Fast Fourier Transforms in CHAPEL

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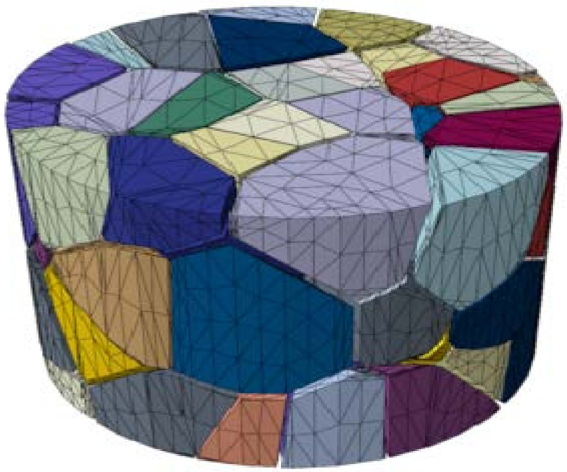
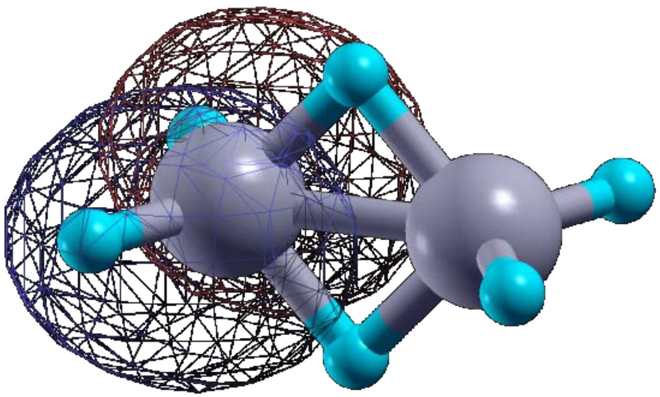
Motivation

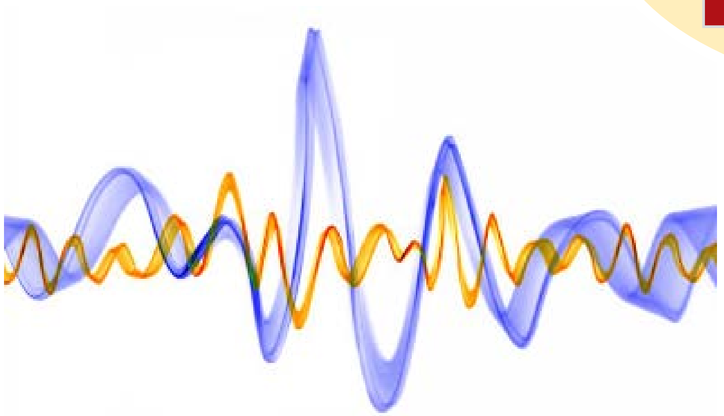


Material Sciences

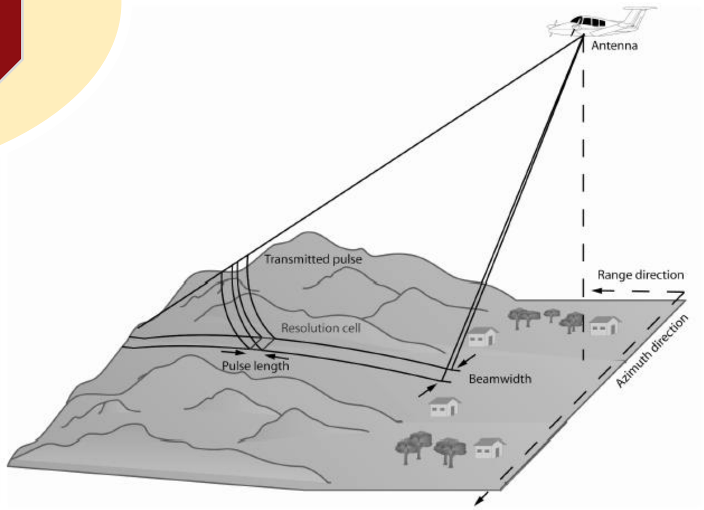


Quantum mechanics

Fourier Transform



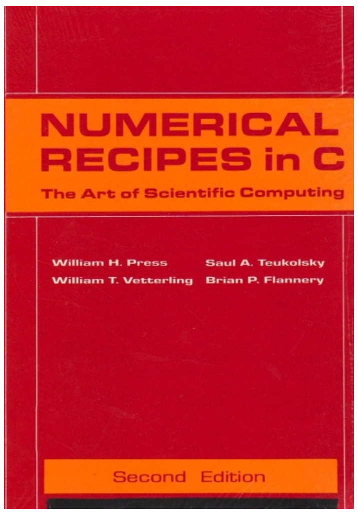
Signal Processing



Synthetic Aperture Radar

Goal

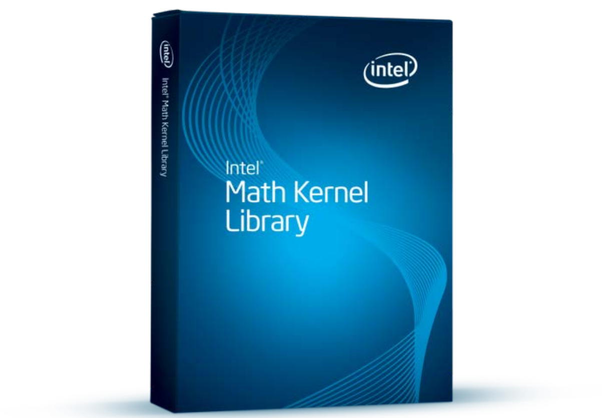
World A



Low Performance

World B

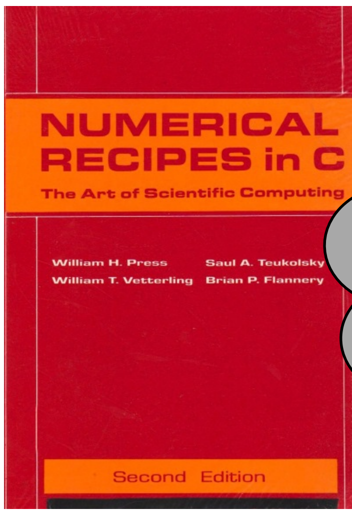
FFTW



> 30 MB of generated or handwritten code

Goal

World A

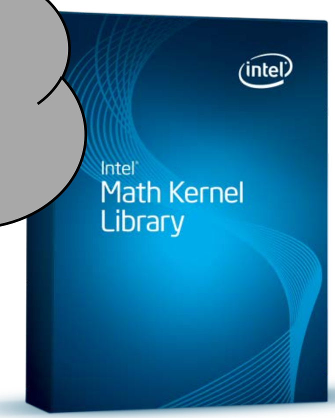


Low Performance

Want best of both worlds

World B

FFTW



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Outline

- Background
- Sequential and Parallel Implementation
- First Attempt in CHAPEL
- Summary

Background

- **Definition**

$$y_k = \sum_{n=0}^{N-1} x_n \cdot e^{-\frac{2\pi jkn}{N}}, k = 1..N$$

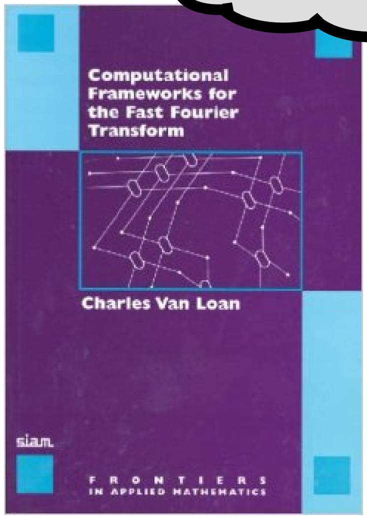
$O(N^2)$

- **Fast implementations**

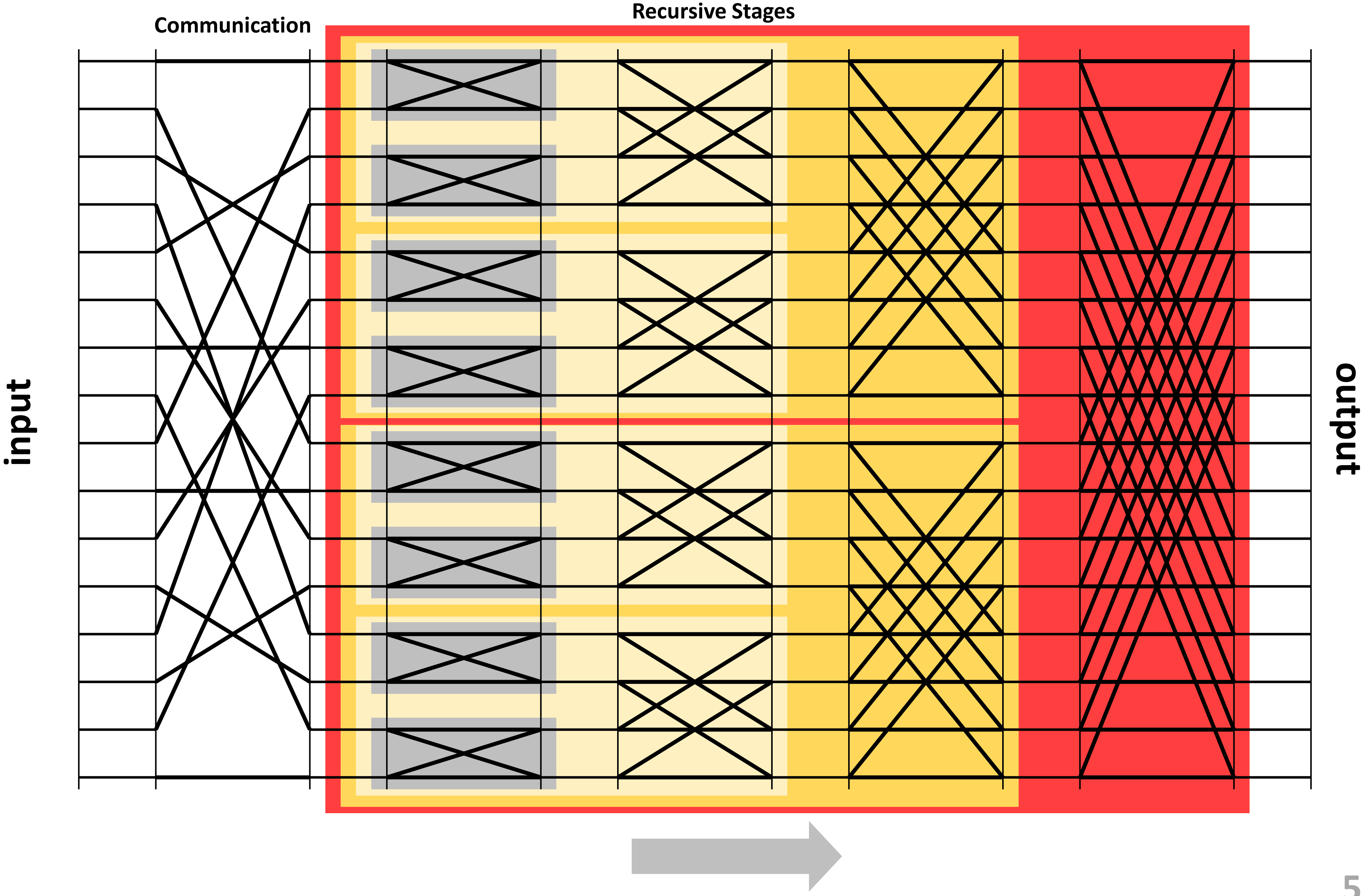
$O(NlogN)$

$$y = DFT_n \cdot x$$

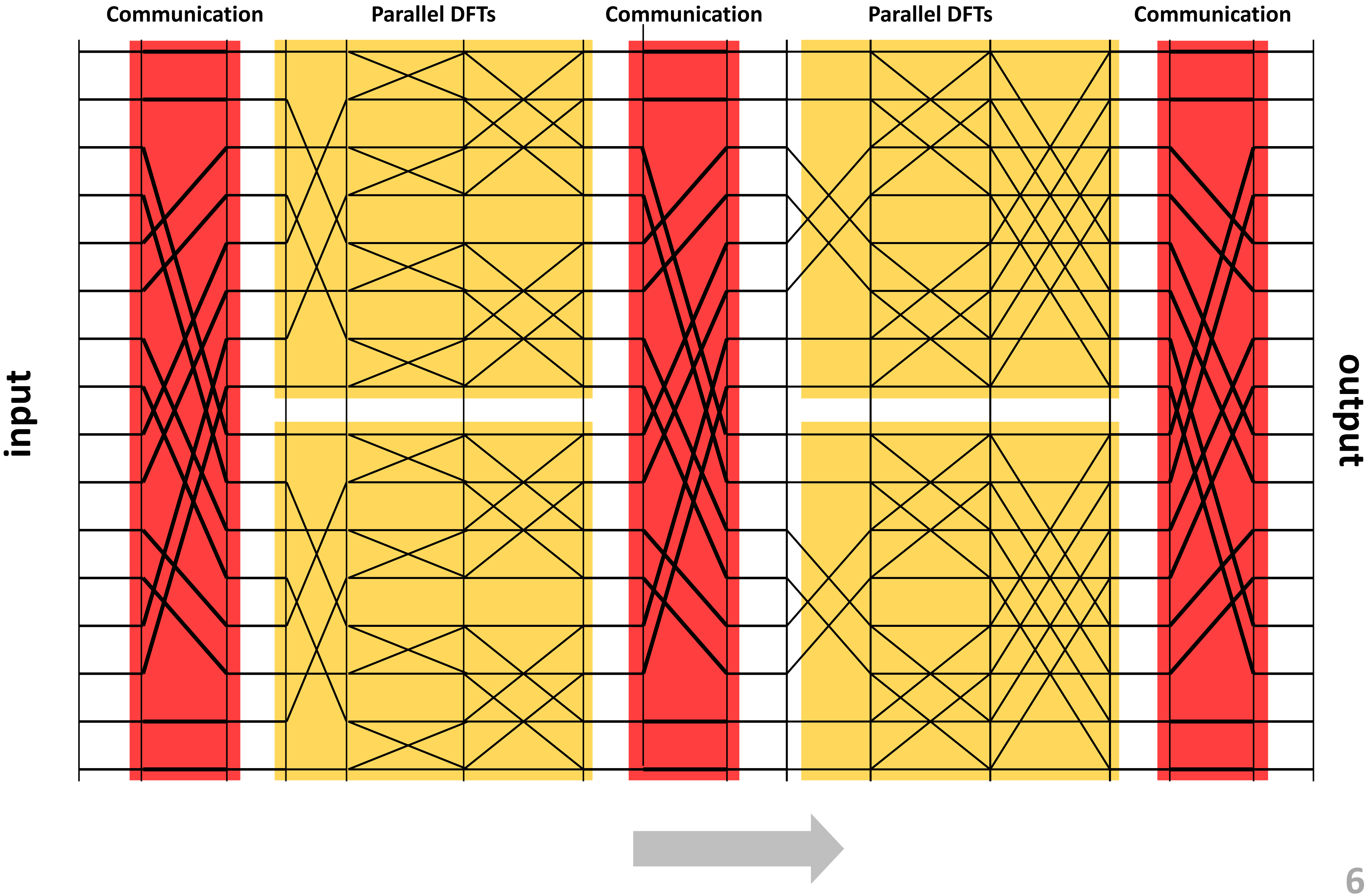
$$DFT_n = \left[\omega_n^{kl}\right]_{0\le k,l<n}, \omega_n = e^{-\frac{2\pi j}{n}}$$



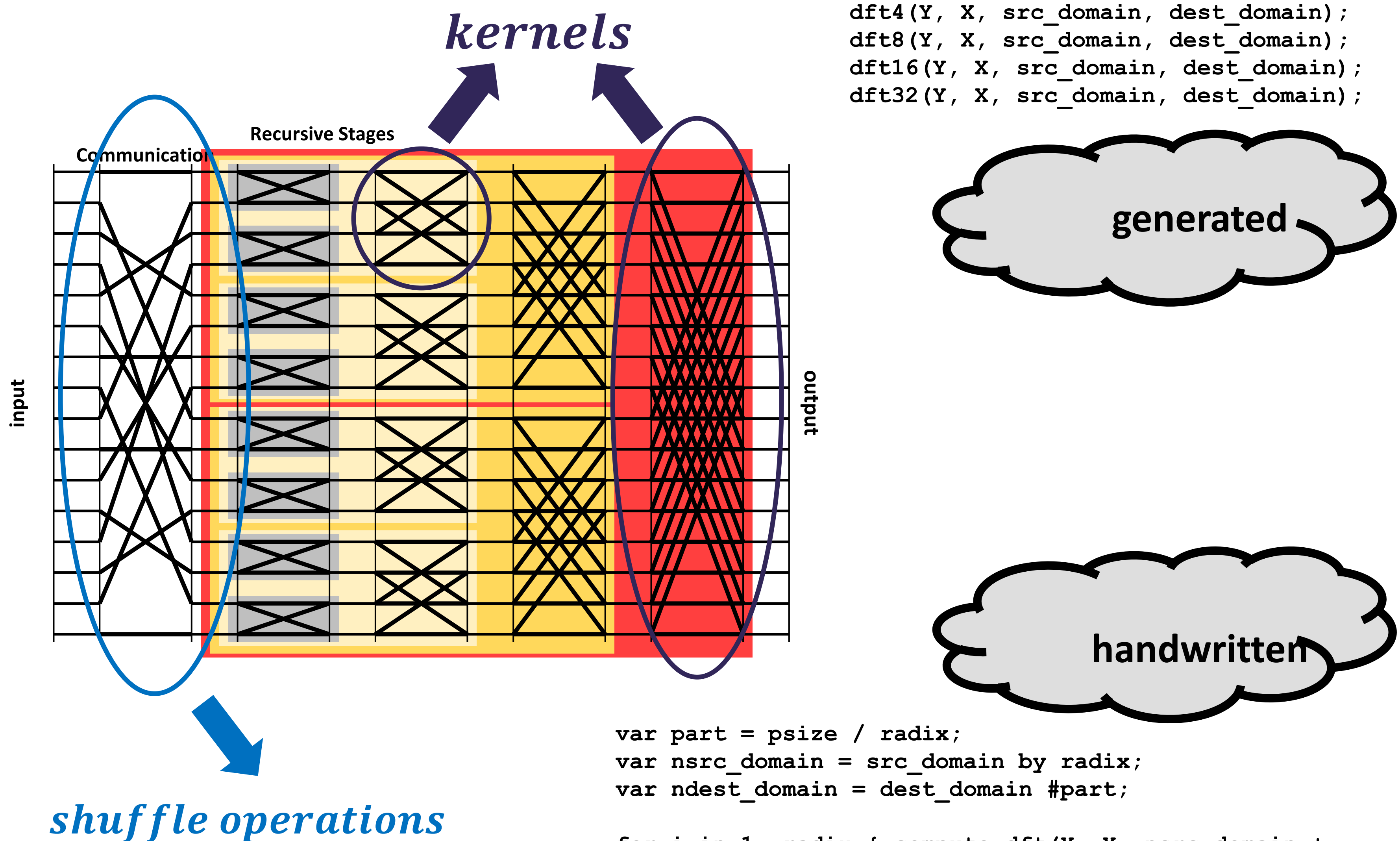
Sequential Recursive Implementation



Parallel Implementation



First attempt in CHAPEL

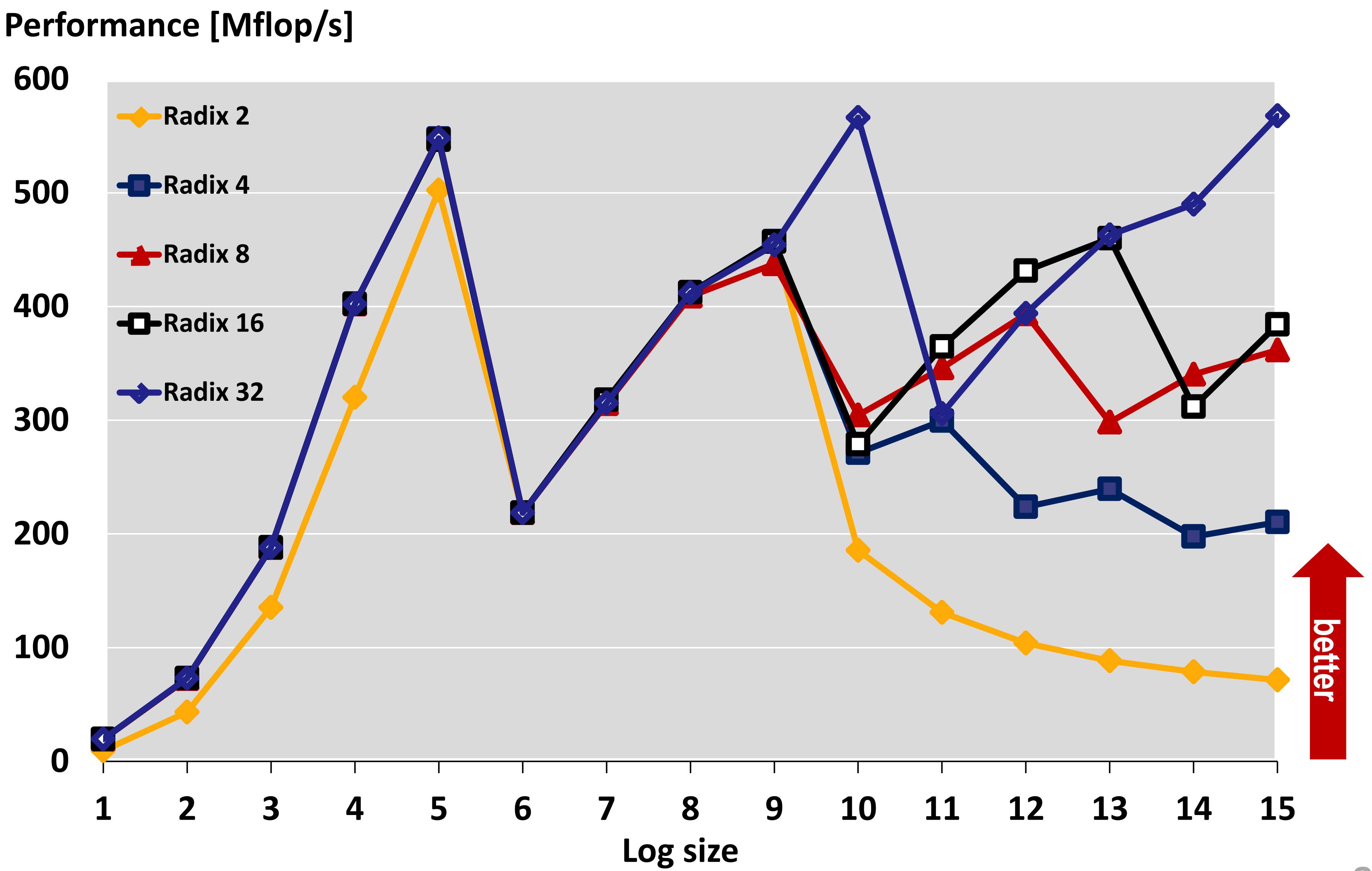



```
dft2(Y, X, src_domain, dest_domain);
dft4(Y, X, src_domain, dest_domain);
dft8(Y, X, src_domain, dest_domain);
dft16(Y, X, src_domain, dest_domain);
dft32(Y, X, src_domain, dest_domain);
```

```
var part = psize / radix;
var nsrc_domain = src_domain by radix;
var ndest_domain = dest_domain #part;

for i in 1..radix { compute_dft(Y, X, nsrc_domain +
(i - 1) * cradix, ndest_domain + (i - 1) * part, …);
}
```

Single Core Intel Haswell 4770K



Summary

- **Single threaded implementation**

  clean implementation; performance still lacking

- **Multiple threads and multiple nodes**

  work in progress; use domains and locals

- **Apply optimizations within CHAPEL**

  we know what is needed to optimize the Fourier transforms; add that knowledge within a compiler such as CHAPEL