Exercise 3

Revert election timeout back to the default value. Set interval for sending heartbeats to a very big value, e.g. 3s. Run the source code, document commands, capture screenshots, explain

My works:

- Set election timeout to 150ms → 299ms (original):

```
// electionTimeout generates a pseudo-random election timeout duration.
func (cm *ConsensusModule) electionTimeout() time.Duration {
    // If RAFT_FORCE_MORE_REELECTION is set, stress-test by deliberately
    // generating a hard-coded number very often. This will create collisions
    // between different servers and force more re-elections.
    if len(os.Getenv("RAFT_FORCE_MORE_REELECTION")) > 0 && rand.Intn(3)
        return time.Duration(150) * time.Millisecond
    } else {
        return time.Duration(150+rand.Intn(150)) * time.Millisecond
    }
}
```

- Notice this method in **“raft.go”:**

```
// startLeader switches cm into a leader state and begins process of heartbe
// Expects cm.mu to be locked.
func (cm *ConsensusModule) startLeader() {
    cm.state = Leader
    cm.dlog("becomes Leader; term=%d, log=%v", cm.currentTerm, cm.log)

    go func() {
        ticker := time.NewTicker(50 * time.Millisecond)
        defer ticker.Stop()
```

```
        // Send periodic heartbeats, as long as still leader.
        for {
            cm.leaderSendHeartbeats()
            <-ticker.C

            cm.mu.Lock()
            if cm.state != Leader {
                cm.mu.Unlock()
                return
            }
            cm.mu.Unlock()
        }
    }()
}
```

- Modify to **3 seconds (3000 milliseconds)**

```
    ticker := time.NewTicker(3 * time.Second)
```

1. TestElectionBasic

- Terminal command for testcase:

```
go test -v -race -run TestElectionBasic |& tee ./log.txt
```

→ **Log**:

```
=== RUN   TestElectionBasic
10:48:57.359176 [0] listening at [::]:51385
10:48:57.359486 [1] listening at [::]:51386
10:48:57.359638 [2] listening at [::]:51387
10:48:57.362335 [0] election timer started (293ms), term=0
10:48:57.362312 [1] election timer started (154ms), term=0
```

```
10:48:57.362335 [2] election timer started (150ms), term=0
10:48:57.513324 [2] becomes Candidate (currentTerm=1); log=[]
10:48:57.513577 [2] sending RequestVote to 1: {Term:1 CandidateId:2 LastLogInd
10:48:57.513651 [2] election timer started (155ms), term=1
10:48:57.513567 [2] sending RequestVote to 0: {Term:1 CandidateId:2 LastLogInd
10:48:57.517880 [1] RequestVote: {Term:1 CandidateId:2 LastLogIndex:0 LastLogT
10:48:57.517968 [1] ... term out of date in RequestVote
10:48:57.517998 [1] becomes Follower with term=1; log=[]
10:48:57.518052 [1] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:48:57.518220 [1] election timer started (267ms), term=1
10:48:57.519117 [2] received RequestVoteReply {Term:1 VoteGranted:true}
10:48:57.519164 [2] wins election with 2 votes
10:48:57.519207 [2] becomes Leader; term=1, log=[]
10:48:57.519350 [2] sending AppendEntries to 1: ni=0, args={Term:1 LeaderId:2 P
10:48:57.519357 [2] sending AppendEntries to 0: ni=0, args={Term:1 LeaderId:2 P
10:48:57.521853 [0] RequestVote: {Term:1 CandidateId:2 LastLogIndex:0 LastLog
10:48:57.521930 [0] ... term out of date in RequestVote
10:48:57.521950 [0] becomes Follower with term=1; log=[]
10:48:57.521987 [0] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:48:57.522079 [0] election timer started (262ms), term=1
10:48:57.522677 [2] received RequestVoteReply {Term:1 VoteGranted:true}
10:48:57.522697 [1] in election timer term changed from 0 to 1, bailing out
10:48:57.522725 [2] while waiting for reply, state = Leader
10:48:57.522684 [0] in election timer term changed from 0 to 1, bailing out
10:48:57.524062 [2] in election timer state=Leader, bailing out
10:48:57.524739 [0] AppendEntries: {Term:1 LeaderId:2 PrevLogIndex:0 PrevLog
10:48:57.524868 [0] AppendEntries reply: {Term:1 Success:true}
10:48:57.525627 [1] AppendEntries: {Term:1 LeaderId:2 PrevLogIndex:0 PrevLogT
10:48:57.525734 [1] AppendEntries reply: {Term:1 Success:true}
10:48:57.664826 [0] becomes Dead
10:48:57.664973 [1] becomes Dead
10:48:57.665058 [2] becomes Dead
--- PASS: TestElectionBasic (0.31s)
PASS
10:48:57.668455 [1] in election timer state=Dead, bailing out
```

```
10:48:57.672642 [0] in election timer state=Dead, bailing out
ok    github.com/eliben/raft   1.743s
```

- Terminal command for HTML visualization:

```
Get-Content ./log.txt | go run ../tools/raft-testlog-viz/main.go
```

→ **Result:** **PASS**

```
PASS TestElectionBasic map[0:true 1:true 2:true] ; entries: 39
... Emitted file:///tmp/TestElectionBasic.html

PASS
```

2. TestElectionLeaderDisconnect + TestElectionLeaderDisconnectThenReconnect + TestElectionLeaderDisconnectThenReconnect5

- Terminal command for testcase:

```
go test -v -race -run TestElectionLeaderDisconnect |& tee ./log.txt
```

→ **Log**:

```
=== RUN   TestElectionLeaderDisconnect
10:51:29.054160 [0] listening at [::]:51693
10:51:29.054463 [1] listening at [::]:51694
10:51:29.054660 [2] listening at [::]:51695
10:51:29.056949 [2] election timer started (170ms), term=0
10:51:29.056971 [0] election timer started (166ms), term=0
10:51:29.056986 [1] election timer started (167ms), term=0
10:51:29.228351 [0] becomes Candidate (currentTerm=1); log=[]
```

```
10:51:29.228351 [1] becomes Candidate (currentTerm=1); log=[]
10:51:29.228350 [2] becomes Candidate (currentTerm=1); log=[]
10:51:29.228593 [0] sending RequestVote to 1: {Term:1 CandidateId:0 LastLogInd
10:51:29.228801 [2] election timer started (249ms), term=1
10:51:29.228894 [2] sending RequestVote to 0: {Term:1 CandidateId:2 LastLogInd
10:51:29.228622 [0] election timer started (218ms), term=1
10:51:29.228920 [2] sending RequestVote to 1: {Term:1 CandidateId:2 LastLogInd
10:51:29.228615 [1] sending RequestVote to 2: {Term:1 CandidateId:1 LastLogInde
10:51:29.229228 [1] election timer started (246ms), term=1
10:51:29.228766 [0] sending RequestVote to 2: {Term:1 CandidateId:0 LastLogInd
10:51:29.229373 [1] sending RequestVote to 0: {Term:1 CandidateId:1 LastLogInde
10:51:29.233259 [1] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLog
10:51:29.233334 [1] ... RequestVote reply: &{Term:1 VoteGranted:false}
10:51:29.233542 [2] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLog
10:51:29.233624 [2] ... RequestVote reply: &{Term:1 VoteGranted:false}
10:51:29.234201 [2] RequestVote: {Term:1 CandidateId:1 LastLogIndex:0 LastLog
10:51:29.234288 [2] ... RequestVote reply: &{Term:1 VoteGranted:false}
10:51:29.234347 [0] received RequestVoteReply {Term:1 VoteGranted:false}
10:51:29.234390 [0] received RequestVoteReply {Term:1 VoteGranted:false}
10:51:29.234841 [1] received RequestVoteReply {Term:1 VoteGranted:false}
10:51:29.235734 [1] RequestVote: {Term:1 CandidateId:2 LastLogIndex:0 LastLog
10:51:29.235794 [1] ... RequestVote reply: &{Term:1 VoteGranted:false}
10:51:29.236609 [2] received RequestVoteReply {Term:1 VoteGranted:false}
10:51:29.236640 [0] RequestVote: {Term:1 CandidateId:1 LastLogIndex:0 LastLog
10:51:29.236722 [0] ... RequestVote reply: &{Term:1 VoteGranted:false}
10:51:29.237237 [0] RequestVote: {Term:1 CandidateId:2 LastLogIndex:0 LastLog
10:51:29.237316 [0] ... RequestVote reply: &{Term:1 VoteGranted:false}
10:51:29.237721 [1] received RequestVoteReply {Term:1 VoteGranted:false}
10:51:29.238072 [2] received RequestVoteReply {Term:1 VoteGranted:false}
10:51:29.449991 [0] becomes Candidate (currentTerm=2); log=[]
10:51:29.450246 [0] sending RequestVote to 1: {Term:2 CandidateId:0 LastLogInd
10:51:29.450257 [0] sending RequestVote to 2: {Term:2 CandidateId:0 LastLogIn
10:51:29.450311 [0] election timer started (289ms), term=2
10:51:29.454499 [1] RequestVote: {Term:2 CandidateId:0 LastLogIndex:0 LastLog
10:51:29.454623 [1] ... term out of date in RequestVote
10:51:29.454674 [1] becomes Follower with term=2; log=[]
```

```
10:51:29.454762 [1] ... RequestVote reply: &{Term:2 VoteGranted:true}
10:51:29.455117 [2] RequestVote: {Term:2 CandidateId:0 LastLogIndex:0 LastLog
10:51:29.455217 [2] ... term out of date in RequestVote
10:51:29.455264 [2] becomes Follower with term=2; log=[]
10:51:29.455327 [1] election timer started (183ms), term=2
10:51:29.455314 [2] ... RequestVote reply: &{Term:2 VoteGranted:true}
10:51:29.455521 [2] election timer started (276ms), term=2
10:51:29.455578 [0] received RequestVoteReply {Term:2 VoteGranted:true}
10:51:29.455675 [0] wins election with 2 votes
10:51:29.455714 [0] becomes Leader; term=2, log=[]
10:51:29.455805 [0] received RequestVoteReply {Term:2 VoteGranted:true}
10:51:29.455883 [0] while waiting for reply, state = Leader
10:51:29.456017 [0] sending AppendEntries to 1: ni=0, args={Term:2 LeaderId:0 P
10:51:29.455999 [0] sending AppendEntries to 2: ni=0, args={Term:2 LeaderId:0
10:51:29.459128 [2] in election timer term changed from 1 to 2, bailing out
10:51:29.459392 [1] in election timer term changed from 1 to 2, bailing out
10:51:29.459882 [1] AppendEntries: {Term:2 LeaderId:0 PrevLogIndex:0 PrevLog
10:51:29.460018 [1] AppendEntries reply: {Term:2 Success:true}
10:51:29.460634 [0] in election timer state=Leader, bailing out
10:51:29.463028 [2] AppendEntries: {Term:2 LeaderId:0 PrevLogIndex:0 PrevLog
10:51:29.463159 [2] AppendEntries reply: {Term:2 Success:true}
10:51:29.508198 [TEST] Disconnect 0
10:51:29.646542 [1] becomes Candidate (currentTerm=3); log=[]
10:51:29.646789 [1] sending RequestVote to 0: {Term:3 CandidateId:1 LastLogInd
10:51:29.646782 [1] sending RequestVote to 2: {Term:3 CandidateId:1 LastLogInd
10:51:29.646900 [1] election timer started (283ms), term=3
10:51:29.648606 [2] RequestVote: {Term:3 CandidateId:1 LastLogIndex:0 LastLog
10:51:29.648699 [2] ... term out of date in RequestVote
10:51:29.648732 [2] becomes Follower with term=3; log=[]
10:51:29.648780 [2] ... RequestVote reply: &{Term:3 VoteGranted:true}
10:51:29.648951 [2] election timer started (273ms), term=3
10:51:29.649212 [1] received RequestVoteReply {Term:3 VoteGranted:true}
10:51:29.649281 [1] wins election with 2 votes
10:51:29.649308 [1] becomes Leader; term=3, log=[]
10:51:29.649458 [1] sending AppendEntries to 2: ni=0, args={Term:3 LeaderId:1 P
10:51:29.649444 [1] sending AppendEntries to 0: ni=0, args={Term:3 LeaderId:1 P
```

```
10:51:29.652822 [2] AppendEntries: {Term:3 LeaderId:1 PrevLogIndex:0 PrevLog
10:51:29.652908 [2] AppendEntries reply: {Term:3 Success:true}
10:51:29.655983 [2] in election timer term changed from 2 to 3, bailing out
10:51:29.657159 [1] in election timer state=Leader, bailing out
10:51:29.859136 [0] becomes Dead
10:51:29.859289 [1] becomes Dead
10:51:29.859430 [2] becomes Dead
--- PASS: TestElectionLeaderDisconnect (0.81s)
=== RUN   TestElectionLeaderDisconnectThenReconnect
10:51:29.860647 [0] listening at [::]:51702
10:51:29.860899 [1] listening at [::]:51703
10:51:29.861073 [2] listening at [::]:51704
10:51:29.863675 [2] election timer started (261ms), term=0
10:51:29.863710 [0] election timer started (229ms), term=0
10:51:29.863690 [1] election timer started (222ms), term=0
10:51:29.869766 [2] in election timer state=Dead, bailing out
10:51:30.094201 [0] becomes Candidate (currentTerm=1); log=[]
10:51:30.094205 [1] becomes Candidate (currentTerm=1); log=[]
10:51:30.094444 [0] election timer started (215ms), term=1
10:51:30.094432 [1] sending RequestVote to 2: {Term:1 CandidateId:1 LastLogInd
10:51:30.094449 [1] sending RequestVote to 0: {Term:1 CandidateId:1 LastLogInd
10:51:30.094546 [0] sending RequestVote to 1: {Term:1 CandidateId:0 LastLogInd
10:51:30.094966 [1] election timer started (270ms), term=1
10:51:30.094988 [0] sending RequestVote to 2: {Term:1 CandidateId:0 LastLogInd
10:51:30.097346 [2] RequestVote: {Term:1 CandidateId:1 LastLogIndex:0 LastLog
10:51:30.097411 [2] ... term out of date in RequestVote
10:51:30.097432 [2] becomes Follower with term=1; log=[]
10:51:30.097478 [2] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:51:30.097578 [2] election timer started (158ms), term=1
10:51:30.098165 [1] received RequestVoteReply {Term:1 VoteGranted:true}
10:51:30.098202 [1] wins election with 2 votes
10:51:30.098228 [1] becomes Leader; term=1, log=[]
10:51:30.098315 [1] sending AppendEntries to 2: ni=0, args={Term:1 LeaderId:1 P
10:51:30.098313 [1] sending AppendEntries to 0: ni=0, args={Term:1 LeaderId:1 P
10:51:30.099025 [2] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLog
10:51:30.099096 [2] ... RequestVote reply: &{Term:1 VoteGranted:false}
```

```
10:51:30.099760 [0] received RequestVoteReply {Term:1 VoteGranted:false}
10:51:30.100218 [0] RequestVote: {Term:1 CandidateId:1 LastLogIndex:0 LastLogT
10:51:30.100267 [0] ... RequestVote reply: &{Term:1 VoteGranted:false}
10:51:30.100371 [1] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLogT
10:51:30.100416 [1] ... RequestVote reply: &{Term:1 VoteGranted:false}
10:51:30.101056 [1] received RequestVoteReply {Term:1 VoteGranted:false}
10:51:30.101061 [0] received RequestVoteReply {Term:1 VoteGranted:false}
10:51:30.101101 [1] while waiting for reply, state = Leader
10:51:30.101082 [2] AppendEntries: {Term:1 LeaderId:1 PrevLogIndex:0 PrevLogT
10:51:30.101183 [2] AppendEntries reply: {Term:1 Success:true}
10:51:30.103262 [0] AppendEntries: {Term:1 LeaderId:1 PrevLogIndex:0 PrevLogT
10:51:30.103386 [0] becomes Follower with term=1; log=[]
10:51:30.103472 [0] AppendEntries reply: {Term:1 Success:true}
10:51:30.103849 [0] election timer started (180ms), term=1
10:51:30.104383 [2] in election timer term changed from 0 to 1, bailing out
10:51:30.105157 [1] in election timer state=Leader, bailing out
10:51:30.164756 [TEST] Disconnect 1
10:51:30.267777 [2] becomes Candidate (currentTerm=2); log=[]
10:51:30.267943 [2] sending RequestVote to 1: {Term:2 CandidateId:2 LastLogInd
10:51:30.268079 [2] sending RequestVote to 0: {Term:2 CandidateId:2 LastLogIn
10:51:30.268135 [2] election timer started (257ms), term=2
10:51:30.271560 [0] RequestVote: {Term:2 CandidateId:2 LastLogIndex:0 LastLog
10:51:30.271672 [0] ... term out of date in RequestVote
10:51:30.271695 [0] becomes Follower with term=2; log=[]
10:51:30.271735 [0] ... RequestVote reply: &{Term:2 VoteGranted:true}
10:51:30.272206 [0] election timer started (297ms), term=2
10:51:30.272755 [2] received RequestVoteReply {Term:2 VoteGranted:true}
10:51:30.272798 [2] wins election with 2 votes
10:51:30.272826 [2] becomes Leader; term=2, log=[]
10:51:30.272910 [2] sending AppendEntries to 1: ni=0, args={Term:2 LeaderId:2 P
10:51:30.272915 [2] sending AppendEntries to 0: ni=0, args={Term:2 LeaderId:2
10:51:30.274022 [0] in election timer term changed from 1 to 2, bailing out
10:51:30.274636 [0] in election timer term changed from 1 to 2, bailing out
10:51:30.274674 [0] AppendEntries: {Term:2 LeaderId:2 PrevLogIndex:0 PrevLog
10:51:30.274757 [0] AppendEntries reply: {Term:2 Success:true}
10:51:30.278427 [2] in election timer state=Leader, bailing out
```

```
10:51:30.515489 [TEST] Reconnect 1
10:51:30.572678 [0] becomes Candidate (currentTerm=3); log=[]
10:51:30.572933 [0] sending RequestVote to 2: {Term:3 CandidateId:0 LastLogIn
10:51:30.573031 [0] election timer started (158ms), term=3
10:51:30.572939 [0] sending RequestVote to 1: {Term:3 CandidateId:0 LastLogIn
10:51:30.576539 [1] RequestVote: {Term:3 CandidateId:0 LastLogIndex:0 LastLog
10:51:30.576636 [1] ... term out of date in RequestVote
10:51:30.576679 [1] becomes Follower with term=3; log=[]
10:51:30.576635 [2] RequestVote: {Term:3 CandidateId:0 LastLogIndex:0 LastLog
10:51:30.576762 [2] ... term out of date in RequestVote
10:51:30.576803 [2] becomes Follower with term=3; log=[]
10:51:30.576740 [1] ... RequestVote reply: &{Term:3 VoteGranted:true}
10:51:30.576850 [2] ... RequestVote reply: &{Term:3 VoteGranted:true}
10:51:30.577002 [1] election timer started (277ms), term=3
10:51:30.577156 [2] election timer started (194ms), term=3
10:51:30.577378 [0] received RequestVoteReply {Term:3 VoteGranted:true}
10:51:30.577439 [0] wins election with 2 votes
10:51:30.577484 [0] becomes Leader; term=3, log=[]
10:51:30.577671 [0] sending AppendEntries to 1: ni=0, args={Term:3 LeaderId:0 P
10:51:30.577716 [0] sending AppendEntries to 2: ni=0, args={Term:3 LeaderId:0
10:51:30.578042 [0] received RequestVoteReply {Term:3 VoteGranted:true}
10:51:30.578103 [0] while waiting for reply, state = Leader
10:51:30.581074 [1] AppendEntries: {Term:3 LeaderId:0 PrevLogIndex:0 PrevLogT
10:51:30.581203 [1] AppendEntries reply: {Term:3 Success:true}
10:51:30.581813 [2] AppendEntries: {Term:3 LeaderId:0 PrevLogIndex:0 PrevLogT
10:51:30.581937 [2] AppendEntries reply: {Term:3 Success:true}
10:51:30.583245 [0] in election timer state=Leader, bailing out
    raft_test.go:91: again leader id got 0; want 2
    raft_test.go:94: again term got 3; want 2
10:51:30.669275 [0] becomes Dead
10:51:30.669403 [1] becomes Dead
10:51:30.669481 [2] becomes Dead
--- FAIL: TestElectionLeaderDisconnectThenReconnect (0.81s)
=== RUN   TestElectionLeaderDisconnectThenReconnect5
10:51:30.672929 [0] listening at [::]:51717
10:51:30.673153 [1] listening at [::]:51718
```

```
10:51:30.673283 [2] listening at [::]:51719
10:51:30.673425 [3] listening at [::]:51720
10:51:30.673556 [4] listening at [::]:51721
10:51:30.677189 [1] in election timer state=Dead, bailing out
10:51:30.677276 [2] in election timer state=Dead, bailing out
10:51:30.679511 [0] election timer started (170ms), term=0
10:51:30.679518 [3] election timer started (184ms), term=0
10:51:30.679528 [2] election timer started (258ms), term=0
10:51:30.679537 [1] election timer started (172ms), term=0
10:51:30.679583 [4] election timer started (193ms), term=0
10:51:30.850696 [0] becomes Candidate (currentTerm=1); log=[]
10:51:30.850827 [0] sending RequestVote to 1: {Term:1 CandidateId:0 LastLogInd
10:51:30.850868 [0] sending RequestVote to 2: {Term:1 CandidateId:0 LastLogIn
10:51:30.850891 [0] sending RequestVote to 3: {Term:1 CandidateId:0 LastLogIn
10:51:30.850944 [0] election timer started (232ms), term=1
10:51:30.850873 [0] sending RequestVote to 4: {Term:1 CandidateId:0 LastLogIn
10:51:30.854134 [3] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLog
10:51:30.854194 [3] ... term out of date in RequestVote
10:51:30.854218 [3] becomes Follower with term=1; log=[]
10:51:30.854253 [3] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:51:30.854370 [3] election timer started (270ms), term=1
10:51:30.854976 [0] received RequestVoteReply {Term:1 VoteGranted:true}
10:51:30.854967 [4] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLog
10:51:30.855028 [4] ... term out of date in RequestVote
10:51:30.855048 [4] becomes Follower with term=1; log=[]
10:51:30.855081 [4] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:51:30.855182 [4] election timer started (269ms), term=1
10:51:30.855721 [0] received RequestVoteReply {Term:1 VoteGranted:true}
10:51:30.855756 [0] wins election with 3 votes
10:51:30.855786 [0] becomes Leader; term=1, log=[]
10:51:30.855841 [1] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLogT
10:51:30.855897 [1] ... term out of date in RequestVote
10:51:30.855919 [1] becomes Follower with term=1; log=[]
10:51:30.855884 [0] sending AppendEntries to 2: ni=0, args={Term:1 LeaderId:0
10:51:30.855951 [1] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:51:30.855980 [0] sending AppendEntries to 4: ni=0, args={Term:1 LeaderId:0
```

```
10:51:30.856017 [0] sending AppendEntries to 3: ni=0, args={Term:1 LeaderId:0 P
10:51:30.855882 [0] sending AppendEntries to 1: ni=0, args={Term:1 LeaderId:0 P
10:51:30.856200 [2] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLog
10:51:30.856248 [2] ... term out of date in RequestVote
10:51:30.856271 [2] becomes Follower with term=1; log=[]
10:51:30.856304 [2] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:51:30.856535 [1] election timer started (156ms), term=1
10:51:30.856591 [2] election timer started (181ms), term=1
10:51:30.856676 [0] received RequestVoteReply {Term:1 VoteGranted:true}
10:51:30.856706 [0] while waiting for reply, state = Leader
10:51:30.857140 [0] received RequestVoteReply {Term:1 VoteGranted:true}
10:51:30.857183 [0] while waiting for reply, state = Leader
10:51:30.860912 [1] in election timer term changed from 0 to 1, bailing out
10:51:30.860953 [4] in election timer term changed from 0 to 1, bailing out
10:51:30.861017 [3] in election timer term changed from 0 to 1, bailing out
10:51:30.860995 [1] AppendEntries: {Term:1 LeaderId:0 PrevLogIndex:0 PrevLogT
10:51:30.861099 [1] AppendEntries reply: {Term:1 Success:true}
10:51:30.861138 [2] in election timer term changed from 0 to 1, bailing out
10:51:30.861101 [3] AppendEntries: {Term:1 LeaderId:0 PrevLogIndex:0 PrevLogT
10:51:30.861219 [3] AppendEntries reply: {Term:1 Success:true}
10:51:30.861425 [0] in election timer state=Leader, bailing out
10:51:30.861634 [2] AppendEntries: {Term:1 LeaderId:0 PrevLogIndex:0 PrevLogT
10:51:30.861744 [2] AppendEntries reply: {Term:1 Success:true}
10:51:30.861992 [4] AppendEntries: {Term:1 LeaderId:0 PrevLogIndex:0 PrevLogT
10:51:30.862077 [4] AppendEntries reply: {Term:1 Success:true}
10:51:30.981235 [TEST] Disconnect 0
10:51:31.026820 [1] becomes Candidate (currentTerm=2); log=[]
10:51:31.026982 [1] sending RequestVote to 2: {Term:2 CandidateId:1 LastLogInd
10:51:31.027049 [1] sending RequestVote to 0: {Term:2 CandidateId:1 LastLogInd
10:51:31.027122 [1] election timer started (216ms), term=2
10:51:31.027007 [1] sending RequestVote to 3: {Term:2 CandidateId:1 LastLogInde
10:51:31.027002 [1] sending RequestVote to 4: {Term:2 CandidateId:1 LastLogInd
10:51:31.031698 [2] RequestVote: {Term:2 CandidateId:1 LastLogIndex:0 LastLogT
10:51:31.031801 [2] ... term out of date in RequestVote
10:51:31.031845 [2] becomes Follower with term=2; log=[]
10:51:31.031909 [2] ... RequestVote reply: &{Term:2 VoteGranted:true}
```

```
10:51:31.032068 [2] election timer started (277ms), term=2
10:51:31.032372 [4] RequestVote: {Term:2 CandidateId:1 LastLogIndex:0 LastLog
10:51:31.032388 [3] RequestVote: {Term:2 CandidateId:1 LastLogIndex:0 LastLog
10:51:31.032445 [4] ... term out of date in RequestVote
10:51:31.032552 [4] becomes Follower with term=2; log=[]
10:51:31.032490 [3] ... term out of date in RequestVote
10:51:31.032638 [3] becomes Follower with term=2; log=[]
10:51:31.032625 [4] ... RequestVote reply: &{Term:2 VoteGranted:true}
10:51:31.032696 [3] ... RequestVote reply: &{Term:2 VoteGranted:true}
10:51:31.032949 [1] received RequestVoteReply {Term:2 VoteGranted:true}
10:51:31.032955 [4] election timer started (204ms), term=2
10:51:31.033104 [3] election timer started (176ms), term=2
10:51:31.033715 [1] received RequestVoteReply {Term:2 VoteGranted:true}
10:51:31.033775 [1] wins election with 3 votes
10:51:31.033813 [1] becomes Leader; term=2, log=[]
10:51:31.033874 [1] received RequestVoteReply {Term:2 VoteGranted:true}
10:51:31.033932 [1] while waiting for reply, state = Leader
10:51:31.034042 [1] sending AppendEntries to 2: ni=0, args={Term:2 LeaderId:1 P
10:51:31.034041 [1] sending AppendEntries to 0: ni=0, args={Term:2 LeaderId:1 P
10:51:31.034066 [1] sending AppendEntries to 3: ni=0, args={Term:2 LeaderId:1 P
10:51:31.034179 [1] sending AppendEntries to 4: ni=0, args={Term:2 LeaderId:1 P
10:51:31.034544 [3] in election timer term changed from 1 to 2, bailing out
10:51:31.035330 [4] in election timer term changed from 1 to 2, bailing out
10:51:31.036194 [3] AppendEntries: {Term:2 LeaderId:1 PrevLogIndex:0 PrevLogT
10:51:31.036292 [3] AppendEntries reply: {Term:2 Success:true}
10:51:31.036694 [2] in election timer term changed from 1 to 2, bailing out
10:51:31.037191 [4] AppendEntries: {Term:2 LeaderId:1 PrevLogIndex:0 PrevLogT
10:51:31.037251 [1] in election timer state=Leader, bailing out
10:51:31.037279 [4] AppendEntries reply: {Term:2 Success:true}
10:51:31.039244 [2] AppendEntries: {Term:2 LeaderId:1 PrevLogIndex:0 PrevLogT
10:51:31.039357 [2] AppendEntries reply: {Term:2 Success:true}
10:51:31.133259 [TEST] Reconnect 0
10:51:31.213299 [3] becomes Candidate (currentTerm=3); log=[]
10:51:31.213518 [3] sending RequestVote to 0: {Term:3 CandidateId:3 LastLogInd
10:51:31.213604 [3] sending RequestVote to 4: {Term:3 CandidateId:3 LastLogInd
10:51:31.213656 [3] sending RequestVote to 2: {Term:3 CandidateId:3 LastLogInd
```

```
10:51:31.213571 [3] election timer started (235ms), term=3
10:51:31.213532 [3] sending RequestVote to 1: {Term:3 CandidateId:3 LastLogInd
10:51:31.218447 [4] RequestVote: {Term:3 CandidateId:3 LastLogIndex:0 LastLog
10:51:31.218482 [0] RequestVote: {Term:3 CandidateId:3 LastLogIndex:0 LastLog
10:51:31.218523 [4] ... term out of date in RequestVote
10:51:31.218543 [0] ... term out of date in RequestVote
10:51:31.218556 [4] becomes Follower with term=3; log=[]
10:51:31.218580 [0] becomes Follower with term=3; log=[]
10:51:31.218605 [4] ... RequestVote reply: &{Term:3 VoteGranted:true}
10:51:31.218619 [0] ... RequestVote reply: &{Term:3 VoteGranted:true}
10:51:31.218963 [4] election timer started (298ms), term=3
10:51:31.219107 [0] election timer started (180ms), term=3
10:51:31.219391 [2] RequestVote: {Term:3 CandidateId:3 LastLogIndex:0 LastLogT
10:51:31.219451 [2] ... term out of date in RequestVote
10:51:31.219463 [3] received RequestVoteReply {Term:3 VoteGranted:true}
10:51:31.219483 [2] becomes Follower with term=3; log=[]
10:51:31.219531 [1] RequestVote: {Term:3 CandidateId:3 LastLogIndex:0 LastLogT
10:51:31.219589 [1] ... term out of date in RequestVote
10:51:31.219616 [1] becomes Follower with term=3; log=[]
10:51:31.219655 [1] ... RequestVote reply: &{Term:3 VoteGranted:true}
10:51:31.219779 [3] received RequestVoteReply {Term:3 VoteGranted:true}
10:51:31.219825 [3] wins election with 3 votes
10:51:31.219853 [3] becomes Leader; term=3, log=[]
10:51:31.220003 [3] sending AppendEntries to 2: ni=0, args={Term:3 LeaderId:3
10:51:31.220062 [1] election timer started (172ms), term=3
10:51:31.220059 [3] sending AppendEntries to 1: ni=0, args={Term:3 LeaderId:3 L
10:51:31.220297 [3] sending AppendEntries to 0: ni=0, args={Term:3 LeaderId:3
10:51:31.220353 [3] sending AppendEntries to 4: ni=0, args={Term:3 LeaderId:3
10:51:31.219533 [2] ... RequestVote reply: &{Term:3 VoteGranted:true}
10:51:31.220798 [3] received RequestVoteReply {Term:3 VoteGranted:true}
10:51:31.220869 [3] while waiting for reply, state = Leader
10:51:31.220862 [2] election timer started (249ms), term=3
10:51:31.221274 [3] received RequestVoteReply {Term:3 VoteGranted:true}
10:51:31.221311 [3] while waiting for reply, state = Leader
10:51:31.222702 [2] in election timer term changed from 2 to 3, bailing out
10:51:31.223125 [4] in election timer term changed from 2 to 3, bailing out
```

```
10:51:31.224237 [3] in election timer state=Leader, bailing out
10:51:31.224178 [2] AppendEntries: {Term:3 LeaderId:3 PrevLogIndex:0 PrevLogT
10:51:31.224284 [2] AppendEntries reply: {Term:3 Success:true}
10:51:31.224627 [4] AppendEntries: {Term:3 LeaderId:3 PrevLogIndex:0 PrevLog
10:51:31.224729 [4] AppendEntries reply: {Term:3 Success:true}
10:51:31.226165 [1] AppendEntries: {Term:3 LeaderId:3 PrevLogIndex:0 PrevLogT
10:51:31.226335 [1] AppendEntries reply: {Term:3 Success:true}
10:51:31.226545 [0] AppendEntries: {Term:3 LeaderId:3 PrevLogIndex:0 PrevLog
10:51:31.226682 [0] AppendEntries reply: {Term:3 Success:true}
    raft_test.go:116: again leader id got 3; want 1
    raft_test.go:119: again term got 3; want 2
10:51:31.290085 [0] becomes Dead
10:51:31.290223 [1] becomes Dead
10:51:31.290312 [2] becomes Dead
10:51:31.290382 [3] becomes Dead
10:51:31.290450 [4] becomes Dead
10:51:31.291168 [2] in election timer state=Dead, bailing out
10:51:31.299684 [0] in election timer state=Dead, bailing out
10:51:31.299696 [4] in election timer state=Dead, bailing out
10:51:31.300222 [1] in election timer state=Dead, bailing out
    leaktest.go:132: leaktest: timed out checking goroutines
    leaktest.go:150: leaktest: leaked goroutine: goroutine 319 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 322 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 352 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
```

```
--- FAIL: TestElectionLeaderDisconnectThenReconnect5 (0.72s)
FAIL
exit status 1
FAIL github.com/eliben/raft   2.908s
```

- Terminal command for HTML visualization:

```
Get-Content ./log.txt | go run ../tools/raft-testlog-viz/main.go
```

→ **Result: 1 PASS, 2 FAIL**

```
PASS TestElectionLeaderDisconnect map[0:true 1:true 2:true TEST:true] ; entries
... Emitted file:///tmp/TestElectionLeaderDisconnect.html

FAIL TestElectionLeaderDisconnectThenReconnect map[0:true 1:true 2:true TEST
... Emitted file:///tmp/TestElectionLeaderDisconnectThenReconnect.html

FAIL TestElectionLeaderDisconnectThenReconnect5 map[0:true 1:true 2:true 3:tr
... Emitted file:///tmp/TestElectionLeaderDisconnectThenReconnect5.html

FAIL
```

3. TestElectionLeaderAndAnotherDisconnect

- Terminal command for testcase:

```
go test -v -race -run TestElectionLeaderAndAnotherDisconnect |& tee ./log.txt
```

→ **Log**:

```
=== RUN   TestElectionLeaderAndAnotherDisconnect
10:53:45.027421 [0] listening at [::]:52010
10:53:45.027659 [1] listening at [::]:52011
10:53:45.027809 [2] listening at [::]:52012
```

```
10:53:45.029621 [0] election timer started (229ms), term=0
10:53:45.029661 [1] election timer started (249ms), term=0
10:53:45.029703 [2] election timer started (280ms), term=0
10:53:45.260916 [0] becomes Candidate (currentTerm=1); log=[]
10:53:45.261199 [0] sending RequestVote to 1: {Term:1 CandidateId:0 LastLogInd
10:53:45.261196 [0] sending RequestVote to 2: {Term:1 CandidateId:0 LastLogInd
10:53:45.261245 [0] election timer started (285ms), term=1
10:53:45.266266 [1] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLog
10:53:45.266347 [1] ... term out of date in RequestVote
10:53:45.266373 [1] becomes Follower with term=1; log=[]
10:53:45.266431 [1] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:53:45.266613 [1] election timer started (163ms), term=1
10:53:45.267436 [0] received RequestVoteReply {Term:1 VoteGranted:true}
10:53:45.267502 [0] wins election with 2 votes
10:53:45.267530 [0] becomes Leader; term=1, log=[]
10:53:45.267644 [0] sending AppendEntries to 1: ni=0, args={Term:1 LeaderId:0
10:53:45.267658 [0] sending AppendEntries to 2: ni=0, args={Term:1 LeaderId:0
10:53:45.267994 [2] RequestVote: {Term:1 CandidateId:0 LastLogIndex:0 LastLog
10:53:45.268063 [2] ... term out of date in RequestVote
10:53:45.268084 [2] becomes Follower with term=1; log=[]
10:53:45.268120 [2] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:53:45.268380 [2] election timer started (288ms), term=1
10:53:45.268811 [0] received RequestVoteReply {Term:1 VoteGranted:true}
10:53:45.268852 [0] while waiting for reply, state = Leader
10:53:45.270051 [1] in election timer term changed from 0 to 1, bailing out
10:53:45.270114 [2] in election timer term changed from 0 to 1, bailing out
10:53:45.270982 [1] AppendEntries: {Term:1 LeaderId:0 PrevLogIndex:0 PrevLog
10:53:45.271092 [1] AppendEntries reply: {Term:1 Success:true}
10:53:45.271538 [0] in election timer state=Leader, bailing out
10:53:45.273090 [2] AppendEntries: {Term:1 LeaderId:0 PrevLogIndex:0 PrevLog
10:53:45.273185 [2] AppendEntries reply: {Term:1 Success:true}
10:53:45.331084 [TEST] Disconnect 0
10:53:45.331676 [TEST] Disconnect 1
10:53:45.437791 [1] becomes Candidate (currentTerm=2); log=[]
10:53:45.438055 [1] sending RequestVote to 0: {Term:2 CandidateId:1 LastLogInd
10:53:45.438072 [1] sending RequestVote to 2: {Term:2 CandidateId:1 LastLogInd
```

```
10:53:45.438092 [1] election timer started (164ms), term=2
10:53:45.569342 [2] becomes Candidate (currentTerm=2); log=[]
10:53:45.569590 [2] election timer started (265ms), term=2
10:53:45.569582 [2] sending RequestVote to 0: {Term:2 CandidateId:2 LastLogIn
10:53:45.569603 [2] sending RequestVote to 1: {Term:2 CandidateId:2 LastLogIn
10:53:45.609236 [1] becomes Candidate (currentTerm=3); log=[]
10:53:45.609435 [1] election timer started (255ms), term=3
10:53:45.609425 [1] sending RequestVote to 0: {Term:3 CandidateId:1 LastLogInd
10:53:45.609418 [1] sending RequestVote to 2: {Term:3 CandidateId:1 LastLogInd
10:53:45.782199 [TEST] Reconnect 1
10:53:45.840667 [2] becomes Candidate (currentTerm=3); log=[]
10:53:45.840918 [2] sending RequestVote to 0: {Term:3 CandidateId:2 LastLogIn
10:53:45.840982 [2] election timer started (222ms), term=3
10:53:45.840955 [2] sending RequestVote to 1: {Term:3 CandidateId:2 LastLogIn
10:53:45.848120 [1] RequestVote: {Term:3 CandidateId:2 LastLogIndex:0 LastLog
10:53:45.848250 [1] ... RequestVote reply: &{Term:3 VoteGranted:false}
10:53:45.849326 [2] received RequestVoteReply {Term:3 VoteGranted:false}
10:53:45.870614 [1] becomes Candidate (currentTerm=4); log=[]
10:53:45.870795 [1] sending RequestVote to 0: {Term:4 CandidateId:1 LastLogInd
10:53:45.870838 [1] sending RequestVote to 2: {Term:4 CandidateId:1 LastLogInd
10:53:45.870830 [1] election timer started (180ms), term=4
10:53:45.875307 [0] RequestVote: {Term:4 CandidateId:1 LastLogIndex:0 LastLog
10:53:45.875307 [2] RequestVote: {Term:4 CandidateId:1 LastLogIndex:0 LastLog
10:53:45.875392 [0] ... term out of date in RequestVote
10:53:45.875416 [2] ... term out of date in RequestVote
10:53:45.875423 [0] becomes Follower with term=4; log=[]
10:53:45.875437 [2] becomes Follower with term=4; log=[]
10:53:45.875468 [2] ... RequestVote reply: &{Term:4 VoteGranted:true}
10:53:45.875479 [0] ... RequestVote reply: &{Term:4 VoteGranted:true}
10:53:45.875599 [2] election timer started (178ms), term=4
10:53:45.875698 [0] election timer started (202ms), term=4
10:53:45.876201 [1] received RequestVoteReply {Term:4 VoteGranted:true}
10:53:45.876239 [1] wins election with 2 votes
10:53:45.876273 [1] becomes Leader; term=4, log=[]
10:53:45.876314 [1] received RequestVoteReply {Term:4 VoteGranted:true}
10:53:45.876347 [1] while waiting for reply, state = Leader
```

```
10:53:45.876415 [1] sending AppendEntries to 0: ni=0, args={Term:4 LeaderId:1 P
10:53:45.876434 [1] sending AppendEntries to 2: ni=0, args={Term:4 LeaderId:1
10:53:45.878407 [2] AppendEntries: {Term:4 LeaderId:1 PrevLogIndex:0 PrevLog
10:53:45.878487 [2] AppendEntries reply: {Term:4 Success:true}
10:53:45.881351 [1] in election timer state=Leader, bailing out
10:53:45.881370 [2] in election timer term changed from 3 to 4, bailing out
10:53:45.881417 [0] AppendEntries: {Term:4 LeaderId:1 PrevLogIndex:0 PrevLogT
10:53:45.881549 [0] AppendEntries reply: {Term:4 Success:true}
10:53:45.935837 [0] becomes Dead
10:53:45.935947 [1] becomes Dead
10:53:45.936006 [2] becomes Dead
--- PASS: TestElectionLeaderAndAnotherDisconnect (0.91s)
PASS
10:53:45.946750 [0] in election timer state=Dead, bailing out
10:53:45.946741 [2] in election timer state=Dead, bailing out
ok    github.com/eliben/raft   2.199s
```

- Terminal command for HTML visualization:

```
Get-Content ./log.txt | go run ../tools/raft-testlog-viz/main.go
```

→ **Result:** **PASS**

```
PASS TestElectionLeaderAndAnotherDisconnect map[0:true 1:true 2:true TEST:tr
... Emitted file:///tmp/TestElectionLeaderAndAnotherDisconnect.html

PASS
```

4. TestDisconnectAllThenRestore

- Terminal command for testcase:

```
go test -v -race -run TestDisconnectAllThenRestore |& tee ./log.txt
```

→ **Log**:

```
=== RUN   TestDisconnectAllThenRestore
10:55:17.822606 [0] listening at [::]:52204
10:55:17.822920 [1] listening at [::]:52205
10:55:17.823030 [2] listening at [::]:52206
10:55:17.825162 [0] election timer started (168ms), term=0
10:55:17.825206 [2] election timer started (178ms), term=0
10:55:17.825202 [1] election timer started (239ms), term=0
10:55:17.926226 [TEST] Disconnect 0
10:55:17.926883 [TEST] Disconnect 1
10:55:17.927013 [TEST] Disconnect 2
10:55:17.996195 [0] becomes Candidate (currentTerm=1); log=[]
10:55:17.996865 [0] sending RequestVote to 1: {Term:1 CandidateId:0 LastLogInd
10:55:17.997299 [0] sending RequestVote to 2: {Term:1 CandidateId:0 LastLogInd
10:55:17.997216 [0] election timer started (248ms), term=1
10:55:18.006440 [2] becomes Candidate (currentTerm=1); log=[]
10:55:18.006557 [2] election timer started (192ms), term=1
10:55:18.006541 [2] sending RequestVote to 0: {Term:1 CandidateId:2 LastLogInd
10:55:18.006543 [2] sending RequestVote to 1: {Term:1 CandidateId:2 LastLogInd
10:55:18.066252 [1] becomes Candidate (currentTerm=1); log=[]
10:55:18.066384 [1] sending RequestVote to 0: {Term:1 CandidateId:1 LastLogInd
10:55:18.066413 [1] election timer started (196ms), term=1
10:55:18.066380 [1] sending RequestVote to 2: {Term:1 CandidateId:1 LastLogInd
10:55:18.207657 [2] becomes Candidate (currentTerm=2); log=[]
10:55:18.207908 [2] sending RequestVote to 1: {Term:2 CandidateId:2 LastLogInd
10:55:18.207955 [2] sending RequestVote to 0: {Term:2 CandidateId:2 LastLogInd
10:55:18.207929 [2] election timer started (286ms), term=2
10:55:18.248220 [0] becomes Candidate (currentTerm=2); log=[]
10:55:18.248424 [0] election timer started (285ms), term=2
10:55:18.248439 [0] sending RequestVote to 1: {Term:2 CandidateId:0 LastLogInd
10:55:18.248525 [0] sending RequestVote to 2: {Term:2 CandidateId:0 LastLogInd
10:55:18.267520 [1] becomes Candidate (currentTerm=2); log=[]
10:55:18.267854 [1] election timer started (223ms), term=2
10:55:18.267845 [1] sending RequestVote to 2: {Term:2 CandidateId:1 LastLogInd
10:55:18.267838 [1] sending RequestVote to 0: {Term:2 CandidateId:1 LastLogInd
```

```
10:55:18.378116 [TEST] Reconnect 0
10:55:18.380816 [TEST] Reconnect 1
10:55:18.381538 [TEST] Reconnect 2
10:55:18.499042 [1] becomes Candidate (currentTerm=3); log=[]
10:55:18.499068 [2] becomes Candidate (currentTerm=3); log=[]
10:55:18.499283 [1] sending RequestVote to 2: {Term:3 CandidateId:1 LastLogInd
10:55:18.499379 [2] sending RequestVote to 1: {Term:3 CandidateId:2 LastLogInd
10:55:18.499448 [1] election timer started (285ms), term=3
10:55:18.499285 [1] sending RequestVote to 0: {Term:3 CandidateId:1 LastLogInd
10:55:18.499551 [2] sending RequestVote to 0: {Term:3 CandidateId:2 LastLogInd
10:55:18.499626 [2] election timer started (266ms), term=3
10:55:18.506476 [1] RequestVote: {Term:3 CandidateId:2 LastLogIndex:0 LastLog
10:55:18.506482 [2] RequestVote: {Term:3 CandidateId:1 LastLogIndex:0 LastLog
10:55:18.506551 [1] ... RequestVote reply: &{Term:3 VoteGranted:false}
10:55:18.506565 [2] ... RequestVote reply: &{Term:3 VoteGranted:false}
10:55:18.506815 [0] RequestVote: {Term:3 CandidateId:1 LastLogIndex:0 LastLog
10:55:18.506862 [0] ... term out of date in RequestVote
10:55:18.506889 [0] becomes Follower with term=3; log=[]
10:55:18.506931 [0] ... RequestVote reply: &{Term:3 VoteGranted:true}
10:55:18.507154 [0] election timer started (163ms), term=3
10:55:18.507557 [2] received RequestVoteReply {Term:3 VoteGranted:false}
10:55:18.507598 [1] received RequestVoteReply {Term:3 VoteGranted:true}
10:55:18.507636 [1] wins election with 2 votes
10:55:18.507663 [1] becomes Leader; term=3, log=[]
10:55:18.507712 [1] received RequestVoteReply {Term:3 VoteGranted:false}
10:55:18.507748 [1] while waiting for reply, state = Leader
10:55:18.507766 [0] RequestVote: {Term:3 CandidateId:2 LastLogIndex:0 LastLog
10:55:18.507811 [0] ... RequestVote reply: &{Term:3 VoteGranted:false}
10:55:18.507814 [1] sending AppendEntries to 2: ni=0, args={Term:3 LeaderId:1 P
10:55:18.508058 [1] sending AppendEntries to 0: ni=0, args={Term:3 LeaderId:1 I
10:55:18.508613 [2] received RequestVoteReply {Term:3 VoteGranted:false}
10:55:18.508701 [0] in election timer term changed from 2 to 3, bailing out
10:55:18.509825 [1] in election timer state=Leader, bailing out
10:55:18.511011 [2] AppendEntries: {Term:3 LeaderId:1 PrevLogIndex:0 PrevLogTe
10:55:18.511090 [2] becomes Follower with term=3; log=[]
10:55:18.511125 [2] AppendEntries reply: {Term:3 Success:true}
```

```
10:55:18.511182 [2] election timer started (254ms), term=3
10:55:18.512007 [0] AppendEntries: {Term:3 LeaderId:1 PrevLogIndex:0 PrevLog
10:55:18.512073 [0] AppendEntries reply: {Term:3 Success:true}
10:55:18.532009 [0] becomes Dead
10:55:18.532101 [1] becomes Dead
10:55:18.532165 [2] becomes Dead
--- PASS: TestDisconnectAllThenRestore (0.71s)
PASS
10:55:18.537909 [0] in election timer state=Dead, bailing out
10:55:18.539964 [2] in election timer state=Dead, bailing out
10:55:18.541409 [2] in election timer state=Dead, bailing out
ok    github.com/eliben/raft   1.977s
```

- Terminal command for HTML visualization:

```
Get-Content ./log.txt | go run ../tools/raft-testlog-viz/main.go
```

→ **Result:** **PASS**

```
PASS TestDisconnectAllThenRestore map[0:true 1:true 2:true TEST:true] ; entries
... Emitted file:///tmp/TestDisconnectAllThenRestore.html

PASS
```

5. TestElectionFollowerComesBack

- Terminal command for testcase:

```
go test -v -race -run TestElectionFollowerComesBack |& tee ./log.txt
```

→ **Log**:

```
=== RUN   TestElectionFollowerComesBack
10:56:42.778123 [0] listening at [::]:52397
10:56:42.778312 [1] listening at [::]:52398
```

```
10:56:42.778376 [2] listening at [::]:52399
10:56:42.779580 [2] election timer started (196ms), term=0
10:56:42.779604 [0] election timer started (203ms), term=0
10:56:42.779601 [1] election timer started (241ms), term=0
10:56:42.980762 [2] becomes Candidate (currentTerm=1); log=[]
10:56:42.981011 [2] election timer started (153ms), term=1
10:56:42.980994 [2] sending RequestVote to 1: {Term:1 CandidateId:2 LastLogIn
10:56:42.981113 [2] sending RequestVote to 0: {Term:1 CandidateId:2 LastLogInd
10:56:42.985458 [1] RequestVote: {Term:1 CandidateId:2 LastLogIndex:0 LastLog
10:56:42.985584 [1] ... term out of date in RequestVote
10:56:42.985628 [1] becomes Follower with term=1; log=[]
10:56:42.985712 [1] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:56:42.985926 [1] election timer started (278ms), term=1
10:56:42.986888 [2] received RequestVoteReply {Term:1 VoteGranted:true}
10:56:42.986941 [2] wins election with 2 votes
10:56:42.986973 [2] becomes Leader; term=1, log=[]
10:56:42.987090 [2] sending AppendEntries to 1: ni=0, args={Term:1 LeaderId:2
10:56:42.987103 [2] sending AppendEntries to 0: ni=0, args={Term:1 LeaderId:2
10:56:42.988883 [0] RequestVote: {Term:1 CandidateId:2 LastLogIndex:0 LastLo
10:56:42.988947 [0] ... term out of date in RequestVote
10:56:42.988967 [0] becomes Follower with term=1; log=[]
10:56:42.989001 [0] ... RequestVote reply: &{Term:1 VoteGranted:true}
10:56:42.989257 [0] AppendEntries: {Term:1 LeaderId:2 PrevLogIndex:0 PrevLog
10:56:42.989331 [0] AppendEntries reply: {Term:1 Success:true}
10:56:42.989577 [0] election timer started (172ms), term=1
10:56:42.989713 [0] in election timer term changed from 0 to 1, bailing out
10:56:42.989751 [1] in election timer term changed from 0 to 1, bailing out
10:56:42.989779 [2] received RequestVoteReply {Term:1 VoteGranted:true}
10:56:42.989816 [2] while waiting for reply, state = Leader
10:56:42.991396 [2] in election timer state=Leader, bailing out
10:56:42.991428 [1] AppendEntries: {Term:1 LeaderId:2 PrevLogIndex:0 PrevLog
10:56:42.991579 [1] AppendEntries reply: {Term:1 Success:true}
10:56:43.080795 [TEST] Disconnect 0
10:56:43.170113 [0] becomes Candidate (currentTerm=2); log=[]
10:56:43.170352 [0] sending RequestVote to 2: {Term:2 CandidateId:0 LastLogIn
10:56:43.170375 [0] sending RequestVote to 1: {Term:2 CandidateId:0 LastLogIn
```

```
10:56:43.170389 [0] election timer started (159ms), term=2
10:56:43.276790 [1] becomes Candidate (currentTerm=2); log=[]
10:56:43.277034 [1] election timer started (273ms), term=2
10:56:43.277044 [1] sending RequestVote to 0: {Term:2 CandidateId:1 LastLogInd
10:56:43.277005 [1] sending RequestVote to 2: {Term:2 CandidateId:1 LastLogInd
10:56:43.280906 [2] RequestVote: {Term:2 CandidateId:1 LastLogIndex:0 LastLo
10:56:43.280996 [2] ... term out of date in RequestVote
10:56:43.281036 [2] becomes Follower with term=2; log=[]
10:56:43.281093 [2] ... RequestVote reply: &{Term:2 VoteGranted:true}
10:56:43.281271 [2] election timer started (202ms), term=2
10:56:43.282226 [1] received RequestVoteReply {Term:2 VoteGranted:true}
10:56:43.282292 [1] wins election with 2 votes
10:56:43.282343 [1] becomes Leader; term=2, log=[]
10:56:43.282505 [1] sending AppendEntries to 2: ni=0, args={Term:2 LeaderId:1
10:56:43.282520 [1] sending AppendEntries to 0: ni=0, args={Term:2 LeaderId:1
10:56:43.287659 [1] in election timer state=Leader, bailing out
10:56:43.288563 [2] AppendEntries: {Term:2 LeaderId:1 PrevLogIndex:0 PrevLog
10:56:43.288709 [2] AppendEntries reply: {Term:2 Success:true}
10:56:43.331663 [0] becomes Candidate (currentTerm=3); log=[]
10:56:43.331788 [0] sending RequestVote to 1: {Term:3 CandidateId:0 LastLogInd
10:56:43.331795 [0] sending RequestVote to 2: {Term:3 CandidateId:0 LastLogIn
10:56:43.331882 [0] election timer started (175ms), term=3
10:56:43.492503 [2] becomes Candidate (currentTerm=3); log=[]
10:56:43.492709 [2] election timer started (164ms), term=3
10:56:43.492762 [2] sending RequestVote to 0: {Term:3 CandidateId:2 LastLogIn
10:56:43.492804 [2] sending RequestVote to 1: {Term:3 CandidateId:2 LastLogIn
10:56:43.496561 [1] RequestVote: {Term:3 CandidateId:2 LastLogIndex:0 LastLog
10:56:43.496675 [1] ... term out of date in RequestVote
10:56:43.496714 [1] becomes Follower with term=3; log=[]
10:56:43.496785 [1] ... RequestVote reply: &{Term:3 VoteGranted:true}
10:56:43.496972 [1] election timer started (157ms), term=3
10:56:43.497274 [2] received RequestVoteReply {Term:3 VoteGranted:true}
10:56:43.497412 [2] wins election with 2 votes
10:56:43.497463 [2] becomes Leader; term=3, log=[]
10:56:43.497642 [2] sending AppendEntries to 0: ni=0, args={Term:3 LeaderId:2
10:56:43.497707 [2] sending AppendEntries to 1: ni=0, args={Term:3 LeaderId:2
```

```
10:56:43.502304 [1] AppendEntries: {Term:3 LeaderId:2 PrevLogIndex:0 PrevLog
10:56:43.502504 [1] AppendEntries reply: {Term:3 Success:true}
10:56:43.502970 [2] in election timer state=Leader, bailing out
10:56:43.513466 [0] becomes Candidate (currentTerm=4); log=[]
10:56:43.513694 [0] election timer started (235ms), term=4
10:56:43.513827 [0] sending RequestVote to 2: {Term:4 CandidateId:0 LastLogIn
10:56:43.513978 [0] sending RequestVote to 1: {Term:4 CandidateId:0 LastLogInd
10:56:43.667478 [1] becomes Candidate (currentTerm=4); log=[]
10:56:43.667725 [1] sending RequestVote to 0: {Term:4 CandidateId:1 LastLogInd
10:56:43.667783 [1] election timer started (272ms), term=4
10:56:43.667750 [1] sending RequestVote to 2: {Term:4 CandidateId:1 LastLogInd
10:56:43.671907 [2] RequestVote: {Term:4 CandidateId:1 LastLogIndex:0 LastLog
10:56:43.672003 [2] ... term out of date in RequestVote
10:56:43.672040 [2] becomes Follower with term=4; log=[]
10:56:43.672115 [2] ... RequestVote reply: &{Term:4 VoteGranted:true}
10:56:43.672300 [2] election timer started (286ms), term=4
10:56:43.672808 [1] received RequestVoteReply {Term:4 VoteGranted:true}
10:56:43.672885 [1] wins election with 2 votes
10:56:43.672925 [1] becomes Leader; term=4, log=[]
10:56:43.673088 [1] sending AppendEntries to 0: ni=0, args={Term:4 LeaderId:1
10:56:43.673114 [1] sending AppendEntries to 2: ni=0, args={Term:4 LeaderId:1 P
10:56:43.677920 [1] in election timer state=Leader, bailing out
10:56:43.677966 [2] AppendEntries: {Term:4 LeaderId:1 PrevLogIndex:0 PrevLog
10:56:43.678042 [2] AppendEntries reply: {Term:4 Success:true}
10:56:43.731708 [TEST] Reconnect 0
10:56:43.753888 [0] becomes Candidate (currentTerm=5); log=[]
10:56:43.753993 [0] sending RequestVote to 1: {Term:5 CandidateId:0 LastLogIn
10:56:43.754027 [0] election timer started (197ms), term=5
10:56:43.754019 [0] sending RequestVote to 2: {Term:5 CandidateId:0 LastLogIn
10:56:43.757131 [1] RequestVote: {Term:5 CandidateId:0 LastLogIndex:0 LastLogT
10:56:43.757221 [1] ... term out of date in RequestVote
10:56:43.757243 [1] becomes Follower with term=5; log=[]
10:56:43.757285 [1] ... RequestVote reply: &{Term:5 VoteGranted:true}
10:56:43.757452 [1] election timer started (219ms), term=5
10:56:43.758184 [0] received RequestVoteReply {Term:5 VoteGranted:true}
10:56:43.758231 [0] wins election with 2 votes
```

```
10:56:43.758262 [0] becomes Leader; term=5, log=[]
10:56:43.758343 [0] sending AppendEntries to 2: ni=0, args={Term:5 LeaderId:0
10:56:43.758347 [0] sending AppendEntries to 1: ni=0, args={Term:5 LeaderId:0
10:56:43.759984 [1] AppendEntries: {Term:5 LeaderId:0 PrevLogIndex:0 PrevLog
10:56:43.760023 [2] RequestVote: {Term:5 CandidateId:0 LastLogIndex:0 LastLo
10:56:43.760056 [1] AppendEntries reply: {Term:5 Success:true}
10:56:43.760066 [2] ... term out of date in RequestVote
10:56:43.760106 [2] becomes Follower with term=5; log=[]
10:56:43.760136 [2] ... RequestVote reply: &{Term:5 VoteGranted:true}
10:56:43.760279 [2] election timer started (217ms), term=5
10:56:43.760644 [0] received RequestVoteReply {Term:5 VoteGranted:true}
10:56:43.760677 [0] while waiting for reply, state = Leader
10:56:43.762694 [2] in election timer term changed from 4 to 5, bailing out
10:56:43.764192 [0] in election timer state=Leader, bailing out
10:56:43.764159 [2] AppendEntries: {Term:5 LeaderId:0 PrevLogIndex:0 PrevLog
10:56:43.764295 [2] AppendEntries reply: {Term:5 Success:true}
10:56:43.887319 [0] becomes Dead
10:56:43.887506 [1] becomes Dead
10:56:43.887597 [2] becomes Dead
10:56:43.887612 [1] in election timer state=Dead, bailing out
10:56:43.890691 [2] in election timer state=Dead, bailing out
    leaktest.go:132: leaktest: timed out checking goroutines
    leaktest.go:150: leaktest: leaked goroutine: goroutine 8 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 81 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 85 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
```

```
        /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 94 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 107 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
--- FAIL: TestElectionFollowerComesBack (1.22s)
FAIL
exit status 1
FAIL github.com/eliben/raft   1.630s
```

- Terminal command for HTML visualization:

```
Get-Content ./log.txt | go run ../tools/raft-testlog-viz/main.go
```

→ **Result:** **FAIL**

```
FAIL TestElectionFollowerComesBack map[0:true 1:true 2:true TEST:true] ; entrie
... Emitted file:///tmp/TestElectionFollowerComesBack.html

FAIL
```

6. TestElectionDisconnectLoop

- Terminal command for testcase:

```
go test -v -race -run TestElectionDisconnectLoop |& tee ./log.txt
```

→ **Log**:

```
=== RUN   TestElectionDisconnectLoop
11:00:42.231471 [0] listening at [::]:52873
11:00:42.231774 [1] listening at [::]:52874
11:00:42.231883 [2] listening at [::]:52875
11:00:42.233978 [2] election timer started (198ms), term=0
11:00:42.233997 [0] election timer started (233ms), term=0
11:00:42.234001 [1] election timer started (196ms), term=0
11:00:42.435295 [2] becomes Candidate (currentTerm=1); log=[]
11:00:42.435297 [1] becomes Candidate (currentTerm=1); log=[]
11:00:42.435647 [1] election timer started (240ms), term=1
11:00:42.435662 [1] sending RequestVote to 0: {Term:1 CandidateId:1 LastLogInd
11:00:42.435849 [1] sending RequestVote to 2: {Term:1 CandidateId:1 LastLogInd
11:00:42.436035 [2] election timer started (153ms), term=1
11:00:42.435986 [2] sending RequestVote to 0: {Term:1 CandidateId:2 LastLogIn
11:00:42.435664 [2] sending RequestVote to 1: {Term:1 CandidateId:2 LastLogInd
11:00:42.439720 [0] RequestVote: {Term:1 CandidateId:1 LastLogIndex:0 LastLog
11:00:42.439718 [1] RequestVote: {Term:1 CandidateId:2 LastLogIndex:0 LastLogT
11:00:42.439797 [0] ... term out of date in RequestVote
11:00:42.439847 [0] becomes Follower with term=1; log=[]
11:00:42.439829 [1] ... RequestVote reply: &{Term:1 VoteGranted:false}
11:00:42.439917 [0] ... RequestVote reply: &{Term:1 VoteGranted:true}
11:00:42.440060 [0] election timer started (201ms), term=1
11:00:42.440565 [0] RequestVote: {Term:1 CandidateId:2 LastLogIndex:0 LastLog
11:00:42.441363 [1] received RequestVoteReply {Term:1 VoteGranted:true}
11:00:42.441438 [1] wins election with 2 votes
11:00:42.441406 [0] ... RequestVote reply: &{Term:1 VoteGranted:false}
11:00:42.441467 [1] becomes Leader; term=1, log=[]
11:00:42.440598 [2] RequestVote: {Term:1 CandidateId:1 LastLogIndex:0 LastLog
11:00:42.441680 [1] sending AppendEntries to 2: ni=0, args={Term:1 LeaderId:1 P
11:00:42.441740 [2] ... RequestVote reply: &{Term:1 VoteGranted:false}
11:00:42.441818 [2] received RequestVoteReply {Term:1 VoteGranted:false}
11:00:42.441803 [1] sending AppendEntries to 0: ni=0, args={Term:1 LeaderId:1 P
11:00:42.442388 [2] received RequestVoteReply {Term:1 VoteGranted:false}
11:00:42.442480 [1] received RequestVoteReply {Term:1 VoteGranted:false}
11:00:42.442522 [1] while waiting for reply, state = Leader
```

```
11:00:42.444298 [0] in election timer term changed from 0 to 1, bailing out
11:00:42.444508 [0] AppendEntries: {Term:1 LeaderId:1 PrevLogIndex:0 PrevLog
11:00:42.444577 [0] AppendEntries reply: {Term:1 Success:true}
11:00:42.445930 [1] in election timer state=Leader, bailing out
11:00:42.446499 [2] AppendEntries: {Term:1 LeaderId:1 PrevLogIndex:0 PrevLog
11:00:42.446571 [2] becomes Follower with term=1; log=[]
11:00:42.446604 [2] AppendEntries reply: {Term:1 Success:true}
11:00:42.446649 [2] election timer started (191ms), term=1
11:00:42.535407 [TEST] Disconnect 1
11:00:42.535820 [TEST] Disconnect 2
11:00:42.606962 [2] becomes Candidate (currentTerm=2); log=[]
11:00:42.607157 [2] sending RequestVote to 1: {Term:2 CandidateId:2 LastLogInd
11:00:42.607202 [2] election timer started (226ms), term=2
11:00:42.607173 [2] sending RequestVote to 0: {Term:2 CandidateId:2 LastLogInd
11:00:42.616872 [2] in election timer term changed from 1 to 2, bailing out
11:00:42.650345 [0] becomes Candidate (currentTerm=2); log=[]
11:00:42.650474 [0] sending RequestVote to 2: {Term:2 CandidateId:0 LastLogIn
11:00:42.650514 [0] election timer started (204ms), term=2
11:00:42.650489 [0] sending RequestVote to 1: {Term:2 CandidateId:0 LastLogIn
11:00:42.838172 [2] becomes Candidate (currentTerm=3); log=[]
11:00:42.838438 [2] election timer started (217ms), term=3
11:00:42.838424 [2] sending RequestVote to 1: {Term:3 CandidateId:2 LastLogIn
11:00:42.838442 [2] sending RequestVote to 0: {Term:3 CandidateId:2 LastLogIn
11:00:42.846644 [TEST] Reconnect 2
11:00:42.849315 [TEST] Reconnect 1
11:00:42.860737 [0] becomes Candidate (currentTerm=3); log=[]
11:00:42.860848 [0] sending RequestVote to 1: {Term:3 CandidateId:0 LastLogIn
11:00:42.860864 [0] election timer started (223ms), term=3
11:00:42.860862 [0] sending RequestVote to 2: {Term:3 CandidateId:0 LastLogIn
11:00:42.863581 [1] RequestVote: {Term:3 CandidateId:0 LastLogIndex:0 LastLog
11:00:42.863680 [1] ... term out of date in RequestVote
11:00:42.863712 [1] becomes Follower with term=3; log=[]
11:00:42.863759 [1] ... RequestVote reply: &{Term:3 VoteGranted:true}
11:00:42.863915 [1] election timer started (176ms), term=3
11:00:42.863947 [2] RequestVote: {Term:3 CandidateId:0 LastLogIndex:0 LastLo
11:00:42.864022 [2] ... RequestVote reply: &{Term:3 VoteGranted:false}
```

```
11:00:42.864604 [0] received RequestVoteReply {Term:3 VoteGranted:true}
11:00:42.864665 [0] wins election with 2 votes
11:00:42.864703 [0] becomes Leader; term=3, log=[]
11:00:42.864766 [0] received RequestVoteReply {Term:3 VoteGranted:false}
11:00:42.864819 [0] while waiting for reply, state = Leader
11:00:42.864895 [0] sending AppendEntries to 1: ni=0, args={Term:3 LeaderId:0
11:00:42.864903 [0] sending AppendEntries to 2: ni=0, args={Term:3 LeaderId:0
11:00:42.868983 [2] AppendEntries: {Term:3 LeaderId:0 PrevLogIndex:0 PrevLog
11:00:42.869056 [2] becomes Follower with term=3; log=[]
11:00:42.869093 [2] AppendEntries reply: {Term:3 Success:true}
11:00:42.869172 [2] election timer started (232ms), term=3
11:00:42.870893 [1] AppendEntries: {Term:3 LeaderId:0 PrevLogIndex:0 PrevLog
11:00:42.871000 [0] in election timer state=Leader, bailing out
11:00:42.871020 [1] AppendEntries reply: {Term:3 Success:true}
11:00:43.000309 [TEST] Disconnect 0
11:00:43.000820 [TEST] Disconnect 1
11:00:43.054681 [1] becomes Candidate (currentTerm=4); log=[]
11:00:43.054950 [1] sending RequestVote to 0: {Term:4 CandidateId:1 LastLogInd
11:00:43.055203 [1] election timer started (292ms), term=4
11:00:43.055197 [1] sending RequestVote to 2: {Term:4 CandidateId:1 LastLogInd
11:00:43.088966 [2] becomes Candidate (currentTerm=4); log=[]
11:00:43.089123 [2] election timer started (239ms), term=4
11:00:43.089130 [2] sending RequestVote to 0: {Term:4 CandidateId:2 LastLogInd
11:00:43.089113 [2] sending RequestVote to 1: {Term:4 CandidateId:2 LastLogInd
11:00:43.089239 [2] in election timer term changed from 3 to 4, bailing out
11:00:43.311303 [TEST] Reconnect 1
11:00:43.313938 [TEST] Reconnect 0
11:00:43.329679 [2] becomes Candidate (currentTerm=5); log=[]
11:00:43.329803 [2] sending RequestVote to 1: {Term:5 CandidateId:2 LastLogInd
11:00:43.330344 [2] election timer started (205ms), term=5
11:00:43.330340 [2] sending RequestVote to 0: {Term:5 CandidateId:2 LastLogIn
11:00:43.332272 [1] RequestVote: {Term:5 CandidateId:2 LastLogIndex:0 LastLog
11:00:43.332345 [1] ... term out of date in RequestVote
11:00:43.332379 [1] becomes Follower with term=5; log=[]
11:00:43.332424 [1] ... RequestVote reply: &{Term:5 VoteGranted:true}
11:00:43.332517 [1] election timer started (289ms), term=5
```

```
11:00:43.333069 [2] received RequestVoteReply {Term:5 VoteGranted:true}
11:00:43.333106 [2] wins election with 2 votes
11:00:43.333144 [2] becomes Leader; term=5, log=[]
11:00:43.333213 [2] sending AppendEntries to 1: ni=0, args={Term:5 LeaderId:2 P
11:00:43.333212 [2] sending AppendEntries to 0: ni=0, args={Term:5 LeaderId:2
11:00:43.335681 [1] in election timer term changed from 4 to 5, bailing out
11:00:43.335848 [0] AppendEntries: {Term:5 LeaderId:2 PrevLogIndex:0 PrevLog
11:00:43.335982 [0] ... term out of date in AppendEntries
11:00:43.336015 [0] becomes Follower with term=5; log=[]
11:00:43.336076 [0] AppendEntries reply: {Term:5 Success:true}
11:00:43.336477 [0] election timer started (281ms), term=5
11:00:43.336542 [0] RequestVote: {Term:5 CandidateId:2 LastLogIndex:0 LastLo
11:00:43.336622 [0] ... RequestVote reply: &{Term:5 VoteGranted:true}
11:00:43.337128 [2] received RequestVoteReply {Term:5 VoteGranted:true}
11:00:43.337179 [2] while waiting for reply, state = Leader
11:00:43.339083 [1] AppendEntries: {Term:5 LeaderId:2 PrevLogIndex:0 PrevLog
11:00:43.339203 [1] AppendEntries reply: {Term:5 Success:true}
11:00:43.340540 [2] in election timer state=Leader, bailing out
11:00:43.464895 [TEST] Disconnect 2
11:00:43.465464 [TEST] Disconnect 0
11:00:43.627176 [0] becomes Candidate (currentTerm=6); log=[]
11:00:43.627381 [0] sending RequestVote to 2: {Term:6 CandidateId:0 LastLogIn
11:00:43.627430 [0] sending RequestVote to 1: {Term:6 CandidateId:0 LastLogIn
11:00:43.627491 [0] election timer started (171ms), term=6
11:00:43.633345 [1] becomes Candidate (currentTerm=6); log=[]
11:00:43.633432 [1] sending RequestVote to 0: {Term:6 CandidateId:1 LastLogIn
11:00:43.633519 [1] election timer started (238ms), term=6
11:00:43.633500 [1] sending RequestVote to 2: {Term:6 CandidateId:1 LastLogIn
11:00:43.775823 [TEST] Reconnect 0
11:00:43.777825 [TEST] Reconnect 2
11:00:43.808110 [0] becomes Candidate (currentTerm=7); log=[]
11:00:43.808279 [0] sending RequestVote to 2: {Term:7 CandidateId:0 LastLogIn
11:00:43.808223 [0] election timer started (174ms), term=7
11:00:43.808523 [0] sending RequestVote to 1: {Term:7 CandidateId:0 LastLogIn
11:00:43.812829 [2] RequestVote: {Term:7 CandidateId:0 LastLogIndex:0 LastLog
11:00:43.812938 [2] ... term out of date in RequestVote
```

```
11:00:43.812960 [2] becomes Follower with term=7; log=[]
11:00:43.813004 [2] ... RequestVote reply: &{Term:7 VoteGranted:true}
11:00:43.813098 [2] election timer started (263ms), term=7
11:00:43.813641 [0] received RequestVoteReply {Term:7 VoteGranted:true}
11:00:43.813671 [0] wins election with 2 votes
11:00:43.813698 [0] becomes Leader; term=7, log=[]
11:00:43.813749 [0] sending AppendEntries to 2: ni=0, args={Term:7 LeaderId:0
11:00:43.813761 [0] sending AppendEntries to 1: ni=0, args={Term:7 LeaderId:0 P
11:00:43.814525 [1] RequestVote: {Term:7 CandidateId:0 LastLogIndex:0 LastLog
11:00:43.814580 [1] ... term out of date in RequestVote
11:00:43.814596 [1] becomes Follower with term=7; log=[]
11:00:43.814633 [1] ... RequestVote reply: &{Term:7 VoteGranted:true}
11:00:43.814721 [1] election timer started (255ms), term=7
11:00:43.815506 [0] received RequestVoteReply {Term:7 VoteGranted:true}
11:00:43.815573 [0] while waiting for reply, state = Leader
11:00:43.815517 [1] AppendEntries: {Term:7 LeaderId:0 PrevLogIndex:0 PrevLogT
11:00:43.815651 [1] AppendEntries reply: {Term:7 Success:true}
11:00:43.818914 [0] in election timer state=Leader, bailing out
11:00:43.819351 [2] AppendEntries: {Term:7 LeaderId:0 PrevLogIndex:0 PrevLogT
11:00:43.819434 [2] AppendEntries reply: {Term:7 Success:true}
11:00:43.823650 [1] in election timer term changed from 6 to 7, bailing out
11:00:43.928912 [TEST] Disconnect 0
11:00:43.929344 [TEST] Disconnect 1
11:00:44.074937 [1] becomes Candidate (currentTerm=8); log=[]
11:00:44.075103 [1] sending RequestVote to 0: {Term:8 CandidateId:1 LastLogInd
11:00:44.075133 [1] election timer started (233ms), term=8
11:00:44.075098 [1] sending RequestVote to 2: {Term:8 CandidateId:1 LastLogInd
11:00:44.084263 [2] becomes Candidate (currentTerm=8); log=[]
11:00:44.084374 [2] election timer started (225ms), term=8
11:00:44.084366 [2] sending RequestVote to 1: {Term:8 CandidateId:2 LastLogIn
11:00:44.084428 [2] sending RequestVote to 0: {Term:8 CandidateId:2 LastLogIn
11:00:44.240300 [TEST] Reconnect 1
11:00:44.242421 [TEST] Reconnect 0
11:00:44.314687 [2] becomes Candidate (currentTerm=9); log=[]
11:00:44.314896 [2] sending RequestVote to 1: {Term:9 CandidateId:2 LastLogInd
11:00:44.314968 [2] sending RequestVote to 0: {Term:9 CandidateId:2 LastLogIn
```

```
11:00:44.315507 [2] election timer started (179ms), term=9
11:00:44.315631 [1] becomes Candidate (currentTerm=9); log=[]
11:00:44.315712 [1] sending RequestVote to 0: {Term:9 CandidateId:1 LastLogInde
11:00:44.316009 [1] election timer started (202ms), term=9
11:00:44.315721 [1] sending RequestVote to 2: {Term:9 CandidateId:1 LastLogInde
11:00:44.318023 [2] RequestVote: {Term:9 CandidateId:1 LastLogIndex:0 LastLog
11:00:44.318105 [2] ... RequestVote reply: &{Term:9 VoteGranted:false}
11:00:44.318460 [0] RequestVote: {Term:9 CandidateId:2 LastLogIndex:0 LastLo
11:00:44.318469 [1] RequestVote: {Term:9 CandidateId:2 LastLogIndex:0 LastLog
11:00:44.318541 [0] ... term out of date in RequestVote
11:00:44.318570 [0] becomes Follower with term=9; log=[]
11:00:44.318555 [1] ... RequestVote reply: &{Term:9 VoteGranted:false}
11:00:44.318620 [0] ... RequestVote reply: &{Term:9 VoteGranted:true}
11:00:44.318851 [0] RequestVote: {Term:9 CandidateId:1 LastLogIndex:0 LastLog
11:00:44.318919 [0] ... RequestVote reply: &{Term:9 VoteGranted:false}
11:00:44.318966 [1] received RequestVoteReply {Term:9 VoteGranted:false}
11:00:44.319218 [0] election timer started (256ms), term=9
11:00:44.319346 [2] received RequestVoteReply {Term:9 VoteGranted:true}
11:00:44.319395 [2] wins election with 2 votes
11:00:44.319425 [2] becomes Leader; term=9, log=[]
11:00:44.319482 [2] received RequestVoteReply {Term:9 VoteGranted:false}
11:00:44.319529 [2] while waiting for reply, state = Leader
11:00:44.319586 [2] sending AppendEntries to 1: ni=0, args={Term:9 LeaderId:2 L
11:00:44.319593 [2] sending AppendEntries to 0: ni=0, args={Term:9 LeaderId:2
11:00:44.319687 [1] received RequestVoteReply {Term:9 VoteGranted:false}
11:00:44.322607 [1] AppendEntries: {Term:9 LeaderId:2 PrevLogIndex:0 PrevLog
11:00:44.322724 [1] becomes Follower with term=9; log=[]
11:00:44.322776 [1] AppendEntries reply: {Term:9 Success:true}
11:00:44.322846 [1] election timer started (222ms), term=9
11:00:44.325678 [2] in election timer state=Leader, bailing out
11:00:44.325641 [0] AppendEntries: {Term:9 LeaderId:2 PrevLogIndex:0 PrevLog
11:00:44.325722 [0] AppendEntries reply: {Term:9 Success:true}
11:00:44.393390 [TEST] Disconnect 2
11:00:44.393844 [TEST] Disconnect 0
11:00:44.526524 [1] becomes Candidate (currentTerm=10); log=[]
11:00:44.526756 [1] election timer started (277ms), term=10
```

```
11:00:44.526742 [1] sending RequestVote to 2: {Term:10 CandidateId:1 LastLogIn
11:00:44.526738 [1] sending RequestVote to 0: {Term:10 CandidateId:1 LastLogIn
11:00:44.533388 [1] in election timer term changed from 9 to 10, bailing out
11:00:44.589550 [0] becomes Candidate (currentTerm=10); log=[]
11:00:44.589750 [0] sending RequestVote to 1: {Term:10 CandidateId:0 LastLogIn
11:00:44.589815 [0] election timer started (242ms), term=10
11:00:44.589795 [0] sending RequestVote to 2: {Term:10 CandidateId:0 LastLogIn
11:00:44.704631 [TEST] Reconnect 0
11:00:44.707100 [TEST] Reconnect 2
11:00:44.807797 [1] becomes Candidate (currentTerm=11); log=[]
11:00:44.808032 [1] sending RequestVote to 0: {Term:11 CandidateId:1 LastLogIn
11:00:44.808074 [1] election timer started (214ms), term=11
11:00:44.808018 [1] sending RequestVote to 2: {Term:11 CandidateId:1 LastLogIn
11:00:44.812748 [0] RequestVote: {Term:11 CandidateId:1 LastLogIndex:0 LastLog
11:00:44.812776 [2] RequestVote: {Term:11 CandidateId:1 LastLogIndex:0 LastLog
11:00:44.812864 [0] ... term out of date in RequestVote
11:00:44.812886 [2] ... term out of date in RequestVote
11:00:44.812910 [0] becomes Follower with term=11; log=[]
11:00:44.812920 [2] becomes Follower with term=11; log=[]
11:00:44.812974 [0] ... RequestVote reply: &{Term:11 VoteGranted:true}
11:00:44.812984 [2] ... RequestVote reply: &{Term:11 VoteGranted:true}
11:00:44.813181 [2] election timer started (205ms), term=11
11:00:44.813282 [0] election timer started (205ms), term=11
11:00:44.814094 [1] received RequestVoteReply {Term:11 VoteGranted:true}
11:00:44.814157 [1] wins election with 2 votes
11:00:44.814212 [1] becomes Leader; term=11, log=[]
11:00:44.814282 [1] received RequestVoteReply {Term:11 VoteGranted:true}
11:00:44.814343 [1] while waiting for reply, state = Leader
11:00:44.814425 [1] sending AppendEntries to 2: ni=0, args={Term:11 LeaderId:1 
11:00:44.814448 [1] sending AppendEntries to 0: ni=0, args={Term:11 LeaderId:1
11:00:44.818637 [2] AppendEntries: {Term:11 LeaderId:1 PrevLogIndex:0 PrevLog
11:00:44.818714 [1] in election timer state=Leader, bailing out
11:00:44.818729 [2] AppendEntries reply: {Term:11 Success:true}
11:00:44.819373 [0] AppendEntries: {Term:11 LeaderId:1 PrevLogIndex:0 PrevLog
11:00:44.819467 [0] AppendEntries reply: {Term:11 Success:true}
11:00:44.819975 [0] in election timer term changed from 10 to 11, bailing out
```

```
11:00:44.858755 [0] becomes Dead
11:00:44.858865 [1] becomes Dead
11:00:44.858921 [2] becomes Dead
11:00:44.863949 [2] in election timer state=Dead, bailing out
11:00:44.863962 [0] in election timer state=Dead, bailing out
    leaktest.go:132: leaktest: timed out checking goroutines
    leaktest.go:150: leaktest: leaked goroutine: goroutine 47 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 128 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 152 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 228 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 240 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
    leaktest.go:150: leaktest: leaked goroutine: goroutine 323 [chan receive]:
        github.com/eliben/raft.(*ConsensusModule).startLeader.func1()
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
        created by github.com/eliben/raft.(*ConsensusModule).startLeader in gorou
            /Users/monsterbox/Documents/WorkSpace/Master/DisSys/Lab3/raft/part
```

```
--- FAIL: TestElectionDisconnectLoop (2.73s)
FAIL
exit status 1
FAIL github.com/eliben/raft   3.028s
```

- Terminal command for HTML visualization:

```
Get-Content ./log.txt | go run ../tools/raft-testlog-viz/main.go
```

→ **Result: FAIL**

```
FAIL TestElectionDisconnectLoop map[0:true 1:true 2:true TEST:true] ; entries: 25
... Emitted file:///tmp/TestElectionDisconnectLoop.html

FAIL
```

7. Results

Test case	Result
TestElectionBasic	PASS
TestElectionLeaderDisconnect	PASS
TestElectionLeaderDisconnectThenReconnect	FAIL
TestElectionLeaderDisconnectThenReconnect5	FAIL
TestElectionLeaderAndAnotherDisconnect	PASS
TestDisconnectAllThenRestore	PASS
TestElectionFollowerComesBack	FAIL
TestElectionDisconnectLoop	FAIL

→ **Explain Result**:

If the heartbeat interval is too large, **Followers** mistakenly believe the **Leader** is down and start new elections unnecessarily. However, some test cases return **PASS** because when a node becomes a **Leader**, it immediately sends a heartbeat

to all other nodes before the long interval starts. This initial heartbeat prevents immediate disconnections.

However, since some test cases end as soon as a **Leader** is elected, they do not wait long enough to observe the issue, leading to a false **PASS**. In contrast, test cases that wait longer to check for disconnections fail because **Followers** eventually time out and trigger new elections.