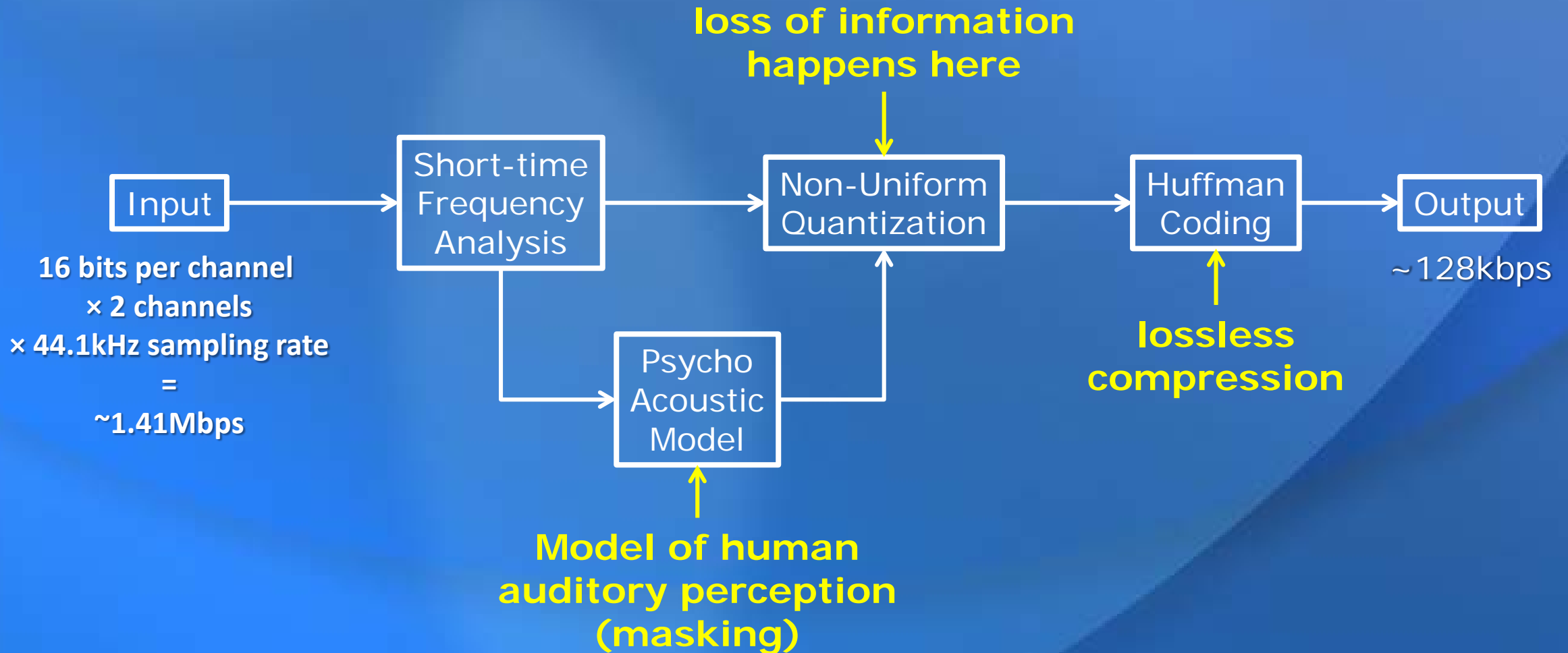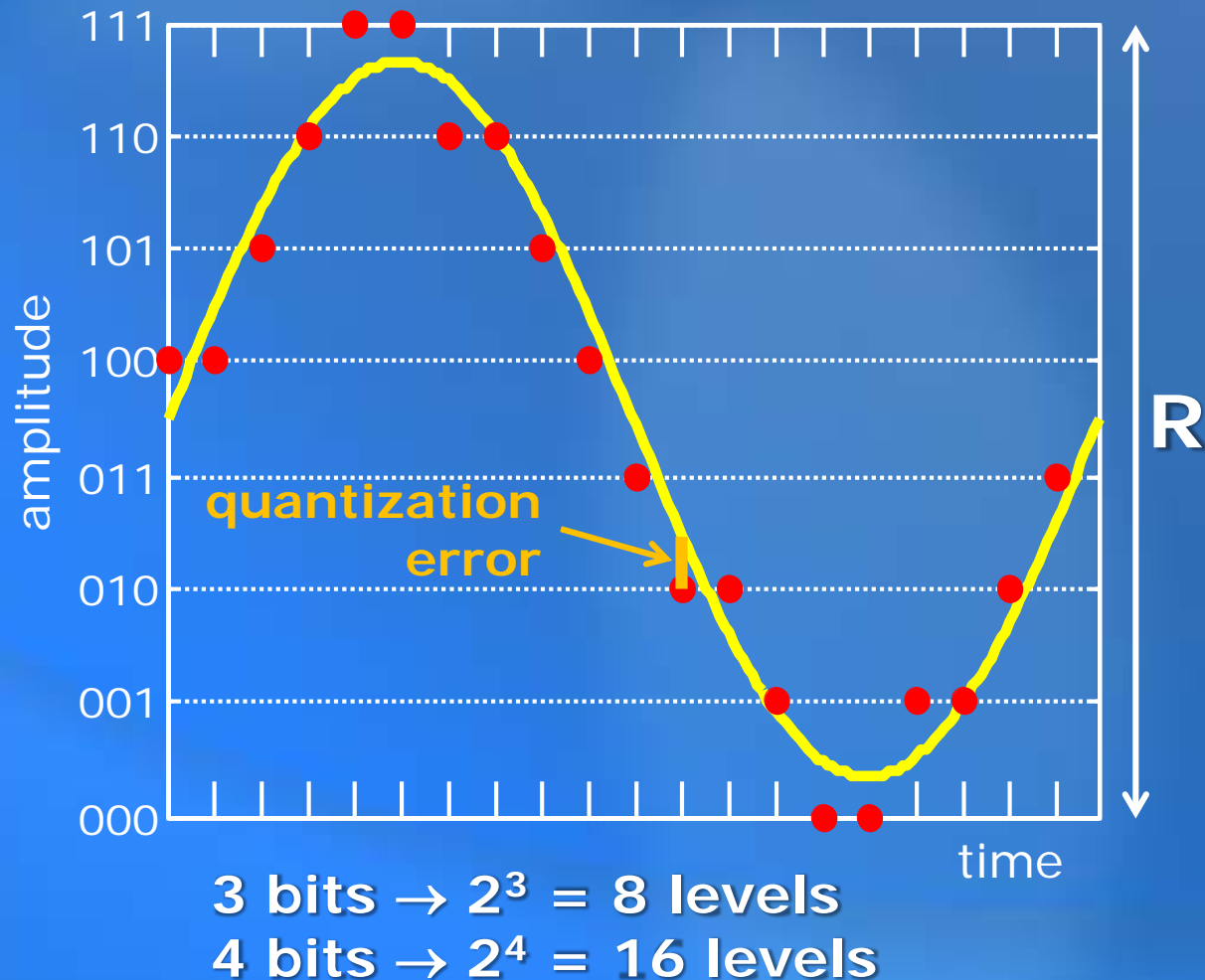# Nonuniform Quantization

Key Steps in MP3 coding
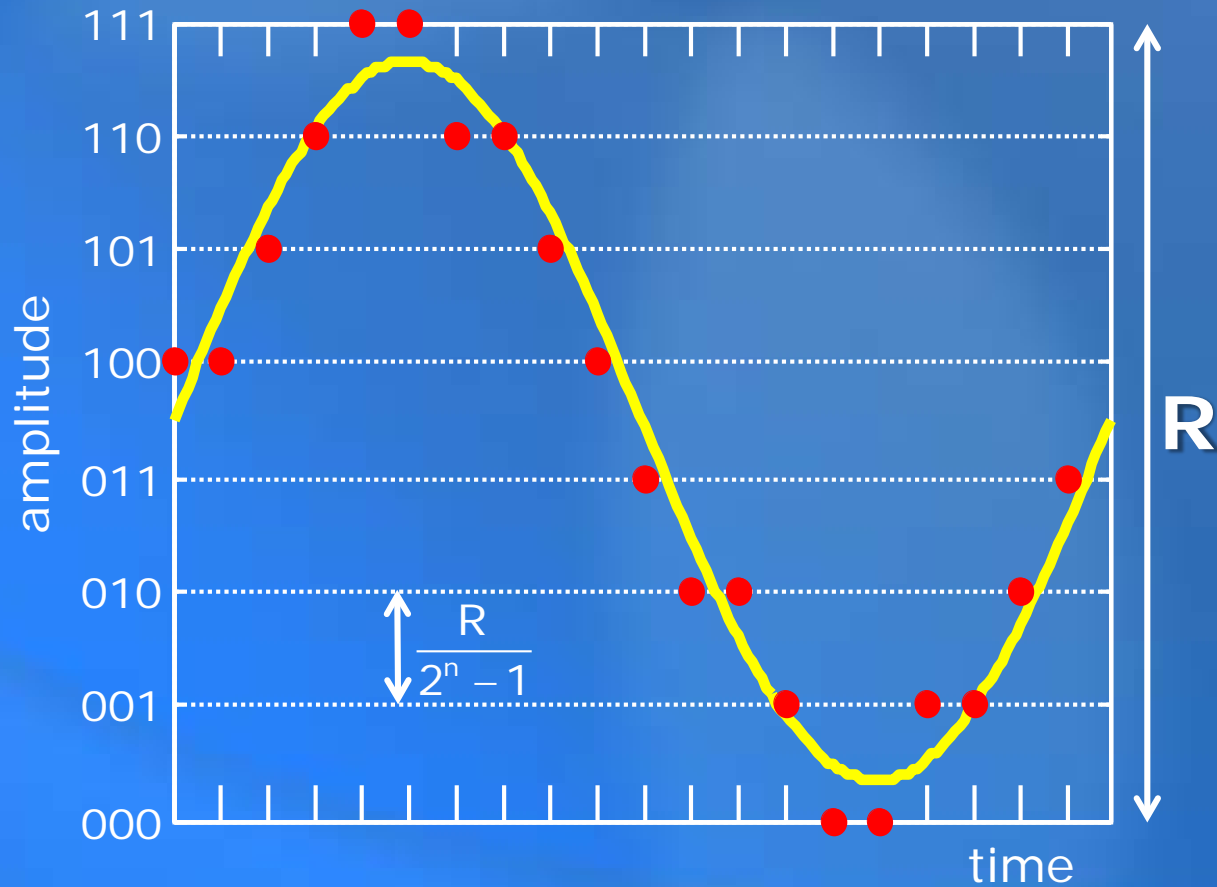
Quantization

Binary numbers have a limited number of values, 2^n, where n is the number of bits.

Quantization

- **Divides the expected signal range, R, into 2^n different levels,**
- **Quantizes the original signal to the closest level.**
- **Leads to quantization error.**

amplitude

time

quantization error

R

3 bits → 2^3 = 8 levels
4 bits → 2^4 = 16 levels

Resolution

amplitude

111
110
101
100
011
010
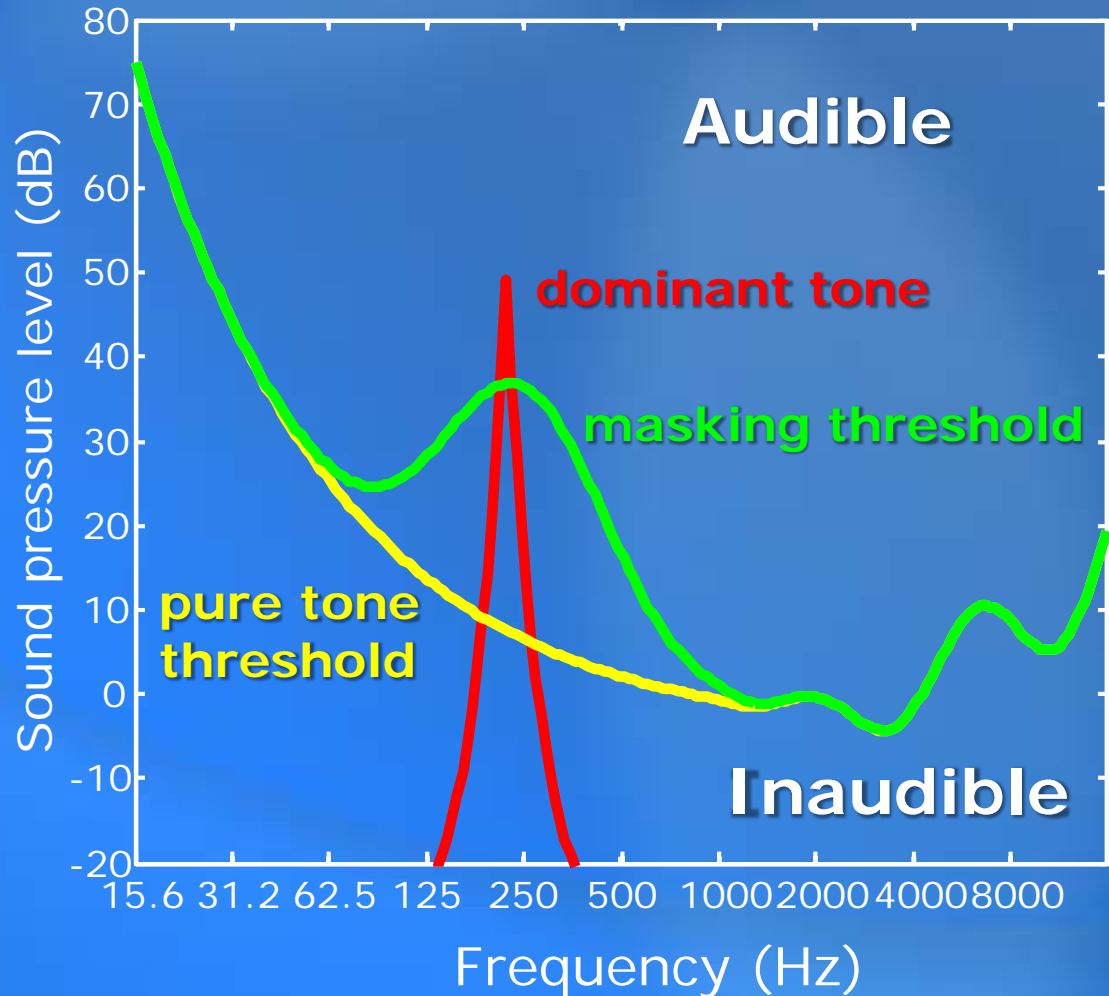001
000

$\dfrac{R}{2^n - 1}$

R

time

Resolution is either measured as

- **the number of bits**

  e.g., n = 3 bits

- **the difference between levels**

  e.g., resolution = $\dfrac{R}{2^n - 1}$

Non-uniform quantization

MP3 quantizes the amplitudes of frequency components with variable resolution:

- Frequency components near a dominant masker are quantized with fewer bits.

Summary

loss of information
happens here

```
                ┌──────────┐                ↓
                │Short-time│        ┌────────────────┐        ┌─────────┐
┌──────┐        │Frequency │───────▶│ Non-Uniform    │───────▶│ Huffman │        ┌────────┐
│Input │───────▶│Analysis  │        │ Quantization   │        │ Coding  │───────▶│ Output │
└──────┘        └──────────┘        └────────────────┘        └─────────┘        └────────┘
```

16 bits per channel
× 2 channels
× 44.1kHz sampling rate
=
~1.41Mbps

```
        ┌────────────┐
        │ Psycho     │
        │ Acoustic   │
        │ Model      │
        └────────────┘
              ↑
```

~128kbps

lossless
compression

Model of human
auditory perception
(masking)