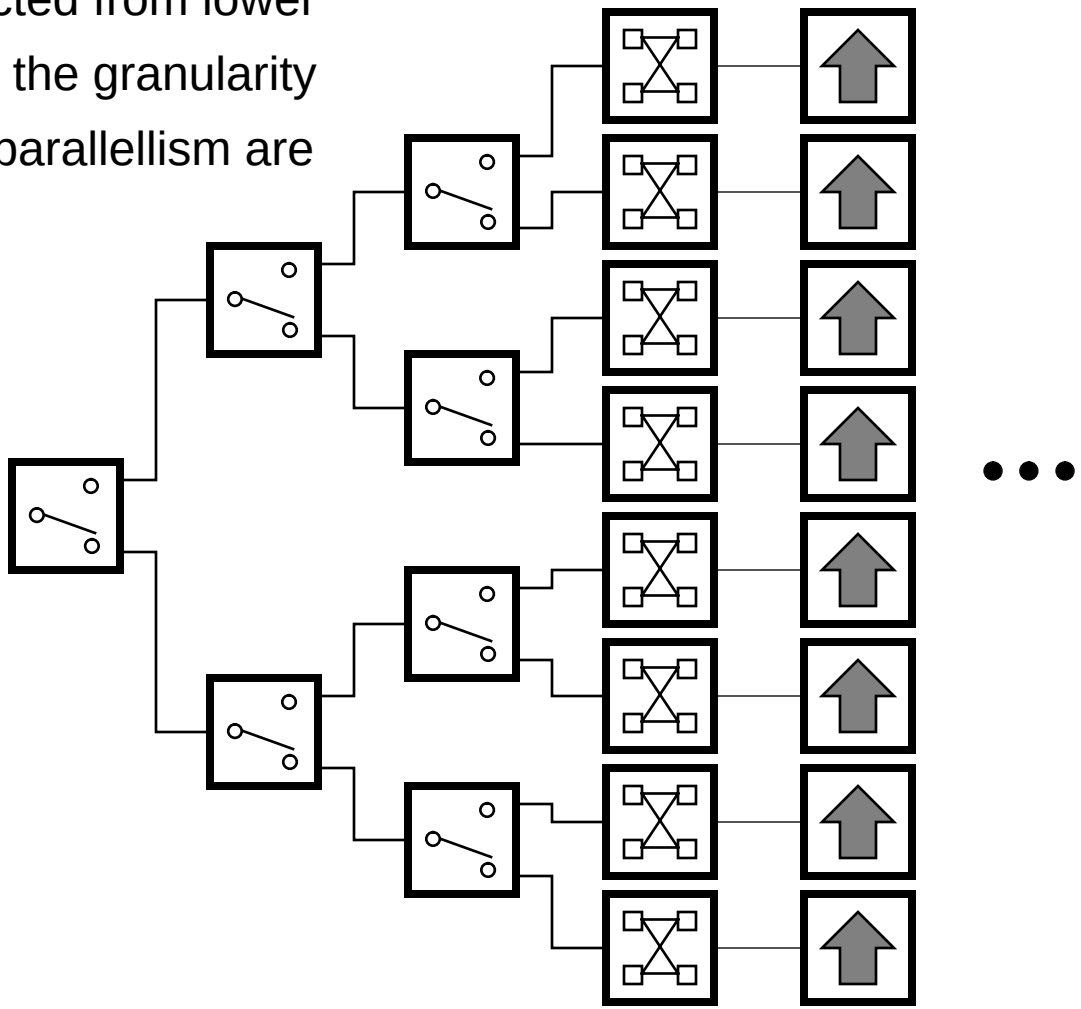
Conclusions

Advantages of higher-order functions:

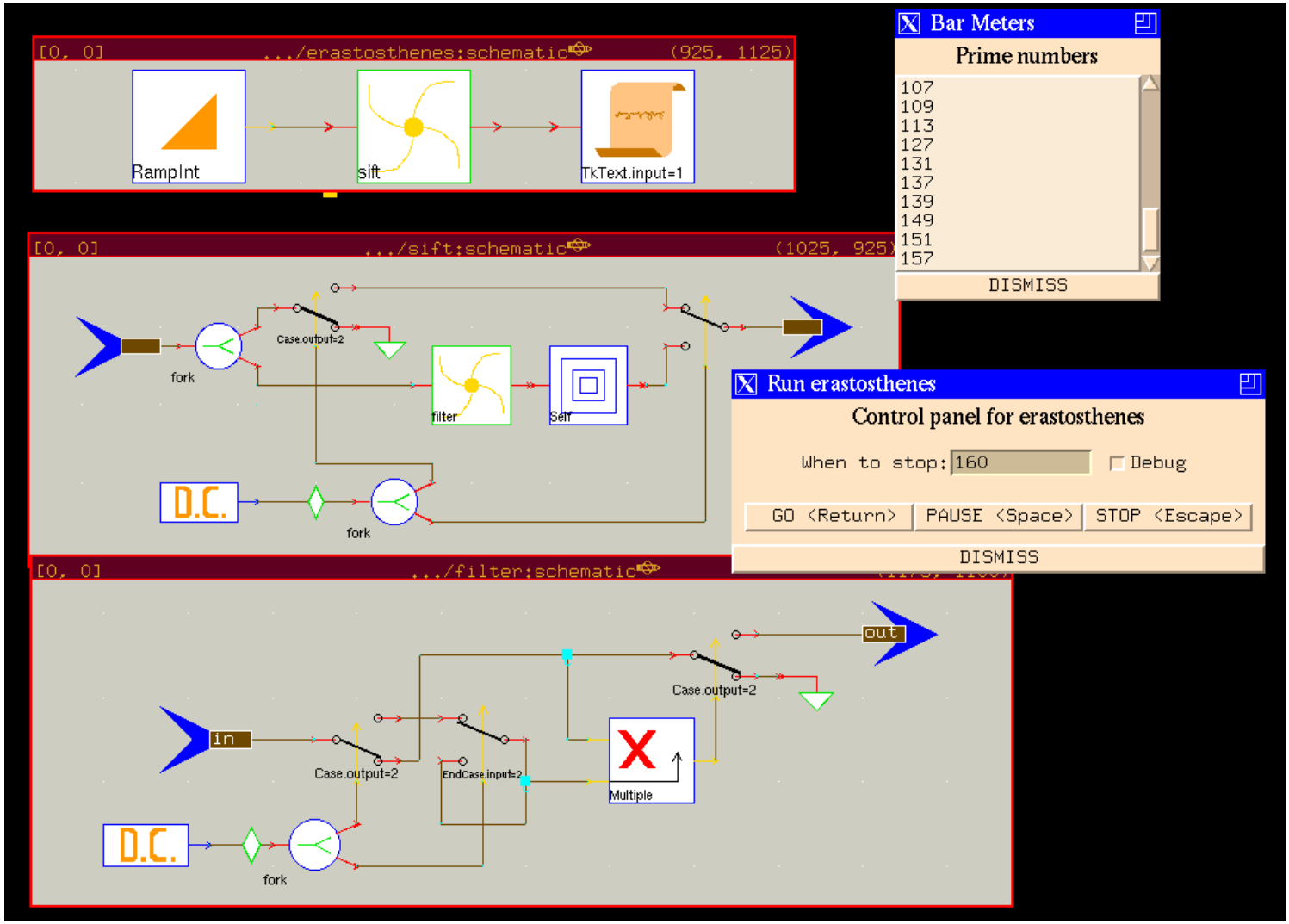
- **Parameterizable parallelism**
- **Improved program modularity**
- **Scalable programming**
- **Recursion**
- **Zero run-time cost in most cases**
- **Expressiveness of a visual syntax**

In SDF, recursion is statically unrolled

In our example, a high-order FFT is constructed from lower order FFTs. So the granularity and degree of parallellism are parameterized.

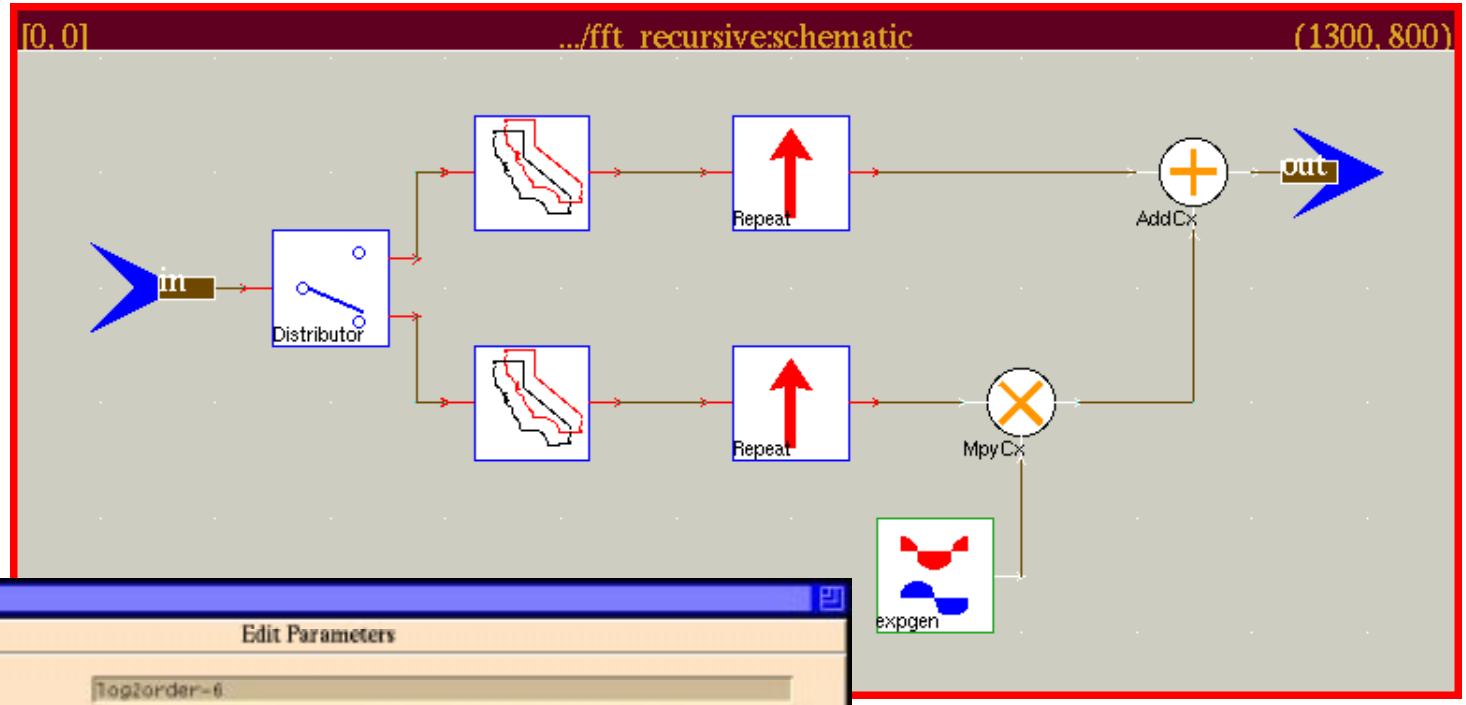


Using Map for Recursion in Dynamic Dataflow



The “sieve of Erastosthenes” is a highly irregular recursive algorithm for computing prime numbers. The DDF domain in Ptolemy can model algorithms of this type.

Using IfThenElse for Recursion

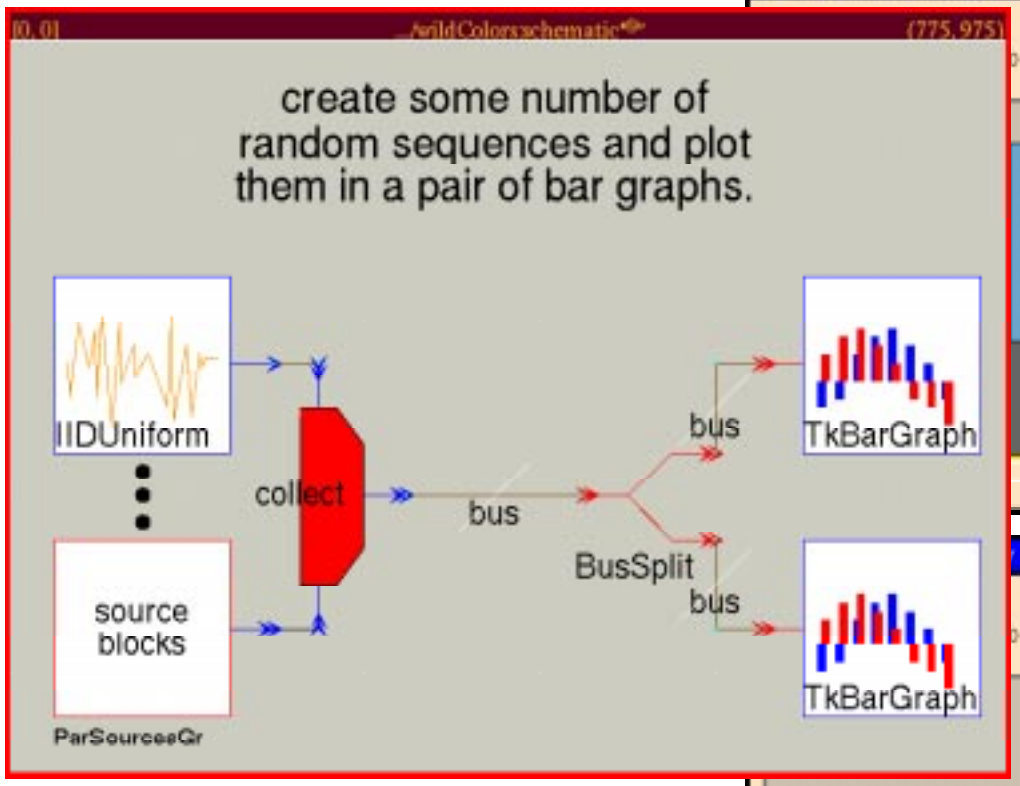


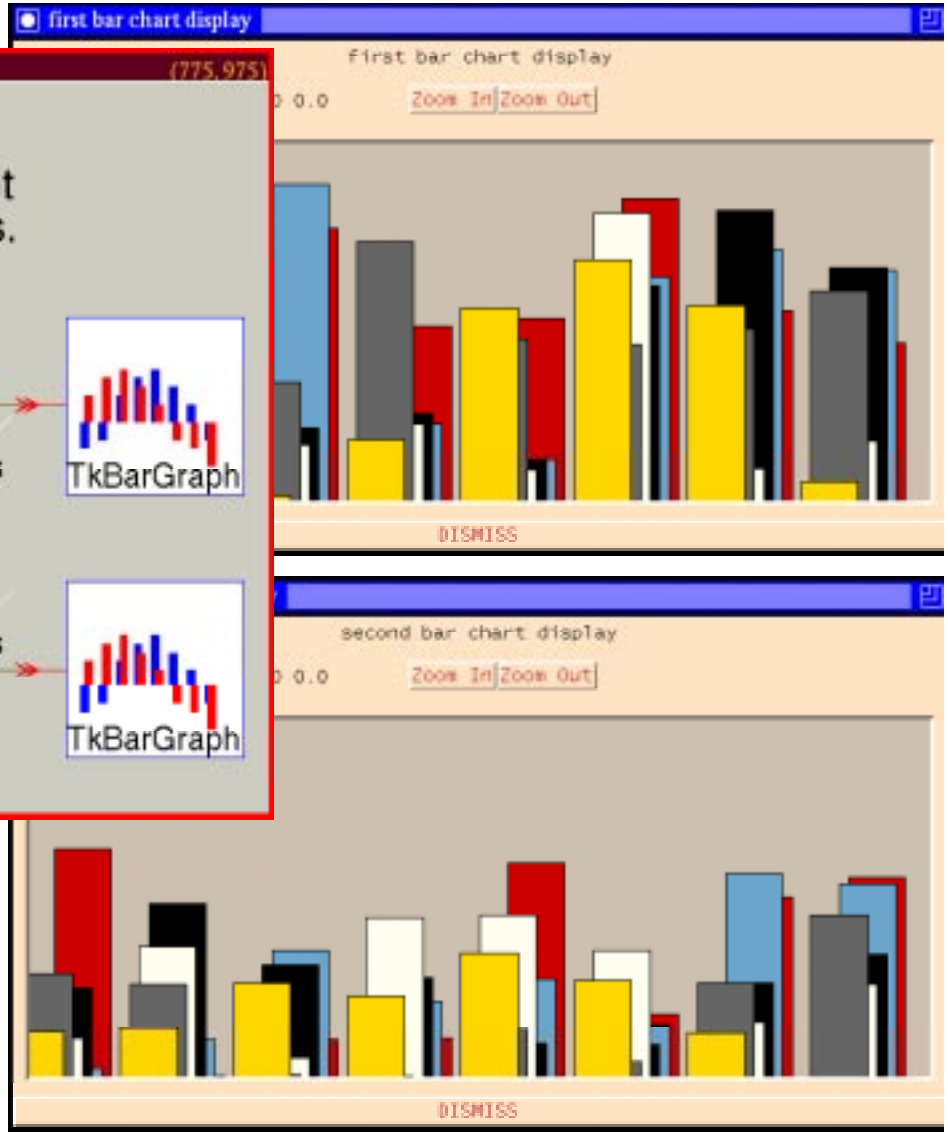
Recursive FFT

granularity of the bottom-level operation is arbitrary

recursion can be unraveled at compile time, avoiding any run-time overhead

Generalization of Map to Signal Sources



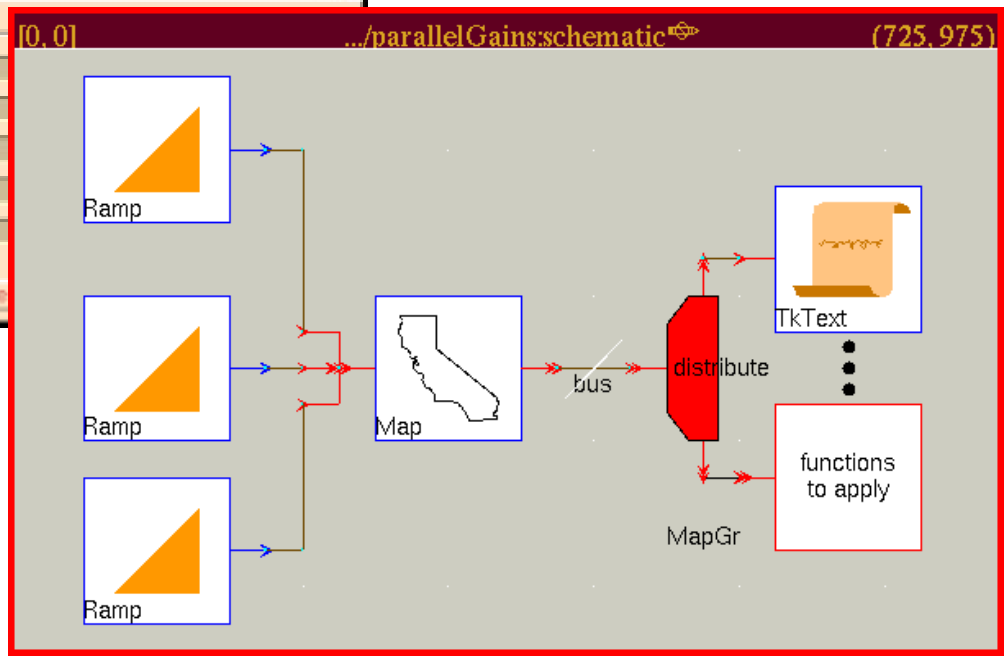


The ParSourcesGr (now called SrcGr) is a Map star with no inputs. The number of instances is determined by the number of outputs. The BusSplit is also an HOF star.

Higher-Order Functions in Ptolemy

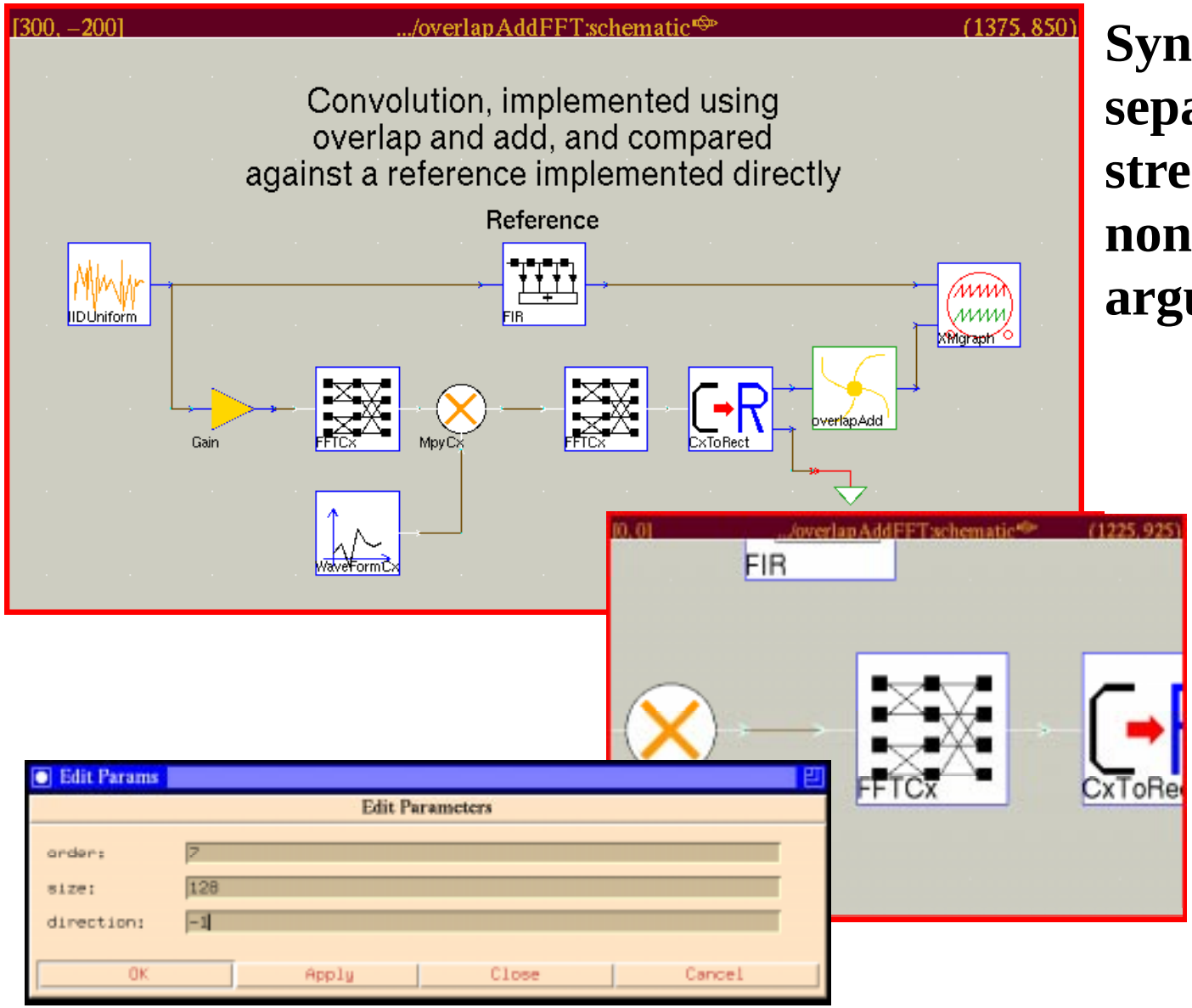
Examples implemented in Ptolemy:

- **Map** (apply a specified function to all inputs)
- **MapGr** (graphical version of Map)
- **IfThenElse** (apply one of two specified functions)
- **Chain** (apply a specified function sequentially)



This example applies gains of 1, 2, and 3 to three successive ramp signals and displays the three results.

Key Idea in Visual Programming



Syntactically separate stream and non-stream arguments.

Higher-Order Functions

HOFs are functions that take functions as arguments and return functions. For example

map *f*

returns a function that applies function *f* to elements of a list. In a typical functional language (Haskell):

scan (*f*, *init*, ⊥) = *init*

scan (*f*, *init*, (*x*:*xs*)) = *f* (*x*,scan(*f*, *init*, *xs*))

where ⊥ means no arguments. So,

scan ((+), 0, *list*)

adds all the elements of a list.

Higher-Order Functions

Wan-Teh Chang

Edward A. Lee

Alan Kamas

Thomas M. Parks

UC Berkeley

Karim P. Khiar

Thomson SGS