

# Idea (1A)

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- Time Multiplexed Architecture
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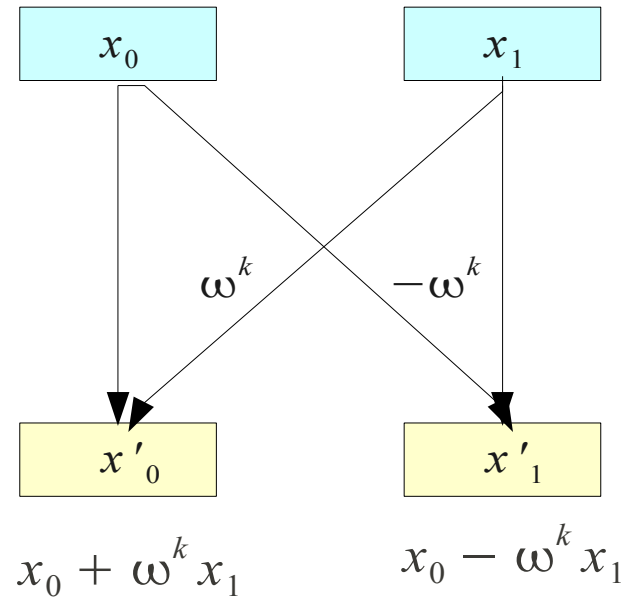
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# The Butterfly Operations

$$x'_0 = x_0 + \omega^k x_1$$

$$x'_1 = x_0 - \omega^k x_1$$



# The Butterfly Time Multiplexed Operations (1)

$$\begin{cases} x'_0 = x_0 + \omega^k x_1 \\ x'_1 = x_0 - \omega^k x_1 \end{cases}$$

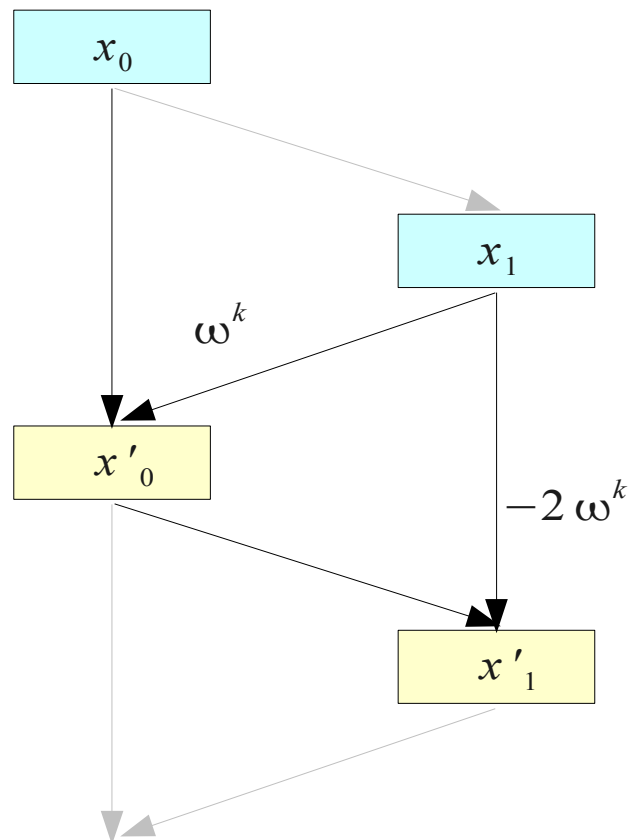
$$x'_0 = x_0 + \omega^k x_1$$

$$x_0 = x'_0 - \omega^k x_1$$

$$x'_1 = x_0 - \omega^k x_1$$

$$\rightarrow x'_1 = x'_0 - \omega^k x_1 - \omega^k x_1$$

$$x'_1 = x'_0 - 2\omega^k x_1$$



# The Butterfly Time Multiplexed Operations (2)

$$\begin{cases} x'_0 = x_0 + \omega^k x_1 \\ x'_1 = x_0 - \omega^k x_1 \end{cases}$$

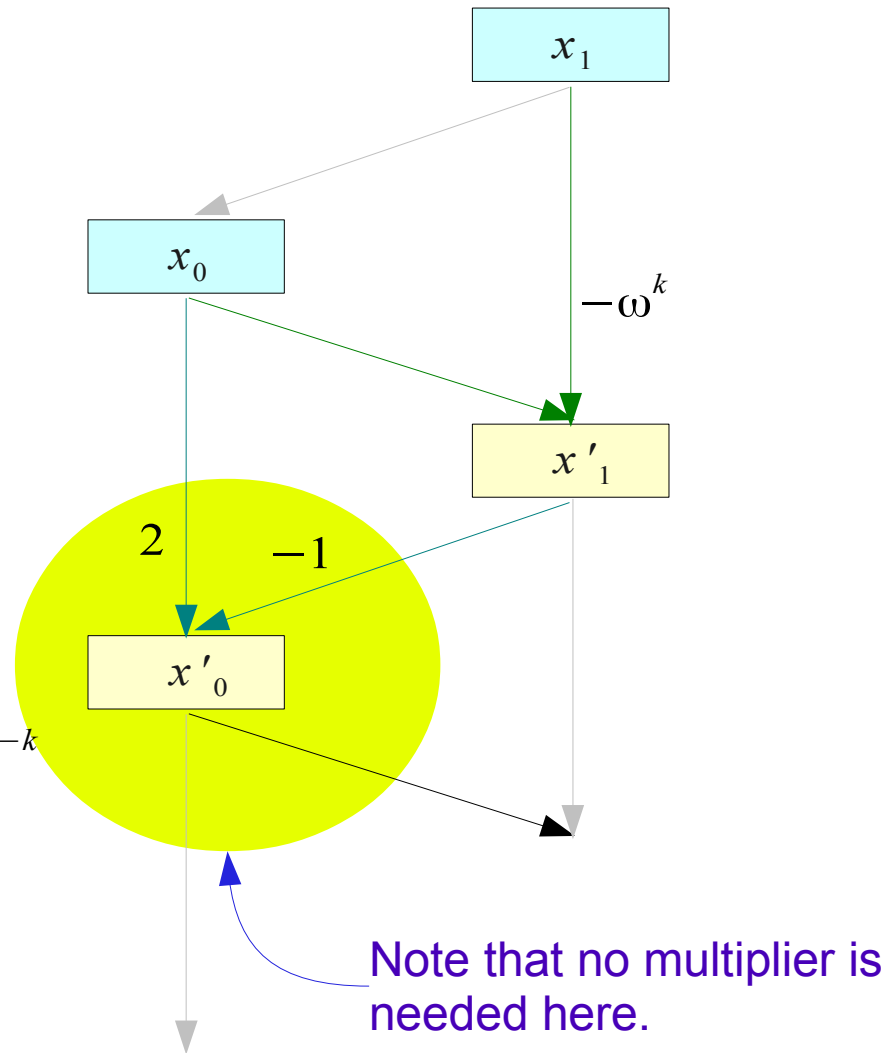
$$x'_1 = x_0 - \omega^k x_1$$

$$x_1 = (x_0 - x'_1)\omega^{-k}$$

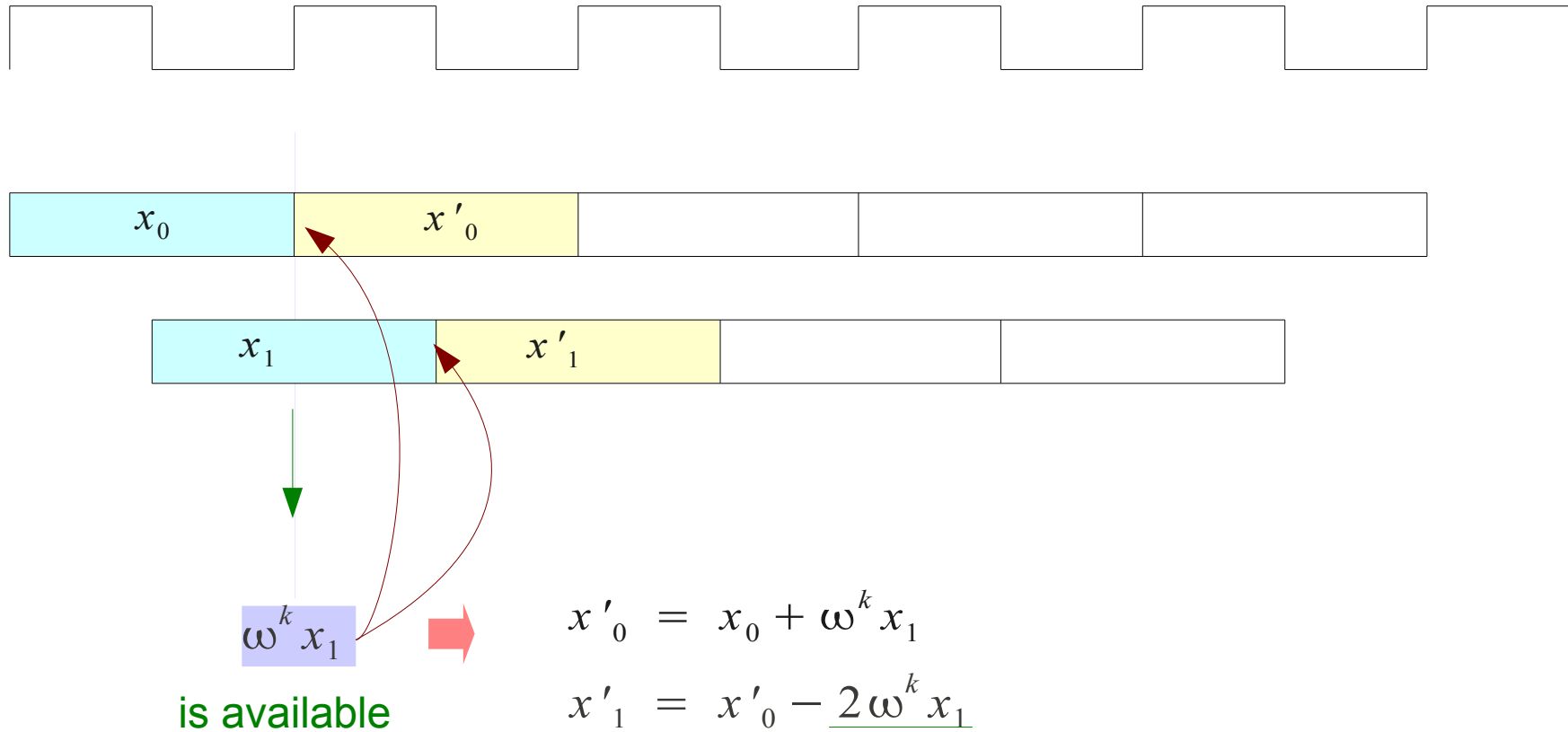
$$x'_0 = x_0 + \omega^k x_1$$

$$\rightarrow x'_0 = x_0 + \omega^k (x_0 - x'_1)\omega^{-k}$$

$$x'_0 = 2x_0 - x'_1$$



# The Butterfly Operations



only one multiplier  
is needed

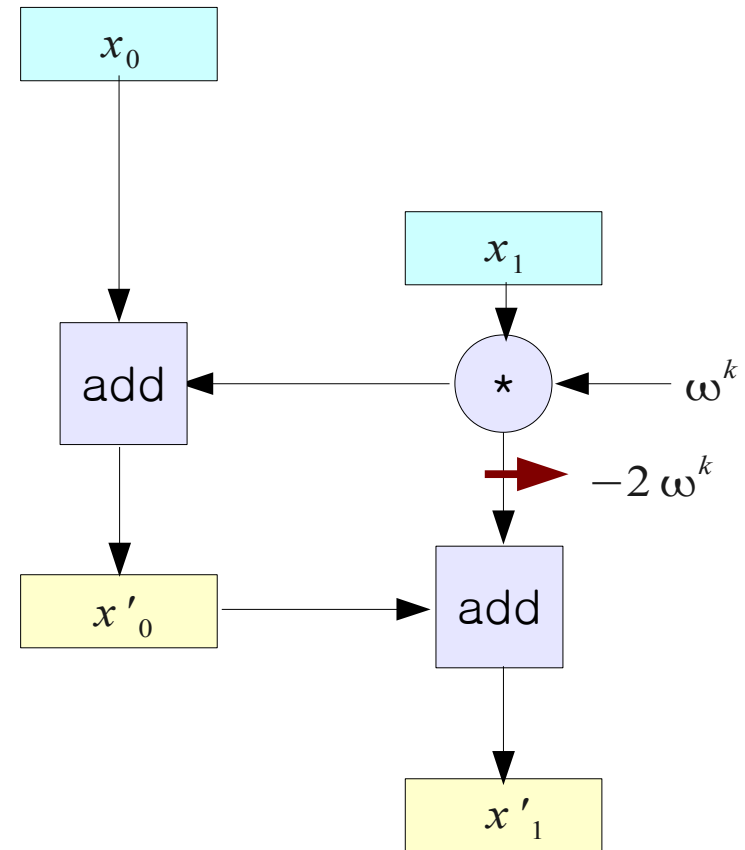
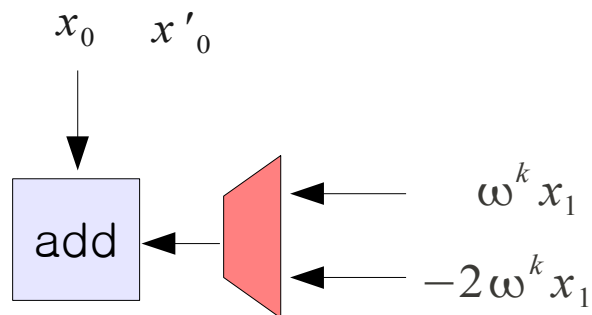
Shift left  $\rightarrow$  wiring

# The Butterfly Operations

$$\begin{cases} x'_0 = x_0 + \omega^k x_1 \\ x'_1 = x_0 - \omega^k x_1 \end{cases}$$

$$x'_0 = x_0 + \omega^k x_1$$

$$x'_1 = x'_0 - 2\omega^k x_1$$



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Combining CORDIC architecture ?

Some background survey on CORDIC + FFT Architecture

Different level of parallelism

High fanout – mux , adder







## References

- [1] <http://en.wikipedia.org/>
- [2] J.H. McClellan, et al., Signal Processing First, Pearson Prentice Hall, 2003
- [3] A “graphical interpretation” of the DFT and FFT, by Steve Mann