漫谈以太坊公链安全

罗元琮　　PeckShield 漏洞研究總监

ISC 互联网安全大会 中国 · 北京
Internet Security Conference 2018　Beijing · China

About Me

罗元琮 (Edward)

- Director of Vulnerability Research at PeckShield
- Has extensive experiences in OS kernel layer with deep knowledge in advanced vulnerability discovery and exploitation
- Before joining PeckShield, I worked for Qihoo 360 as the team lead of C0RE Team, which was recognized by Google as the top research team in 2017. I am now focusing on the security of blockchain infrastructure
- Submitted several vulnerabilities to the Ethereum Foundation

Blockchain Status Quo

ETHEREUM IN 2017

1,090 Dapps & 700+ Tokens

100,000 New Users Per Day

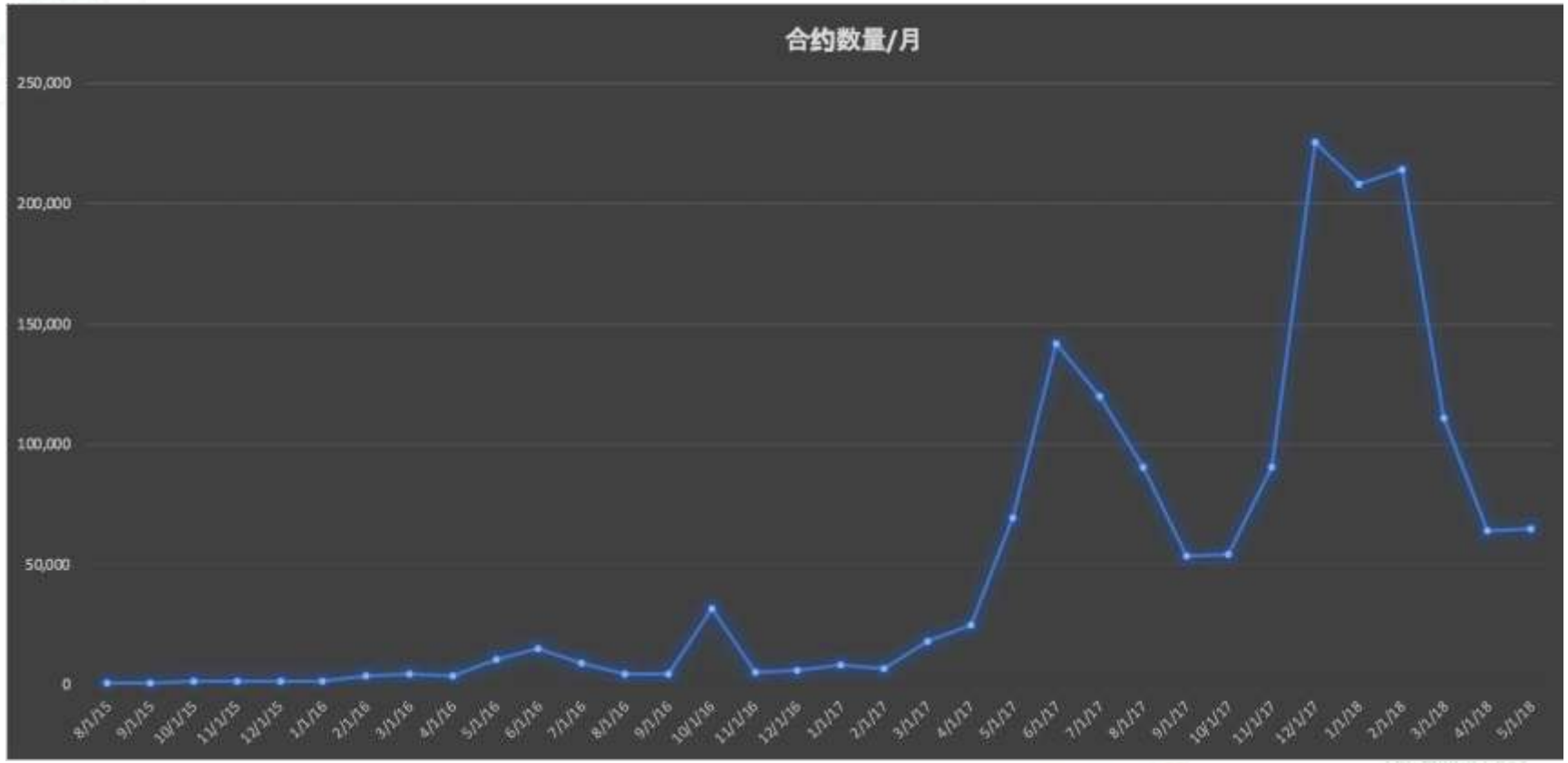
Daily Trading > 1,000,000

MARKET CAP IN 2018

1,845 Cryptocurrencies

Market Cap > 200 Billion

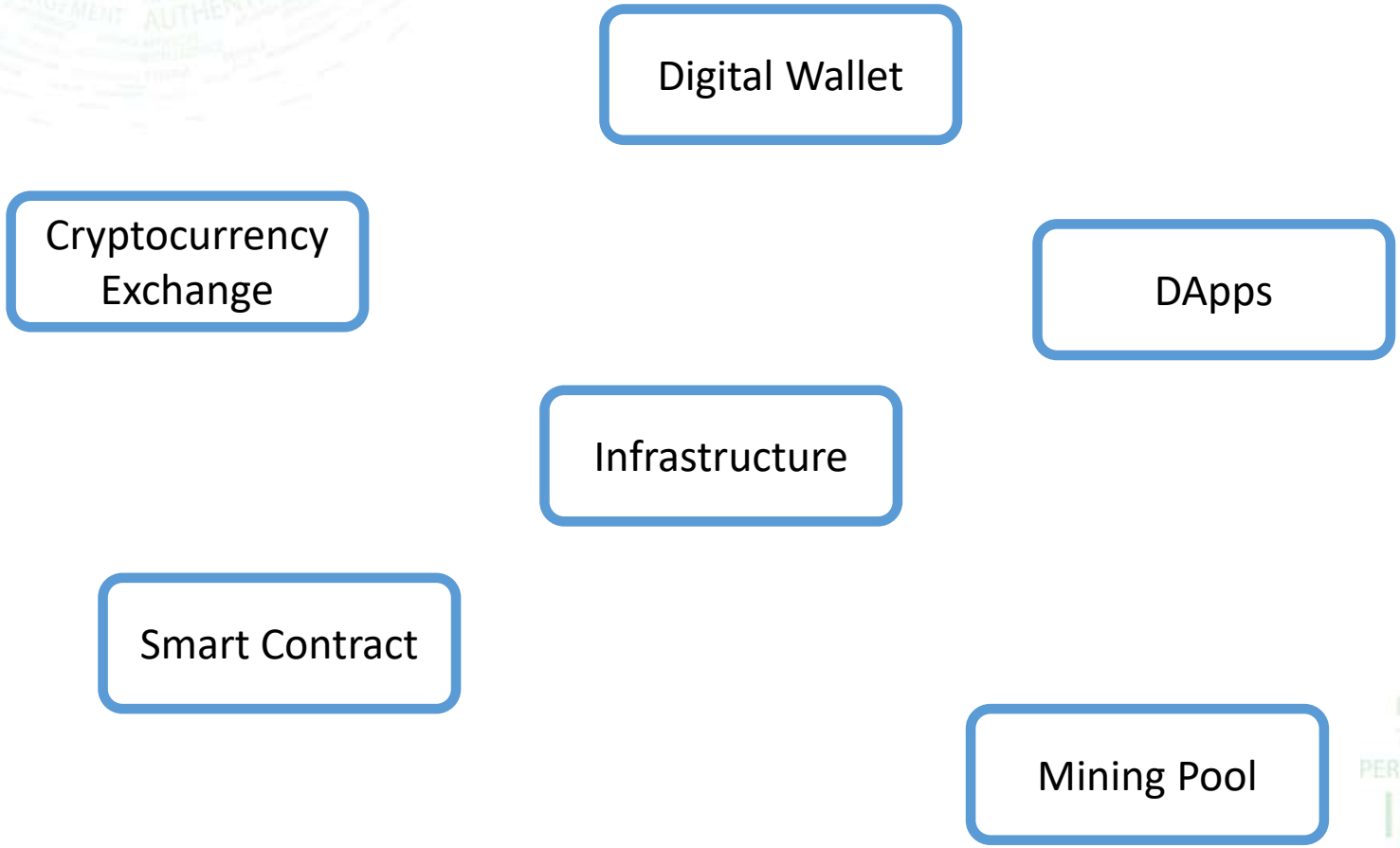
Global GDP Rank: ~50th



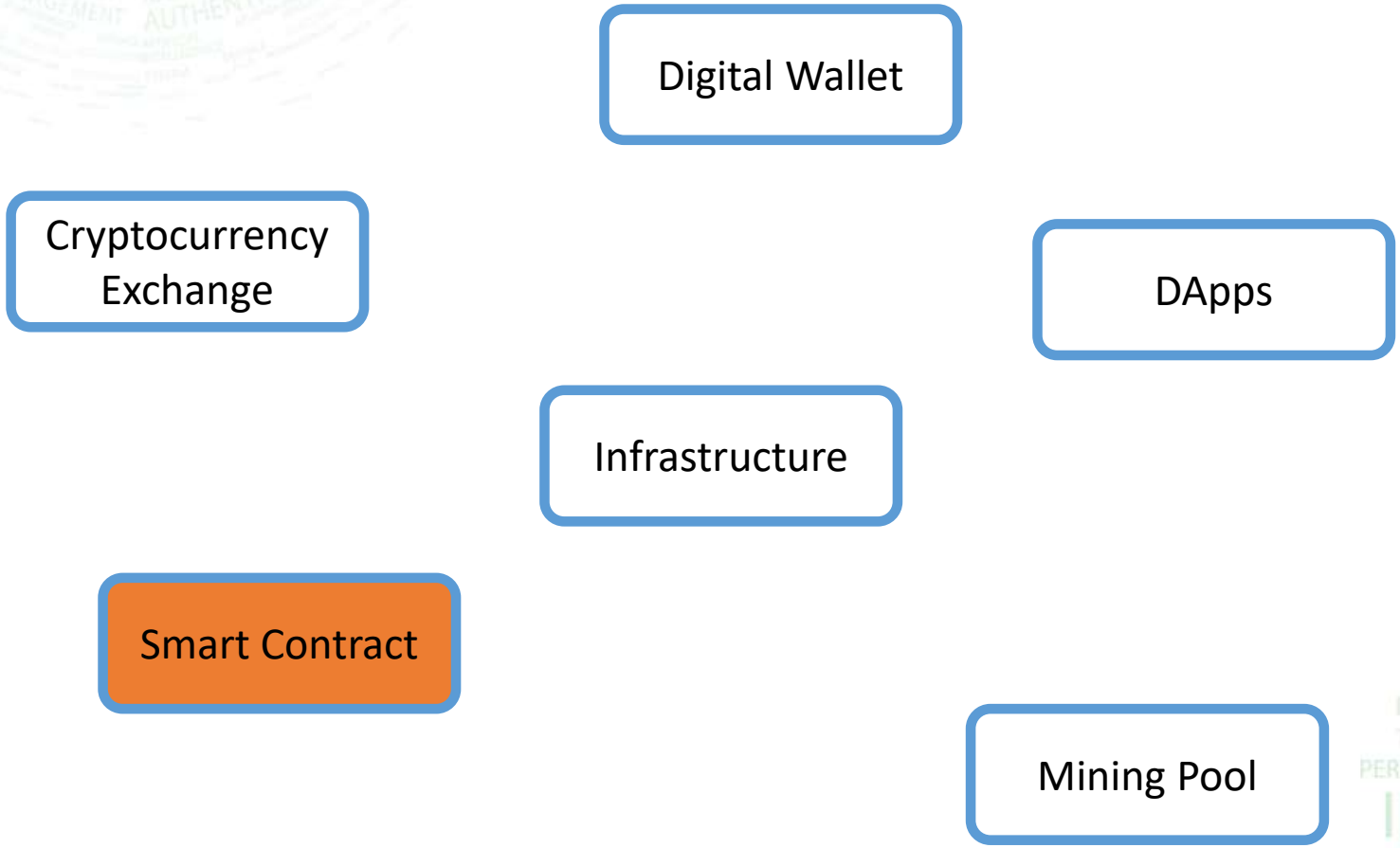
Security Incidents

2018/06	Bithumb Hacks with $31 Million Dollars Stolen
2018/05	EDU, BAIC Smart Contracts Bugs
2018/04	BEC, SMT Smart Contracts Bugs
2018/04	Myetherwallet Suffer from DNS Hijacking
2018/02	BitGrail Hacks with Stolen Nano Tokens of 170 Million Dollars
2018/01	Coincheck Hacks with 530 Million Dollars Stolen
2017/12	Nicehash Hacks with 4700 BTC Missing with 62 Million Dollars
2017/06	Bithumb Hacks with 1 Billion Korean Yuan Loss and 30 Thousand User Info. Leaked
2016/08	Bitfinex Hacks with 120,000 BTC Stolen of 75Million Dollars
2016/01	Cryptsy Hacks with 13,000 BTC and 300,000 LTC Stolen
2015/01	Bitstamp Hacks with 19,000 BTC Stolen
2014/03	Poloniex Hacks with 12.3% BTC Lost
2014/02	Mt.Gox Hacks with Followed Bankruptcy

Blockchain Ecosystem



Blockchain Ecosystem



Security of Smart Contracts

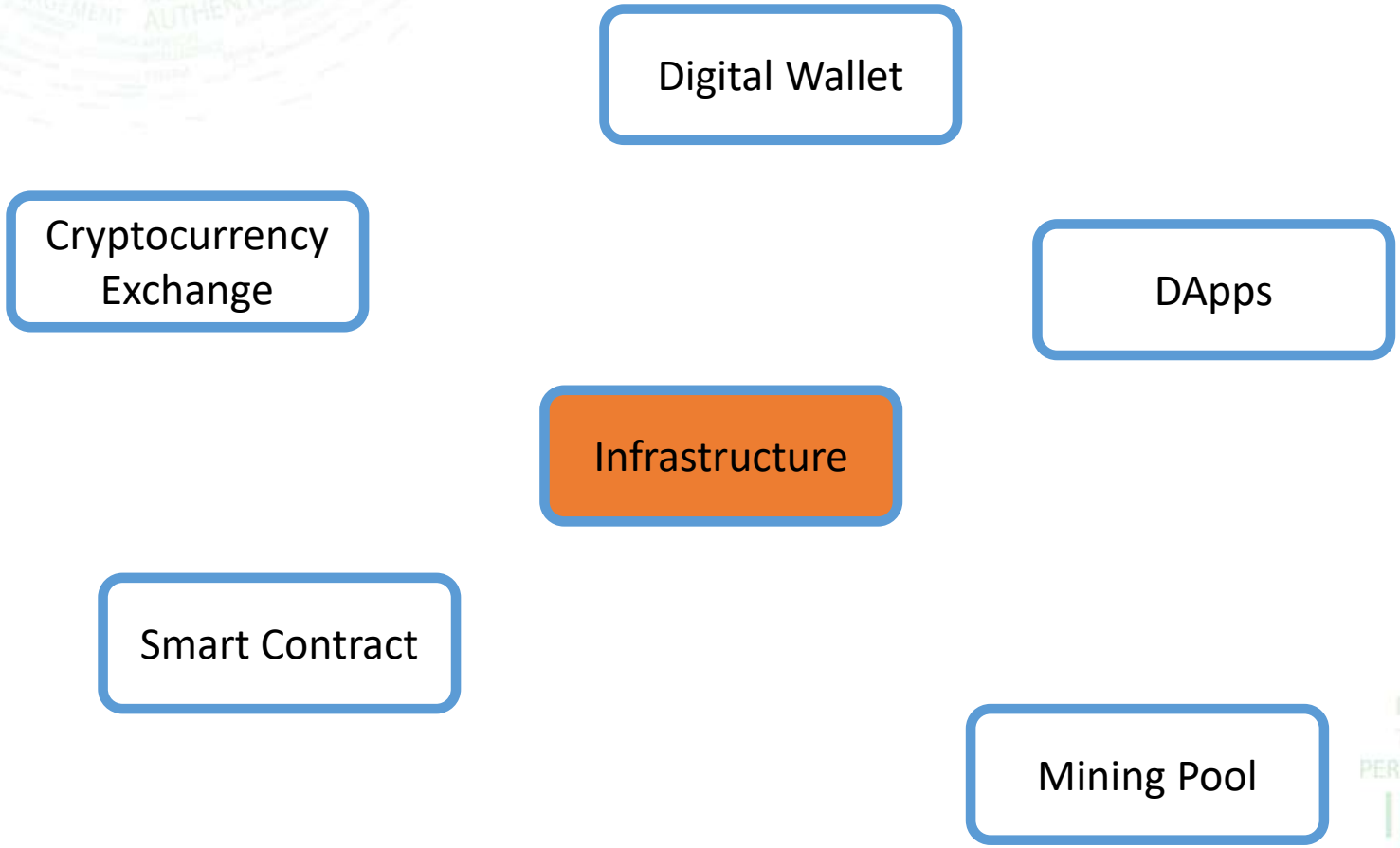
Disclosed by PeckShield	
codename	CVE-ID
batchOverflow	CVE-2018-10299
proxyOverflow	CVE-2018-10376
transferFlaw	CVE-2018-10468
ownerAnyone	CVE-2018-10705
multiOverflow	CVE-2018-10706
burnOverflow	CVE-2018-11239
ceoAnyone	CVE-2018-11329
allowAnyone1	CVE-2018-11397
allowAnyone2	CVE-2018-11398
tradeTrap1	CVE-2018-12017
tradeTrap2	CVE-2018-12062
tradeTrap3	CVE-2018-12079
...	...

Security of Smart Contracts

Blog | Research | Advisories | About

- CVE-2018-12105 - New transferFlaw Bug Identified in an ERC20-Based Smart Contract
- CVE-2018-12084 - New tradeTrap Bug Identified in BitAsean (BAS) Smart Contract
- CVE-2018-12083 - New tradeTrap Bug Identified in GOAL Bonanza (GOAL) Smart Contract
- CVE-2018-12082 - New tradeTrap Bug Identified in Fujinto (NTO) Smart Contract
- CVE-2018-12081 - New tradeTrap Bug Identified in Target Coin (TGT) Smart Contract
- CVE-2018-12080 - New tradeTrap Bug Identified in Internet Node Token (INT) Smart Contract
- CVE-2018-12079 - New tradeTrap Bug Identified in Substratum (SUB) Smart Contract
- CVE-2018-12078 - New tradeTrap Bug Identified in PolyAI (AI) Smart Contract
- CVE-2018-12063 - New tradeTrap (Overflow) Bug Identified in Internet Node Token (INT) Smart Contract
- CVE-2018-12062 - New tradeTrap Bug Identified in SwftCoin (SWFTC) Smart Contract
- CVE-2018-12018 - New Out-of-Bound Access Bug Identified in an Ethereum Client
- CVE-2018-12017 - New tradeTrap Bug Identified in hotchain.io (HCH) Smart Contract
- CVE-2018-11673 - New Memory Leak Bug Identified in an Ethereum Client
- CVE-2018-11585 - New ctorMismatch Bug Identified in MORPH (MORPH) Smart Contract
- CVE-2018-11582 - New balanceAnyone Bug Identified in an ERC20-Based Smart Contract
- CVE-2018-11561 - New distributeFlaw Bug Identified in Multiple ERC20-Based Smart Contracts
- CVE-2018-11446 - New tradeTrap Bug Identified in an ERC20-Based Smart Contract
- CVE-2018-11441 - New tradeTrap Bug Identified in an ERC20-Based Smart Contract

Blockchain Ecosystem



Ethereum Clients

ETHEREUM CLIENTS

geth (golang)

aleth (c++)

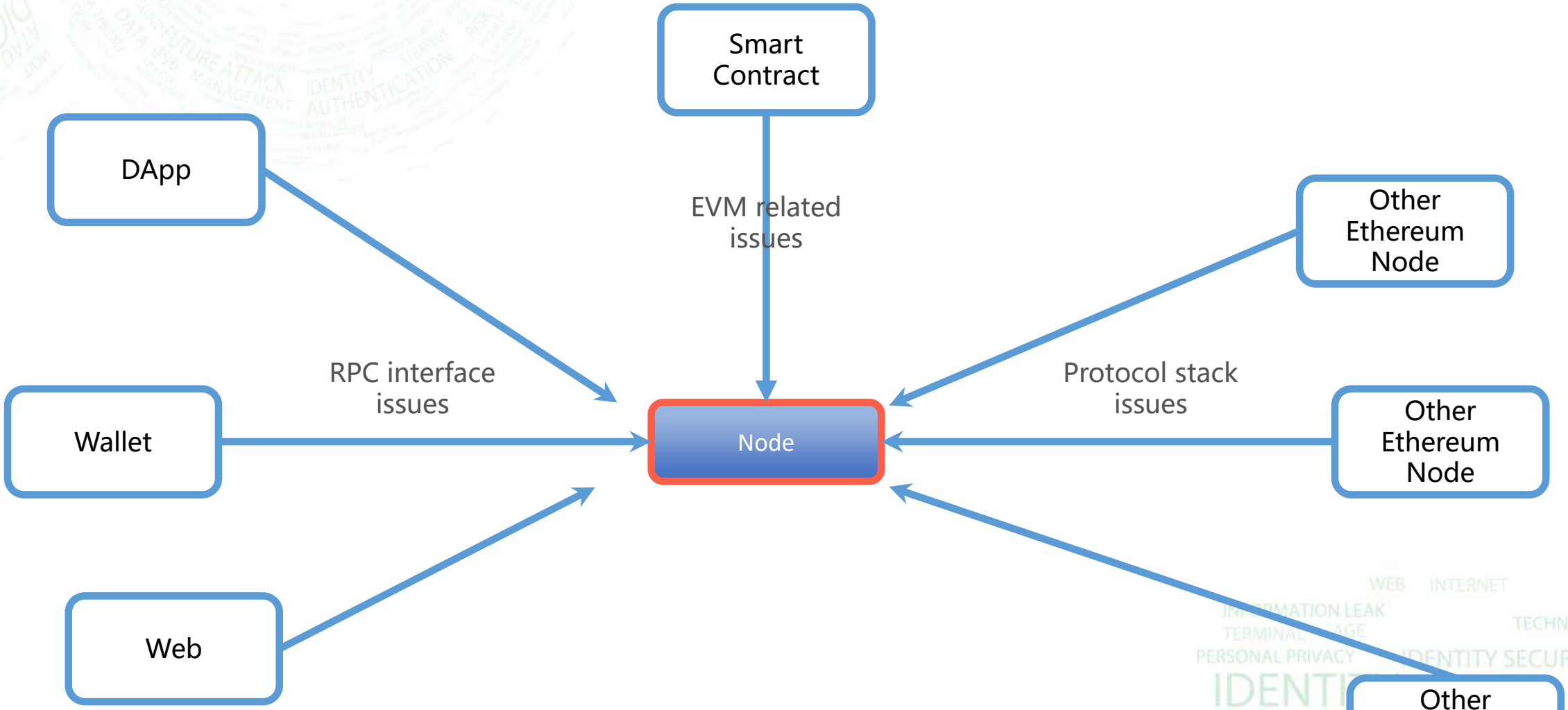
Parity (Rust) – by Parity Technologies

MARKET SHARE

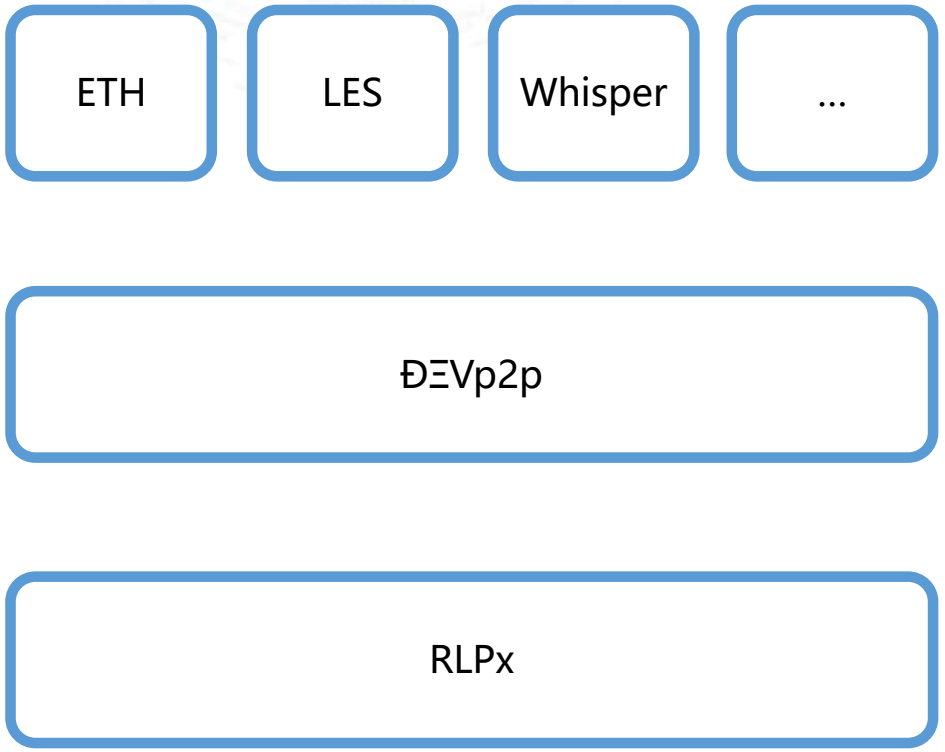
geth ~2/3

parity ~1/3

Attack Surfaces of a Node

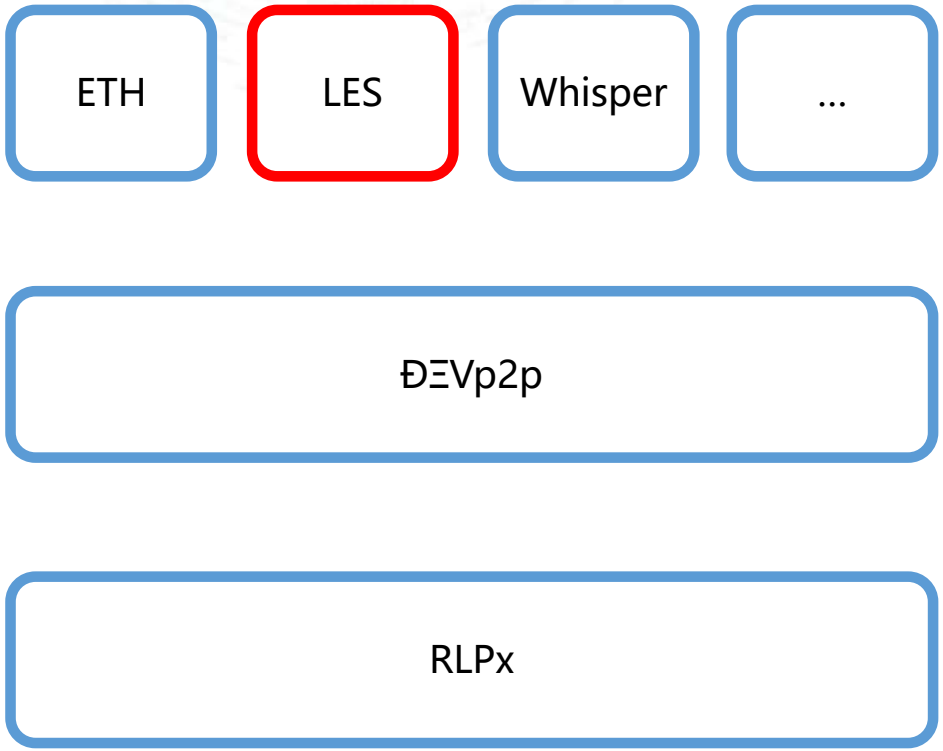


Ethereum Protocol Stack



- Various Sub-protocols
- Support arbitrary sub-protocols (aka capabilities) over the basic wire protocol
- Connection management
- Encrypted Handshake/Authentication
- Peer Persistence
- UDP Node Discovery Protocol

EPoD: CVE-2018-12018



- Various Sub-protocols

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EPoD: CVE-2018-12018

LIGHT ETHEREUM SUBPROTOCOL

- used by "light" clients, which only download block headers as they appear and fetch other parts of the on-demand
- do not mine and therefore do not take part in the consensus process
- Several message handlers for different types of messages
  - StatusMsg, AnnounceMsg, GetBlockBodiesMsg, GetBlockHeadersMsg

```
// getBlockHeadersData represents a block header query.
type getBlockHeadersData struct {
        Origin  hashOrNumber // Block from which to retrieve headers
        Amount  uint64       // Maximum number of headers to retrieve
        Skip    uint64       // Blocks to skip between consecutive headers
        Reverse bool         // Query direction (false = rising towards latest
}
```

```
// hashOrNumber is a combined field for specifying an origin block.
type hashOrNumber struct {
        Hash   common.Hash // Block hash from which to retrieve headers (excludes Number)
        Number uint64      // Block hash from which to retrieve headers (excludes Hash)
}
```

EPoD: CVE-2018-12018


```
// Retrieve the next header satisfying the query
var origin *types.Header
if hashMode {
        origin = pm.blockchain.GetHeaderByHash(query.Origin.Hash)
} else {
        origin = pm.blockchain.GetHeaderByNumber(query.Origin.Number)
}
if origin == nil {
        break
}
```

```
case query.Origin.Hash != (common.Hash{}) && !query.Reverse:
        // Hash based traversal towards the leaf block
        if header := pm.blockchain.GetHeaderByNumber(origin.Number.Uint64() + query.Skip + 1); header != nil {
                if pm.blockchain.GetBlockHashesFromHash(header.Hash(), query.Skip+1)[query.Skip] == query.Origin.Hash {
                        query.Origin.Hash = header.Hash()
                } else {
                        unknown = true
                }
        } else {
                unknown = true
        }
```

EPoD: CVE-2018-12018


```
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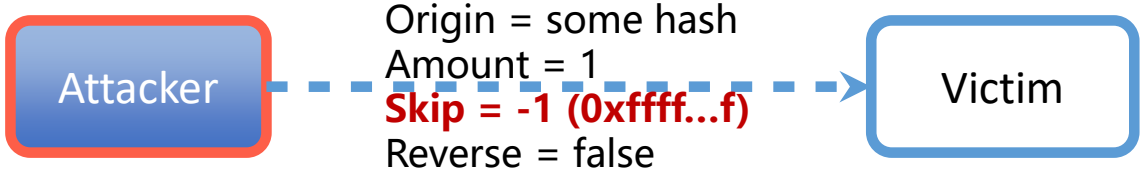


1. Allocate array for max # of blocks
   - allocate (Skip+1):
     Zero-Size Array Allocated

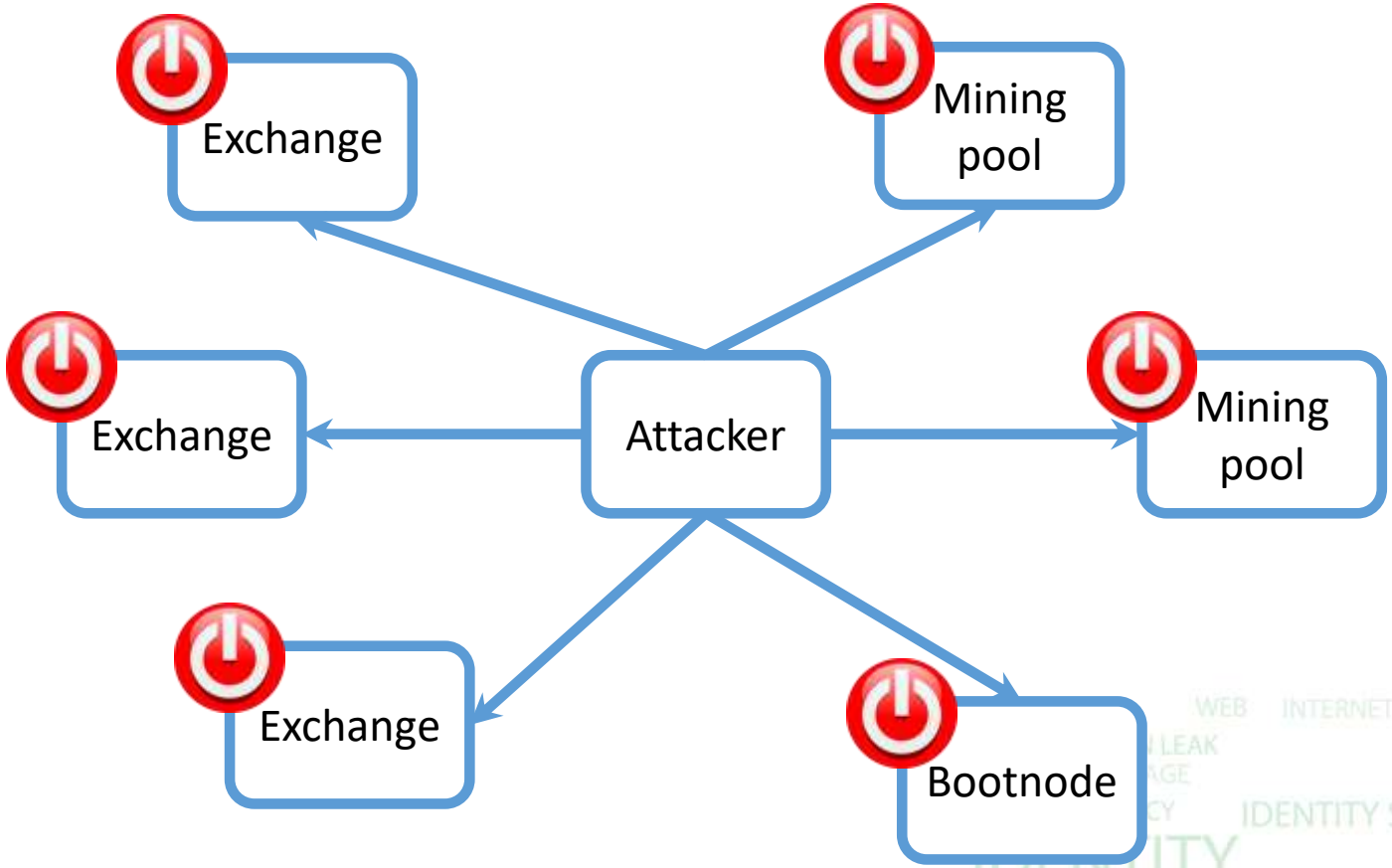
2. Query from returned array[Skip]
   - Access array[-1]:
     Out-of-Bound Read

DEMO

Possible Impacts

POSSIBLE VICTIMS

- Cryptocurrency exchanges
- Mining pools
- Bootnodes



EPoD Patch


```
var (
        current = origin.Number.Uint64()
        next    = current + query.Skip + 1
)
if next <= current {
        infos, _ := json.MarshalIndent(p.Peer.Info(), "", "  ")
        p.Log().Warn("GetBlockHeaders skip overflow attack", "c
        unknown = true
```

EPoD2: CVE-2018-12567


```
case AnnounceMsg:
        ...

        var req announceData
        if err := msg.Decode(&req); err != nil {
                return errResp(ErrDecode, "%v: %v", msg, err)
        }

        ...

        if pm.fetcher != nil {
                pm.fetcher.announce(p, &req)
        }
```

```
// announceData is the network packet for the block announcements.
type announceData struct {
        Hash        common.Hash // Hash of one particular block being announced
        Number      uint64      // Number of one particular block being announced
        Td          *big.Int    // Total difficulty of one particular block being announced
        ReorgDepth uint64
        Update      keyValueList
}
```

EPoD2: CVE-2018-12567


```
func (f *lightFetcher) announce(p *peer, head *announceData) {
        ...

        fp := f.peers[p]
        ...

        n := fp.lastAnnounced
        ...
        if n != nil {
                // n is now the reorg common ancestor, add a new branch of nodes
                // check if the node count is too high to add new nodes
                locked := false
                for uint64(fp.nodeCnt)+head.Number-n.number > maxNodeCount && fp.root != nil {
                        ...
                }
                if n != nil {
                        for n.number < head.Number {
                                nn := &fetcherTreeNode{number: n.number + 1, parent: n}
                                n.children = append(n.children, nn)
                                n = nn
                                fp.nodeCnt++
                        }
                        n.hash = head.Hash
                        n.td = head.Td
                        fp.nodeByHash[n.hash] = n
                }
        }
```

EPoD2: CVE-2018-12567


```
// announceData is the network packet for the block announcements.
type announceData struct {
        Hash        common.Hash // Hash of one particular block being announced
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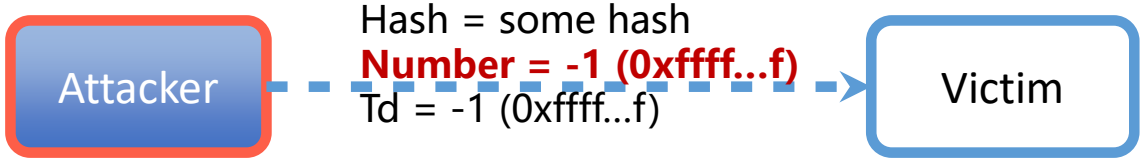
```



- for n < head.Number
  - Allocate fetcherTreeNode
  - Append to n.children
  - Out-of-memory

DEMO

EPoD2 Patch


```
+       // n is now the reorg common ancestor, add a new branch of nodes
+       if n != nil && (head.Number >= n.number+maxNodeCount || head.Number <= n.number) {
+               // if announced head block height is lower or same as n or too far from it to add
+               // intermediate nodes then discard previous announcement info and trigger a resync
+               n = nil
+               fp.nodeCnt = 0
+               fp.nodeByHash = make(map[common.Hash]*fetcherTreeNode)
+       }
        if n != nil {
```

Freether: CVE-2018-11673

- Various Sub-protocols
- Support arbitrary sub-protocols (aka capabilities) over the basic wire protocol
- Connection management
- Encrypted Handshake/Authentication
- Peer Persistence
- UDP Node Discovery Protocol

Freether: CVE-2018-11673

NODE DISCOVERY PROTOCOL

- Aimed at discovering RLPx nodes to connect to
- UDP-based RPC protocol (kademlia-like)
- Defines 4 packet types: ping, pong, findnode and neighbors

```
func (t *udp) handlePacket(from *net.UDPAddr, buf []byte) error {
        packet, fromID, hash, err := decodePacket(buf)
        if err != nil {
                log.Debug("Bad discv4 packet", "addr", from, "err", err)
                return err
        }
        err = packet.handle(t, from, fromID, hash)
        log.Trace("<< "+packet.name(), "addr", from, "err", err)
        return err
}
```

Freether: CVE-2018-11673


```
ping struct {
        Version    uint
        From, To   rpcEndpoint
        Expiration uint64
        // Ignore additional fields (for forward compatibility).
        Rest []rlp.RawValue `rlp:"tail"`
}
```

```
func (req *ping) handle(t *udp, from *net.UDPAddr, fromID NodeID, mac []byte) error {
        if expired(req.Expiration) {
                return errExpired
        }
        t.send(from, pongPacket, &pong{
                To:         makeEndpoint(from, req.From.TCP),
                ReplyTok:   mac,
                Expiration: uint64(time.Now().Add(expiration).Unix()),
        })
        if !t.handleReply(fromID, pingPacket, req) {
                // Note: we're ignoring the provided IP address right now
                go t.bond(true, fromID, from, req.From.TCP)
        }
        return nil
}
```

Freether: CVE-2018-11673

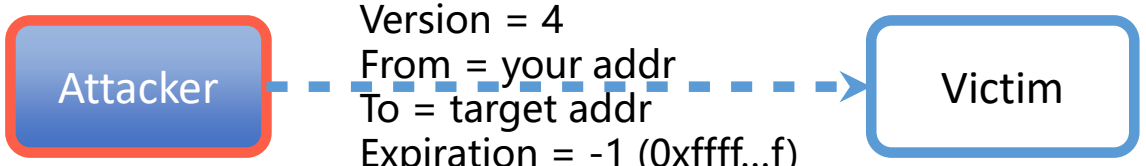
```
node, fails := tab.db.node(id), tab.db.findFails(id)
age := time.Since(tab.db.bondTime(id))
var result error
if fails > 0 || age > nodeDBNodeExpiration {

        tab.bondmu.Lock()
        w := tab.bonding[id]
        if w != nil {
                // Wait for an existing bonding process to complete.
                tab.bondmu.Unlock()
                <-w.done
        } else {
                // Register a new bonding process.
                w = &bondproc{done: make(chan struct{})}
                tab.bonding[id] = w
                tab.bondmu.Unlock()
                // Do the ping/pong. The result goes into w.
                tab.pingpong(w, pinged, id, addr, tcpPort)
                // Unregister the process after it's done.
                tab.bondmu.Lock()
                delete(tab.bonding, id)
                tab.bondmu.Unlock()
        }
        // Retrieve the bonding results
        result = w.err
        if result == nil {
                node = w.n
        }
}
```

Freether: CVE-2018-11673

```
// Request a bonding slot to limit network usage
<-tab.bondslots
defer func() { tab.bondslots <- struct{}{} }()
```

```
ping struct {
        Version    uint
        From, To   rpcEndpoint
        Expiration uint64
        // Ignore additional fields (for forward compatibility).
        Rest []rlp.RawValue `rlp:"tail"`
}
```



1. Generate many key pairs
2. Sign the ping packets with each private key
3. Flood the victim with many ping packets
4. Each ping will consume a goroutine resource after 16 pending ping requests

DEMO

Freether Patch


```
+       // Add the node to the table. Before doing so, ensure that we have a recent enough pong
+       // recorded in the database so their findnode requests will be accepted later.
+       n := NewNode(fromID, from.IP, uint16(from.Port), req.From.TCP)
+       if time.Since(t.db.lastPongReceived(fromID)) > nodeDBNodeExpiration {
+               t.sendPing(fromID, from, func() { t.addThroughPing(n) })
+       } else {
+               t.addThroughPing(n)
        }
+       t.db.updateLastPingReceived(fromID, time.Now())
```

Conclusion

- Blockchian can’ t function without the fundamental components
  - Infrastructure (nodes)
  - Mining pool
  - …
- Vulnerability could exist in any aspects of the blockchain ecosystem
  - EPoD / EPoD2
  - Freether
- Some suggestions
  - Smart contract audit before going online
  - Security response after going online
  - Community / Bounty Program

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谢 谢！

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