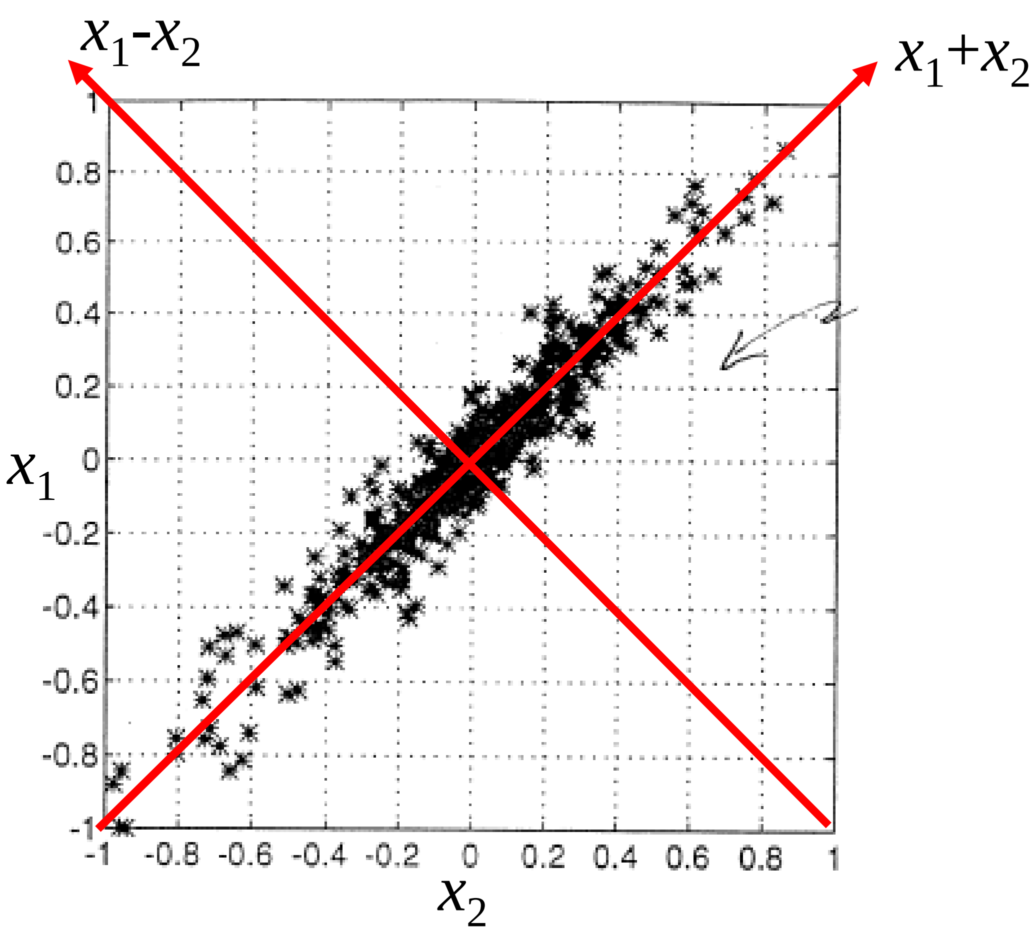
Ch. 11 Differential Encoding

Very Brief Overview

Motivation

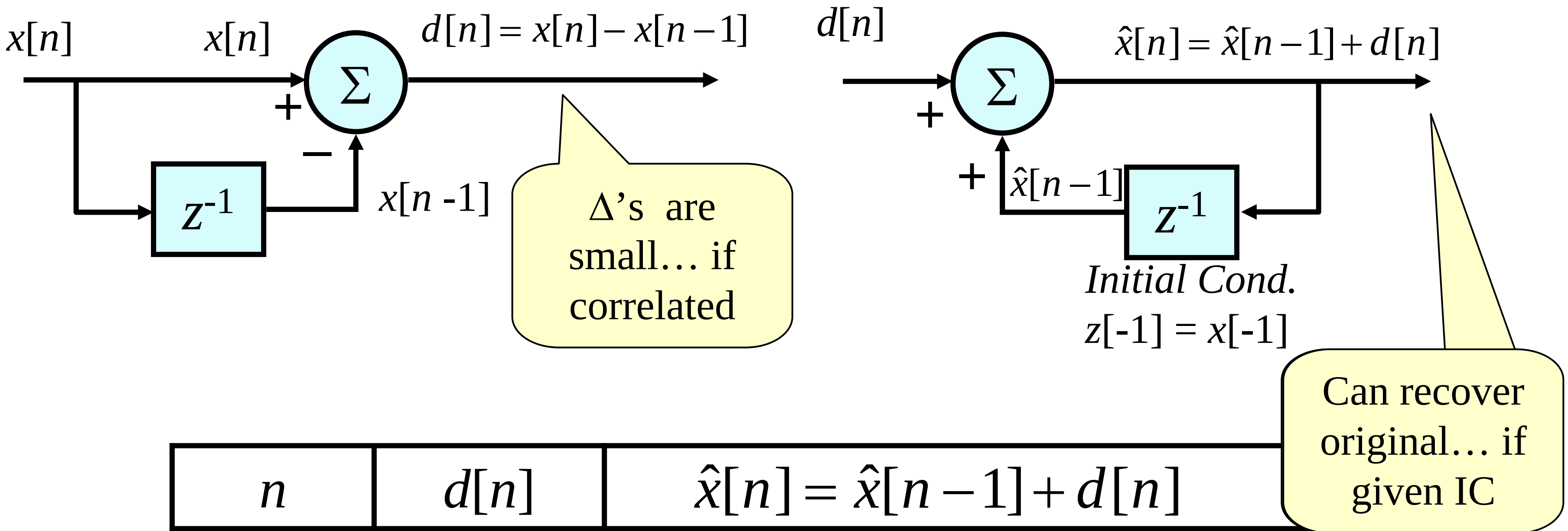
We saw that VQ is one way to exploit correlation between samples…

Differential Encoding is another way to exploit correlation



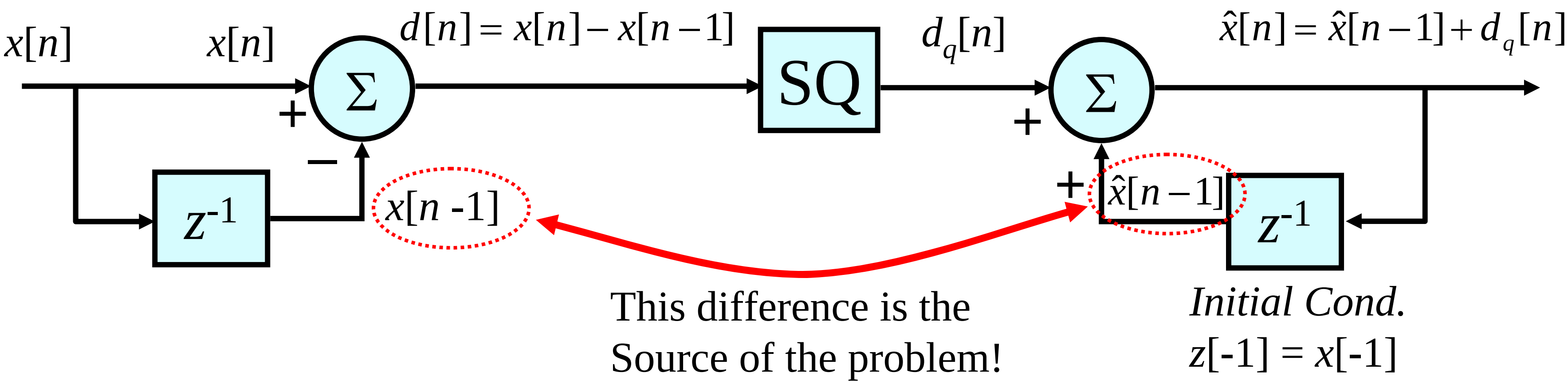
On these new axes… the high correlation results in a small dynamic range along the difference axis… can better quantize along that axis for a given rate.

Underlying Idea



n	$d[n]$	$\hat{x}[n] = \hat{x}[n-1] + d[n]$
-1		$x[-1]$ (IC)
0	$x[0] - x[-1]$	$x[-1] + (x[0] - x[-1]) = x[0]$
1	$x[1] - x[0]$	$x[0] + (x[1] - x[0]) = x[1]$
2	$x[2] - x[1]$	$x[1] + (x[2] - x[1]) = x[2]$
3	$x[3] - x[2]$	$x[2] + (x[3] - x[2]) = x[3]$

So… what happens when we put a quantizer into the system?



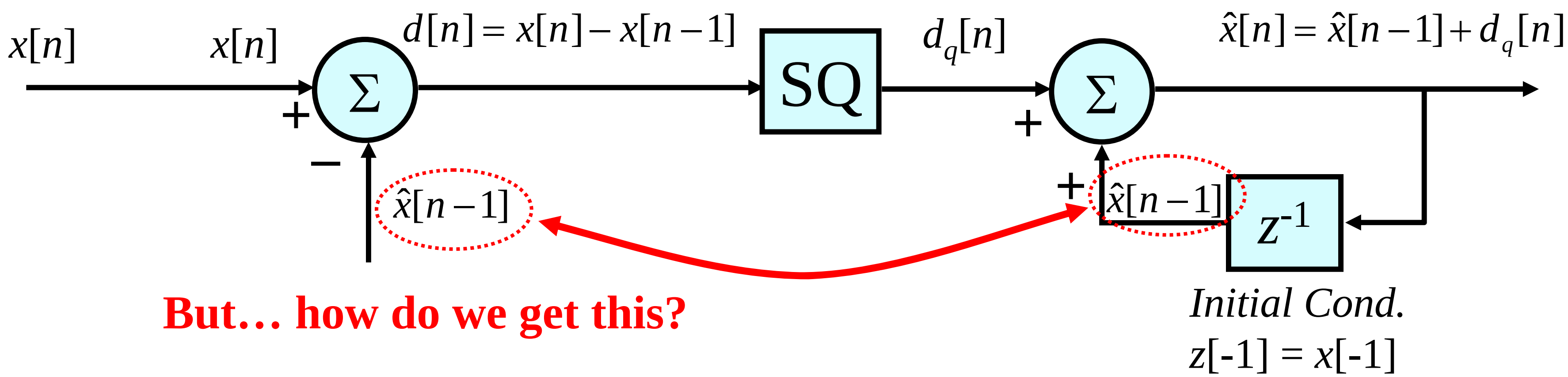
n	$d_q[n]$	$\hat{x}[n] = \hat{x}[n-1] + d_q[n]$
-1		$x[-1]$ (IC)
0	$x[0] - x[-1] + q[0]$	$x[-1] + (x[0] - x[-1] + q[0]) = x[0] + q[0]$
1	$x[1] - x[0] + q[1]$	$x[0] + q[0] + (x[1] - x[0] + q[1]) = x[1] + q[0] + q[1]$
2	$x[2] - x[1] + q[2]$	$x[1] + q[0] + q[1] + (x[2] - x[1] + q[2]) = x[2] + q[0] + q[1] + q[2]$

Quant. Error Accumulates!

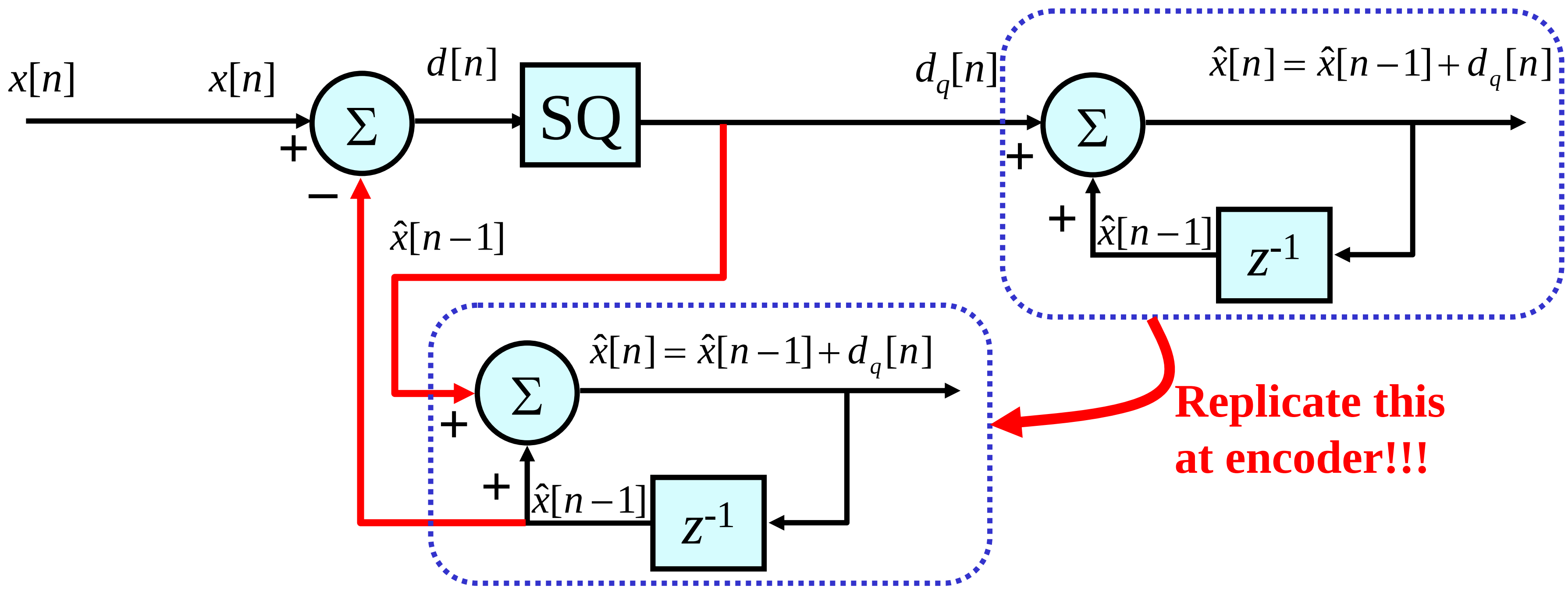
$$Var\{q[0] + q[1] + \cdots + q[n]\} = (n+1)\sigma_q^2$$

(Assuming $q[n]$ is zero mean, white process)

Quant. Noise Power grows linearly!!

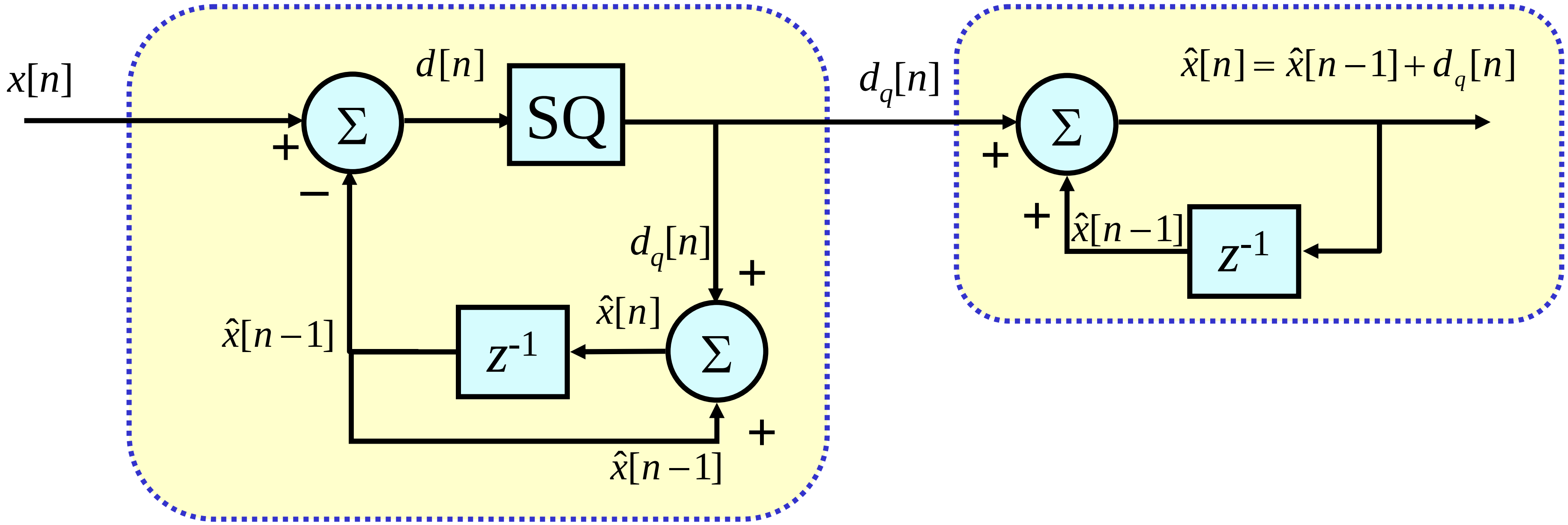


x[n]
x[n]
d[n] = x[n] − x[n−1]
SQ
d_q[n]
x̂[n] = x̂[n−1] + d_q[n]
+
−
+
+
x̂[n−1]
x̂[n−1]
z^-1
But… how do we get this?
Initial Cond.
z[-1] = x[-1]



x[n]
x[n]
d[n]
SQ
d_q[n]
x̂[n] = x̂[n−1] + d_q[n]
+
−
x̂[n−1]
+
+
x̂[n−1]
z^-1
x̂[n] = x̂[n−1] + d_q[n]
+
+
x̂[n−1]
z^-1
Replicate this
at encoder!!!

Now… just re-draw it to get **DPCM** approach:



- Can replace delays by FIR “N-tap” Linear Predictors
  - Recall our coverage of linear prediction and AR Models
  - Can make the linear predictor adaptive to track a varying AR model (ADPCM)
- Applications Include:
  - Speech
  - Remote Sensing
  - EEG & ECG Signals
  - Etc.