Secure Multicast of Anti-Collusion Fingerprinted Video

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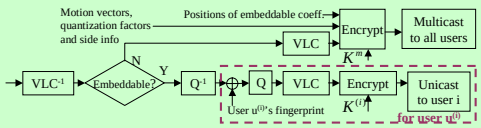
1. Motivation

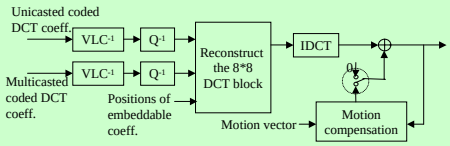
- Multimedia Fingerprinting:
  - Protect multimedia content after decryption
  - Embed identification info. in each distributed copy
- Distribution of Fingerprinted Copies:
  - A huge volume of data and a large number of users
  - Unicasting each fingerprinted copy is inefficient
  - Traditional multicast cannot be directly applied
- Desired distribution schemes:
  - Robust against collusion attacks and other attacks
  - Preserve the secrecy of the embedded fingerprint
  - Achieves bandwidth efficiency

2. General Fingerprint Multicast

- Spread Spectrum Fingerprint Embedding:
  - Robust against many attacks and widely used in multimedia fingerprinting
  - Not all coefficients are embeddable due to perceptual constraints, and a non-embeddable coefficients has the same value in all copies
- A general fingerprint multicast scheme:
  - Non-embeddable coefficients → multicast to all users
  - Uniquely fingerprinted coefficients → unicast
- Can be used with most spread spectrum embedding based fingerprint design:



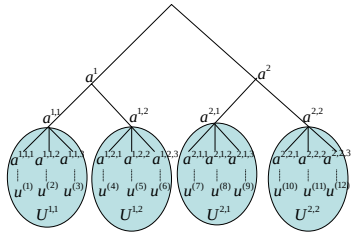
(a) Fingerprint embedding and distribution at the server's side



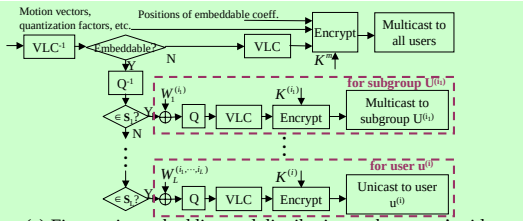
(b) Decoding at the receiver's side

A MPEG-2 based general fingerprint multicast scheme for video-on-demand applications

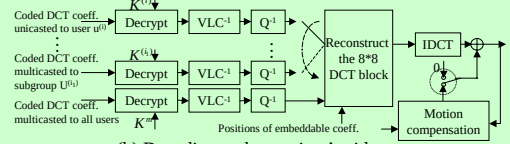
3. A Joint Fingerprint Design and Distribution Scheme



- Tree based fingerprint design:
  - Some users are more likely to collude with each other than others due to geographical or social reasons
  - Group users who are more likely to collude with other together to be more robust against collusion attacks
- In the tree based fingerprint design, some fingerprints are shared by a subgroup of users
  - If TDMA based fingerprint modulation is used, then some fingerprinted coefficients are also shared by the users in the same subgroup.
- Joint fingerprint design and distribution scheme:
  - Achieve both the robustness and bandwidth efficiency
  - Explore the special structure of the fingerprint design to further improve the bandwidth efficiency
    - Shared fingerprinted coefficients → multicast to the users in the subgroup
  - Increase the complexity of the underlying network and that of the sender and the receivers



(a) Fingerprint embedding and distribution at the server's side

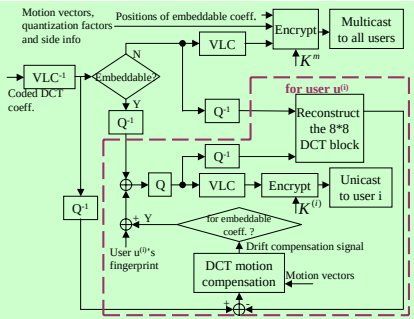


(b) Decoding at the receiver's side

A MPEG-2 based joint fingerprint design and distribution scheme for video-on-demand applications

4. Fingerprint Drift Compensation

- Fingerprint drift:
  - The encoder and decoder use reconstructed *unfingerprinted* and *fingerprinted* copies for motion compensation. → The difference: the embedded FP.
  - FP from different frames may accumulate
- Fingerprint drift compensation:
  - Improve the perceptual quality (1~1.5dB) without extra communication overhead



FP drift compensation in general fingerprint multicast scheme

5. Bandwidth Efficiency

	L'	MG(L')	RB(L')	Miss am	Carphone	Flower
M=1000, L=3 D=[2, 5, 100] p=[1/4, 1/4, 1/2]	0	1	2	0.23	0.41	0.52
	1	3	3	0.22	0.34	0.43
	2	13	4	0.20	0.31	0.39
M=5000, L=4 D=[2, 5, 5, 100] p=[1/6, 1/6, 1/6, 1/2]	0	1	2	0.18	0.35	0.46
	1	3	3	0.16	0.30	0.39
	2	13	4	0.15	0.27	0.35
	3	65	5	0.14	0.25	0.32
M=10000, L=4 D=[4, 5, 5, 100] p=[1/6, 1/6, 1/6, 1/2]	0	1	2	0.16	0.34	0.43
	1	5	3	0.14	0.28	0.37
	2	25	4	0.13	0.26	0.33
	3	125	5	0.13	0.23	0.30

6. Conclusions

- Bandwidth efficiency of the two schemes:
  - General fingerprint multicast: reduces the communication cost by 48% ~ 84%.
  - Joint fingerprint design and distribution: reduces the communication cost by 57% ~ 87%.
  - Depend on: the number of users, the characteristics of sequences & network and computation constraints
- Comparison of the two schemes:
  - General fingerprint multicast: recommended for sequences with fewer embeddable coefficients.
  - Joint fingerprint design and distribution: preferred on sequences with much more embeddable coefficients.