FlexIO: Location Flexible Execution of In Situ Analytics for Large Scale Scientific Applications

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Motivation

"Big Data" Sciences:
- Scientific Simulations may generate TBs of data per run
- Data is the key to scientific insights
- "*Time to Insight*" is critical for scientists' productivity

I/O Bottleneck:
- I/O capacity not well provisioned on High End machines
- Severe I/O overheads for simulation and analytics at scale

In Situ Data Analytics: Addressing the I/O Bottleneck
- Analyze data at simulation time
- Online data inspection, manipulation, and processing
- Reduce disk I/O activities
  - Save time and power
- Deliver timely insights
  - Improve productivity

Challenges

Need for location flexibility:
- There are multiple options to place in situ analytics
- Placement can impact performance and cost
- No single best placement exists
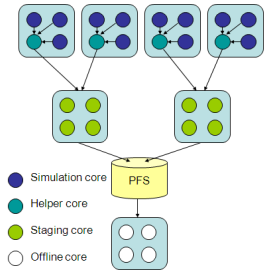
Requirements for I/O middleware:
- Support diverse placement options
- Require minimal effort in changing analytics placement
- High performance data movement between simulation and analytics
- Provide performance information for tuning placement

FlexIO Middleware

FlexIO middleware for coupling parallel simulations with in-situ analytics:
- Flexibility in `where' and 'when' analytics codes are run
- Driven by ADIOS IO interface
- Alter placements without changes to application/analysis codes
- Mobile "Data Conditioning Plug-ins" for dynamic data reduction
- Fast, scalable intra- and inter-node data movement
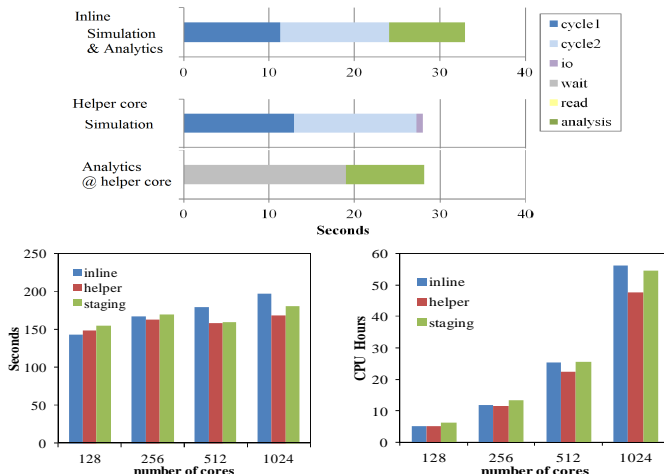- Online monitoring of computation and data movement
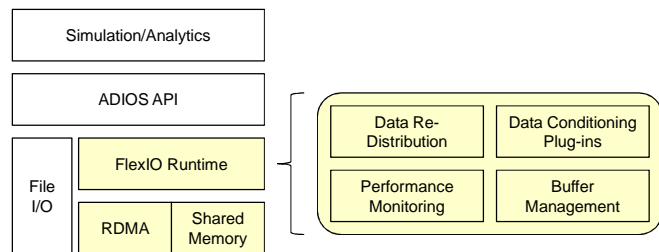
Case Study I: Pixie3D
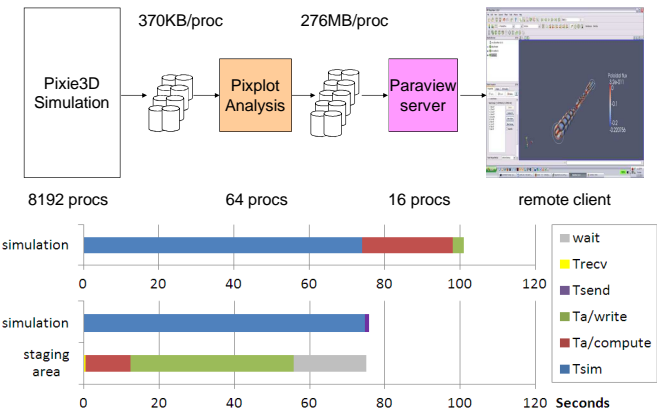
Using 0.78% additional nodes offloading Pixplot and I/O to staging area increases performance by 33% in comparison to inline placement

Case Study II: GTS

GTS fusion simulation code is coupled with a series of analytics (particle distribution function, range query, 2D histogram)

Placing analysis on helper cores in compute nodes achieves the best performance & cost due to spare cycles available there

Summary

Conclusions:
- Placement of in situ analytics has significant impact on end-to-end performance and cost
- FlexIO middleware supports diverse placement options for in situ analytics under uniform high level I/O APIs
- Significant performance & cost improvements achieved through flexible placement for real applications

Ongoing and future work:
- Porting FlexIO middleware to Cray XK6 platform
- Dynamic resource provisioning and automatic placement

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