### 3.11 LRU缓存

#### 3.11.1 题目以及要求

**题目描述:**

请你设计并实现一个满足 *LRU* (最近最少使用) 缓存 约束的数据结构。

实现 *LRUCache* 类：

*LRUCache*(*int* *capacity*) 以 正整数 作为容量 *capacity* 初始化 *LRU* 缓存

*int* *get*(*int* *key*) 如果关键字 *key* 存在于缓存中，则返回关键字的值，否则返回 -1 。

*void* *put*(*int* *key*, *int* *value*) 如果关键字 *key* 已经存在，则变更其数据值 *value* ；如果不存在，则向缓存中插入该组 *key*-*value* 。如果插入操作导致关键字数量超过 *capacity* ，则应该逐出 最久未使用的关键字。

#### 3.11.2 概要设计

设计图如下:



#### 3.11.3算法分析

**算法说明:**

由于其没有对有序性没有很强的要求,故只需要用一个双向链表做哈希映射即可,需要特别说明的是,这里的映射值是指向这个节点的指针,而非这个节点的位序,因为遍历到这个节点也是需要时间的.

对于*get*操作,首先判断*key*是否存在,如果存在,则返回映射至节点的值,并将节点取出移动至头部.

对于*put*操作,首先判断其*key*是否存在,如果不存在,则只需要在头部插入新节点,并将key加入哈希表中,如果超出容量,则删除尾部最久未使用的节点即可.如果存在,则先通过哈希表定位,更新*value*值,再将其取出放到头部即可.

**时间复杂度分析:**

哈希表的查找与双向链表的删除与插入均可以以的时间复杂度运行.

**3.11.4使用说明**

输入若干行：

第一行输入一个整数*capacity*表示LRU缓存的容量。

后面每行输入为*put*或*get*：

如果指令为*put*类型，后面需要输入两个整数表示*key*和*value*。

如果指令为*get*类型，后面需要输入一个整数表示*key*。

提示：



最多调用次 *get* 和 *put*

程序名称为11*.cpp* , 程序在*Clion 2023.1,MVSC 17.0*编译器下能正常调试运行,程序运行如图

图形用户界面, 应用程序

描述已自动生成

##### 3.11.5测试结果及分析

* 第一组数据:特殊情况,capacity为1

IN:

1

put 4002 33279

put 1172 97467

get 1172

get 1172

get 1172

put 425 43112

get 1172

put 8881 93307

put 5396 63084

put 269 24999

put 9475 99514

put 2863 3281

get 4002

put 986 52955

get 986

get 5396

put 2301 68855

get 1172

put 8124 20867

get 2863

get 8124

put 2069 58374

put 8249 16404

get 5396

get 2301

put 5097 69983

put 9439 45924

get 5097

put 6715 43762

get 6715

get 6715

get 6715

get 9439

get 8249

get 6715

get 8249

get 2301

get 2863

put 6105 69574

put 8327 91084

get 8249

get 2863

get 2863

put 5253 71283

put 8169 79340

put 3177 29838

get 8249

get 8327

put 8769 74973

get 8327

put 8609 46865

put 345 42275

put 5343 5059

put 6108 896

get 8124

get 5253

put 9965 18419

get 9439

put 4966 27454

get 6108

put 7082 52704

get 6105

put 6655 19945

put 7957 9424

put 5607 95091

get 2069

put 4888 49972

get 5607

put 3924 87852

get 8249

get 269

get 8609

get 8169

get 7082

get 7082

OUT:

97467

97467

97467

-1

-1

52955

-1

-1

-1

20867

-1

-1

-1

43762

43762

43762

-1

-1

43762

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

-1

* 第二组数据:特殊情况只有get操作

IN:

15

get 1

get 2

get 4

get 8

get 2

get 1

get 2

get 4

get 8

get 2

-1

-1

-1

-1

-1

-1

-1

-1

-1

* 第三组数据:

IN:

5

get 5538

put 2280 26699

get 2280

put 4231 88196

get 2280

put 7727 23231

get 7727

get 4231

put 6167 54296

put 5454 86617

put 4324 21290

get 5454

put 2124 63635

get 7727

put 1647 34074

put 5851 89988

get 7727

put 4260 10469

get 2280

put 5829 18541

put 7545 89557

get 5454

get 4324

put 3467 33800

put 7637 89195

put 1690 38591

put 1912 63533

put 5593 90650

put 121 15093

get 5454

OUT:

-1

26699

26699

23231

88196

86617

-1

-1

-1

-1

-1

-1

* 第四组数据:

IN:

10

put 5437 97086

put 3750 2502

put 9591 71010

get 3750

get 3750

get 9591

put 9515 66012

put 7528 65980

put 3146 65745

get 7528

put 7893 9420

get 7893

put 2155 27731

put 3989 5603

get 7528

get 3750

get 5437

get 7528

put 6318 45454

put 1258 1345

put 1645 60160

get 3989

get 6318

put 1949 2707

get 2155

put 4251 33868

put 410 78294

get 1645

put 9615 36480

get 1258

put 381 89179

put 739 90174

put 1054 89055

put 9424 20071

put 7040 50257

get 3750

get 7528

get 7893

get 2155

get 3750

get 3146

get 7528

get 7893

put 8281 97707

put 7932 24336

put 8035 72966

get 381

put 6672 6843

put 1055 26176

get 1054

OUT:

2502

2502

71010

65980

9420

65980

2502

97086

65980

5603

45454

27731

60160

1345

-1

-1

-1

-1

-1

-1

-1

-1

89179

89055

* 第五组数据:

IN:

10

put 5408 79706

put 2129 34315

get 5408

get 5408

get 2129

get 5408

put 4465 89634

put 6206 86571

put 4901 14334

put 1861 56362

get 2129

get 6206

put 7586 71034

put 5640 47305

put 2293 86328

put 4664 93378

get 2129

put 8599 32110

put 2467 21679

get 2129

put 4770 91786

put 6289 31701

get 5408

get 4465

get 6206

get 5640

put 947 9573

put 4483 6226

put 7018 71840

put 4181 98315

put 7128 48146

get 8599

get 7128

get 2129

put 767 22511

put 4448 61219

get 8599

get 6289

get 2467

put 2178 77851

get 7586

put 873 21002

get 4181

put 1572 58292

get 6289

get 947

put 5324 36866

put 7207 69051

put 1960 43399

get 1960

put 2482 89740

put 7637 8318

put 5764 6261

get 947

get 1572

put 314 53684

get 767

put 1374 59902

put 6812 1274

put 3480 88334

get 5764

put 7779 71483

get 314

put 7285 29656

get 7285

get 4770

put 4827 42927

put 6414 94563

get 4901

get 8599

get 5764

put 1980 86575

get 8066

get 2293

put 7708 19296

put 2323 38922

put 9733 6117

get 4827

put 8549 10311

put 2806 42406

put 9783 28415

put 8425 65355

get 2467

get 8425

get 2178

get 8549

get 767

put 906 26259

get 7637

put 2064 11774

get 947

put 7549 60954

put 6874 79866

put 7663 47145

get 2806

put 7373 80151

put 3635 7986

put 2316 14414

put 3465 15681

get 4901

OUT:

79706

79706

34315

79706

34315

86571

34315

34315

-1

-1

86571

47305

-1

48146

34315

-1

-1

-1

-1

98315

-1

-1

43399

-1

58292

-1

6261

53684

29656

-1

-1

-1

6261

-1

-1

42927

-1

65355

-1

10311

-1

-1

-1

42406

-1

* 第六组数据:

IN:

300

put 2338 67032

get 2338

put 5630 18944

put 9619 50258

get 2338

put 1027 4690

get 5630

put 6211 18979

get 9619

get 5630

get 5630

get 6211

get 6211

get 1027

put 331 70005

get 331

put 6804 39358

get 9619

get 9619

get 1027

get 1027

put 2239 45686

put 2149 63871

get 2239

get 1027

get 1027

get 1027

get 5630

put 1664 44871

get 1664

get 2239

get 1027

get 1027

put 4542 90155

get 1027

put 9052 30021

get 1664

put 6209 48217

get 6209

get 6804

put 6525 45046

put 2547 69411

put 6952 4668

put 623 95222

put 5439 1086

get 6804

put 7786 20051

put 9694 95723

put 5858 66797

put 6969 13606

get 6804

get 331

put 6452 36766

put 5527 50343

put 9577 45323

put 8023 14838

put 5671 44826

put 6427 43220

put 1286 40431

get 5630

get 1027

put 4998 41453

get 2547

put 5612 8763

get 5612

put 6753 26268

put 7985 16108

put 8672 25416

get 9052

get 9052

put 3079 80420

put 2276 70977

put 4273 55780

get 9619

get 3079

get 331

put 7647 72616

get 7786

put 3933 13216

get 1664

get 2276

put 3657 31317

put 5437 27909

get 1286

put 5269 12354

get 5439

put 2140 85652

put 8513 63358

get 4998

put 7418 88821

put 4470 5254

get 5858

put 3346 19475

put 4428 25749

get 9052

get 5269

get 3657

put 9944 6830

get 4998

get 6753

OUT:

67032

67032

18944

50258

18944

18944

18979

18979

4690

70005

50258

50258

4690

4690

45686

4690

4690

4690

18944

44871

45686

4690

4690

4690

44871

48217

39358

39358

39358

70005

18944

4690

69411

8763

30021

30021

50258

80420

70005

20051

44871

70977

40431

1086

41453

66797

30021

12354

31317

41453

26268

* 第七组数据:

IN:

300

put 644 34804

put 6916 68264

put 8808 12546

put 2322 27121

get 644

put 3569 53571

put 5187 43565

put 2321 51581

put 8672 4560

put 6456 59721

put 6176 32005

get 3569

get 6916

get 6456

put 3566 95202

put 8411 99953

put 106 41396

get 6916

put 2627 33986

get 6176

get 8672

get 3566

get 2321

put 8901 71444

put 9107 63657

get 2322

get 2321

get 2322

get 8411

put 3033 19065

get 3566

put 5570 2083

put 1531 14836

put 2140 38444

get 8411

put 616 31624

get 6456

get 106

get 812

get 2627

get 644

put 5123 47752

put 8082 85827

put 9444 56032

get 106

get 2140

get 3033 19065

put 975 68712

get 6456 2083

put 6635 70698

get 3566 38444

get 7800

put 7137 47213

get 812

put 9612 74301

put 5183 51314

get 8082

get 1531

get 6456

get 644

get 616

put 2760 34872

put 7368 42747

put 9000 36336

get 6916

put 9283 94429

get 1510

get 8901

get 2627

get 8901

put 5094 95960

put 3461 75488

get 5094

get 8808

put 6668 63901

put 5293 39636

get 9283

put 6470 19553

put 6592 1378

get 3033

get 2760

put 3255 728

get 2627

put 4141 8207

get 644

put 6544 93012

put 4684 55384

get 6544

get 5293

get 6456

put 9615 74690

get 3566

put 1078 48766

get 4684

get 9283

get 9444

put 4581 21684

put 9699 39268

put 9839 79821

put 9287 25737

get 1078

get 9000

put 5135 63619

put 1419 18510

get 9107

get 9283

put 4336 84590

get 5293

get 2760

put 2689 26334

get 616

put 5306 98397

get 7368

get 7137

get 1419

put 1343 37338

put 1550 29282

put 4841 44285

put 9097 15116

put 754 83364

put 8723 50797

put 8301 15942

get 754

put 9521 72644

put 6018 65039

put 2030 13068

get 2689

put 4333 80982

put 2944 44201

put 4442 74875

put 8038 84241

get 8301

put 9368 39872

put 9226 5003

get 644

get 3569

get 9287

put 5757 98895

put 8403 41373

put 1127 73291

get 5094

put 2220 7563

get 6018

get 9839

get 754

put 6852 16481

put 2570 99128

put 5865 2205

get 9097

get 7137

get 2322

get 2321

put 2802 4685

put 6844 4957

put 7648 92122

get 6635

put 7892 17866

put 9493 96183

put 7159 53062

get 7159

put 3035 84869

put 7766 11413

get 2627

put 1121 35507

put 4465 45813

put 3764 98660

put 6899 41124

get 9699

put 2622 46438

put 3102 42824

put 9078 75481

get 4336

put 1033 71606

put 1288 114

get 4336

put 4109 81388

put 1906 25393

get 9287

get 9699

put 2168 94322

get 5183

put 6268 61906

put 225 28158

get 5094

put 8093 91819

put 8187 71551

put 9385 22726

get 6899

put 2515 44164

put 5212 13767

get 8082

get 6635

get 9226

put 1810 90123

put 5368 45357

get 4333

get 6916

get 4333

get 4841

get 7892

put 6956 93775

get 2220

put 4712 85488

get 2220

get 5094

put 7660 4445

get 6668

get 1810

get 8723

put 2743 31821

get 754

get 3102

get 6268

get 3255

put 6356 29044

get 975

get 9615

get 1288

get 9444

get 1343

get 4684

get 3255

get 9493

get 3255

get 9226

put 5004 38519

put 6337 35593

get 6544

get 8901

put 2833 588

put 4815 39974

get 1906

put 449 25303

put 2941 57502

get 7159

get 9493

get 9283

get 4841

put 2183 49127

put 6968 59804

get 1531

put 9490 20365

put 3017 82610

put 2926 59204

get 1531

put 5784 6456

put 691 38754

put 5508 70358

get 8082

put 3716 37909

put 2639 28779

put 8727 35690

put 1171 49565

get 1810

get 7159

put 2647 21468

put 9142 107

get 6356

get 3033

get 5004

get 8723

get 3461

get 2140

put 5736 73989

get 1127

get 8727

get 9615

get 7660

get 6916

get 9490

put 9602 43034

get 6899

put 3694 9502

get 8723

get 8093

put 9668 72082

get 2833

put 6381 7025

put 8203 17905

put 8156 31113

get 2322

put 6707 73177

put 8491 70997

put 581 51060

put 120 36886

get 6844

get 4442

get 2941

put 9373 69296

put 3078 54785

put 1402 46750

get 5187

get 9699

get 2760

get 7892

get 2944

put 7503 93365

put 1741 45201

put 1100 18821

put 4762 17003

get 8491

put 2429 52590

get 1127

get 106

put 8659 38534

get 9839

get 6356

get 9602

put 6429 87196

get 6337

put 6520 7677

put 3436 90870

put 9766 9636

put 6286 92496

get 8659

get 5784

get 9368

get 4465

get 7137

get 7137

put 1308 92709

get 6268

get 2944

get 4442

put 9797 99781

put 8810 63689

get 5570

put 2018 90529

get 4333

get 4712

get 1308

get 9142

put 9465 48045

get 5212

get 2639

put 631 6960

put 5317 17948

put 7662 24132

put 5410 30883

put 1722 71866

put 1685 98013

put 2544 40951

get 2183

put 5984 13343

get 644

put 2563 70769

get 3102

put 3005 35581

get 2743

put 7593 75110

put 5243 21561

get 9602

put 4799 14386

put 1985 31465

get 1906

get 3694

get 3017

put 9091 41255

get 1121

put 5823 78843

get 812

get 7159

get 8093

get 8301

get 2743

get 812

get 8203

get 2760

get 2570

get 2941

put 9507 48750

get 8203

get 6470

get 8411

put 9945 57062

get 1127

get 3033

get 8301

get 8301

get 2544

put 1635 87970

get 2321

get 2639

put 527 25950

put 46 25074

put 3131 55592

put 3079 35318

put 3810 93817

get 9107

put 7819 73051

get 6176

get 6456

put 4683 4483

put 2767 438

put 2717 50802

get 9107

get 1722

get 9091

get 5410

put 7858 10399

put 2433 98133

put 683 70230

get 5317

get 2627

get 8156

put 5592 40295

put 5694 88374

get 5123

put 6967 22484

get 2515

put 7113 98513

get 4333

get 5368

put 8722 43842

put 6481 57094

put 7602 65317

put 1251 49415

put 7806 65993

get 4762

put 9691 59490

get 6429

put 1209 30288

get 2760

put 7731 31462

put 148 82675

get 3569

get 2647

put 6905 57194

put 3541 43011

put 7974 32091

get 9615

put 3024 36479

put 8742 61463

put 5609 12744

get 7806

put 6139 86782

put 5987 88890

get 9091

put 208 56741

put 9103 79347

put 1361 9948

get 9097

get 9602

put 6725 10941

get 1171

put 2760 26822

get 4336

put 5903 27269

get 6592

put 6500 47640

put 6428 90799

put 1757 32019

put 8647 78301

get 8742

get 8808

get 2321

get 6635

put 7330 13392

put 4674 90459

get 3255

put 3329 94108

get 1127

get 2743

put 9064 410

get 2717

get 2622

get 1033

get 1308

put 8600 80226

get 8082

get 2429

put 6836 49749

get 2622

get 9521

get 9368

get 6456

get 3033

put 3043 17743

put 2691 11968

put 7988 76457

get 6356

get 106

put 7195 42385

put 74 5680

put 4944 23553

get 6956

get 2429

get 1402

put 4511 35795

put 2746 92695

put 9113 56934

put 3205 14399

get 2926

get 9091

put 539 21813

put 8504 19904

get 8810

get 6852

get 6500

put 7367 10344

get 6268

get 7819

put 5271 2923

put 4421 24234

put 5127 90734

put 4330 77970

get 9078

get 3716

put 1146 26513

get 5127

put 8276 73543

put 8179 8697

get 6725

get 8082

get 3461

put 6102 39313

get 812

get 2220

get 1402

put 5201 23170

get 6102

get 6916

put 2367 52638

get 2944

get 6139

put 8733 1038

put 1203 59975

get 225

put 423 26705

get 8491

put 8840 39415

put 4112 20193

get 5757

get 1722

get 527

get 8672

get 3005

put 9470 93489

put 3534 47686

get 5183

put 8578 79579

put 9123 94825

put 2199 34992

put 1265 18871

get 5293

get 1308

put 4253 27583

get 5317

put 5711 73065

put 912 38789

get 8504

put 7203 70108

put 7061 36982

put 3813 70696

get 1033

get 6852

get 4465

get 9490

put 1639 15017

put 9842 88407

get 423

get 6967

put 3605 87845

put 535 95346

get 3810

get 7766

get 5306

get 7766

put 9513 31879

get 3255

get 6176

put 9155 36338

get 74

put 3812 92244

put 7578 78978

put 6106 17310

put 1672 6170

put 5214 59549

get 7367

put 8519 72490

get 1722

put 5259 20501

get 8403

get 9842

get 539

get 616

get 1685

get 5609

put 9985 55166

get 9000

put 367 62929

get 1343

put 1962 26861

put 6338 90015

get 1685

put 6003 4545

get 4762

get 3569

put 2757 70997

get 9668

get 7137

put 8132 11042

get 5183

get 1685

get 2767

get 3716

get 1419

get 9490

get 5368

get 3812

get 9612

get 6139

get 7800

put 2425 97377

get 8156

put 3874 53940

get 8156

get 8519

put 8814 50394

get 3005

put 6713 13236

put 8803 48861

put 1012 35928

put 5497 25983

put 5547 18233

get 8491

put 1582 79194

get 4683

get 8727

put 4993 64299

get 5497

get 2760

get 6286

get 8600

get 2321

put 5128 20793

get 8082

get 2030

put 6566 41619

put 7130 79536

put 9787 15069

put 3317 41027

get 9521

get 5410

get 7203

get 1209

put 2888 81216

put 4325 74513

get 8727

get 6635

get 2689

get 5903

put 3407 10194

put 3008 83472

put 6216 66370

get 9287

get 7648

put 9310 65196

put 2752 24218

get 1146

get 7892

get 9103

get 1419

get 6905

put 9457 98992

get 9226

put 7814 45221

get 2944

get 3874

put 9359 91175

get 8038

get 9615

put 7019 54389

get 812

put 7392 41684

get 7330

get 5508

put 6803 57846

get 148

get 6003

put 2340 71129

get 6216

put 4937 22876

put 3297 55312

get 7368

get 1639

get 4841

get 6725

get 4336

get 148

put 5428 59963

put 3200 10

get 527

get 5187

put 7920 91026

get 6286

get 1985

put 2116 10601

put 2076 39568

get 9797

get 9766

get 8093

get 6803

get 9842

put 1129 61301

put 6832 93605

put 4837 30482

put 4895 95405

get 8803

get 4684

put 7215 53834

get 7368

get 1672

get 9444

put 4686 82651

get 4815

get 2340

put 9755 99579

put 61 84882

get 3035

put 4679 51322

put 2588 58130

get 9699

put 9444 42182

put 249 65486

get 5212

put 8625 83337

get 7330

put 8918 89954

put 6739 54387

put 8425 56381

put 2206 35027

put 2753 13164

get 367

put 2898 60335

put 6503 79407

put 7771 34304

put 2409 77418

get 6968

put 9799 71749

put 6466 18742

put 3064 9731

get 2752

put 754 56927

put 5659 92329

get 2076

put 9070 35368

put 9933 53352

get 3716

put 6411 97232

get 6428

get 2627

get 5865

put 6048 42613

put 4817 722

put 5742 39674

put 7002 25958

put 8977 37490

put 1264 77756

put 5012 88403

put 4792 63801

get 6832

put 816 47142

put 7065 83696

put 2951 7304

get 8082

get 7920

put 194 7323

put 3564 14867

put 9010 63219

get 1209

put 6885 20112

put 8956 93889

put 3107 1852

put 6640 71304

put 423 71338

put 5496 9259

get 5214

get 6429

put 1660 97933

get 194

put 7883 69505

get 3436

get 5508

get 9010

put 2066 57327

get 816

put 750 27630

put 9263 70924

get 6268

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get 7392

put 5103 27344

get 6968

put 167 45591

get 6338

put 8078 9612

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put 7011 79762

put 3952 25803

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get 8491

put 3569 82290

put 7749 49347

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get 7203

put 1555 90312

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put 4128 49044

get 6470

put 3808 60534

get 7593

put 1185 72284

get 2544

put 3205 3686

put 6210 69784

get 2066

get 7814

put 6479 43708

put 91 24126

put 2798 98611

get 754

put 301 59243

put 8480 43735

get 754

put 7159 37556

get 4815

get 644

get 1185

put 4384 60814

get 1209

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put 7609 7294

get 2330

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put 19 22420

get 8276

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put 4239 68040

get 9668

get 208

get 1985

get 7368

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get 1660

put 7583 67584

get 5212

get 6852

get 2030

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get 6852

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get 2760

get 7130

put 6029 19468

put 734 54380

get 9985

get 8808

get 9107

get 9615

get 1685

get 9000

put 3146 68480

get 2116

put 1466 81343

put 1432 65707

get 4442

get 7203

put 1559 43752

put 3218 89992

get 6337

get 1343

get 6356

put 6902 46031

put 8921 82874

put 1433 88325

get 2018

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get 5123

put 976 96541

get 5402

put 4118 32938

get 9945

put 3673 27060

get 3812

put 4418 38542

get 1433

get 8808

put 291 23835

get 9493

put 9796 19656

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put 6296 72806

put 9607 36838

get 3107

get 4253

put 9981 6478

get 4712

get 9839

put 9451 6654

get 9615

put 7984 75201

get 6456

get 9263

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get 691

put 6080 4497

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get 3452

put 8483 91166

get 3008

get 2944

put 5052 16216

put 601 36282

get 1012

put 3030 31274

get 9607

get 7766

put 1912 79574

get 9839

get 1852

get 8840

get 535

get 6844

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get 7578

get 1510

get 7819

get 750

get 644

put 8098 29285

put 7951 14570

put 6838 33319

get 2760

put 1094 96084

get 2588

get 9368

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get 8203

get 2199

put 8854 71078

get 9097

get 5243

put 6485 3885

put 2153 7426

get 2588

put 9701 55619

get 3107

put 8068 39497

put 7290 31897

put 8003 13049

put 5721 31006

get 2951

put 4082 91725

put 5675 30031

get 1402

put 4073 34193

get 2743

put 4623 4800

put 3929 86255

get 5012

get 5201

get 5711

put 9525 51858

put 5129 91118

get 8680

put 5378 96124

put 6861 65534

get 5368

put 5003 68428

put 9011 78947

put 7169 12460

put 7186 55112

put 193 25319

put 5822 76102

put 7362 9294

get 6852

put 1119 30461

get 5243

OUT:

34804

53571

68264

59721

68264

32005

4560

95202

51581

27121

51581

27121

99953

95202

99953

59721

41396

-1

33986

34804

41396

38444

19065