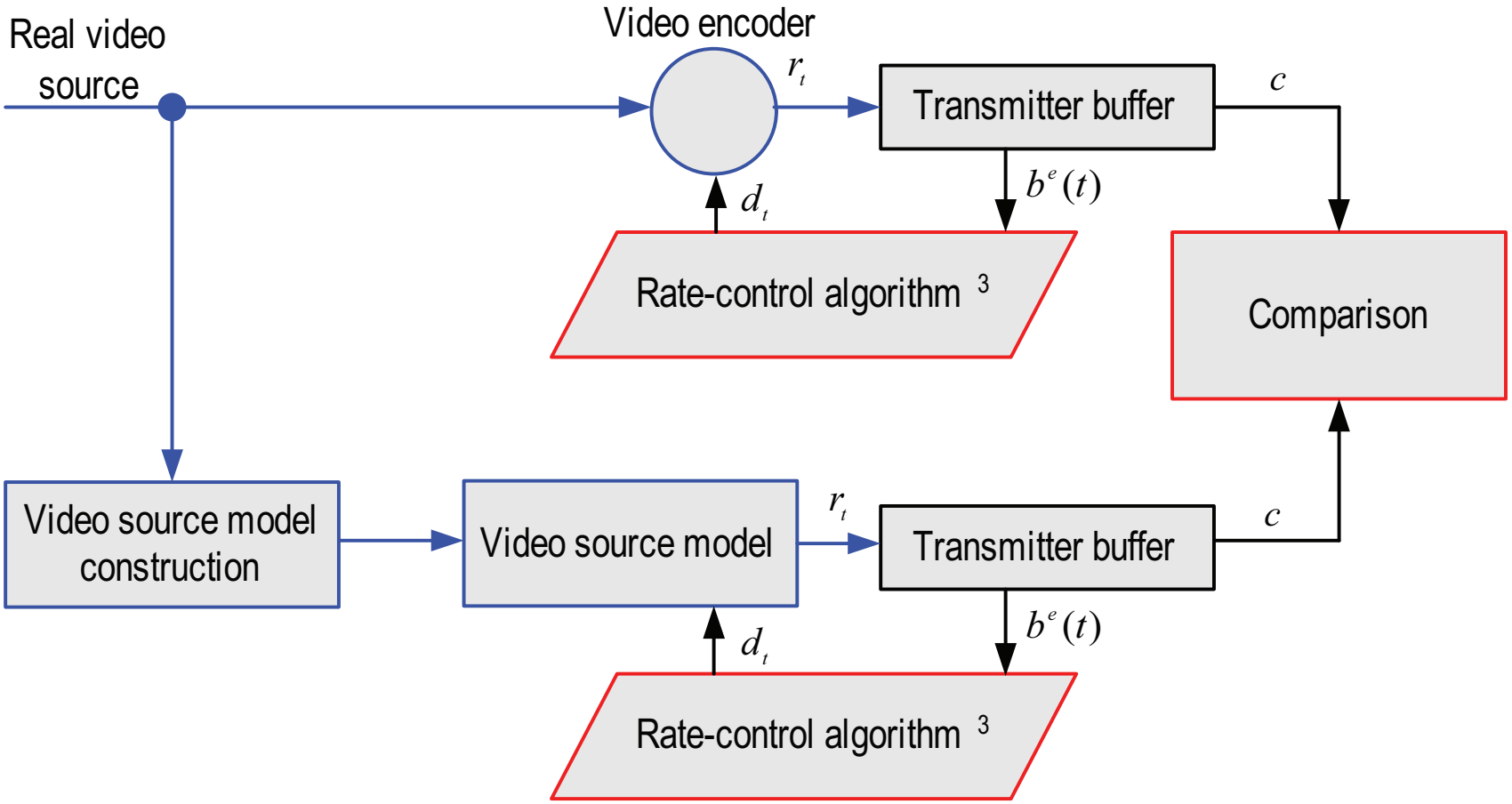
- experimentally rate-distortion function is calculated
- technique of least squares is used to define the model parameters $(\alpha_1, \alpha_2)$.

[2] M. Dai, D. Loguinov, H. Radha, "Rate-distortion modeling of scalable video coders", *International Conference on Image Processing*, vol. 2, pp. 1093–1096, 2004

# Video source model scheme



# Video source model checking by using rate-distortion control algorithm[3]




[3] E. Belyaev, A. Turlikov and A. Ukhanova, "Rate-distortion control in wavelet-based video compression systems with memory restriction", XI International Symposium on Problems of Redundancy in Information and Control Systems, Russia, 2007.

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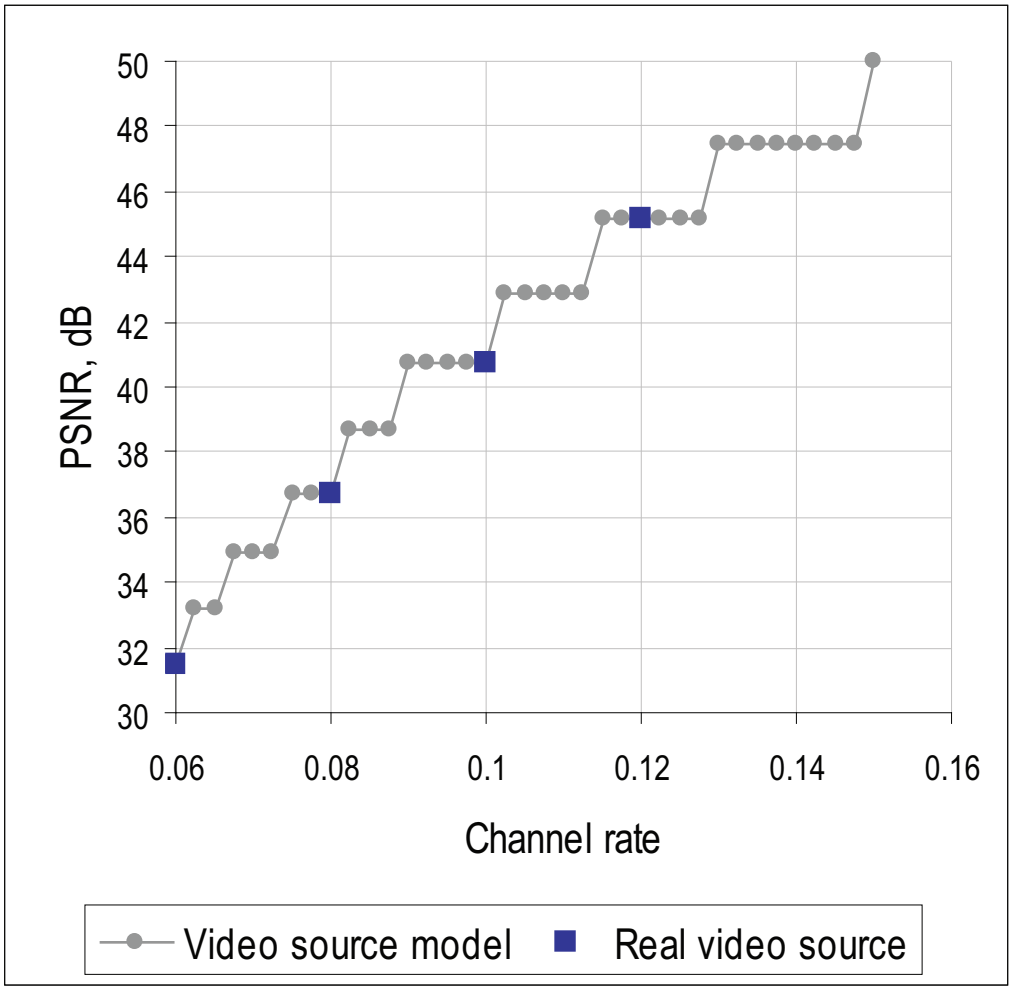


Figure shows PSNR dependence for frame from channel rate for real and modulated data with the fixed transmitter buffer size.

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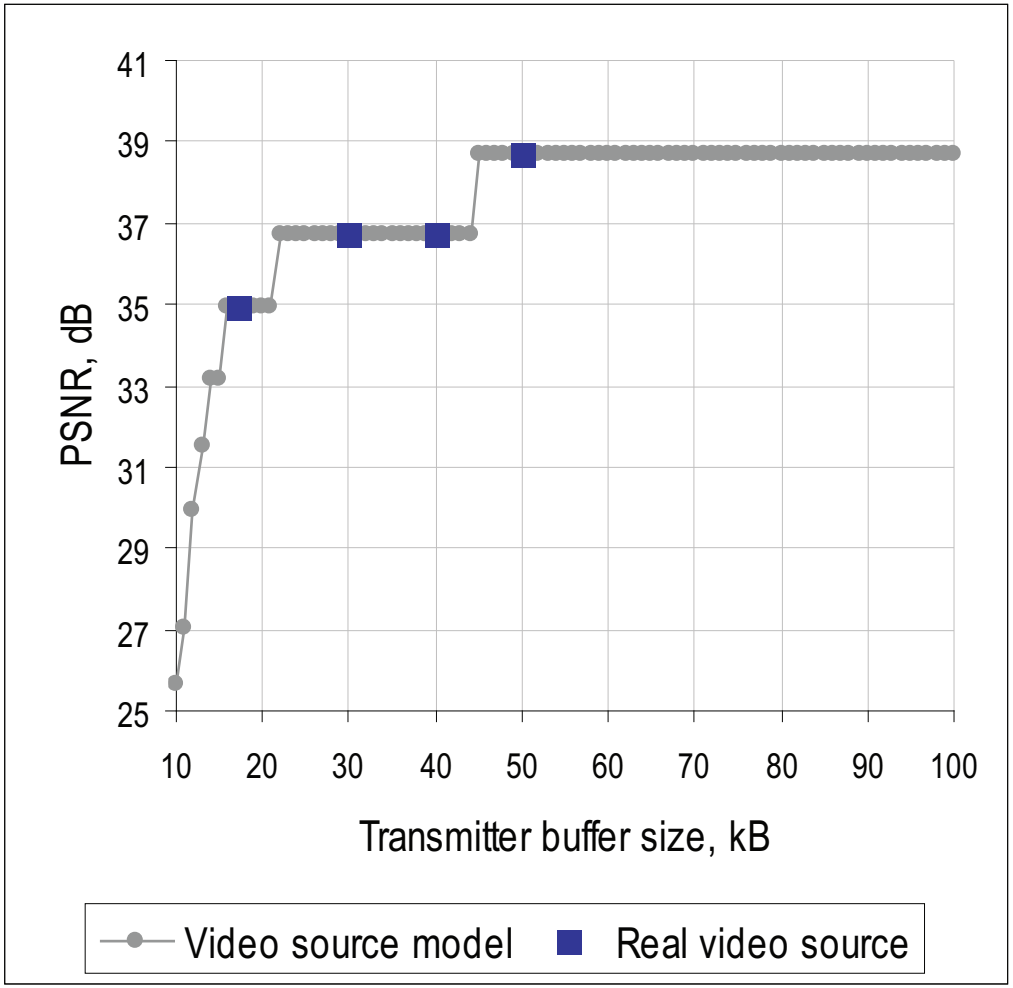


Figure shows PSNR dependence for frame from transmitter buffer size for real and modulated data for the fixed channel rate.

# Conclusions

Advantages of the proposed rate-control testing scheme:

- Suitable video source model is proposed
- Testing time is significantly less than in traditional scheme
- Testing could be done over the big video sequence data
- It is possible to construct wide set of test data

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