Debugging Distributed Systems

Donny Nadolny

donny@pagerduty.com

SREcon16

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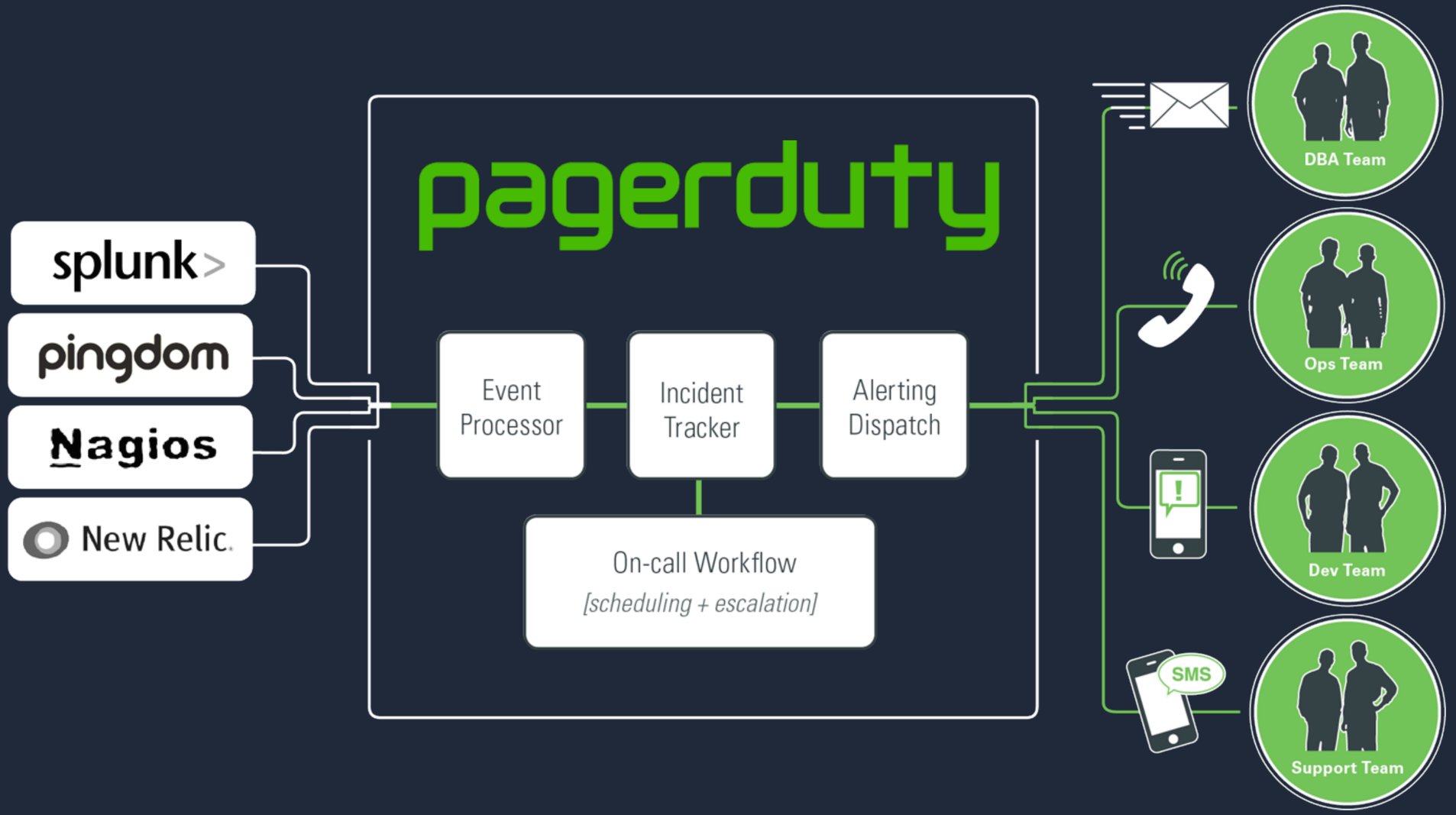

splunk>
pingdom
Nagios
New Relic
pagerduty
Event Processor
Incident Tracker
Alerting Dispatch
On-call Workflow
[scheduling + escalation]
DBA Team
Ops Team
Dev Team
SMS
Support Team

What is ZooKeeper

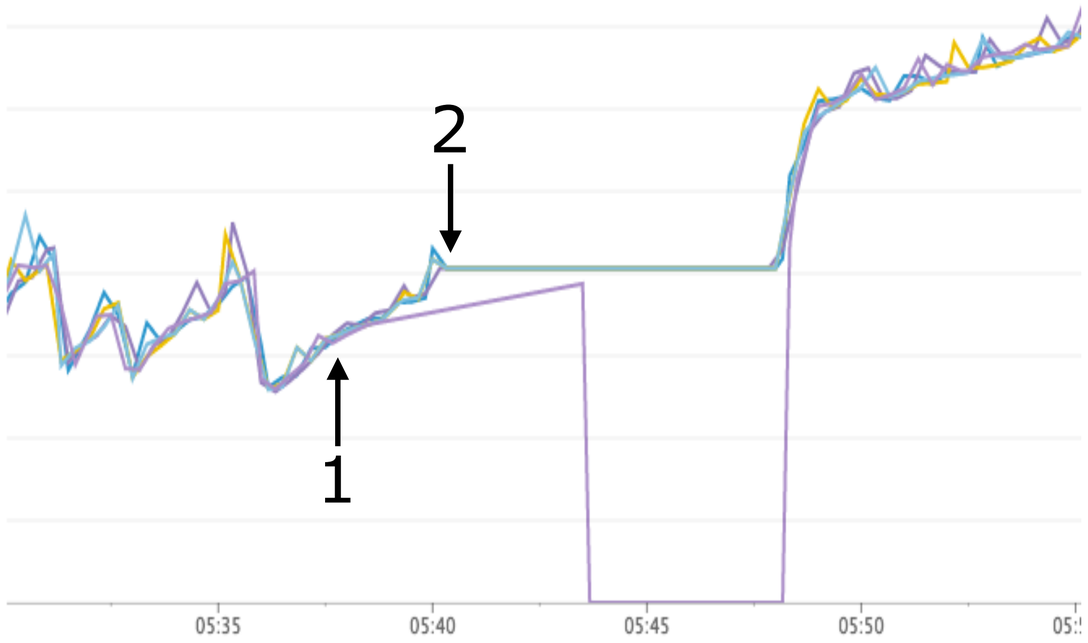
- Distributed system for building distributed systems
- Small in-memory filesystem

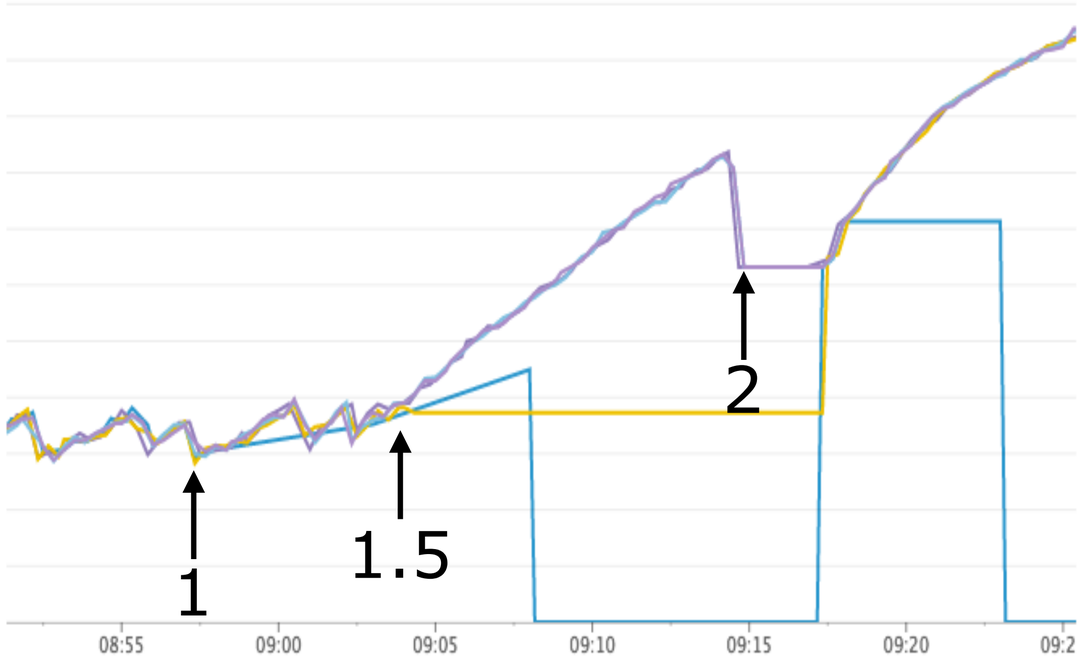
ZooKeeper at PagerDuty

- Distributed locking
- Consistent, highly available

The Failure

- Network trouble, one follower falls behind
- ZooKeeper gets stuck - leader still up





Fault Injection Finding

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  - `sshfs donny@some_server:/home/donny /mnt`
- Similar failure profile

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  - `sshfs donny@some_server:/home/donny /mnt`
- Similar failure profile
- Re-examine disk latency… nope, was a red herring

Deep Health Checks

- First warning: application monitoring
- ZooKeeper: used `ruok`
- Added deep health check

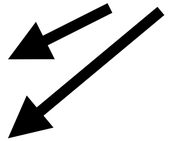
The Stack Trace

```
"LearnerHandler-/123.45.67.89:45874" prio=10 tid=0x00000000024bb800 nid=0x3d0d runnable
[0x00007fe6c3193000]
   java.lang.Thread.State: RUNNABLE
3 → at java.net.SocketOutputStream.socketWrite0(Native Method)
      at java.net.SocketOutputStream.socketWrite(SocketOutputStream.java:113)
      …
      at org.apache.jute.BinaryOutputArchive.writeBuffer(BinaryOutputArchive.java:118)
      …
      at org.apache.jute.BinaryOutputArchive.writeRecord(BinaryOutputArchive.java:123)
      at org.apache.zookeeper.server.DataTree.serializeNode(DataTree.java:1115)
2 → - locked <0x00000000d4cd9e28> (a org.apache.zookeeper.server.DataNode)
      at org.apache.zookeeper.server.DataTree.serializeNode(DataTree.java:1130)
      …
1 → at org.apache.zookeeper.server.ZKDatabase.serializeSnapshot(ZKDatabase.java:467)
      at org.apache.zookeeper.server.quorum.LearnerHandler.run(LearnerHandler.java:493)
```

Write Snapshot Code (simplified)

```
void serializeNode(OutputArchive output, String path) {
    DataNode node = getNode(path);
    String[] children = {};
    synchronized (node) {
        output.writeString(path, "path");
        output.writeRecord(node, "node");
        children = node.getChildren();
    }
    for (String child : children) {
        serializeNode(output, path + "/" + child);
    }
}
```

Blocking network write

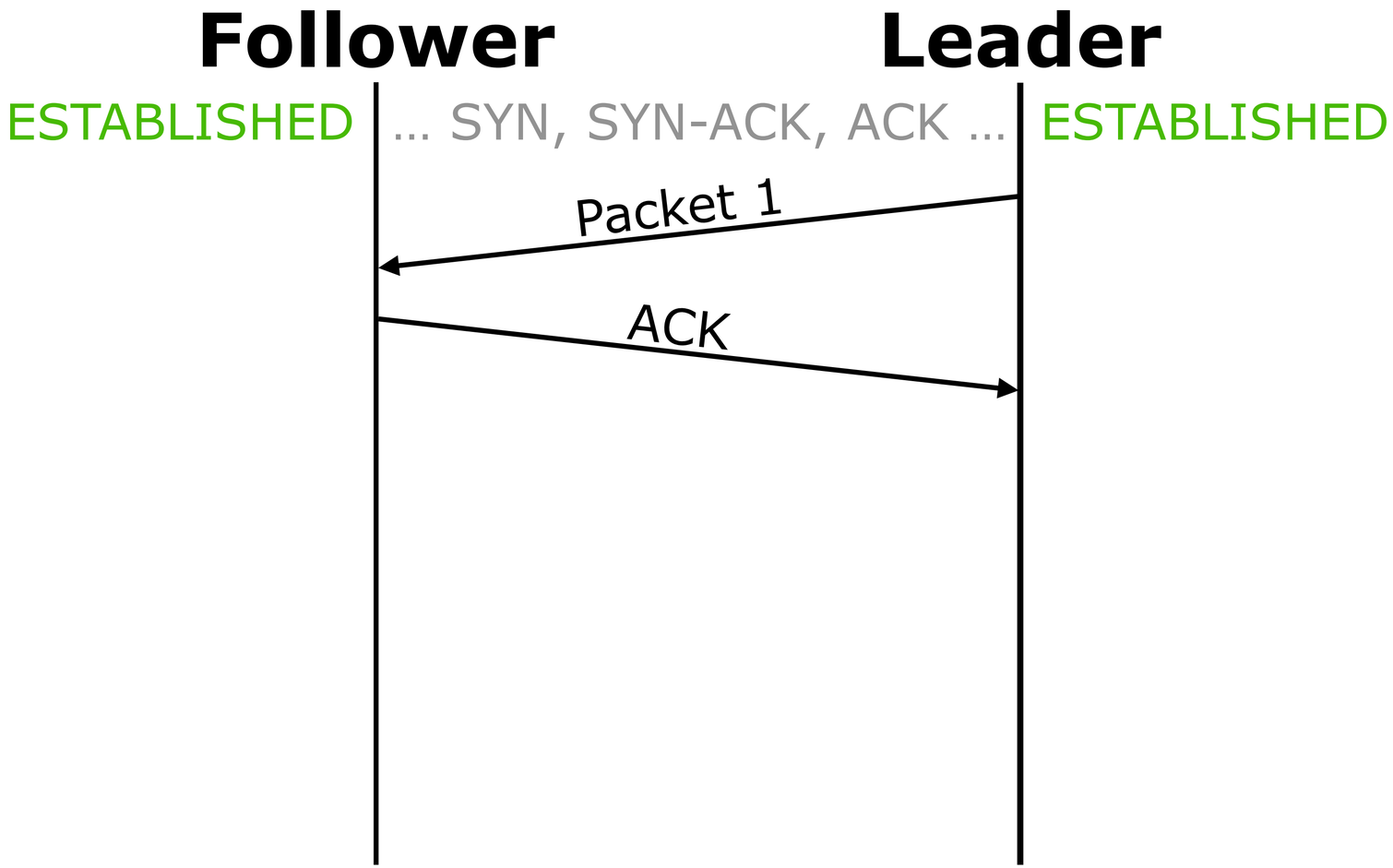


ZooKeeper Heartbeat

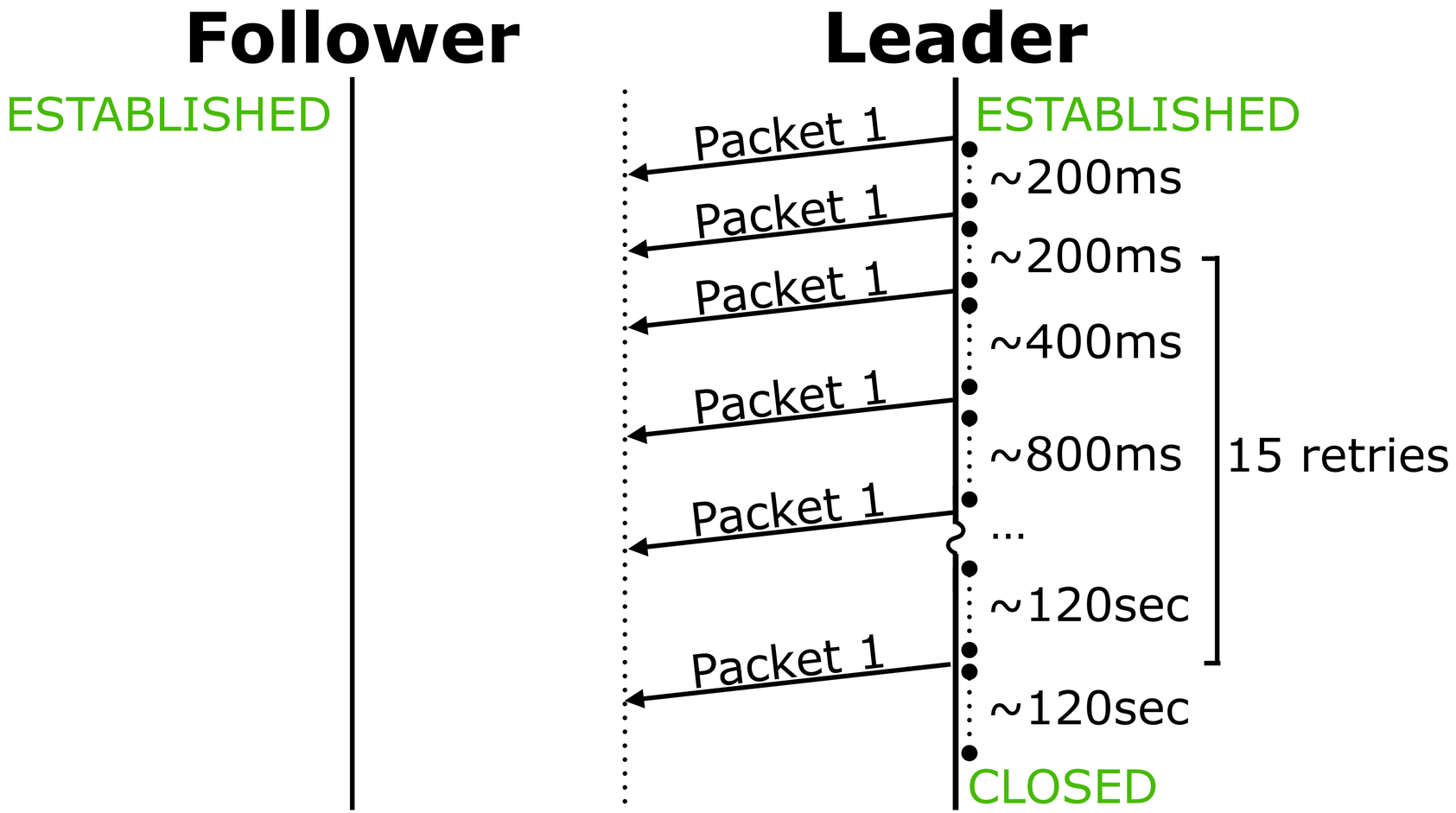
- Why didn’t a follower take over?
- ZK heartbeat: message from leader to follower, follower times out

TCP

TCP Data Transmission



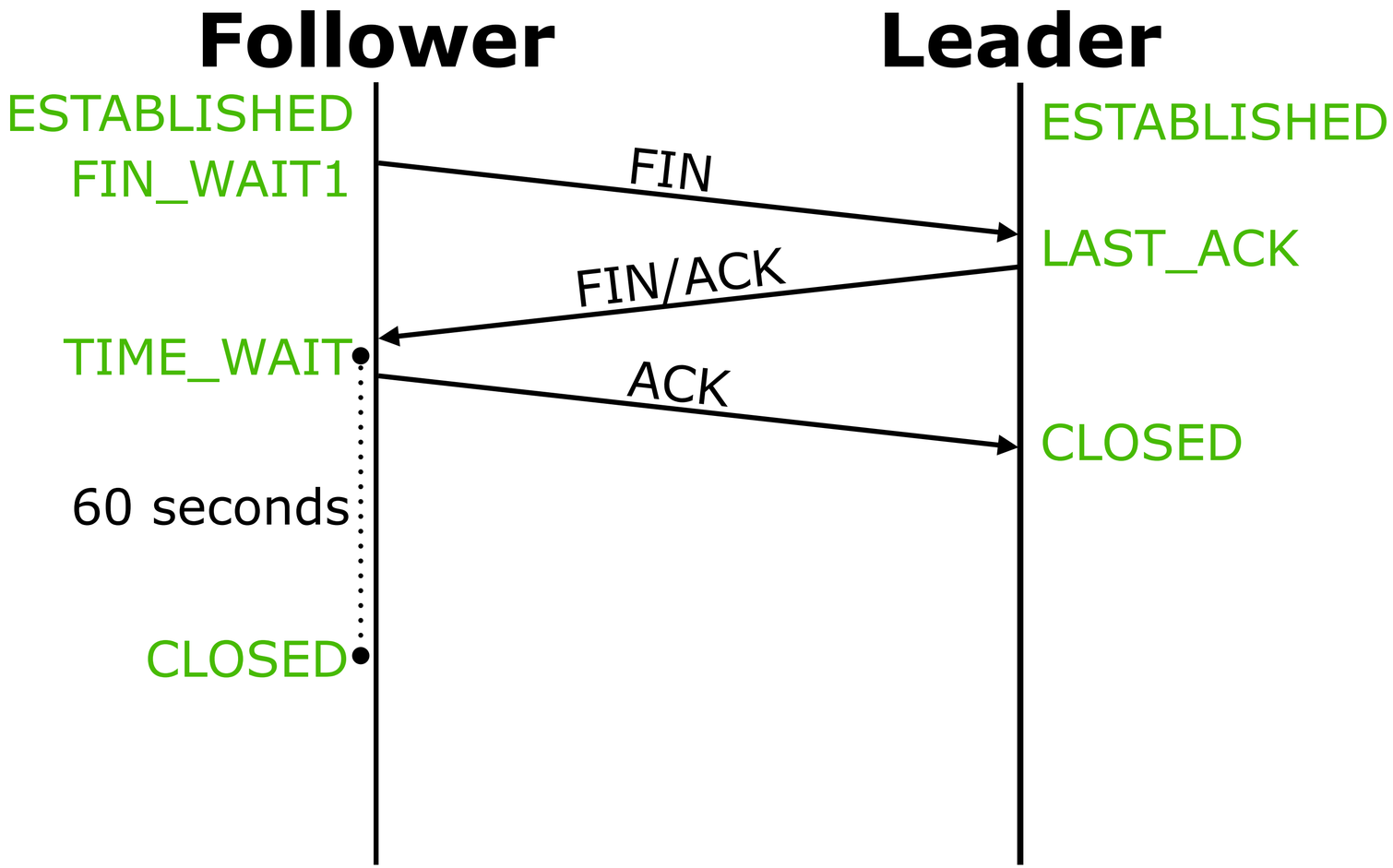
TCP Data Transmission



TCP Retransmission (Linux Defaults)

- Retransmission timeout (RTO) is based on latency
- TCP_RTO_MIN = 200 ms
- TCP_RTO_MAX = 2 minutes
- /proc/sys/net/ipv4/tcp_retries2 = 15 retries
- 0.2 + 0.2 + 0.4 + 0.8 + … + 120 = 924.8 seconds (**15.5 mins**)

TCP Close Connection



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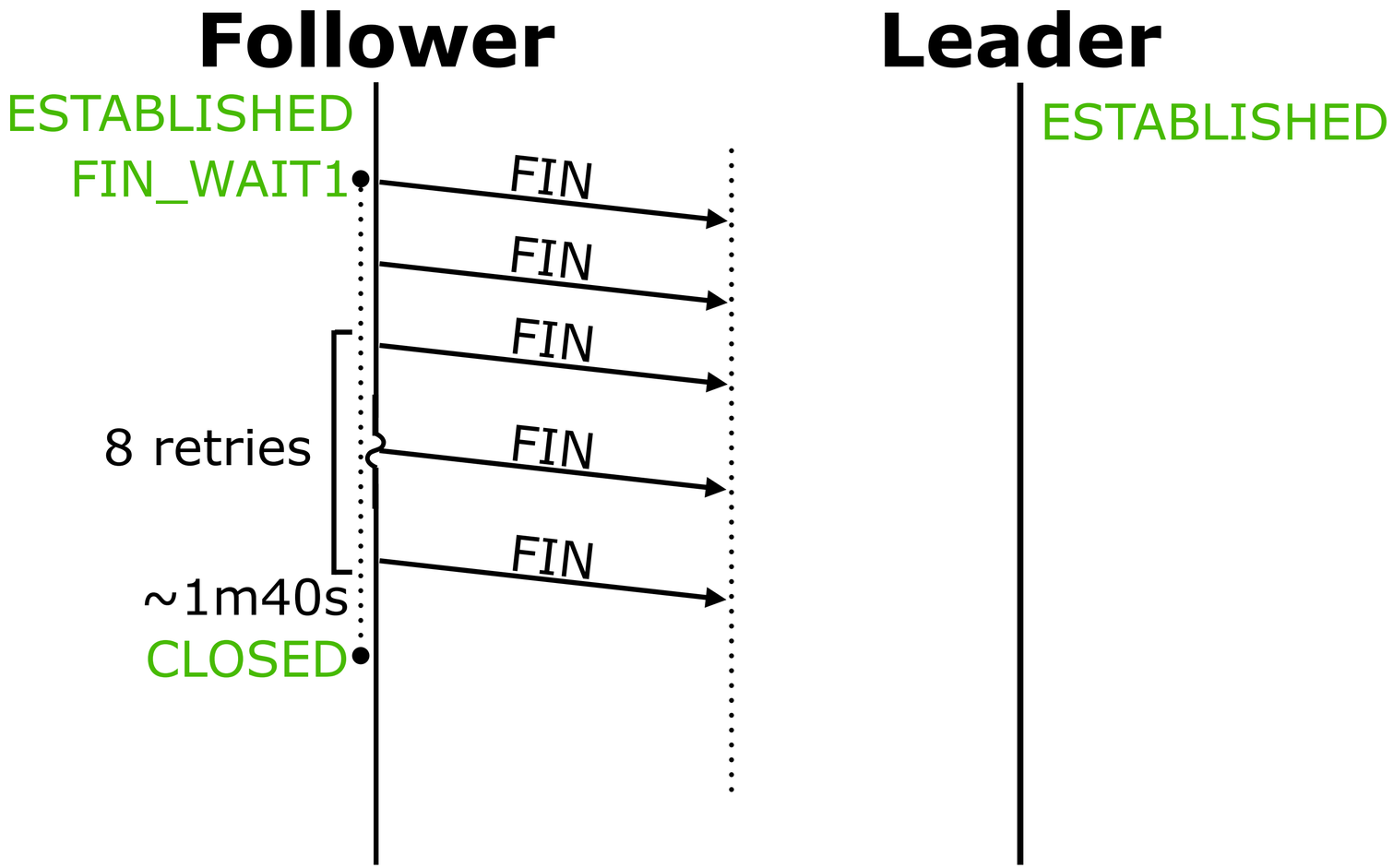

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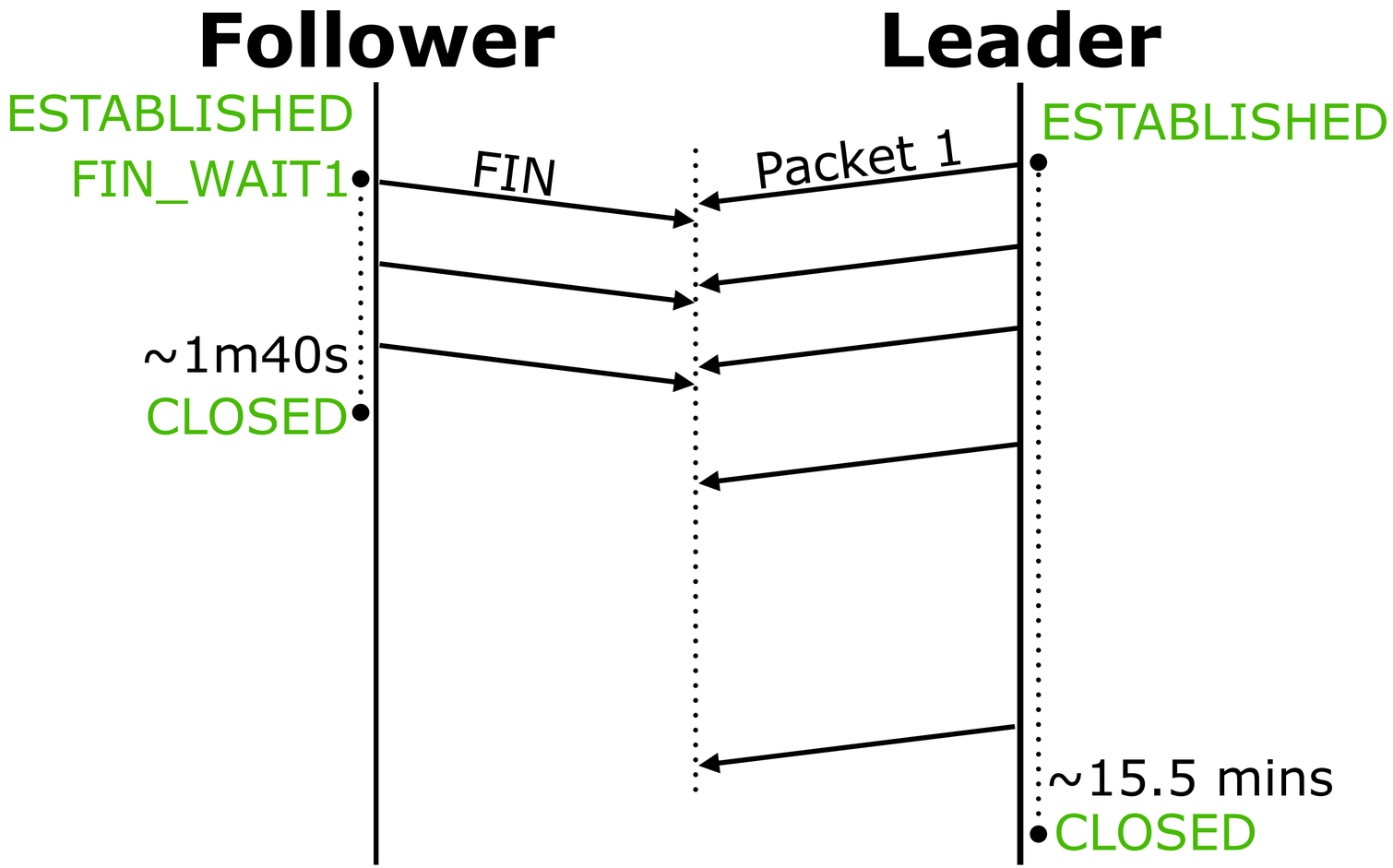

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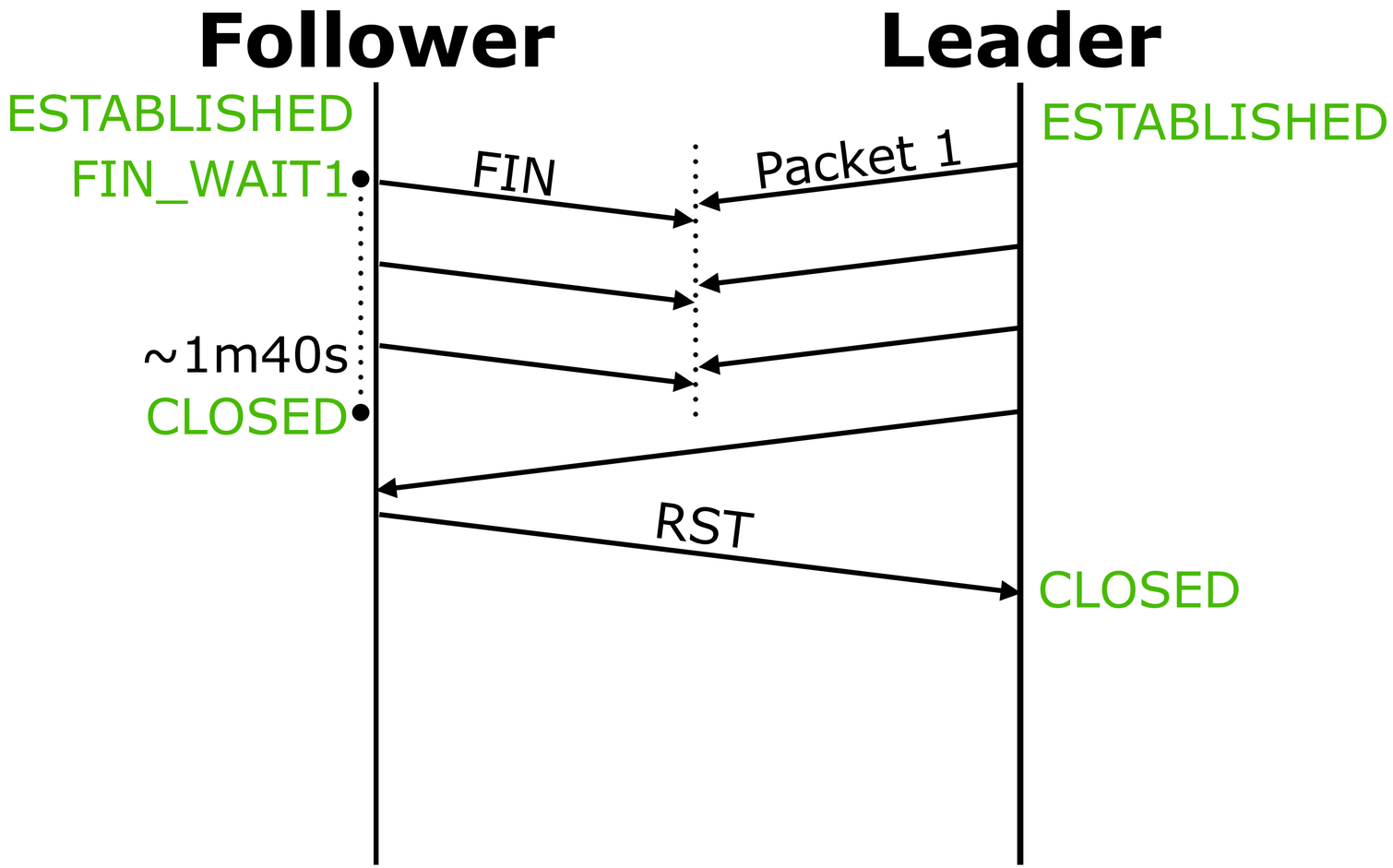

syslog - Dropped Packets on Follower

- 06:51:47 iptables: WARN: IN=eth0 OUT= MAC=00:0d:12:34:56:78:12:34:56:78:12:34:56:78 **SRC=<leader_ip>** **DST=<follower_ip>** LEN=54 TOS=0x00 PREC=0x00 TTL=44 ID=36370 DF PROTO=TCP SPT=3888 DPT=36416 WINDOW=227 RES=0x00 **ACK** **PSH** URGP=0

iptables

```
iptables -A INPUT -m state --state ESTABLISHED,RELATED -j ACCEPT

iptables -A INPUT -p tcp --dport 80 -j ACCEPT
```

... more rules to accept connections ...

```
iptables -A INPUT -j DROP
```

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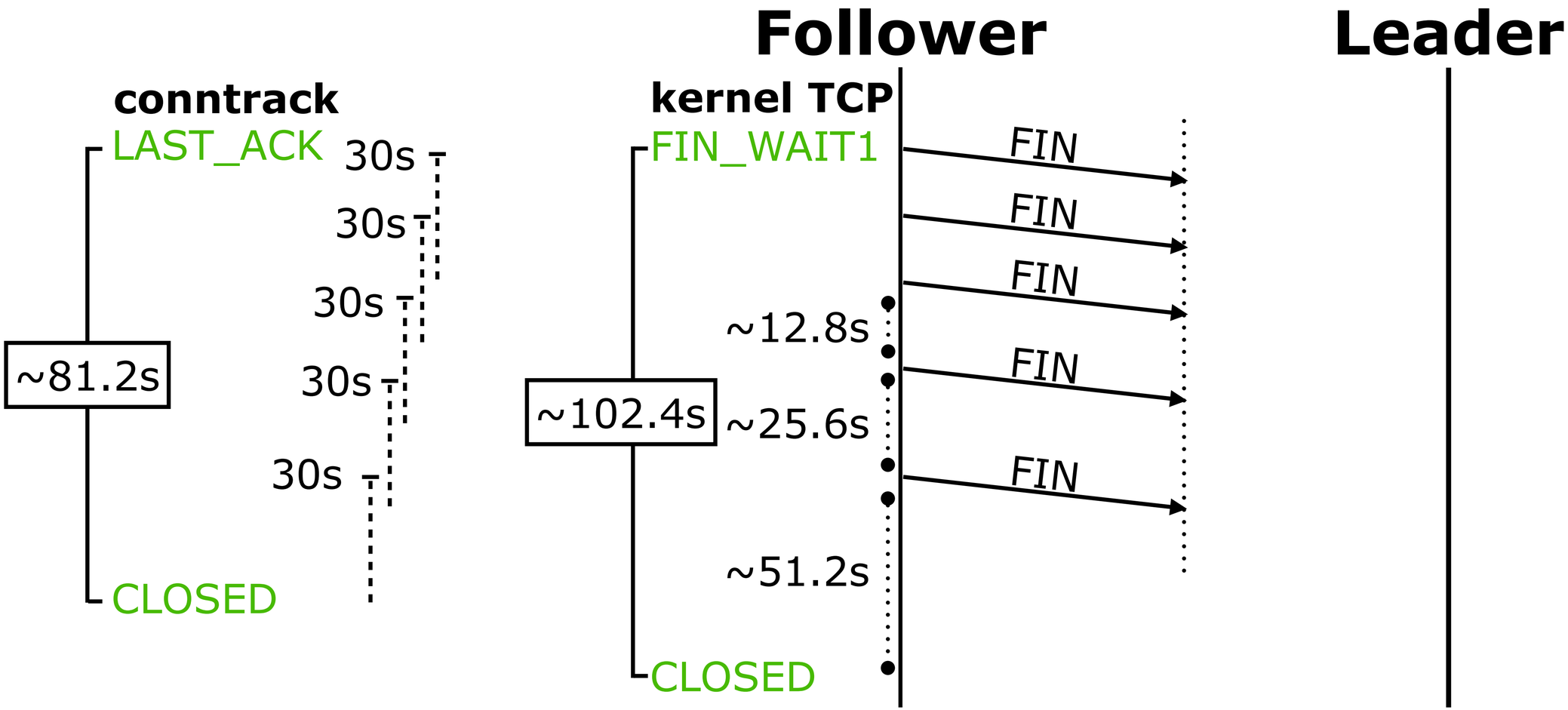
But: iptables connections != netstat connections

conntrack Timeouts

- From `linux/net/netfilter/nf_conntrack_proto_tcp.c`:
- [TCP_CONNTRACK_LAST_ACK] = 30 SECS

TCP Close Connection



The Full Story

- Packet loss
- Follower falls behind, requests snapshot
- (Packet loss continues) follower closes connection
- Follower conntrack forgets connection
- Leader now stuck for ~15 mins, even if network heals

Lessons

Lesson 1

- Don’t lock and block
- TCP can block for a *really* long time
- Interfaces / abstract methods make analysis harder

Lesson 2

- Leader/follower heartbeats should be deep health checks!

Questions?

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Link:

“Network issues can cause cluster to hang due to near-deadlock”
https://issues.apache.org/jira/browse/ZOOKEEPER-2201