Adapting Distributed Shared Memory Applications in Diverse Environments

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Overview

- Motivation
- Related work
- View model
- Experiments and Results

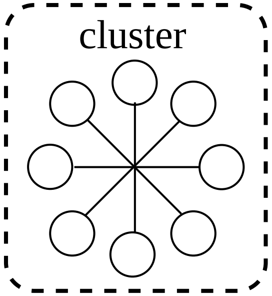
Motivation: An Application

Application:

A Matrix Multiply implemented using Lazy Release Consistency (LRC) for a cluster of Linux nodes with Ethernet interconnect.

Motivation: Diverse Environments

Problem: Computation environments are diverse.



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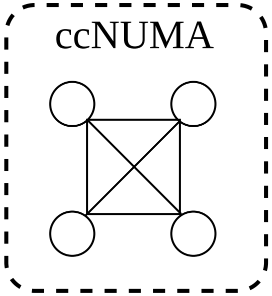

- Poor resource utilisation

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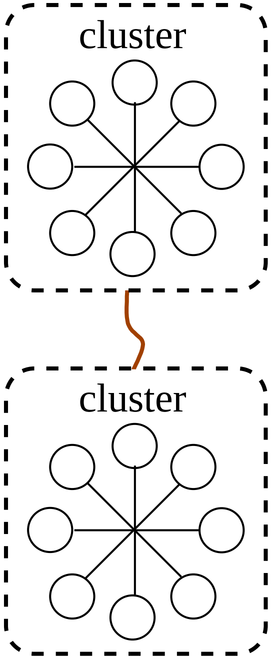

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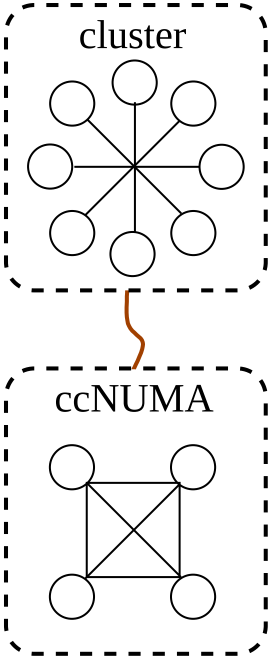

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- Heterogeneous environments poorly supported

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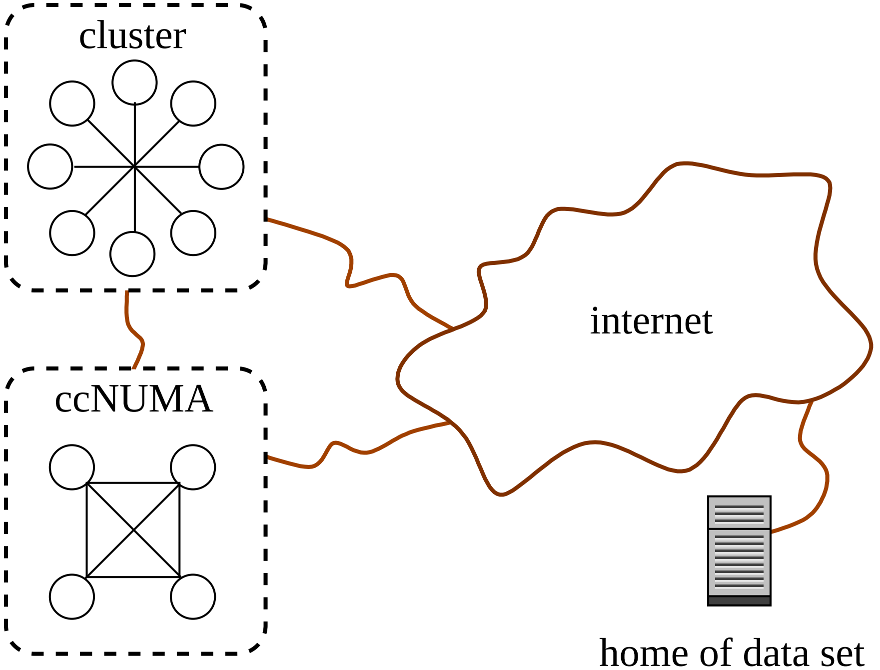

- Poor resource utilisation
- Environment structure ignored
- Heterogeneous environments poorly supported
- Wide-area poorly supported

Goals

- Run-time adaption to different homogeneous environments
- Optimise for environment structure
- Utilise resources of heterogeneous environments

Related Work (Existing Solutions)

- Run-time adaption to different homogeneous environments:
  $\Rightarrow$ Protocol selection in DSM-PM2
- Optimise for environment structure:

- Utilise resources of heterogeneous environments:

Related Work (Existing Solutions)

- Run-time adaption to different homogeneous environments:
  - ⇒ Protocol selection in DSM-PM2
- Optimise for environment structure:
  - ⇒ Home-based protocols eg. Home-based LRC
  - ⇒ Hybrid protocols eg. Albatross
- Utilise resources of heterogeneous environments:

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- Utilise resources of heterogeneous environments:
  - ⇒ Poor performing generic software protocols

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- Utilise resources of heterogeneous environments:
  ⇒ Poor performing generic software protocols

✗ No *overall* solution

Can we develop a flexible model to meet goals?

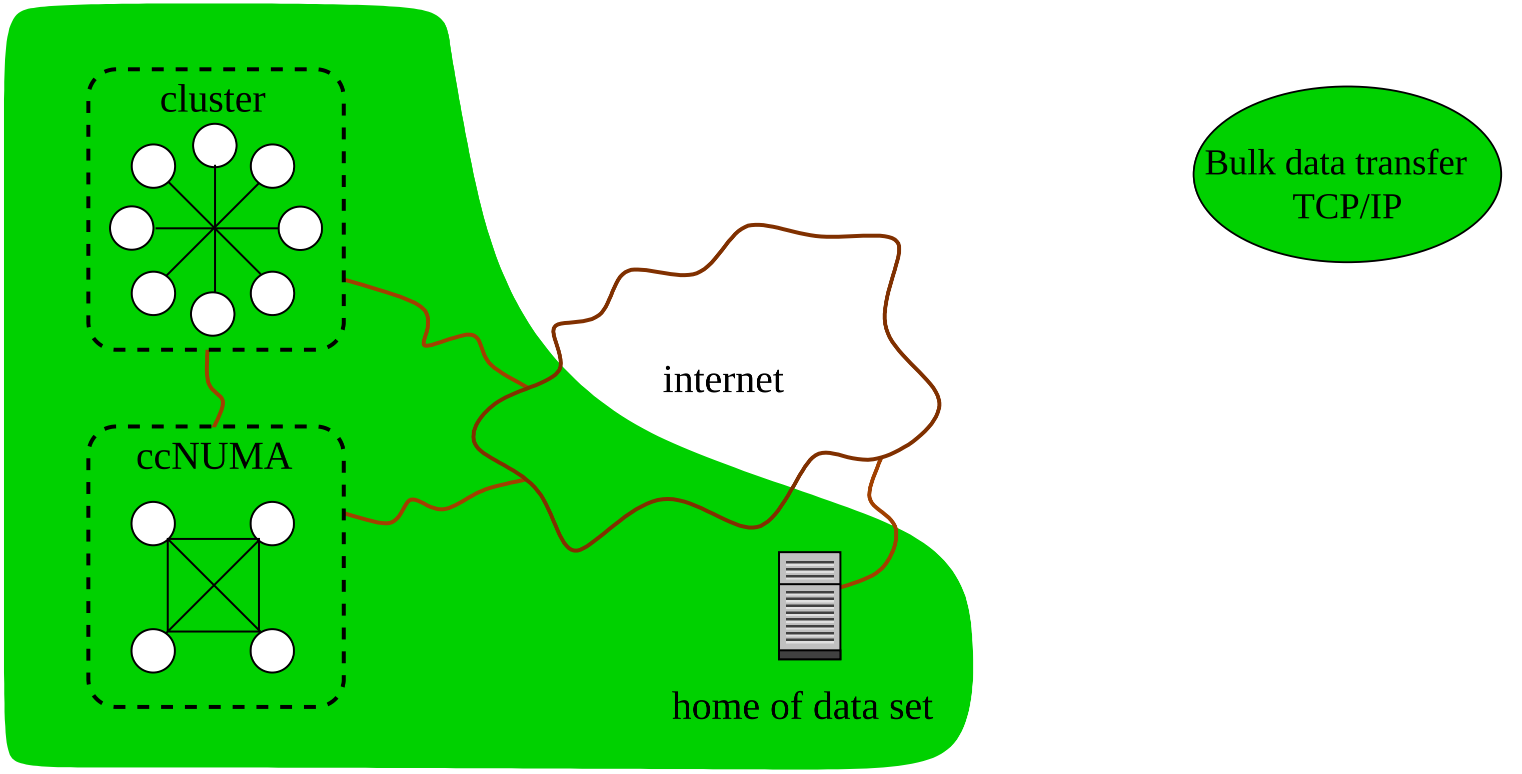
View Model

Views: An abstraction for protocol encapsulation

- The view model separates:
  - programming model,
  - consistency protocol,
  - communication protocol,
  - sharing interactions,
  - execution environments,

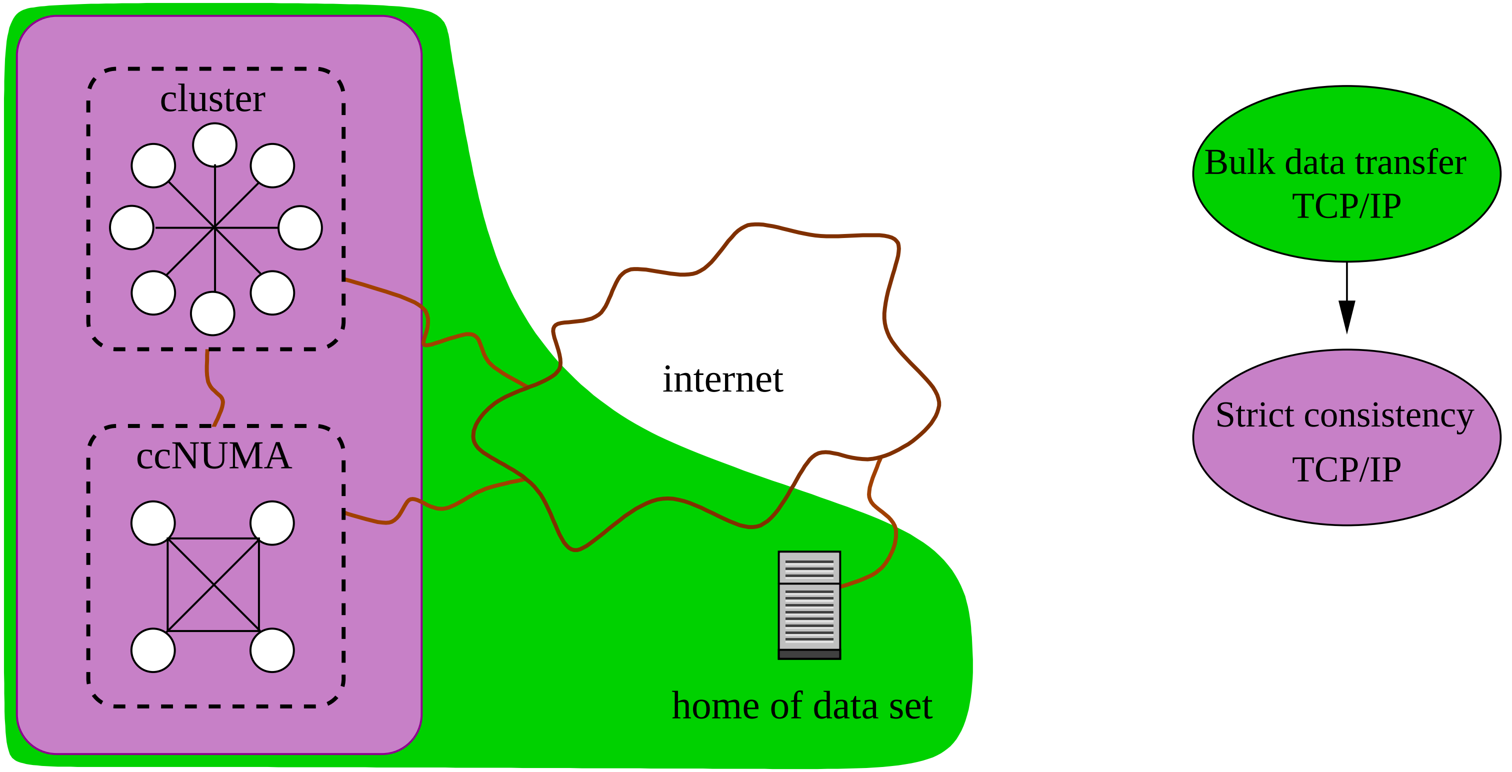
to give us *flexibility*.

Approach using Views



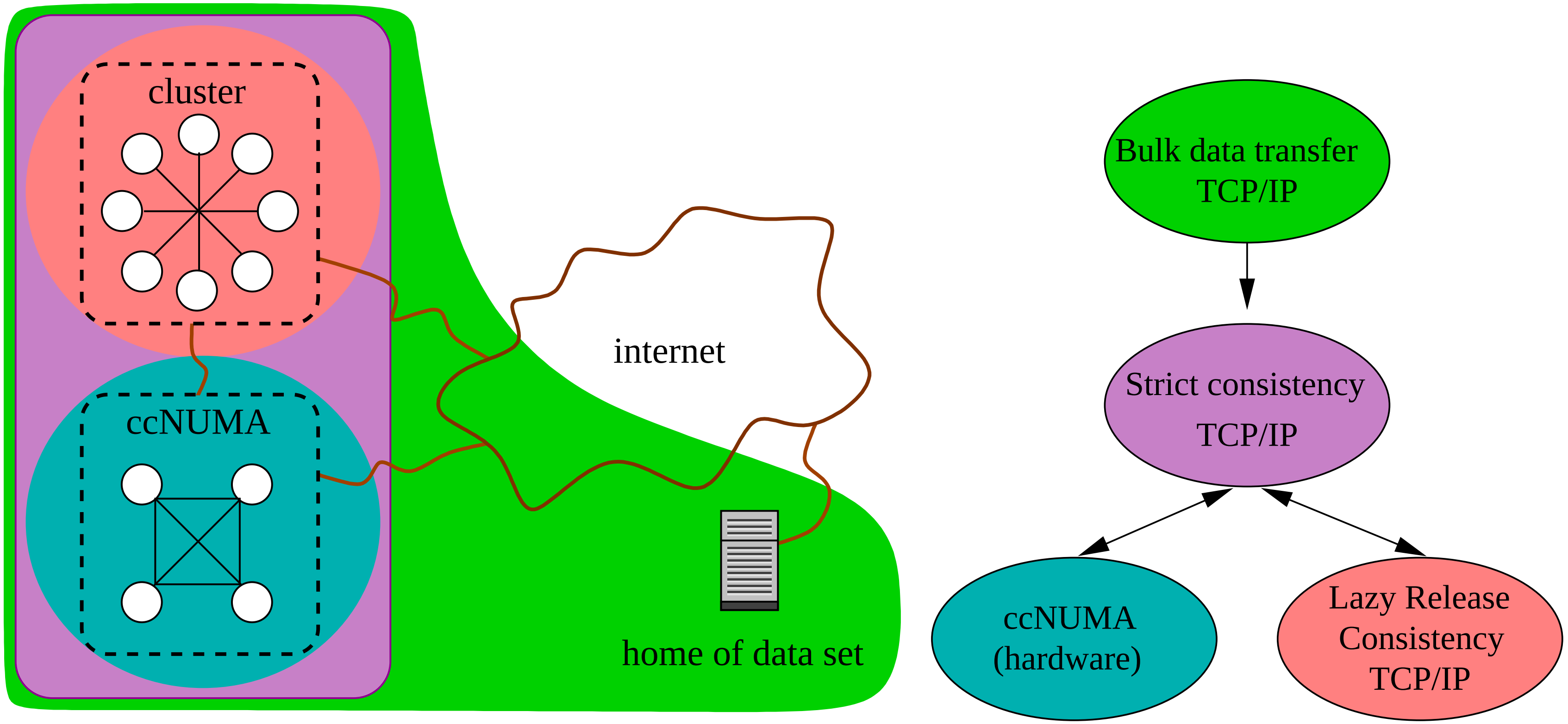
- Green view: single protocol, identical to traditional approach

Approach using Views



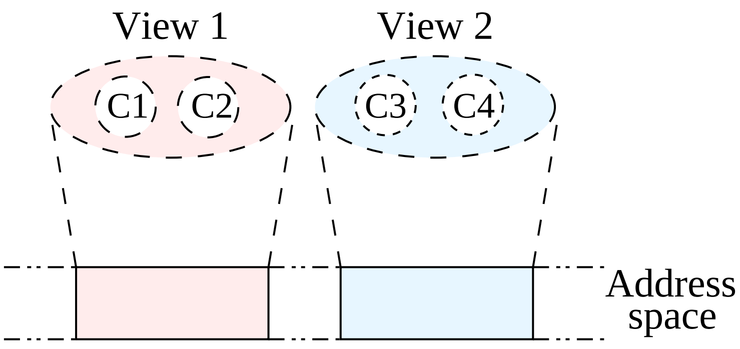
- Green view: single protocol, identical to traditional approach
- Purple view: data access localised to clusters

Approach using Views



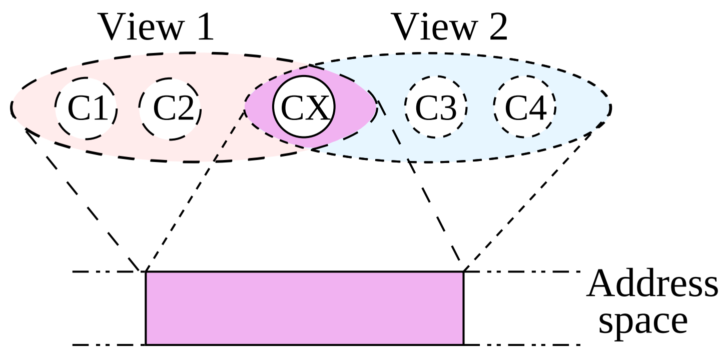
- Green view: single protocol, identical to traditional approach
- Purple view: data access localised to clusters
- Pink/Blue view: use optimised protocols

Views: Non-Overlapping



- View clients (e.g. C1) represent data sharers such as threads.
- An application may utilise many views.
- Can use different data sharing semantics for different data regions.

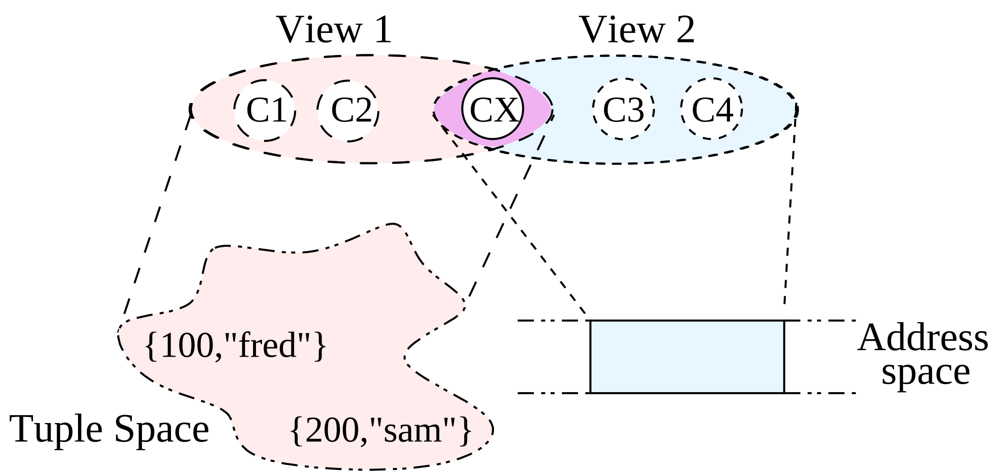
Views: Overlapping



- Each view may have a different consistency behaviour
- Views interact to represent the same data element
- *Conceptual client* CX proxies operations
- CX provided for *free* by view model
- Can use different data sharing semantics for same region

✓Great for heterogeneous environments!

Views: Mapped Views



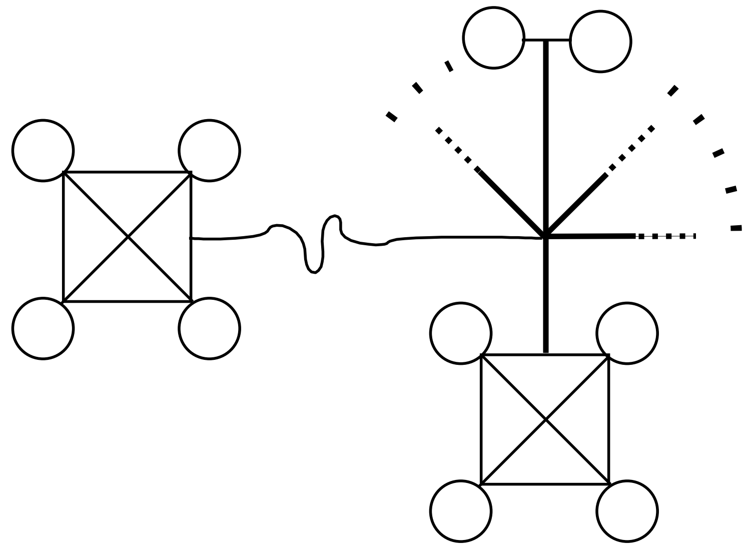
- Extension to overlapping views.
- *Mapping client* implements a mapping function that translates view operations

Experiment: DSM Matrix Multiply

- 1200 x 1200 matrix multiply
- Cluster 1: Itanium 4-way SMP
- Cluster 2: Itanium 4-way ccNUMA + six Itanium 2-way SMP
- Cluster 2 has 1000Mbit internal switch
- Cluster 1 and 2 are connected via 100Mbit link
- Three view configurations: traditional, two domain, multi-protocol two domain.

Experiment: View Configurations

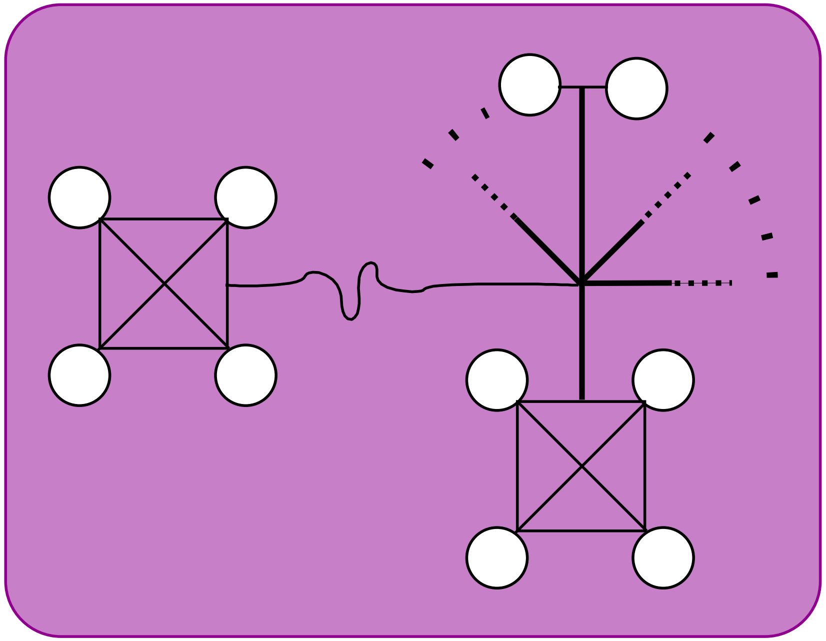
Environment:



- Multi-cluster of 20 CPUs.

Experiment: View Configurations

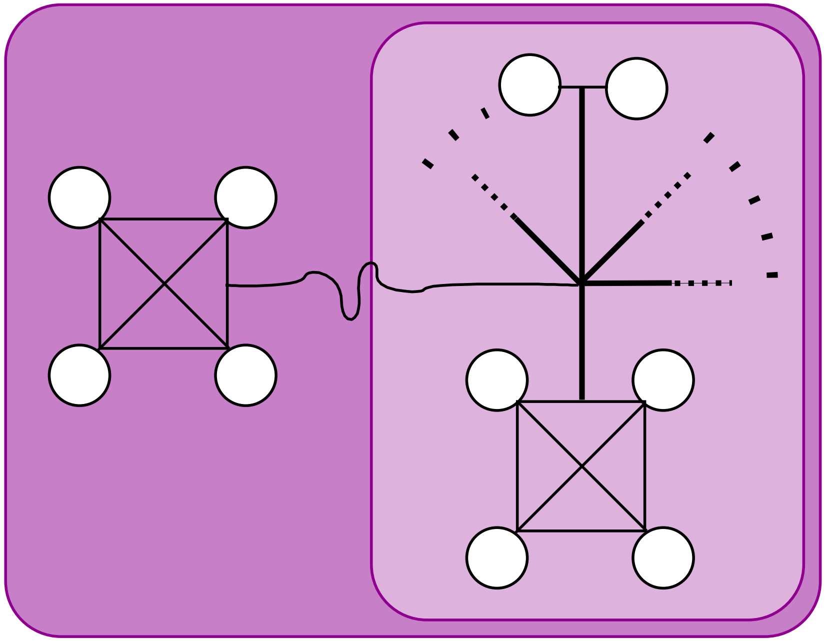
Traditional/single domain:



- Strict consistency over all nodes.

Experiment: View Configurations

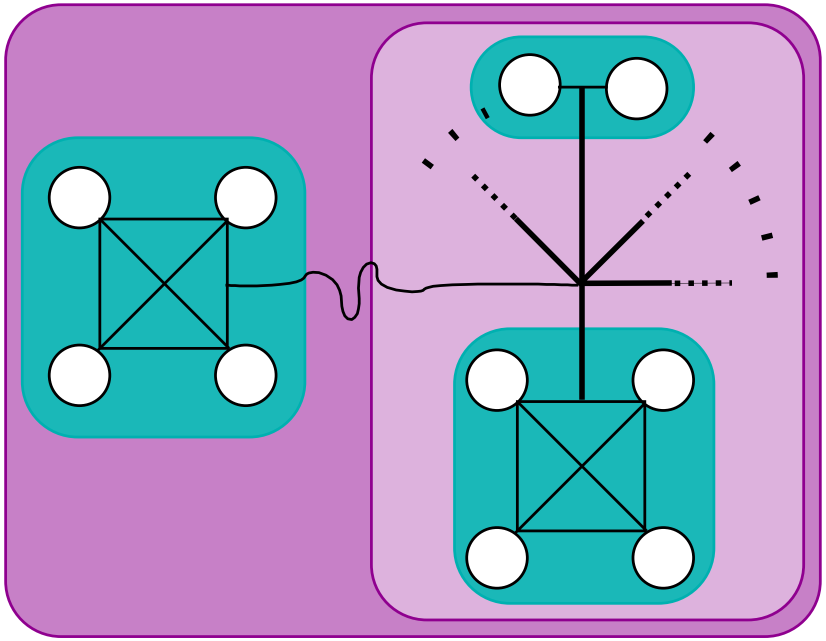
Two locality domains:



- Two views of strict consistency.

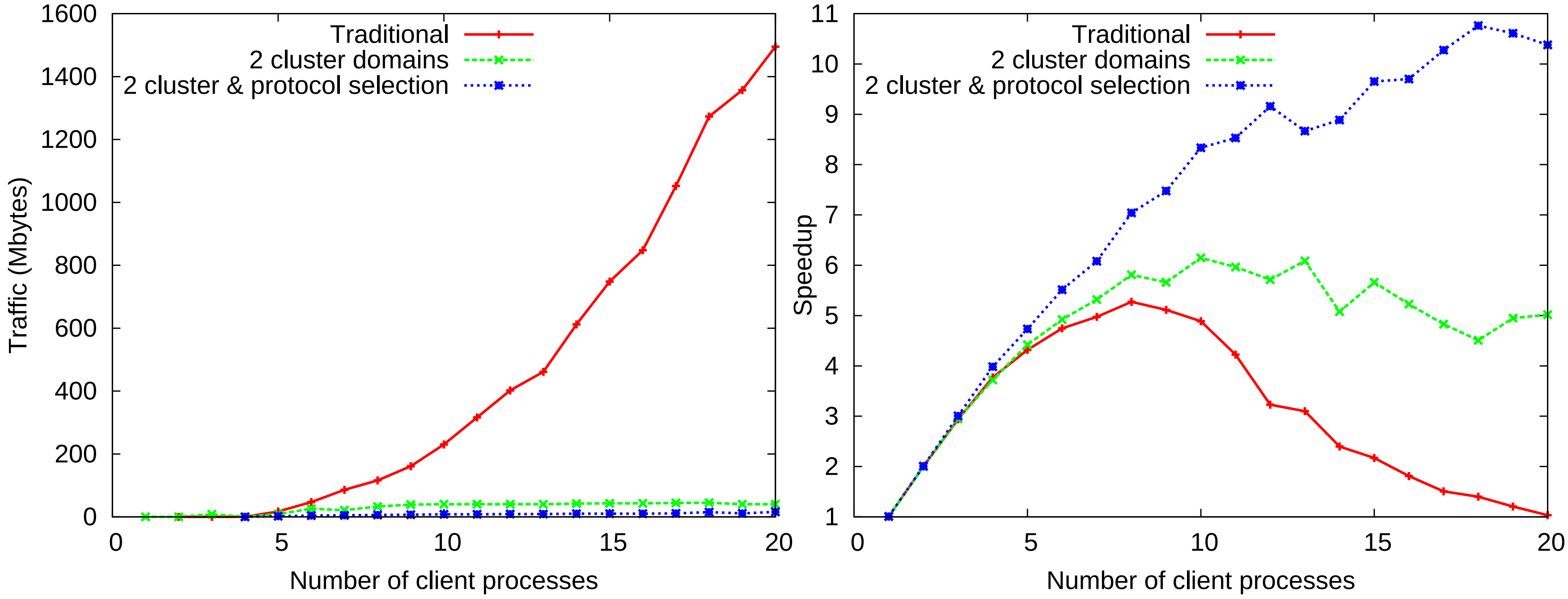
Experiment: View Configurations

Two locality domains, multi-protocol:



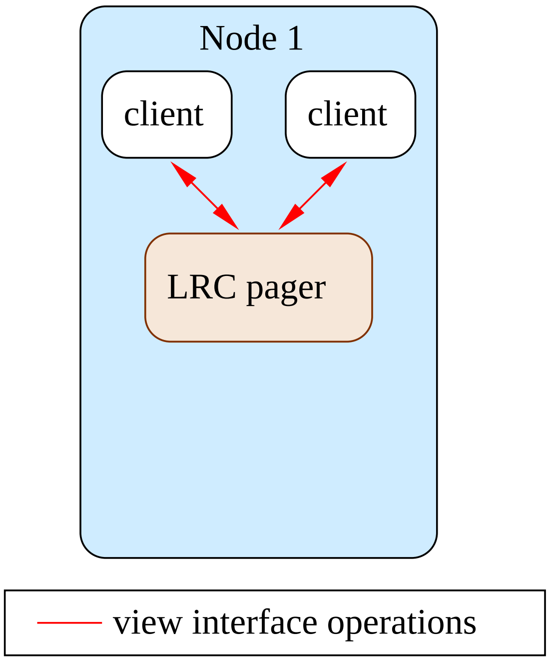
- Two views of strict consistency.
- Internal multi-reader/multi-writer (MRMW) views on each multi-processor.

Matrix Multiply Results



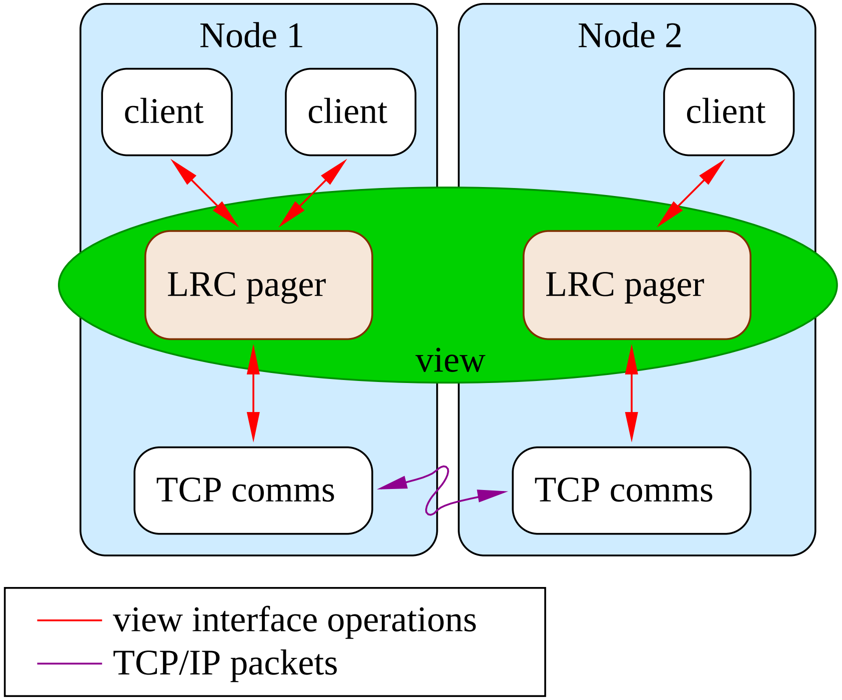
- Poor traditional performance due to false-sharing
- Two domain improves performance by reducing inter-cluster communication
- Two domain with protocol selection improves performance further by utilising ccNUMA/SMP resources

View Architecture



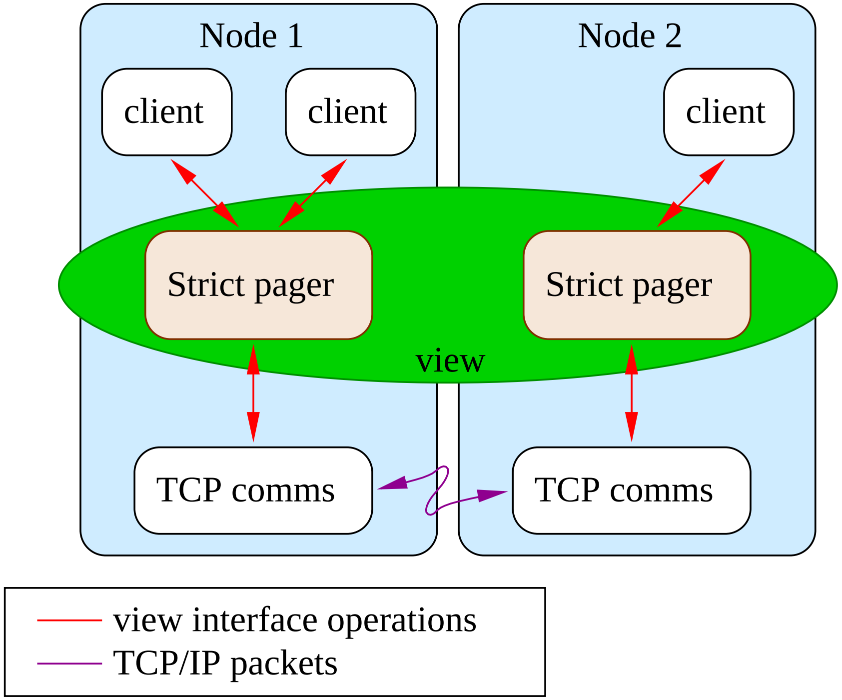
- Clients on same node communicate using view interface operations
- Separation of client and protocol pager

View Architecture



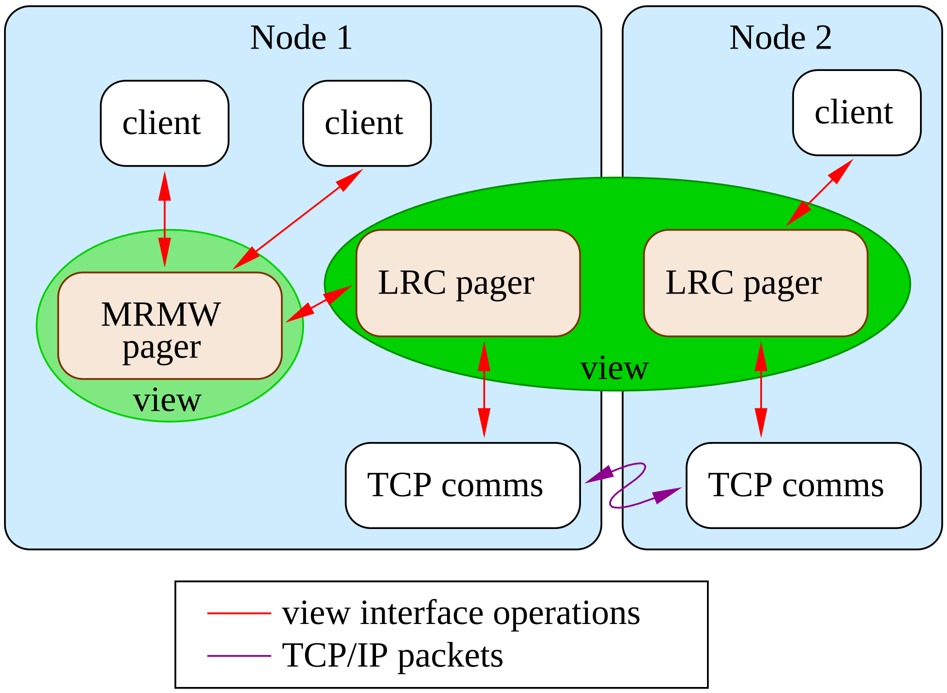
- Pagers communicate with remote clients just like other clients

View Architecture



- Protocol selection requires only change of view specification
- No change to clients necessary

View Architecture



- Pagers communicate with different views just like other clients
- Views encapsulate a group of data sharers

How do Views work?

Views Operations

update request	requests updates for given region
update propagate	propagate updates for given region
protection request	request access for given region
protection propagate	indication of new region access
token request	request a synchronisation token
token response	receive a synchronisation token
view create	create a new view
view select	select a view for use
view unselect	release a view

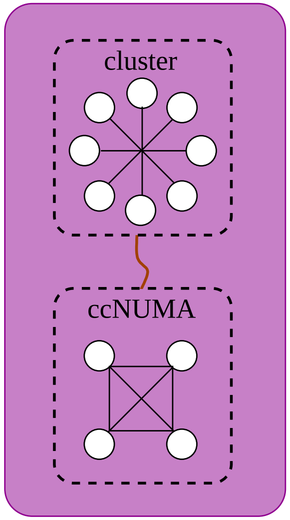
Creating and Using Views

Combination of three methods:

1. direct application use,
2. middleware or library,
3. system and administrative domains.

Example application use

```
view1 = view_create (0, base, end, Strict);
    :
view_select (view1);
```



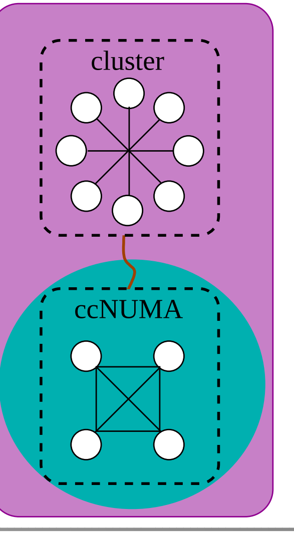
Creating and Using Views

Combination of three methods:

1. direct application use,
2. middleware or library,
3. system and administrative domains.

Example application use

```
view1 = view_create (0, base, end, Strict);
    :
view2 = view_create (view1, base, end,MRMW);
    :
view_select (view2);
```



Conclusions

Summary:

- Resource utilisation and performance improvements
- Protocol inter-operability avoids new hybrid protocols

Future work:

- Other programming models such as MPI.
  - Already examined single-sided MPI.
- Programming model interoperability
- Views for bulk data transfer, check-pointing etc.
- Comprehensive benchmarking: SPLASH, NAS, etc.
- Views in a wide area, single-system-image environment.

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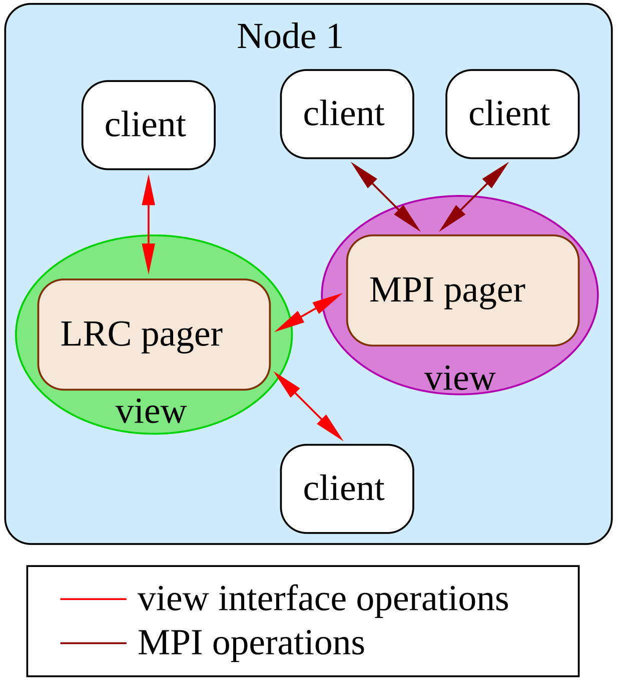
Questions?

Application Interoperability



- Different view pagers communicate using view interface operations
- Mechanism for visualisation, multi-model applications, ..

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