ENPM 603
Theory and Applications of Digital Signal Processing

DFT Filter Banks with Polyphase Decomposition
(A Discussion of the Term Project)

Emre Gunduzhan

Spectral Notching by MDFT Filter Banks

> Goal is suppressing narrowband interference by using Modified DFT (MDFT) filter banks.
  - Separate the distorted signal into its subbands
  - Analyze the subbands to find which ones are distorted vs clean
  - Discard portions of the distorted subbands and combine the clean ones to reconstruct the signal

> MDFT filter banks can be used for subband decomposition with almost perfect or perfect reconstruction.

> The filter banks can also be implemented efficiently using polyphase decomposition.

Project Steps

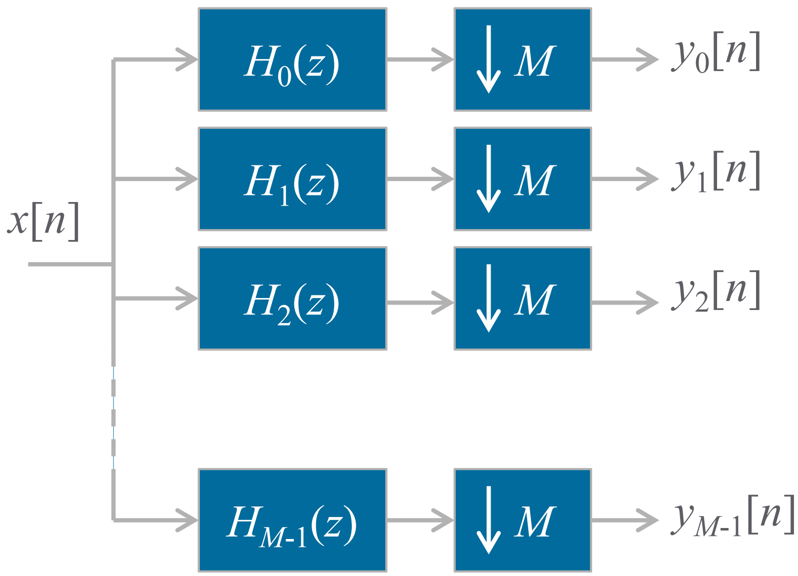
> Read the reference to understand MDFT operation with polyphase implementation (figures 6, 9-12).

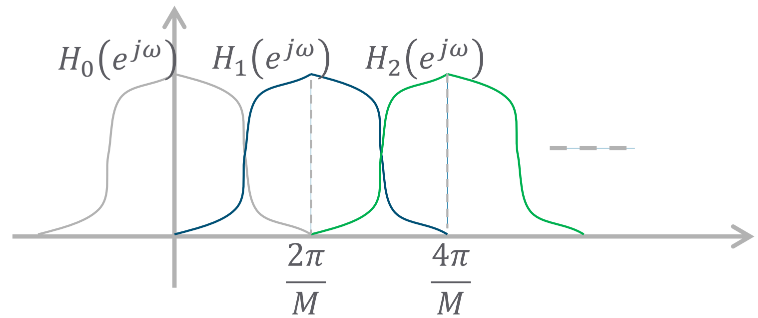
> Implement polyphase MDFT analysis and synthesis in MATLAB for 64 subband channels (i.e., M=64) by choosing an appropriate prototype filter.

> Implement spectral notching. The simplest way would be comparing the average power in each subband channel with a threshold, and replacing that signal by zeros if the average power exceeds the threshold. The thresholds for each subband channel will be given.

> Use your implementation to filter the given distorted signals.

DFT Filter Banks





$$H_k(e^{j\omega}) = H_0(e^{j(\omega - \frac{2\pi k}{M})})$$

$$h_k[n] = h_0[n]e^{j\frac{2\pi k}{M}n}$$

> Each filter is obtained by modulating the chosen prototype filter.

> Each filter passes a different frequency channel, which may have some overlap with the adjacent channels.

Prototype Filter

> Causal linear-phase FIR filter.

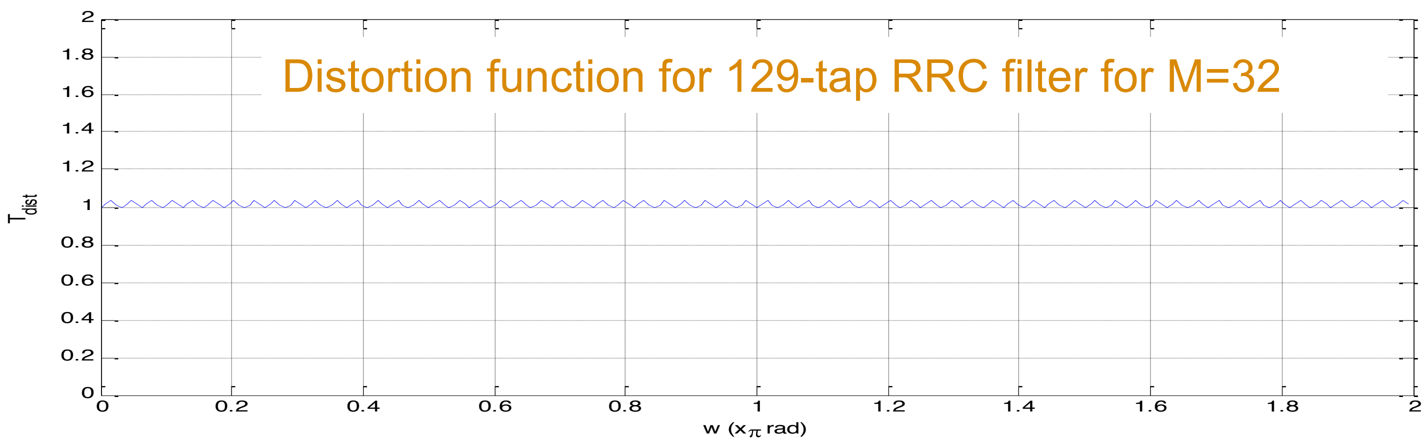
> Selection of the prototype filter impacts filter bank performance.

> Negligible distortion and small aliasing are desired

$$|T_{dist}(e^{j\omega})| = |\frac{1}{M}\sum_{k=0}^{M-1} H_k{}^2(e^{j\omega})| \approx 1$$

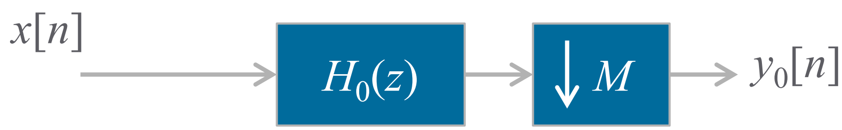
$$|T_{alias}(e^{j\omega})| = \left(\sum_{l=1}^{M-1} |\frac{1}{M}\sum_{k=0}^{M-1} H_k(e^{j\omega})H_k(e^{j(\omega-\frac{2\pi l}{M})})|^2\right)^{1/2} \approx 0$$

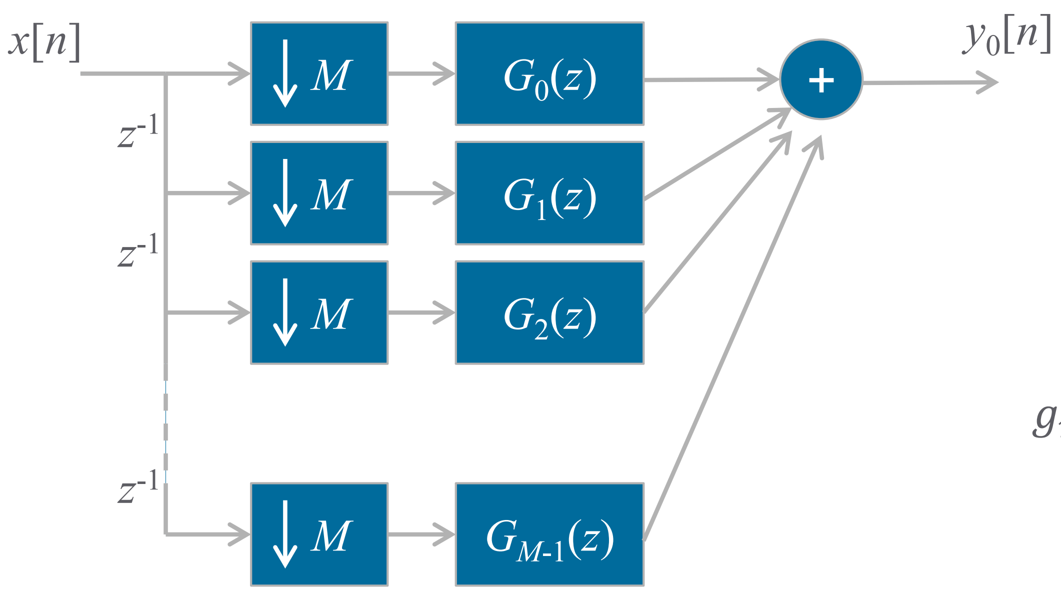
> The reference paper suggests 65-tap root raised-cosine filter for M=8, or provides coefficients of a 4M-tap filter for M=4, 8, 16, or 32.



Efficient Implementation Using Polyphase Decomposition

Recall that the following two structures are equivalent:

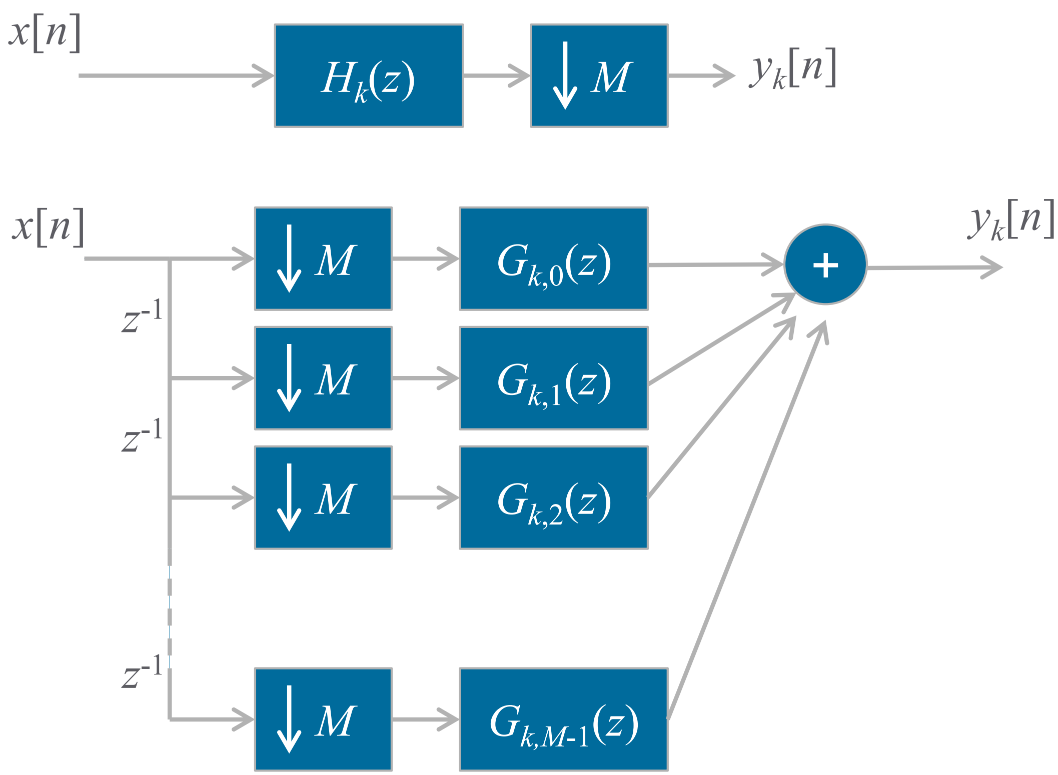




$$g_m[n] = h_0[nM + m]$$

Efficient Implementation Using Polyphase Decomposition (cont'd)

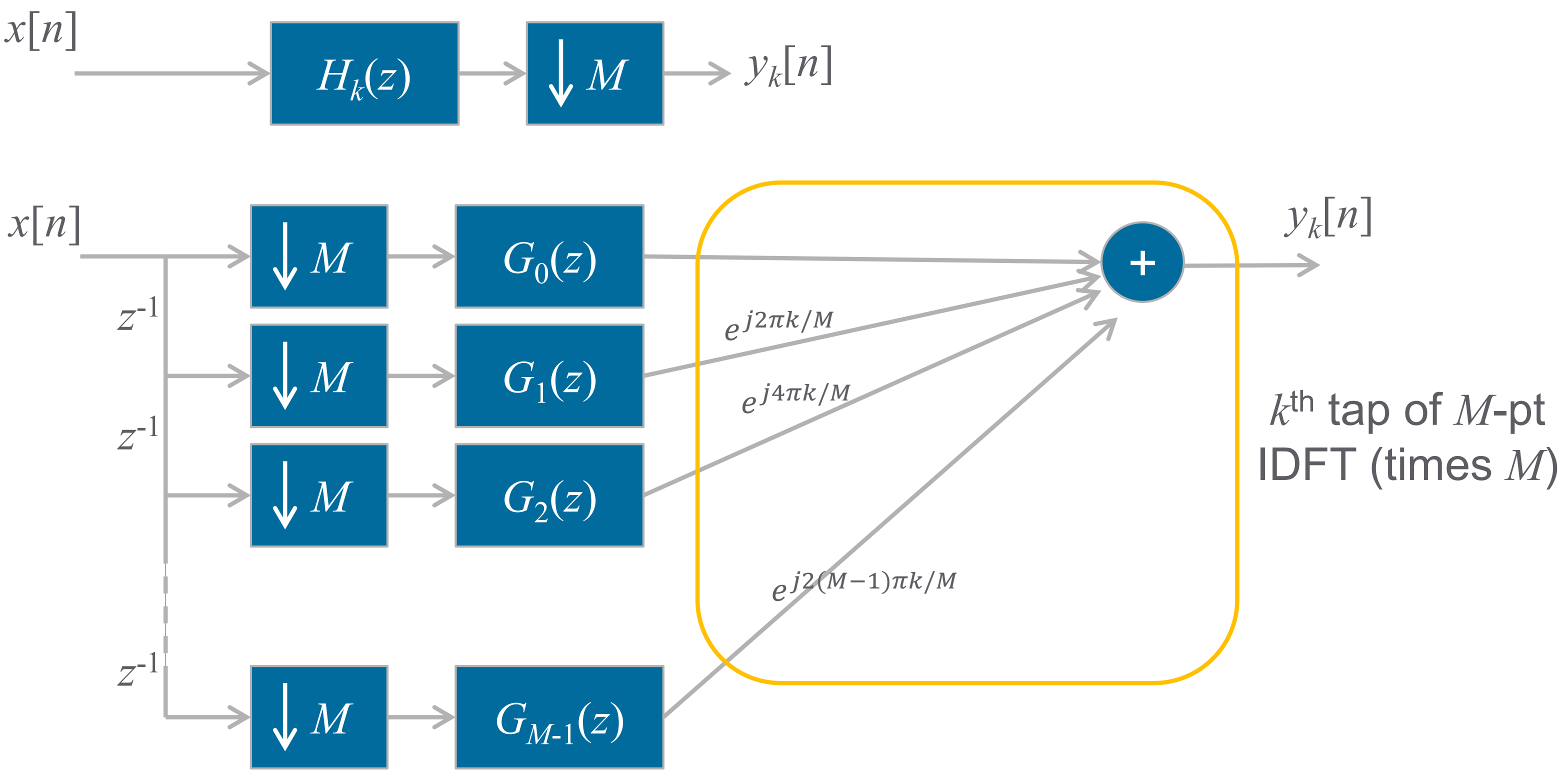
For DFT banks we can generalize the decomposition as follows:



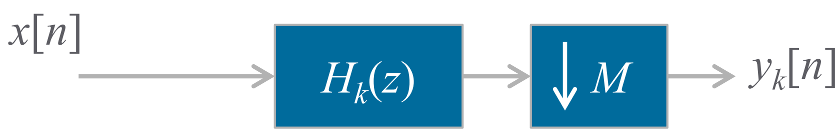
Polyphase filters are modulated versions of the k=0 polyphase filters

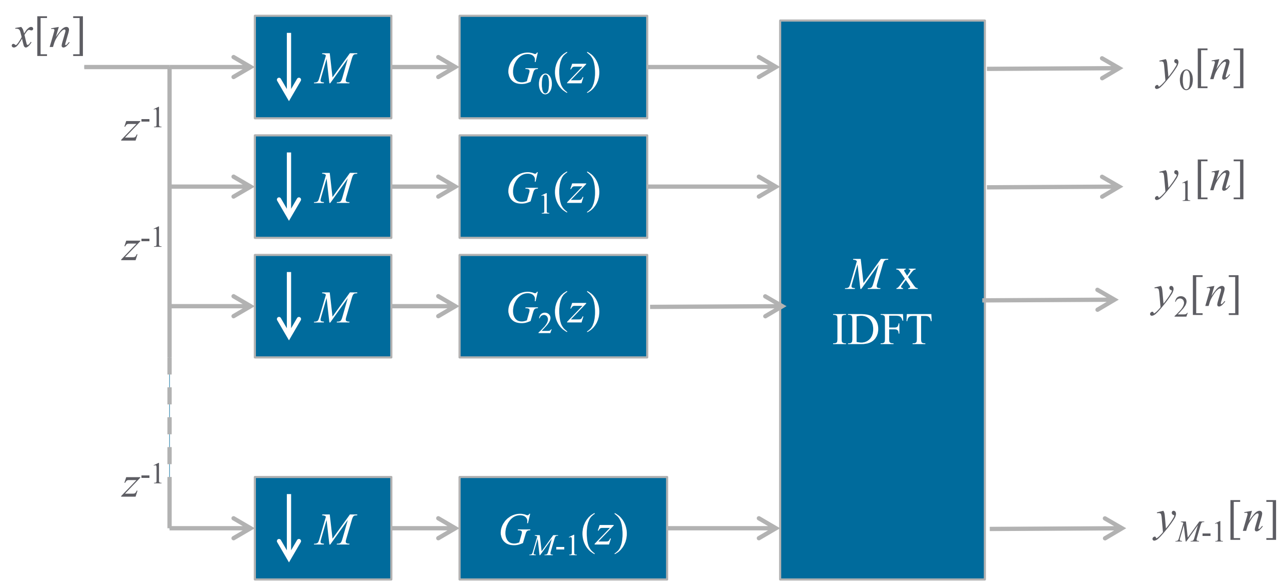
$$g_{k,m}[n] = h_k[nM+m] = h_0[nM+m]e^{j\frac{2\pi k}{M}(nM+m)} = g_m[n]e^{j\frac{2\pi k}{M}m}$$

Realization Using DFT

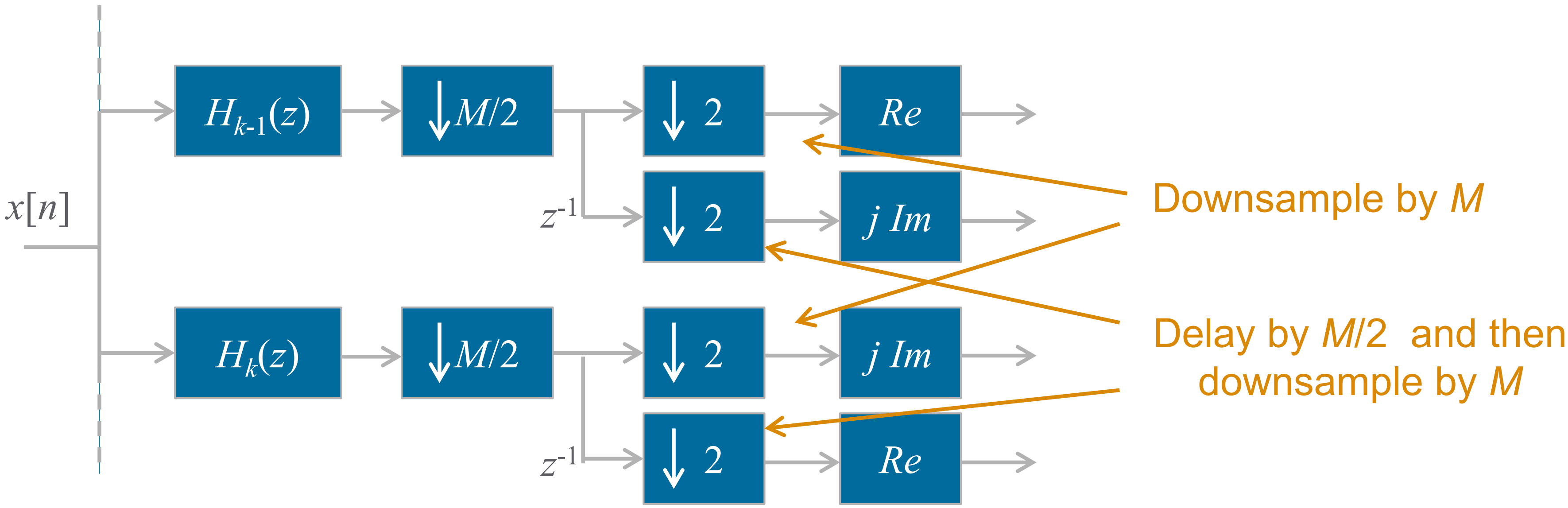


Realization Using DFT (cont'd)





Modified DFT Filter Banks



> DFT filter banks do not cancel aliasing.

> MDFT filter banks use two-step decimation and compensates aliasing from adjacent spectra (see derivation for Eqn 24 in the paper).

> Similar to DFT filter banks, efficient polyphase realization exists (see Figures 6 and 9 in the paper).