

Ontology VBFT 共识算法性能测试报告

TPS (Transaction per Second) 每秒交易处理笔数, 反映了系统在同一时间内能处理业务的最大能力, 是区块链的核心性能指标之一。Apache JMeter 是 Apache 组织开发的基于 Java 的压力测试工具, 本文使用 JMeter 对 Ontology 0.8.2 版本做压测, 将测试过程及结果记录如下。

一、测试环境

每个节点为微软云虚拟机, 共 7 个共识节点, 硬件配置如下:

1. CPU: 单节点 8CPU, 具体信息如下:

- 名称: Intel (R) Xeon (R) CPU E5-2673 v3
- 主频: 2.40GHz
- 缓存大小: 30720 KB
- 核数: 8

2. 内存: 单节点 27G

3. 硬盘: 固态硬盘, 大小 50G, 读写速率限制不超过 25MB/s

软件配置如下:

- 系统信息: ubuntu 16.04.4 LTS
- Go 环境: go1.9.3 linux/amd64

二、Ontology 参数

Ontology 版本为 0.8.2

启动命令:

```
./ontology --maxtxinblock 120000 --gaslimit 0 --rest --localrpc --  
disableeventlog --loglevel 2
```

三、测试步骤

- 使用 go-sdk 构造一批不同的 ONT 转账交易, 确保其 hash 不一样, 每笔交易的转账数额为 1;
- 启动 ontology 测试网络, 共 7 个节点;
- 查询交易发送的目标账户的余额, 并记录;
- 使用 JMeter 将这批交易发送到测试网络上, 配置 500 个线程发送, 设置固定吞吐量定时器控制发送速率; 记录开始发送交易时间。
- 查看节点日志, 通过 log 中 numtx 观察落账交易数量, 出现第一个非空块时记录时间, 发送完毕后, 连续出现三个以上的空块时, 可认为交易已经处理完毕, 取最后一个非空块的时间作为落账结束时间;
- 查询交易发送的目标账户的余额, 并记录;
- 计算余额差值, 除以测试时间, 即可得 TPS。

四、Jmeter 配置

1. 线程数与发送次数配置:

```
<ThreadGroup guiclass="ThreadGroupGui" testclass="ThreadGroup" testname="压测" enabled="true">  
  <stringProp name="ThreadGroup.on_sample_error">continue</stringProp>  
  <elementProp name="ThreadGroup.main_controller" elementType="LoopController" guiclass="LoopControllerPanel" testclass="LoopController" testname="循环控制器" enabled="true">  
    <boolProp name="LoopController.continue_forever">false</boolProp>  
    <stringProp name="LoopController.loops">6000</stringProp>  
  </elementProp>  
  <stringProp name="ThreadGroup.num_threads">500</stringProp>  
  <stringProp name="ThreadGroup.ramp_time">0</stringProp>  
  <longProp name="ThreadGroup.start_time">149794383000</longProp>  
  <longProp name="ThreadGroup.end_time">149794383000</longProp>  
  <boolProp name="ThreadGroup.scheduler">false</boolProp>  
  <stringProp name="ThreadGroup.duration">300</stringProp>  
  <stringProp name="ThreadGroup.delay"></stringProp>  
</ThreadGroup>
```

LoopController.loops=6000, ThreadGroup.num_threads=500; 前者代表一个线程发送的交易的次数, 后者代表开启的线程数, 二者相乘得出的值为发送的交易数, 此处为 3,000,000。

2. 发送速率配置:

使用固定吞吐量定时器配置交易发送速率, 此处为每分钟 360,000, 即每秒发送 6,000 笔交易, 见下图:

```
<ConstantThroughputTimer guiClass="TestBeanGUI" testClass="ConstantThroughputTimer" testName="Constant Throughput Timer" enabled="true">
  <intProp name="calcMode">2</intProp>
  <doubleProp>
    <name>throughput</name>
    <value>480000</value>
    <savedValue>0.0</savedValue>
  </doubleProp>
</ConstantThroughputTimer>
```

五、 交易发送情况

```
Starting the test @ Sun Jun 10 10:24:44 UTC 2018 (1528626284036)
Waiting for possible Shutdown/StopTestNow/Heapdump message on port 4445
summary + 92395 in 00:00:16 = 5837.4/s Avg: 2 Min: 0 Max: 276 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180706 in 00:00:30 = 6023.5/s Avg: 1 Min: 0 Max: 76 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 273101 in 00:00:46 = 5959.3/s Avg: 1 Min: 0 Max: 276 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180765 in 00:00:30 = 6025.5/s Avg: 1 Min: 0 Max: 59 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 453866 in 00:01:16 = 5985.5/s Avg: 1 Min: 0 Max: 276 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180549 in 00:00:30 = 6018.3/s Avg: 1 Min: 0 Max: 200 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 634415 in 00:01:46 = 5994.8/s Avg: 1 Min: 0 Max: 276 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180744 in 00:00:30 = 6024.8/s Avg: 1 Min: 0 Max: 149 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 815159 in 00:02:16 = 6001.4/s Avg: 1 Min: 0 Max: 276 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180592 in 00:00:30 = 6019.7/s Avg: 2 Min: 0 Max: 158 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 995751 in 00:02:46 = 6004.7/s Avg: 1 Min: 0 Max: 276 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180634 in 00:00:30 = 6020.5/s Avg: 2 Min: 0 Max: 135 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 1176385 in 00:03:16 = 6007.1/s Avg: 1 Min: 0 Max: 276 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180402 in 00:00:30 = 6014.0/s Avg: 1 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 1356787 in 00:03:46 = 6008.1/s Avg: 1 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180612 in 00:00:30 = 6020.4/s Avg: 1 Min: 0 Max: 158 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 1537399 in 00:04:16 = 6009.5/s Avg: 1 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180751 in 00:00:30 = 6025.0/s Avg: 1 Min: 0 Max: 83 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 1718150 in 00:04:46 = 6011.1/s Avg: 1 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180444 in 00:00:30 = 6014.8/s Avg: 2 Min: 0 Max: 179 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 1898594 in 00:05:16 = 6011.5/s Avg: 1 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180804 in 00:00:30 = 6026.6/s Avg: 2 Min: 0 Max: 78 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 2079398 in 00:05:46 = 6012.8/s Avg: 2 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180557 in 00:00:30 = 6018.8/s Avg: 3 Min: 0 Max: 180 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 2259955 in 00:06:16 = 6013.3/s Avg: 2 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180814 in 00:00:30 = 6027.1/s Avg: 2 Min: 0 Max: 129 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 2440769 in 00:06:46 = 6014.3/s Avg: 2 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180586 in 00:00:30 = 6019.5/s Avg: 1 Min: 0 Max: 145 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 2621355 in 00:07:16 = 6014.7/s Avg: 2 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180757 in 00:00:30 = 6025.2/s Avg: 1 Min: 0 Max: 1006 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 2802112 in 00:07:46 = 6015.3/s Avg: 2 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 500 Started: 500 Finished: 0
summary + 180458 in 00:00:30 = 6015.3/s Avg: 2 Min: 0 Max: 129 Err: 0 (0.00%) Active: 441 Started: 500 Finished: 59
summary + 2982570 in 00:08:16 = 6015.3/s Avg: 2 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 0 Started: 500 Finished: 500
summary + 17430 in 00:00:03 = 5985.6/s Avg: 2 Min: 0 Max: 68 Err: 0 (0.00%) Active: 0 Started: 500 Finished: 500
summary + 3000000 in 00:08:19 = 6015.2/s Avg: 2 Min: 0 Max: 1036 Err: 0 (0.00%) Active: 0 Started: 500 Finished: 500
Tidying up ... @ Sun Jun 10 10:33:02 UTC 2018 (1528626782912)
```

可以看出共发送了 3,000,000 笔交易, 耗时 00:08:19, 即 499 秒, 则交易发送速率为 6012 笔/s

六、 出块情况

```
2018/06/10 09:48:00.512713 [WARN] GID 43344, vbft actor receives block complete event. block height=1, numtx=4321
2018/06/10 09:48:02.919650 [WARN] GID 109784, vbft actor receives block complete event. block height=2, numtx=9703
2018/06/10 09:48:05.878377 [WARN] GID 150061, vbft actor receives block complete event. block height=3, numtx=14400
2018/06/10 09:48:08.561392 [WARN] GID 225028, vbft actor receives block complete event. block height=4, numtx=10055
2018/06/10 09:48:11.650838 [WARN] GID 304143, vbft actor receives block complete event. block height=5, numtx=14861
2018/06/10 09:48:15.181540 [WARN] GID 399472, vbft actor receives block complete event. block height=6, numtx=18831
2018/06/10 09:48:19.496678 [WARN] GID 511089, vbft actor receives block complete event. block height=7, numtx=22257
2018/06/10 09:48:24.159543 [WARN] GID 636995, vbft actor receives block complete event. block height=8, numtx=25690
2018/06/10 09:48:29.402181 [WARN] GID 770020, vbft actor receives block complete event. block height=9, numtx=27259
2018/06/10 09:48:34.776556 [WARN] GID 899697, vbft actor receives block complete event. block height=10, numtx=30891
2018/06/10 09:48:41.792609 [WARN] GID 1095607, vbft actor receives block complete event. block height=11, numtx=36593
2018/06/10 09:48:48.669747 [WARN] GID 1269533, vbft actor receives block complete event. block height=12, numtx=39768
2018/06/10 09:48:55.648056 [WARN] GID 1452600, vbft actor receives block complete event. block height=13, numtx=41161
2018/06/10 09:49:03.385120 [WARN] GID 1646169, vbft actor receives block complete event. block height=14, numtx=43718
2018/06/10 09:49:11.259886 [WARN] GID 1857685, vbft actor receives block complete event. block height=15, numtx=45621
2018/06/10 09:49:19.149051 [WARN] GID 2056367, vbft actor receives block complete event. block height=16, numtx=47084
2018/06/10 09:49:27.513761 [WARN] GID 2275678, vbft actor receives block complete event. block height=17, numtx=48656
2018/06/10 09:49:35.913447 [WARN] GID 2495451, vbft actor receives block complete event. block height=18, numtx=48778
2018/06/10 09:49:44.081030 [WARN] GID 2691866, vbft actor receives block complete event. block height=19, numtx=49299
2018/06/10 09:49:55.011252 [WARN] GID 2976875, vbft actor receives block complete event. block height=20, numtx=57902
2018/06/10 09:50:05.457429 [WARN] GID 3248776, vbft actor receives block complete event. block height=21, numtx=60794
2018/06/10 09:50:15.224281 [WARN] GID 3485640, vbft actor receives block complete event. block height=22, numtx=59927
2018/06/10 09:50:25.062192 [WARN] GID 3736184, vbft actor receives block complete event. block height=23, numtx=47937
2018/06/10 09:50:37.128825 [WARN] GID 4052950, vbft actor receives block complete event. block height=24, numtx=70027
2018/06/10 09:50:48.095621 [WARN] GID 4329024, vbft actor receives block complete event. block height=25, numtx=70968
2018/06/10 09:50:59.846264 [WARN] GID 4632254, vbft actor receives block complete event. block height=26, numtx=69064
2018/06/10 09:51:11.660534 [WARN] GID 4932480, vbft actor receives block complete event. block height=27, numtx=71635
2018/06/10 09:51:23.479395 [WARN] GID 5235912, vbft actor receives block complete event. block height=28, numtx=71611
2018/06/10 09:51:34.856738 [WARN] GID 5508747, vbft actor receives block complete event. block height=29, numtx=67764
2018/06/10 09:51:47.755924 [WARN] GID 5844259, vbft actor receives block complete event. block height=30, numtx=71317
```

```

2018/06/10 09:51:59.308871 [WARN ] GID 6120604, vbft actor receives block complete event. block height=31, numtx=74741
2018/06/10 09:52:11.033717 [WARN ] GID 6426049, vbft actor receives block complete event. block height=32, numtx=70801
2018/06/10 09:52:23.792137 [WARN ] GID 6765435, vbft actor receives block complete event. block height=33, numtx=74519
2018/06/10 09:52:37.010993 [WARN ] GID 7098719, vbft actor receives block complete event. block height=34, numtx=74024
2018/06/10 09:52:49.369623 [WARN ] GID 7396878, vbft actor receives block complete event. block height=35, numtx=76979
2018/06/10 09:53:01.611356 [WARN ] GID 7672814, vbft actor receives block complete event. block height=36, numtx=76575
2018/06/10 09:53:13.447058 [WARN ] GID 7955340, vbft actor receives block complete event. block height=37, numtx=72900
2018/06/10 09:53:25.270380 [WARN ] GID 8245756, vbft actor receives block complete event. block height=38, numtx=72780
2018/06/10 09:53:38.296914 [WARN ] GID 8547373, vbft actor receives block complete event. block height=39, numtx=70501
2018/06/10 09:53:50.646294 [WARN ] GID 8845695, vbft actor receives block complete event. block height=40, numtx=78254
2018/06/10 09:54:03.159994 [WARN ] GID 9130191, vbft actor receives block complete event. block height=41, numtx=74702
2018/06/10 09:54:16.236645 [WARN ] GID 9438359, vbft actor receives block complete event. block height=42, numtx=74272
2018/06/10 09:54:28.440134 [WARN ] GID 9723988, vbft actor receives block complete event. block height=43, numtx=77254
2018/06/10 09:54:41.397108 [WARN ] GID 10026794, vbft actor receives block complete event. block height=44, numtx=77337
2018/06/10 09:54:54.840603 [WARN ] GID 10326973, vbft actor receives block complete event. block height=45, numtx=76698
2018/06/10 09:55:07.474155 [WARN ] GID 10618583, vbft actor receives block complete event. block height=46, numtx=75070
2018/06/10 09:55:22.057667 [WARN ] GID 10948235, vbft actor receives block complete event. block height=47, numtx=84266
2018/06/10 09:55:38.707830 [WARN ] GID 11324325, vbft actor receives block complete event. block height=48, numtx=87832
2018/06/10 09:55:52.576422 [WARN ] GID 11625595, vbft actor receives block complete event. block height=49, numtx=90065
2018/06/10 09:56:08.419038 [WARN ] GID 11997292, vbft actor receives block complete event. block height=50, numtx=91352
2018/06/10 09:56:22.970390 [WARN ] GID 12212115, vbft actor receives block complete event. block height=51, numtx=94231
2018/06/10 09:56:33.085948 [WARN ] GID 12246749, vbft actor receives block complete event. block height=52, numtx=56955
2018/06/10 09:57:16.467531 [WARN ] GID 12267613, vbft actor receives block complete event. block height=53, numtx=0

```

七、 测试结果

按照上文所述步骤，进行十次测试，取十次结果的平均值，最终结果如下：

交易数	发送速率	发送时间	落账成功率	块数	处理时间	TPS	峰值
300 万	6000/s	500s	99.1%	40	562s	5341	5536

注 1：TPS = 成功交易数 / (完成落账时间 - 开始发送交易时间)

注 2：峰值即是系统稳定运行所能达到的最大 TPS，算法为取落账过程中中间时段的一到两分钟之内的落账笔数，除以落账时间算得。

八、 性能分析

目前用 7 个节点测试，TPS 达到了 5300 以上。

测试过程中，使用不同的发送速率，不同的交易量进行测试，测试结果 TPS 都达到了 5000 以上。最终的测试结果，也就是 VBFT 的峰值 TPS，超过了 5500，达到 5536 左右。

另外，本次测试发现如下问题：

1. 出块情况不稳定，多次测试过程中发现，块大小（包含的交易数）、出块间隔均不稳定；
2. 交易量、交易发送速度越高，测出的 TPS 越低，所以上述测试结果为一个平均值；
3. 观察 log 发现 “[ERROR]server 7 verify proposal blk from 1 failed, blk 23, txs 120000, err: duplicated transaction detected” 出现的较为频繁；