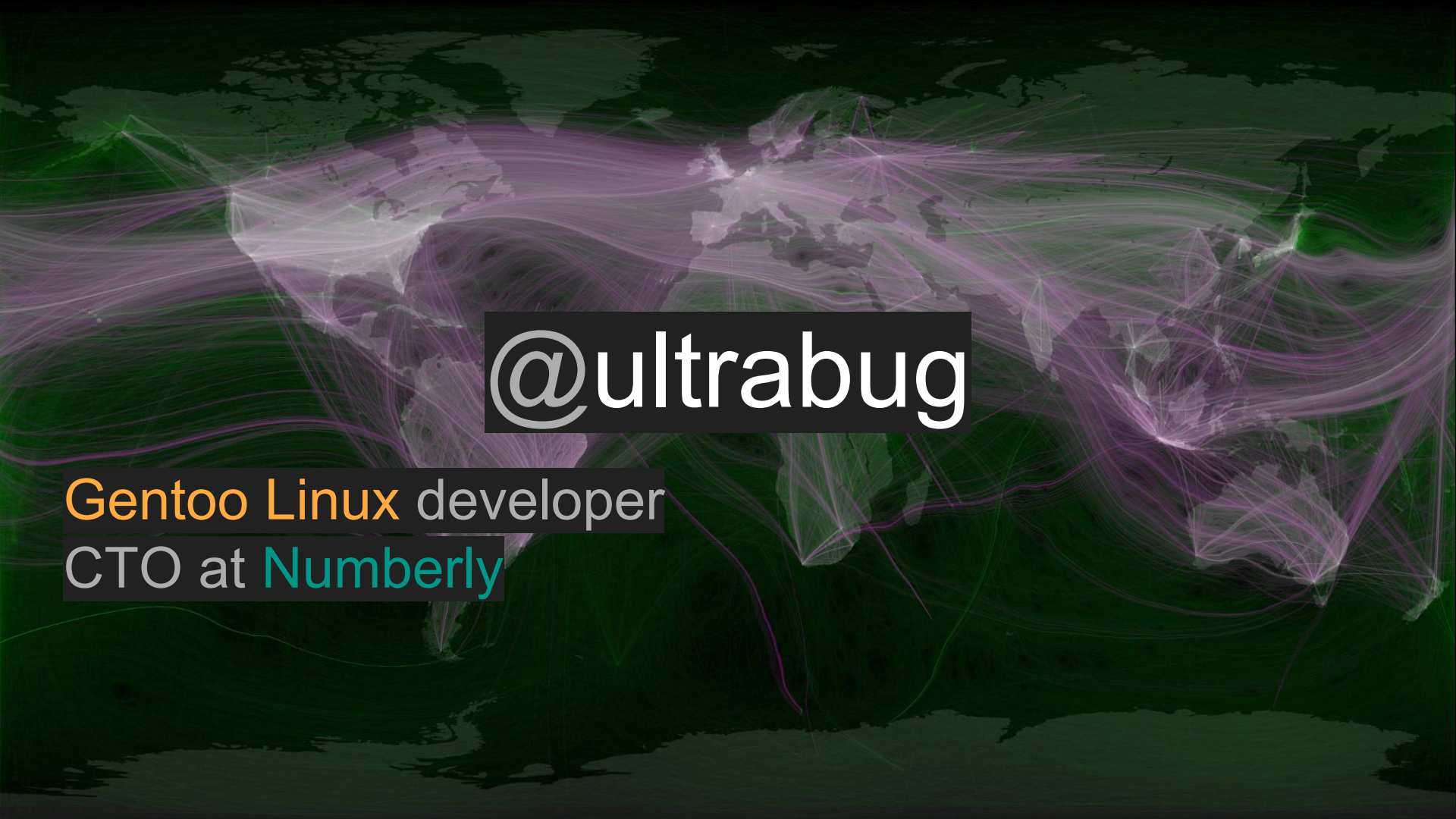

Consistent Hashing
in your python applications
Europython 2017


@ultrabug
Gentoo Linux developer
CTO at Numberly

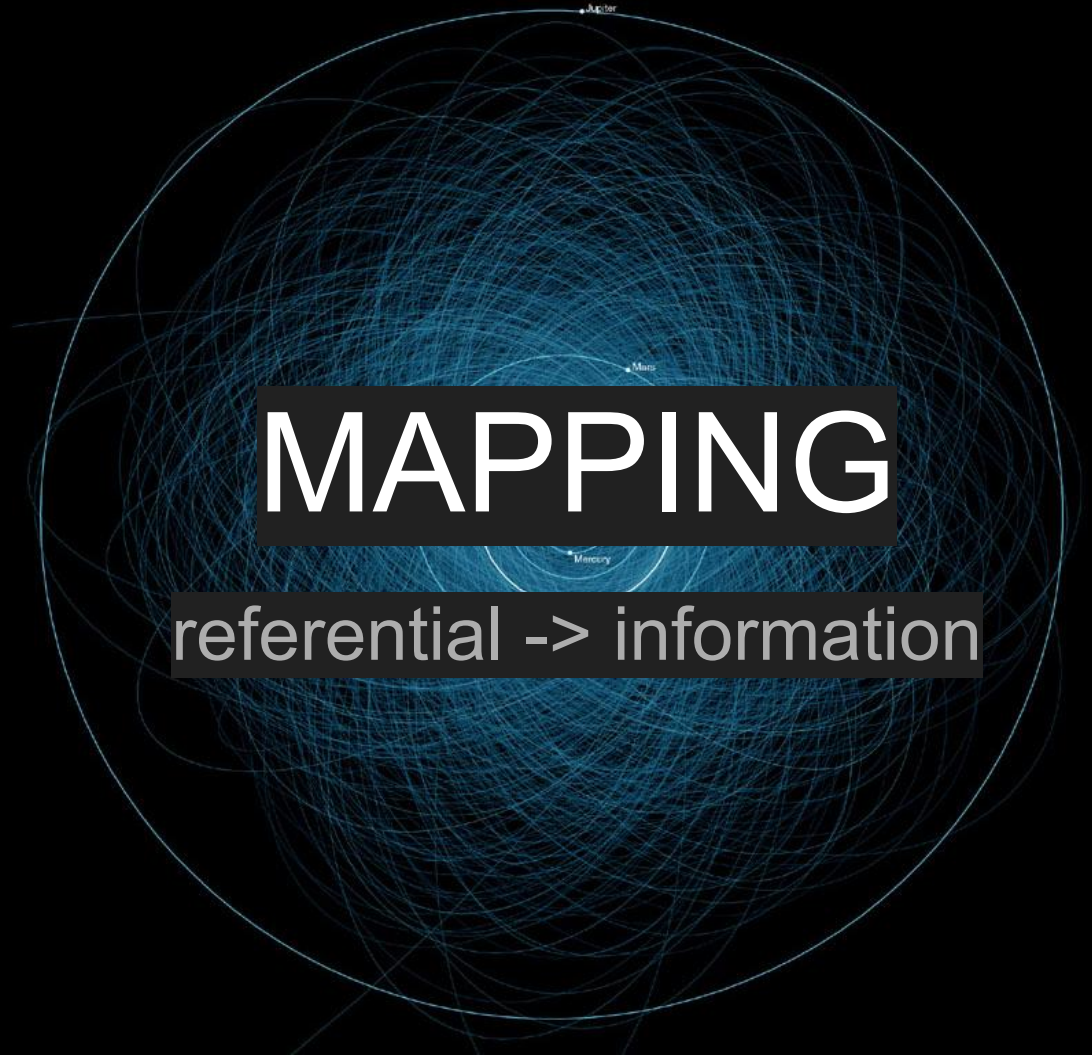
History & main use cases

Distributed (web) caching (Akamai)

P2P (Chord & BitTorrent)

Distributed databases (data distribution / sharding)

- Amazon DynamoDB
- Cassandra / ScyllaDB
- Riak
- CockroachDB



MAPPING

referential -> information

J Jóhanna

Jóhanna Björk Weisshappel sjúkraliði
Birkigrund 55 200 Kóp 566 8824, 895 8433
Jóhanna Þórsdóttir Wium 661 3640, 691 5075
691 9796, 698 3640
Jóhanna Zoëga Sunnubraut 42 200 Kóp 554 3373
Jóhanna Þorbergsdóttir Hlynsalir 3
201 Kóp 564 1556, 845 9551
Jóhanna Þorbjargardóttir
Grundarstígur 12 270 Mos 557 5164, 863 4252, 695 2005
Jóhanna Þorbjarnardóttir
Dalatanga 13 108 Rey 568 1006, 892 8390
Jóhanna María Þorbjarnardóttir
Stórholt 31 105 Rey 552 5774, 898 7049
Jóhanna Þorbjörnsdóttir bankastarfari
Blómvangur 12 220 Hfj 586 1748, 661 8792, 698 1748
Jóhanna Margrét Þorgeirsdóttir Mosgerði 23
108 Rey 553 3970
Jóhanna Þorgilsdóttir
Sunnuvegi 9 220 Hfj 555 4699, 695 6704, 698 3797
Jóhanna Þorgrímsdóttir
Kjarrhólma 38 200 Kóp 564 4541, 661 9838
Jóhanna Þorkelsdóttir Dyrenholm 4 201 Kóp 557 8092
Jóhanna Þorkelsdóttir grunnskólakennari
Seiðakvísl 17 113 Rey 561 8595, 861 9595
Jóhanna Helga Þorkelsdóttir Stórholt 45 105 Rey 848 4891
Jóhanna Þorleifsdóttir
Gerðhömrum 34 112 Rey 567 5442, 897 7202
Jóhanna G Þormar Mánabraut 9 200 Kóp 564 2436
Jóhanna Þorsteinsdóttir Blöndubíló 25
105 Rey 561 6034, 8
Jóhanna Þorsteinsdóttir Hlíðartúni 4 225 Álft 6
Jóhanna Helga Þorsteinsdóttir hjúkrunarfr
Brekkusmára 1 201 Kóp 567 4224, 8
Jóhanna Margrét Þorsteinsdóttir sjúkraliði
Hólmasíð 2 210 Rey 822 7522, 5
Jóhanna S Þorsteinsdóttir
Fjarnaholt 11 112 Rey 567 2140, 8
Jóhanna Á Þorvaldsdóttir kennari
Austurgerði 2 200 Kóp 554 0558, 8
Jóhanna Erla Þorvaldsdóttir Gullengi 11 112 Rey 5
Jóhanna Þórarinsdóttir Hæðargerði 28
200 Kóp 564 2472, 6
Jóhanna Þórdórsdóttir fræðslu- og upplýsingafulltr
Skipasundi 11 104 Rey 568 7877, 8
Jóhanna Þórðardóttir
Hraunstu Laugarási 104 Rey 456 1159, 6
Jóhanna Þórðardóttir Kristnibraut 31 113 Rey 5
Jóhanna Þórðardóttir Suðurtanga 22
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Jóhanna Þórðardóttir veitingam Bakkavör 11
170 Selt 5
Jóhanna Halla Þórðardóttir
Þverásgranda 43 113 Rey 551 2402, 8
Jóhanna Margrét Þórðardóttir
Suðurbraut 22 220 Hfj 554 2777, 8
Jóhanna Sif Þórðardóttir Langarimalla 12 200 Kóp 6
Jóhanna Vigdís Þórðardóttir myndlistarm
Bergþórugötu 55
101 Rey 551 3219, 897 0014, 8
- Netfang ..... johanna@khi.is
Jóhanna Þórhallsdóttir
Hæðargarði 35 108 Rey 553 2857, 6
Jóhanna Bergmann Þórhallsdóttir
Gwendargarða 4 113 Rey 567 1804, 847 6806, 6
Jóhanna Katrín Þórhallsdóttir
Hæðargarði 34 108 Rey 567 8988, 8
Jóhanna V Þórhallsdóttir söngk
Háaleiti 18 105 Rey 562 2027, 8
- Netfang ..... giovanna@vortex.is
Jóhanna Þórisdóttir Lautasmára 14
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- Netfang ..... rambla@isl.is
Jóhanna Þórisdóttir Stuðlaseli 3 109 Rey 5
Jóhanna Þórisdóttir Tjarnarbóli 8
170 Selt 445 2846, 8
Jóhanna Bryndís Þórisdóttir
Álfaseli 21 109 Rey 567 9226, 8
Jóhanna M Þórisdóttir Stigahlíð 36
105 Rey 588 0973, 8
- Netfang ..... hannmaja@isl.is
Jóhanna Mjöll Þórmarsdóttir
Efstasundi 5 210 Gbæ 562 5579, 6
Jóhanna Þórodóttir Kleppsvegi 14
105 Rey 553 6665, 8
Jóhanna Þórólfsdóttir Löngubrekku 3 105 Rey 5
Jóhanna Þórsdóttir Efstasundi 27 221 Hfj 6
Jóhanna Ögmundsdóttir 823 1113
Jóhanna Ögmundsdóttir Aðalþingi 11
108 Rey 553 2606, 869 2603
Jóhanna Kjartansdóttir Örvar
Skólagerði 23 101 Rey 551 7385, 660 8649
Jóhanna Margrét Öxnevad
Bergþórugötu 3 101 Rey 486 6071, 846 6657
Jóhanndine Færseth Hrísmóum 4 210 Gbæ 565 6554
Jóhannes Agnarsson Hólmgarði 21
108 Rey 551 0347, 698 0347
Jóhannes Albertsson veitstjóri Álfheimum 48 104 Rey 553 6095
Jóhannes Arason Dalbraut 27 105 Rey 557 7762
Jóhannes Arason Hlíðargerði 5 108 Rey 897 6983
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Jóhannes Ari Arason viðskiptafr Brekkuhjalla 4
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Jóhannes Ægir Arnarson Flúðaseli 42 109 Rey 892 9322
Jóhannes Atlason sprottakennari Selvað 5 110 Rey 557 3375
Jóhannes Axelsson Blöndubíl 19 110 Rey 847 7758
Jóhannes Þór Ágústarson Vatnsstíg 3
101 Rey 561 3039, 699 3039
Jóhannes Ágústsson Álfamýri 57 108 Rey 588 0966
Jóhannes Ágústsson Hofteigi 41 105 Rey 552 5536
Jóhannes Ágústsson Hófsgötu 41 101 Rey 555 2694
Jóhannes J Ágústsson tölvufr Breiðvangi 35 220 Hfj 555 0914
Jóhannes Magnús Ármannsson Merkurgötu 11
220 Hfj 555 0914
Jóhannes Arnason Starengi 90 112 Rey 586 2035, 691 4079
- Netfang ..... jolurd@simnet.is

Jóhannes Árnason
Tjarnarbóli 9 210 Gbæ 565 6303, 898 4646, 898 4686
Jóhannes Árnason nemi
Hjarðarhaga 23 107 Rey 551 8036, 698 4165
Jóhannes Kristberg Árnason Austurbergi 38
111 Rey 557 2807
Jóhannes Ingi Árnasson 698 3197
Jóhannes Sævar Arsælsson 616 6578
Jóhannes Ásbjörnsson Kapsásakr 4 203 Kóp 517 6450
Jóhannes Ásgeirsson Hulduland 32
108 Rey 553 4753, 698 6934
JÓHANNES ÁSGEIRSSON hrl Hagmunastofa
Suðurlandsbraut 10 108 Rey 568 1677, 568 7310
- Fax 568 1726
Jóhannes Helgi Ásgeirsson Vephúsum 13 112 Rey 699 4464
Jóhannes Ástvaldsson Eiðistorgi 5 170 Selt 562 1179, 863 5275
Jóhannes Bachmann sölumaður
Dofraborgum 7 112 Rey 587 7793, 898 0877
Jóhannes Baldursson
Langholtsvegi 150 104 Rey 869 4725, 568 4725
- Netfang ..... johannesbaldursson@simnet.is
Jóhannes Freyr Baldursson
Furubyggð 36 270 Mos 566 7646, 899 1067
Jóhannes Ægir Baldursson framreiðslunemi
Orrahólmi 4 105 Rey 562 3002, 891 7008
Jóhannes Laxdal Baldvinsson
Laufásvegi 22 101 Rey 517 7369, 698 0369
Jóhannes Ómar Barkarson sölum Krummahólum 10
111 Rey 587 7229
Jóhannes Bárðarson guitarnúður
Hverafold 66 112 Rey 567 1753, 866 7074
Jóhannes Benediktsson Tjnigbtu 8
101 Rey 552 7216, 865 3584
Jóhannes Benediktsson takstr Hávallagötu 22
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Geir Benjamínsson húsasmiður
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Berg sölu 064
Bergsteins
Bergsveins 094
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Bergsveins
Bergtjörfi 821
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A Bjarnas 613
Bjarni Bja
um 5 112 710
Bragi Bja
á 3 107 Rey 632
Ingi Bjarn
49 105 Rey 145
O Bjarnas
ð 35 112 Rey 024
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Björnsso 409
Björnsso
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Ingi Dan 294
Djoraldss
Bjarni Ei 297
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Egilsson
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Egilsson Strandvegi 13 210 Gbæ 661 9707
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13 316 Gbæ 517 9887, 696 9277, 661 9707
Jóhannes Einarsson skrúðmeistari
Hólaberg 13 221 Hfj 555 2836, 862 2836
Jóhannes Einarsson verkfr
Hafnarsæl 4 108 Rey 553 3984, 843 9984
Fax 553 3984
- Netfang ..... jeinars@ipt.is
Jóhannes G Einarsson Ásgarði 73
108 Rey 588 7919, 893 1737
Jóhannes Harrý Einarsson bifvélav
Hörgslandi 11 210 Gbæ 565 6338, 692 0331
Jóhannes Eiríksson Jámhálsi 2 110 Rey 820 5430
Jóhannes Eiríksson
Viðarási 21 110 Rey 567 3850, 517 8240, 517 8241
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Kórsölum 1 201 Kóp 557 2465, 899 4299
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Jóhannes Eyfjörð Eiríksson
Reykjamel 17 270 Mos 566 7791, 898 4796
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..... 553 5676
Jóhannes Eliasson hárskeri Kórsölum 3 201 Kóp 554 0930
Jóhannes Ellertsson bifreiðasmiður
Sævðarsundi 14 104 Rey 581 2387, 894 2208
Jóhannes Erlingsson Kristnibraut 97 113 Rey 892 4093
Jóhannes Garðar Erlingsson véltæ
Kastalabergi 23 221 Hfj 565 1548, 865 6503
Jóhannes Örn Erlingsson hugbúnaðarsérfr
Grettisgötu 2 101 Rey 692 3616

Jóhannes Þorgeir Ernstsson
Goðalandi 16 104 Rey 5
Jóhannes Fossdal Ostabúðin 8 101 Rey 5
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Fjarðarhvammi 111 112 Rey 5
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Garðafelli 11 210 Gbæ 5
Jóhannes H Garðarsson Álfheimum 22
108 Rey 5
Jóhannes Óli Garðarsson forstöðumaður
Barðaströnd 7 113 Rey 517 3704, 8
Jóhannes Georgsson Kirkjubóli 15
113 Rey 5
Jóhannes Georgsson Laugarnesvegi 84
105 Rey 893 8324, 8
Jóhannes Georgsson bifvélavirki Stórateigi 22
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Jóhannes Gíslason Garðastræti 18 101 Rey 5
Jóhannes Gíslason Miðtúni 56 105 Rey 5
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Byggðarenda 20 108 Rey 553 0111, 8
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Dalsbraut 18 112 Rey 568 8806, 8
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Jóhannes Ellert Guðlaugsson refsiendur
Krummahólum 2 111 Rey 557 3846, 8
Jóhannes Kristján Guðlaugsson Grundarvegi 1
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Jóhannes Guðmannsson Barðavogi 1
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Lyngbrekku 11 200 Kóp 561 3771, 899 2551, 8
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Jóhannes Guðmundsson bifreiðasmiður
Ljósheimum 4 104 Rey 553 6629, 8
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Bolfagörðum 97 170 Selt 561 8330, 8
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Bólstaðarhlíð 26 105 Rey 553 3329, 8
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Sörlaskjóli 60 107 Rey 5
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101 Rey 5
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Laugalæk 48 105 Rey 553 6703, 8
Jóhannes Baldur Guðmundsson
Dalatanga 4 270 Mos 587 2229, 617 7107, 7
Jóhannes Bjarni Guðmundsson
Fawsölm 6 210 Gbæ 544 1307, 8
Jóhannes Geir Guðmundsson Skólavarg 6 220 Hfj 5
Jóhannes H Guðmundsson
Dofraborgum 9 112 Rey 557 3304, 8
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Vallarhúsum 28 112 Rey 568 0324, 8
Jóhannes L Guðmundsson
Álfkonuvegi 137 200 Kóp 554 7442, 8
JÓHANNES Þ GUÐMUNDSSON Miðtúnsst 58
105 Rey 5
- Netfang ..... jesus@simnet.is
Jóhannes Örn Guðmundsson 695 9063, 699 6670, 8
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Jóhannes Guðnason 5
Jóhannes Guðnason Krummahólum 10
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Kleppsvegi 14 105 Rey 588 6142, 8
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Jóhannes Gunnarsson Mávahlíð 16 105 Rey 5
Jóhannes Gunnarsson formaður
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Jóhannes Gunnarsson tollendurskoðandi
Kvistalandi 33 113 Rey 553 7804, 8
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Orrahólmi 37 105 Rey 553 8307, 8
Jóhannes Jón Gunnarsson framreiðslum Sólvallagötu 10 101 Rey 552 4422, 8
Jóhannes M Gunnarsson tæknif Grófarseli 9
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Jóhannes Páll Gunnarsson 562 6244, 691 3286, 8
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Jóhannes V Gunnarsson 5
Jóhannes Gunnlaugsson 552 4121, 8
Melseli 6 109 Rey 5
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Torfufelli 25 111 Rey 5
Jóhannes Már Gylfason Jöklaseli 45 ..... 770 0838, 8
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Jóhannes Júlíus Hafstein 517 9364, 8
Hólmgarði 49 108 Rey 5
Jóhannes Halldórsson Álfheimum 36 ..... 588 1319, 8
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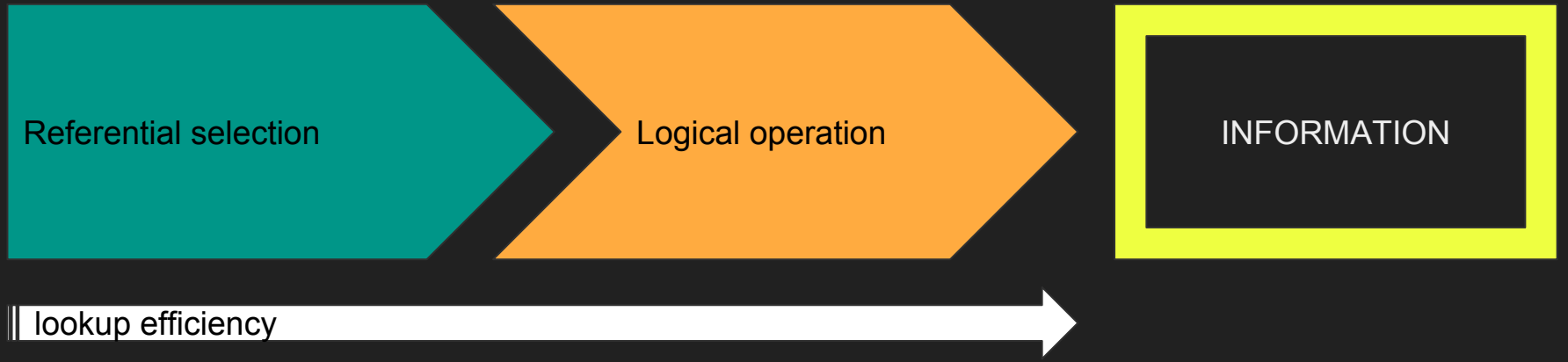
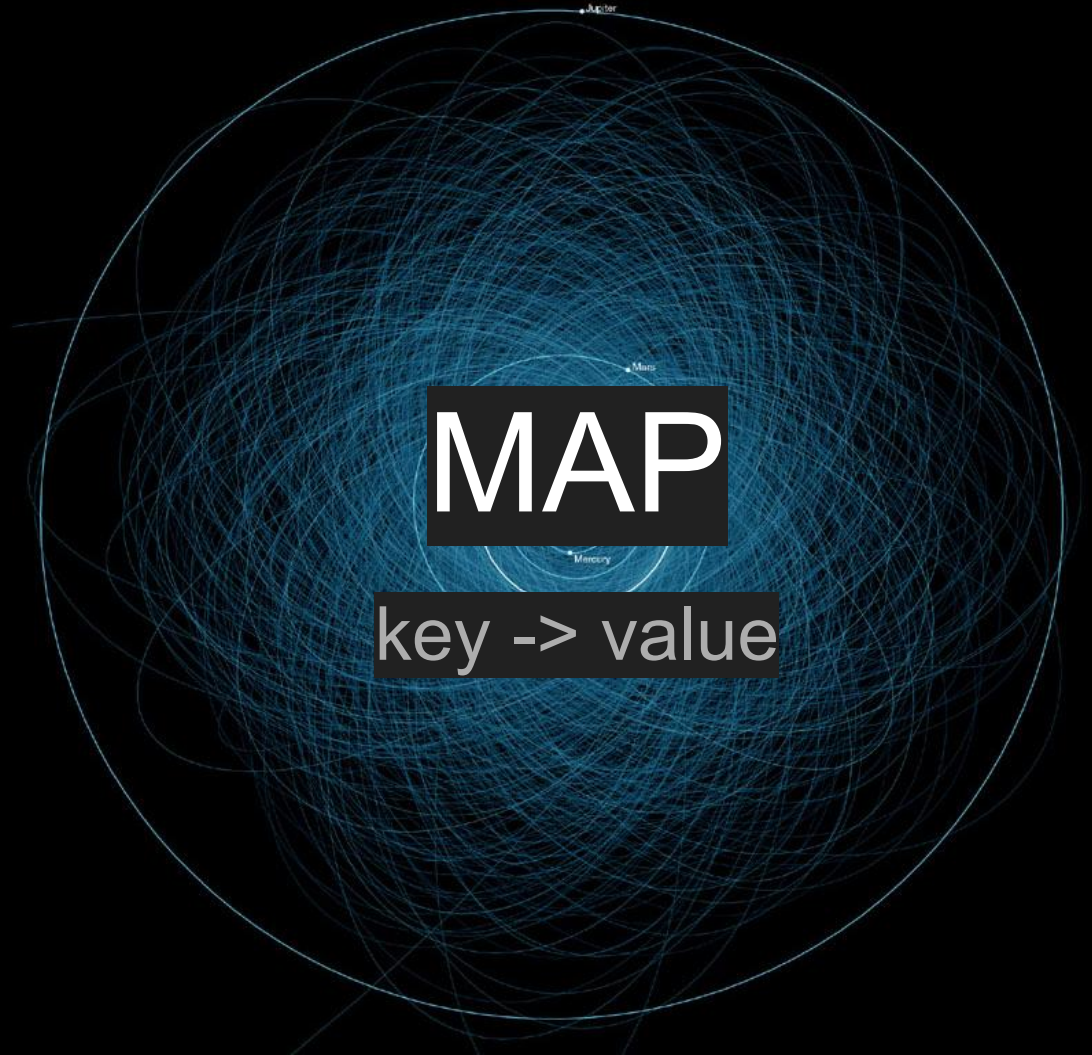
Jóhannes Halldórsson cand mag Valhvammi 4
105 Rey 5
Jóhannes Halldórsson húsasm 551 4504, 8
Bolfagranda 5 107 Rey 5
- Fax 5
Jóhannes Halldórsson húsasmíðameistari 567 6210, 8
Logafold 44 112 Rey 5
Jóhannes Halldórsson rennism 555 1107, 893 1316, 8
Lyngmóum 11 210 Gbæ 5

Map logic


Referential selection
Logical operation
INFORMATION
lookup efficiency



MAP

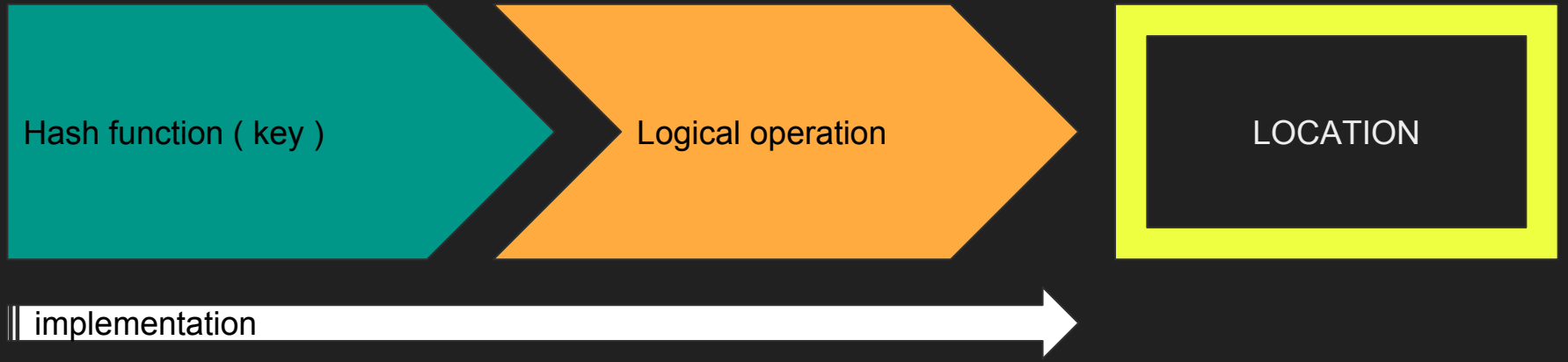
key -> value

Python dict()

{key: value}

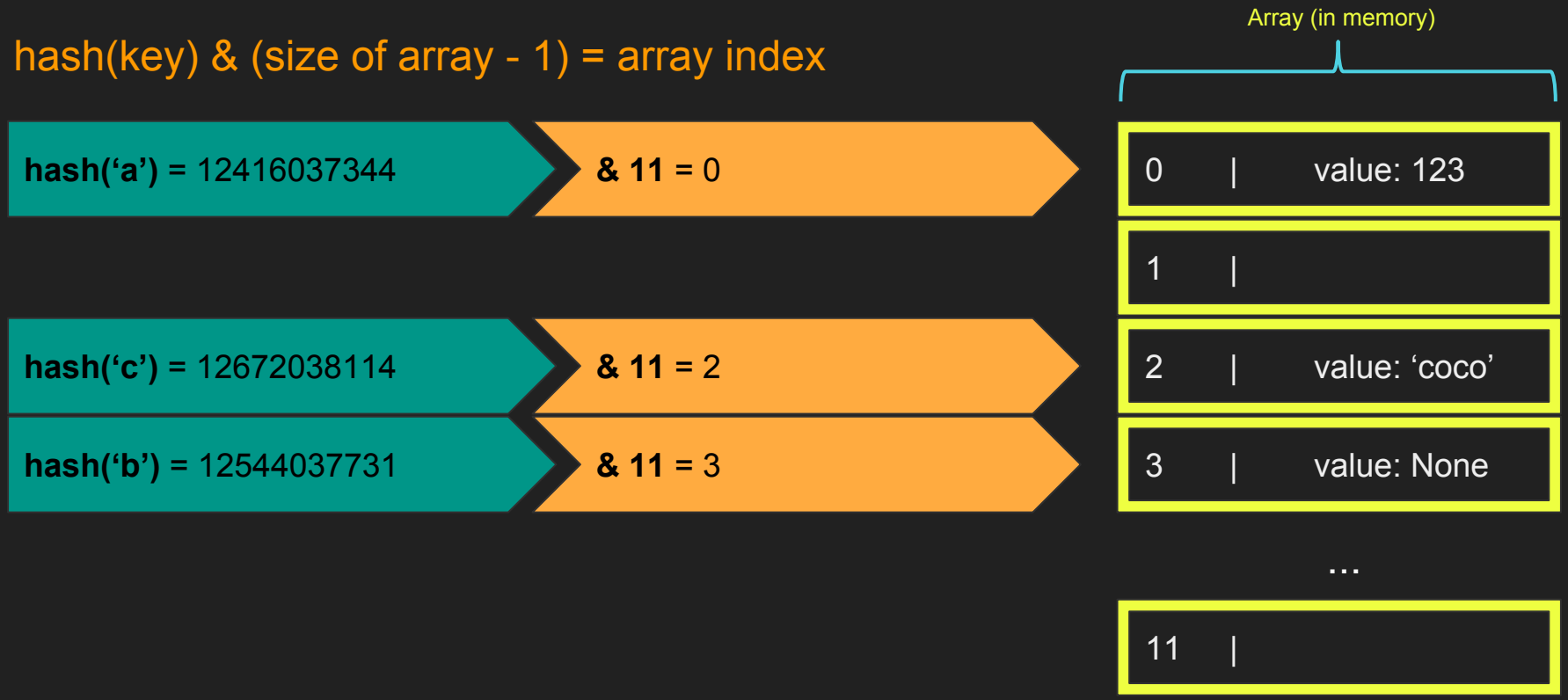
Python dict() is a Hash Table

Hash Table logic



Python dict() implementation

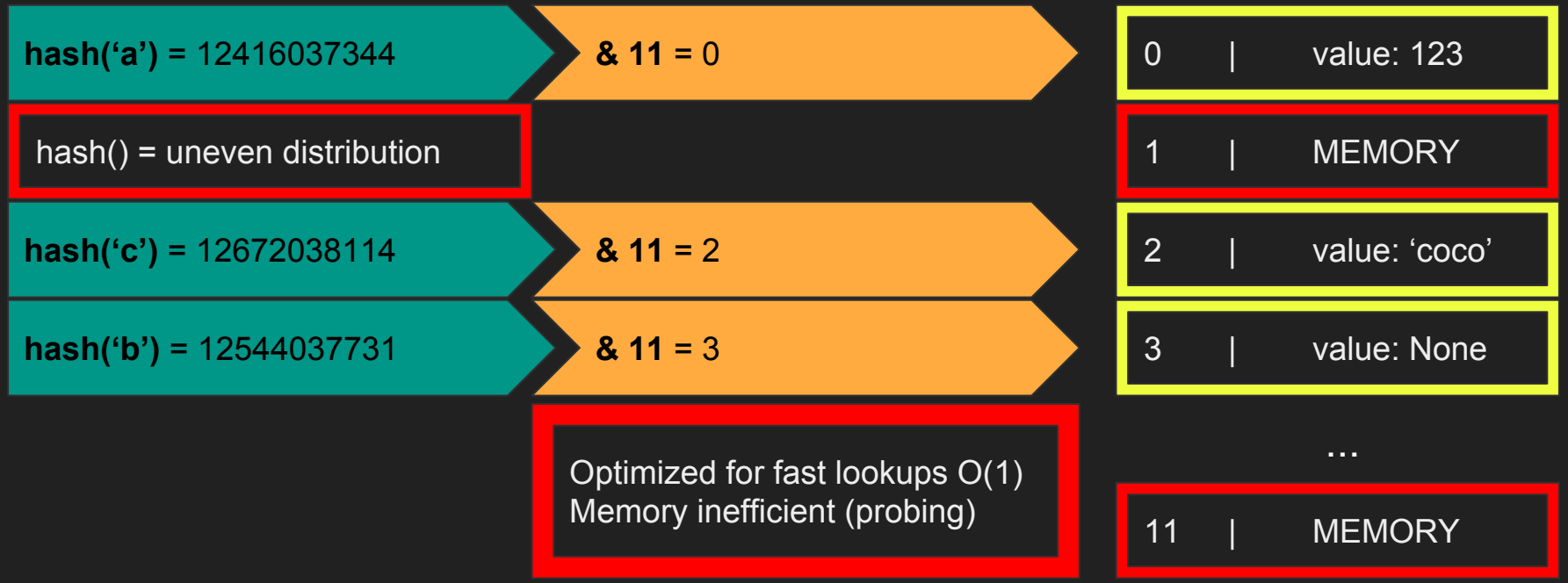
hash(key) & (size of array - 1) = array index



Key factors to consider

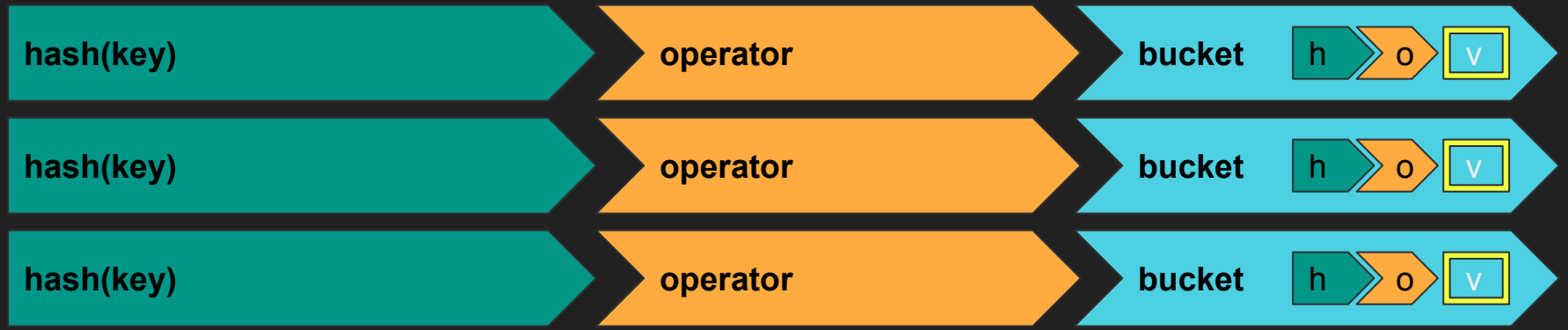
Python dict efficiency & scaling

hash(key) & (size of array - 1) = array index



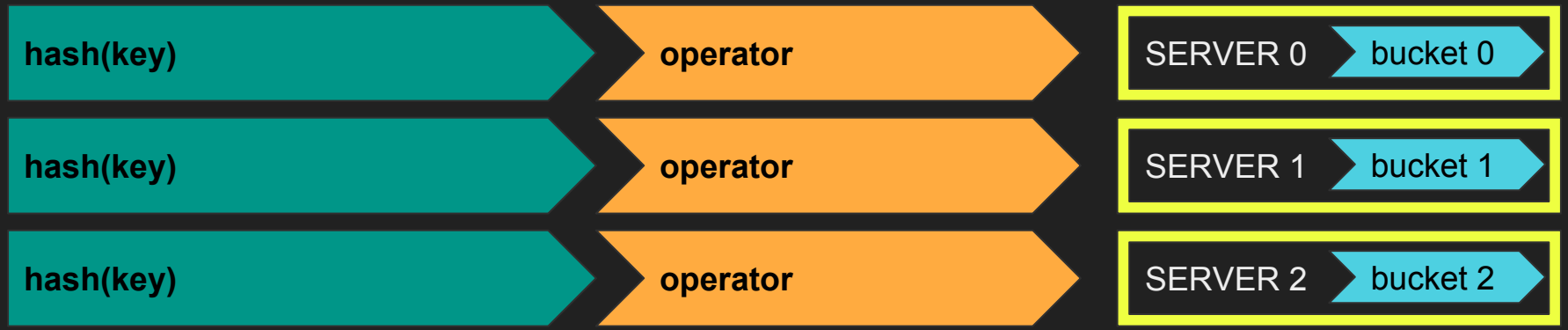

Distributed Hash Tables
(DHT)

Split your key space into buckets



the hash function will impact the size of each bucket

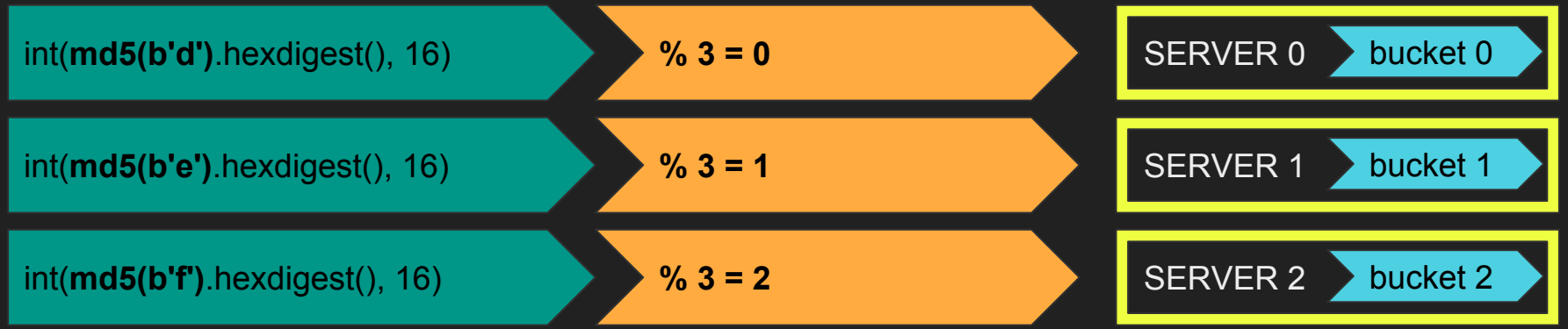
Distribute your buckets to servers



what's the best operator function to find the server hosting the bucket for my key ?

Naive DHT implementation

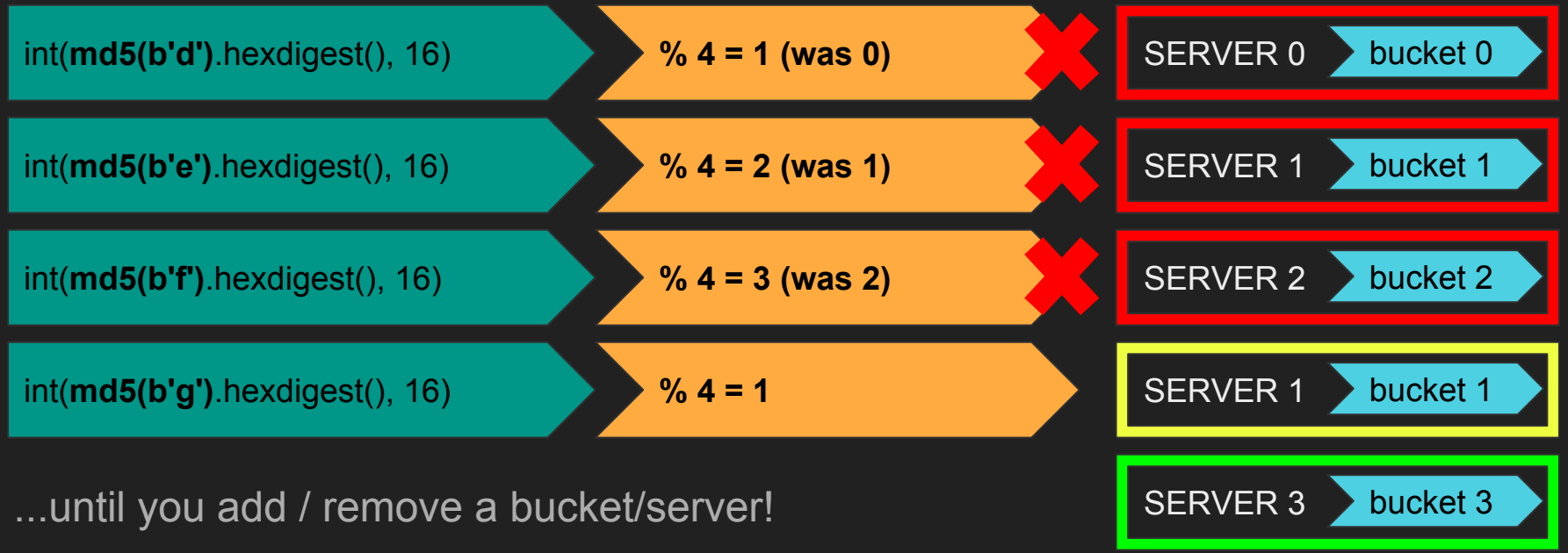
md5(key) % (number of buckets) = server



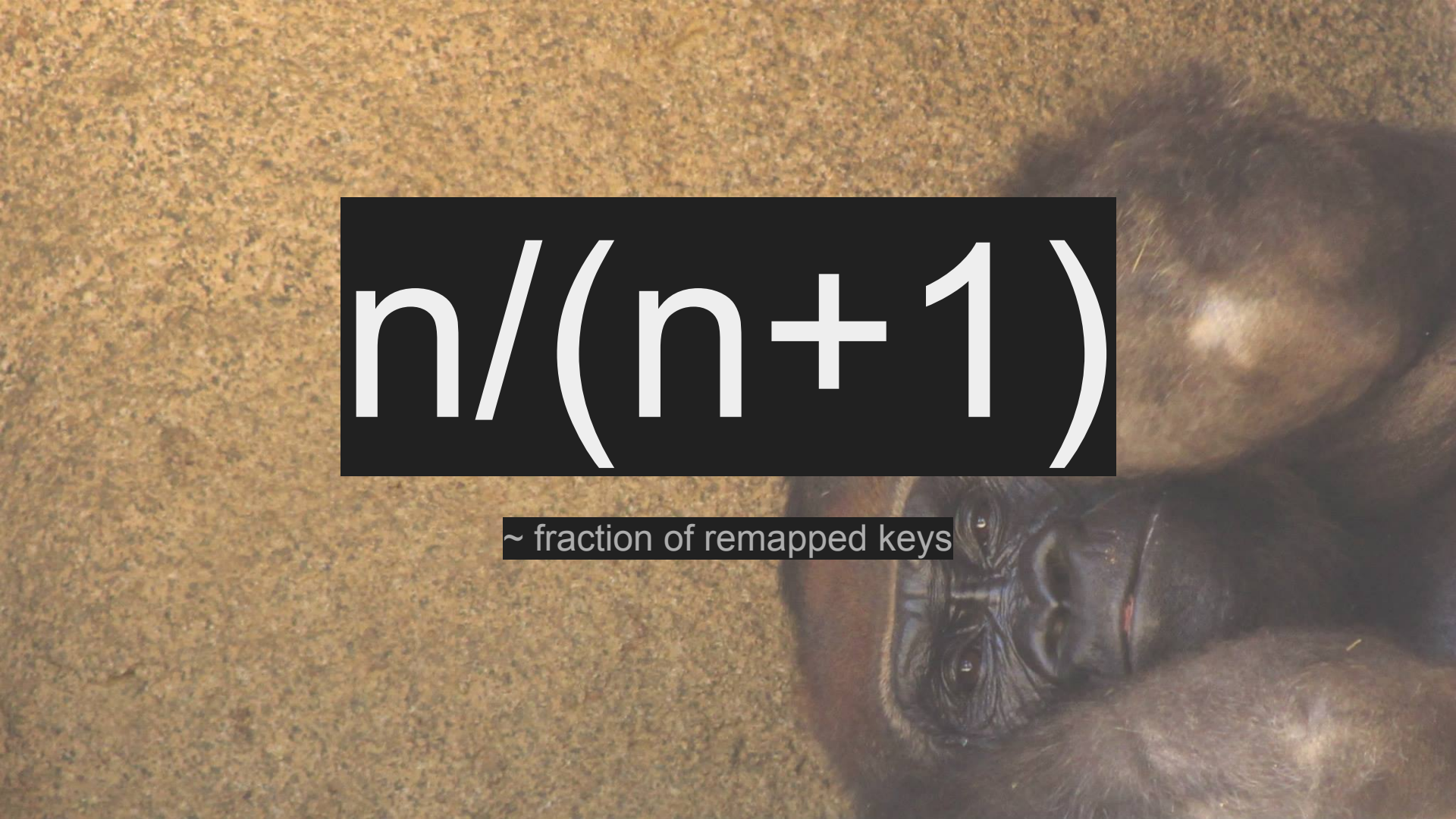
simple & looking good...

Naive DHT implementation

md5(key) % (number of buckets) = server



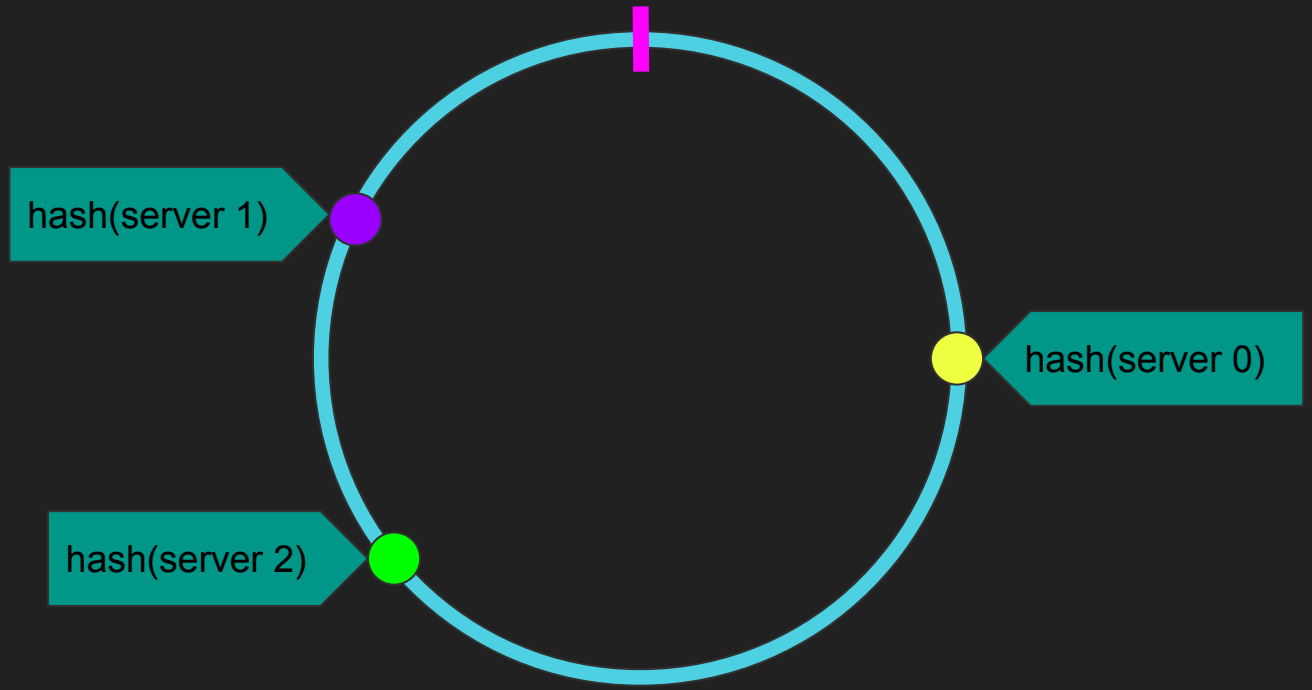
...until you add / remove a bucket/server!


n/(n+1)
~ fraction of remapped keys

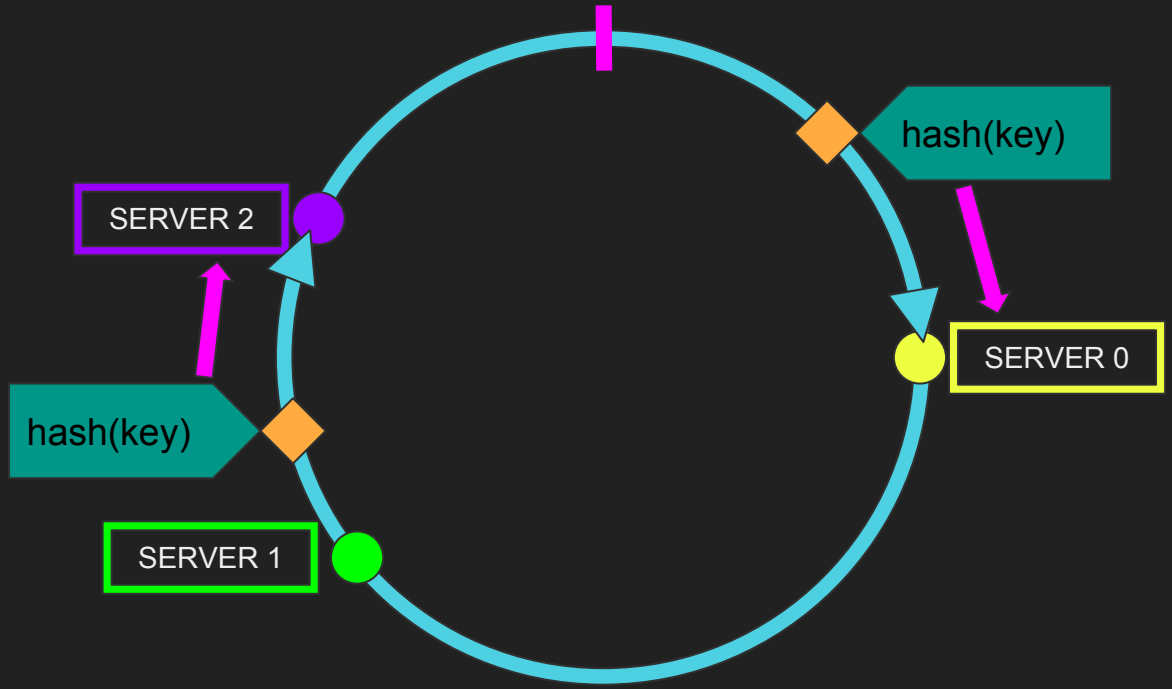

HELP!
we need consistency


The Hash Ring

Place your servers on the continuum (ring)

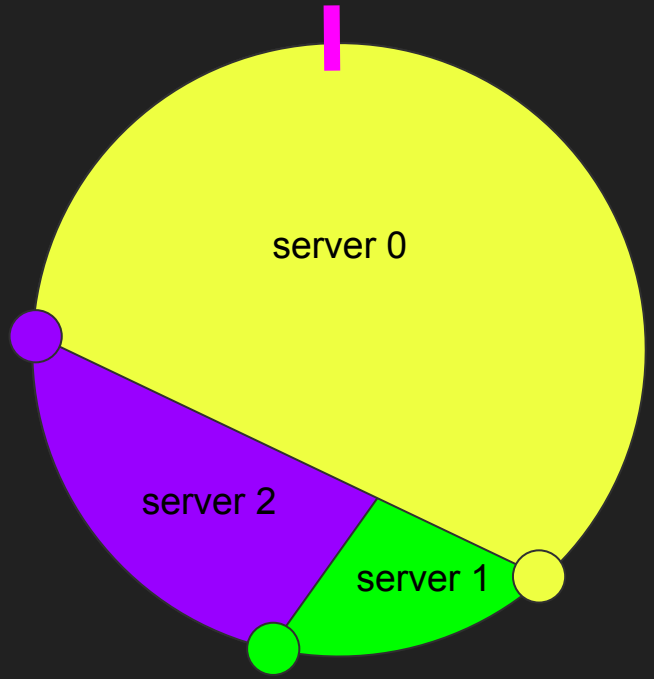


Keys' bucket is on the next server in the ring




1/n
~ fraction of remapped keys

Uneven partitions lead to hotspots



hash functions are not perfect

Which hash function to use ?

Cryptographic hash functions

- MD5
- SHA1
- SHA256

Non cryptographic hash functions

- CityHash (google)
- Murmur (v3)

\+ standard

\+ adoption

\- need conversion to int

\+ optimized for key lookups

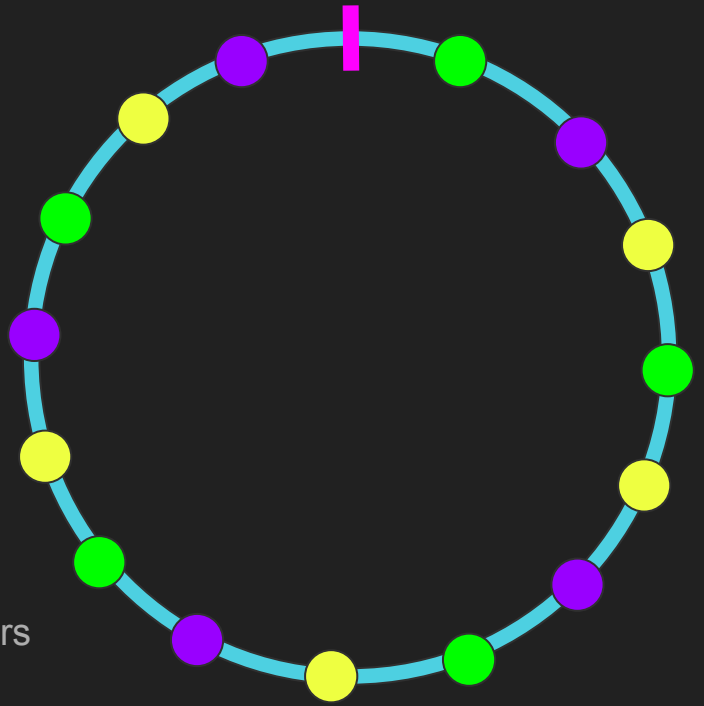
\+ fast

\- need of C libs

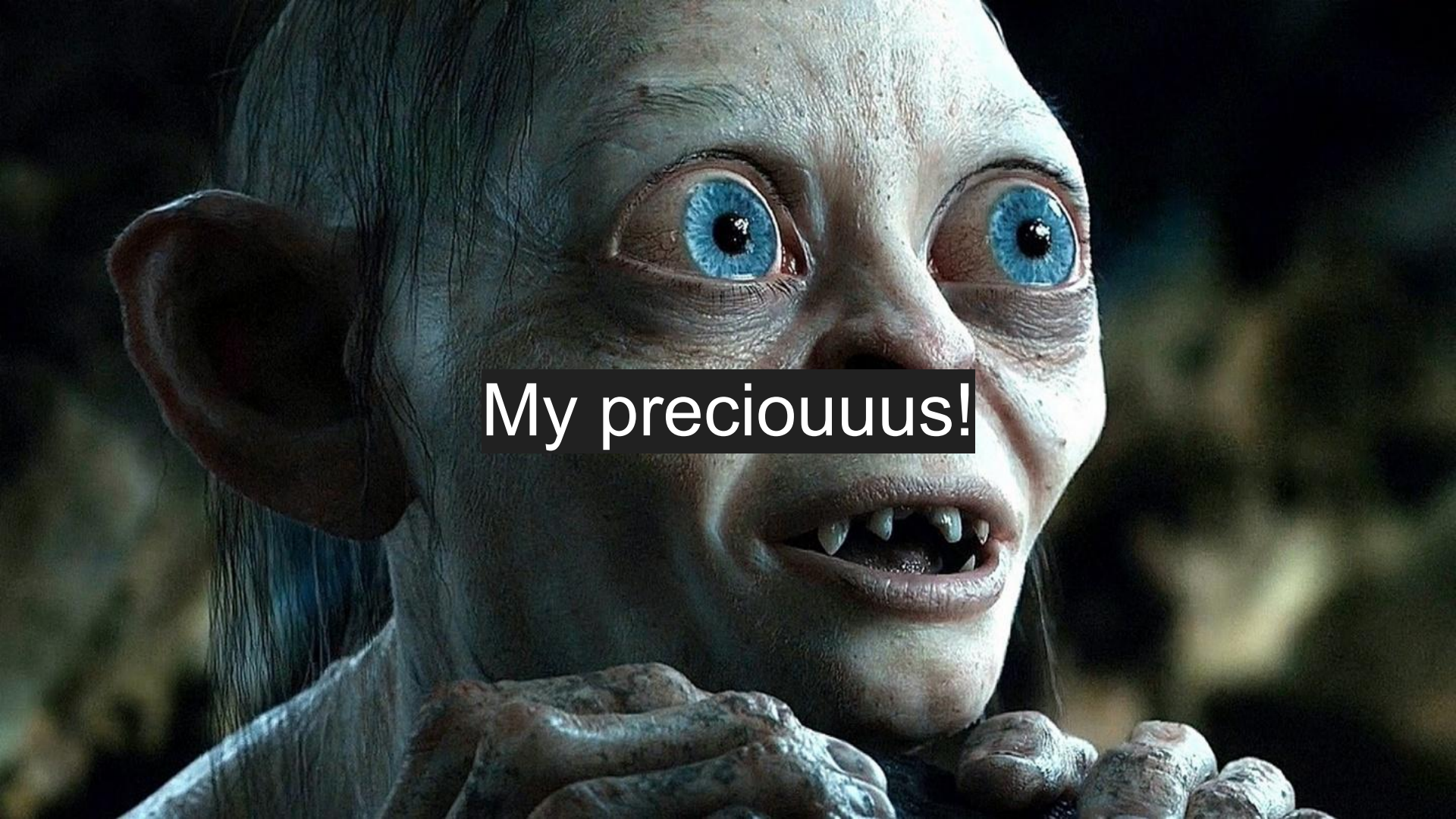
SHAX - MD5 - CityHash128 - Murmur3 - CityHash64 - CityHash32

speed

Hash Rings vnodes & weights mitigate hotspots

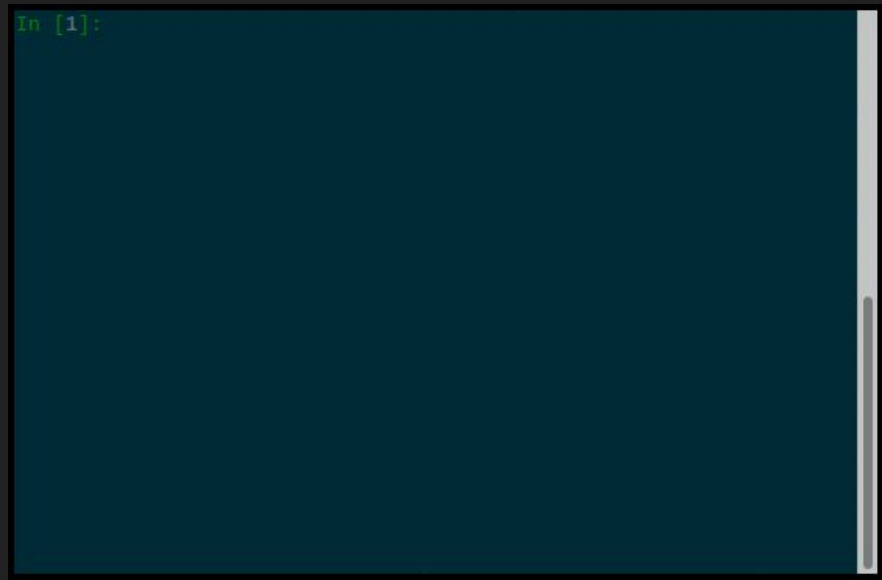


reduces load variance on servers


My preciouuus!

Consistent Hashing implementations in python

ConsistentHashing	A simple implement of consistent hashing
consistent_hash	The algorithm is the same as libketama
hash_ring	Using md5 as hashing function
python-continuum	Using md5 as hashing function
uhashring	Full featured, ketama compatible

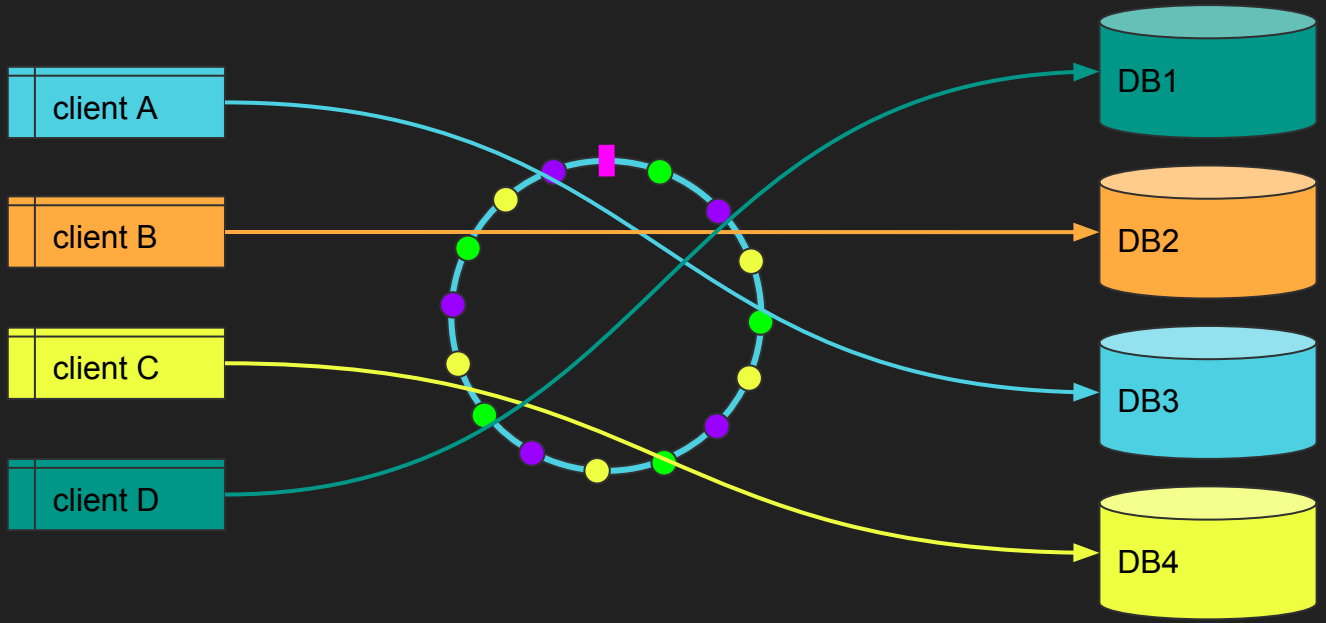


uhashring

```
In [29]: nodes = {
    ...:     '/mnt/disk1/': {
    ...:         'instance': open('/mnt/disk1/commitlog', 'a')
    ...:     },
    ...:     '/mnt/disk2/': {
    ...:         'instance': open('/mnt/disk2/commitlog', 'a')
    ...:     },
    ...:     '/mnt/disk3/': {
    ...:         'instance': open('/mnt/disk3/commitlog', 'a')
    ...:     },
    ...:     '/mnt/disk4/': {
    ...:         'instance': open('/mnt/disk4/commitlog', 'a')
    ...:     },
    ...: }
```

Example use case #1

Database instances distribution



Example use case #1

Database instances distribution

```
4  import pymysql.cursors
5
6  from uhashring import HashRing
7
8  nodes = {
9      'mydb1.local': {
10         'instance': pymysql.connect(host='mydb1.local', user='user', password='passwd', db='db'),
11         'port': 3306
12     },
13     'mydb2.local': {
14         'instance': pymysql.connect(host='mydb2.local', user='user', password='passwd', db='db'),
15         'port': 3306
16     },
17     'mydb3.local': {
18         'instance': pymysql.connect(host='mydb3.local', user='user', password='passwd', db='db'),
19         'port': 3306
20     },
21     'mydb4.local': {
22         'instance': pymysql.connect(host='mydb4.local', user='user', password='passwd', db='db'),
23         'port': 3306
24     },
25 }
```

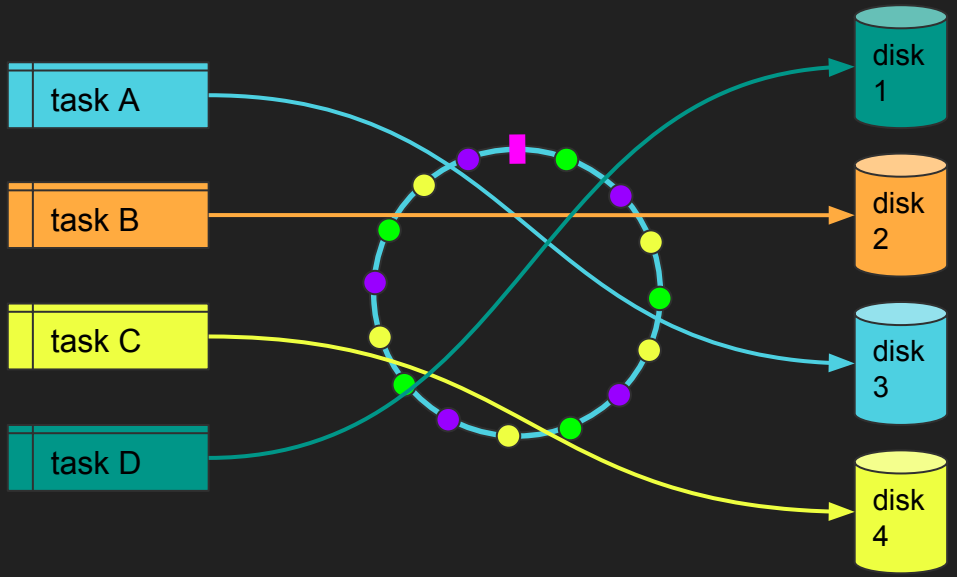
Example use case #1

Database instances distribution

```
27 # create the ring
28 hr = HashRing(nodes)
29
30 # we have some data and use the key to distribute it on the right server
31 some_data = {
32     'client A': 'user data of client A',
33     'client B': 'user data of client B',
34     'client C': 'user data of client C',
35     'client D': 'user data of client D'
36 }
37
38 # use the ring intuitively
39 for partition_key, data in some_data.items():
40     with hr[partition_key].cursor() as cursor:
41         sql = "INSERT INTO `users` (`data`) VALUES (%s)"
42         cursor.execute(sql, (data))
43
44     # hr[partition_key] == 'instance' of selected node (pymysql.connect)
45     hr[partition_key].commit()
```

Example use case #2

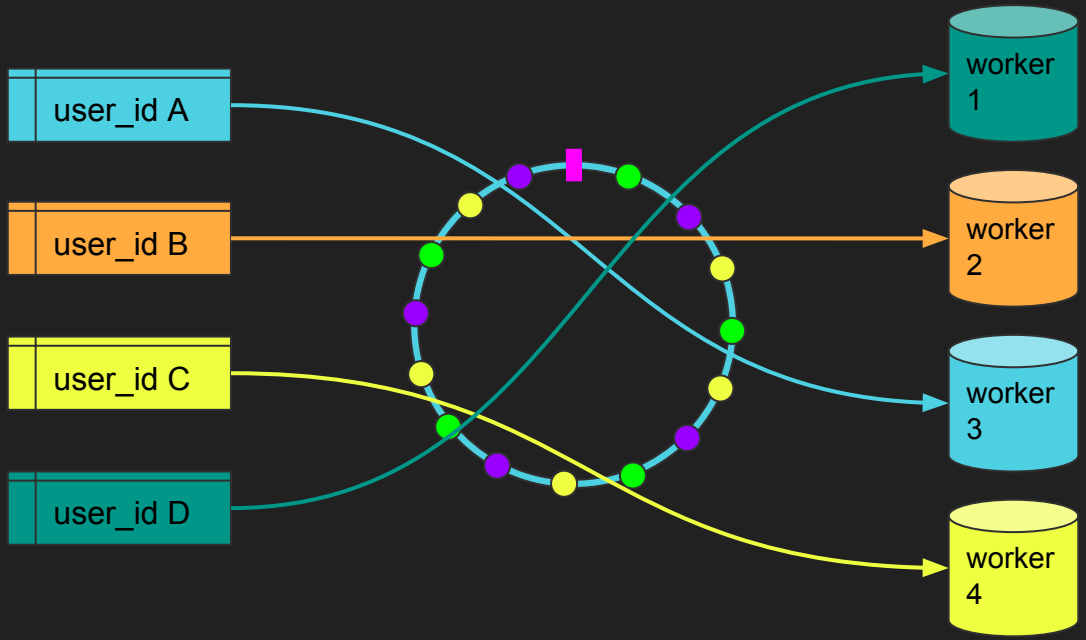
Disk & network I/O distribution




```python
nodes = {
    '/mnt/disk1/': {
        'instance': open('/mnt/disk1/commitlog', 'a')
    },
    '/mnt/disk2/': {
        'instance': open('/mnt/disk2/commitlog', 'a')
    },
    '/mnt/disk3/': {
        'instance': open('/mnt/disk3/commitlog', 'a')
    },
    '/mnt/disk4/': {
        'instance': open('/mnt/disk4/commitlog', 'a')
    },
}
hr = HashRing(nodes)


# dummy function to showcase disk I/O write balancing
def dummy_writer(task_id):
    output_data = '{} output'.format(task_id)

    # keep a trace of our write time
    write_id = str(uuid4())
    hr[task_id].write('{}:{}\n'.format(write_id, task_id))

    # write the actual data on a file
    file_path = '{}/{}.out'.format(hr.get_node(task_id), write_id)
    with open(file_path, 'w') as output_file:
        output_file.write(output_data)


# dummy function to showcase disk I/O read balancing
def dummy_reader(task_id):
    output_files = listdir(hr.get_node(task_id))
    for file_name in output_files:
        if file_name.endswith('.out'):
            file_path = '{}/{}'.format(hr.get_node(task_id), file_name)
            with open(file_path, 'r') as input_file:
                print(input_file.read())


dummy_writer('task_for_real')
dummy_writer('task_for_the_win')
dummy_writer('task_down')
dummy_writer('task_is_known')
dummy_writer('task_g')
dummy_reader('task_for_the_win')
```

Example use case #3

Log & tracing consistency

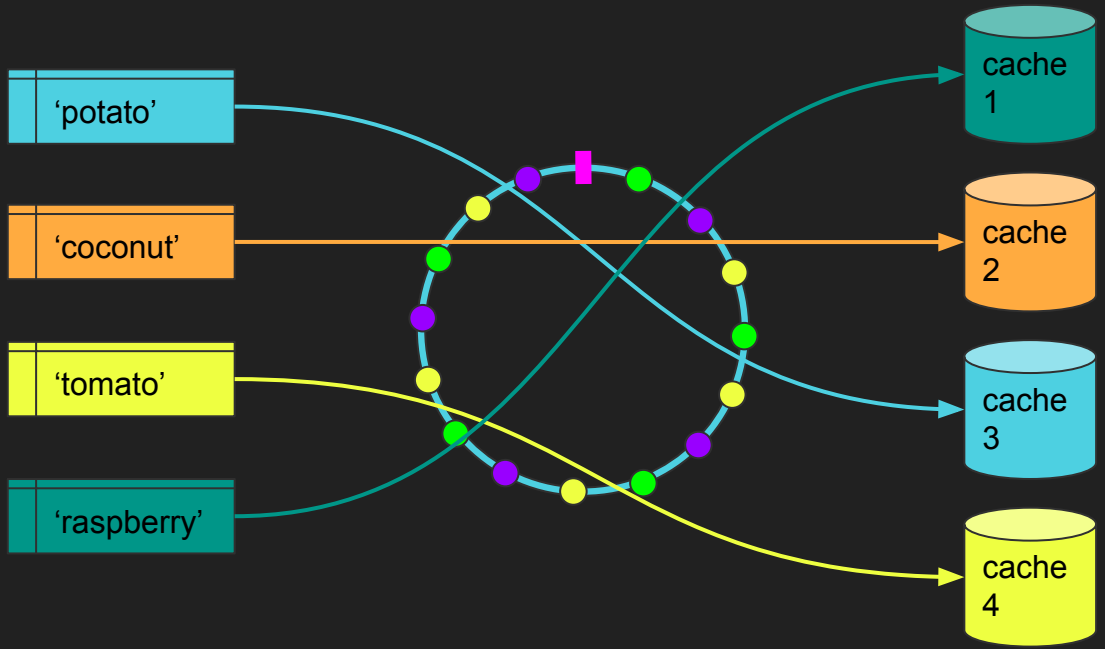



```python
from beanstalkc import Connection
from uhashring import HashRing

nodes = {
    'server_1': {
        'instance': Connection(host='server_1'),
        'port': 11300
    },
    'server_2': {
        'instance': Connection(host='server_2'),
        'port': 11300
    },
    'server_3': {
        'instance': Connection(host='server_3'),
        'port': 11300
    },
    'server_4': {
        'instance': Connection(host='server_4'),
        'port': 11300
    },
}

# create the ring
hr = HashRing(nodes)

# we get some jobs from a local beanstalkd server
# and forward them based on their content
local_bean = Connection(host='localhost')
while True:
    job = local_bean.reserve()

    # assume that the first char of the job
    # content is the routing key
    routing_key = job.body[0]

    # forward the job based on the routing key
    hr[routing_key].put(job.body)

    # delete our local copy
    job.delete()
```

Example use case #4

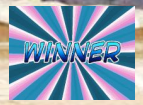
python-memcached consolidation

```python
#!/usr/bin/env python3
# -*- coding: utf-8 -*-

import memcache

from uhashring import monkey
monkey.patch_memcache()

mc = memcache.Client(['node1:11211', 'node2:11211'])

```



Live demo raffle

List of GIFs

One of the GIF is the winner 

Every participant is a node (bucket)

hash(WINNER_GIF_URL) picks the winner node


http://ep17.nbly.co
(silly live demo)


Thanks
github.com/ultrabug/ep2017
github.com/ultrabug/uhashring
@ultrabug