Legion Bootcamp:

Building Abstractions for Legion Applications

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Legion is designed for two classes of users: **DSL & Library Authors** and **Advanced Application Devs.**

DSL & Library Authors

Developers of **high-level languages** and **libraries** that help increase application developer productivity.

Advanced Application Devs.

Users of MPI, SHMEM, CUDA, etc. that develop their applications and **re-write** for new architectures.

Legion focuses on providing a **common framework** which can achieve **portable performance across a range of architectures**.

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Developer productivity in Legion is a *second-class* design constraint.

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Performance & Extensibility are #1.

And this is perfectly reasonable.

Many ways to **increase developer productivity** when targeting Legion’s C/C++ interfaces directly.

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This talk presents **a few.**

Interface: Odds are you'll be writing to the **C++ interface.**

C Interface – Language Devs.

C++ Interface – Application Devs.

Build Containers that encapsulate **container properties** and **manage storage** through **logical regions**.

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Goal: replicate familiar **structures** & **operations** on structures.

Goal: **reproduce** familiar function signatures at the **top level**.

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Ex. 1: An *Array* Stickman

```
struct Array {
 IndexSpace is;
 FieldSpace fs;
 LogicalRegion lr;
 LogicalPartition lp;
 Domain lDom;
};
```

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Conceptual Structure of the *Array*

Ex. 1: An *Array* Stickman

```
struct Array {
 IndexSpace is;
 FieldSpace fs;
 LogicalRegion lr;
 LogicalPartition lp;
 Domain lDom;
};
```

Used Primarily for Inquiry & Task Launch

Ex. 1: An *Array* Stickman

Type of Array Elements

```
template <typename T>
void
create(uint64_t length,
       Context &context,
       HighLevelRuntime *lrt);
```

Length of *Array*

Legion Handles Used in **`create`**

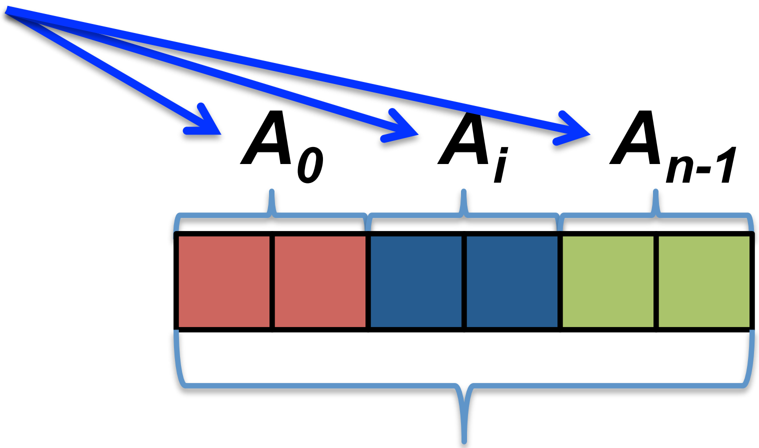
Ex. 1: An *Array* Stickman

```
void
partition(uint64_t n,
           Context &context,
           HighLevelRuntime *lrt);
```

Creates **n**

Disjoint

Partitions



A_0 A_i A_{n-1}

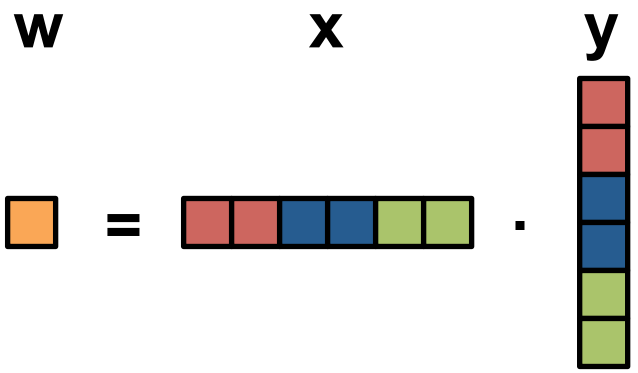
Entire Array *A*

Ex. 1: An *Array* Stickman

```
void
free(Context &ctx,
     HighLevelRuntime *lrt);
```

Ex. 1: Using the *Array* Stickman

```
double
dotprod(Array &x,
        Array &y,
        Context &context,
        HighLevelRuntime *lrt);
```



Ex. 1: Using the *Array* Stickman

```
/* dotprod() (Pseudo) Code Snippet */
double dotprod(Vector &x, Vector &y, . . .) {
   IndexLauncher il(DOT_TID, x.lDom,
                         TaskArgument(NULL, 0), aMap);
```

Create an IndexLauncher

Here **x** and **y**’s Launch Domains are Equivalent, so One is Chosen

```
}
```

Ex. 1: Using the *Array* Stickman

```
/* dotprod() (Pseudo) Code Snippet */
double dotprod(Vector &x, Vector &y, . . .) {
```

```
  il.add_region_requirement(
        RegionRequirement(x.lp, 0, RO, EX, x.lr)
  ); il.add_field(0, x.fid);
  /* Similarly, add RegionRequirement for y */
```

Add Region Requirements

```
}
```

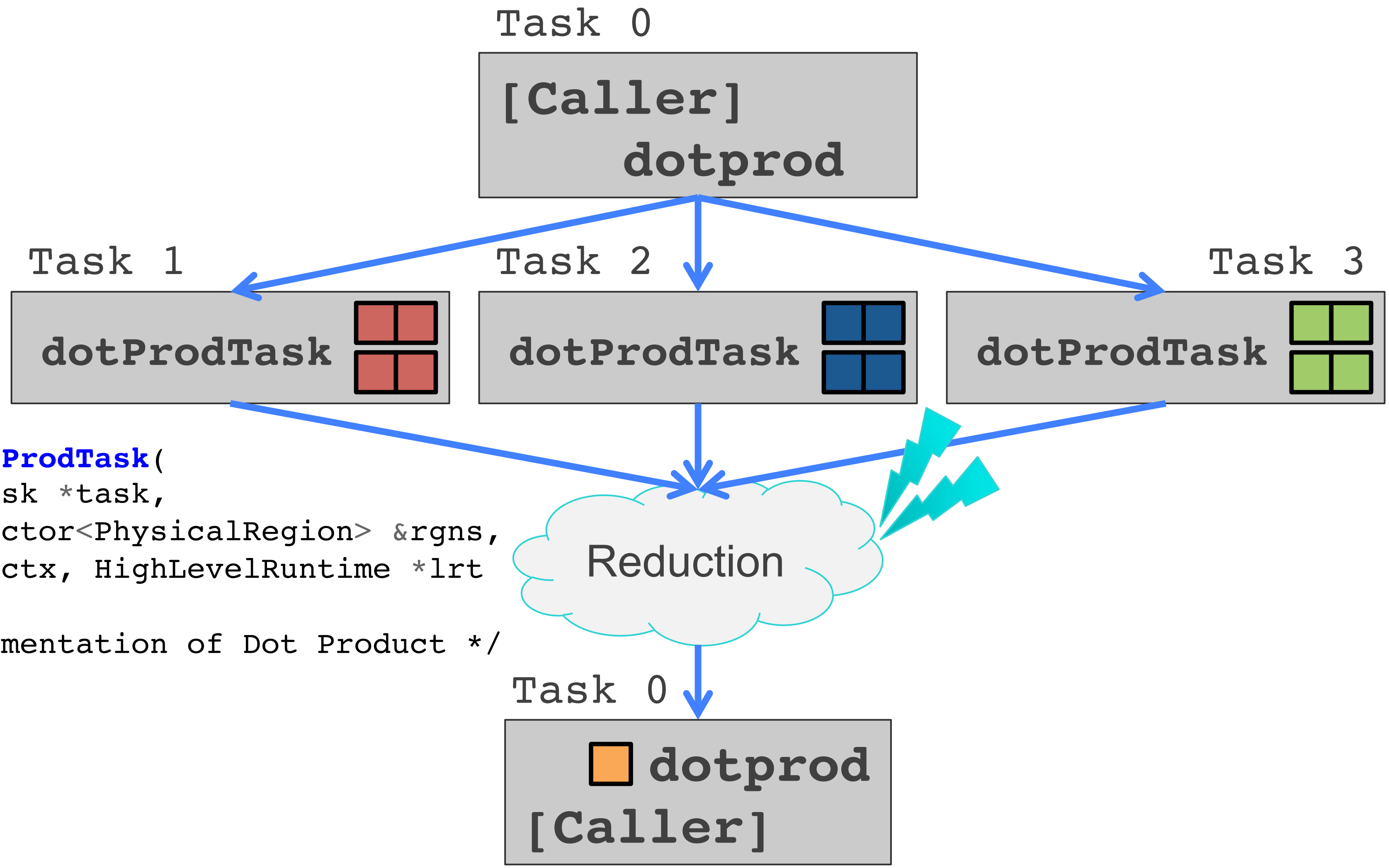
Ex. 1: Using the *Array* Stickman

```
/* dotprod() (Pseudo) Code Snippet */
double dotprod(Vector &x, Vector &y, . . .) {
```

Execute the IndexSpace
and
Return Result to Caller

```
  Future f = rt->exec_idx_space(ctx, il, RED_ID);
  return f.get_result<double>();
}
```

Ex. 1: Using the *Array* Stickman



Task 0

[Caller] dotprod

Task 1

dotProdTask

Task 2

dotProdTask

Task 3

dotProdTask

Reduction

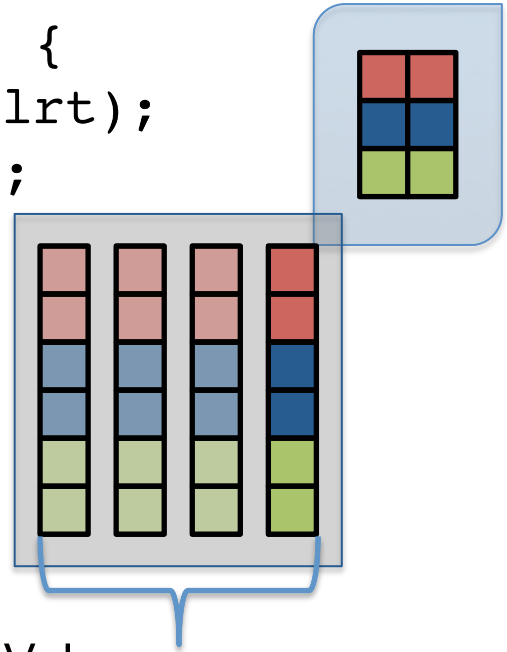
Task 0

dotprod [Caller]

```
double dotProdTask(
  const Task *task,
  const vector<PhysicalRegion> &rgns,
  Context ctx, HighLevelRuntime *lrt
){
  /* Implementation of Dot Product */
}
```

Ex. 2: *Sparse Matrices* and CG

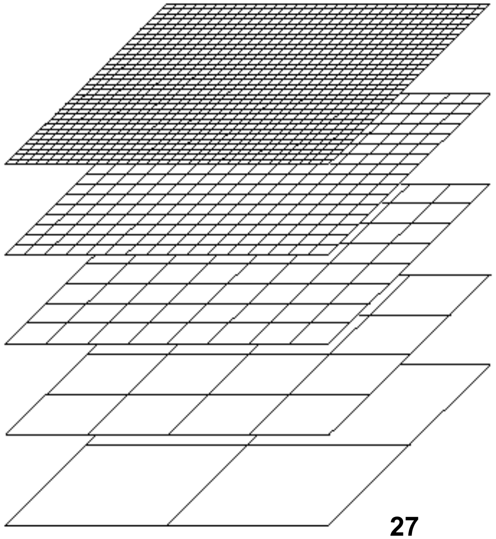
```
CGData cgData(A.nRows, ctx, lrt);
. . .
for (int64_t k = 1; k <= maxIters
     && (normr / normr0 > tolerance); ++k) {
  if (doPreconditioning) mg(A, r, z, ctx, lrt);
  else waxpby(1.0, r, 0.0, r, z, ctx, lrt);
  . . .
  spmv(A, p, Ap, ctx, lrt);
  dotprod(p, Ap, pAp, ctx, lrt);
  alpha = rtz / pAp;
  waxpby(1.0, x, alpha, p, x, ctx, lrt);
  waxpby(1.0, r, -alpha, Ap, r, ctx, lrt);
  dotprod(r, r, normr, ctx, lrt);
  normr = sqrt(normr);
  . . .
}
cgData.free(ctx, lrt);
```



A_0: Values
A_1: Matrix Indices
A_2: # of Non-Zeros in Row
A_3: Diagonal

Ex. 3: Multigrid

```
if (A.mgData) {
  const int64_t nPre = A.mgData->nPresmootherSteps;
  for (int64_t i = 0; i < nPre; ++i) {
    symgs(A, x, r, ctx, lrt);
  }
  spmv(A, x, A.mgData->Axf, ctx, lrt);
  restriction(A, r, ctx, lrt);
  mg(*A.Ac, A.mgData->rc, A.mgData->xc, ctx, lrt);
  prolongation(A, x, ctx, lrt);
  const int64_t nPost = A.mgData->nPostsmootherSteps;
  for (int64_t i = 0; i < nPost; ++i) {
    symgs(A, x, r, ctx, lrt);
  }
}
else symgs(A, x, r, ctx, lrt);
```



Some Code Doing This:

https://github.com/losalamos/CODY/tree/master/legion/lgncg

Help Us Help You: We’re writing a Legion debugger and need input.

Anything About:

Features, **Use Cases**, Tricky Bugs

Specifics Please ☺

Questions?

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