Introduction to the Viterbi Algorithm

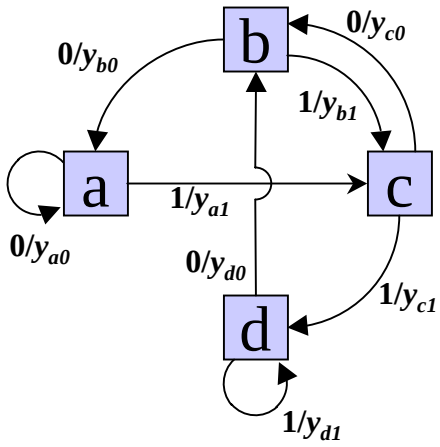
Rhett Davis

EECS 290A

February 16, 1999

Problem Statement:

Estimate the state of a system
given a noisy observation, *optimally*

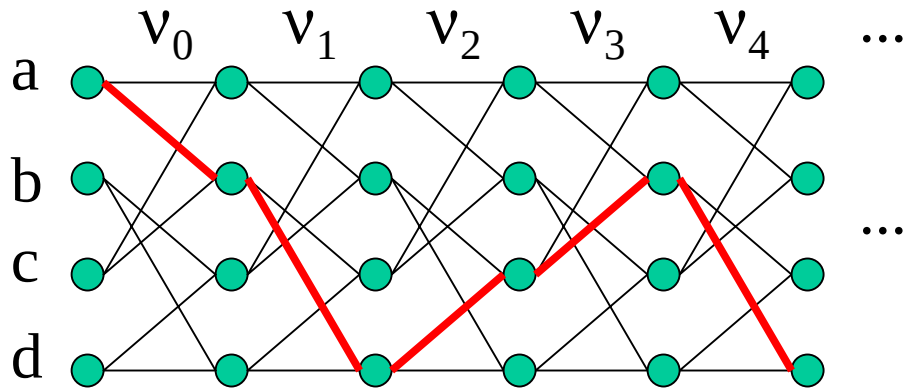


$v_i = f(y_i)$

observations	v_0	v_1	v_2	v_3	v_4	...
estimates	a	c	d	b	c	...

Build a Trellis

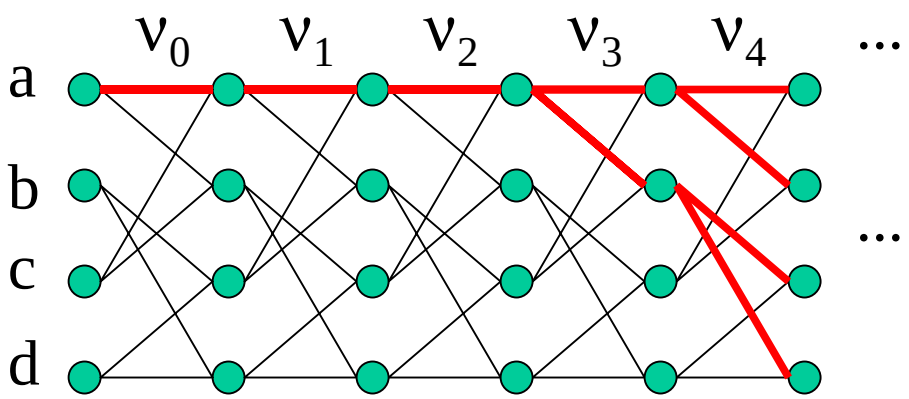
Trellis - a graphical representation of possible state evolution



Branch - a transition from one point in the trellis to another

Path - a group of connected branches through the trellis

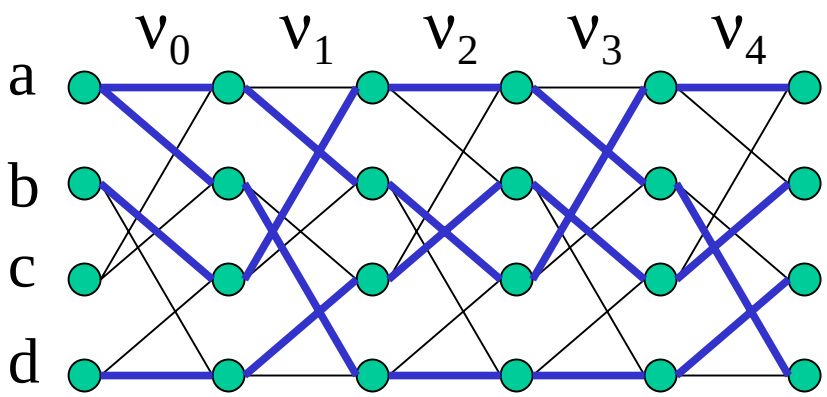
Maximum Likelihood Sequence Detection (MLSD)



$P(a|\nu_0, \nu_1, \nu_2, \nu_3, \nu_4)$
$P(b|\nu_0, \nu_1, \nu_2, \nu_3, \nu_4)$
$P(c|\nu_0, \nu_1, \nu_2, \nu_3, \nu_4)$
$P(d|\nu_0, \nu_1, \nu_2, \nu_3, \nu_4)$

Path Metric: $PM=f(\nu_0, \nu_1, \nu_2, \nu_3, \nu_4)$

Viterbi Algorithm

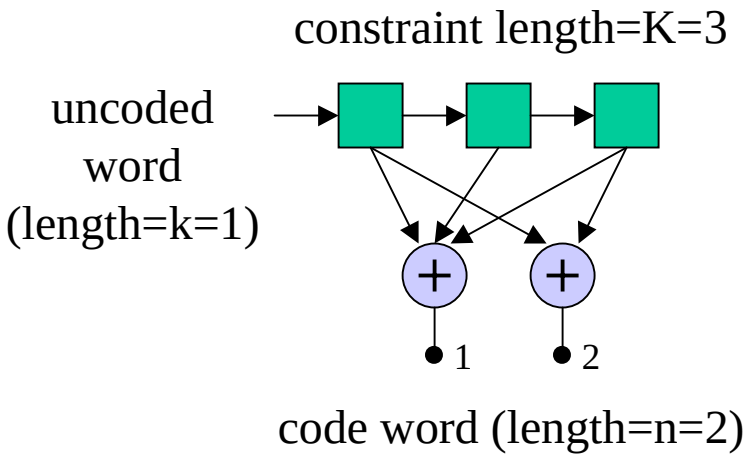


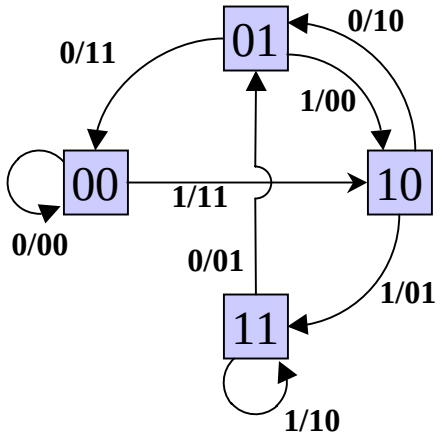
PM = Σ BM
(Branch metrics)

Each state has one *survivor path* which is the most likely path

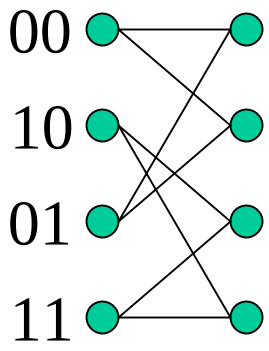
See http://www.alantro.com/html/viterbi.html

Application to Convolutional Coding

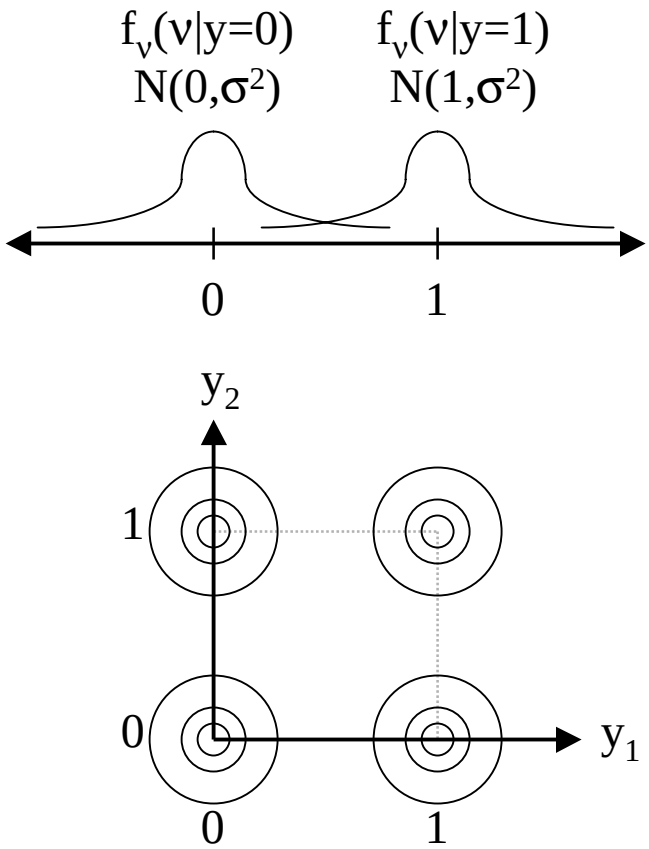




No. of states = $2^{(K-1)}$



Branch Metric Calculation



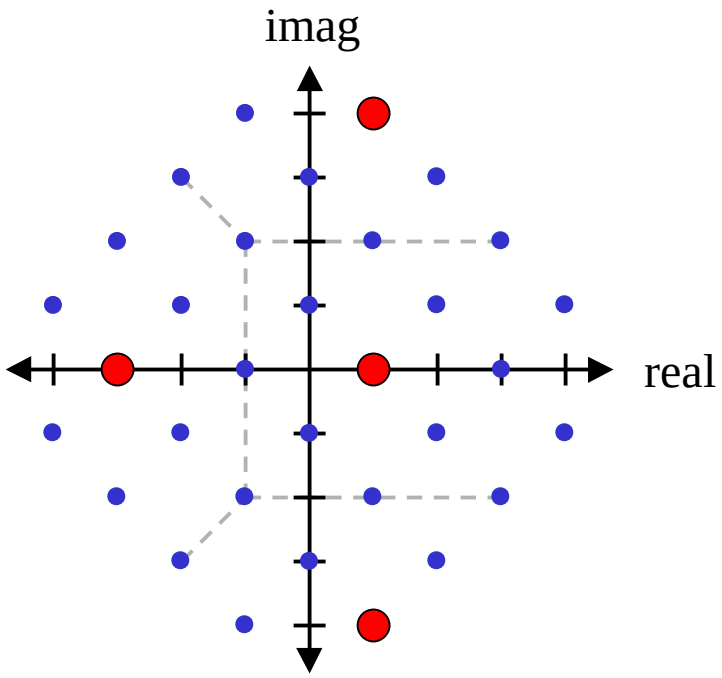
$$BM_{00\text{-}00} = BM_{00} = \sqrt{(0-v_1)^2 + (0-v_2)^2}$$

$$BM_{00\text{-}10} = BM_{11} = \sqrt{(1-v_1)^2 + (1-v_2)^2}$$

$$BM_{10\text{-}01} = BM_{10} = \sqrt{(1-v_1)^2 + (0-v_2)^2}$$

$$\vdots \qquad \vdots \qquad \vdots$$

Application to Trellis Coded Modulation



Convolutionally code some
bits to choose a sub-constellation,
use the remaining bits to choose
between the points in a sub-constell.

Example:

32-QAM
3 bits used in coder
(8 sub-constellations,
4 bits per sub-constellation)

Source: V.32 modem for Motorola DSP, Dion D. Messer

TCM Trellis