or, equivalently

$$W(z) = X(z) - (a_1 z^{-1} + a_2 z^{-2} + \cdots + a_M z^{-M})W(z)$$
$$Y(z) = (b_0 + b_1 z^{-1} + \cdots + b_L z^{-L})W(z)$$

which become in the time domain:

$$\boxed{\begin{aligned} w(n) &= x(n) - a_1 w(n-1) - \cdots - a_M w(n-M) \\ y(n) &= b_0 w(n) + b_1 w(n-1) + \cdots + b_L w(n-L) \end{aligned}} \tag{7.2.3}$$

The block diagram realization of this system is shown in Fig. 7.2.4 for the case $M = L$. If $M \neq L$ one must draw the *maximum* number of common delays, that is, $K = \max(M, L)$. Defining the internal states by

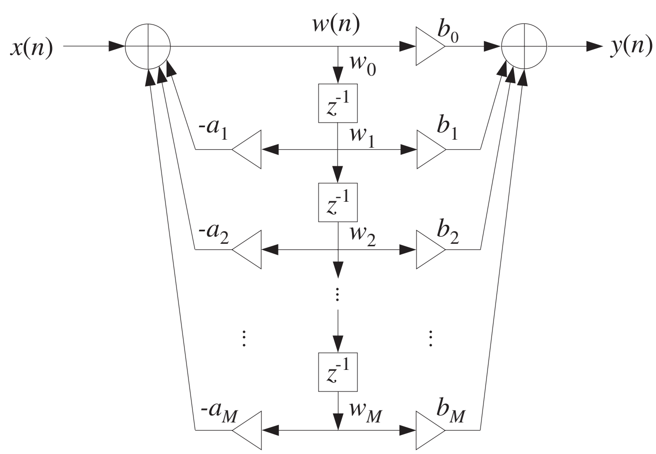

Fig. 7.2.4 Canonical realization form of Mth order IIR filter.

$$w_i(n) = w(n-i) = w_{i-1}(n-1), \quad i = 0, 1, \ldots, K$$

we may rewrite the system (7.2.3) in the form:

$$\boxed{\begin{aligned} w_0(n) &= x(n) - a_1 w_1(n) - \cdots - a_M w_M(n) \\ y(n) &= b_0 w_0(n) + b_1 w_1(n) + \cdots + b_L w_L(n) \\ w_i(n+1) &= w_{i-1}(n), \quad i = K, K-1, \ldots, 1 \end{aligned}} \tag{7.2.4}$$

This leads to the following sample-by-sample filtering algorithm:

$$\boxed{\begin{aligned} &\textit{for each input sample } x \textit{ do:} \\ &\quad w_0 = x - a_1 w_1 - a_2 w_2 - \cdots - a_M w_M \\ &\quad y = b_0 w_0 + b_1 w_1 + \cdots + b_L w_L \\ &\quad w_i = w_{i-1}, \quad i = K, K-1, \ldots, 1 \end{aligned}} \tag{7.2.5}$$