COL380

Introduction to
Parallel & Distributed Programming

Agenda

- Parallel IO
- Parallel/distributed programming frameworks

Parallel File Systems

- Multiple disk servers
  - ➡ With multiple network paths to disks
- Designed for performance
  - ➡ Large block sizes (~MB)
  - ➡ Parallel fetch
  - ➡ Concurrent I/O
  - ➡ Metadata operations less performant
- Traditional file API
  - ➡ Additional APIs for faster access

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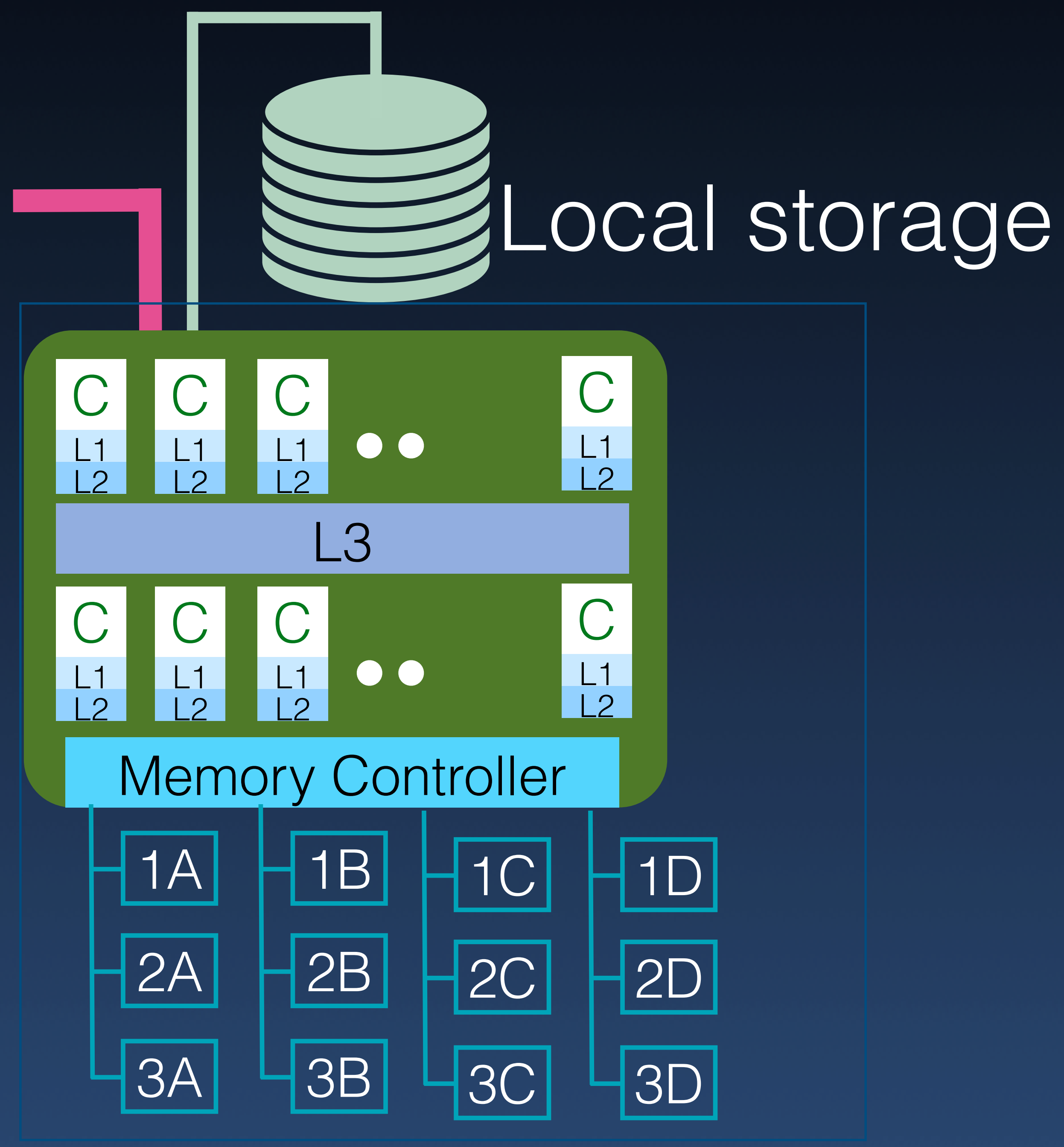

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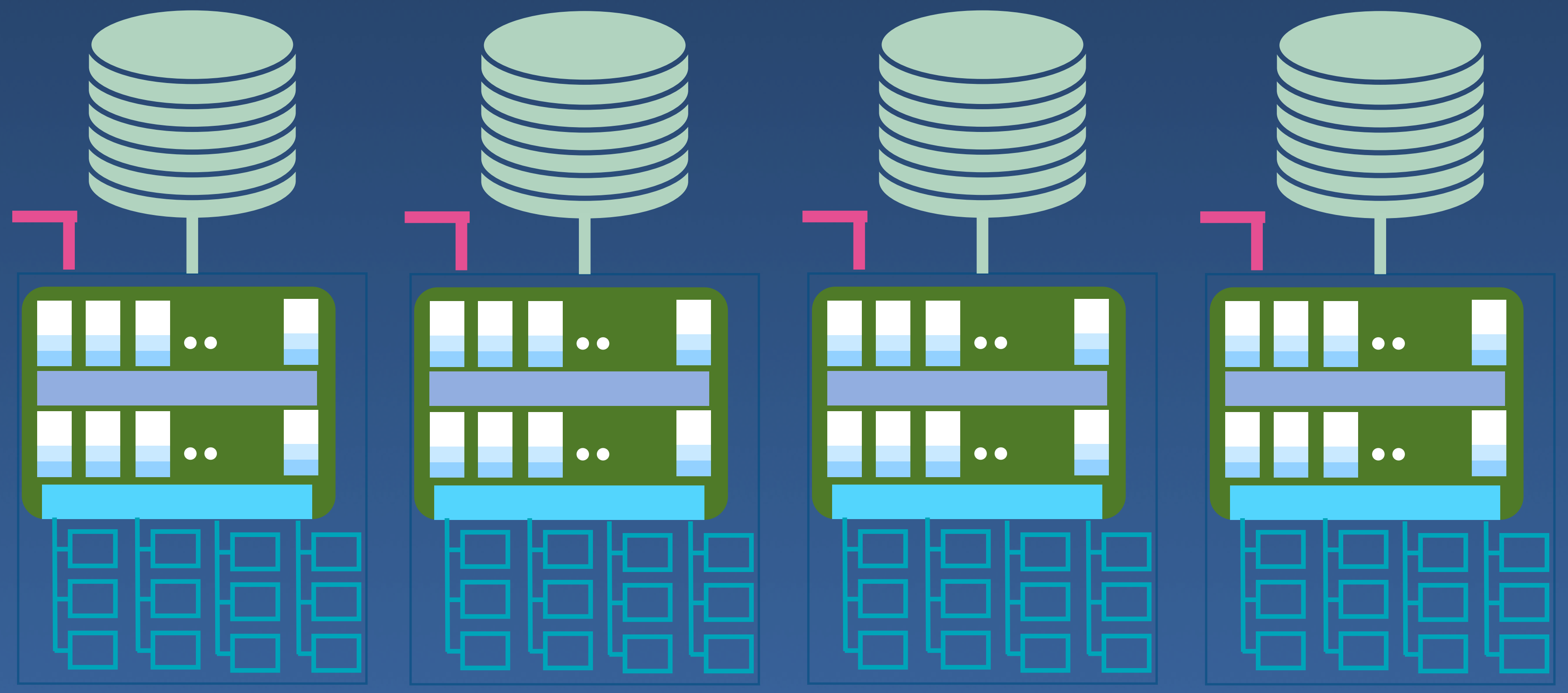

Distributed Storage

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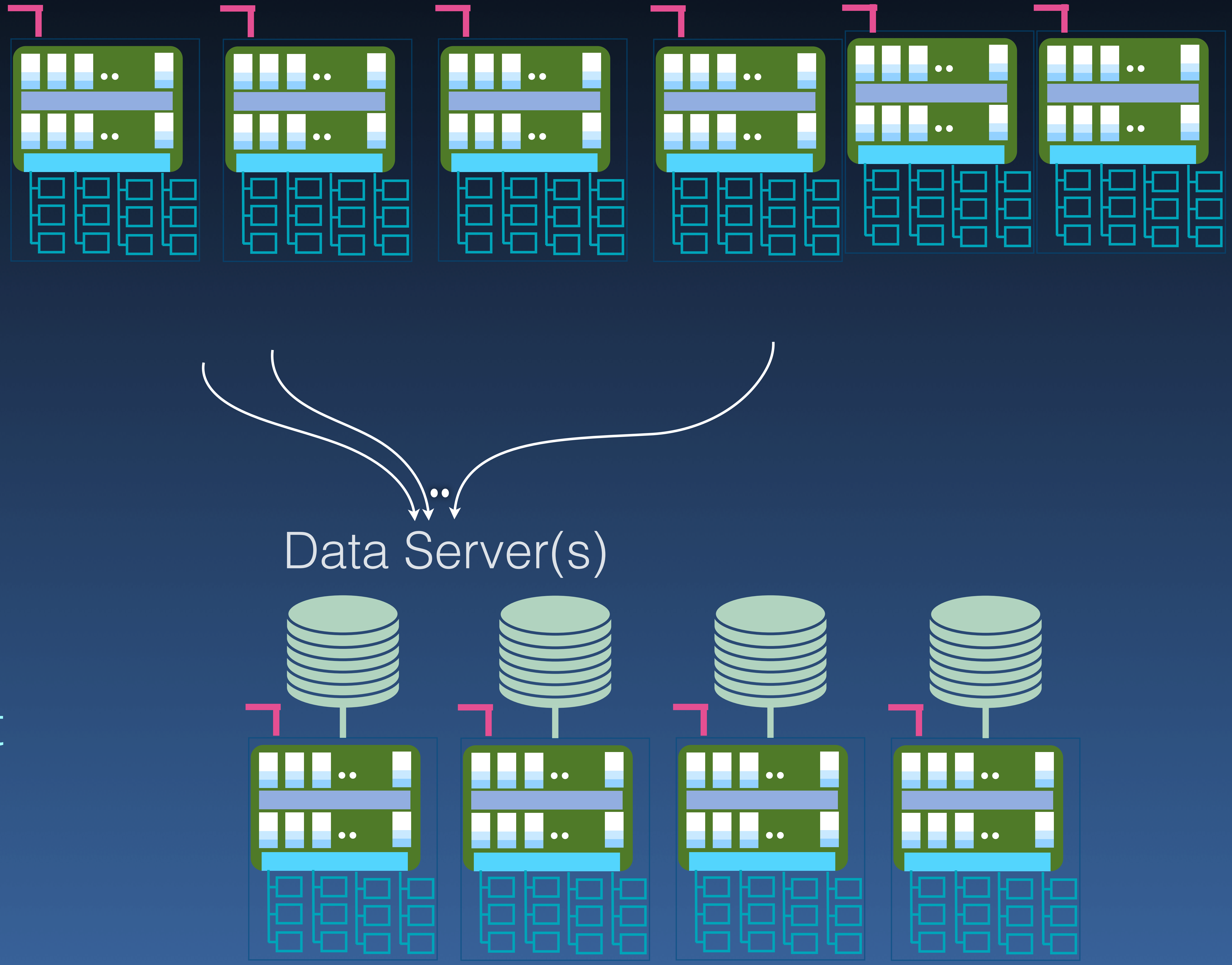

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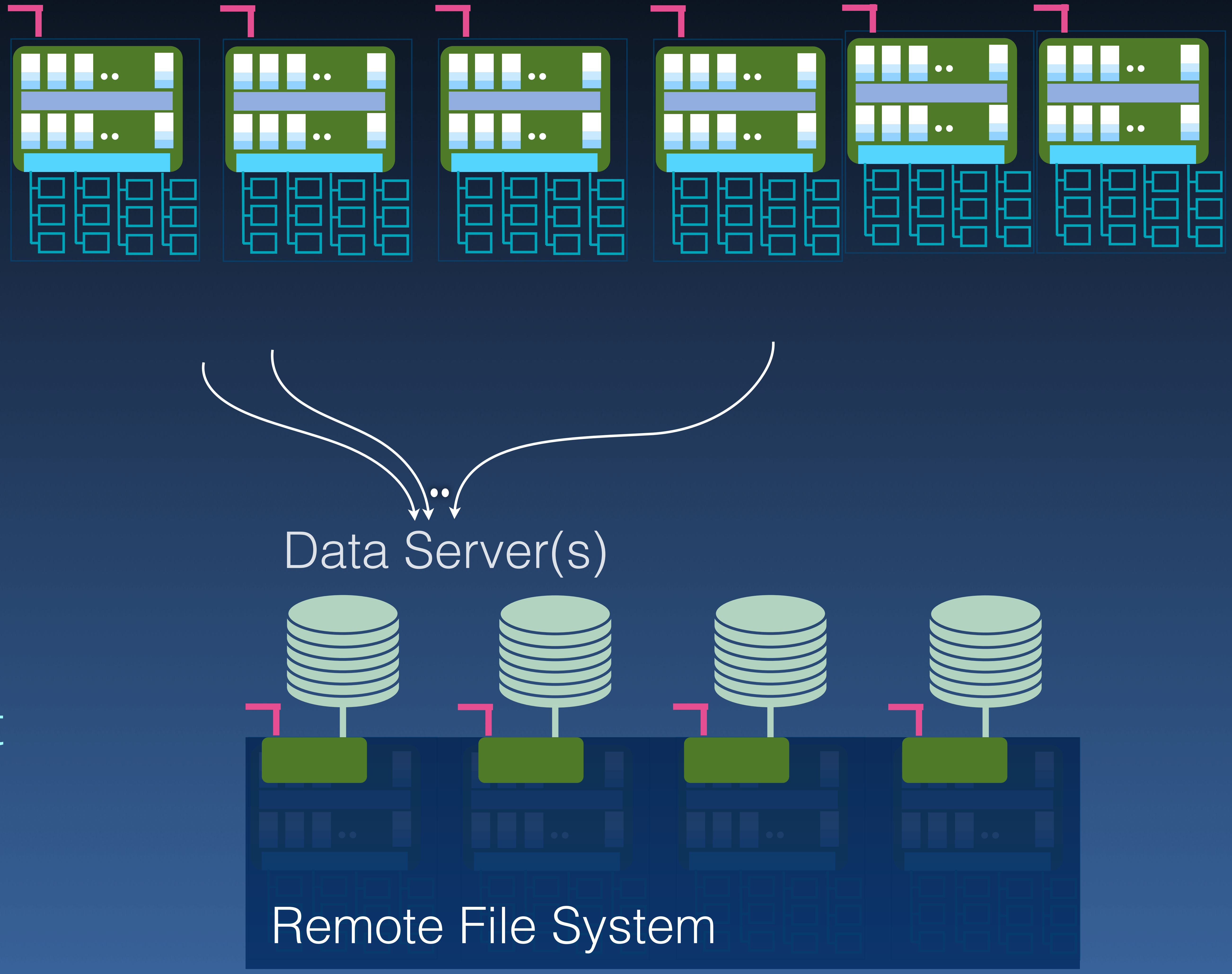

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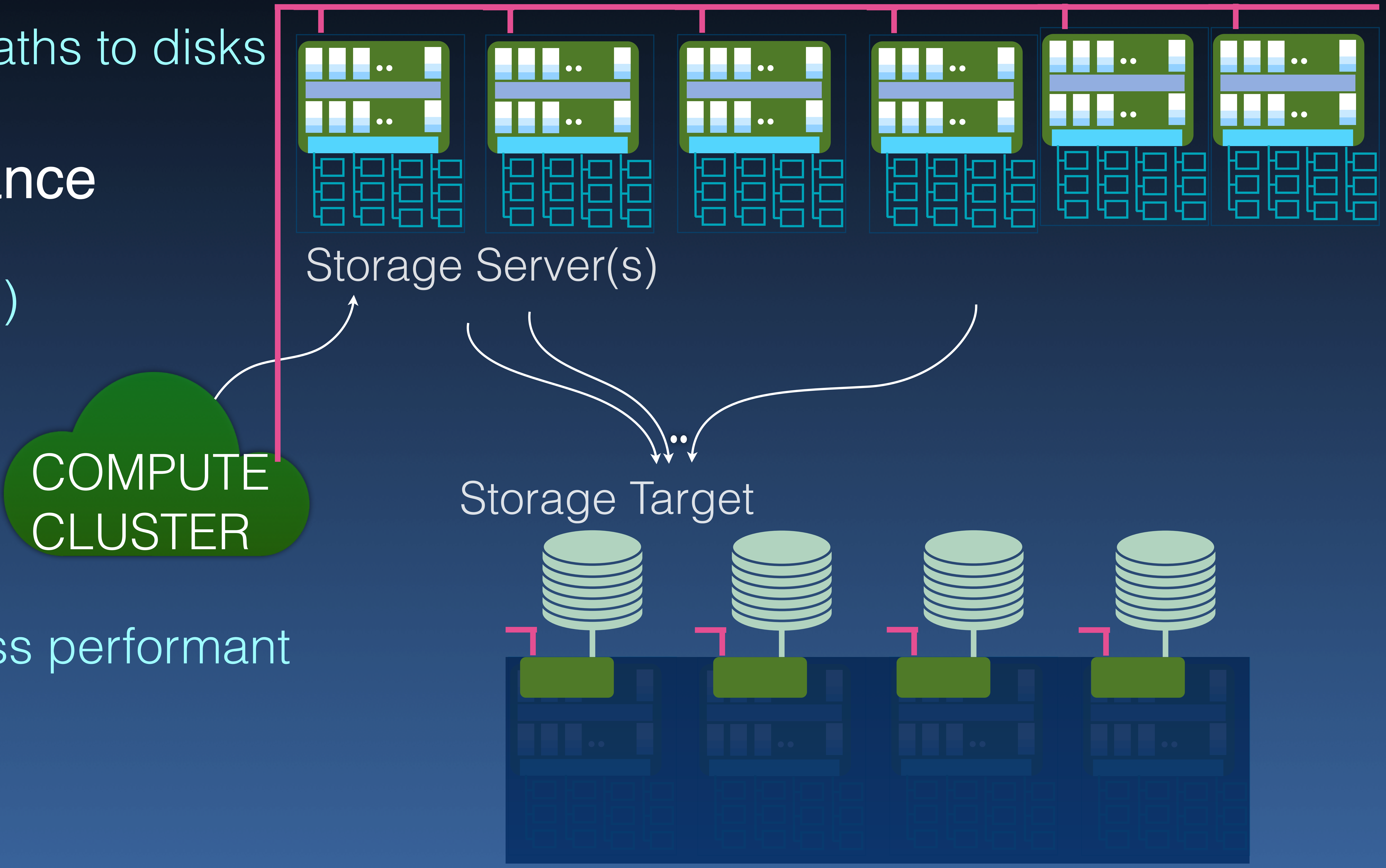

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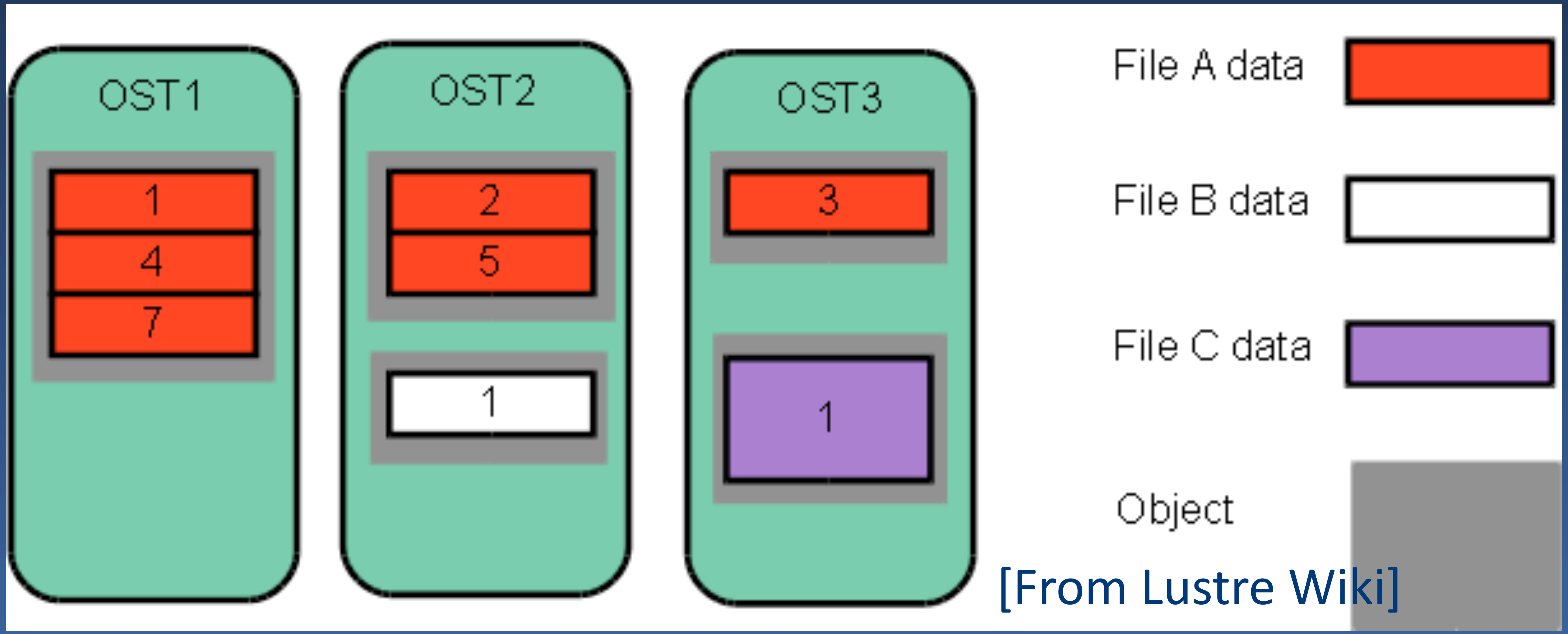
PFS Striping

- Configuration per file
  - ➡ number of stripes, stripe size, and OSTs to use

Stripe counts

File A: 3
File B: 1
File C: 1

Stripe size of File C is larger



[From Lustre Wiki]

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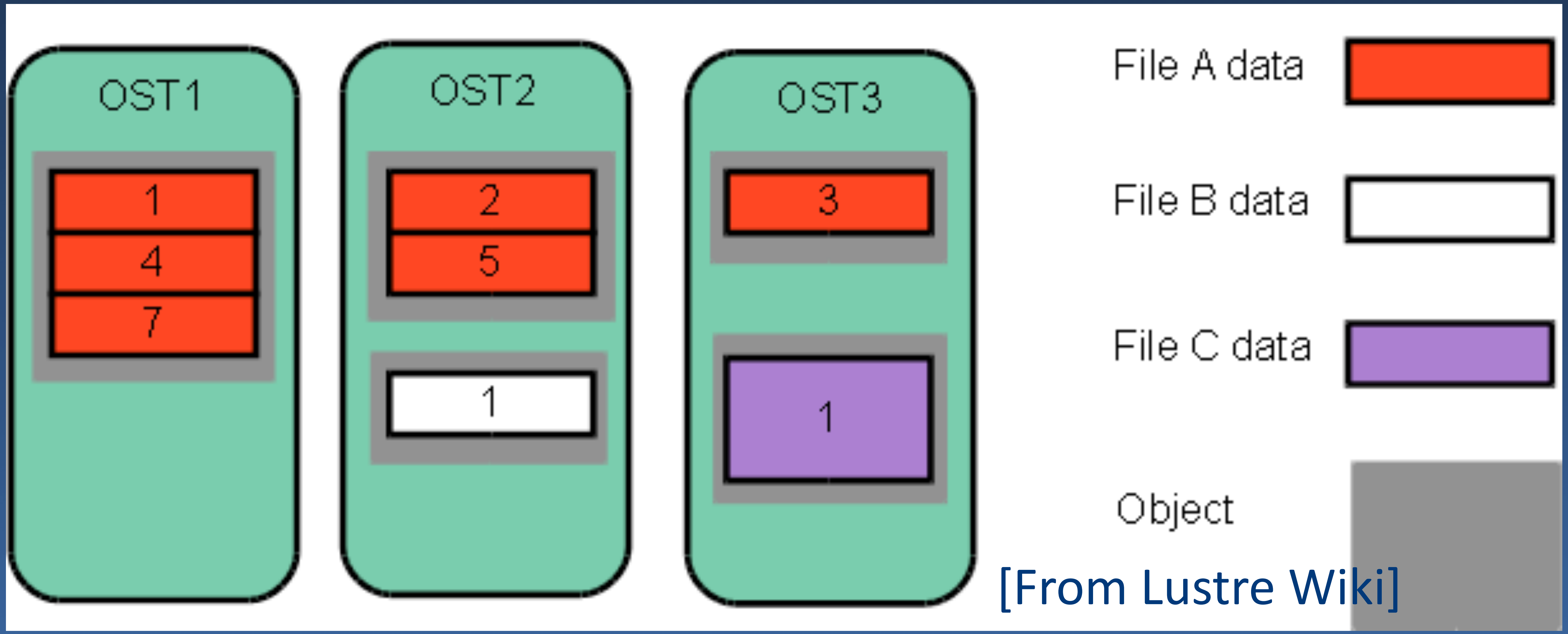

[From Lustre Wiki]

```
> lfs getstripe <filename>
> lfs setstripe <dirname>
```

Example: Collective IO

```
MPI_Comm_size(MPI_COMM_WORLD, &size );
MPI_File_open(MPI_COMM_WORLD, "file", MPI_MODE_RDWR|MPI_MODE_CREATE,
                    MPI_INFO_NULL, &fh ); // Collective, Blocking

MPI_File_write_ordered( fh, buf, 1, MPI_INT, &status );// Collective write in order of ranks
MPI_Barrier(MPI_COMM_WORLD);                           // Let all writes complete

MPI_File_seek( fh, 0, MPI_SEEK_SET );                  // Each separately ‘rewinds’ to the top
MPI_File_read_all( fh, buf, size, MPI_INT, &status );  // All read size ints from their fh

MPI_File_seek_shared(fh, 0, MPI_SEEK_SET );            // Collective rewind of shared fh
MPI_File_read_ordered(fh, buf, 1, MPI_INT, &status );  // Collective read in order of ranks

MPI_File_close( &fh );
```

IO Variants

- Location

  MPI_File_read_**at**(fh, offset, buffer, count, datatype, &status)

- Non-blocking

  MPI_File_**i**read(fh, buffer, count, datatype, &request)

- Collective

  MPI_File_read_**all**(fh, buffer, count, datatype, &status)

- Shared File pointer (Common data IO)

  MPI_File_read_**shared**(fh, buffer, count, datatype, &status) // Not collective

  MPI_File_read_**ordered** (fh, buffer, count, datatype, &status) // Collective

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See:
MPI_File_set_atomicity
MPI_File_sync

File View

- 3-tuple: <displacement, etype, filetype>
  - ➡ byte displacement from the start of the file
  - ➡ etype: data unit type
  - ➡ filetype: portion of the file visible to the process
- MPI_File_set_view

File View

Map data structures with file data

Derived type

File View

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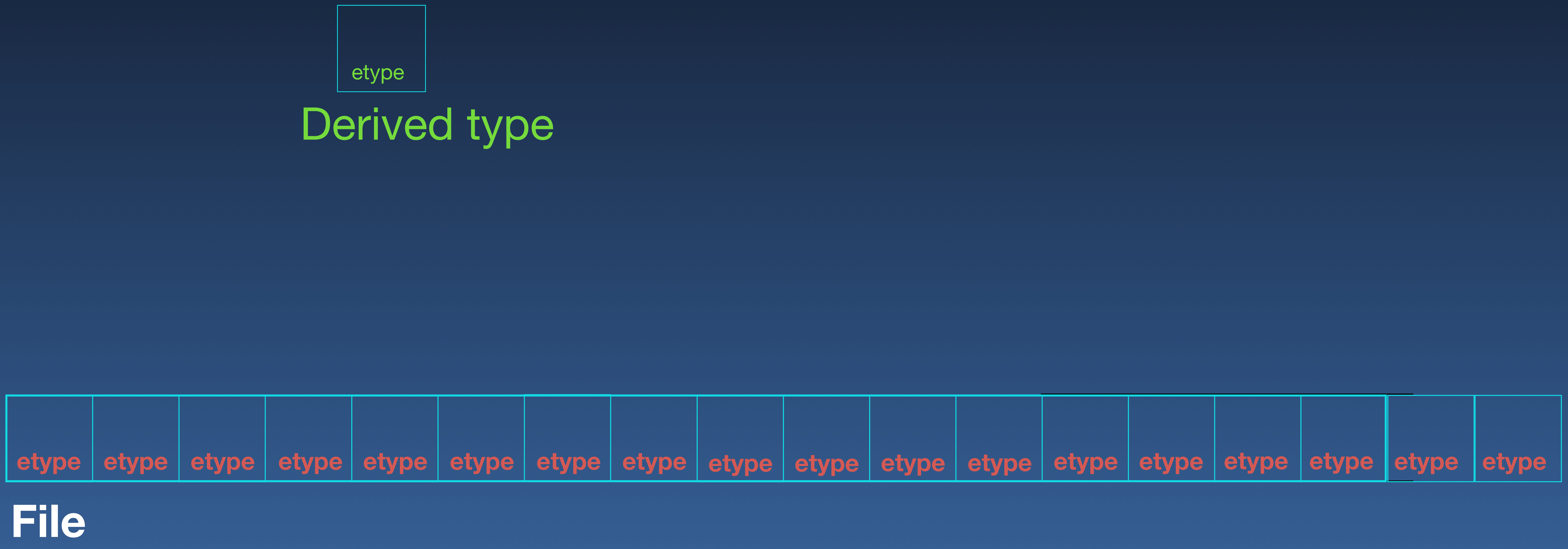

etype

Derived type

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File

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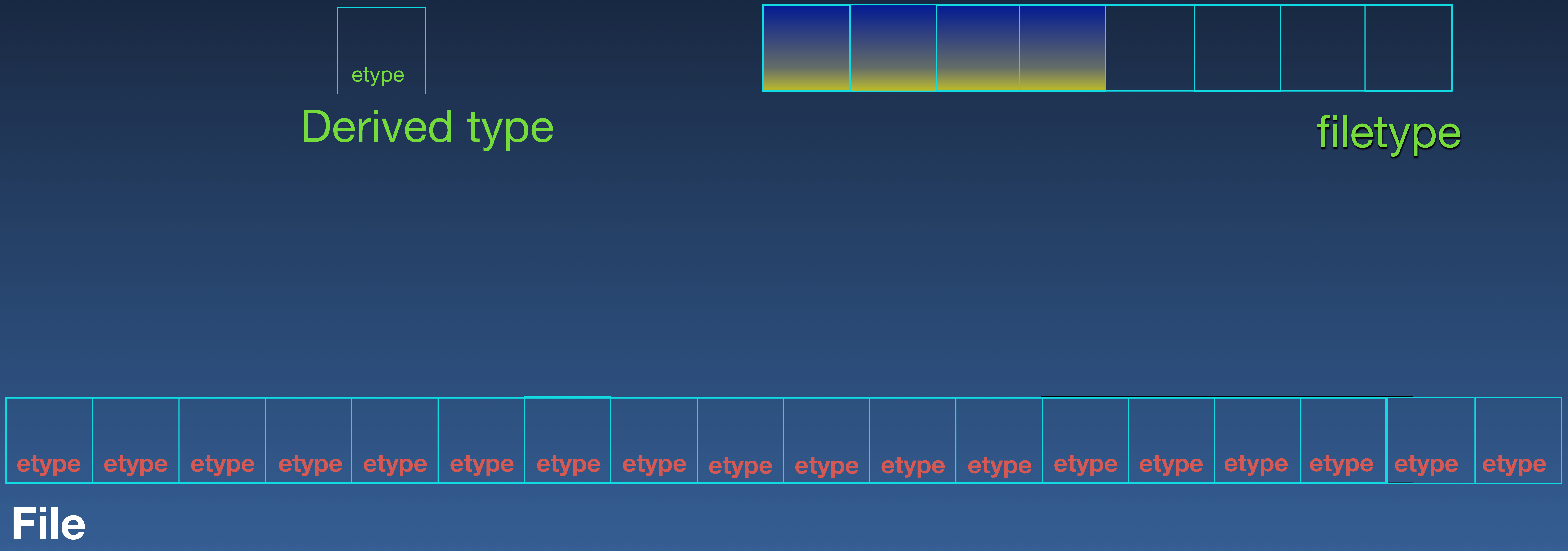
File View

Map data structures with file data



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File

File View

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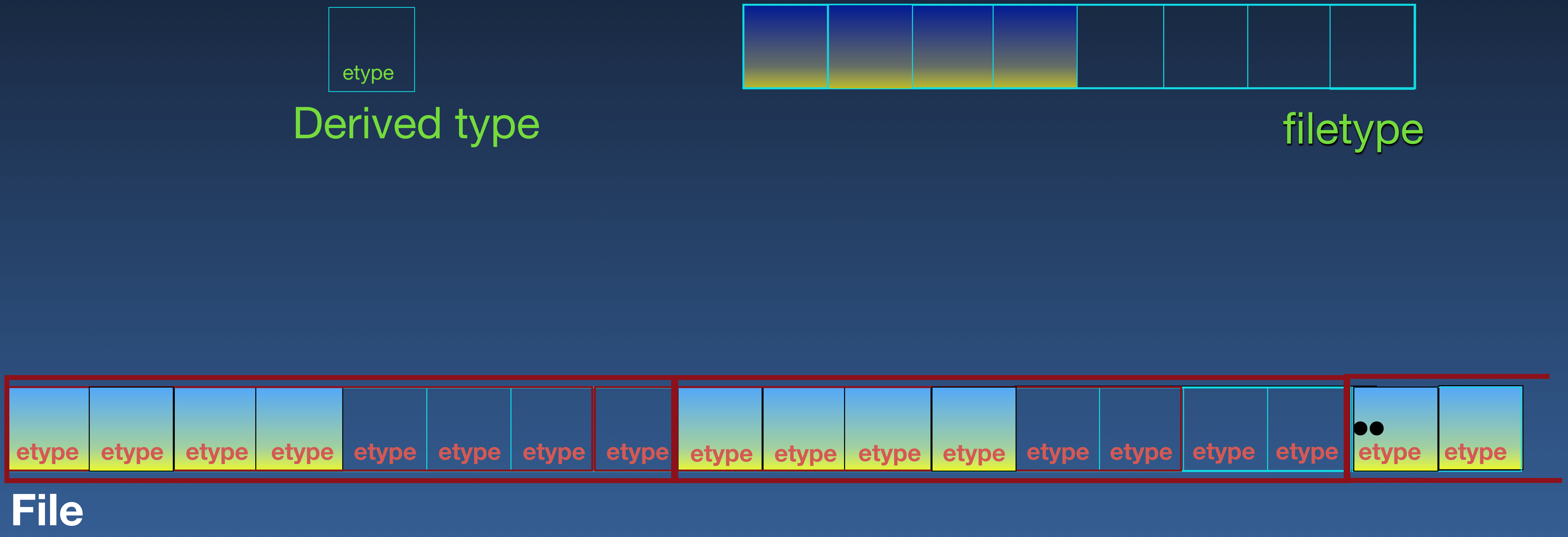

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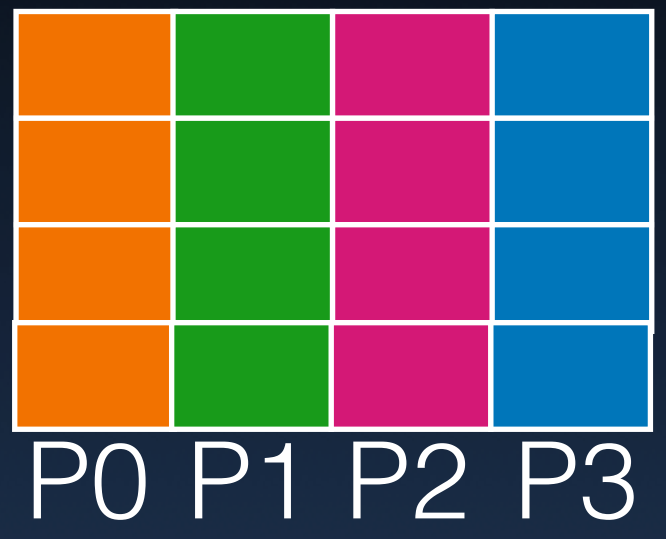
Example: Views in IO



block-column distribution

```
MPI_Comm_rank(MPI_COMM_WORLD, &rank );
MPI_Comm_size(MPI_COMM_WORLD, &nproc );
MPI_Type_contiguous (4, MPI_DOUBLE, &etype);
MPI_Type_commit ( &etype );

for ( i = 0; i < 4; i++) {
      displ[i] = rank + i * nproc;
      blocklength[i] = 1;
}
MPI_Type_indexed (4, blocklength, displ, etype, &filetype );
MPI_Type_commit ( &filetype );

MPI_File_open ( MPI_COMM_WORLD,"file", MPI_MODE_RDONLY, MPI_INFO_NULL , &fh);
MPI_File_set_view (fh, 0, etype, filetype, "native", MPI_INFO_NULL);
MPI_File_read_all (fh, buf, 16, etype, &status );
MPI_File_close ( &fh );
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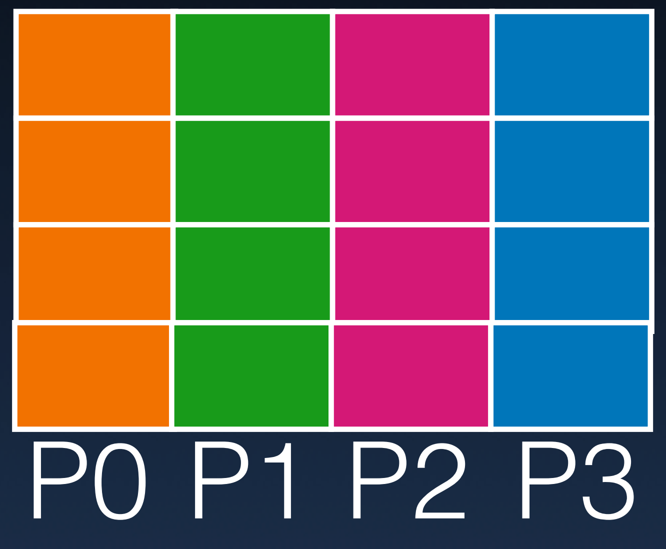
In P0's view, the file consists of only its data

Example: Views in IO



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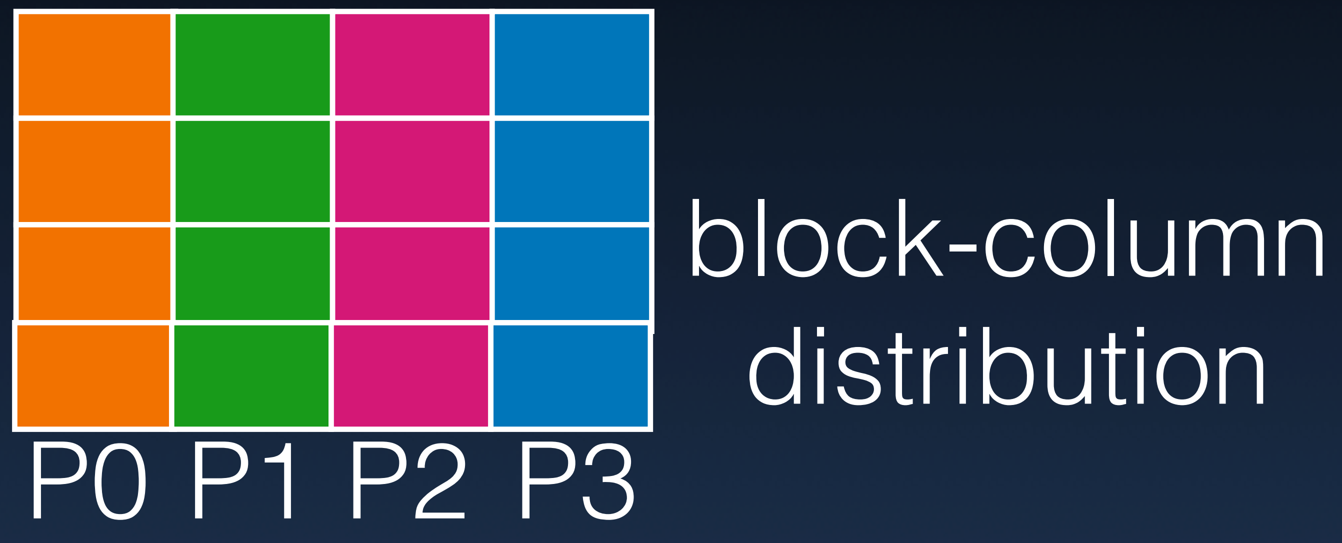

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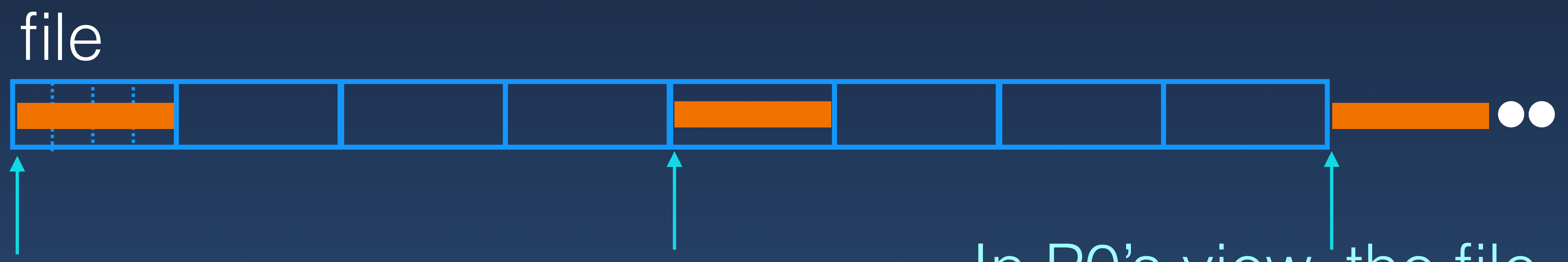

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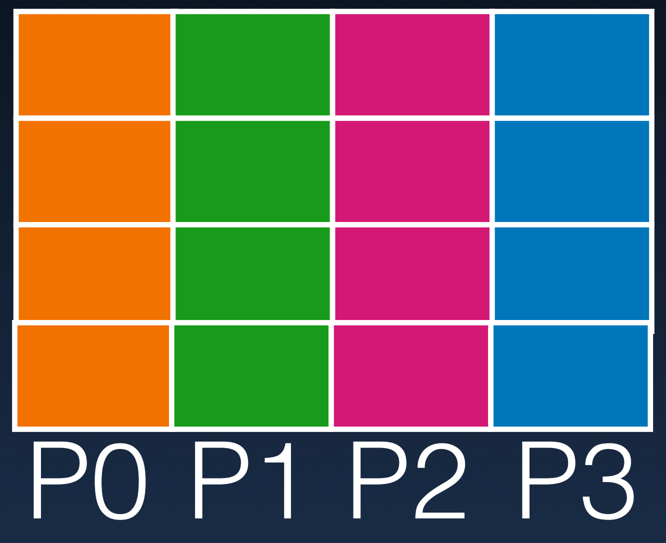

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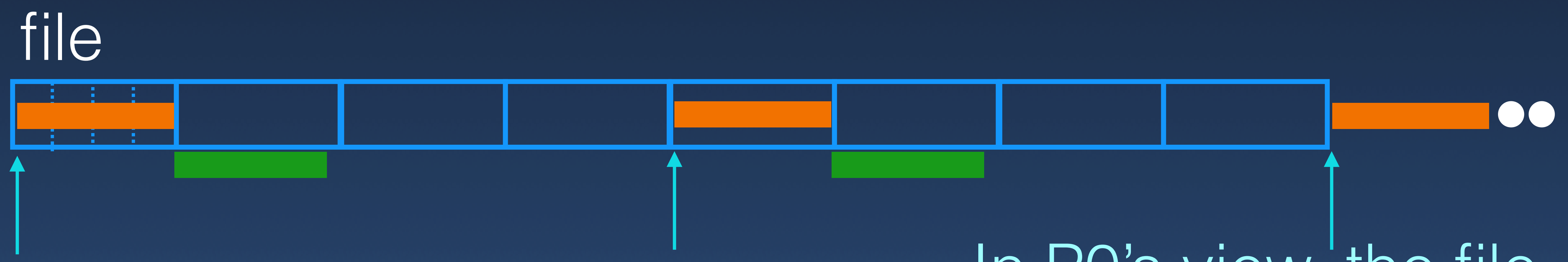

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Review

- Basic structure of parallel file system
- MPI File IO
  - ➡ Collective, individual, shared
  - ➡ Data type and file views