Parallel Access of Dense Extendible Arrays

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Outline

Problem Statement

Problem:
An allocation of a multidimensional array in a parallel file system such that:

- any dimension is allowed to expand.
- parallel applications read/write/manipulate entire array or sub-arrays
- array can be extended without reorganizing previously allocated elements,
- define a mapping function and its inverse for element access.

Data types: integers, floats, double and complex types.

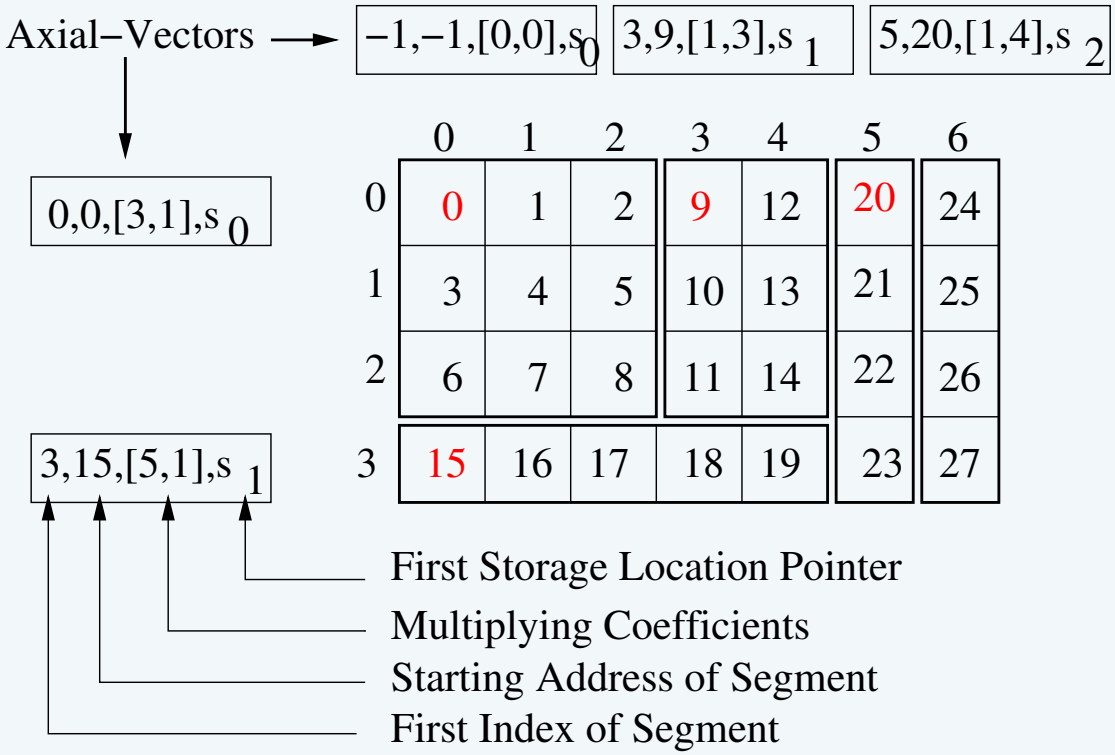
Illustration of an Extendible Array

- A 2-D array initially defined as $A[3][3]$ and then extended by by 2 columns, then by 1 row, followed by 1 column and so on.

	0	1	2	3	4	5	6
0	0	1	2	9	12	20	24
1	3	4	5	10	13	21	25
2	6	7	8	11	14	22	26
3	15	16	17	18	19	23	27

- The labels in the cells are location addresses of the elements.
- An element $A\langle 2,5\rangle$ maps to location 22
- The address calculation is done by a function denoted as:
  $\mathscr{F}_*(i_0, i_1, \ldots, i_{k-1}) \rightarrow I$
  and an inverse $\mathscr{F}_*^{-1}(I) \rightarrow \langle i_0, i_1, \ldots, i_{k-1}\rangle$

Linear Mapping for an Extendible Array



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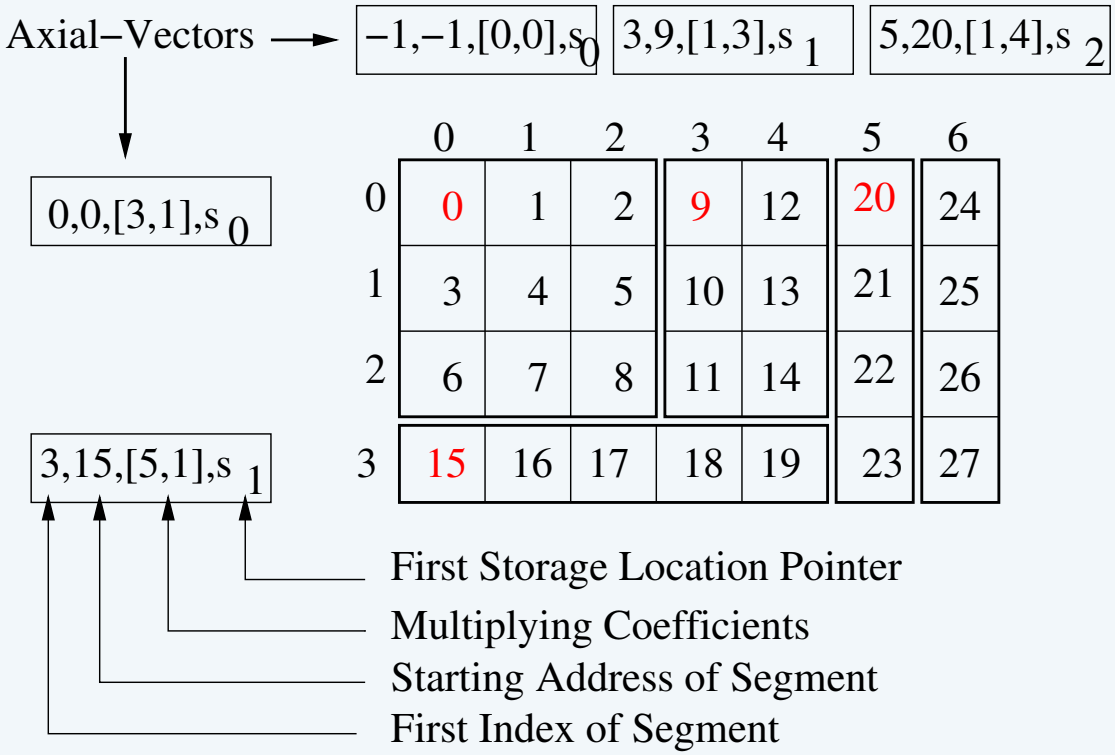
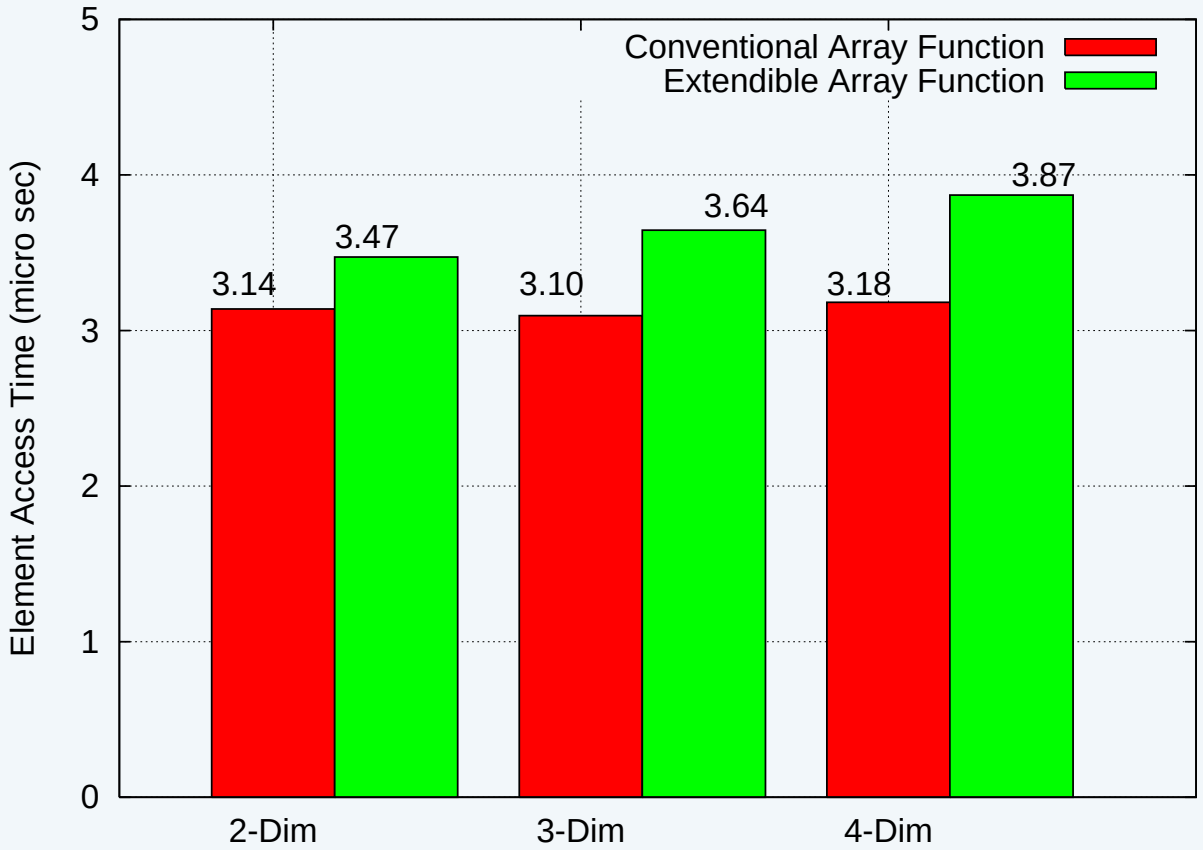


- The element $A\langle 2,5\rangle$ is located in either segment of row 2 with start address 0 or segment of column 5 with start address 20.
- It is always allocated in segment with maximum starting address.
- The address of $A\langle 2,5\rangle$ is computed by the algorithm $\mathscr{F}_*()$.

Comparison of File Element Access Cost



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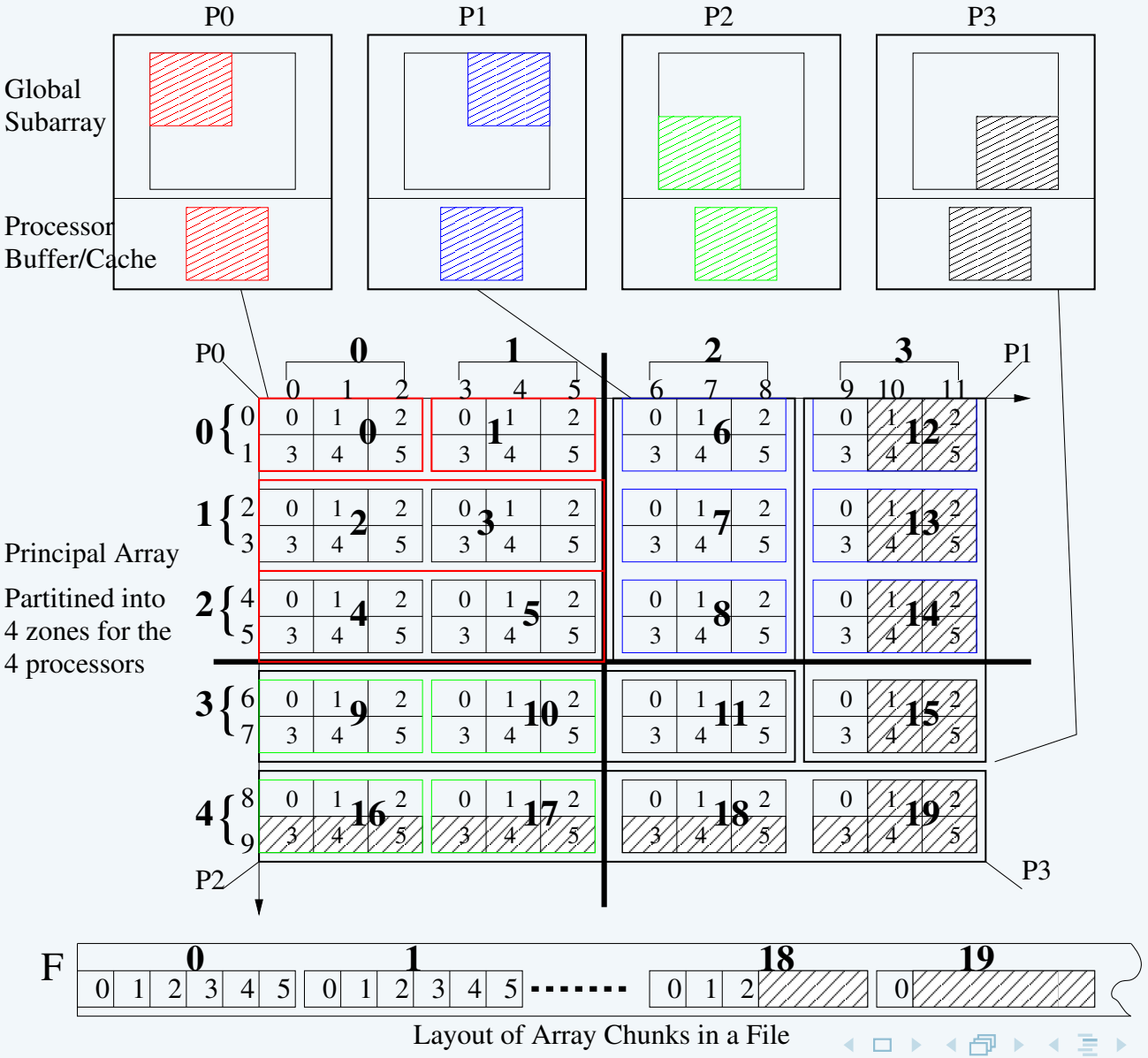
- The *Axial-Vectors* are retained in a Meta-Data file but read into memory at each session.
- Additional information in the Meta-Data include the bounds of the array, the chunk-shapes, etc.

The Allocation Scheme



Accessing Extendible Arrays (The pDRXA Library)

- Array is distributed by Block, Block partitioning scheme and along chunk boundaries. Block-Cyclic partitioning not yet
- A process controls a region of sub-array called a *zone* and an application can sub-arrays with either independent or collective I/O.

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- The processing model is consistent with the Global-Array toolkit model for parallel processing of arrays.
- The idea then is to define the access functions to be consistent with the Disk Resident Array library of GA and leverage the scientific processing capability of GA.

Future Work Plans

- There are a number of popular and established standard array oriented file formats that the methods can be used to support.
  - HDF4/HDF5 and their derivatives - HDF5-EOS, HDF5-Lite.
  - HDF5 allows extendibility in any dimension using data chunking and manages the chunks using a B-Tree index.
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- An API of pDRXA consistent with those of DRA should make it accessible to any application that uses GA.
- NetCDF {NCAR} and parallel NetCDF {SDM Center} can utilize pDRXA access functions without reliance on HDF5