# Charm++ (and a bit of Argo) Perspective

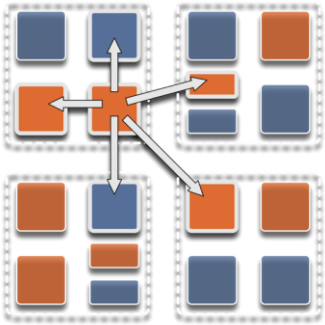
Laxmikant (Sanjay) Kale
http://charm.cs.illinois.edu
Parallel Programming Laboratory
Department of Computer Science
University of Illinois at Urbana Champaign

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

PARALLEL PROGRAMMING LAB
DEPT. OF COMPUTER SCIENCE, UNIVERSITY OF ILLINOIS
PPL UIUC

# Charm++: basic programming model

- Eliminate "processor" and "node" from scientific programmer's vocabulary
  - Well, almost
- Overdecomposition:
  - Programmer "over-decomposes" work/data units
- Migratability:
  - units can be migrated by RTS during execution
- Asynchrony
- RTS empowered via introspection + adaptivity
  - Naming and location management
  - Dynamic Load Balancing
  - Resilience, power management, ..



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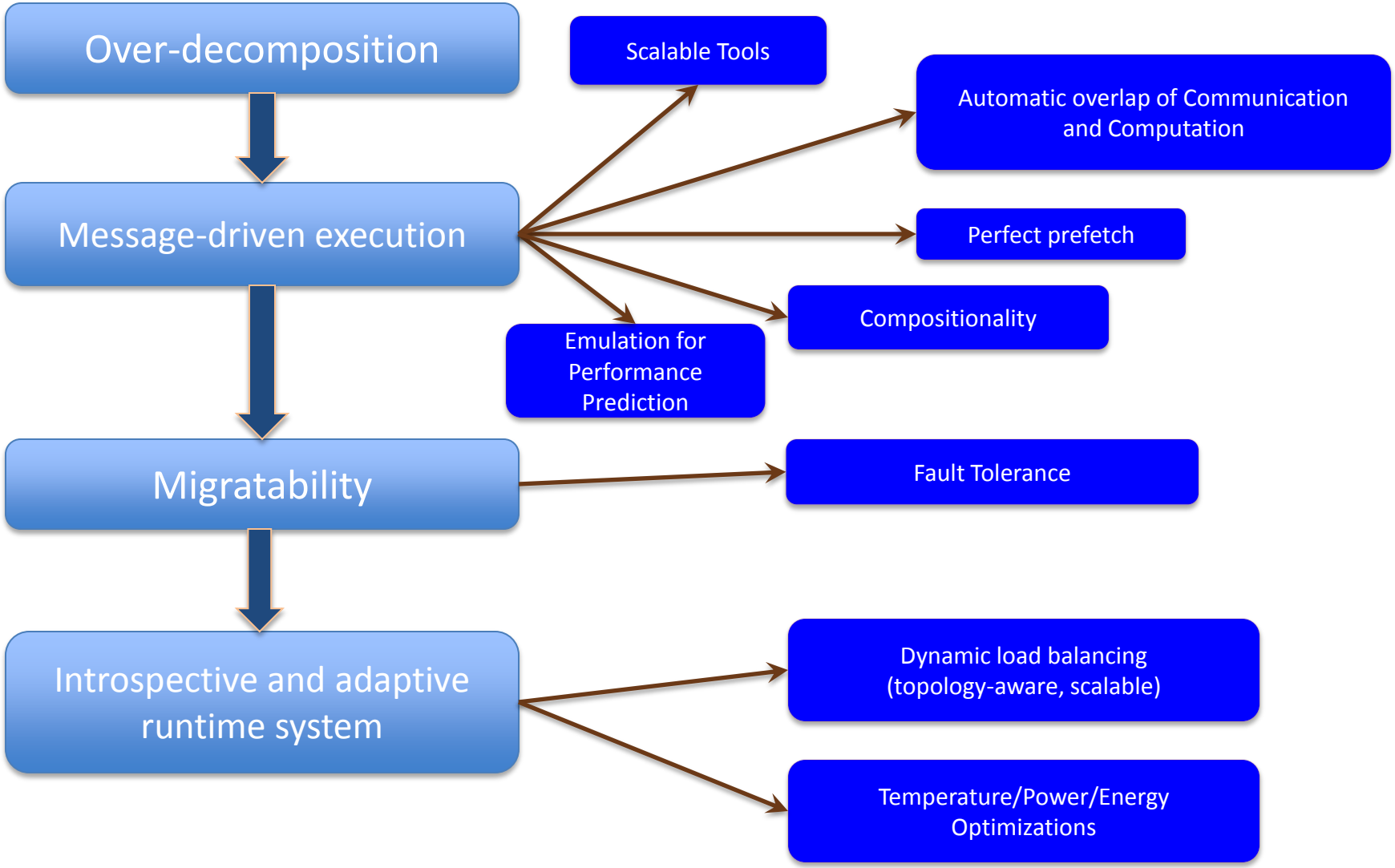
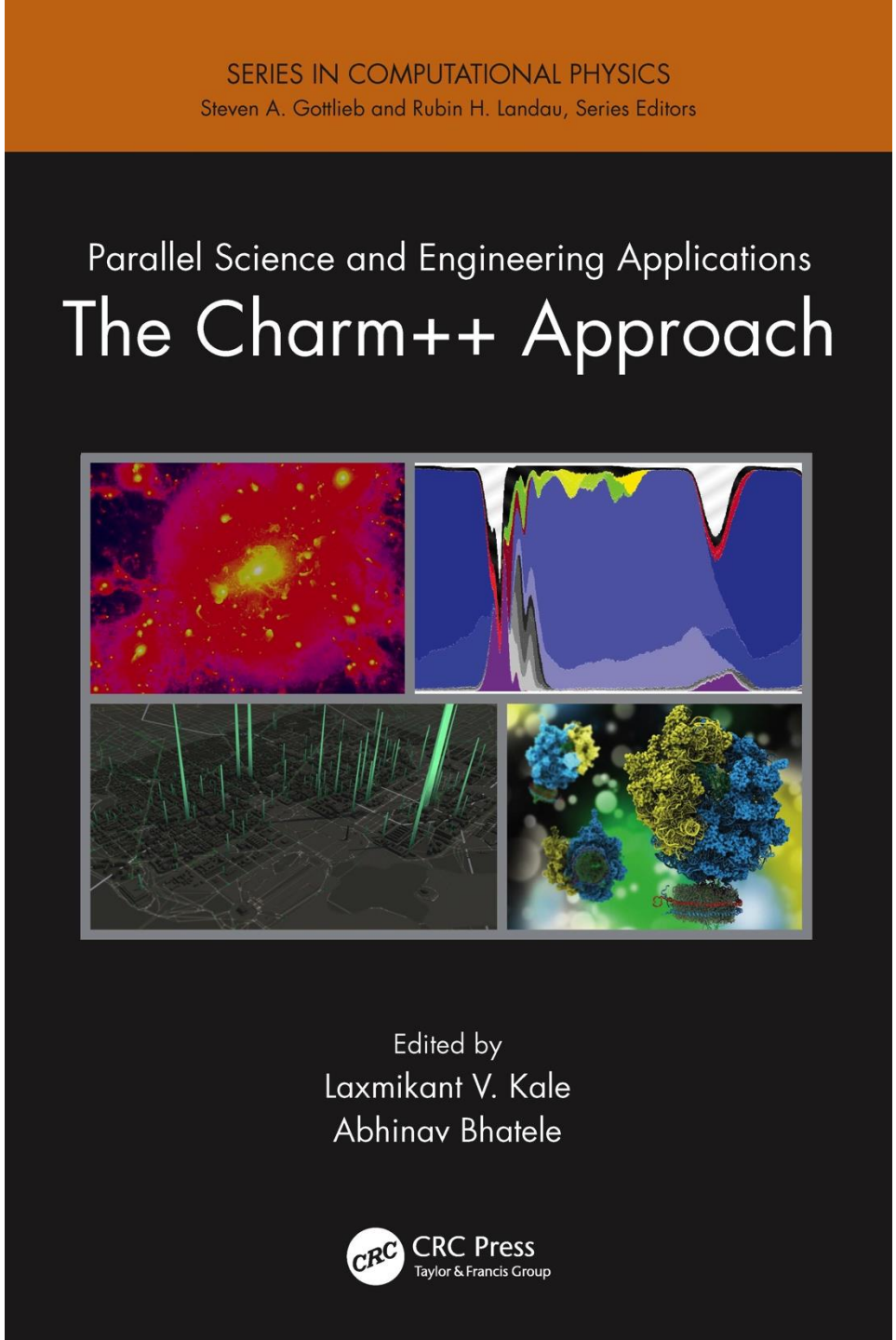
# Benefits in Charm++



A just-published book
surveys seven major applications developed using Charm++

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# Major Charm++ Applications of interest here

- NAMD: Classical Molecular Dynamics
  - Scales to million cores, used extenively
- OpenAtom: Car-Parinello Quantum chemistry
  - Scales to 100k+ cores, main users at IBM
  - GW-BSE being added for excited states modeling
- ChaNGa: Computational astronomy treecode
  - Scales to 300k+ cores, multi-time-scales, used by the astro community
- Episimdemics: Agent based contagion propagation
- Many others…
- Mini-apps: http://charmplusplus.org/benchmarks/
- New: XPACC: Plasma Combustion at Illinois:
  - (not charm++ yet)

# MPI-Charm++Interoperability

Paper in preparation

| Application | Library | Productivity | Performance |
|---|---|---|---|
| CHARM in MPI (on Chombo) | HistSort in Charm++ | 195 lines removed | 48x speed up in Sorting |
| EpiSimdemics | MPI IO | Write to single file | 256x faster input |
| NAMD | FFTW | 280 lines less | Similar performance |
| Charm++'s Load Balancing | ParMETIS | Parallel graph partitioning | Faster applications |

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# Power/Energy Optimizations

- <u>**E.g. Cooling energy reduction**</u>
- Set the thermostat to a higher temperature
- Monitor core temperatures every few seconds
- Reduce frequency if core is hot, increase if not
- Problem: This will cause load imbalance
  - RTS migrates objects around to balance load
  - Saves cooling energy
    - while reducing timing penalty
    - SC11 paper
  - Many additional power/energy/temperature optimizations completed and in progress
  - http://charm.cs.uiuc.edu/research/energy

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# Fault Tolerance in Charm++/AMPI

- Four Approaches Available:
  - Disk-based checkpoint/restart
  - In-memory double checkpoint w auto. restart
  - Proactive object migration
  - Message-logging: scalable fault tolerance
- Common Features:
  - Easy checkpoint: migrate-to-disk
  - Based on dynamic runtime capabilities
  - Use of object-migration
  - Can be used in concert with load-balancing schemes

# Argo: DOE OS/Runtime Project

- (I am a small part of Argo.. Not quite representing it)
- Whole-machine optimizations
  - Resource allocation (and reallocation) among jobs
- Node-OS
- Argobots: Concurrency mechanisms within a node
- Beacon/Expose
  - Introspection, instrumentation pub/sub capabilities
- Will support language/DSL (x-stack) runtimes

# Our Interest from ExMatEx

- MiniApps
  - Well described
  - Friendly to new models
- Scale-bridging issues are of great interest
  - We think Charm++ methodology will be very useful
- Trying Charm++: Please contact us!
  - Unpublished in-preparation material (book chapters)
  - Personal assistance can reduce learning barriers significantly
- Joint projects with ExMatEx participants