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mdspan in C++: A Case Study in the Integration of Performance Portable Features into International Language Standards

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NNSA U.S. DEPARTMENT OF ENERGY

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dsh.fyi/TODO

Disclaimer

Disclaimer

This presentation contains some C++ source code.

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- Support for arbitrary (rectangular) shapes, mixing of static and runtime extents, layout customization, and memory access customization

Design Overview

Basic Usage

```
void some_function(double* data, float* data2) {

  // std::dynamic_extent means it's a dimension given at runtime
  auto my_matrix = mdspan<double, dynamic_extent, dynamic_extent>(data, 20, 40);

  // runtime and compile-time dimensions can be mixed
  auto other_matrix = mdspan<float, 20, dynamic_extent>(data2, 40);

  /* ... */

  my_matrix(17, 34) = 3.14;
  other_matrix(0, 12) = my_matrix(17, 34);
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View **`data`** as a 20x40 matrix of doubles (runtime extents)

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Mixed compile-time and runtime dimensions

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Access to values uses the parenthesis operator

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- `std::extents` is a class template that expresses the shape of the `mdspan`.

subspan

```
auto s = mdspan<double, 3, 4, 5>(data);
s(1, 2, 3) = 2.78;
auto s2 = subspan(s, 1, pair{1, 3}, all);
assert(s2(1, 3) == s(1, 2, 3));
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  - compressed layouts (with the help of an `AccessorPolicy`)

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  - Access data stored in a compressed format of some sort
  - Access data atomically (using P0019, `atomic_ref`)

Benchmarks

Sum3D

```
for(ptrdiff_t i = 0; i < s.extent(0); ++i) {
  for (ptrdiff_t j = 0; j < s.extent(1); ++j) {
    for (ptrdiff_t k = 0; k < s.extent(2); ++k) {
      sum += s(i, j, k);
    }
  }
}
```

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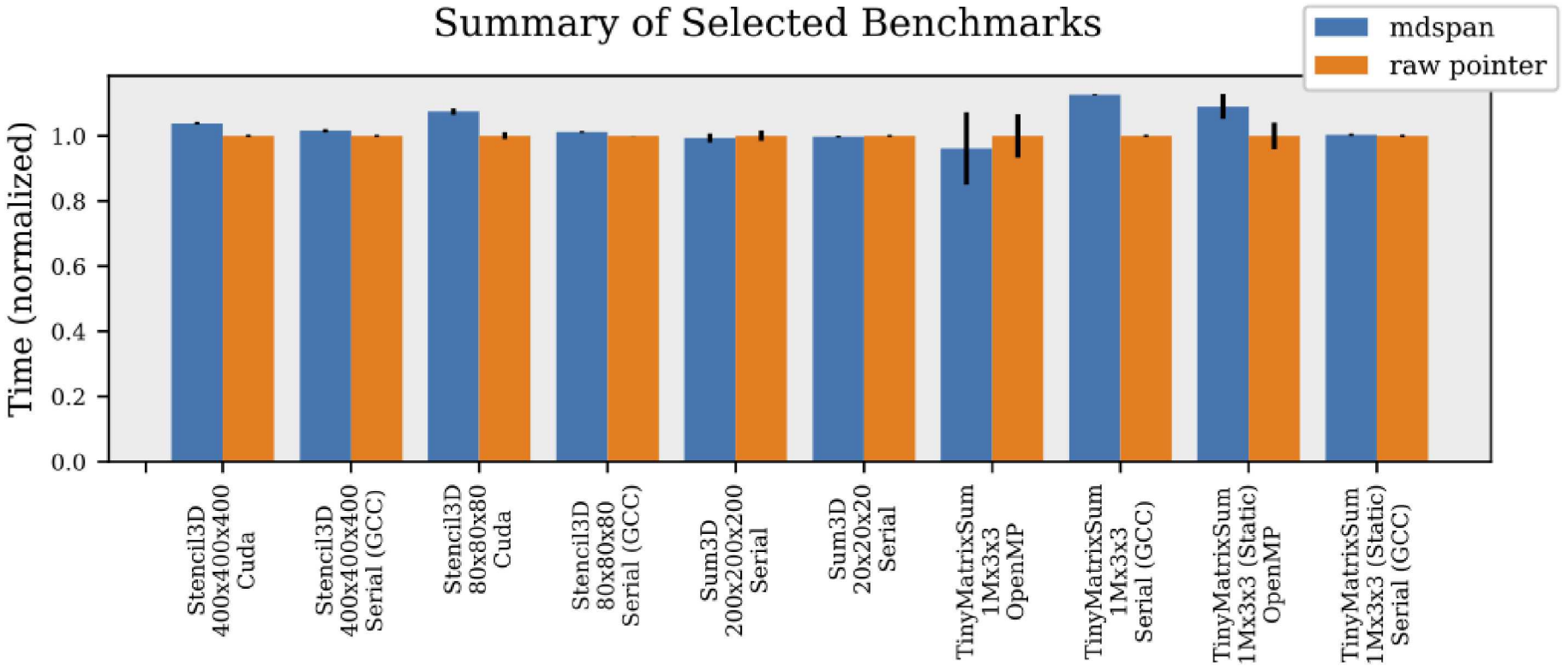
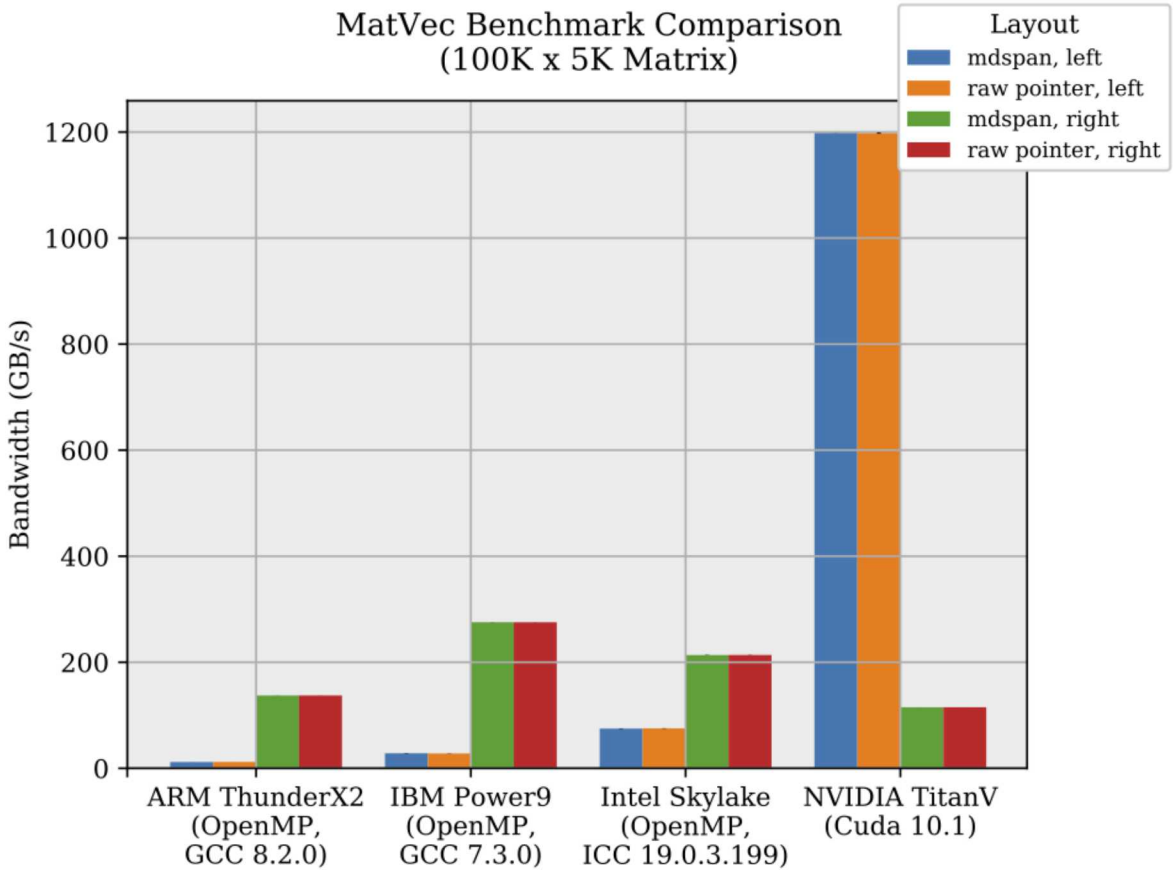
```

```
for(ptrdiff_t i = 0; i < x; ++i) {
  for (ptrdiff_t j = 0; j < y; ++j) {
    for (ptrdiff_t k = 0; k < z; ++k) {
      sum += s_ptr[k + j*z + i*y*z];
    }
  }
}
```

Comparison to Raw Pointer



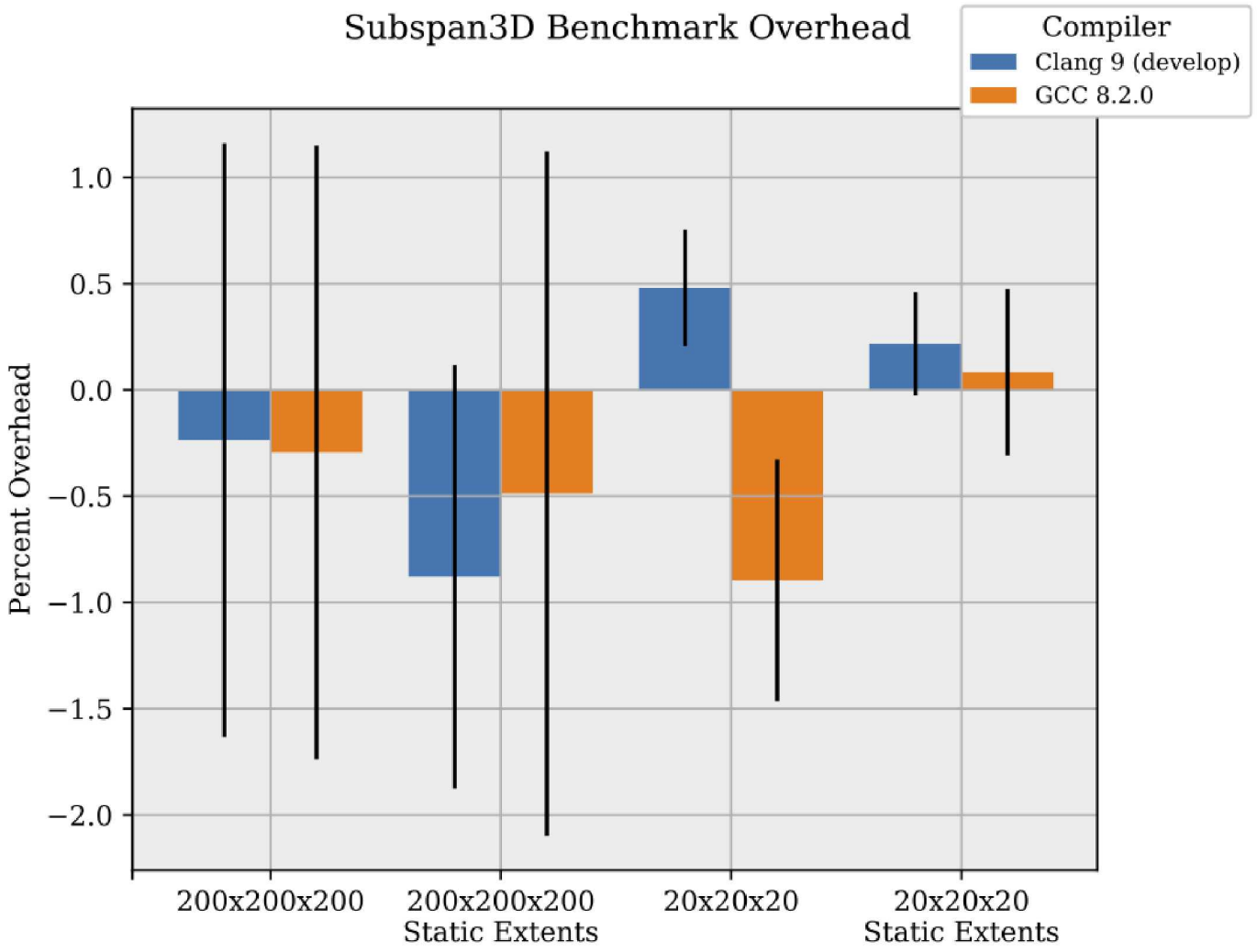
Effect of Layout on `MatVec`



Subspan3D: Abstraction Overhead Stress Test

```
for(ptrdiff_t i = 0; i < s.extent(0); ++i) {
  auto sub_i = subspan(s, i, all, all);
  for (ptrdiff_t j = 0; j < s.extent(1); ++j) {
    auto sub_i_j = subspan(sub_i, j, all);
    for (ptrdiff_t k = 0; k < s.extent(2); ++k) {
      sum += sub_i_j(k);
    }
  }
}
```

Subspan3D Overhead



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  - Feedback is appreciated!

Questions?