Scalaris
○○
○

Wiki on Scalaris
○○○
○○○○○○
○○○○○○○○

Questions
○

Scalable Data Models with the Transactional Key-Value Store Scalaris

Nico Kruber   Michael Berlin

Zuse Institut Berlin
Parallel and Distributed Systems

20th November
INGI 2012 Doctoral School Day in Cloud Computing

Scalaris
○○
○

Wiki on Scalaris
○○○
○○○○○○
○○○○○○○○

Questions
○

Outline

Scalaris
Introduction
Scalability

Wiki on Scalaris
MediaWiki Introduction
Data Model
Optimisations

Scalaris
●○
○

Wiki on Scalaris
○○○
○○○○○○
○○○○○○○○

Questions
○

Scalaris - A Transactional Key-Value Store

Web 2.0 Application

layer implements...

Transaction Layer: **Paxos Commit**
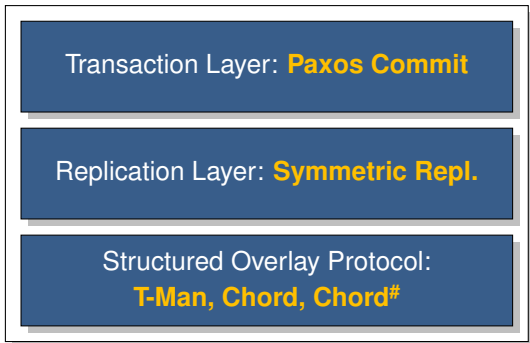
...strong consistency,
atomicity, isolation

Replication Layer: **Symmetric Repl.**

...availability

Structured Overlay Protocol:
T-Man, Chord, Chord#

...scalability

...
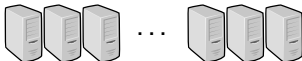
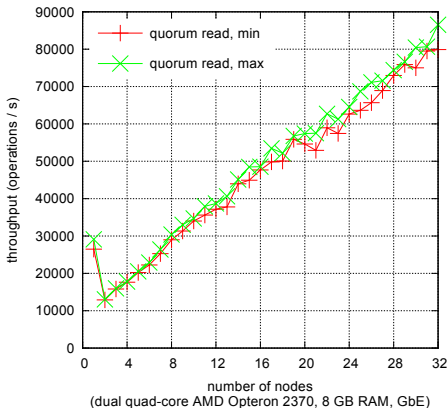**many standard internet nodes in datacenters or P2P**

Scalaris - Operations

- supported in core:
    - `read(Key)`
    - `write(Key, Value)`
- convenience operations in APIs:
    - `add_del_on_list(Key, ToAdd, ToRemove)`
    - `add_on_nr(Key, ToAdd)`
    - `test_and_set(Key, OldValue, NewValue)`
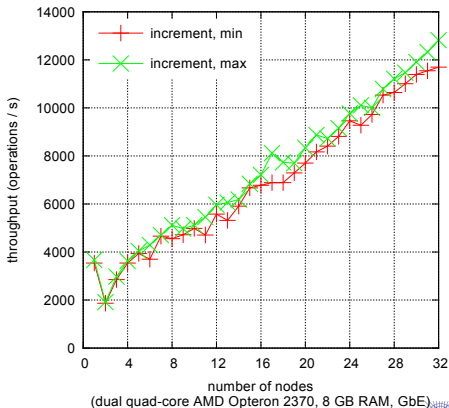- as single operations or as part of a transaction
- support for bundling requests

Scalaris
○○
●

Wiki on Scalaris
○○○
○○○○○○
○○○○○○○○

Questions
○

Scalaris - Scalability

Quorum-Read Benchmark
(10 clients/node, 10000 quorum-reads/key)

- quorum read, min
- quorum read, max

throughput (operations / s)

number of nodes
(dual quad-core AMD Opteron 2370, 8 GB RAM, GbE)

Increment Benchmark
(10 clients/node, 1000 incs/key)

- increment, min
- increment, max

throughput (operations / s)

number of nodes
(dual quad-core AMD Opteron 2370, 8 GB RAM, GbE)

Scalaris
○○
○

Wiki on Scalaris
●○○
○○○○○○
○○○○○○○○

Questions
○

Wikitext A-Z

Scalaris

Page Talk Read Change View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

Main Page
New changes
Show any entry
Help

▼ Toolbox
What links here
Special pages

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Edit summary
Save page   Show preview   Show changes   Cancel | Editing help (opens in new

Scalaris
○○

Wiki on Scalaris
●○○
○○○○○○
○○○○○○○○

Questions
○

Wikitext A-Z

Page | Talk | Read | Change | View history | Search

Berlin

page title including namespace

You are not logged in. Your IP address will be recorded in this page's edit history.

Main Page
New changes
Show any entry
Help

▼ Toolbox
What links here
Special pages

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Edit summary

Save page | Show preview | Show changes | Cancel | Editing help (opens in new

Scalaris

Wiki on Scalaris
● ○ ○
○ ○ ○ ○ ○ ○
○ ○ ○ ○ ○ ○ ○

Questions
○

Wikitext A-Z

Page   Talk   Read   Change   View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Main Page
New changes
Show any entry
Help

▼ Toolbox
  What links here
  Special pages

page title including namespace

link to another page

Edit summary
Save page   Show preview   Show changes   Cancel | Editing help (opens in new

Scalaris
○○
○

Wiki on Scalaris
●○○
○○○○○○
○○○○○○○○

Questions
○

Wikitext A-Z

page title including namespace

link to another page

template inclusion

Scalaris
○○
○

Wiki on Scalaris
●○○
○○○○○○
○○○○○○○○

Questions
○

Wikitext A-Z

page title including namespace

link to another page

template inclusion

category the page belongs to

Scalaris

○○
○

Wiki on Scalaris

○●○
○○○○○○
○○○○○○○○

Questions

○

Wiki Operations

Page Talk   Read Change View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Scalaris

Main Page
New changes
Show any entry
Help

▼ Toolbox
  What links here
  Special pages

Edit summary
Save page Show preview Show changes Cancel | Editing help (opens in new

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○○

Questions
○

Wiki Operations

Page | Talk   Read | Change | View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

show page: read revisions

Edit summary

Save page | Show preview | Show changes   Cancel | Editing help (opens in new

Scalaris

Main Page
New changes
Show any entry
Help

▼ Toolbox
  What links here
  Special pages

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○

Questions
○

Wiki Operations

Page | Talk   Read   Change   View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

''' 'Berlin' ''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin|]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]

Edit summary
Save page | Show preview | Show changes | Cancel | Editing help (opens in new

revision history overview
show page: read revisions

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○○

Questions
○

Wiki Operations

search for articles
revision history overview
show page: read revisions

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○○

Questions
○

Wiki Operations

search for articles
revision history overview
show page: read revisions
redirect to random article

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○

Questions
○

Wiki Operations

Page | Talk   Read   Change   View history   Search

Scalaris

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin|]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]

Edit summary
Save page | Show preview | Show changes | Cancel | Editing help (opens in new

Main Page
New changes
Help

Show any entry

Toolbox
What links here
Special pages

search for articles
revision history overview
show page: read revisions
redirect to random article
backlinks ("what links here")

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○○

Questions
○

Wiki Operations

Page | Talk   Read   Change   View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

' ''Berlin'' ' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin|]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]

Main Page
New changes
Help
Show any entry

Toolbox
What links here
Special pages

Edit summary

Save page | Show preview | Show changes | Cancel | Editing help (opens in new

search for articles

revision history overview

show page: read revisions

redirect to random article

backlinks ("what links here")

save new revision

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○

Questions
○

Editing Pages

Page | Talk | Read | Change | View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Edit summary

Save page | Show preview | Show changes | Cancel | Editing help (opens in new

Main Page
New changes
Show any entry
Help

▼ Toolbox
What links here
Special pages

Do atomically:

1. store new revision
2. update page object
3. add new backlinks
4. remove old backlinks
5. add to new categories
6. remove from old categories
7. if new page:
   a) add to page list
   b) increase page counter

Editing Pages

Scalaris

Main Page
New changes
Show any entry
Help

Toolbox
  What links here
  Special pages

Page Talk   Read Change View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Edit summary

Do atomically:

1. store new revision
2. update page object
3. add new backlinks
4. remove old backlinks
5. add to new categories
6. remove from old categories
7. if new page:
   a) add to page list
   b) increase page counter

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○○

Questions
○

Editing Pages

Page Talk Read Change View history

Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union]] by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Edit summary

Save page   Show preview   Show changes   Cancel | Editing help (opens in new

Main Page
New changes
Show any entry
Help

▼ Toolbox
What links here
Special pages

Do atomically:

1. store new revision
2. update page object
3. add new backlinks
4. remove old backlinks
5. add to new categories
6. remove from old categories
7. if new page:
   a) add to page list
   b) increase page counter

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○○

Questions
○

Editing Pages

Page Talk Read Change View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Edit summary
Save page Show preview Show changes | Cancel | Editing help (opens in new

Main Page
New changes
Show any entry
Help

▼ Toolbox
  What links here
  Special pages

Do atomically:

1. store new revision
2. update page object
3. add new backlinks
4. remove old backlinks
5. **add to new categories**
6. **remove from old categories**
7. if new page:
   a) add to page list
   b) increase page counter

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○

Questions
○

Editing Pages

Scalaris

Page | Talk | Read | Change | View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

Main Page
New changes
Show any entry
Help

▼ Toolbox
  What links here
  Special pages

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Edit summary
Save page | Show preview | Show changes | Cancel | Editing help (opens in new

Do atomically:

1. store new revision
2. update page object
3. add new backlinks
4. remove old backlinks
5. add to new categories
6. remove from old categories
7. if new page:
   a) add to page list
   b) increase page counter

Scalaris
○○
○

Wiki on Scalaris
○○●
○○○○○○
○○○○○○○○

Questions
○

Editing Pages

Page Talk   Read Change View history   Search

Berlin

You are not logged in. Your IP address will be recorded in this page's edit history.

Main Page
New changes
Show any entry
Help

▼ Toolbox
What links here
Special pages

```
'''Berlin''' is the [[Capital of
Germany|capital]] city of [[Germany]] and
is one of the 16 [[states of Germany]].
With a population of 3.45 million
people, Berlin is Germany's largest city.
It is the second [[Largest cities of the
European Union by population within city
limits|most populous city proper]] and the
seventh [[Largest urban areas of the
European Union|most populous urban area]]
in the [[European Union]].

<!--TEMPLATES-->
{{Navboxes
|list=
{{Berlin}}
{{Cities in Germany}}
}}

<!--CATEGORIES-->
[[Category:Berlin| ]]
[[Category:States of Germany]]
[[Category:German state capitals]]
[[Category:Capitals in Europe]]
```

Edit summary
Save page   Show preview   Show changes   Cancel | Editing help (opens in new

Do atomically:

1. store new revision

2. update page object

3. add new backlinks

4. remove old backlinks

5. add to new categories

6. remove from old categories

7. if new page:
   a) add to page list
   b) increase page counter

Scalaris
○○
○

Wiki on Scalaris
○○○
●○○○○○
○○○○○○○○

Questions
○

Wiki on Scalaris - Data Layout (1)

\<title\>:page	page information (JSON object)

Main Page:page

```
{"title": "Main Page", "id": 1,
 "redirect": false,    "curRev": <rev>}
```

\<title\>:rev:\<id\>	single page revision (JSON object)

Main Page:rev:1

```
{"text": <text>,       "id": 1,
 "minor": false,       "comment": "",
 "timestamp": <date>,  "contributor": <user>}
```

Scalaris
○○
○

Wiki on Scalaris
○○○
○●○○○○
○○○○○○○○

Questions
○

Wiki on Scalaris - Data Layout (2)

<title>:revs	list of revision info for history

Main Page:revs

```
[{"id": 2,              "size": 10,
  "minor": false,       "comment": "",
  "timestamp": <date>,  "contributor": <user>},
 {"id": 1,              "size": 4,
  "minor": false,       "comment": "",
  "timestamp": <date>,  "contributor": <user>}]
```

Scalaris
OO
O

Wiki on Scalaris
OOO
OOO●OOO
OOOOOOOO

Questions
O

Wiki on Scalaris - Data Layout (3)

<title>:blpages	list of page titles linking to <title>
European Union:blpages	

```
["Berlin"]
```

<cat_title>:cpages	list of page titles inside a category
Category:States of Germany:cpages	

```
["Berlin"]
```

<cat_title>:cpages:count	number of pages inside a category
Category:States of Germany:cpages:count	

```
1
```

Scalaris
○○
○

Wiki on Scalaris
○○○
○○○●○○
○○○○○○○○

Questions
○

Wiki on Scalaris - Data Layout (4)

pages:\<namespace\>	list of pages in \<namespace\>
pages:	

```
["Main Page", "Berlin"]
```

pages:\<namespace\>:count	number of pages in \<namespace\>
pages::count	

```
2
```

stats:pageedits	total number of page edits

```
3
```

Scalaris
○○
○

Wiki on Scalaris
○○○
○○○○●○
○○○○○○○○

Questions
○

Data Model - Scalability (read)

Scalaris
○○
○

Wiki on Scalaris
○○○
○○○○○●
○○○○○○○○

Questions
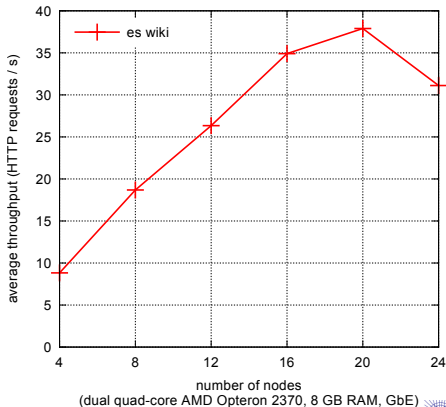○

Data Model - Scalability (edit)

Increment Benchmark
(10 clients/node, 1000 incs/key)

Wiki Edit Benchmark
(32 clients/node, 4 bench workers, 10000 ops)

Scalaris
○○
○

Wiki on Scalaris
○○○
○○○○○○
●○○○○○○○

Questions
○

Data Model - Value Sizes

type	count	avg	min	max
articles_count	1	159	159	159
backlink_pagelist	1 588 390	274	189	493 369
category_count	43 082	157	157	158
category_pagelist	43 082	373	190	24 259
page	714 763	1 567	401	438 675
pagelist	20	325 049	176	4 409 738
pagelist_count	20	158	156	159
revision_list	714 763	369	317	592
siteinfo	1	593	593	593
template_pagelist	13 964	633	189	466 249

Scalaris
○○
○

Wiki on Scalaris
○○○
○○○○○○
○●○○○○○○

Questions
○

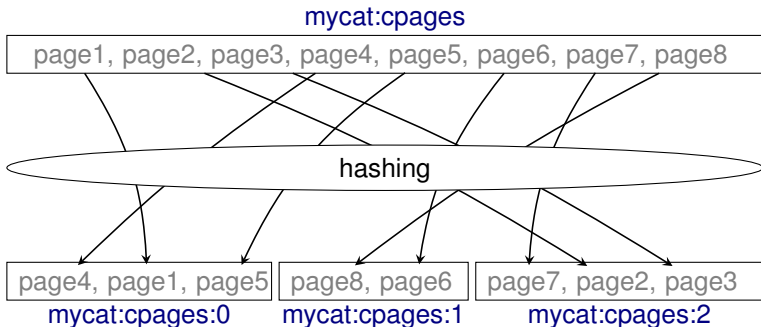# Data Model - Solution: Partitioning!

a) spread randomly over partitions
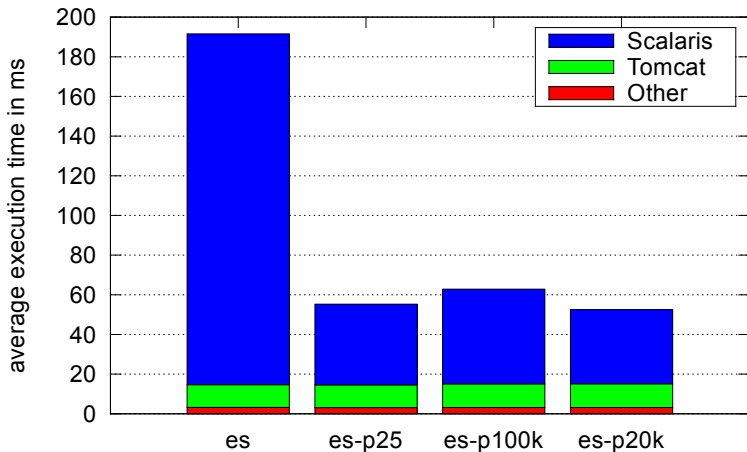 - unpredictable partition position
  - suitable for e.g. counters

Scalaris
○○
○

Wiki on Scalaris
○○○
○○○○○○
○○●○○○○○

Questions
○
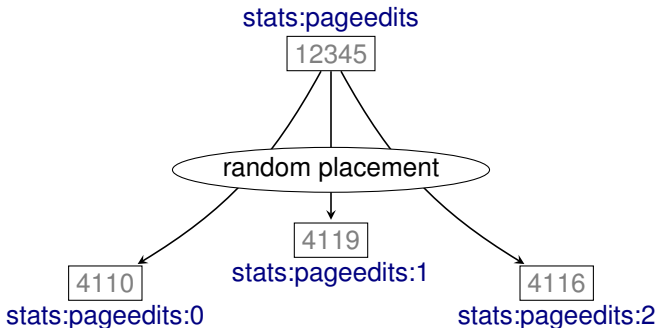
Data Model - Solution: Partitioning!

b) spread list contents with hashing
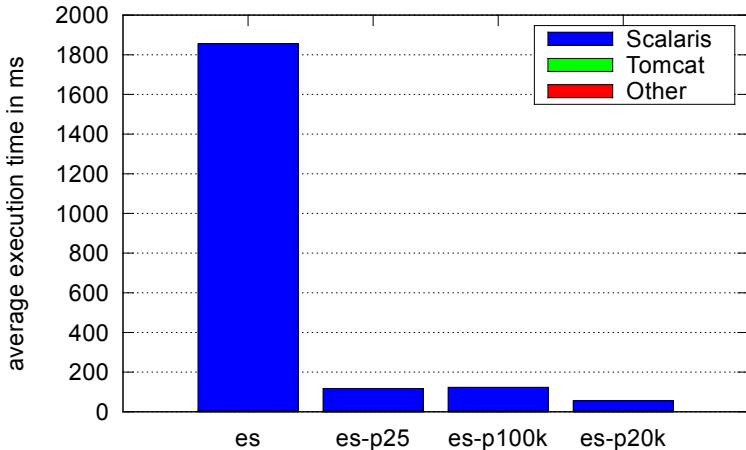- allows efficient lookup and delete
- suitable for e.g. lists

mycat:cpages

| page1, page2, page3, page4, page5, page6, page7, page8 |

hashing

| page4, page1, page5 | page8, page6 | page7, page2, page3 |

mycat:cpages:0   mycat:cpages:1   mycat:cpages:2

Scalaris
○○
○

Wiki on Scalaris
○○○
○○○○○○
○○○●○○○○

Questions
○

Data Model - Partitioning Schemes

es	plain es wiki
es-p25	split all lists, counters into 25
es-p50e	max pagelist size 100k, article counter 3, edit stats 50
es-p250e	max pagelist size 20k, article counter 3, edit stats 50

Scalaris
○○
○

Wiki on Scalaris
○○○
○○○○○○
○○○○●○○○

Questions
○

Optimisation Results (page edit)

Scalaris
○○
○

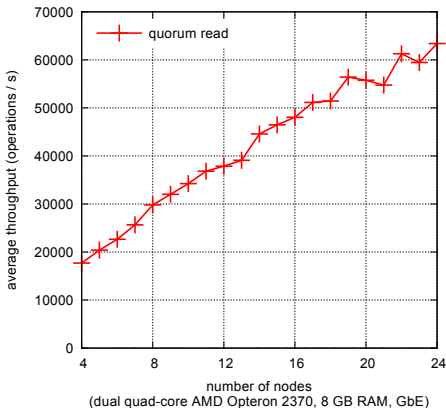Wiki on Scalaris
○○○
○○○○○○
○○○○○●○○

Questions
○

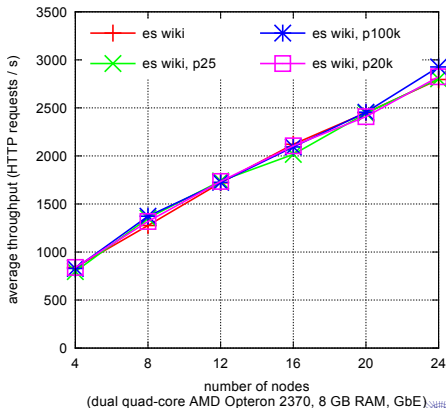## Optimisation Results (page create)

Optimisation Results - Scalability (read)

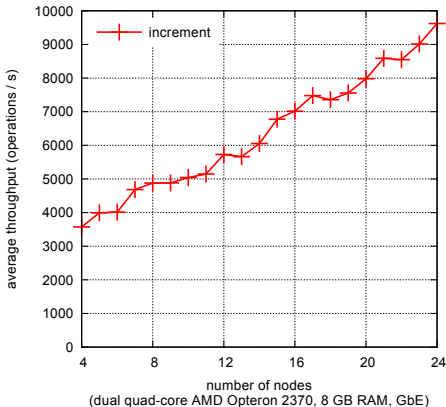Quorum-Read Benchmark
(10 clients/node, 10000 quorum-reads/key)

Wiki Read Benchmark
(32 clients/node, 4 bench workers, 100000 ops)

Scalaris
○○
○

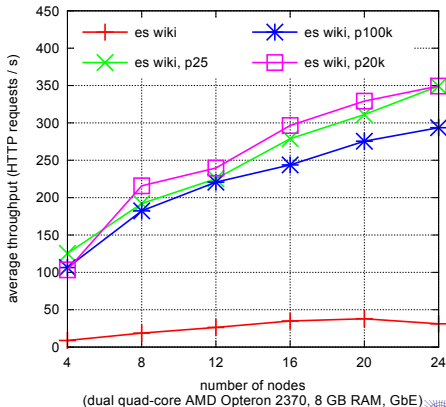Wiki on Scalaris
○○○
○○○○○○
○○○○○○○●

Questions
○

Optimisation Results - Scalability (edit)

Increment Benchmark
(10 clients/node, 1000 incs/key)

Wiki Edit Benchmark
(32 clients/node, 4 bench workers, 10000 ops)

Questions

http://scalaris.googlecode.com