CS 744: SPLIT ANNOTATIONS

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ADMINISTRIVIA

Course Project Checkins – due tomorrow!

In-class project presentations

- Dec 8th and Dec 10th
- Sign up sheet on Piazza

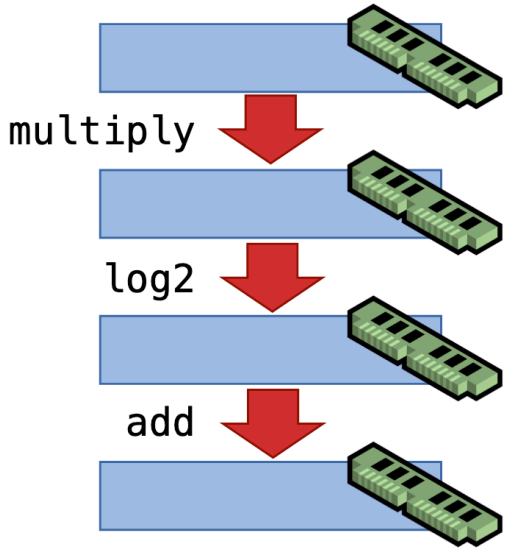
NEW HARDWARE AND DATA MODELS

SETTING

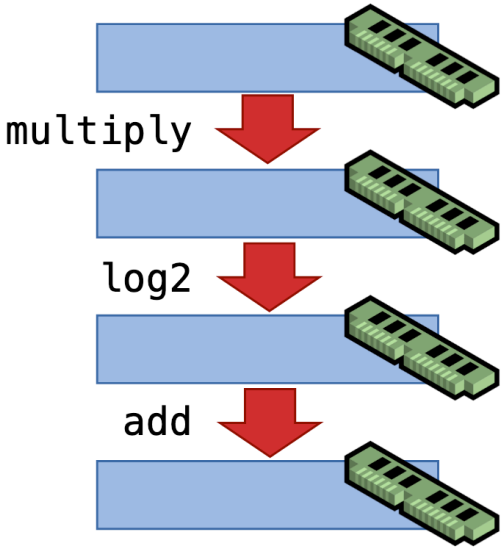
Multi-core machines

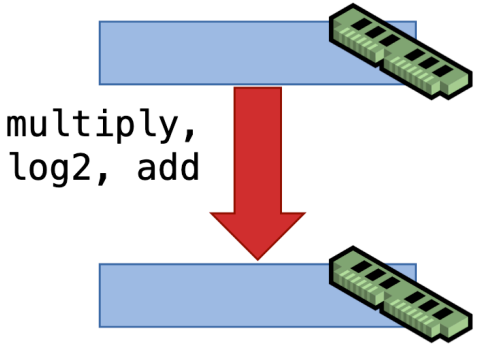
Multiple functions and libraries

```
// inputs are double arrays with `len` elems
vdLog1p(len, d1, d1);// d1 = log(d1)
vdAdd(len, d1, tmp, d1);// d1 = d1 + tmp
// d1 = d1 / vol_sqrt
vdDiv(len, d1, vol_sqrt, d1);
```



COMPILER-BASED APPROACHES





Replace every library call to emit intermediate representation (IR)

Compile all the IR together

Lots of code change required!

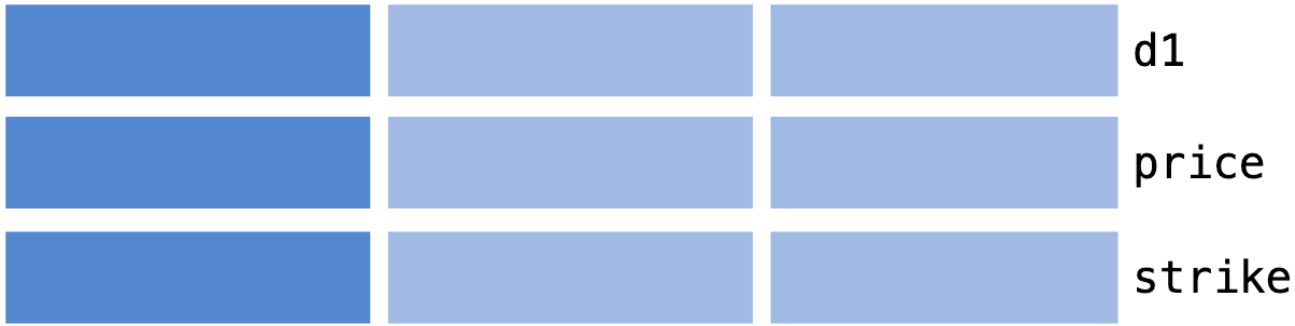
GOALS

Provide data movement optimizations across libraries

Require minimal or no changes to existing libraries

Leverage existing hand-tuned code for speedups

APPROACH




```
d1 = price * strike
d1 = np.log2(d1) + strike
```

SPLIT ANNOTATIONS

```
@splittable(
    size: SizeSplit(size), a: ArraySplit(size),
    mut out: ArraySplit(size))
void vdLog1p(long size, double*a, double*out)
```

Split types: N⟨V0...Vn⟩ e.g,: ArraySplit⟨10, 2⟩ for 10 element array, 2 pieces

Split annotation:

Name and split type to each argument and return value

IMPLEMENTING SPLIT API

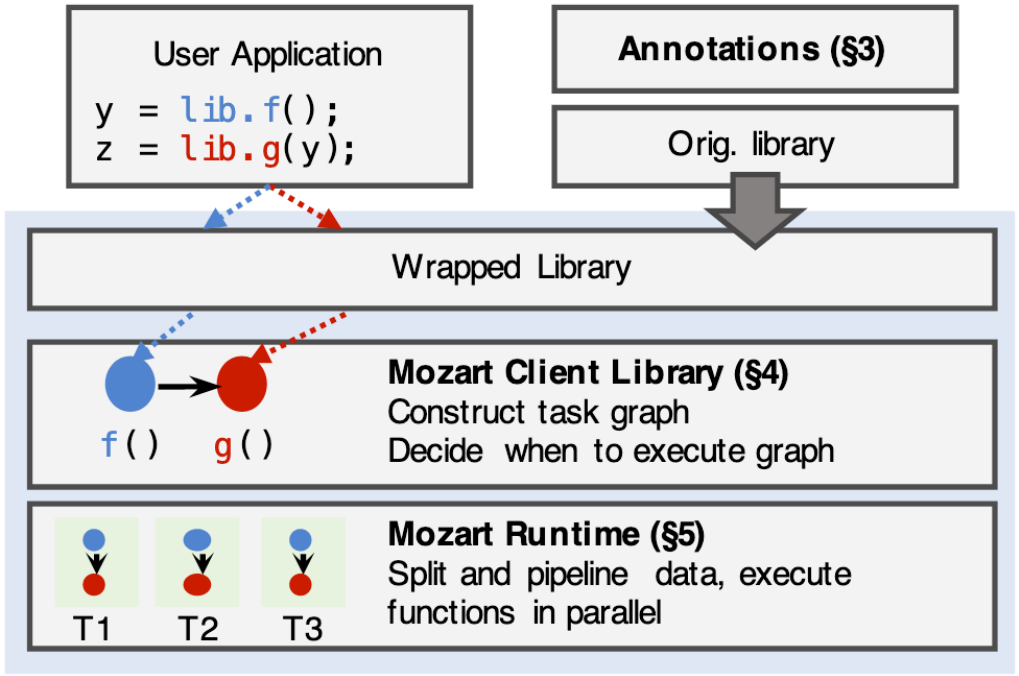
```
NameConstructor(A0,...An)=> Parameters
```

```
Split(D arg, int start, int end, Parameters)=> D
```

```
Merge(Vector<D>, Parameters)=> D
```

```
@splittable(m:MatrixSplit(m, axis), axis:_)
    -> ReduceSplit(axis)
vector sumReduceToVector(matrix m, int axis);
```

MOZART DESIGN



PYTHON CLIENT LIBRARY

Writing Annotations: Function decorators

```
@sa((DataFrameSplit(), DataFrameSplit()), {}, DataFrameSplit())
def divide(series, value):
```

Capturing the graph

- Wraps original Python function and registers in graph
- Returns a Future object

Evaluation Points

- Lazily evaluate by overriding __getattribute__

MOZART RUNTIME

Take dataflow graph → execution plan

Series of **stages** each stage split, pipeline and merge

Choosing a batch size

Set number of elements per batch using L2 cache size

SUMMARY

Applications compose data processing libraries

Data movement is bottleneck on multi-core machines

Key idea: Split and pipeline data across functions

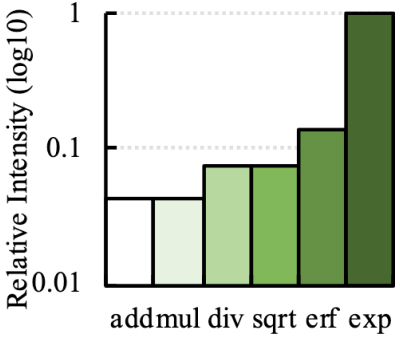
Split Annotations to reduce programmer effort

Mozart: Client library and runtime for lazy evaluation

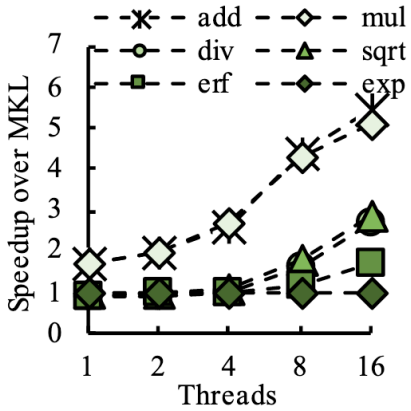
DISCUSSION

https://forms.gle/F2LJ21qFkBGWyypB7

How does the dataflow graph that is executed by Mozart compare to dataflow graphs we have seen in other systems like Spark/PyTorch etc.



(a) Relative Intensity



(b) Speedup over no SAs

NEXT STEPS

Next class: TPU

Project check-ins on HotCRP!