Removal of the UVM Requirement from Tpetra: CrsGraph and CrsMatrix

Karen Devine for the Tpetra Team

Geoff Danielson, Tim Fuller, Jonathan Hu, Brian Kelley, Kyungjoo Kim,
Chris Siefert, Timothy Smith

Updated: November 23, 2021

SAND2021-15113 O

Key changes for Tpetra::CrsGraph/CrsMatrix users (details to follow)

Same as MultiVector

1. Capture host and device views in separate scopes
   - Don’t hold raw pointers to data
   - Let views go out of scope as soon as you’re done working with them
2. Separate scope for local operations and Tpetra operations on an object
   - Tpetra (and, indeed, Trilinos) operations can choose where to access data
3. Indicate intended usage of views
   - ReadOnly, ReadWrite, OverwriteAll
4. Reduce switching between host and device accesses
   - Be aware of data synchronization
5. Update code to remove use of deprecated interfaces
   1. -D Tpetra_ENABLE_DEPRECATED_CODE=OFF
6. getLocalMatrix*() and getLocalGraph*() build Kokkos’ matrix and graph ON DEMAND now (rather than returning stored data structures); use wisely
7. Functions returning raw pointers to CrsMatrix/CrsGraph data are dangerous and deprecated
8. Functions returning Teuchos::ArrayView of CrsMatrix/CrsGraph data are dangerous and deprecated

#1: Designate Host/Device for local graph/matrix

Scoping rules apply – cannot hold both device and host pointers in same scope

```
// Deprecated – device option

auto graphDevice = g.getLocalGraph();
auto matrixDevice = m.getLocalMatrix();
```

```
// New interfaces
{
auto graphDevice =
     g.getLocalGraphDevice();
auto matrixDevice =
     m.getLocalMatrixDevice();
}
{
auto graphHost =
     g.getLocalGraphHost();
auto matrixHost =
     m.getLocalMatrixHost();
}
```

New functions identify host or device use of Kokkos::CrsGraph and KokkosSparse::CrsMatrix. Scoping rules apply!

#2: Use new getLocalGraphHost, getLocalMatrixHost where appropriate

```
// Deprecated (from Ifpack2)

auto Alocal = A.getLocalMatrix();
Arowmap =
  Kokkos::create_mirror_view(Alocal.graph.row_map);
Aentries =
  Kokkos::create_mirror_view(Alocal.graph.entries);
Avalues =
  Kokkos::create_mirror_view(Alocal.values);
Kokkos::deep_copy(Arowmap, Alocal.graph.row_map);
Kokkos::deep_copy(Aentries, Alocal.graph.entries);
Kokkos::deep_copy(Avalues, Alocal.values);

… Use Arowmap, Aentries, Avalues as input …
```

```
// New interfaces

auto Alocal =
     m.getLocalMatrixHost();
Arowmap = Alocal.graph.row_map;
Aentries = Alocal.graph.entries;
Avalues = Alocal.graph.values;


… Use Arowmap, Aentries, Avalues
as input …
```

New functions identify host or device use of Kokkos::CrsGraph and KokkosSparse::CrsMatrix. Scoping rules apply!

#3: Use CrsGraph::getLocalGraph() wisely

```
// NOT Efficient

auto numrows =
  g.getLocalGraph().row_map.extent(0)-1;
auto nnz =
  g.getLocalGraph().entries.extent(0);


auto rowptr = g.getLocalGraph().row_map;
auto colidx = g.getLocalGraph().entries;
```

```
// Better


auto numrows = g.getNodeNumRows();
auto nnz = g.getNodeNumEntries();



auto lclGraphHost = g.getLocalGraphHost();
auto rowptr = lclGraphHost.row_map;
auto colidx = lclGraphHost.entries;
```

getLocalGraphHost/Device() builds graph ON DEMAND now, rather than returning a stored pointer

#4: Use CrsMatrix::getLocalMatrix() wisely

```
// NOT Efficient



rowptr = m.getLocalMatrix().graph.row_map;
colidx = m.getLocalMatrix().graph.entries;
values = m.getLocalMatrix().values;
```

```
// Better

auto mlocal = m.getLocalMatrixDevice();
rowptr = mlocal.graph.row_map;
colidx = mlocal.graph.entries;
values = mlocal.values;
```

getLocalMatrixHost/Device() builds KokkosSparse::CrsMatrix ON DEMAND now, rather than returning a stored pointer

#5: Don’t hold/grab/hand-out pointers to raw data

```
// DANGER DANGER DANGER

typename
  AbstractConcreteMatrixAdapter<
    Tpetra::RowMatrix<Scalar, LocalOrdinal, GlobalOrdinal, Node>, DerivedMat>
    ::super_t::spmtx_vals_t
  AbstractConcreteMatrixAdapter<
    Tpetra::RowMatrix<Scalar,
                      LocalOrdinal,
                      GlobalOrdinal,
                      Node>,
    DerivedMat>::getSparseValues() const
  {
    typename super_t::local_matrix_t lm = this->mat_->getLocalMatrixHost();
    return lm.values.data();
  }
```

Tpetra can not track use of raw data() pointer; cannot sync appropriately
Applies to CrsGraph, CrsMatrix, MultiVector

#6: Returned Teuchos::ArrayViews are dangerous and deprecated

```
// Deprecated

m.getLocalRowView(row, indices_AV,
                  values_AV);
m.getGlobalRowView(row, indices_AV,
                   values_AV);

m.getLocalRowCopy(row, indices_AV,
                  values_AV);
m.getGlobalRowCopy(row, indices_AV,
                   values_AV);
```

```
// New interface returns Kokkos::Views

m.getLocalRowView(row, indices_KV,
                  values_KV);
m.getLocalRowCopy(row, indices_KV,
                  values_KV);
m.getGlobalRowView(row, indices_KV,
                   values_KV);
m.getGlobalRowCopy(row, indices_KV,
                   values_KV);
```

Tpetra cannot track usage of data in Teuchos::ArrayView for sync/modify

#7: Returned raw pointers are dangerous and deprecated

```
// Deprecated

m.getLocalRowView(row, indices_raw,
                  values_raw, nentries);
```

```
// New interface returns Kokkos::Views


m.getLocalRowView(row, indices_KV,
                  values_KV);
```

Tpetra cannot track usage of data in raw pointers for sync/modify

Other deprecations will (likely) follow

Deprecations:

- Fewer Teuchos::ArrayRCPs in interfaces, more Kokkos Views
- Greater reliance on access tags (e.g., Tpetra::Access::ReadWrite) instead of function naming conventions (e.g., getDataNonConst and getData)
- More consistent naming (unambiguous Host/Device in function names, ”Local” vs “Node”, etc.)

Impact on applications / packages:

- Easily adopted changes by applications and packages (name changes rather than logic changes)
- Will be deprecated as time/staff permits
- Will be summarized and documented on wiki

For more info

- Email
  - tpetra-developers@software.sandia.gov
  - kddevin@sandia.gov
- Wiki
  - Tpetra info: https://github.com/trilinos/Trilinos/wiki/Tpetra-Information-Page
  - UVM removal info: https://snl-wiki.sandia.gov/display/TRIL/UVM+Removal