BACK PROPAGATION ALGORITHM ON THE CONNECTION MACHINE

Xiru Zhang

Michael Mckenna

- Back propagation is the most widely used "neural network" learning algorithm.

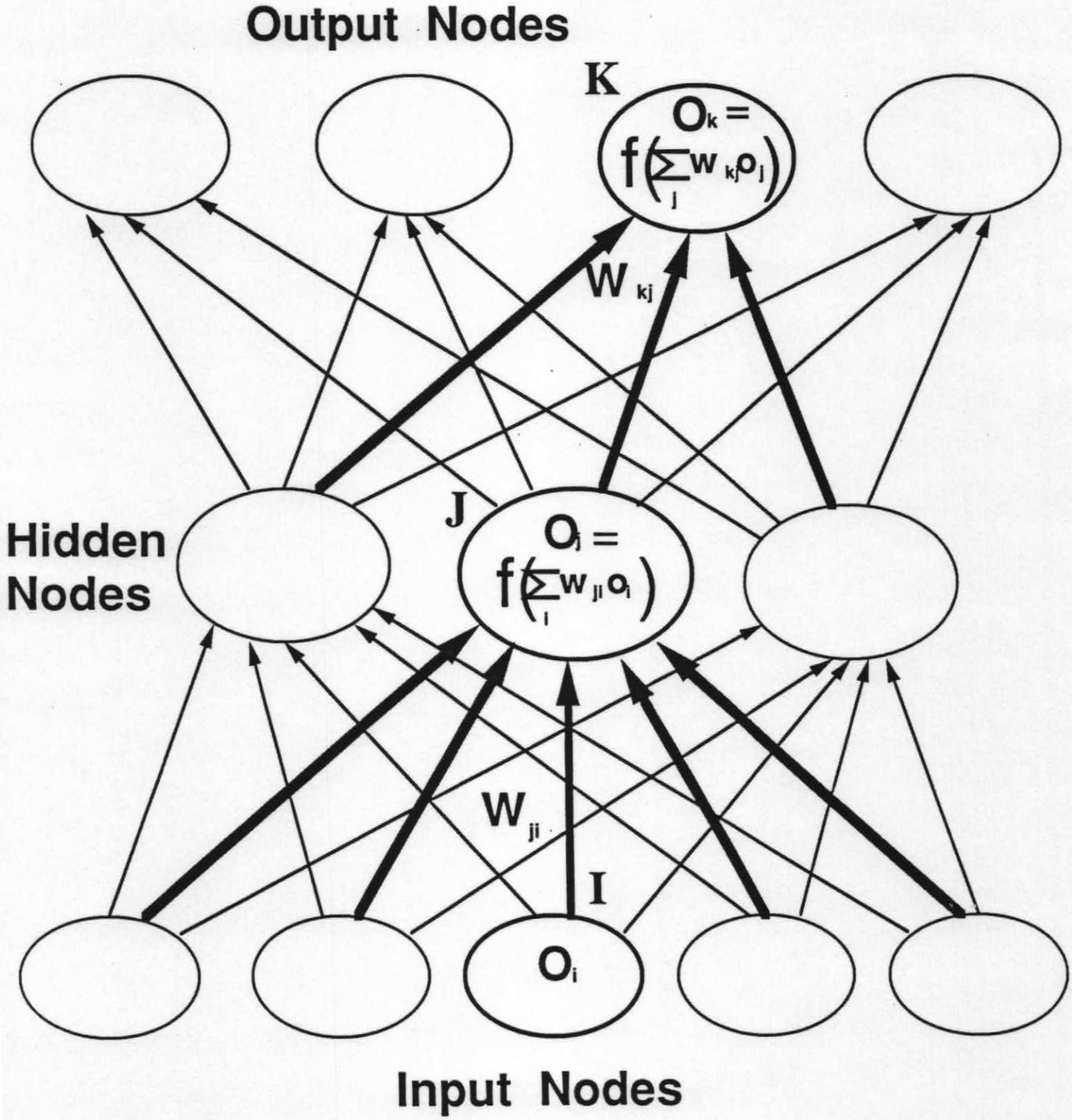
- The new CM implementation:

  - Use NEWS as main communication operations

  - > 40 million weight updates per second on a 64k CM

  - No special requirement (size, topology, etc.) is needed in order for a network to run at the above speed.

A Layered Network



THE ALGORITHM

1. Compute Output (forward pass):

$$O_j = f(\sum_i W_{ji} \cdot O_i)$$

where:

$f(x) = \frac{1}{1+e^{-x}}$;

O_j – the output of node J;

W_{ji} – the weight from node I to node J.

2. Compute Error (backward pass):

- For output layer:

$$\delta_k = O_k \cdot (1 - O_k) \cdot (T_k - O_k)$$

- For hidden layer(s):

$$\delta_j = O_j \cdot (1 - O_j) \cdot \sum_k W_{kj} O_j$$

where:

T_k – the ideal output for output node K;

δ_k – the error at output node K;

δ_j – the error at hidden node J;

W_{kj} – the weight from node J to node K.

3. Change Weights:

- For a particular training patter P:

$$\Delta W_{ji}^{p} = \eta \cdot \delta_{j}^{p} \cdot O_{i}^{p}$$

- Change weights after one cycle through all training patterns:

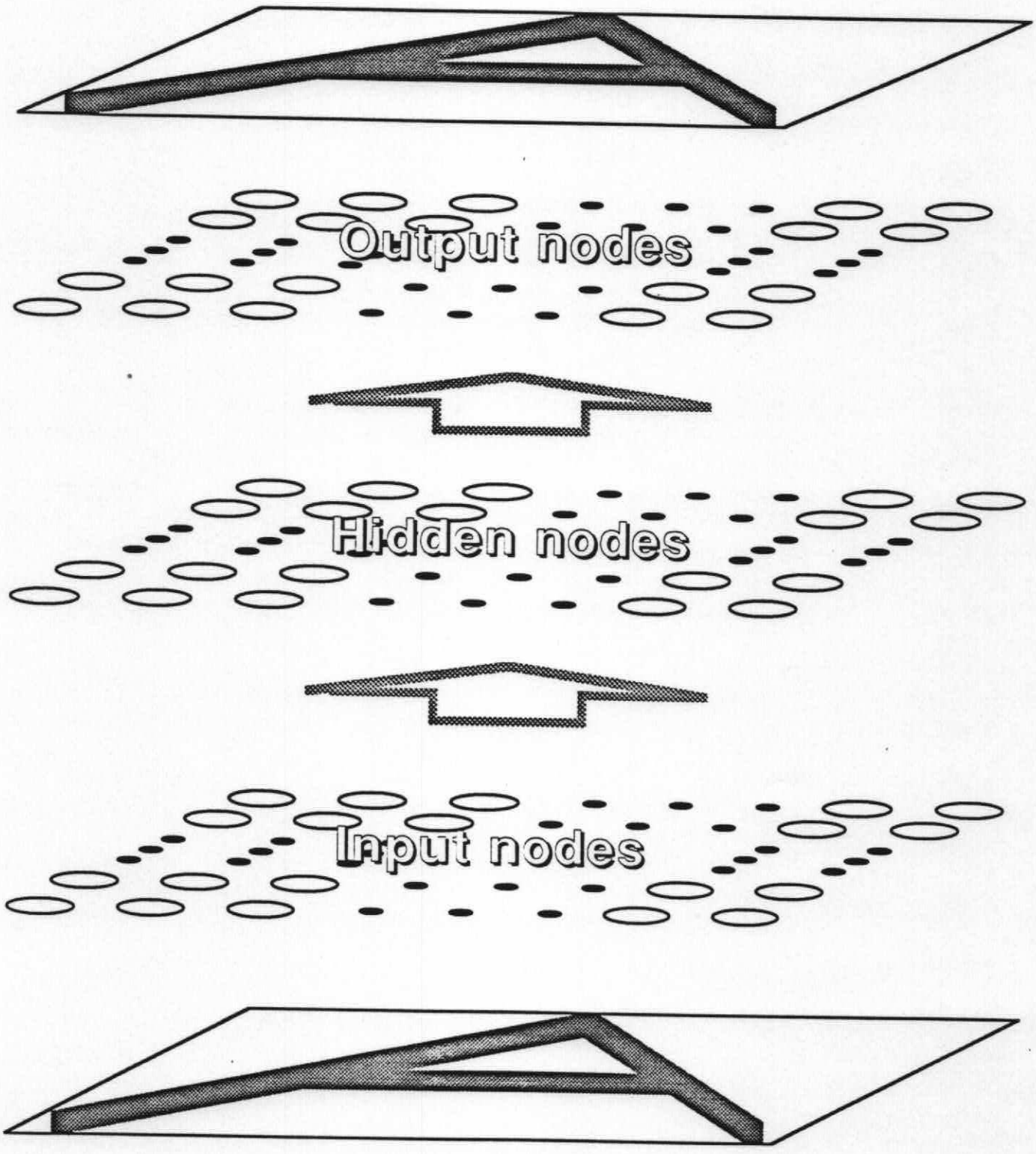
$$W_{ji} = W_{ji} + \sum_{p} \Delta W_{ji}^{p}$$

where:

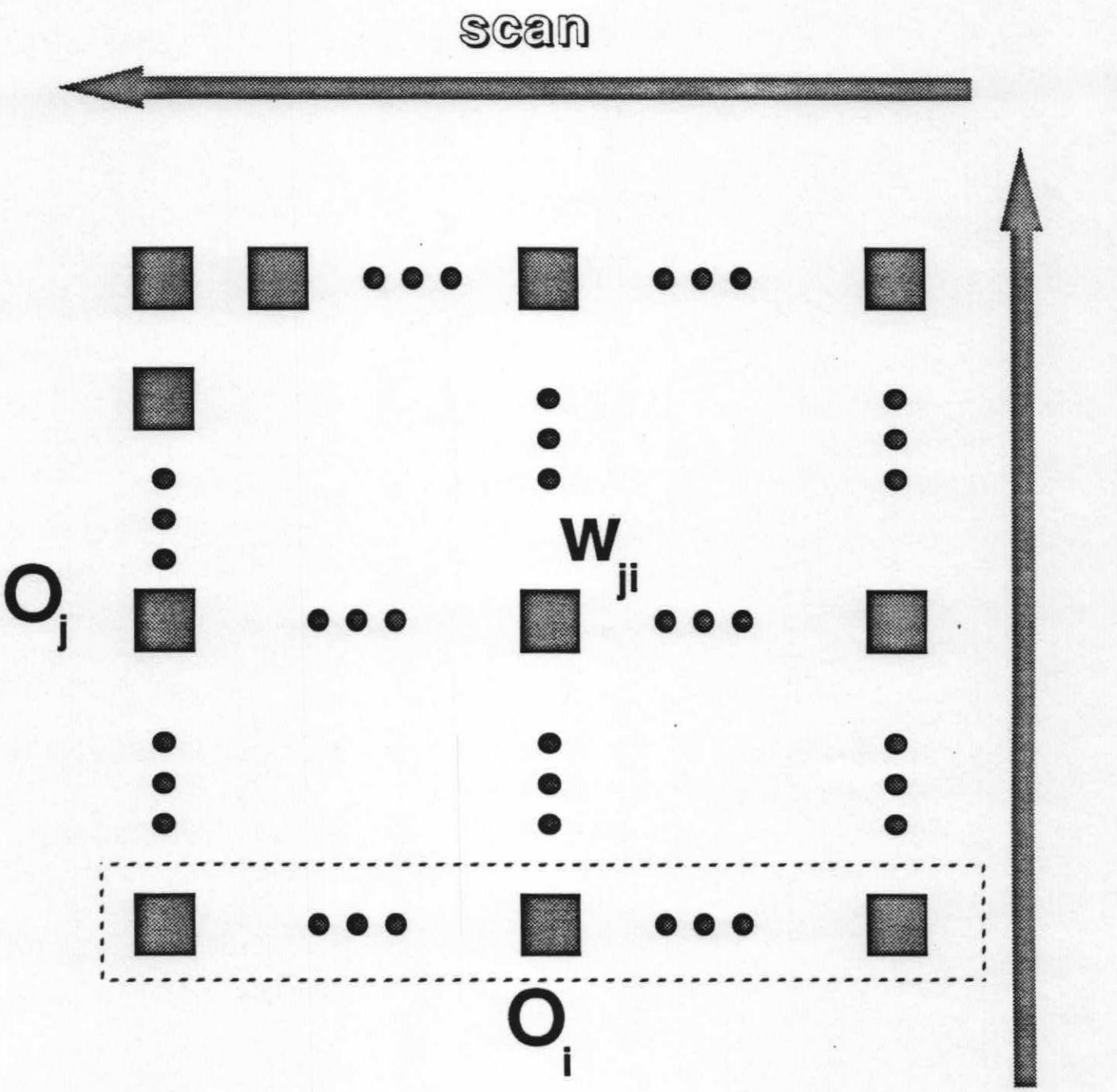
η – learning rate;

ΔW_{ji}^{p} – weight change caused by a training pattern.

Example: Character Mapping

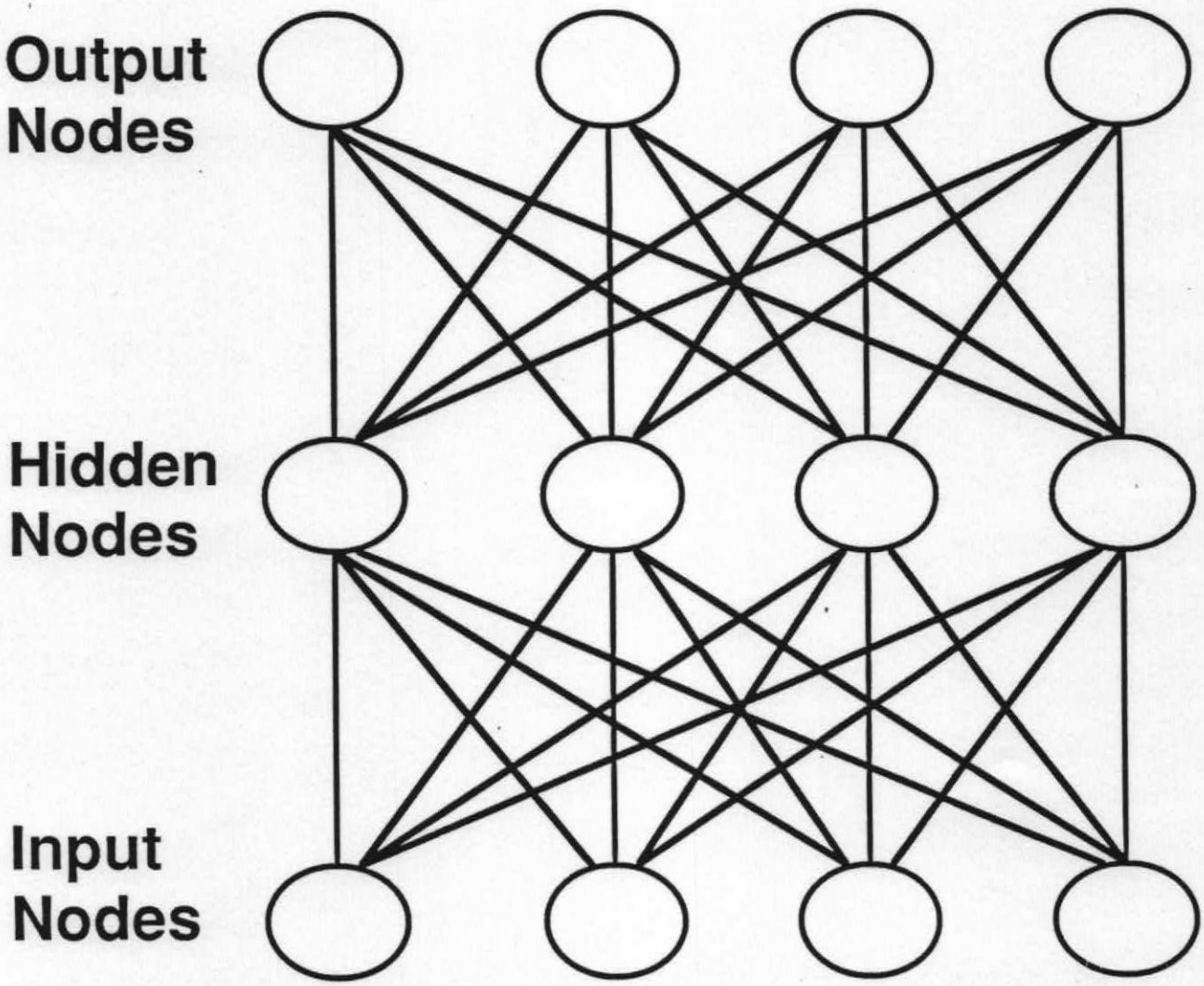


The Old Implementations



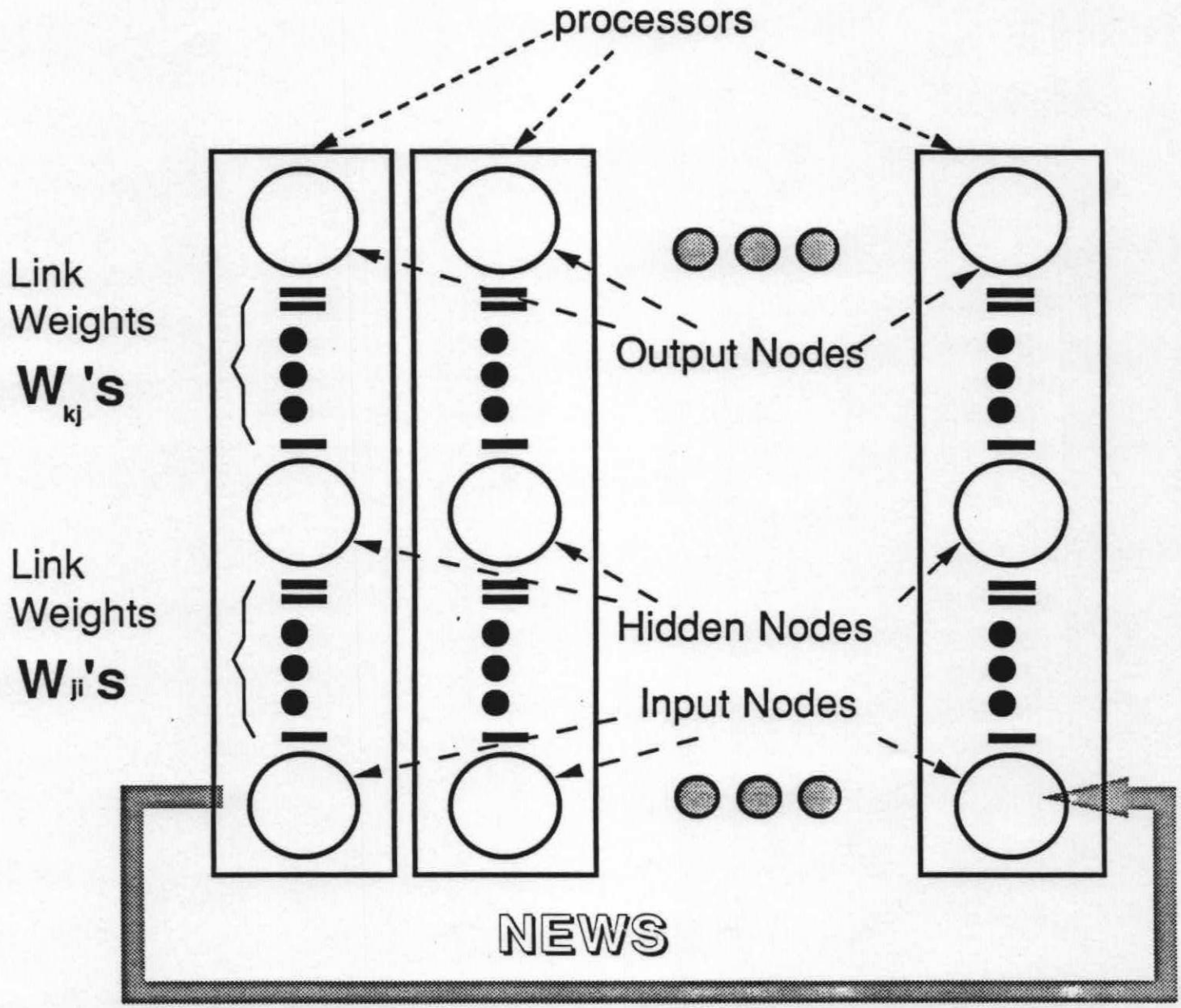
{ Spread, Multiply, Scan }$^+$

A Simple Network



The New Implementation

- **The simplest case**



{ Multiply, News, Add }$^{+}$

The New Implementation

- **Replicated networks**
- **Shared weights**