CLARISSE: Cross-Layer Abstractions and Run-time for I/O Software Stack of Extreme-Scale Systems

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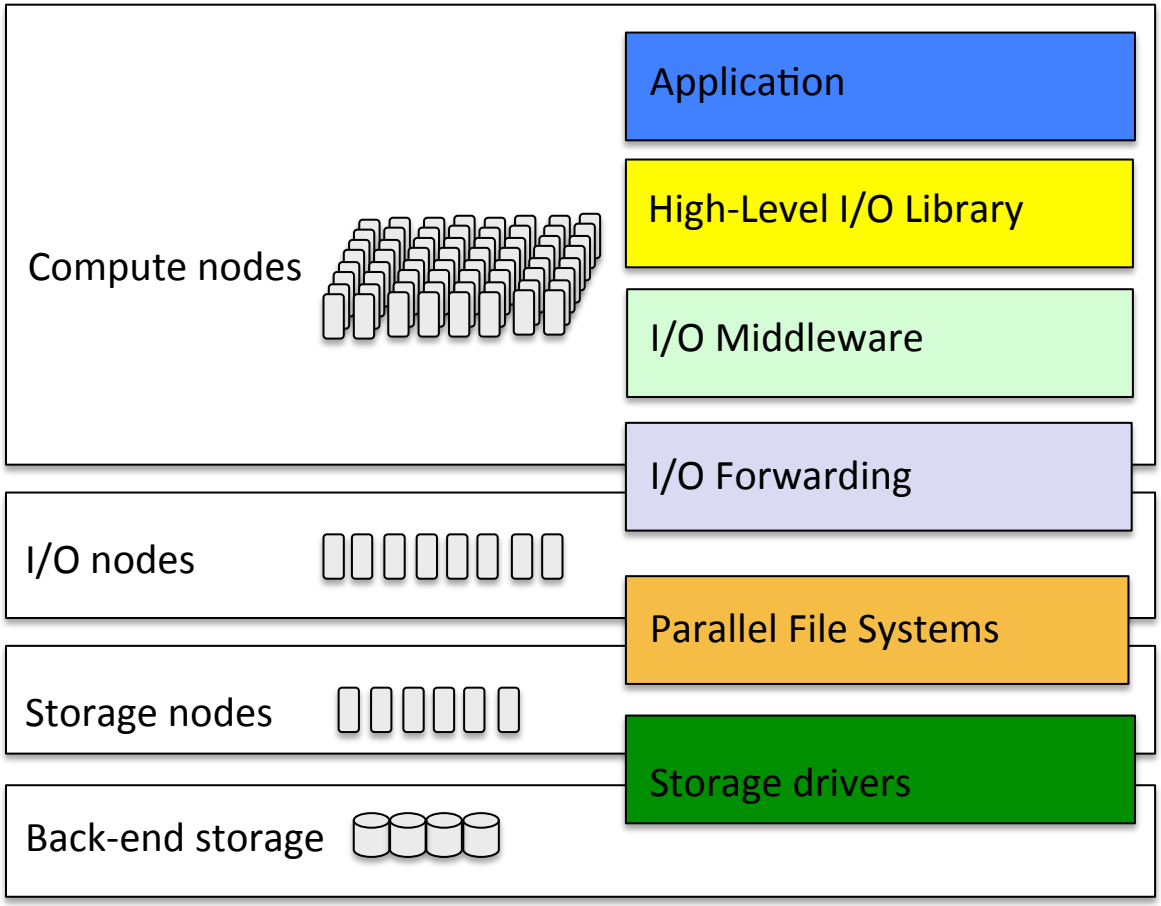
Outline

- Motivation
- Goals
- CLARISSE Approach
- CLARISSE Architecture
- Challenges
- Conclusions

Current problems of storage I/O stack



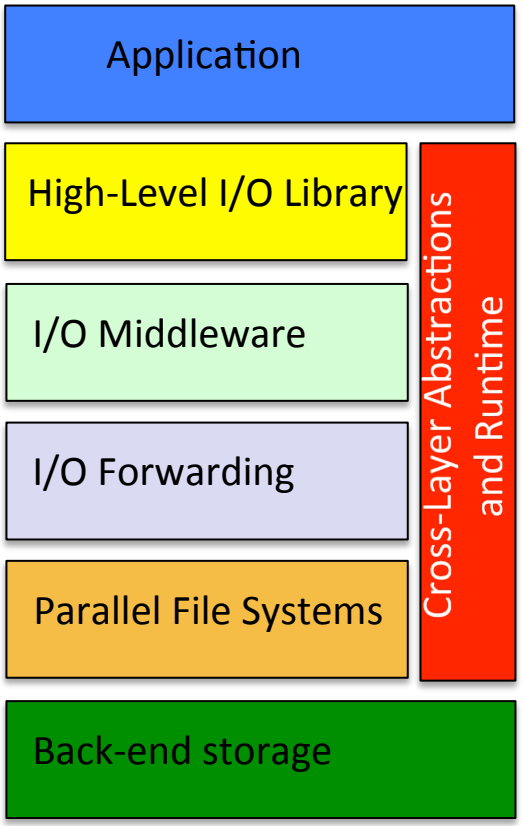
- Long path from compute nodes to final storage impacts performance (latency, throughput)
- Storage I/O optimizations are local: Difficult to perform global optimizations
- Cross-layer adaptive control mechanisms are not available (e.g for data staging, dynamic load balancing, resilience)

CLARISSE goals

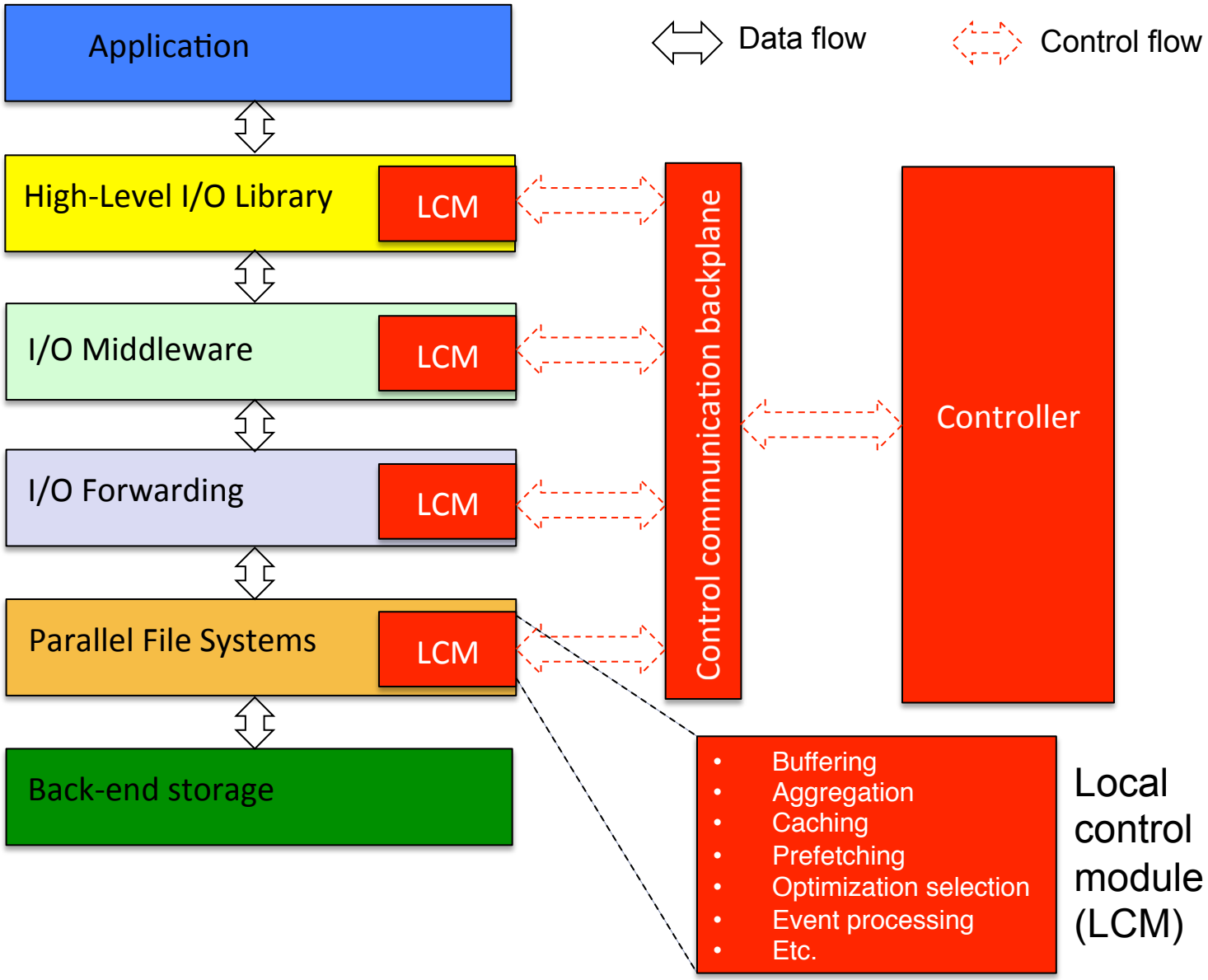
- Enable global optimizations of the software I/O stack
- Separation of data flow and control flow through the storage hierarchy
- Develop a run-time for cross-layer control of the data flow
  - Data staging
  - Data locality

CLARISSE approach

- Global logical view of optimizations space
  - Distributed application of global optimization
  - Facilitate the combination of local optimizations based on a global view
- Cross-layer abstractions and run-time
  - Facilitate the flow of control and data across the I/O stack
  - Decouple the data and control planes
    - Control backplane
    - Abstractions for controlling the data plane
- Control adaptation to application context
  - Applications run unmodified
  - Flexibly define control policies adapted to the requirements of each application
- Data flow optimizations
  - Coordinated cross-layer buffering, caching, prefetching
  - Run-time optimizations (e.g. load-aware data staging)

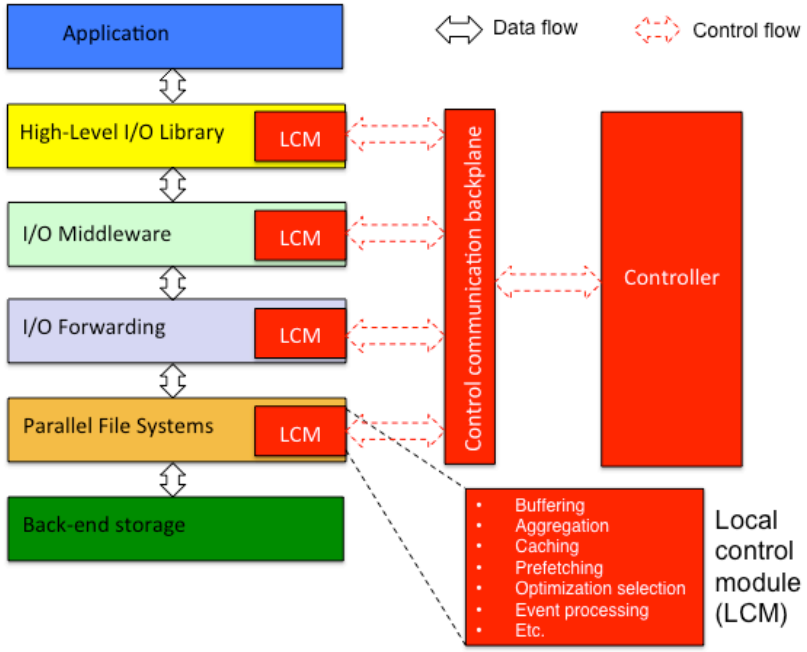


CLARISSE Architecture



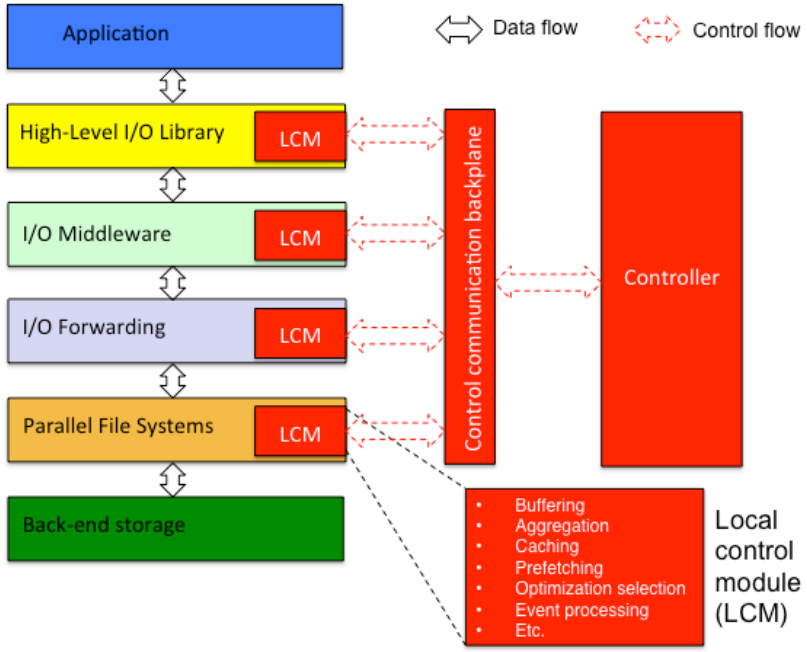
Controller

- Cross-layer logic
- Gathers information
  - Application patterns
  - Data related attributes
  - System characteristics
  - Available optimizations
  - Run-time events and statistics
- Global optimization inference
- Distributes the control decisions to LCMs
- API for defining control policies
  - e.g. prediction, load-aware, data locality-aware



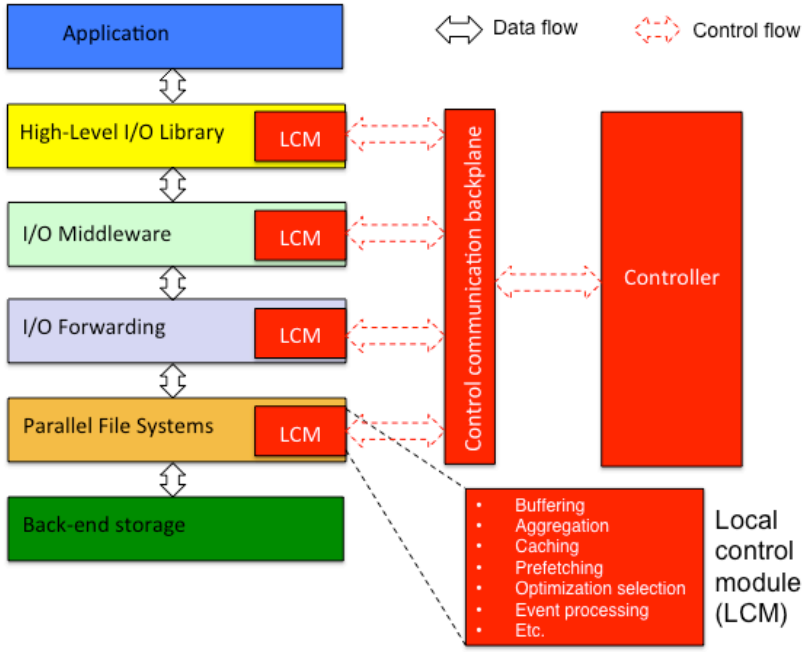
Local control module (LCM)

- Enforce control at I/O software stack layers
- Select local optimizations
- Event processing
- Collects run-time information and forwards them to controller
- Optional
  - Not all layers have to provide it
  - Each layer can use a default policy



Communication backplane

- Coordination between controller and I/O software stack layers
- Generic
- Event-based: react to user-defined criteria
- Low overhead: low interference with the system workings
- Potential candidates
  - CIFTS: A Coordinated Infrastructure for Fault-Tolerant Systems
  - Beacon: The communication backplane of ARGO, an exascale operating system



Challenges

- Scalability
  - Minimize the controlling infrastructure interference
- Minimal modifications
  - Unmodified applications
  - Small number of changes to the current I/O stack
- Distributed protocols for control and data flow
- Resilience
  - Behavior under failure of controlling infrastructure
- Extensibility
  - Simplicity of adding new control policies

Related work

- Software Defined Networking (e.g. Open Flow): global control based on separation of control and data flow
- I/O Flow (Microsoft Research): A Software Defined Storage Architecture for virtualized data centers
- Fast Forward (Intel et al.): redesign of the storage I/O stack
- Argo (ANL et al.): whole-system view and optimization based on a OS/R environment
- Hobbes (Sandia et al.): a lightweight OS/R environment with flexibility to build custom runtimes
- SIOX (University of Hamburg et al.): collect system-wide information to learn storage I/O optimizations

Conclusions

- Global optimization of storage I/O stack
- Decoupling control and data flow
- Optimize storage access
- Benefits
  - Mechanisms for global view of the storage I/O activity on extreme scale machines
  - Evolution of the I/O software stack based on whole system view
  - Run-time for controlling data flow and data locality

Thank you