

BBotDB

A Key-Bounding-Box-Value Store

Demo Paper: Large Scale Spatial Data Processing with User Defined Filters in BBoxDB

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Database Systems for New Applications

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Outline

- 1 Multi-Dimensional Data in Key-Value Stores
 - Key-Value stores
 - Partitioning data
- 2 BBoxDB – Architecture and User Defined Filters
 - BBoxDB
 - Architecture
 - User defined filters
- 3 Demonstration and Summary

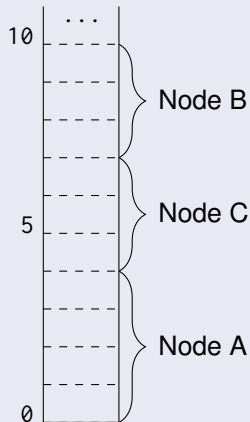
Basics

Key-value stores. . .

- have a simple data model: *key* and *value*.
- support at least the operations `put(table, key, value)` and `get(table, key)`.
- don't support features like *joins* or *transactions*.
- can be implemented as a distributed system.

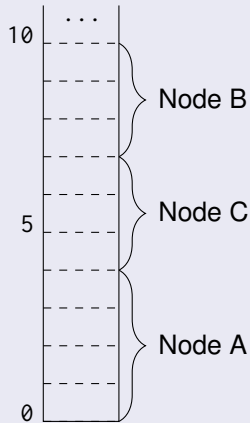
Partitioning data

Range partitioning



Partitioning data

Range partitioning

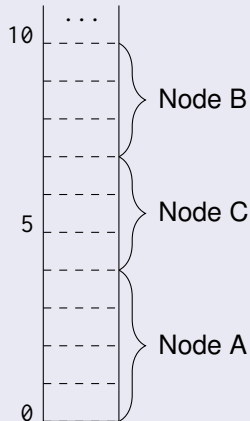


The key is important. . .

- to determine which node is responsible for a value.
- to locate the value on the node efficiently (e.g., *binary search* on sorted key-value pairs).

Partitioning data

Range partitioning



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Data access path

Keys are the data access path in a key-value store. If a key is not known, an expensive full data scan is needed.

Multi-dimensional data in key-value stores

One-dimensional data (e.g., a customer record)

customerid=1234,
firstname=John,
lastname=Doe



1234

Multi-dimensional data in key-value stores

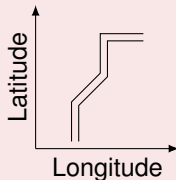
One-dimensional data (e.g., a customer record)

customerid=1234,
firstname=John,
lastname=Doe

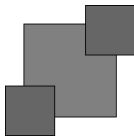


1234

Two-dimensional data (e.g., a road)



?



BBoxDB

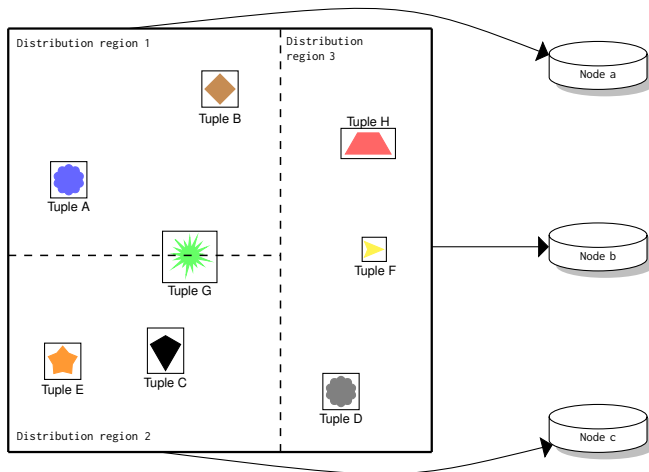
A Key-Bounding-Box-Value Store

BBoxDB – A distributed key-bounding-box-value store

BBoxDB...

- is a distributed *key-bounding-box-value store*.
- stores each value together with a *bounding box*. The bounding box determines the location of the value in the n -dimensional space.
- can handle n -dimensional *point* and *non-point* big data.
- partitions the space dynamically and redistributes the data.
- stores data co-partitioned for efficient spatial joins.
- is freely available and licensed under the *Apache 2.0* license.

Partitioning the space



Supported Operations

The most important operations

- **Store new data:**
`put(table, key, hyperrectangle, value)`
- **Retrieve data:**
`getByRange(table, hyperrectangle)`
- **Execute a spatial join:**
`join(table1, table2, hyperrectangle)`

Supported Operations

The most important operations

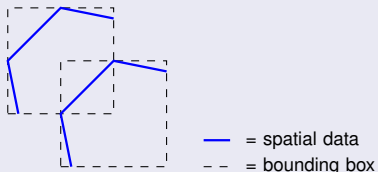
- **Store new data:**
`put(table, key, hyperrectangle, value)`
- **Retrieve data:**
`getByRange(table, hyperrectangle)`
- **Execute a spatial join:**
`join(table1, table2, hyperrectangle)`

Query processing in BBoxDB

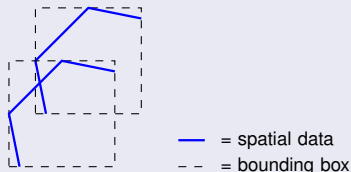
BBoxDB is a generic datastore; values are plain arrays of bytes. The semantics of the stored values are unknown. The software performs operations (e.g., range queries or spatial joins) **only** on the bounding boxes of the data.

Spatial data with overlapping bounding boxes

Spatial data **is not** intersecting



Spatial data **is** intersecting



Bounding boxes / Spatial join

Overlapping bounding boxes are a necessary but not a sufficient criterion for a spatial join on real geometries.

User defined filters

Motivation for user defined filters

User defined filters. . .

- enhance the query processor, so that the stored values can be decoded (e.g., GeoJSON encoded values).

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User defined filters. . .

- enhance the query processor, so that the stored values can be decoded (e.g., GeoJSON encoded values).
- **turn the generic data store into a specialized system for a specific data type (e.g., spatial joins on the real geometries of stored values become possible).**

Implementation details

User defined filters in BBoxDB

- The UDF acts as a filter and refines the output of the query processor.
- The creation of a new UDF is simple: only the two methods of the interface `UserDefinedFilter` need to be implemented.
- The method `filterTuple` refines range queries; the method `filterJoinCandidate` refines join queries.
- The UDF is compiled into *Java bytecode* and is loaded dynamically at runtime.
- Existing Java libraries can be used (e.g., the *Esri Geometry API for Java*).

Demonstration

Summary

BBoxDB...

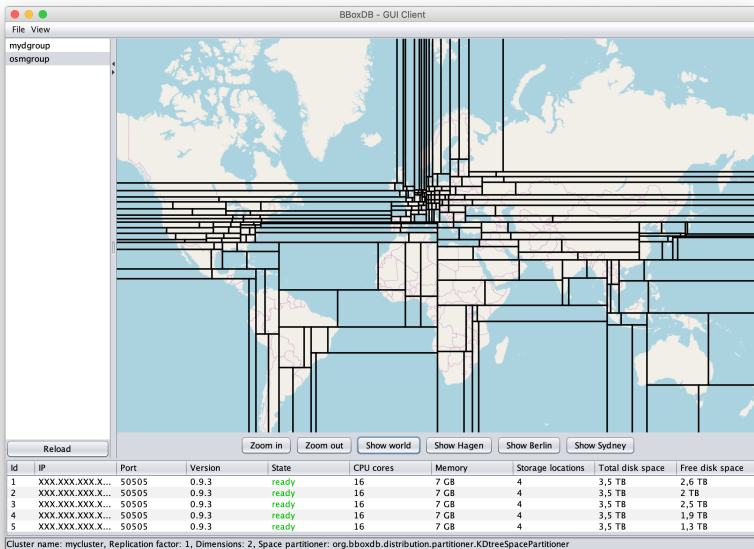
- is a *distributed key-bounding-box-value store*.
- enhances the key-value data model with a bounding box.
- executes operations only on the bounding boxes of the data.
- **can be enhanced by user defined filters. They turn BBoxDB into a system that is specialized on a certain data type.**
- is written in *Java* and licensed under the *Apache 2.0 license*.

Questions?

Further information

- Web: <https://bboxdb.org>
- Github: <https://github.com/jnidzwetzki/bboxdb>
- Twitter: @bboxdb
- Google Groups: <https://groups.google.com/forum/bboxdb>

Backup Slides



BBoxDB – GUI Client

File View

San Gabriel Mountains National Monument
 San Gabriel Wilderness
 Sheep Mountain Wilderness
 Cuyamaca Wilderness

Moorpark, Simi Valley, Thousand Oaks, Agoura Hills, Calabasas, Malibu, Santa Monica, Inglewood, Hawthorne, Manhattan Beach, Gardena, Compton, Torrance, Lomita, Rancho Palos Verdes, San Fernando, Burbank, Glendale, Pasadena, Altadena, Arcadia, Duarte, Glendora, San Dimas, Claremont, Rancho Cucamonga, Ontario, Chino, Eastvale, Norco, Corona, Fullerton, Anaheim, Villa Park, Santa Ana, CA 241 Toll, Long Beach, Seal Beach, Garden Grove, Cypress, Los Alamitos, Signal Hill, Lakewood, Bellflower, Norwalk, Downey, Lynwood, Whittier, Rowland Heights, Chino Hills, Brea, Yorba Linda, La Habra, La Puente, Diamond Bar, Chino Hills State Park, Corona

CA 118, CA 91

Zoom in Zoom out Show world Show LA Show Berlin Show Sydney Execute query Clear map Show result details Show Bounding Boxes

Id	IP	Port	Version	State	CPU cores	Memory	Storage locations	Total disk space	Free disk space
1	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2,6 TB
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Longitude -118.96682739257812 Latitude 33.81224331648926

BBBoxDB – GUI Client

The screenshot displays the BBBoxDB GUI Client interface. At the top, there is a menu bar with 'File' and 'View' options. Below the menu is a map of Los Angeles, California, with several bounding boxes overlaid in red and yellow. The map includes labels for various neighborhoods and landmarks such as Santa Monica, Venice, Mar Vista, Palms, Culver City, Beverly Hills, and Century City. Major freeways like CA 1, CA 2, CA 10, CA 101, CA 105, CA 110, CA 118, CA 170, CA 174, CA 210, CA 230, CA 240, CA 260, CA 270, CA 280, CA 300, CA 330, CA 340, CA 370, CA 380, CA 405, CA 407, CA 408, CA 409, CA 410, CA 415, CA 420, CA 425, CA 430, CA 435, CA 440, CA 445, CA 450, CA 455, CA 460, CA 465, CA 470, CA 475, CA 480, CA 485, CA 490, CA 495, CA 500, CA 505, CA 510, CA 515, CA 520, CA 525, CA 530, CA 535, CA 540, CA 545, CA 550, CA 555, CA 560, CA 565, CA 570, CA 575, CA 580, CA 585, CA 590, CA 595, CA 600, CA 605, CA 610, CA 615, CA 620, CA 625, CA 630, CA 635, CA 640, CA 645, CA 650, CA 655, CA 660, CA 665, CA 670, CA 675, CA 680, CA 685, CA 690, CA 695, CA 700, CA 705, CA 710, CA 715, CA 720, CA 725, CA 730, CA 735, CA 740, CA 745, CA 750, CA 755, CA 760, CA 765, CA 770, CA 775, CA 780, CA 785, CA 790, CA 795, CA 800, CA 805, CA 810, CA 815, CA 820, CA 825, CA 830, CA 835, CA 840, CA 845, CA 850, CA 855, CA 860, CA 865, CA 870, CA 875, CA 880, CA 885, CA 890, CA 895, CA 900, CA 905, CA 910, CA 915, CA 920, CA 925, CA 930, CA 935, CA 940, CA 945, CA 950, CA 955, CA 960, CA 965, CA 970, CA 975, CA 980, CA 985, CA 990, CA 995, CA 1000 are also visible.

Below the map is a control bar with buttons for 'Zoom in', 'Zoom out', 'Show world', 'Show LA', 'Show Berlin', 'Show Sydney', 'Execute query', 'Clear map', 'Show result details', and 'Show Bounding Boxes' (checked). Below the control bar is a table with 10 columns: Id, IP, Port, Version, State, CPU cores, Memory, Storage locations, Total disk space, and Free disk space. The table contains 5 rows of data. At the bottom of the interface, the coordinates 'Longitude -118.5563850402832 Latitude 34.03004255953751' are displayed.

Id	IP	Port	Version	State	CPU cores	Memory	Storage locations	Total disk space	Free disk space
1	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2,6 TB
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Longitude -118.5563850402832 Latitude 34.03004255953751

BBBoxDB – GUI Client

File View

Longitude -118.47587585449219 Latitude 34.011546304843755

Id	IP	Port	Version	State	CPU cores	Memory	Storage locations	Total disk space	Free disk space
1	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2,6 TB
2	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2 TB
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BBoxDB - GUI Client

File View

BBoxDB - Execute query

Query

Type: Range query

Table 1: osmgroup_road

Color for table 1: Red

Table 2: mydgroup_table1

Color for table 2: Green

Parameter

Longitude begin: -118.51312637329102

Longitude end: -118.47587585449219

Latitude begin: 34.011546304843755

Latitude end: 34.05066824173537

Name:

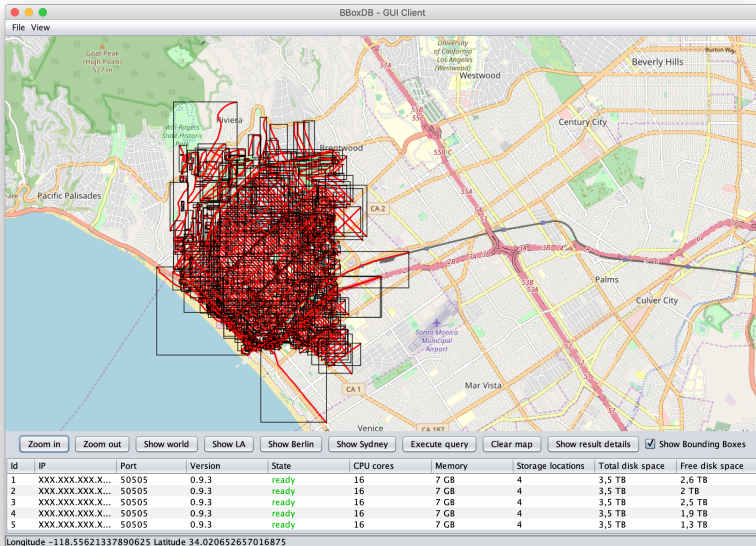
Value:

Close Execute

Zoom in Zoom out Show world Show LA Show Berlin Show Sydney Execute query Clear map Show result details Show Bounding Boxes

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1	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2,6 TB
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Longitude -118.54351043701172 Latitude 34.028762179464465



BBoxDB – GUI Client

The screenshot shows the BBoxDB GUI Client interface. At the top, there's a title bar with window control buttons and the text 'BBoxDB – GUI Client'. Below that is a 'File View' menu. The main area is a map of Los Angeles, California, with a dense red grid overlaying a central urban area. The map includes labels for various neighborhoods like Westwood, Century City, Beverly Hills, and Culver City, as well as landmarks like the University of California Los Angeles and Santa Monica Municipal Airport. At the bottom of the map area, there's a toolbar with buttons for 'Zoom in', 'Zoom out', 'Show world', 'Show LA', 'Show Berlin', 'Show Sydney', 'Execute query', 'Clear map', 'Show result details', and 'Show Bounding Boxes'. Below the toolbar is a table with 10 columns: 'Id', 'IP', 'Port', 'Version', 'State', 'CPU cores', 'Memory', 'Storage locations', 'Total disk space', and 'Free disk space'. The table contains 5 rows of data. At the very bottom, there's a status bar showing 'Longitude -118.54848861694336 Latitude 34.035590649919314'.

Id	IP	Port	Version	State	CPU cores	Memory	Storage locations	Total disk space	Free disk space
1	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2,6 TB
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Longitude -118.54848861694336 Latitude 34.035590649919314

BBoxDB - GUI Client

File View

Table: osmgroup_road
 Id: 13318443
 tiger:cfcc: A41
 name_1: South Anita Avenue
 tiger:reviewed: no
 name: Anita Avenue
 tiger:name_base: Anita
 tiger:name_type_1: Ave
 tiger:name_type: Ave
 tiger:name_base_1: Anita
 tigername_direction_prefix_1: S
 highway: residential
 tiger:county: Los Angeles, CA

Zoom in Zoom out Show world Show LA Show Berlin Show Sydney Execute query Clear map Show result details Show Bounding Boxes

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Longitude -118.48308563232422 Latitude 34.057210513510306

BBBoxDB – GUI Client

File View

Zoom in Zoom out Show world Show LA Show Berlin Show Sydney Execute query Clear map Show result details Show Bounding Boxes

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Longitude -118.48651885986328 Latitude 34.02719724424856

BBoxDB - GUI Client

File View

The screenshot shows the BBoxDB GUI Client interface. The main window displays a map of Topanga State Park and surrounding areas. A dialog box titled "BBoxDB - Execute query" is open in the foreground, allowing the user to define a query. The dialog has two sections: "Query" and "Parameter".

Query Section:

- Type: Join
- Table 1: osmgroup_road
- Color for table 1: Red
- Table 2: osmgroup_forest
- Color for table 2: Green

Parameter Section:

- Longitude begin: -118.59758377075195
- Longitude end: -118.48651885986328
- Latitude begin: 34.02719724424856
- Latitude end: 34.09659569101262
- Name: (empty field)
- Value: (empty field)

Buttons: Close, Execute

Map controls: Zoom in, Zoom out, Show world, Show LA, Show Berlin, Show Sydney, Execute query, Clear map, Show result details, Show Bounding Boxes

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5	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	1,3 TB

Longitude -118.61406326293945 Latitude 34.06033924761299

BBBoxDB – GUI Client

File View

Zoom in Zoom out Show world Show LA Show Berlin Show Sydney Execute query Clear map Show result details Show Bounding Boxes

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Longitude -118.61217498779297 Latitude 34.048108084909835

BBoxDB - GUI Client

File View

Zoom in Zoom out Show world Show LA Show Berlin Show Sydney Execute query Clear map Show result details Show Bounding Boxes

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Longitude -118.55187892913818 Latitude 34.03957367053948

BBoxDB - GUI Client

File View

Table: osmgroup_road
 Id: 42766630
 surface: asphalt
 abutters: residential
 tigerreviewed: yes
 source_ref: AMS09_DSC6390
 source: usgs_imagery_2006,survey:image
 tigername_type: Rd
 tigercounty: Los Angeles, CA
 tigercfcc: A41
 name: Temescal Canyon Road
 lanes: 4
 tigername_base: Temescal Canyon
 highway: secondary
 cycleway: lane

Table: osmgroup_forest
 Id: 63918822
 natural: wood

Zoom in Zoom out Show world Show LA Show Berlin Show Sydney Execute query Clear map Show result details Show Bounding Boxes

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1	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2,6 TB
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Longitude -118.53110790252686 Latitude 34.0451211375758

BBoxDB - GUI Client

File View

BBoxDB - Execute query

Query

Type: **Join**

Table 1: **osmgroup_road**

Color for table 1: **Red**

Table 2: **osmgroup_forest**

Color for table 2: **Green**

Parameter

Longitude begin: **-118.54711532592773**

Longitude end: **-118.51823329925537**

Latitude begin: **34.034381481654364**

Latitude end: **34.05262386500679**

Name: **.UserDefinedGeoJsonSpatialFilter**

Value:

Close **Execute**

Zoom in Zoom out Show world Show LA Show Berlin Show Sydney Execute query Clear map Show result details Show Bounding Boxes

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Longitude -118.52823257446289 Latitude 34.034025840649385

BBoxDB - GUI Client

File View

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Longitude -118.55269432067871 Latitude 34.040889448752345

BBoxDB - GUI Client

File View

Table: osmgroup_road
 Id: 390152905
 tiger:cfcc: A41
 surface: asphalt
 tiger:reviewed: no
 name: Bowdoin Street
 lanes: 2
 tigername_base: Bowdoin
 tigername_type: St
 highway: residential
 tiger:county: Los Angeles, CA

Table: osmgroup_forest
 Id: 639188222
 natural: wood

Zoom in Zoom out Show world Show LA Show Berlin Show Sydney Execute query Clear map Show result details Show Bounding Boxes

Id	IP	Port	Version	State	CPU cores	Memory	Storage locations	Total disk space	Free disk space
1	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2,6 TB
2	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2 TB
3	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	2,5 TB
4	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	1,9 TB
5	XXX.XXX.XXX.X...	50505	0.9.3	ready	16	7 GB	4	3,5 TB	1,3 TB

Longitude -118.53076457977295 Latitude 34.046365711752664