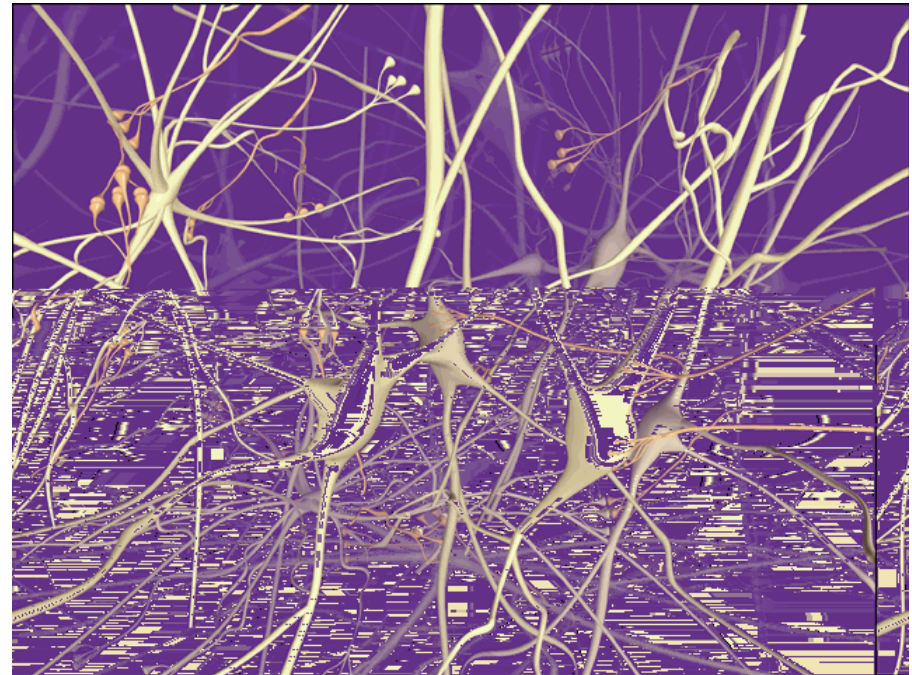
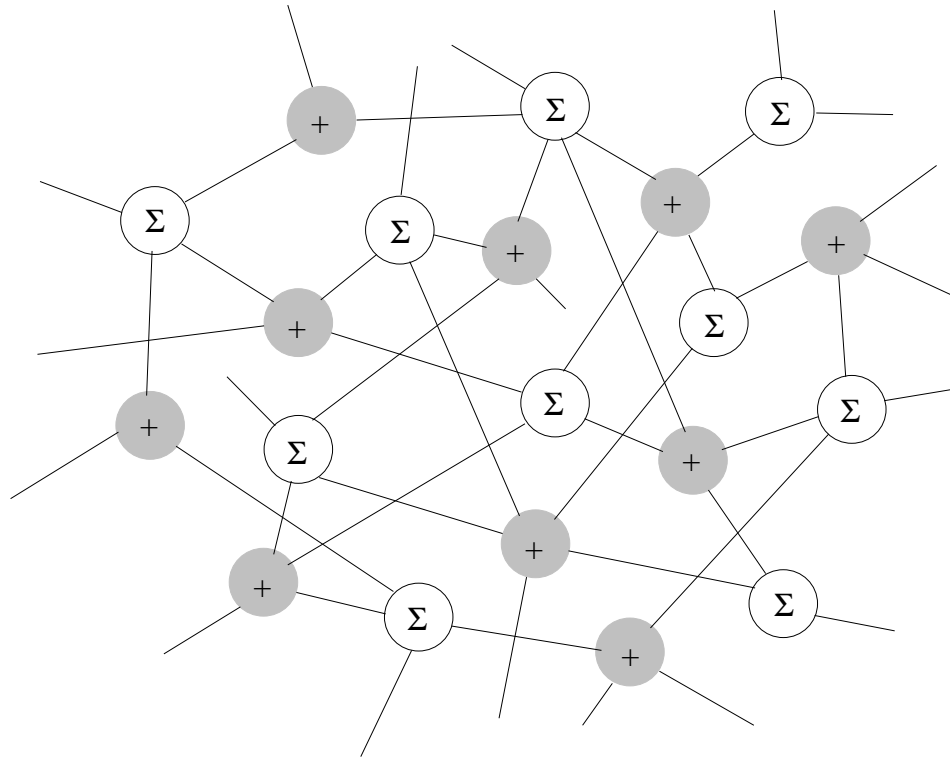


Graphs, codes and the cortex

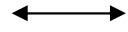
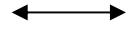
Claude Berrou, Vincent Gripon and Xiaoran Jiang

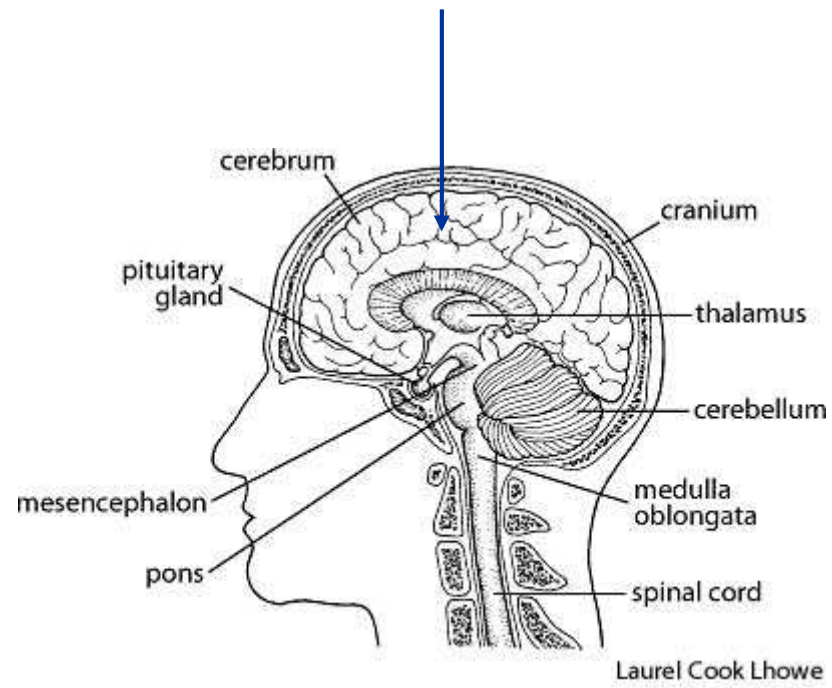
RISC-E, October 19, 2011

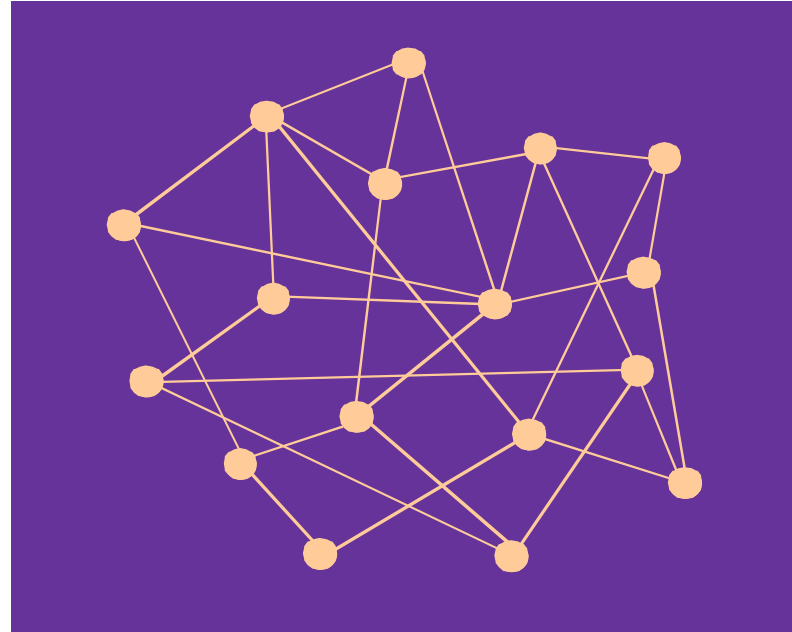
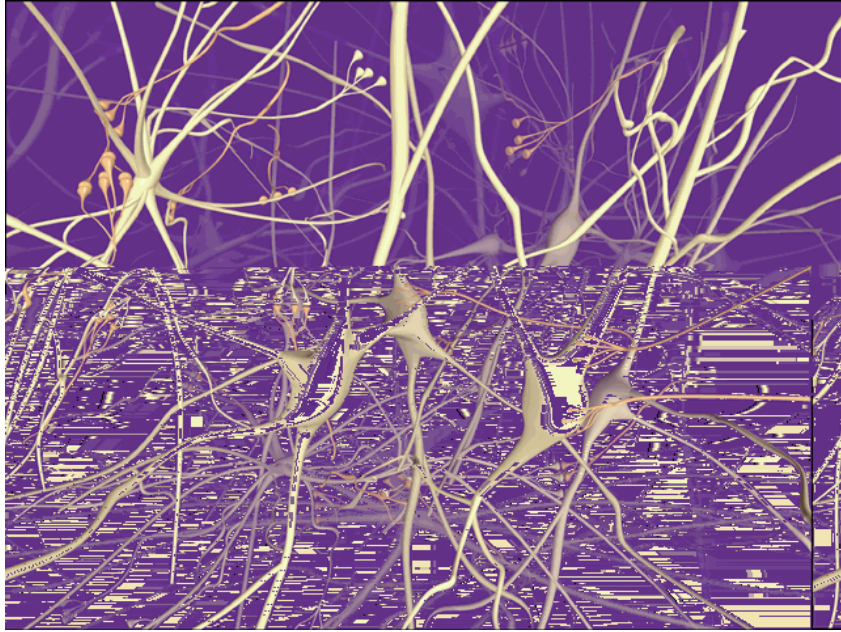


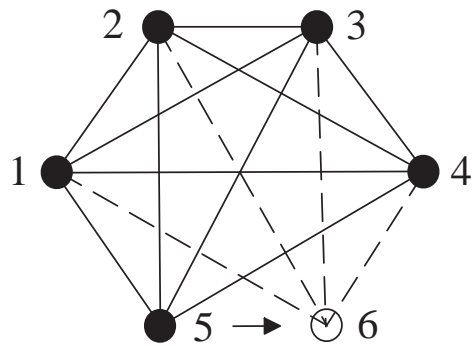
Σ

"If you want to understand life, don't think about vibrant, throbbing gels and oozes, think about information technology."
(Richard Dawkins, *The blind watchmaker*, 1986, Norton, p. 112)

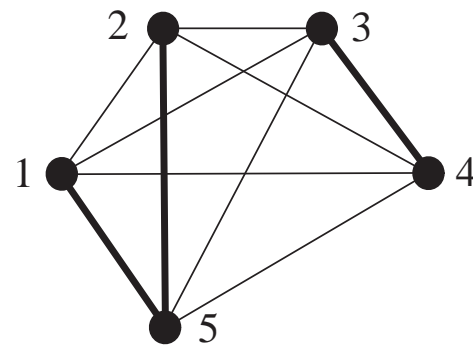








(a)



(b)

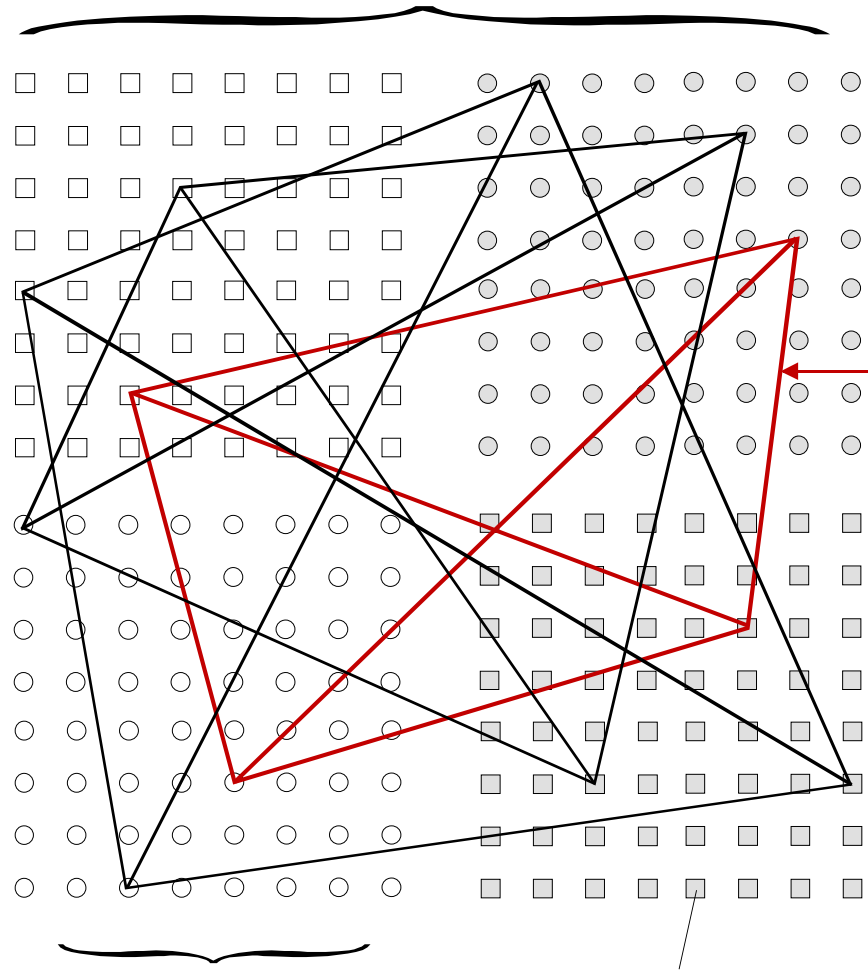
c vertices:

$$d_{\min} = 2(c-1)$$

$$R = \frac{\left\lfloor \frac{c+1}{2} \right\rfloor}{\frac{c(c-1)}{2}} = \frac{1}{c-1} \quad (\text{for } c \text{ even})$$

$$F = Rd_{\min} = 2$$

network = macrocolumn



neural clique

l fanals per column,

M messages

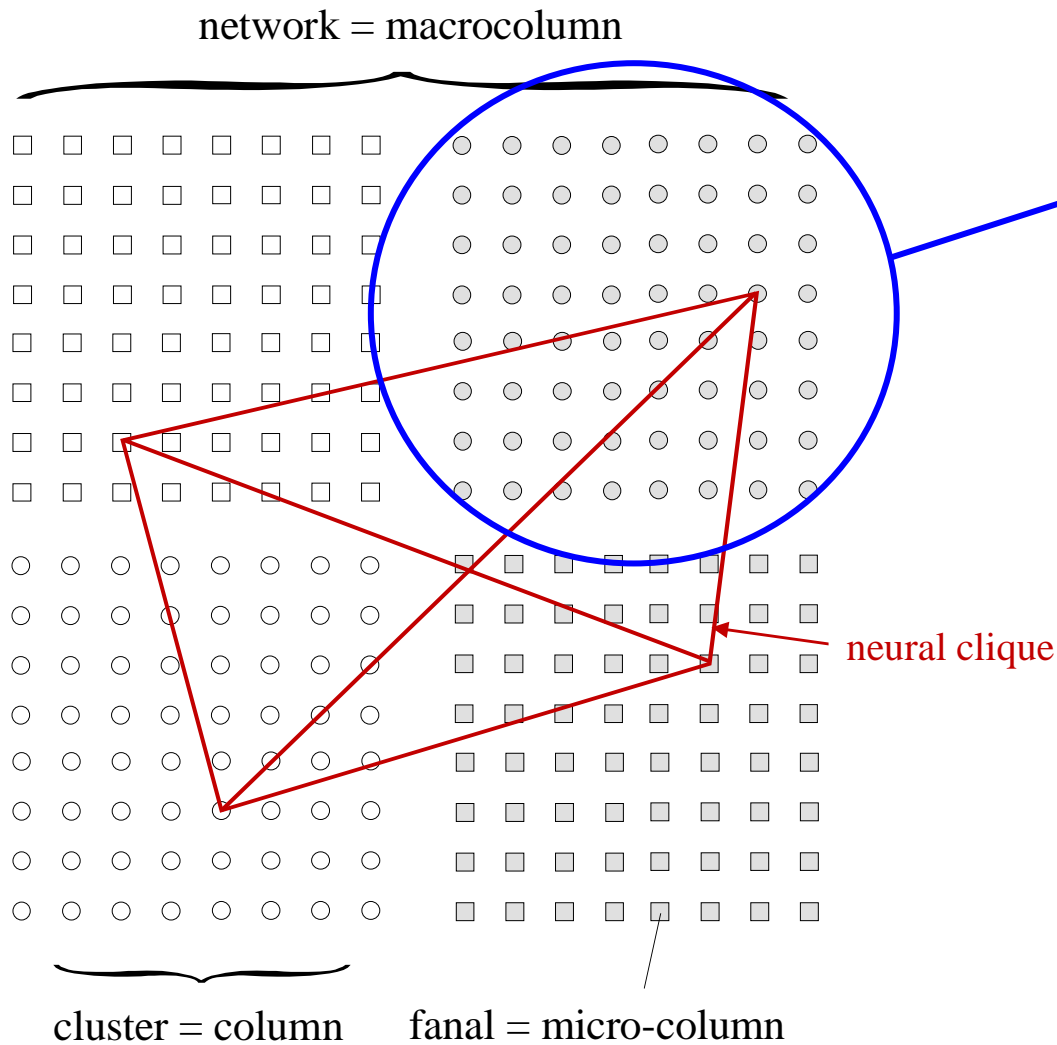
\Rightarrow density d

$$d = 1 - \left(1 - \frac{1}{l^2}\right)^M$$

$$\approx \frac{M}{l^2} \text{ if } M \ll l^2$$

cluster = column

fanal = micro-column



a constant-weight
code^(*) with length l
and weight $w = 1$

$$k = \log_2(l) \text{ bits} \Rightarrow$$

$$R = \log_2(l)/l$$

$d_{\min} = 2$ only but easy to
decode according to the
winner-take-all (WTA)
rule (max function)

(*) F. J. MacWilliams and N. J. A. Sloane,
The theory of error-correcting codes, pp.
526-527, North-Holland, 1979.

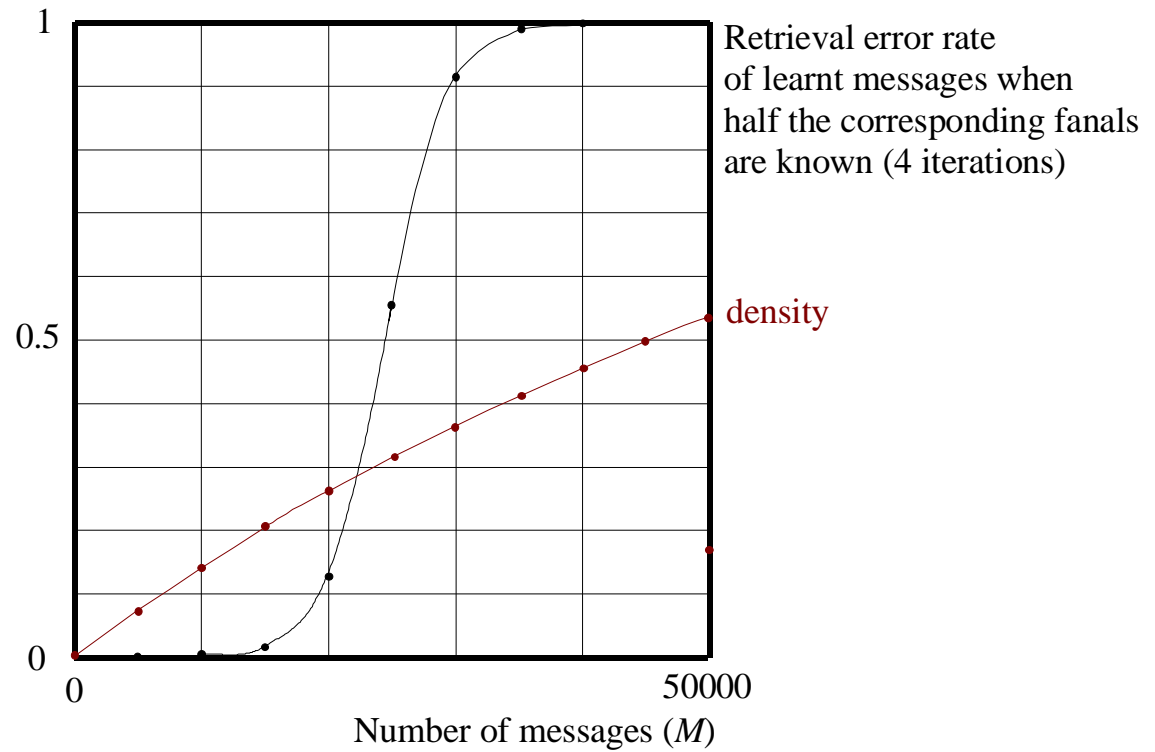
Gains compared to Hopfield networks (with the same amount of memory used):

diversity : 250

capacity : 20

efficiency : 20

(52% instead of 2.6%)



$c = 8$ clusters, $l = 256$ fanals

Messages of $8 \cdot \log_2(256) = 64$ bits

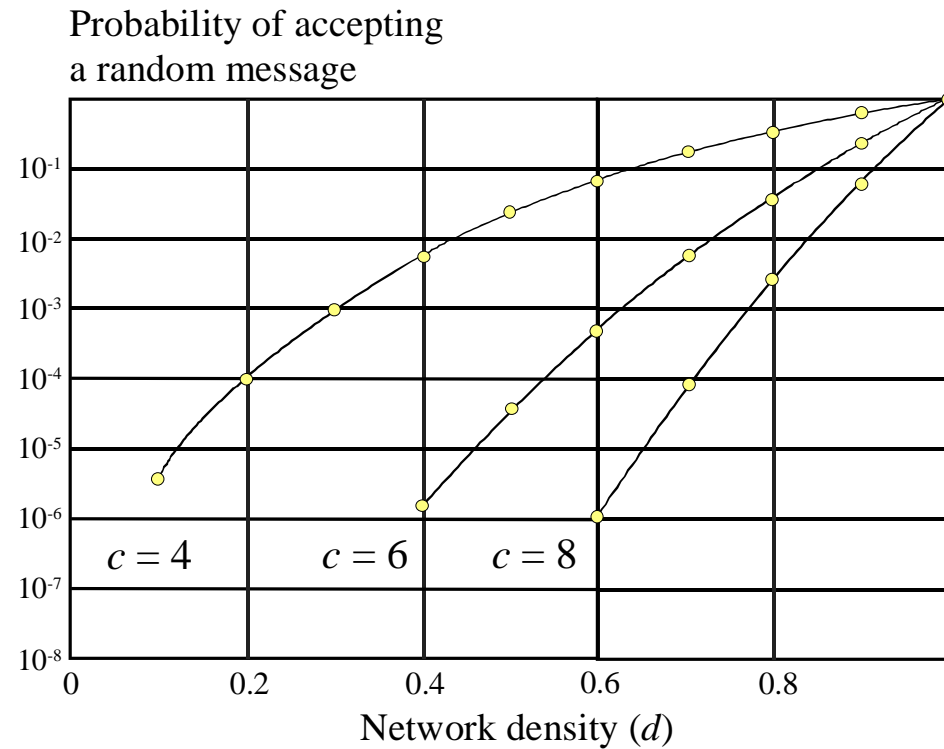
Gains compared to Hopfield networks (with the same amount of memory used and $c = 4$):

diversity : 1071

capacity : 52

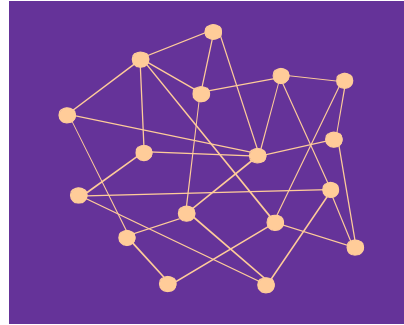
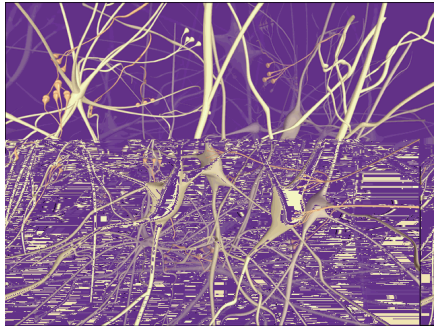
efficiency : 52

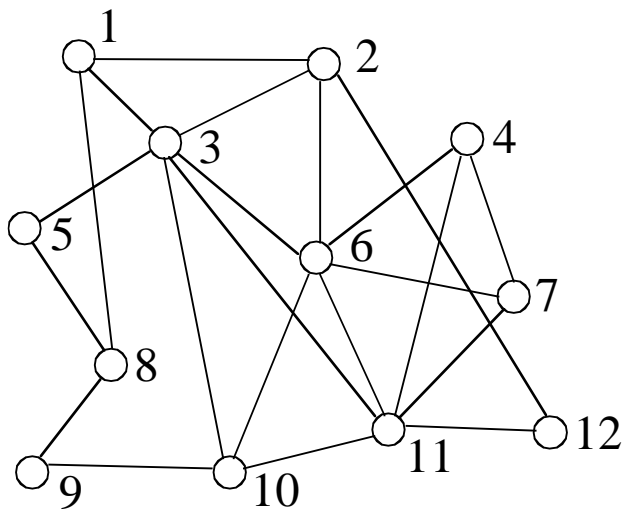
(137% instead of 2.6%)



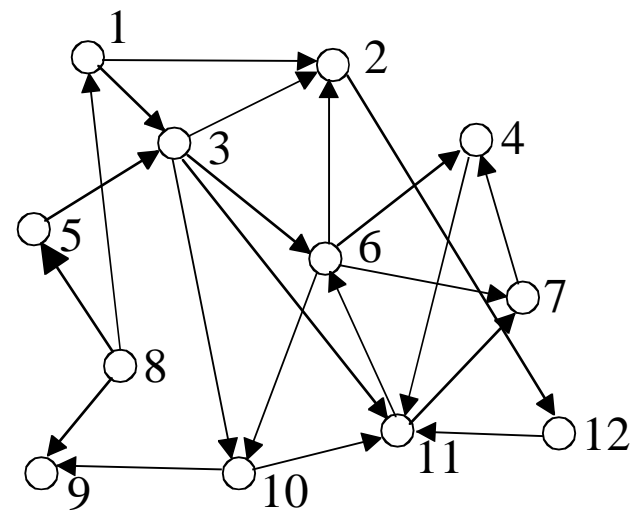
$c = 4, 6$ or 8 clusters, $l = 512$ fanals

Messages of $c \cdot \log_2(512) = 9c$ bits

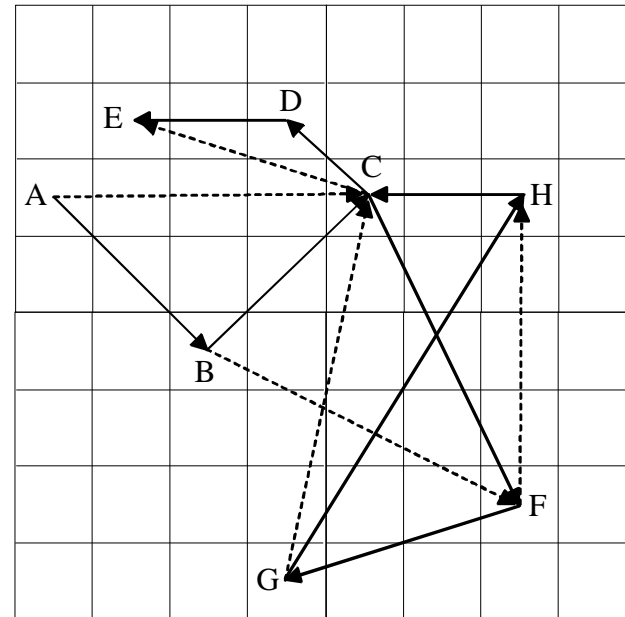
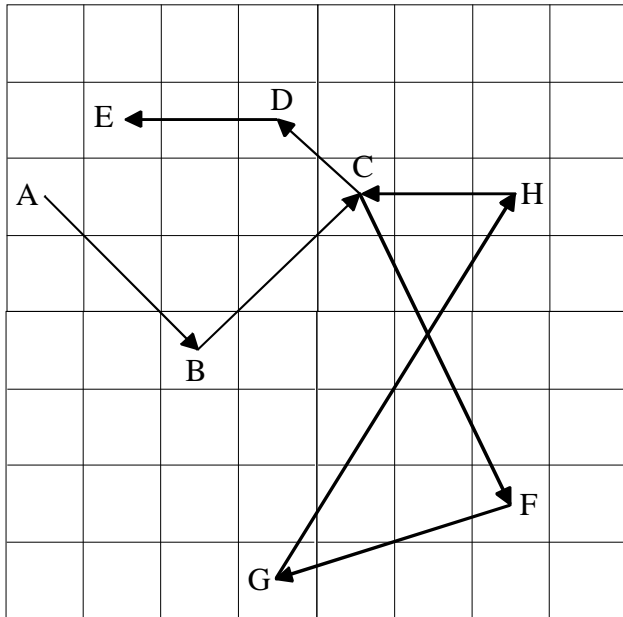


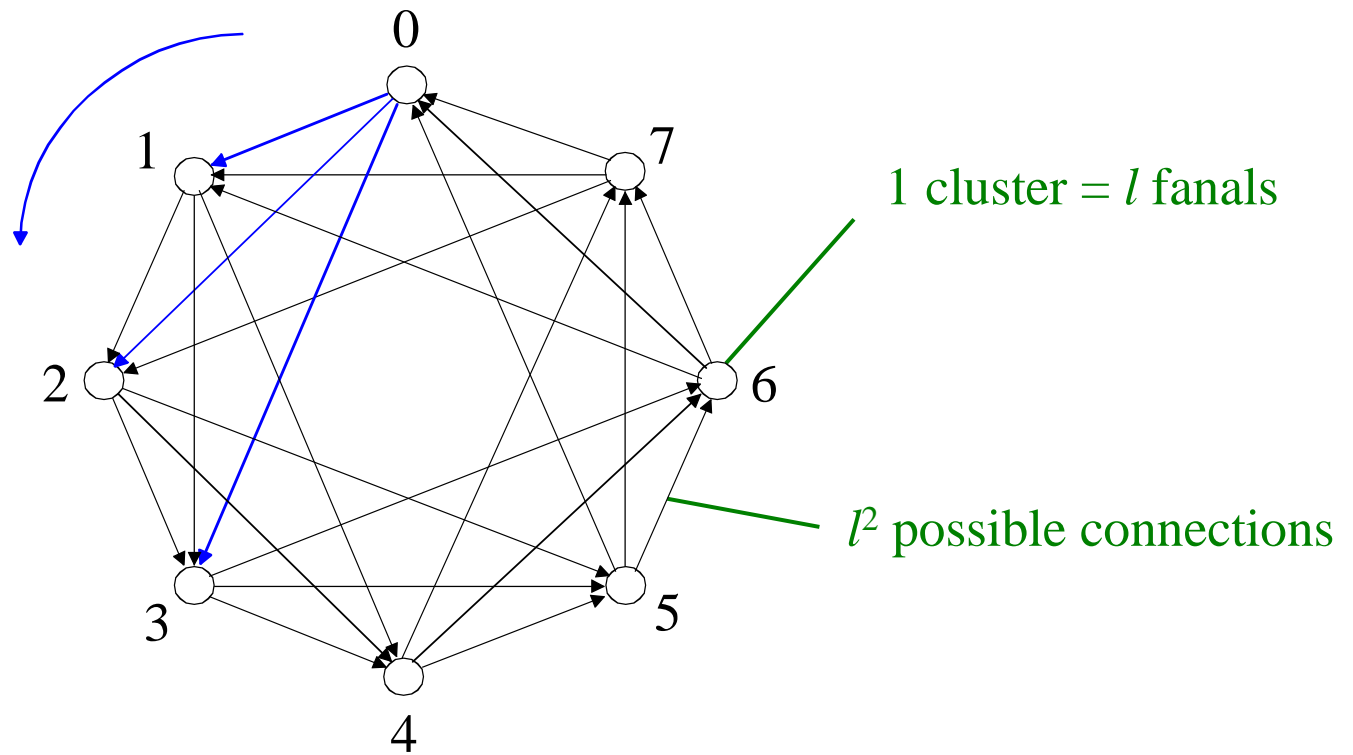


(a)



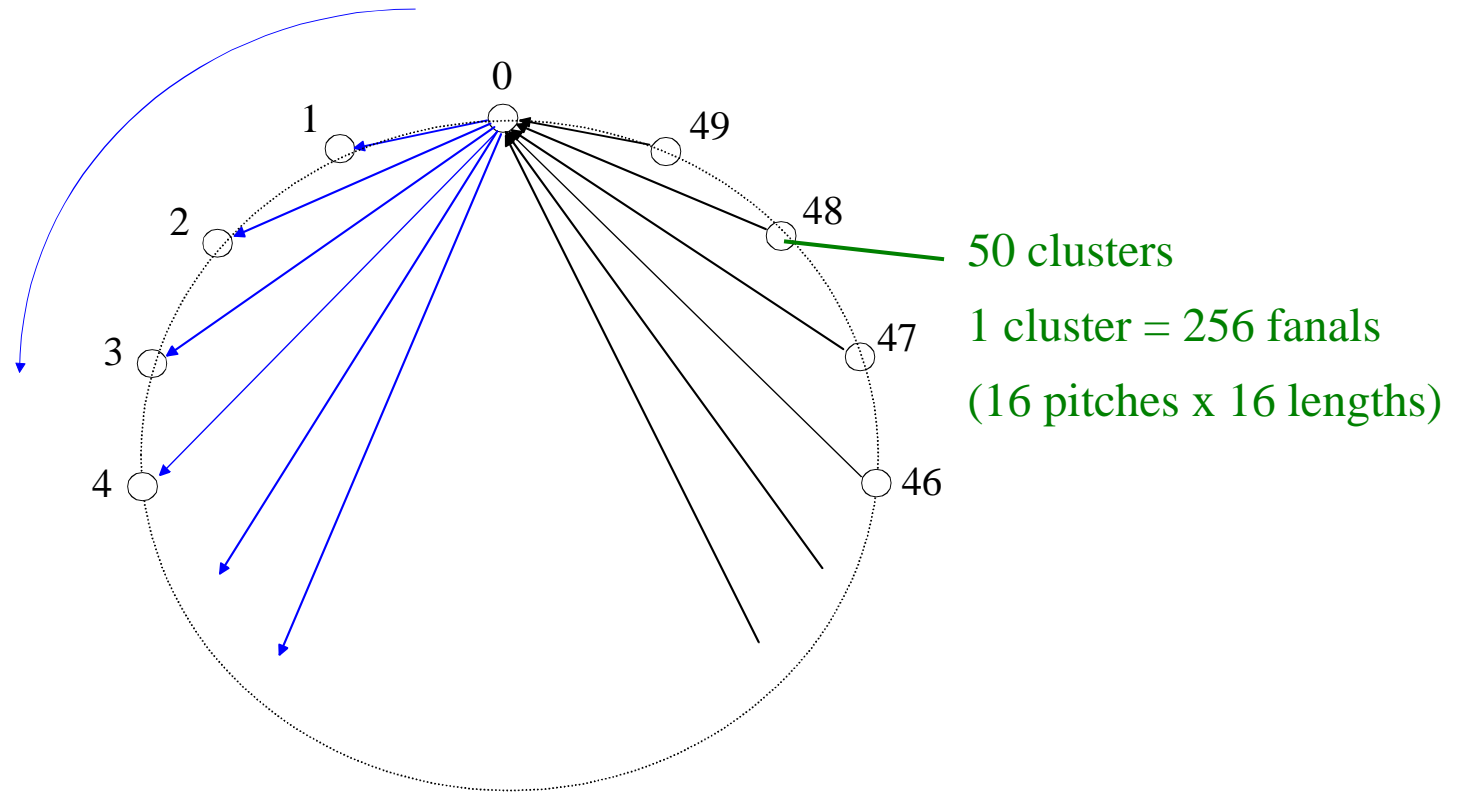
(b)





(not yet published)

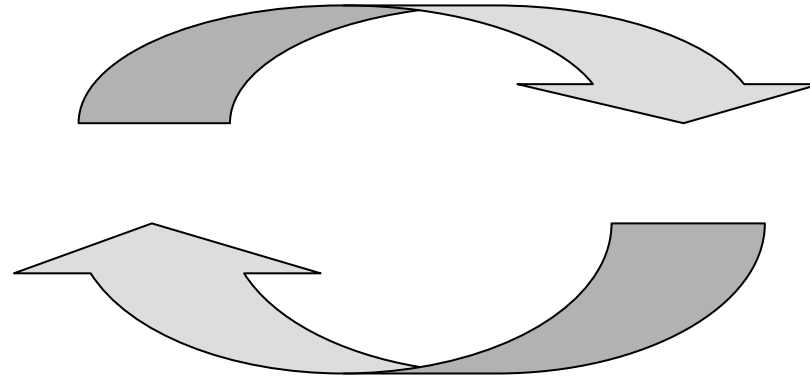
time overlapping
= 20



This network of 12800 fanals is able to learn 1800 pieces of music, each having 1000 notes and to retrieve each of them from the first 20 notes, with a failure rate of 10^{-2} .

That is a plausible explanation of the way the neocortex, **which is a graphical machine**, performs its sequential operations!

Conclusion



- **Implementing electronic machines having the ability to learn a lot of information and to produce new one by association, fusion, crossbreeding and deduction,**
- **Contributing to the understanding of the biological long and short term memories,**
- **Find applications to telecommunications**