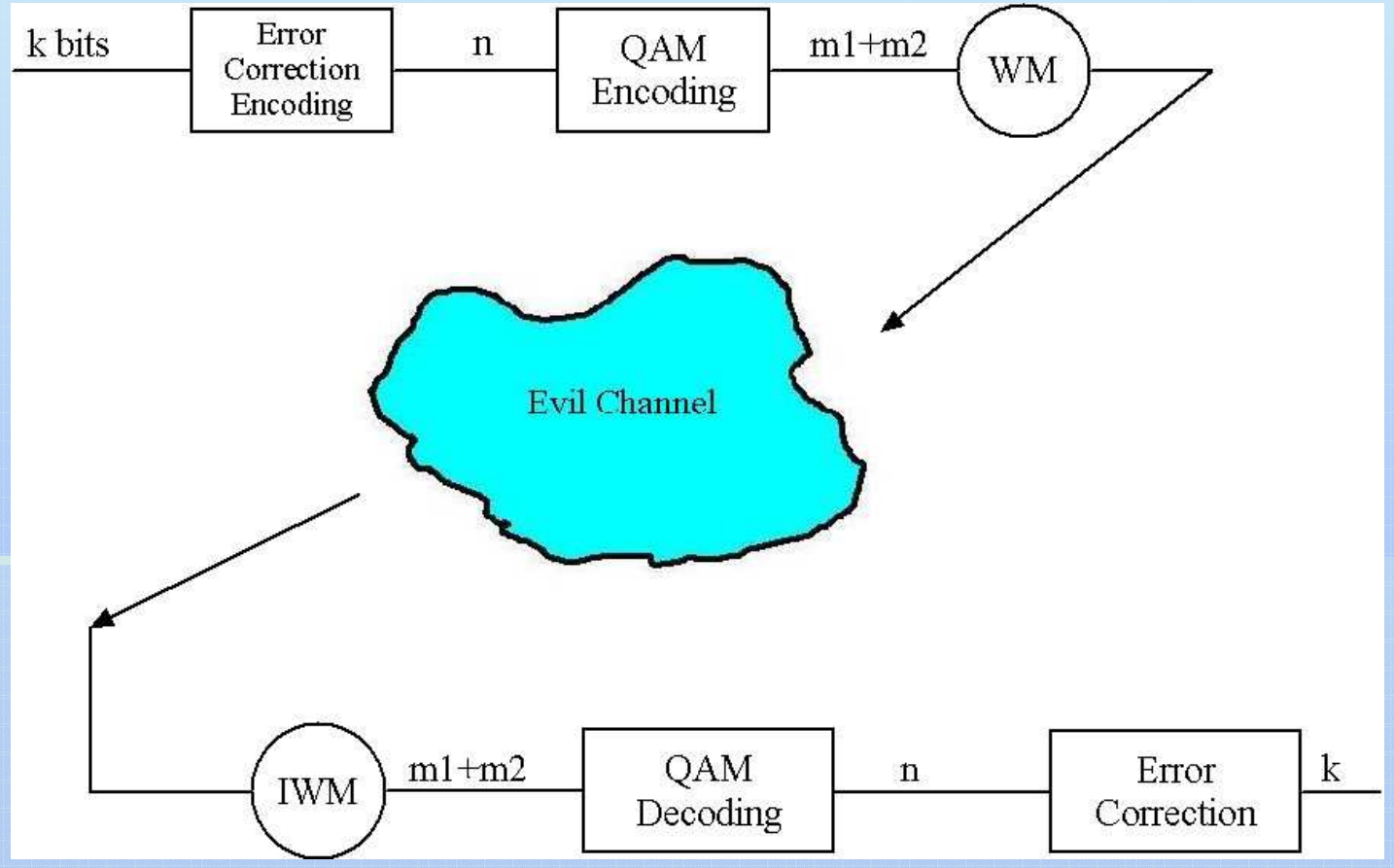
Method to Increase Watermark Robustness

Adam Brickman
abrick@mail.utexas.edu
Department of Electrical & Computer Engineering
The University of Texas at Austin
April 30, 2003

Introduction

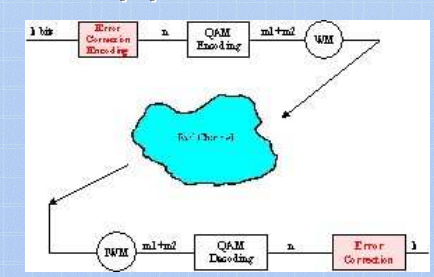
- What is watermarking?
- How does it relate to a channel problem?
- How can we make watermarking more reliable?
- Possible solution: Add redundancy!
  - Made possible by multiple audio channels
  - Use multiple watermarking schemes

Overview of Method



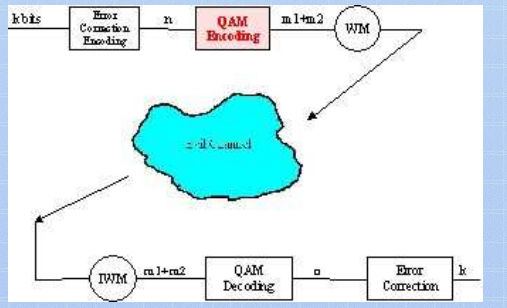
Error Correction: Linear Block Codes

- A *(n, k)* block code is …
  - Defined by $M = 2^k$ binary sequences of length *n*.
  - Code words make up code set
- Linear – Any linear combination of two code words is also a code word.
- Example: (5,2) – {00000, 10100, 01111, 11011}
- Hamming codes
  - $n = 2^m - 1$
  - $k = 2^m - m - 1, m \geq 2$
  - Uses parity to determine which bit (if any) has flipped because of channel
- Decode using “soft” or “hard” decision

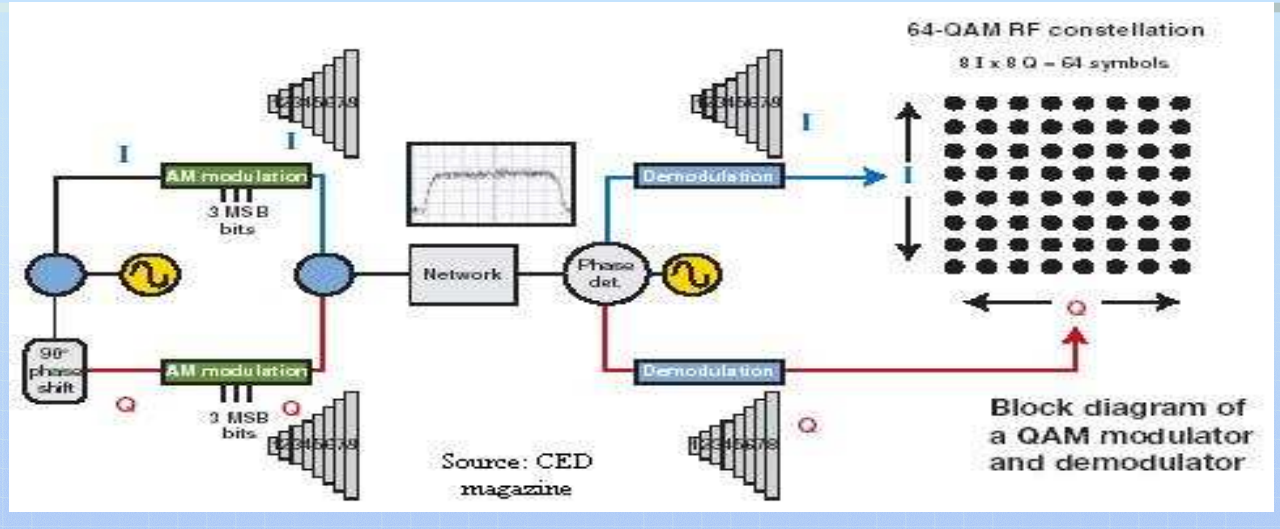


Quadrature Amplitude Modulation

- Combined digital amplitude and phase modulation
- $u_m(t) = A_{mc} \cdot g_T(t) \cdot \cos(w_c t) + A_{ms} \cdot g_T(t) \cdot \sin(w_c t)$
  - $u_m(t)$ is the transmitted signal
  - $g_T(t)$ is the transmission pulse
  - $\{A_{mc}, A_{ms}\}$ = set of amplitude levels
- M = number of QAM constellation points
- Simulataneously transmit $\log_2(M_1 * M_2)$ bits
  - $M_1 = 2^{k1}$
  - $M_2 = 2^{k2}$

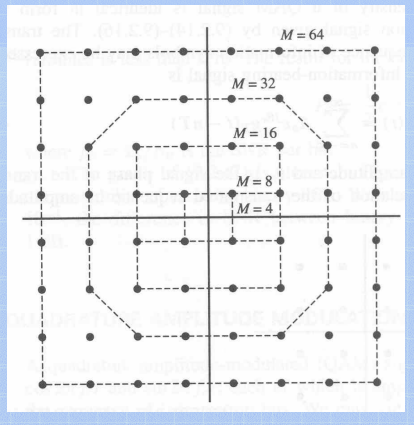


Quadrature Amplitude Modulation

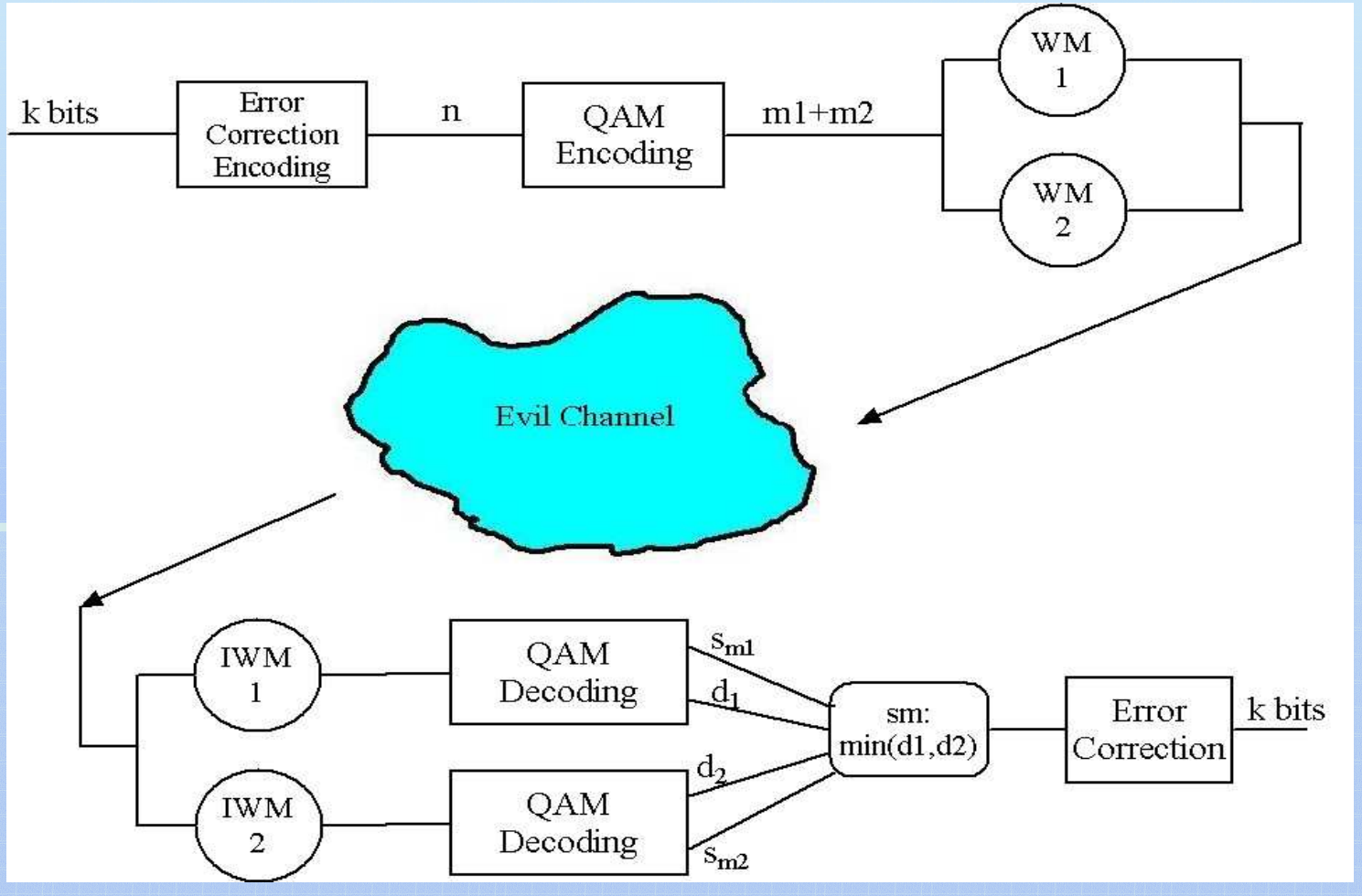


- Geometric representation of encoded symbol s_m

$$s_m = \left(\sqrt{E_s}A_{mc}, \sqrt{E_s}A_{ms},\right)$$

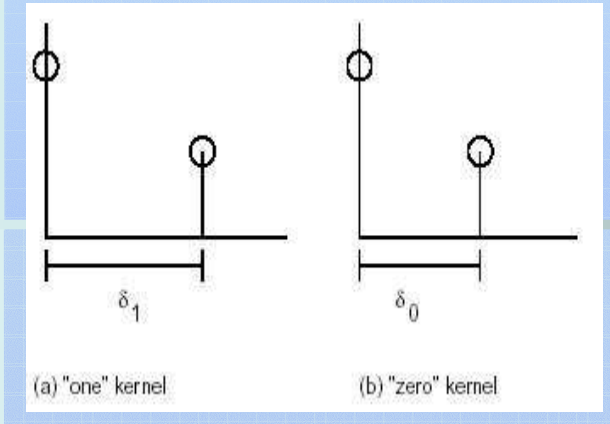


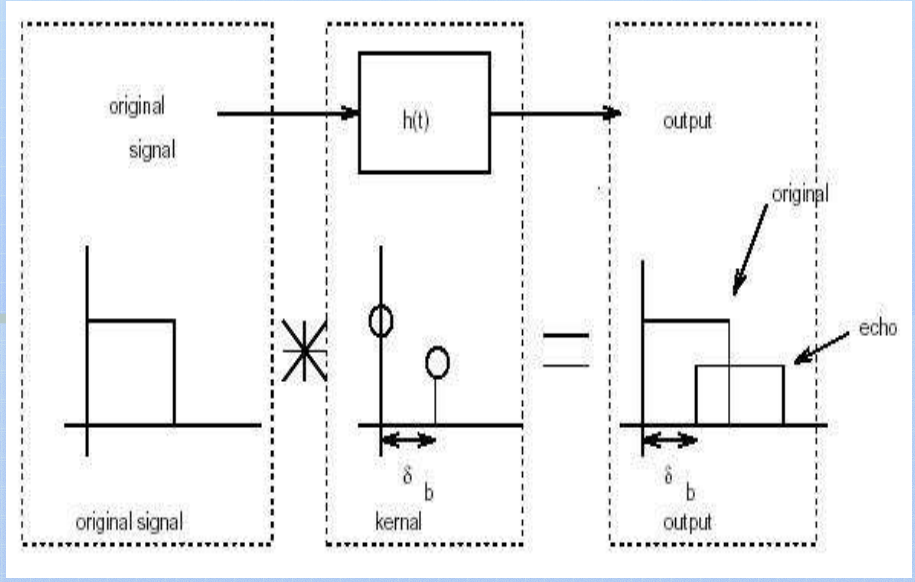
Revised Block Diagram



Watermark Method 1: Echo Hiding

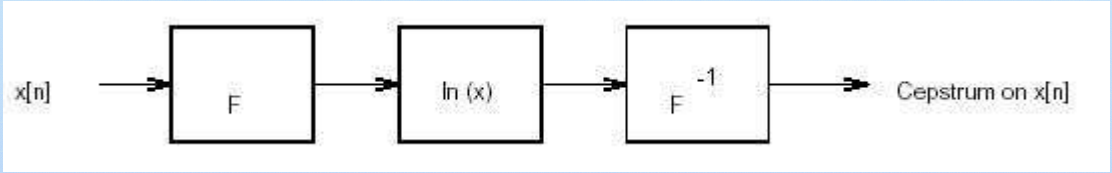
- Authors: Daniel Gruhl, Anthony Lu, Walter Bender



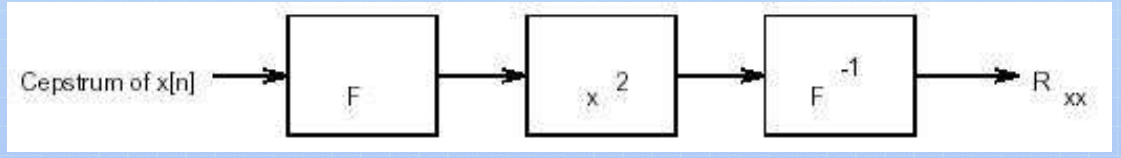


Echo Hiding - Decoding

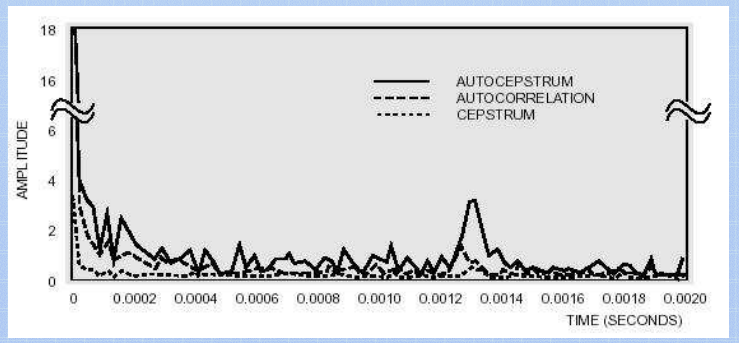
Step 1 - Find cepstrum of y[n] = conv(x,e)



Step 2 – Find autocepstrum of y[n]



Step 3 - Find peak at echo offset

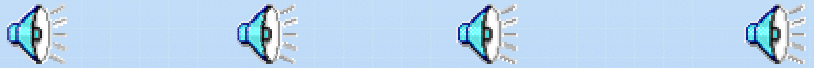


Method 2 – LSB Replacement

- Current Implementation
  - Take cover audio
  - Replace LSB with hidden message
  - Encode length of hidden message
- Future Implementation
  - Spread message bits in time using a m-sequence

Results

- Echo Hiding
  - Inaudible for echo decay rate of .3
  - Noticeable for decay rates above .6



orig. 0.3 0.7 1.0

- LSB Encoding
  - Great for replacing bits 10 - 16
  - Likely to be more susceptible to attacks

Bit 1 (MSB) Bit 5 Bit 8 Bit 10 Bit 16

- Expected results of channel coding
  - Improved reliability and robustness
  - *At worst,* no change.

Future Work

- Investigate other forms of error correction encoding
- Explore other methods of QAM decoding
- Use more sophisticated watermarking schemes
- Can extend this approach to higher dimensional signals, such as Dolby 5.1 Surround sound.