



Real-time multicast p2p video streaming architecture based on scalable multiple descriptions

Alfio Lombardo, Diego Reforgiato, Giovanni Schembra
Università degli studi di Catania
Catania, Italy



Lorenzo Favalli, Marco Folli
Università degli studi di Pavia
Pavia, Italy

Outline

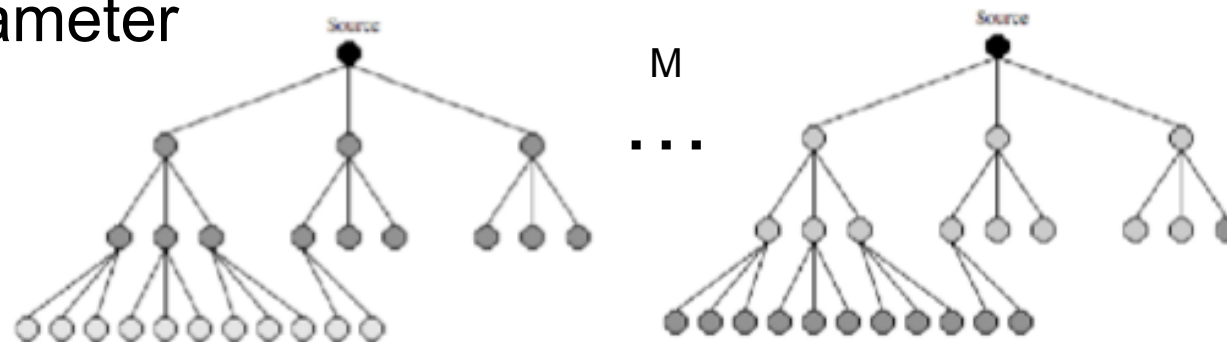


- System description
- Part 1: network construction and management
 - Tree construction algorithm
 - Temporal analysis of the protocol behaviour
- Part 2: Video coder structure
 - H.264/SVC
 - MDC
- Case study

System description



- Live broadcast platform. CIF video subsampled in 4 QCIF
- Video source distributes video stream to peers in multipoint fashion distributed in different multiple descriptions trees
- Video encoded with an H.264 multiple description encoder
- Multipoint achieved with P2P approach configuring a multiple tree-structured overlay network
- $N=85$ peers (5 classes) organized in M trees. F is the fan-out parameter

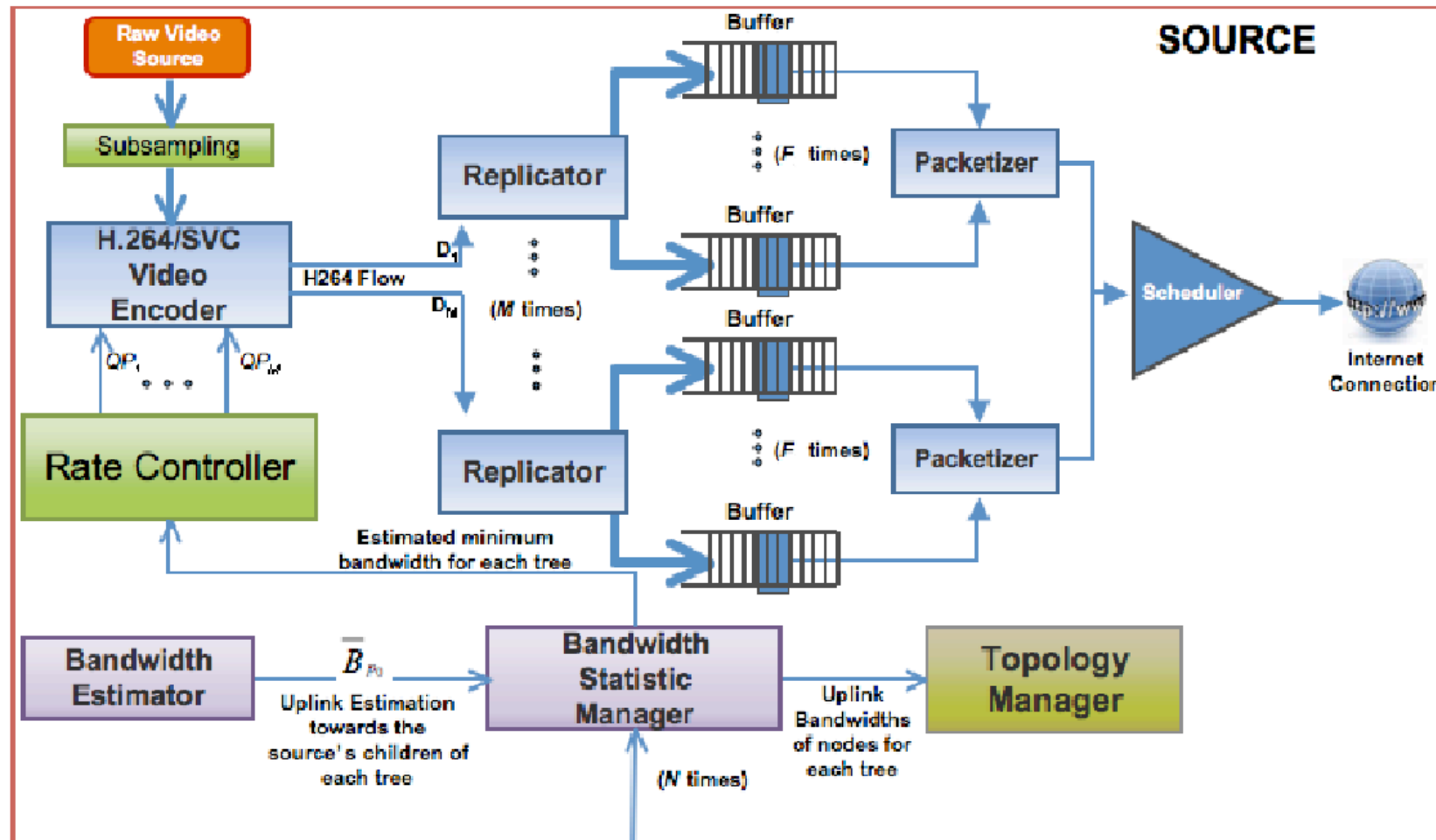


No peer churn but:



- Application is considered “stable”
- Focus on bandwidth fluctuations
- Churn handled in other multicast tree applications with local/centralized tree control at the cost of some additional signalling (CoopNet/SlitStream) or Zag+ (??)

Video source (1/2)

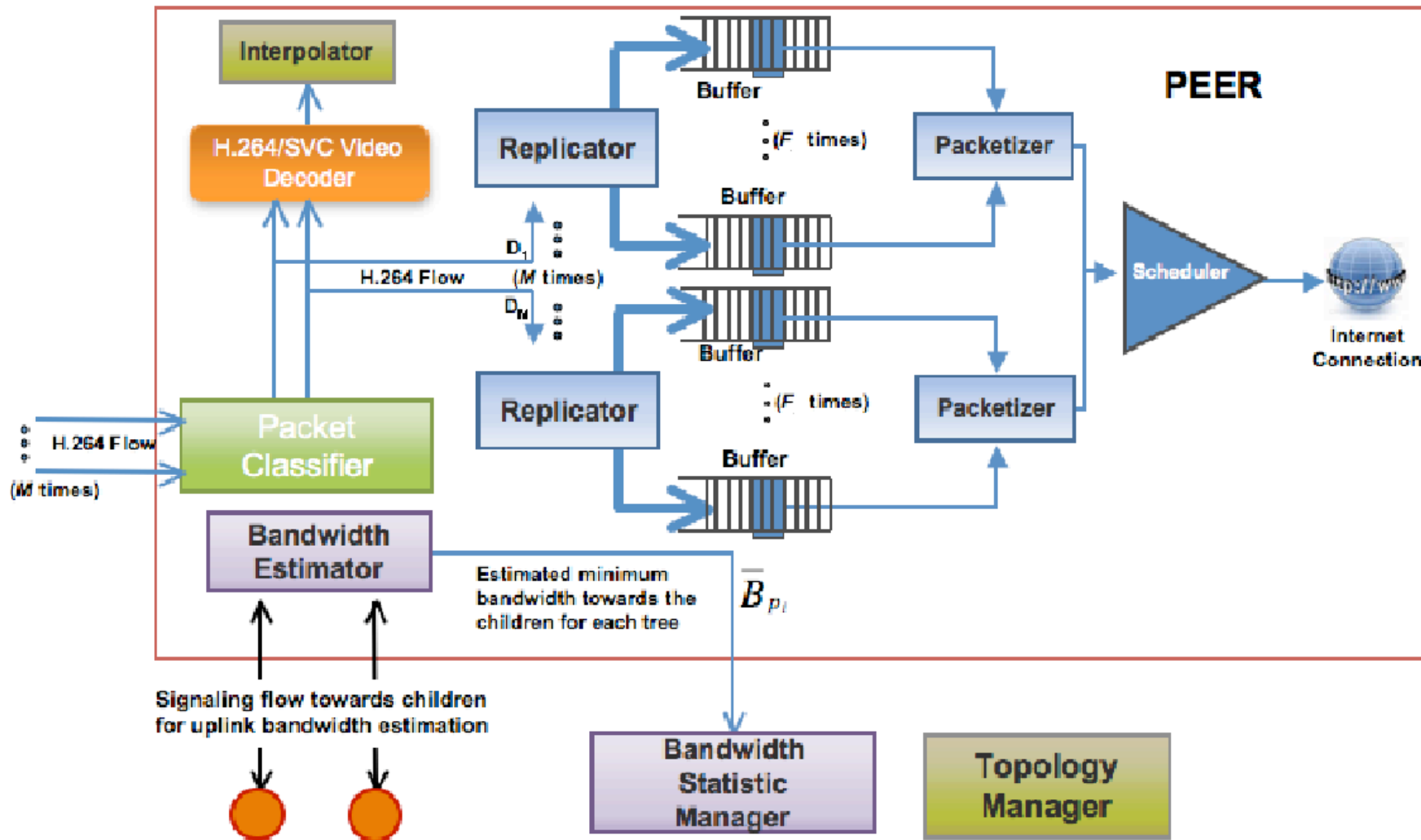


$$\bar{B}_{p_1} \dots \bar{B}_{p_N}$$

Exponentially-weighted moving average (EWMA)

$$\bar{B}_{p_i}(n) = \alpha \cdot \bar{B}_{p_i}(n-1) + (1-\alpha) \cdot B_{p_i}(n)$$

Generic peer





NETWORK CONSTRUCTION AND MANAGEMENT

Tree construction algorithm (1/2)



- N peers belonging to 5 classes and M trees
- Each peer is internal in one tree and leaf in $M-1$ trees
- Example for $M=2$. **nDST** and **nDRT** (non-distributed structured/random tree)

Main tree

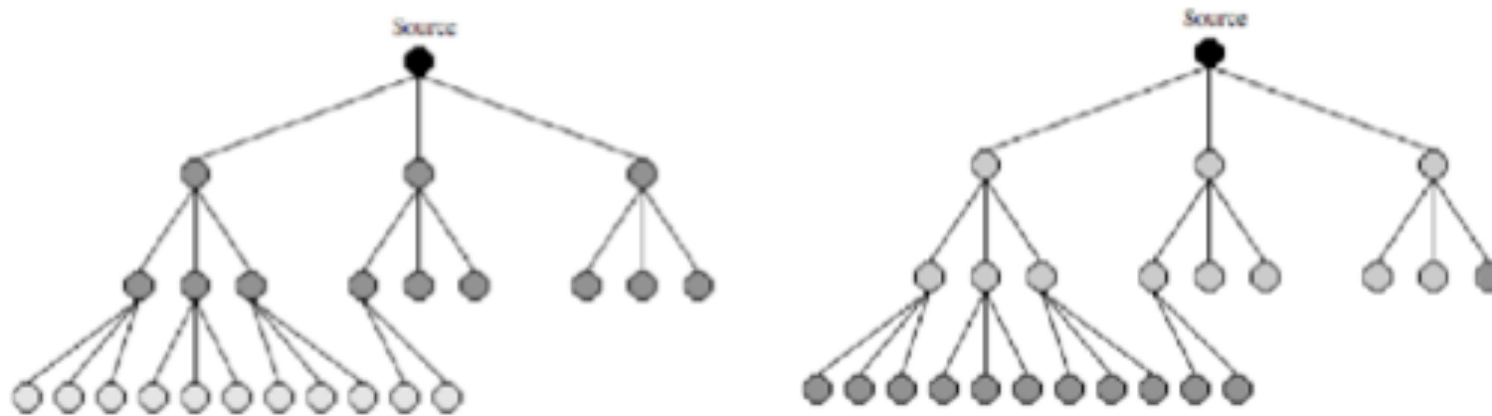
- Peers estimates uplink bandwidth towards all the others.
- Every 10 secs they send all values to Topology Manager
- Every 30 secs it chooses the F peers with highest uplink bandwidth and connects them as children of the source

Tree construction algorithm (2/2)



Secondary tree

- First, each peer leaf of the main tree is chosen and sorted in decreasing order of uplink bandwidth
- Then, they are connected in a top-down manner filling each level



$$N=24, M=2, F=3$$

Bandwidth generation process



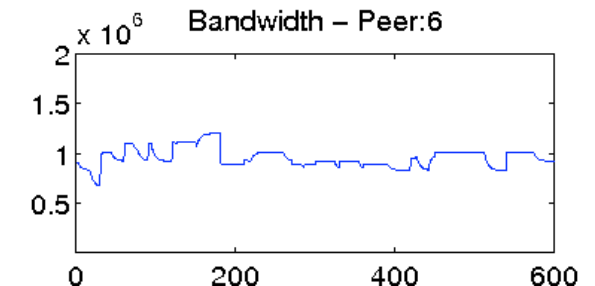
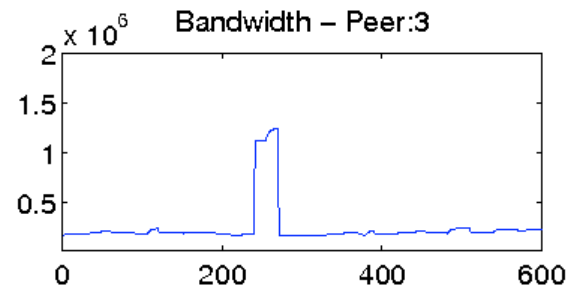
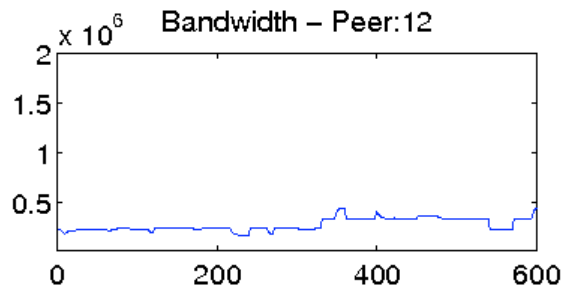
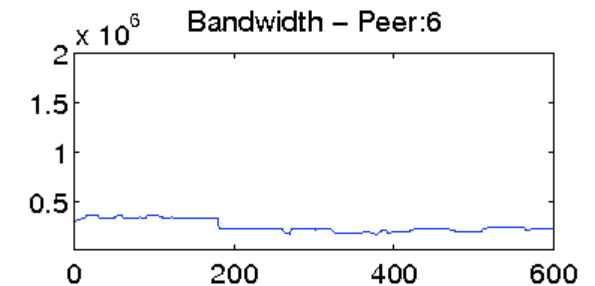
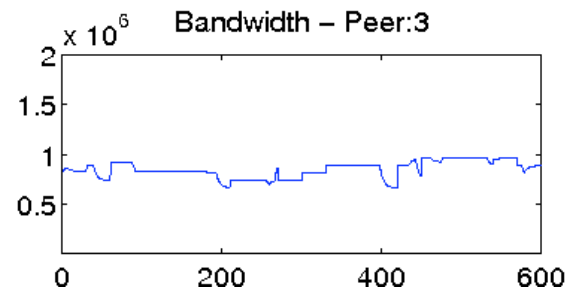
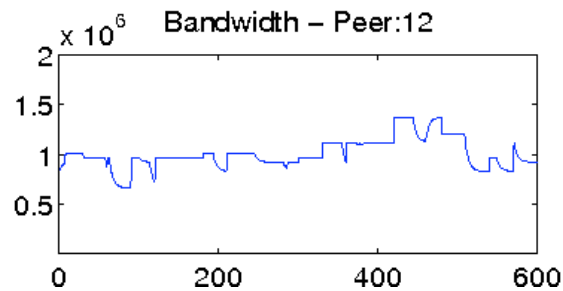
- We generate uplink bandwidth behaviour capturing first and second-order statistics for a given peer.
- We used a modified version of the Switched Batch Bernoulli Process (SBPP), the most general Markov modulated process in the discrete-time domain.
- 4 states for Markov transition matrix, 1 sec slot, 60 secs mean permanence
- Standard deviation = 2.4 secs and mean value = $[(h - (C-1)) \cdot 10\% + 1] \cdot W_{[i]}$
- EWMA control parameter = 0.8

Temporal analysis (1/3)



- nDST dataset with $F=2$ and $N=85$
- Generated trees have 6 levels where the last one contains 22 leaves

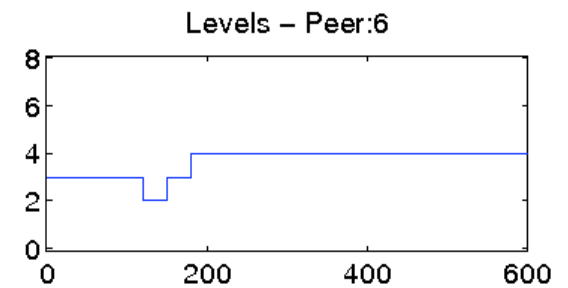
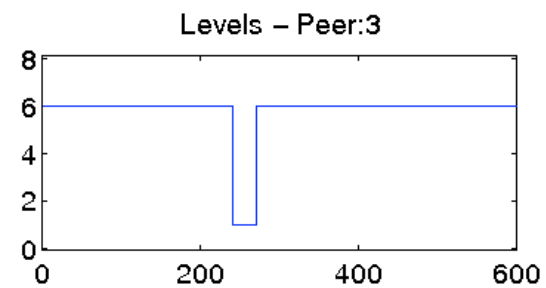
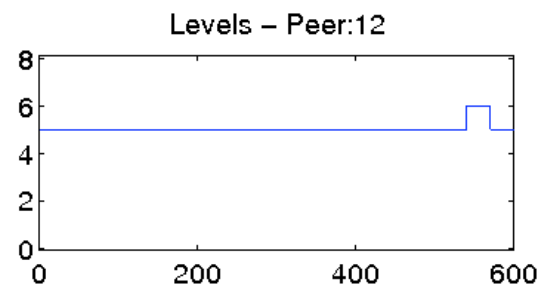
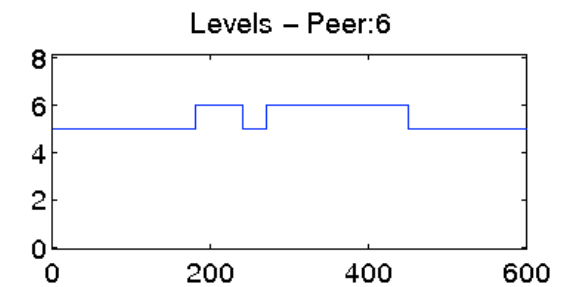
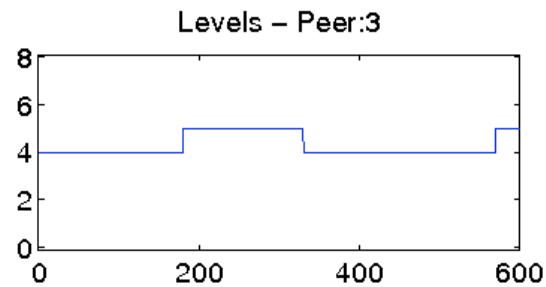
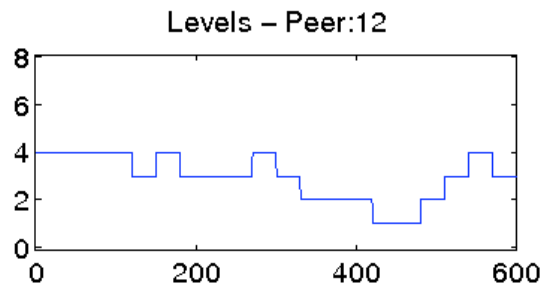
Bandwidth



Temporal analysis (2/3)



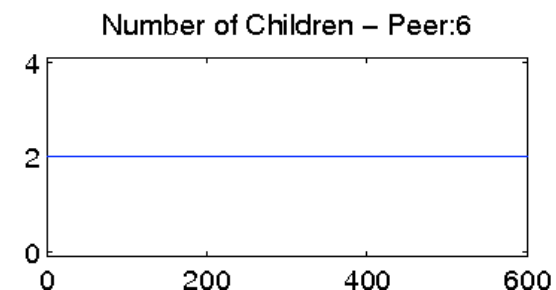
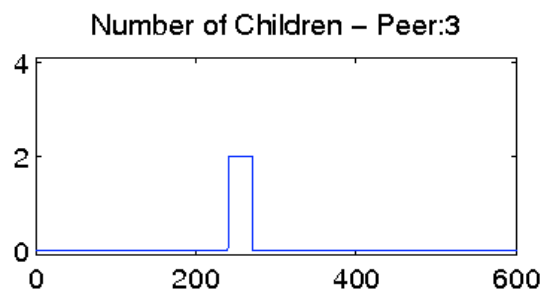
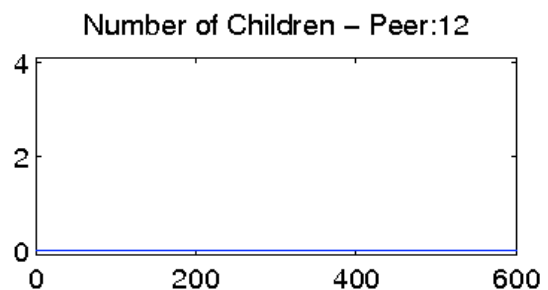
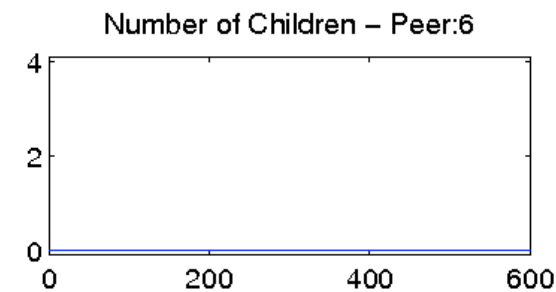
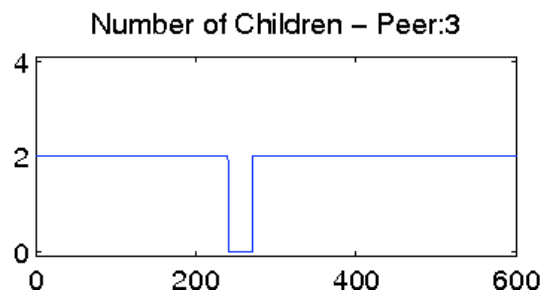
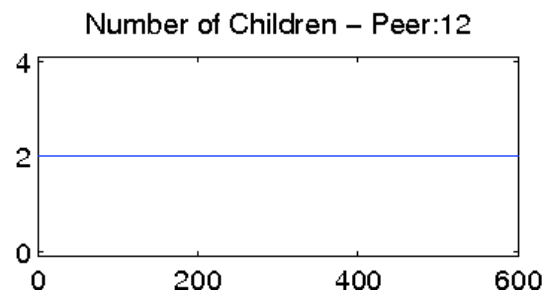
Levels



Temporal analysis (3/3)



Number of Children





VIDEO CODER STRUCTURE

H.264/SVC - ILPS



- As first interpretation, each layer can be coded independently from the others
- It is possible to exploit the redundancy by predict each layer from the lower layer
- Techniques applied
 - prediction of macroblocks
 - prediction of motion vectors
 - prediction of residual
- Provides spatial and coarse grain scalability

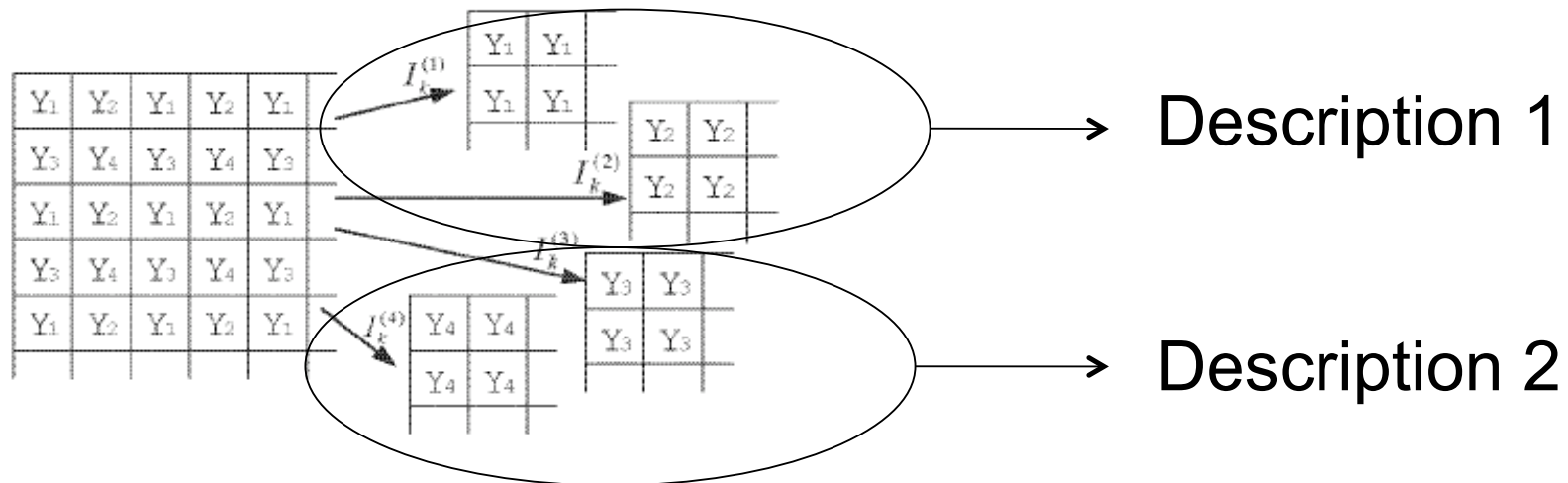
Multiple Description Coding



- From the original sequence, several subsequences are obtained in different ways
- Each independently decodable subsequence is called description
- Receiving all description, ideally recovers the sequence with original quality
- Most common multiple description algorithms
 - Spatial MDC
 - Temporal MDC
 - SNR MDC

Redundancy

- Adjacent pixels are clearly correlated
- How to reduce redundancy?
 - Differential encoding of some sub-sampled descriptions
 - Exploit some form of more complex prediction among some of the descriptions



Translated onto H.264

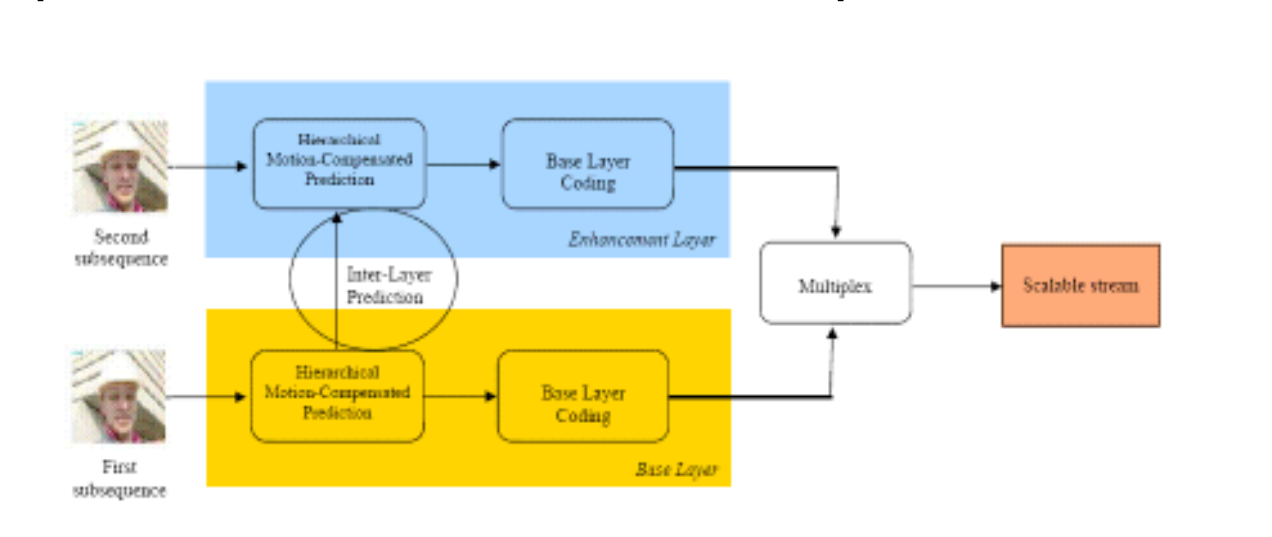


- Use scalability options of H.264/SVC
- Subsampling performed before the coder to be (almost) fully compatible
- H.264/SVC is a layered coder with several tools to remove redundancy among layers
 - Prediction of macroblocks using up-sampled lower resolution signals
 - Prediction of motion vectors using up-sampled lower resolution motion vectors
 - Prediction of residual signals using up-sampled residual signals of the lower resolution layer

ILPS – MDSC algorithm



- Start from the PSS-MD scheme
- Instead of independently code and transmit four descriptions, it couples two subsampled subsequences to form a description
- Use the ILPS to exploit the redundancy between the subsequences that form the description



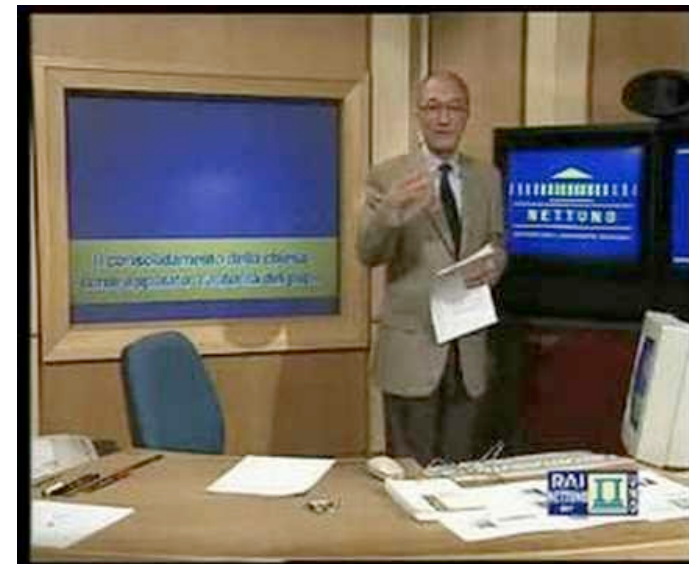
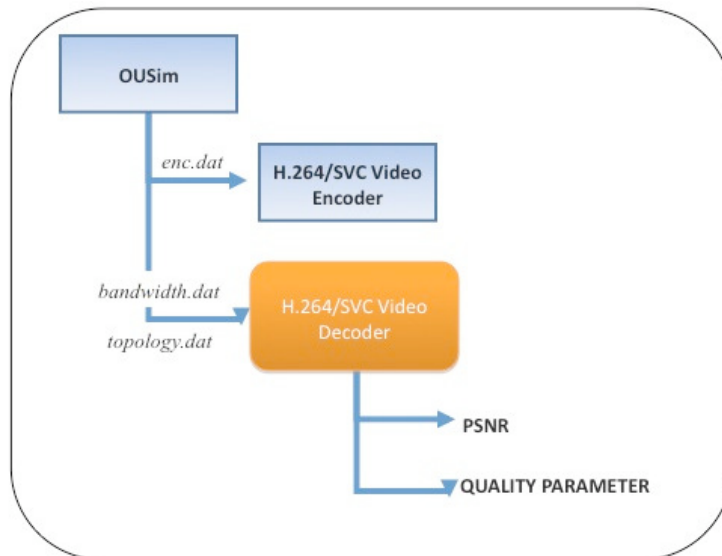


RESULTS

Case Study



- Coder used: H.264/SVC ver. 8.1 with this parameters:
 - YUV 4:2:0 CIF sequence with 24 fps
 - $\frac{1}{4}$ pixel accuracy for motion estimation
 - Single reference frame
 - GOP size of 8
 - I frame every second
 - 16x16, 16x8, 8x16, 8x8 inter-prediction block with SAD metric
 - Context-based binary arithmetic coding



Unbalanced descriptions



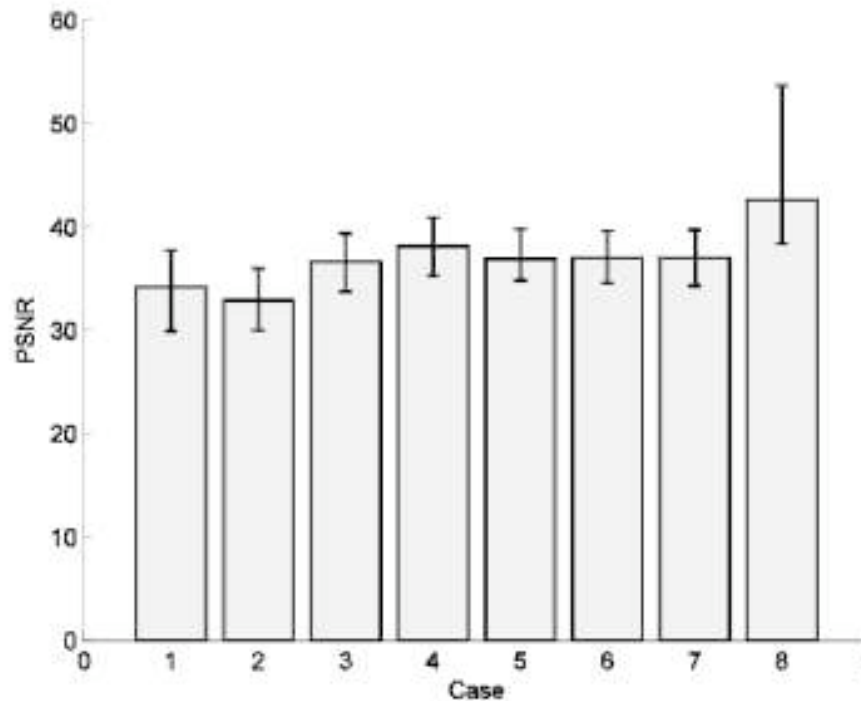
Descr, A / Descr. B	Nothing received	Base Layer (BL_A)	Full Desc. (FD_A)
Nothing received	0	1	4
Base Layer (BL_B)	2	3	6
Full Desc. (FD_B)	5	7	8

Different cases of received descriptions

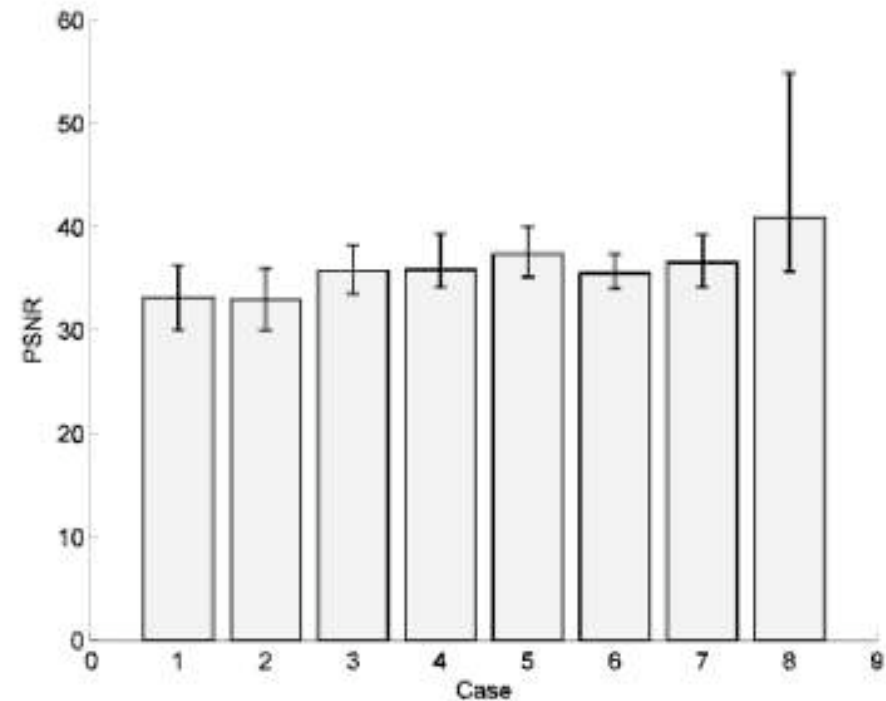
$(BL_A), (FD_A), (BL_B), (FD_B)$	1	2	3	4	5	6	7	8
50799, 62946, 16659, 33224	32,3717	27,5162	30,101	32,4353	28,128	30,5528	29,3483	29,7342
55468, 92317, 55468, 64992	32,4887	32,1685	33,2221	33,236	32,3151	33,192	32,64	32,865
111000, 271000, 166000, 369000	34,437	34,772	36,3055	36,6678	37,869	36,7247	37,0749	38,5796
166000, 332000, 166000, 610000	35,3175	34,772	36,9787	37,6563	38,5855	37,394	38,0457	39,9398
332939, 536038, 299791, 366344	36,564	35,7214	38,7844	39,2534	37,7199	39,0156	38,1726	40,1907
443000, 629000, 295000, 370000	36,8566	35,6964	39,0228	39,5533	38,0545	39,2093	38,5453	40,7863
507000, 629000, 166000, 332000	37,0395	34,772	38,2234	39,2173	37,7023	38,3849	38,3094	40,2963
554000, 923000, 166000, 407000	37,0784	34,772	38,2608	40,4825	38,0735	38,9851	38,6326	41,6407
616000, 629000, 201000, 320000	37,1703	35,1369	38,7145	36,4008	37,7744	36,8783	38,4299	37,7201
1665489, 4440419, 1670975, 6499794	37,5768	36,7378	41,2275	43,4108	43,4702	42,3304	42,5185	57,7418
5549671, 9231988, 1665083, 4070112	37,6577	36,738	41,357	43,7324	43,3287	42,506	42,5706	58,9646

Performances with unbalanced descriptions

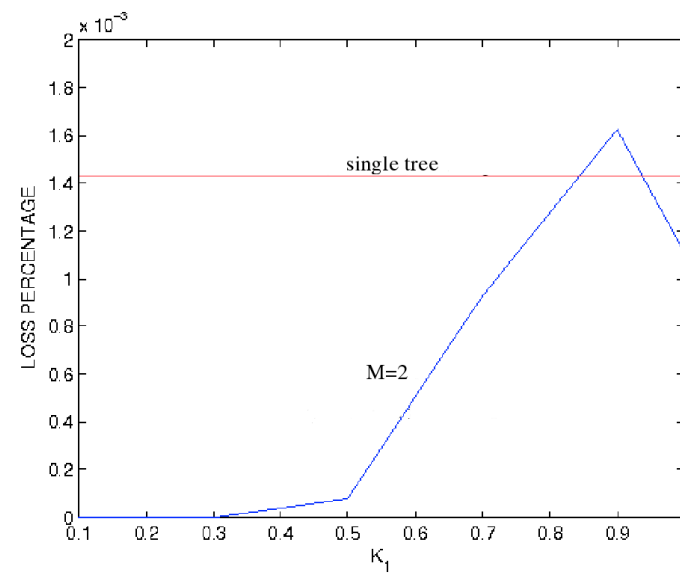
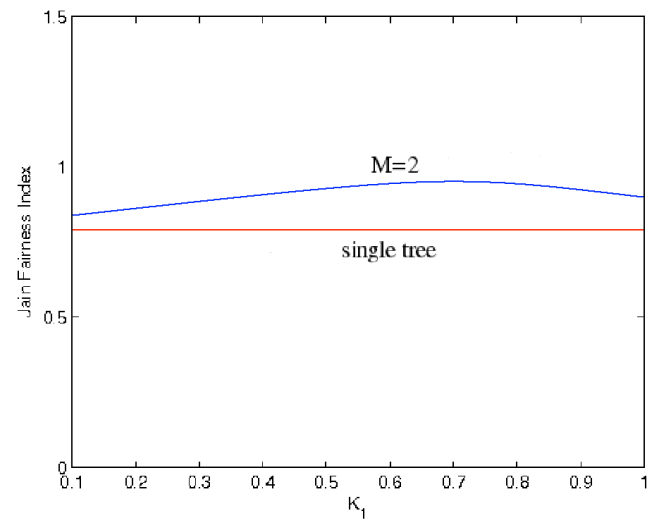
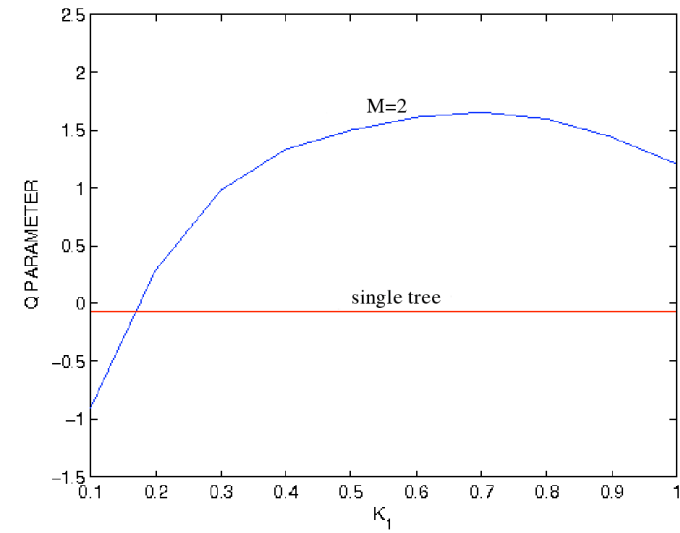
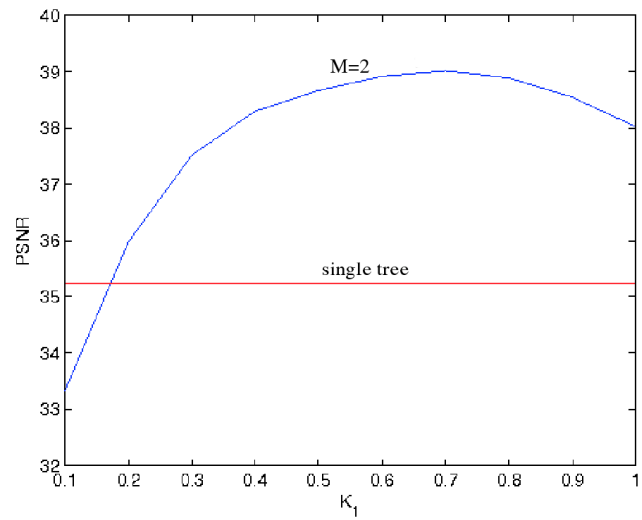
Results (1/2)



Two children, non distributed



Two children, random



Conclusions



- Increasing the number of information received, the performances of the multiple description algorithm increase
- Best when both description are fully received
- The proposed tree construction algorithm (nDST) outperforms the random trees (nDRT)
- The fifth class shows worst performances due to the lower bandwidth available to the peers



THANKS