Validator Architecture

March 24th

PRYSM

A Product of Offchain Labs

Quick Intro

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Prysm Team @ Offchain Labs

Prev: JPMC

Refresher

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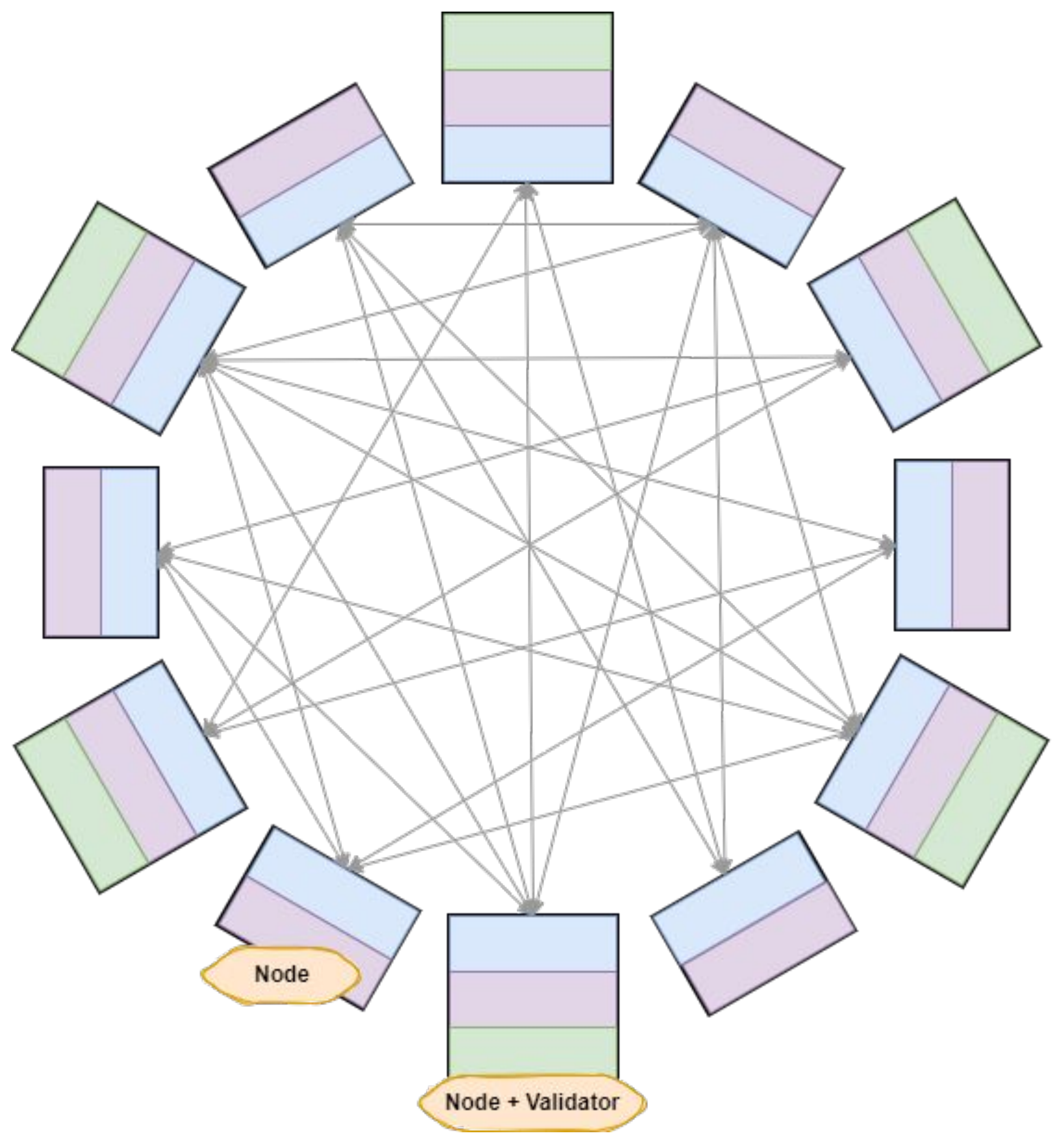
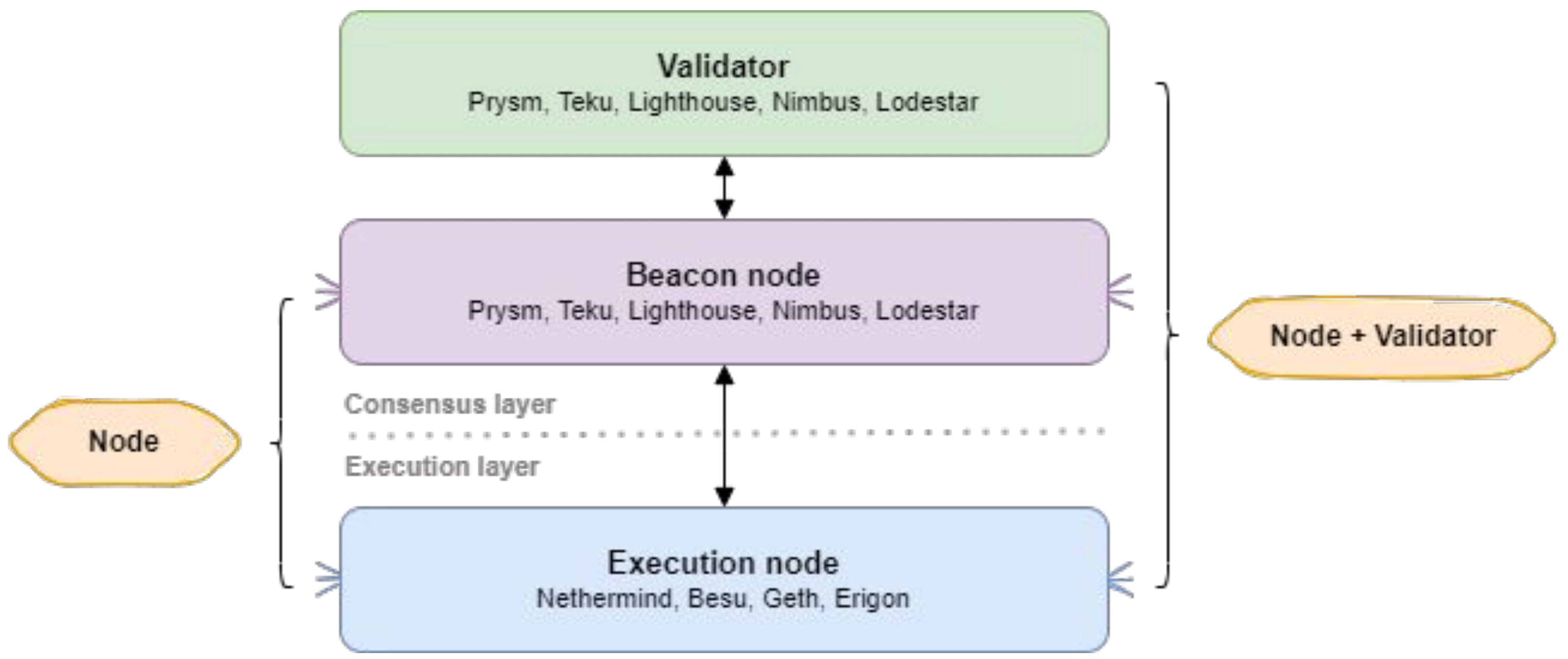
Ethereum Node Architecture




Validator
Prysm, Teku, Lighthouse, Nimbus, Lodestar
Beacon node
Prysm, Teku, Lighthouse, Nimbus, Lodestar
Consensus layer
Execution layer
Execution node
Nethermind, Besu, Geth, Erigon
Node
Node + Validator

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Purpose of the validator client

1. **Manage/Use** your validator **keystores**

- Import
- Backup
- Edit settings
- Sign
- Remove
- Slashing Protection
- ...

- JSON files that store your public and private validator key information
- Generated from the deposit CLI

2. Perform validator **protocol duties**

- Propose blocks
- Attest
- Aggregate
- Sync Committee

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Prysm Validator Client

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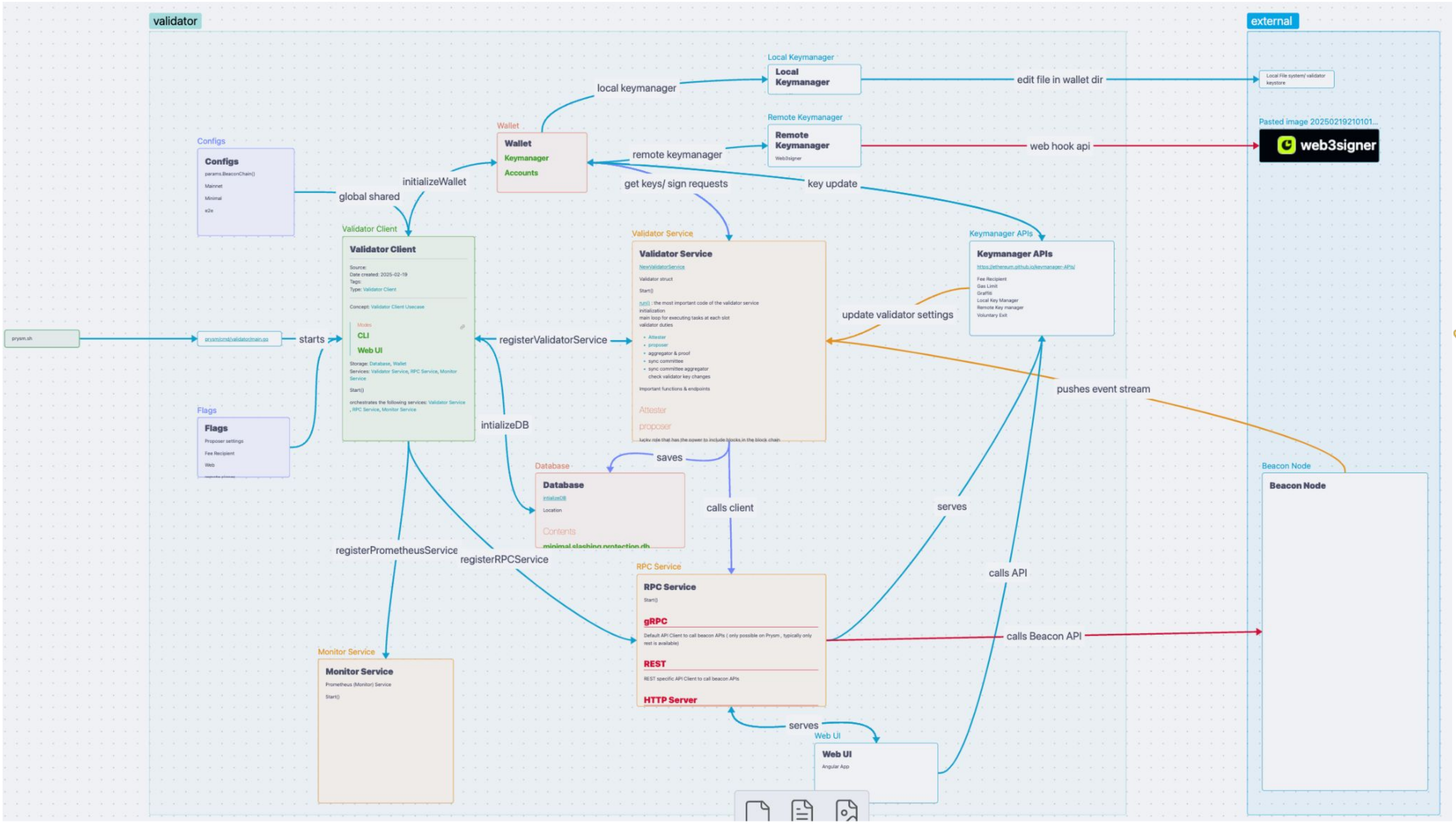
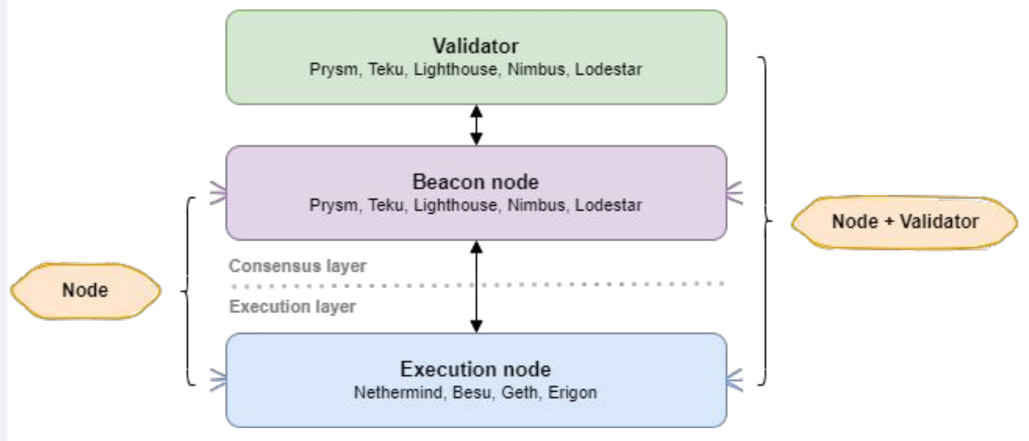
High level view

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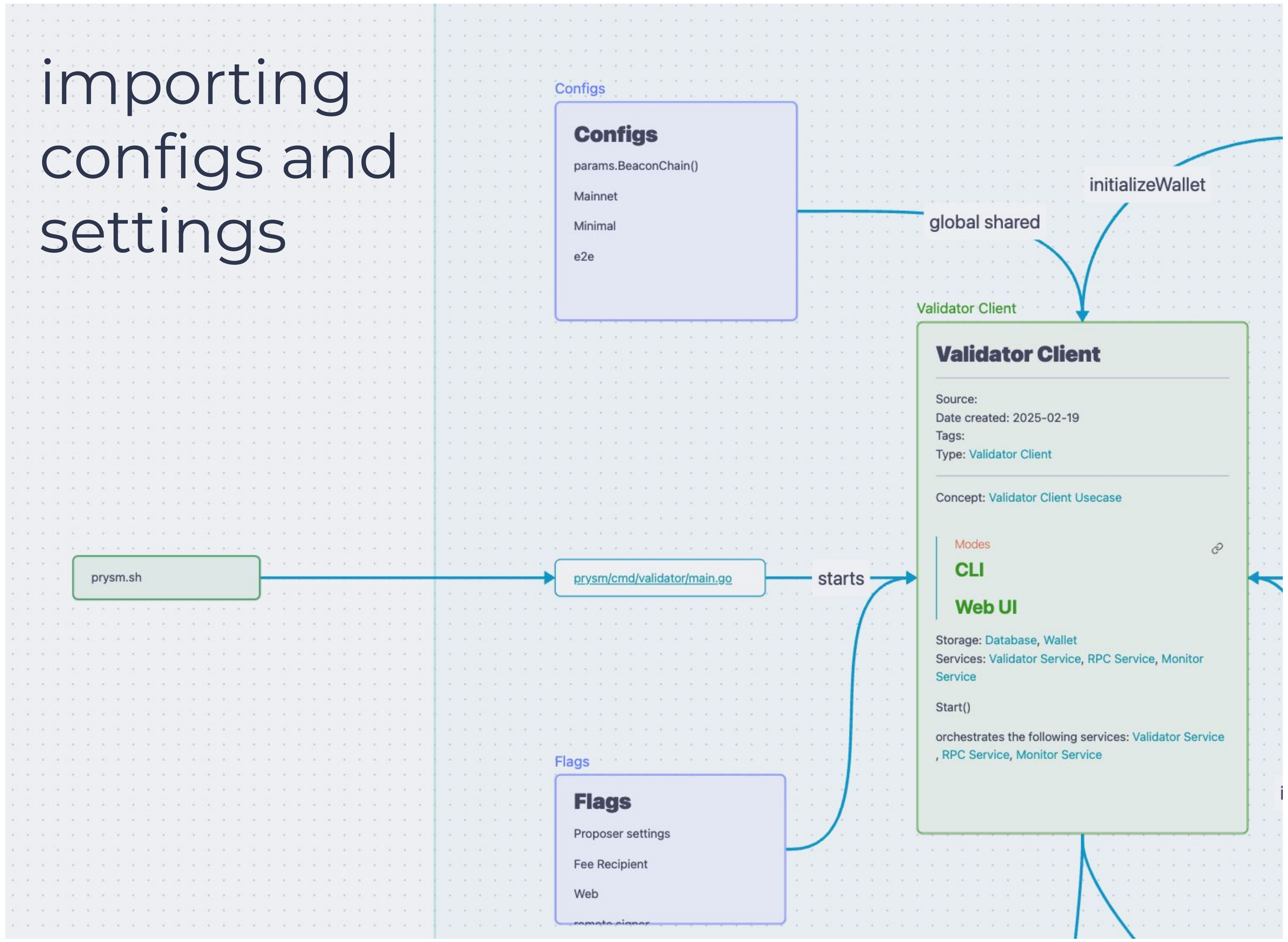
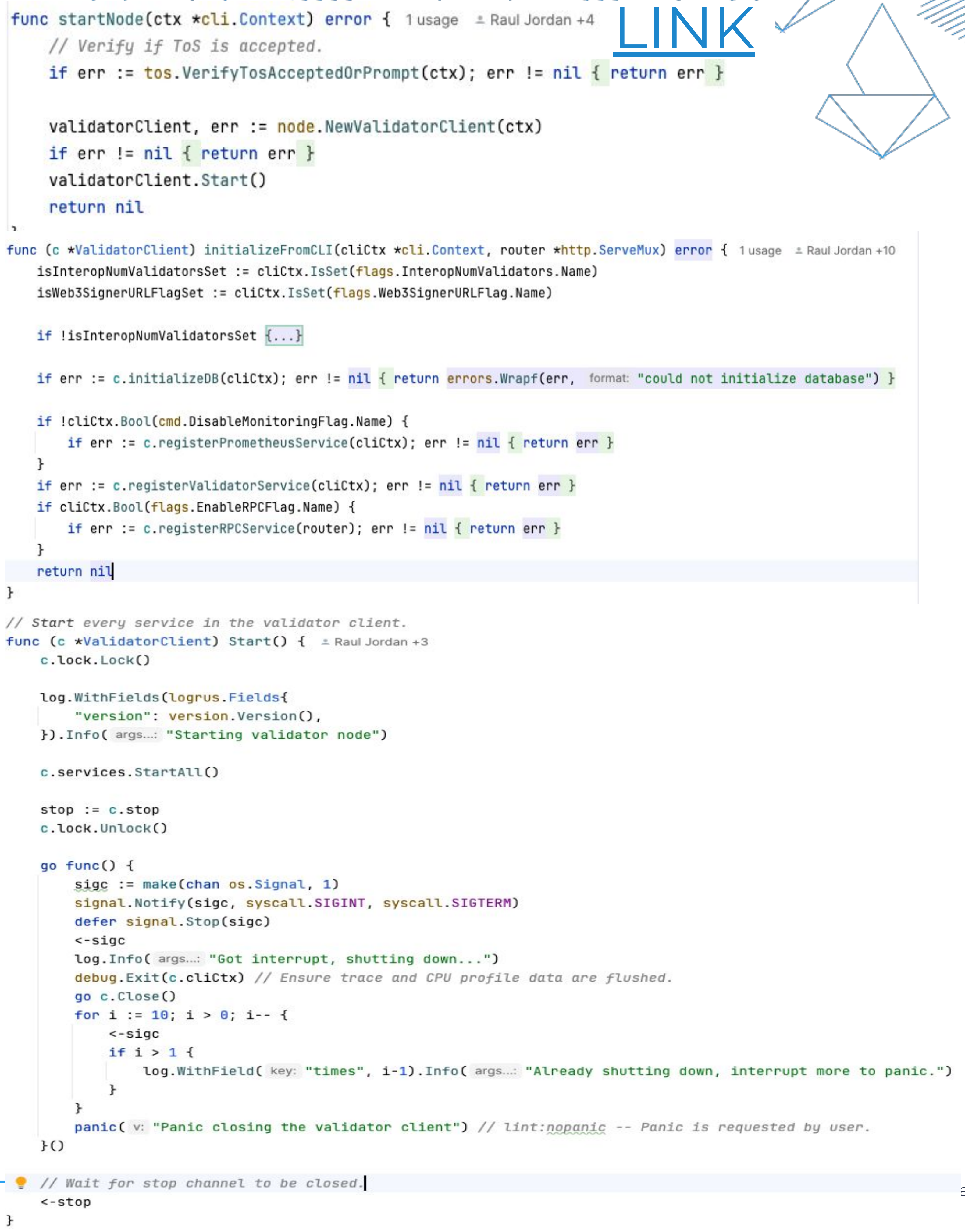
Validator Client Type



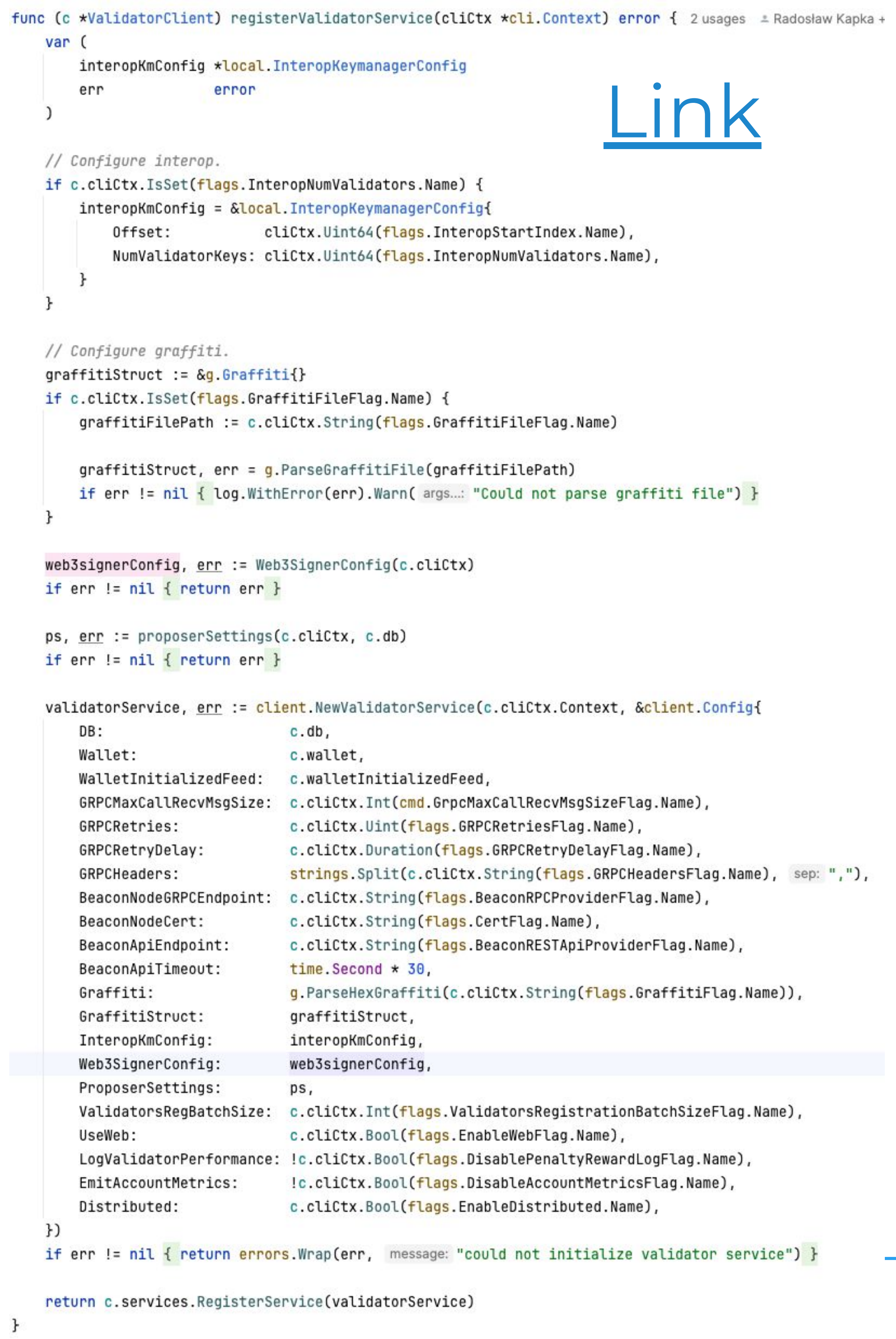


```go
func startNode(ctx *cli.Context) error {  1 usage  Raul Jordan +4
    // Verify if ToS is accepted.
    if err := tos.VerifyTosAcceptedOrPrompt(ctx); err != nil { return err }

    validatorClient, err := node.NewValidatorClient(ctx)
    if err != nil { return err }
    validatorClient.Start()
    return nil
}
```

```go
func (c *ValidatorClient) initializeFromCLI(cliCtx *cli.Context, router *http.ServeMux) error {  1 usage  Raul Jordan +10
    isInteropNumValidatorsSet := cliCtx.IsSet(flags.InteropNumValidators.Name)
    isWeb3SignerURLFlagSet := cliCtx.IsSet(flags.Web3SignerURLFlag.Name)

    if !isInteropNumValidatorsSet {...}

    if err := c.initializeDB(cliCtx); err != nil { return errors.Wrapf(err,  format: "could not initialize database") }

    if !cliCtx.Bool(cmd.DisableMonitoringFlag.Name) {
        if err := c.registerPrometheusService(cliCtx); err != nil { return err }
    }
    if err := c.registerValidatorService(cliCtx); err != nil { return err }
    if cliCtx.Bool(flags.EnableRPCFlag.Name) {
        if err := c.registerRPCService(router); err != nil { return err }
    }
    return nil
}
```

```go
// Start every service in the validator client.
func (c *ValidatorClient) Start() {  Raul Jordan +3
    c.lock.Lock()

    log.WithFields(logrus.Fields{
        "version": version.Version(),
    }).Info( args...: "Starting validator node")

    c.services.StartAll()

    stop := c.stop
    c.lock.Unlock()

    go func() {
        sigc := make(chan os.Signal, 1)
        signal.Notify(sigc, syscall.SIGINT, syscall.SIGTERM)
        defer signal.Stop(sigc)
        <-sigc
        log.Info( args...: "Got interrupt, shutting down...")
        debug.Exit(c.cliCtx) // Ensure trace and CPU profile data are flushed.
        go c.Close()
        for i := 10; i > 0; i-- {
            <-sigc
            if i > 1 {
                log.WithField( key: "times", i-1).Info( args...: "Already shutting down, interrupt more to panic.")
            }
        }
        panic( v: "Panic closing the validator client") // lint:nopanic -- Panic is requested by user.
    }()

    // Wait for stop channel to be closed.
    <-stop
}
```

Registered Services



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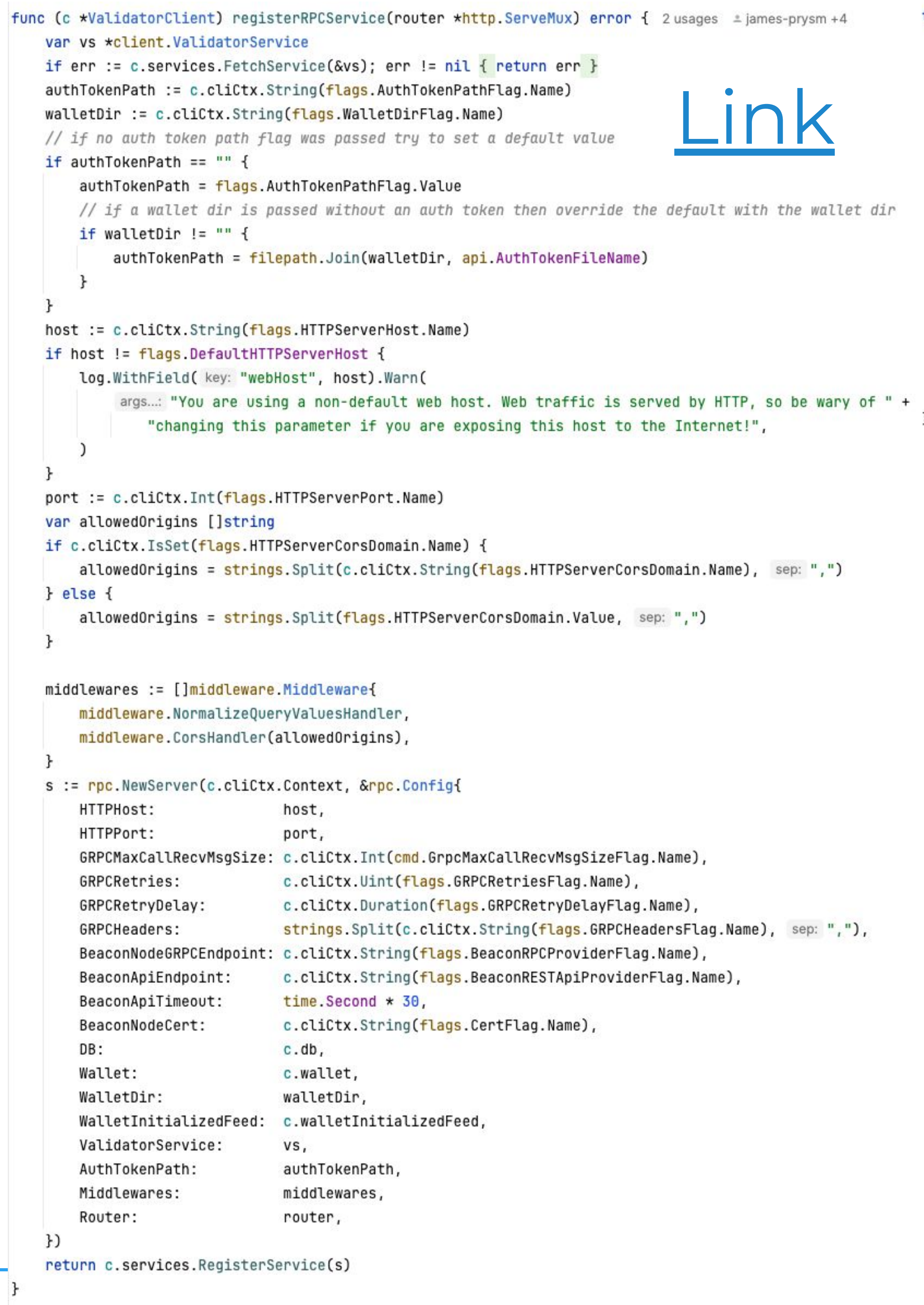
```go
func (c *ValidatorClient) registerValidatorService(cliCtx *cli.Context) error {  2 usages  ≛ Radosław Kapka +
    var (
        interopKmConfig *local.InteropKeymanagerConfig
        err             error
    )

    // Configure interop.
    if c.cliCtx.IsSet(flags.InteropNumValidators.Name) {
        interopKmConfig = &local.InteropKeymanagerConfig{
            Offset:           cliCtx.Uint64(flags.InteropStartIndex.Name),
            NumValidatorKeys: cliCtx.Uint64(flags.InteropNumValidators.Name),
        }
    }

    // Configure graffiti.
    graffitiStruct := &g.Graffiti{}
    if c.cliCtx.IsSet(flags.GraffitiFileFlag.Name) {
        graffitiFilePath := c.cliCtx.String(flags.GraffitiFileFlag.Name)

        graffitiStruct, err = g.ParseGraffitiFile(graffitiFilePath)
        if err != nil { log.WithError(err).Warn( args...: "Could not parse graffiti file") }
    }

    web3signerConfig, err := Web3SignerConfig(c.cliCtx)
    if err != nil { return err }

    ps, err := proposerSettings(c.cliCtx, c.db)
    if err != nil { return err }

    validatorService, err := client.NewValidatorService(c.cliCtx.Context, &client.Config{
        DB:                      c.db,
        Wallet:                  c.wallet,
        WalletInitializedFeed:   c.walletInitializedFeed,
        GRPCMaxCallRecvMsgSize:  c.cliCtx.Int(cmd.GrpcMaxCallRecvMsgSizeFlag.Name),
        GRPCRetries:             c.cliCtx.Uint(flags.GRPCRetriesFlag.Name),
        GRPCRetryDelay:          c.cliCtx.Duration(flags.GRPCRetryDelayFlag.Name),
        GRPCHeaders:             strings.Split(c.cliCtx.String(flags.GRPCHeadersFlag.Name),  sep: ","),
        BeaconNodeGRPCEndpoint:  c.cliCtx.String(flags.BeaconRPCProviderFlag.Name),
        BeaconNodeCert:          c.cliCtx.String(flags.CertFlag.Name),
        BeaconApiEndpoint:       c.cliCtx.String(flags.BeaconRESTApiProviderFlag.Name),
        BeaconApiTimeout:        time.Second * 30,
        Graffiti:                g.ParseHexGraffiti(c.cliCtx.String(flags.GraffitiFlag.Name)),
        GraffitiStruct:          graffitiStruct,
        InteropKmConfig:         interopKmConfig,
        Web3SignerConfig:        web3signerConfig,
        ProposerSettings:        ps,
        ValidatorsRegBatchSize:  c.cliCtx.Int(flags.ValidatorsRegistrationBatchSizeFlag.Name),
        UseWeb:                  c.cliCtx.Bool(flags.EnableWebFlag.Name),
        LogValidatorPerformance: !c.cliCtx.Bool(flags.DisablePenaltyRewardLogFlag.Name),
        EmitAccountMetrics:      !c.cliCtx.Bool(flags.DisableAccountMetricsFlag.Name),
        Distributed:             c.cliCtx.Bool(flags.EnableDistributed.Name),
    })
    if err != nil { return errors.Wrap(err,  message: "could not initialize validator service") }

    return c.services.RegisterService(validatorService)
}
```



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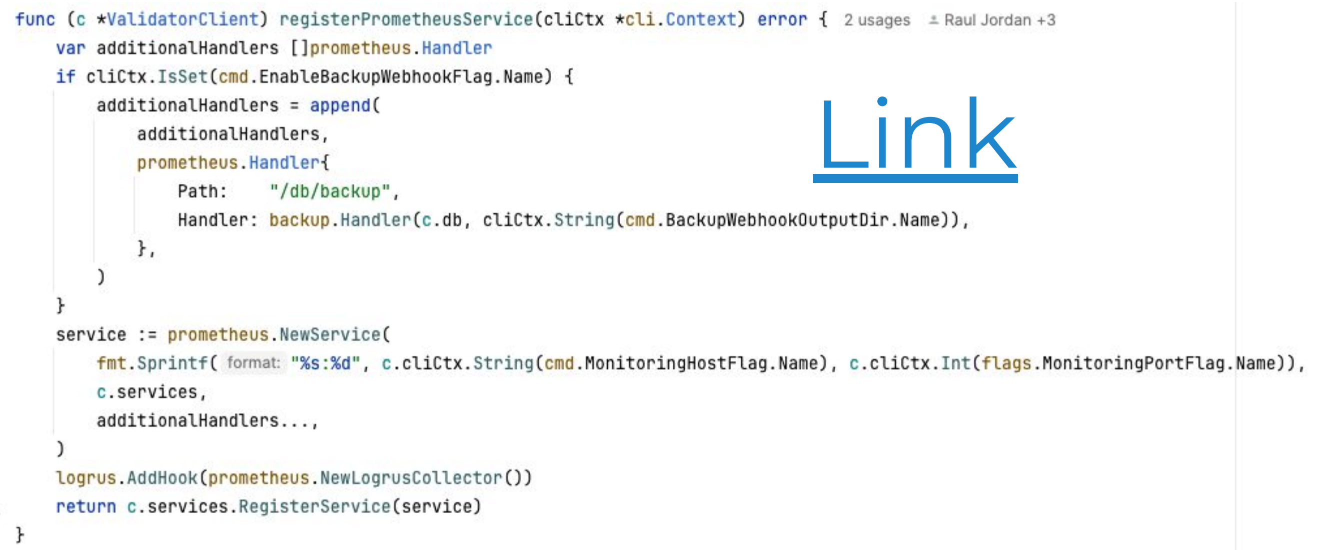
```go
func (c *ValidatorClient) registerRPCService(router *http.ServeMux) error {  2 usages  ≛ james-prysm +4
    var vs *client.ValidatorService
    if err := c.services.FetchService(&vs); err != nil { return err }
    authTokenPath := c.cliCtx.String(flags.AuthTokenPathFlag.Name)
    walletDir := c.cliCtx.String(flags.WalletDirFlag.Name)
    // if no auth token path flag was passed try to set a default value
    if authTokenPath == "" {
        authTokenPath = flags.AuthTokenPathFlag.Value
        // if a wallet dir is passed without an auth token then override the default with the wallet dir
        if walletDir != "" {
            authTokenPath = filepath.Join(walletDir, api.AuthTokenFileName)
        }
    }
    host := c.cliCtx.String(flags.HTTPServerHost.Name)
    if host != flags.DefaultHTTPServerHost {
        log.WithField( key: "webHost", host).Warn(
             args...: "You are using a non-default web host. Web traffic is served by HTTP, so be wary of " +
                "changing this parameter if you are exposing this host to the Internet!",
        )
    }
    port := c.cliCtx.Int(flags.HTTPServerPort.Name)
    var allowedOrigins []string
    if c.cliCtx.IsSet(flags.HTTPServerCorsDomain.Name) {
        allowedOrigins = strings.Split(c.cliCtx.String(flags.HTTPServerCorsDomain.Name),  sep: ",")
    } else {
        allowedOrigins = strings.Split(flags.HTTPServerCorsDomain.Value,  sep: ",")
    }

    middlewares := []middleware.Middleware{
        middleware.NormalizeQueryValuesHandler,
        middleware.CorsHandler(allowedOrigins),
    }
    s := rpc.NewServer(c.cliCtx.Context, &rpc.Config{
        HTTPHost:               host,
        HTTPPort:               port,
        GRPCMaxCallRecvMsgSize: c.cliCtx.Int(cmd.GrpcMaxCallRecvMsgSizeFlag.Name),
        GRPCRetries:            c.cliCtx.Uint(flags.GRPCRetriesFlag.Name),
        GRPCRetryDelay:         c.cliCtx.Duration(flags.GRPCRetryDelayFlag.Name),
        GRPCHeaders:            strings.Split(c.cliCtx.String(flags.GRPCHeadersFlag.Name),  sep: ","),
        BeaconNodeGRPCEndpoint: c.cliCtx.String(flags.BeaconRPCProviderFlag.Name),
        BeaconApiEndpoint:      c.cliCtx.String(flags.BeaconRESTApiProviderFlag.Name),
        BeaconApiTimeout:       time.Second * 30,
        BeaconNodeCert:         c.cliCtx.String(flags.CertFlag.Name),
        DB:                     c.db,
        Wallet:                 c.wallet,
        WalletDir:              walletDir,
        WalletInitializedFeed:  c.walletInitializedFeed,
        ValidatorService:       vs,
        AuthTokenPath:          authTokenPath,
        Middlewares:            middlewares,
        Router:                 router,
    })
    return c.services.RegisterService(s)
}
```



Link

```go
func (c *ValidatorClient) registerPrometheusService(cliCtx *cli.Context) error {  2 usages  ≛ Raul Jordan +3
    var additionalHandlers []prometheus.Handler
    if cliCtx.IsSet(cmd.EnableBackupWebhookFlag.Name) {
        additionalHandlers = append(
            additionalHandlers,
            prometheus.Handler{
                Path:    "/db/backup",
                Handler: backup.Handler(c.db, cliCtx.String(cmd.BackupWebhookOutputDir.Name)),
            },
        )
    }
    service := prometheus.NewService(
        fmt.Sprintf( format: "%s:%d", c.cliCtx.String(cmd.MonitoringHostFlag.Name), c.cliCtx.Int(flags.MonitoringPortFlag.Name)),
        c.services,
        additionalHandlers...,
    )
    logrus.AddHook(prometheus.NewLogrusCollector())
    return c.services.RegisterService(service)
}
```

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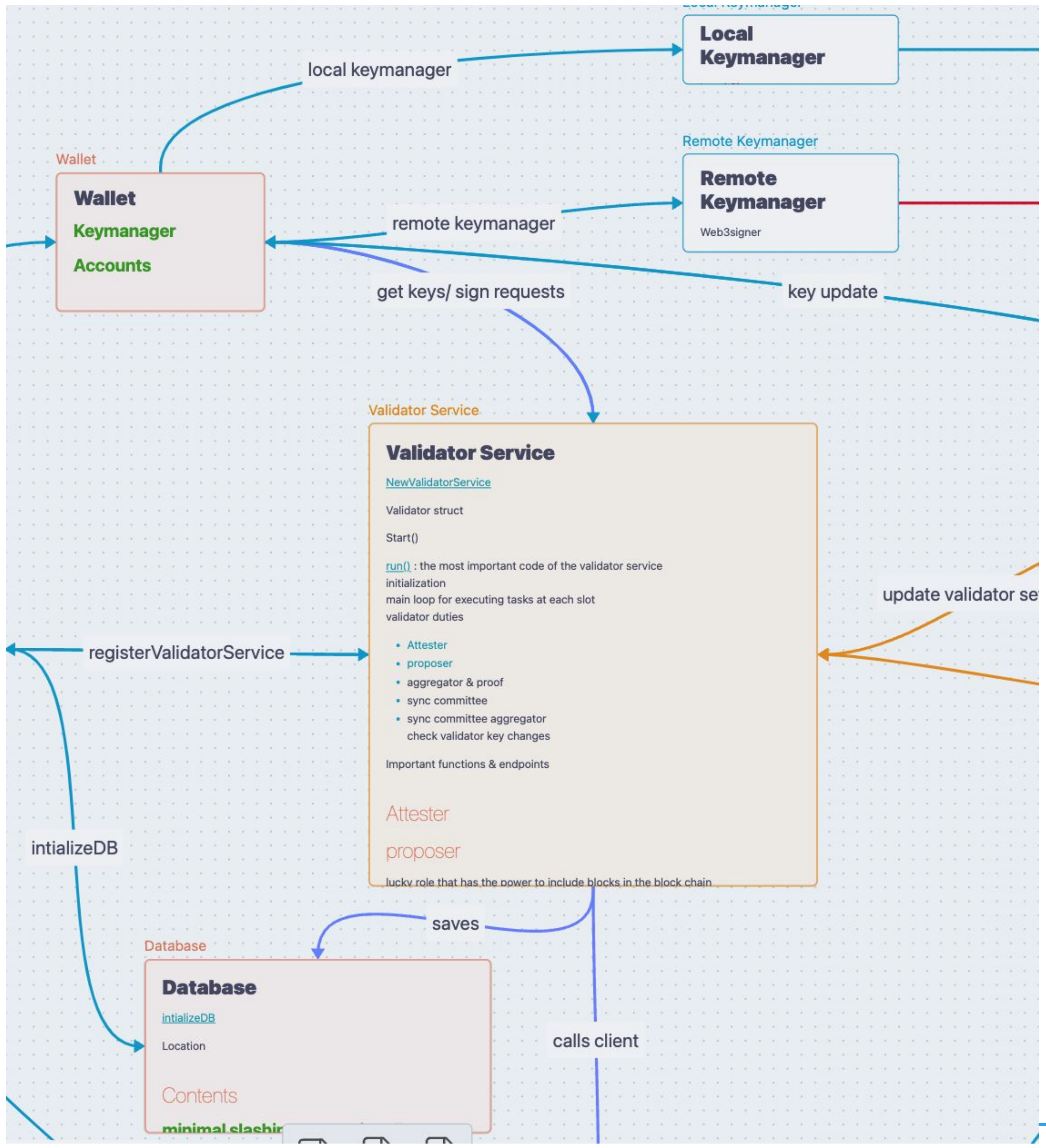
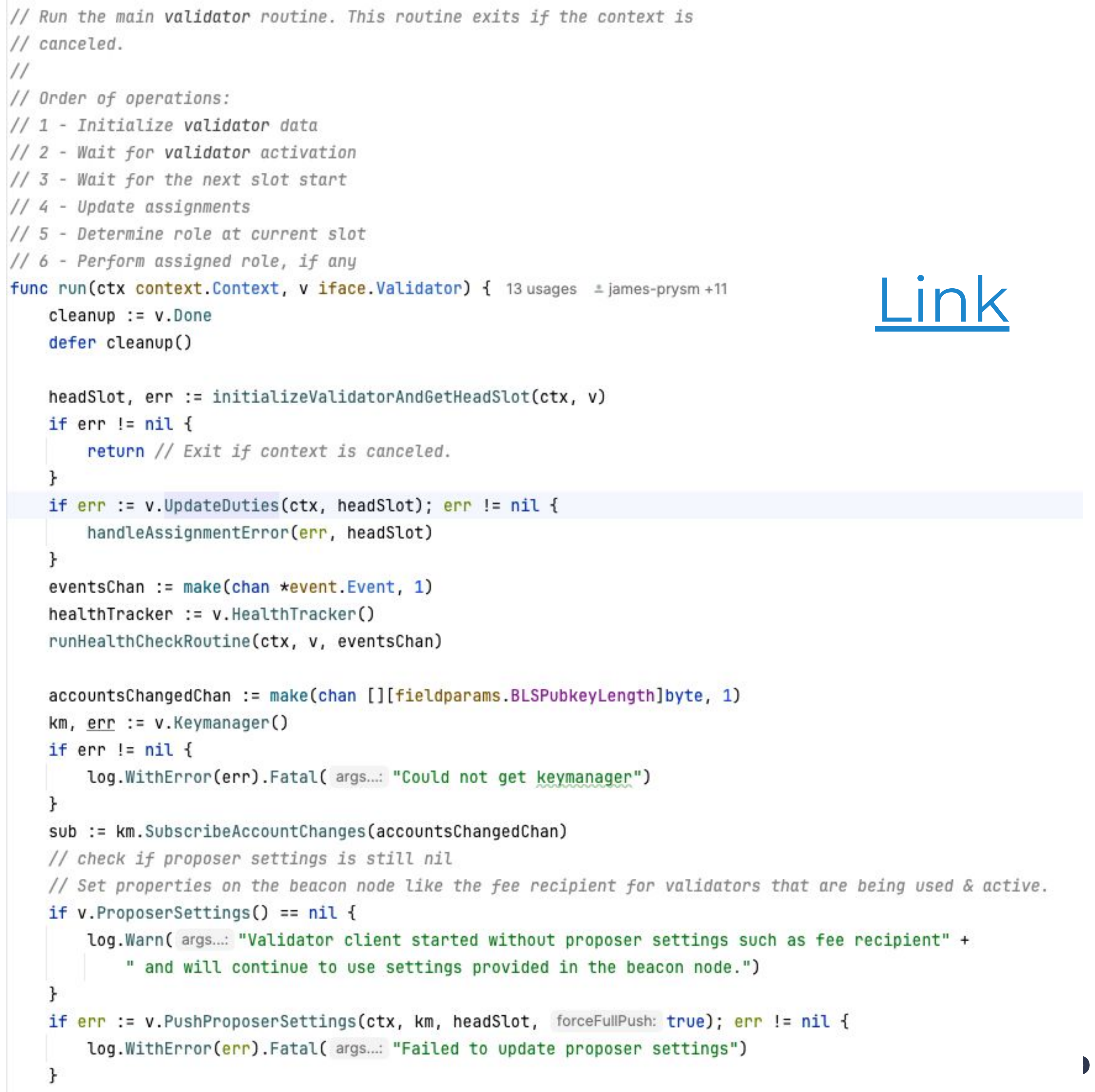
Validator Service





```go
// Run the main validator routine. This routine exits if the context is
// canceled.
//
// Order of operations:
// 1 - Initialize validator data
// 2 - Wait for validator activation
// 3 - Wait for the next slot start
// 4 - Update assignments
// 5 - Determine role at current slot
// 6 - Perform assigned role, if any
func run(ctx context.Context, v iface.Validator) {  13 usages  ± james-prysm +11
	cleanup := v.Done
	defer cleanup()

	headSlot, err := initializeValidatorAndGetHeadSlot(ctx, v)
	if err != nil {
		return // Exit if context is canceled.
	}
	if err := v.UpdateDuties(ctx, headSlot); err != nil {
		handleAssignmentError(err, headSlot)
	}
	eventsChan := make(chan *event.Event, 1)
	healthTracker := v.HealthTracker()
	runHealthCheckRoutine(ctx, v, eventsChan)

	accountsChangedChan := make(chan [][fieldparams.BLSPubkeyLength]byte, 1)
	km, err := v.Keymanager()
	if err != nil {
		log.WithError(err).Fatal( args...: "Could not get keymanager")
	}
	sub := km.SubscribeAccountChanges(accountsChangedChan)
	// check if proposer settings is still nil
	// Set properties on the beacon node like the fee recipient for validators that are being used & active.
	if v.ProposerSettings() == nil {
		log.Warn( args...: "Validator client started without proposer settings such as fee recipient" +
			" and will continue to use settings provided in the beacon node.")
	}
	if err := v.PushProposerSettings(ctx, km, headSlot,  forceFullPush: true); err != nil {
		log.WithError(err).Fatal( args...: "Failed to update proposer settings")
	}
```

Link

Validator Service Initialization

Link

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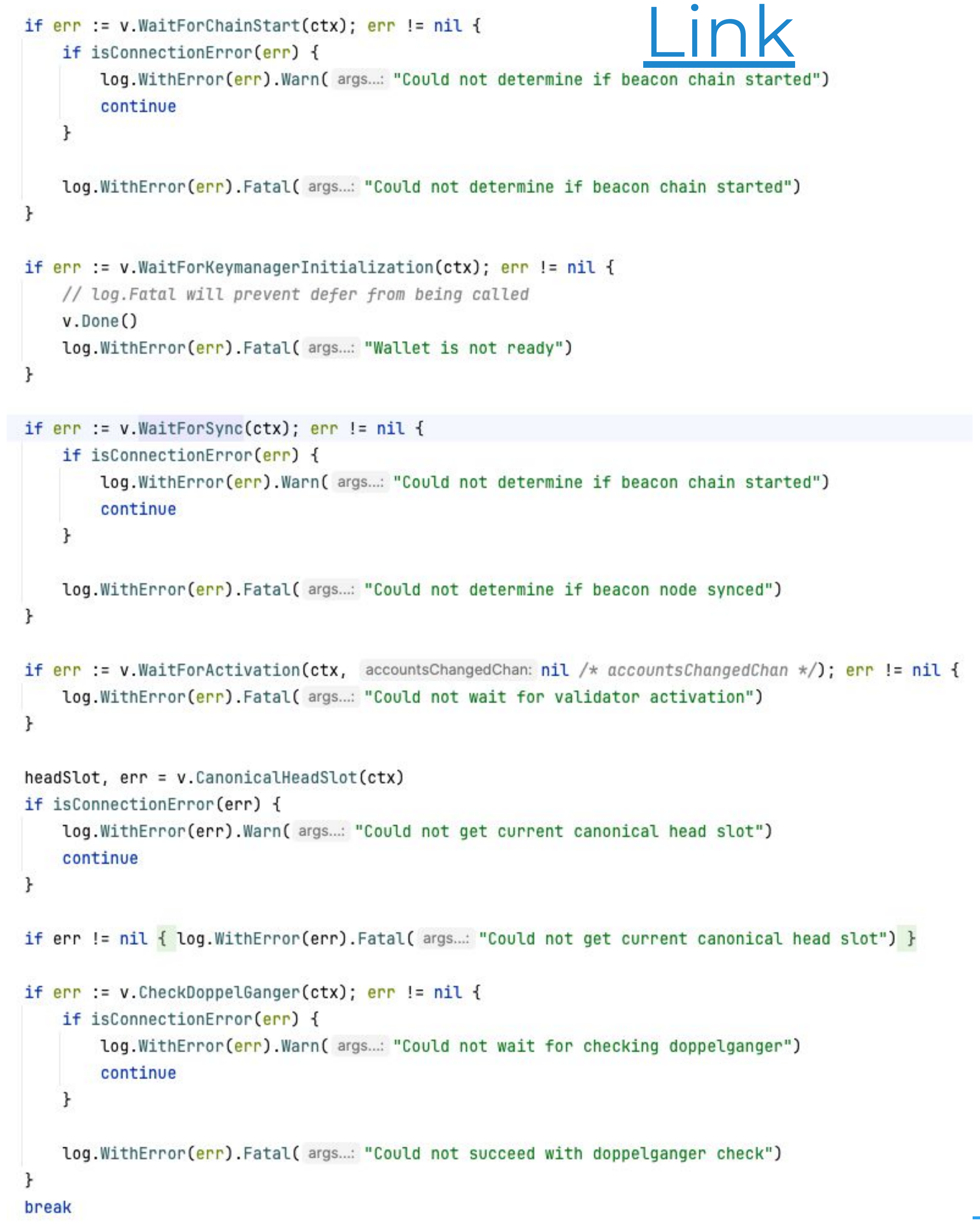
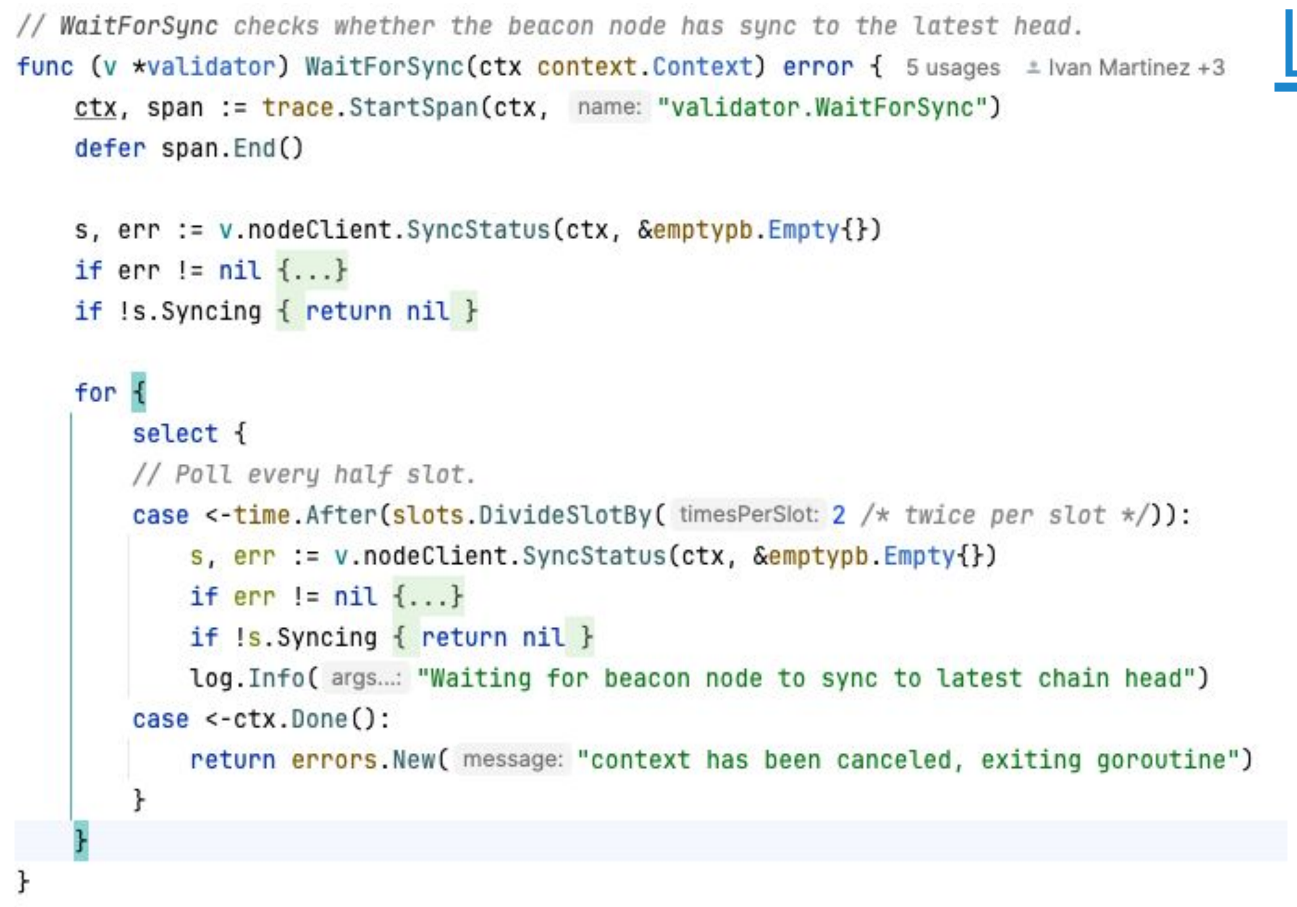
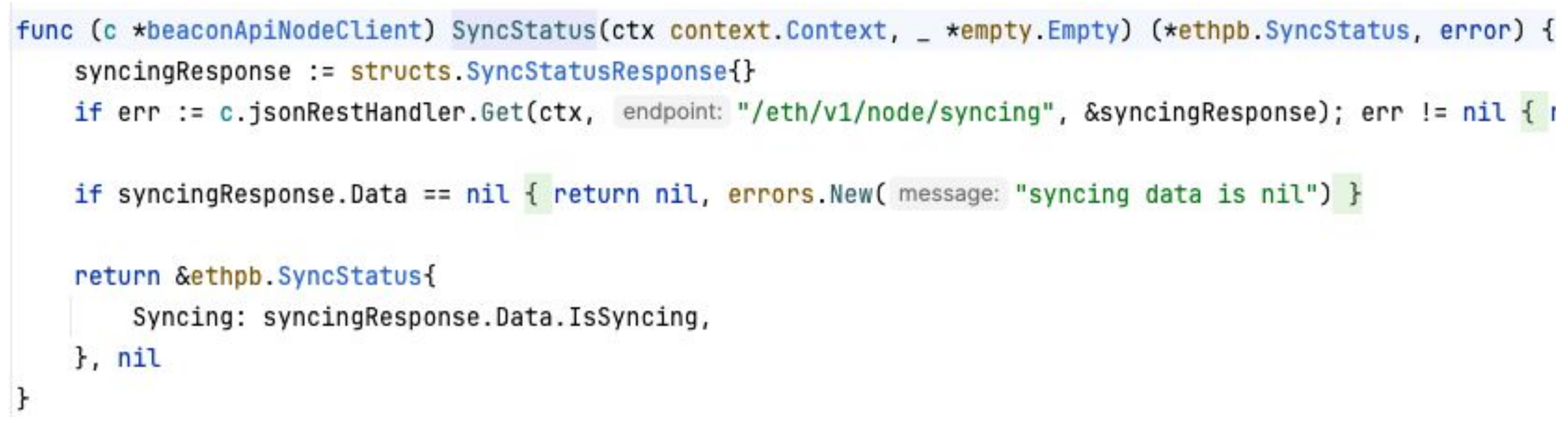


```
if err := v.WaitForChainStart(ctx); err != nil {
    if isConnectionError(err) {
        log.WithError(err).Warn( args...: "Could not determine if beacon chain started")
        continue
    }

    log.WithError(err).Fatal( args...: "Could not determine if beacon chain started")
}

if err := v.WaitForKeymanagerInitialization(ctx); err != nil {
    // log.Fatal will prevent defer from being called
    v.Done()
    log.WithError(err).Fatal( args...: "Wallet is not ready")
}

if err := v.WaitForSync(ctx); err != nil {
    if isConnectionError(err) {
        log.WithError(err).Warn( args...: "Could not determine if beacon chain started")
        continue
    }

    log.WithError(err).Fatal( args...: "Could not determine if beacon node synced")
}

if err := v.WaitForActivation(ctx,  accountsChangedChan: nil /* accountsChangedChan */); err != nil {
    log.WithError(err).Fatal( args...: "Could not wait for validator activation")
}

headSlot, err = v.CanonicalHeadSlot(ctx)
if isConnectionError(err) {
    log.WithError(err).Warn( args...: "Could not get current canonical head slot")
    continue
}

if err != nil { log.WithError(err).Fatal( args...: "Could not get current canonical head slot") }

if err := v.CheckDoppelGanger(ctx); err != nil {
    if isConnectionError(err) {
        log.WithError(err).Warn( args...: "Could not wait for checking doppelganger")
        continue
    }

    log.WithError(err).Fatal( args...: "Could not succeed with doppelganger check")
}
break
```



```
// WaitForSync checks whether the beacon node has sync to the latest head.
func (v *validator) WaitForSync(ctx context.Context) error {  5 usages  ± Ivan Martinez +3
    ctx, span := trace.StartSpan(ctx,  name: "validator.WaitForSync")
    defer span.End()

    s, err := v.nodeClient.SyncStatus(ctx, &emptypb.Empty{})
    if err != nil {...}
    if !s.Syncing { return nil }

    for {
        select {
        // Poll every half slot.
        case <-time.After(slots.DivideSlotBy( timesPerSlot: 2 /* twice per slot */)):
            s, err := v.nodeClient.SyncStatus(ctx, &emptypb.Empty{})
            if err != nil {...}
            if !s.Syncing { return nil }
            log.Info( args...: "Waiting for beacon node to sync to latest chain head")
        case <-ctx.Done():
            return errors.New( message: "context has been canceled, exiting goroutine")
        }
    }
}
```



```
func (c *beaconApiNodeClient) SyncStatus(ctx context.Context, _ *empty.Empty) (*ethpb.SyncStatus, error) {
    syncingResponse := structs.SyncStatusResponse{}
    if err := c.jsonRestHandler.Get(ctx,  endpoint: "/eth/v1/node/syncing", &syncingResponse); err != nil {

    if syncingResponse.Data == nil { return nil, errors.New( message: "syncing data is nil") }

    return &ethpb.SyncStatus{
        Syncing: syncingResponse.Data.IsSyncing,
    }, nil
}
```

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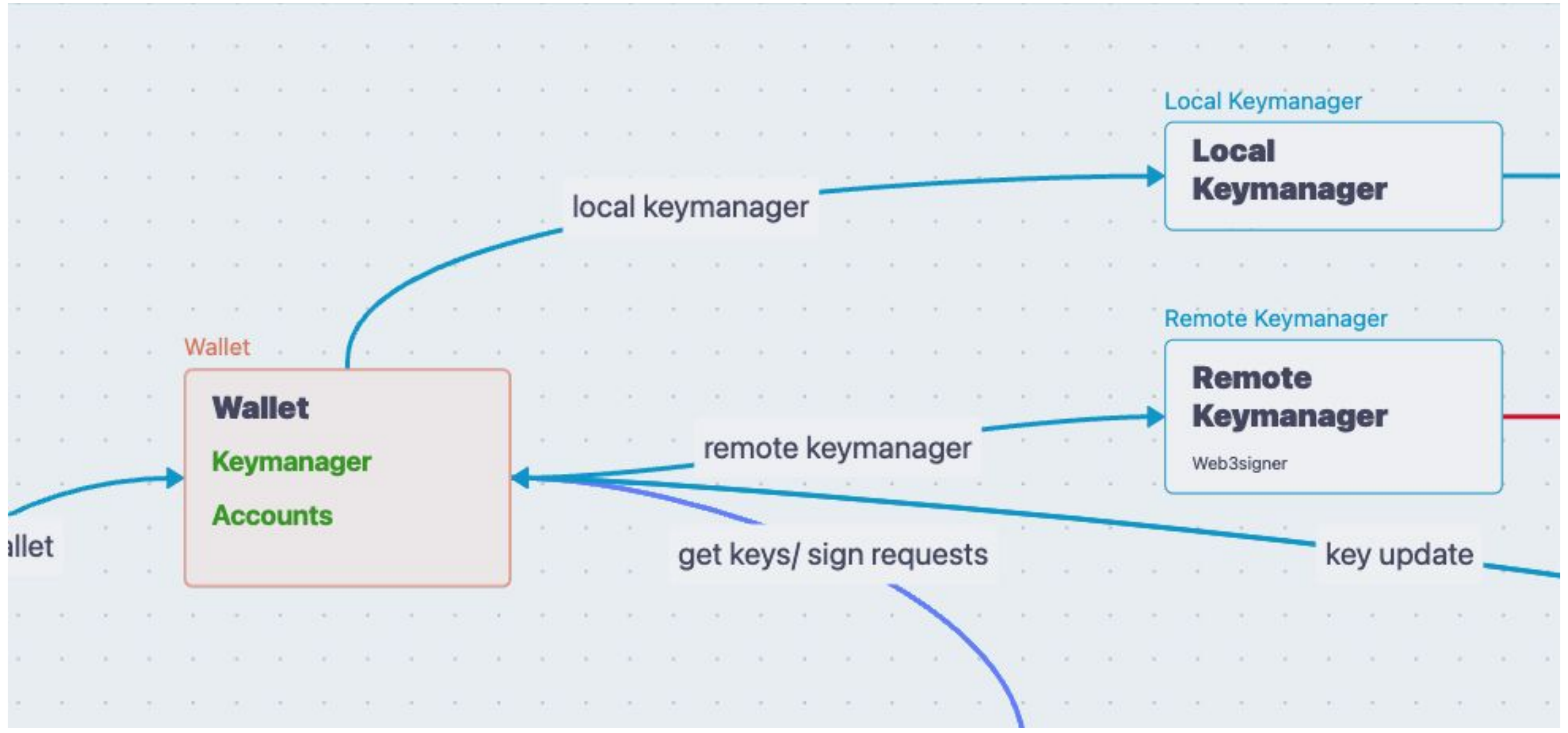
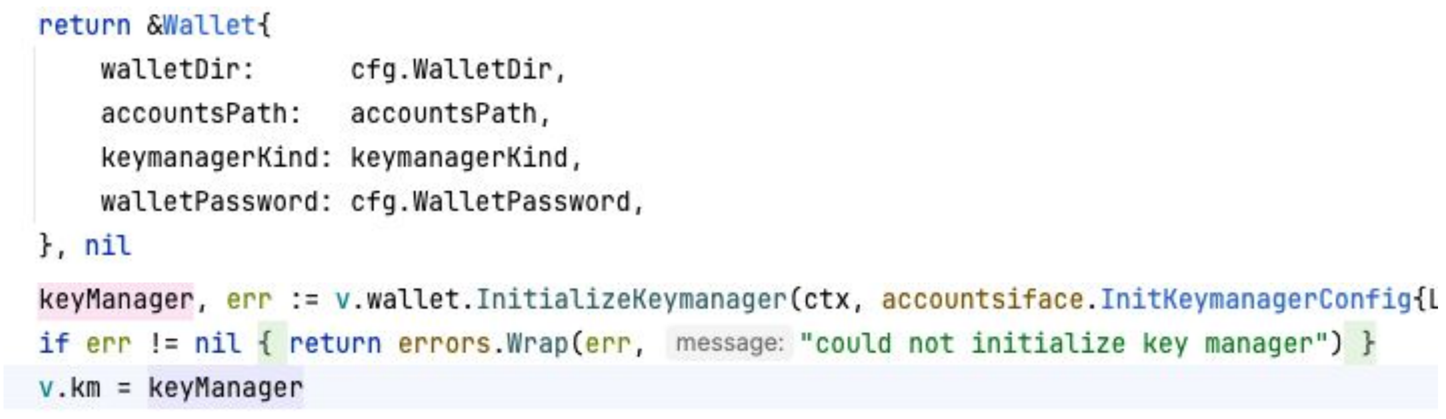
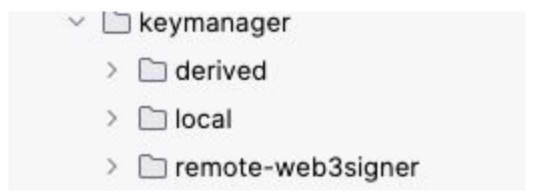
Wallet (local keymanager)





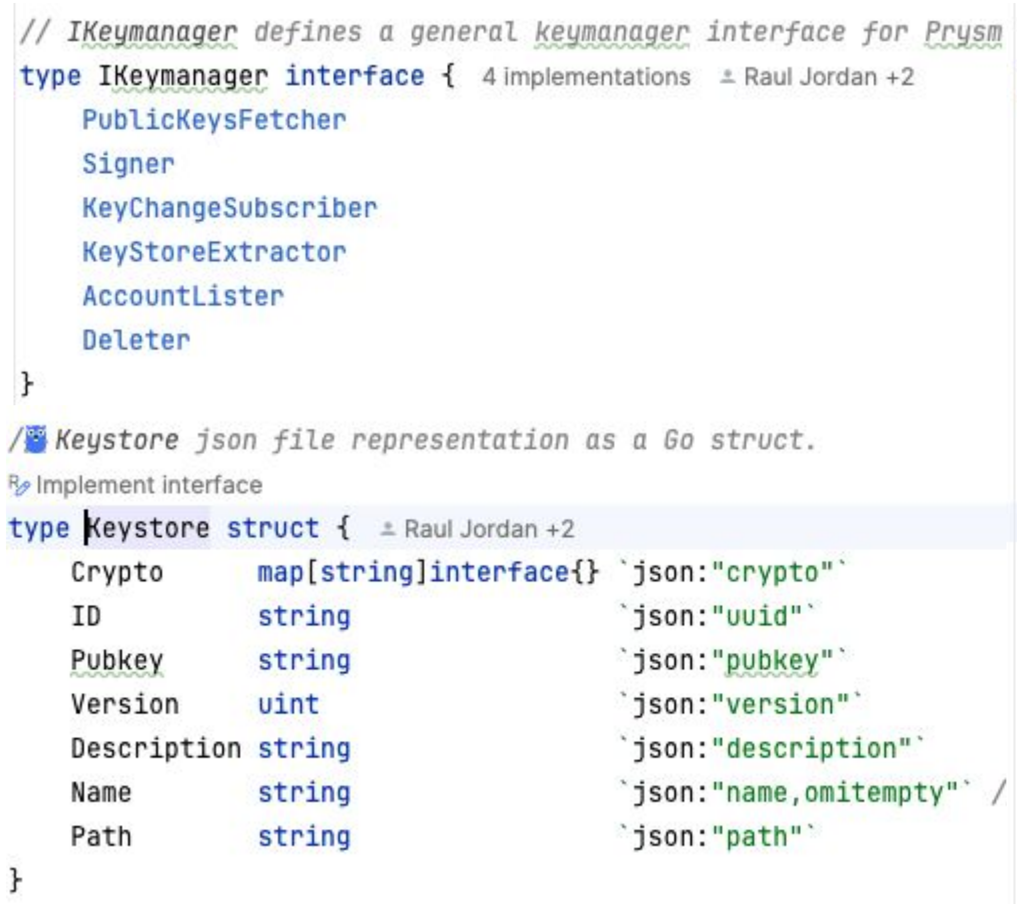
```go
return &Wallet{
    walletDir:      cfg.WalletDir,
    accountsPath:   accountsPath,
    keymanagerKind: keymanagerKind,
    walletPassword: cfg.WalletPassword,
}, nil
```

```go
keyManager, err := v.wallet.InitializeKeymanager(ctx, accountsiface.InitKeymanagerConfig{L
if err != nil { return errors.Wrap(err,  message: "could not initialize key manager") }
v.km = keyManager
```



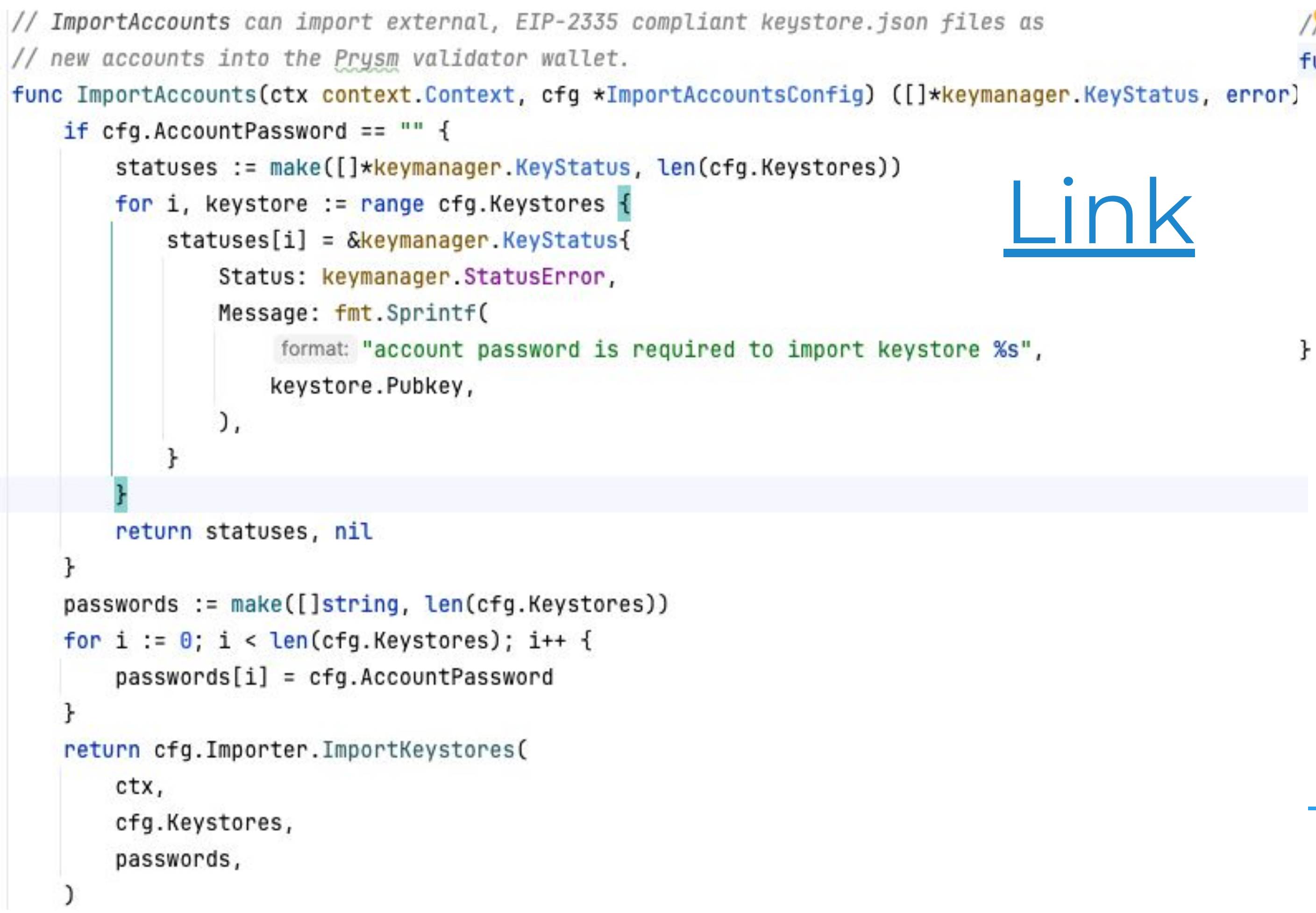
```
⌄ 🗀 keymanager
  › 🗀 derived
  › 🗀 local
  › 🗀 remote-web3signer
```

[Link]



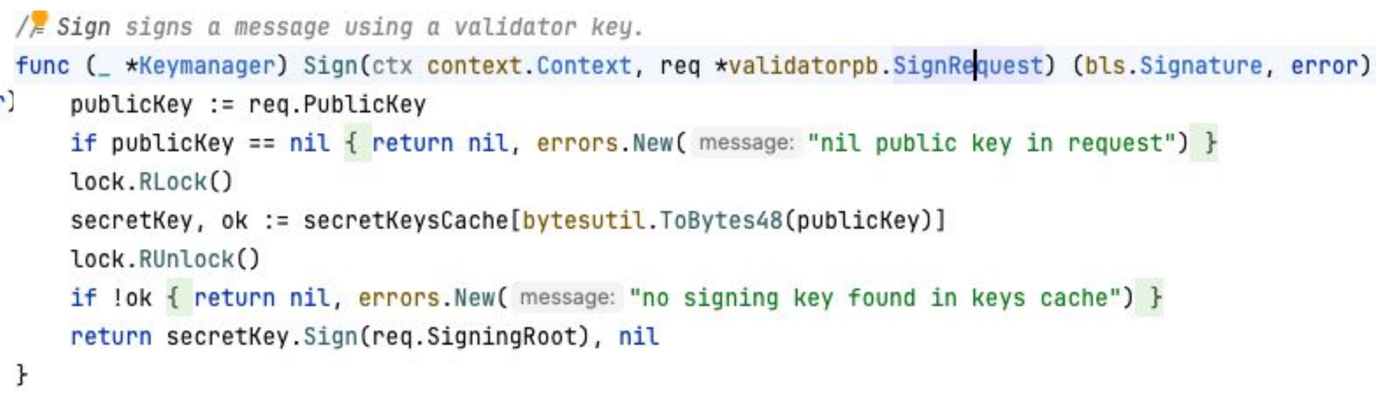
```go
// IKeymanager defines a general keymanager interface for Prysm
type IKeymanager interface {  4 implementations  ≗ Raul Jordan +2
    PublicKeysFetcher
    Signer
    KeyChangeSubscriber
    KeyStoreExtractor
    AccountLister
    Deleter
}
```

```go
// Keystore json file representation as a Go struct.
Implement interface
type Keystore struct {  ≗ Raul Jordan +2
    Crypto      map[string]interface{} `json:"crypto"`
    ID          string                 `json:"uuid"`
    Pubkey      string                 `json:"pubkey"`
    Version     uint                   `json:"version"`
    Description string                 `json:"description"`
    Name        string                 `json:"name,omitempty"` /
    Path        string                 `json:"path"`
}
```



```go
// ImportAccounts can import external, EIP-2335 compliant keystore.json files as
// new accounts into the Prysm validator wallet.
func ImportAccounts(ctx context.Context, cfg *ImportAccountsConfig) ([]*keymanager.KeyStatus, error)
    if cfg.AccountPassword == "" {
        statuses := make([]*keymanager.KeyStatus, len(cfg.Keystores))
        for i, keystore := range cfg.Keystores {
            statuses[i] = &keymanager.KeyStatus{
                Status: keymanager.StatusError,
                Message: fmt.Sprintf(
                     format: "account password is required to import keystore %s",
                    keystore.Pubkey,
                ),
            }
        }
        return statuses, nil
    }
    passwords := make([]string, len(cfg.Keystores))
    for i := 0; i < len(cfg.Keystores); i++ {
        passwords[i] = cfg.AccountPassword
    }
    return cfg.Importer.ImportKeystores(
        ctx,
        cfg.Keystores,
        passwords,
    )
```

[Link]



```go
// Sign signs a message using a validator key.
func (_ *Keymanager) Sign(ctx context.Context, req *validatorpb.SignRequest) (bls.Signature, error)
    publicKey := req.PublicKey
    if publicKey == nil { return nil, errors.New( message: "nil public key in request") }
    lock.RLock()
    secretKey, ok := secretKeysCache[bytesutil.ToBytes48(publicKey)]
    lock.RUnlock()
    if !ok { return nil, errors.New( message: "no signing key found in keys cache") }
    return secretKey.Sign(req.SigningRoot), nil
}
```

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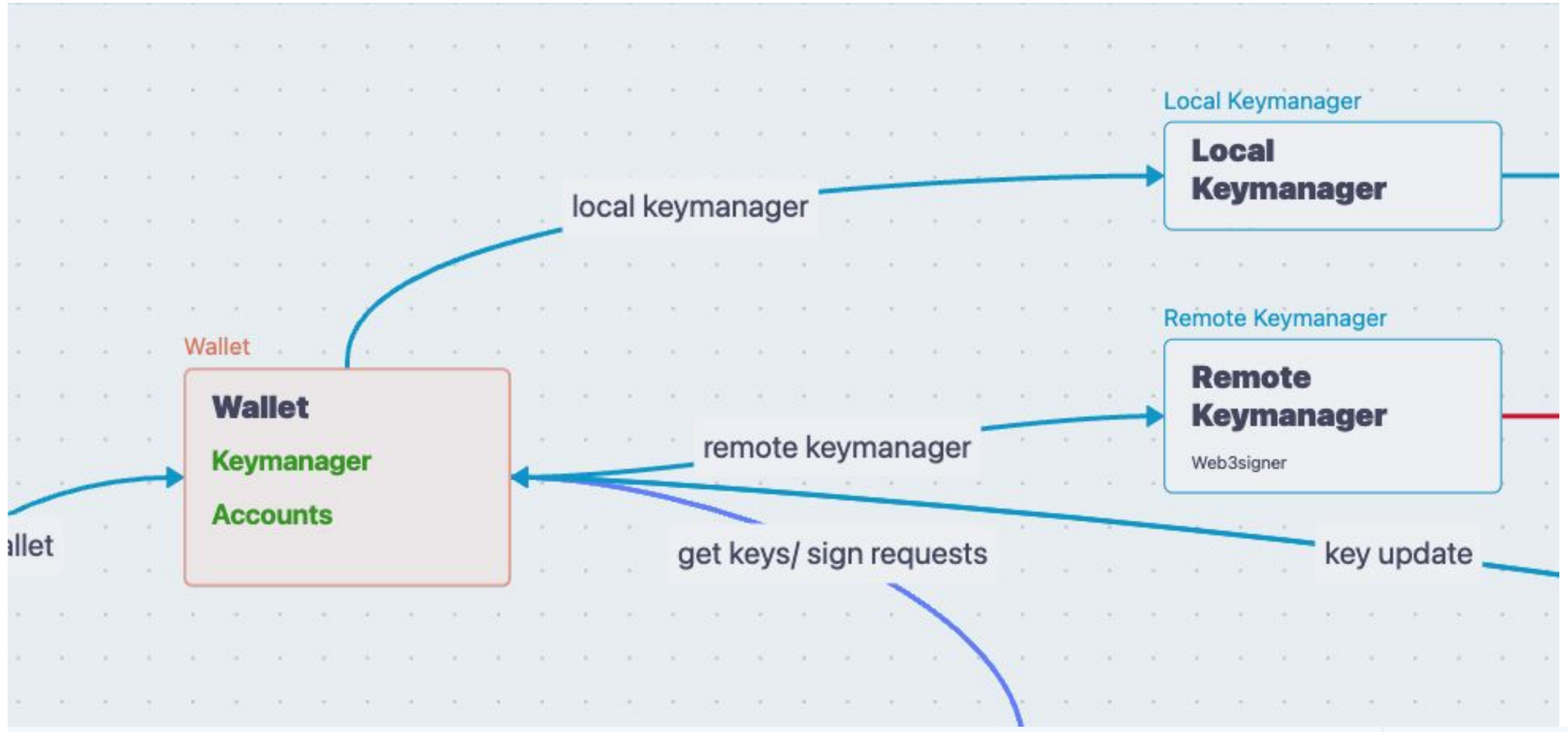
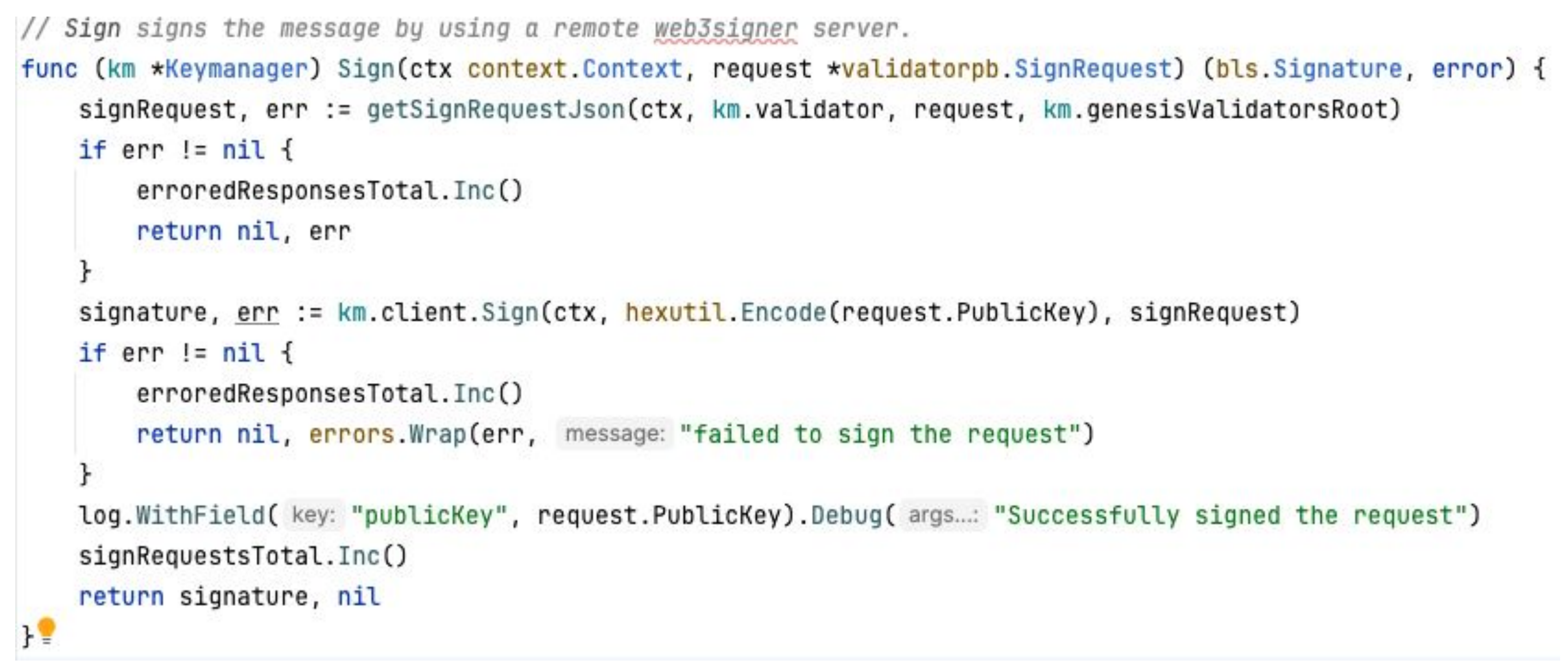
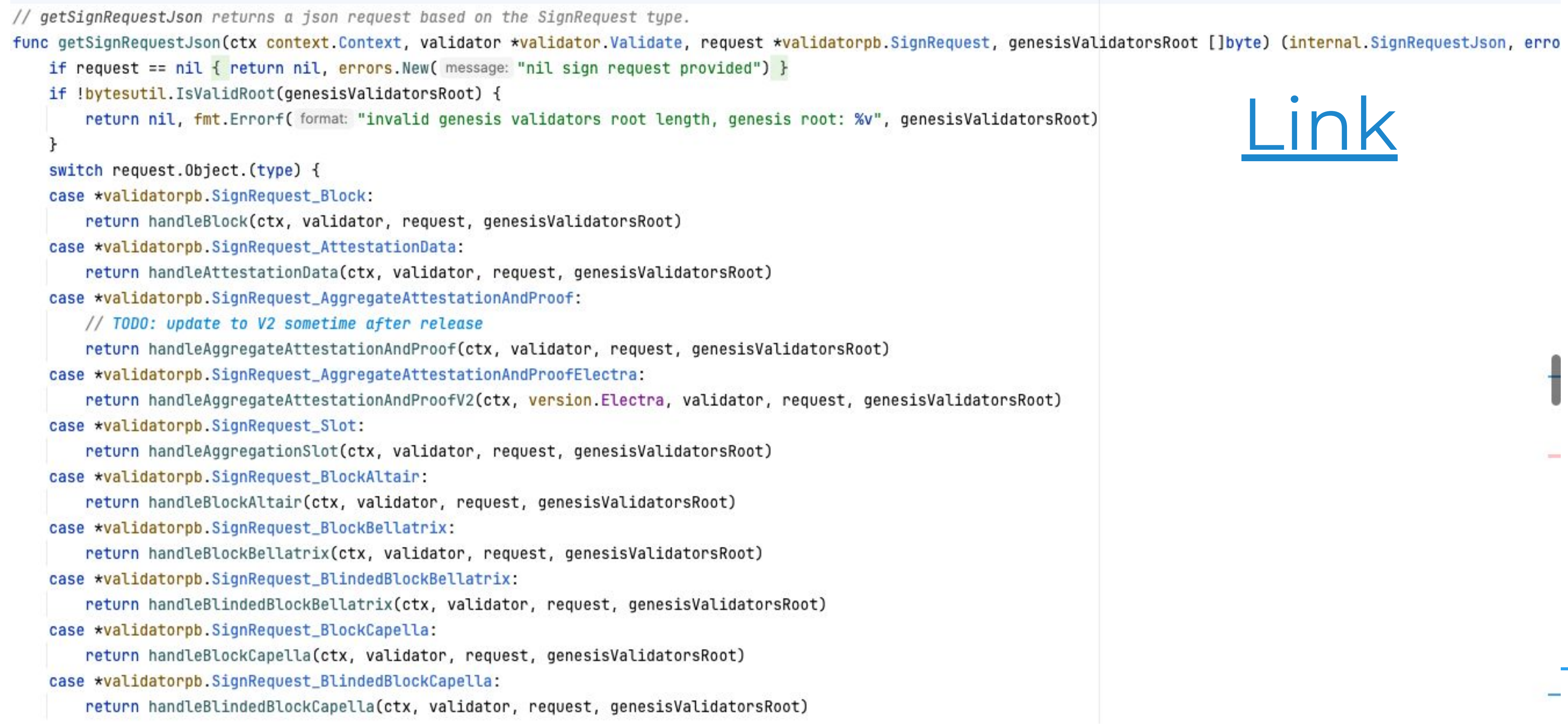
Wallet (remote keymanager)



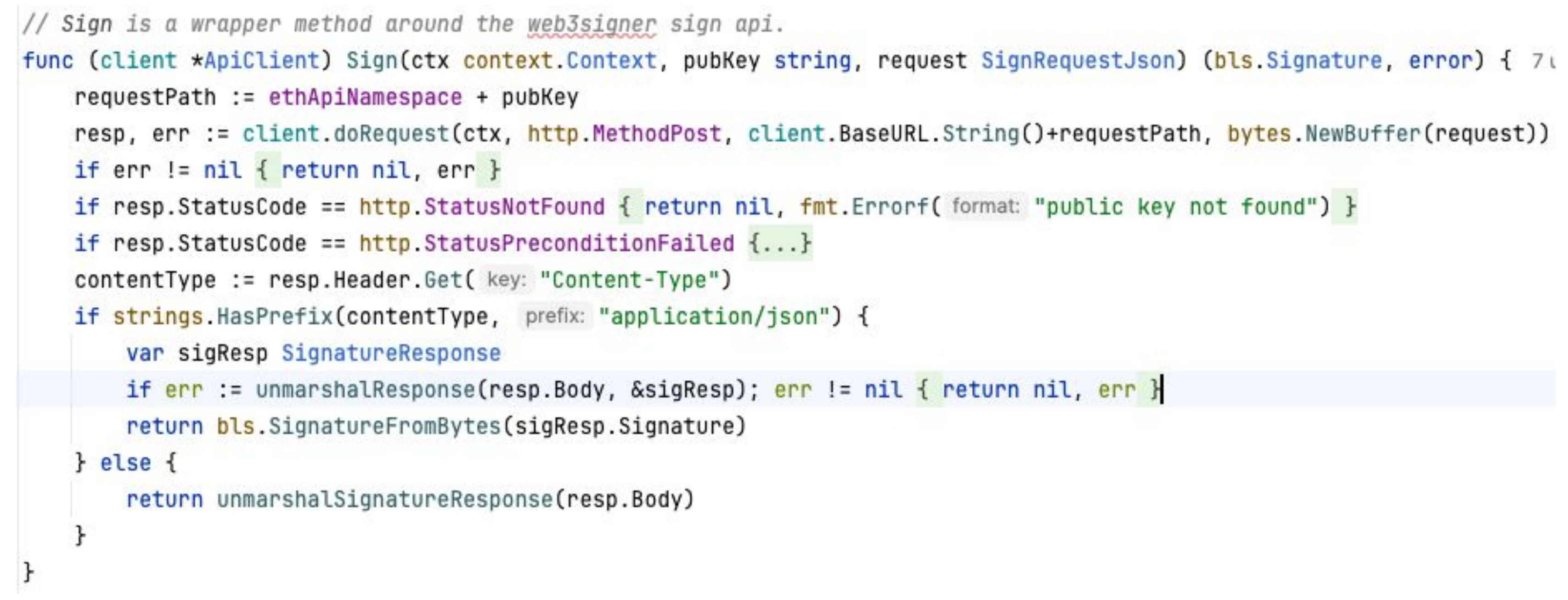


```go
// Sign signs the message by using a remote web3signer server.
func (km *Keymanager) Sign(ctx context.Context, request *validatorpb.SignRequest) (bls.Signature, error) {
    signRequest, err := getSignRequestJson(ctx, km.validator, request, km.genesisValidatorsRoot)
    if err != nil {
        erroredResponsesTotal.Inc()
        return nil, err
    }
    signature, err := km.client.Sign(ctx, hexutil.Encode(request.PublicKey), signRequest)
    if err != nil {
        erroredResponsesTotal.Inc()
        return nil, errors.Wrap(err,  message: "failed to sign the request")
    }
    log.WithField( key: "publicKey", request.PublicKey).Debug( args...: "Successfully signed the request")
    signRequestsTotal.Inc()
    return signature, nil
}
```



```go
// getSignRequestJson returns a json request based on the SignRequest type.
func getSignRequestJson(ctx context.Context, validator *validator.Validate, request *validatorpb.SignRequest, genesisValidatorsRoot []byte) (internal.SignRequestJson, erro
    if request == nil { return nil, errors.New( message: "nil sign request provided") }
    if !bytesutil.IsValidRoot(genesisValidatorsRoot) {
        return nil, fmt.Errorf( format: "invalid genesis validators root length, genesis root: %v", genesisValidatorsRoot)
    }
    switch request.Object.(type) {
    case *validatorpb.SignRequest_Block:
        return handleBlock(ctx, validator, request, genesisValidatorsRoot)
    case *validatorpb.SignRequest_AttestationData:
        return handleAttestationData(ctx, validator, request, genesisValidatorsRoot)
    case *validatorpb.SignRequest_AggregateAttestationAndProof:
        // TODO: update to V2 sometime after release
        return handleAggregateAttestationAndProof(ctx, validator, request, genesisValidatorsRoot)
    case *validatorpb.SignRequest_AggregateAttestationAndProofElectra:
        return handleAggregateAttestationAndProofV2(ctx, version.Electra, validator, request, genesisValidatorsRoot)
    case *validatorpb.SignRequest_Slot:
        return handleAggregationSlot(ctx, validator, request, genesisValidatorsRoot)
    case *validatorpb.SignRequest_BlockAltair:
        return handleBlockAltair(ctx, validator, request, genesisValidatorsRoot)
    case *validatorpb.SignRequest_BlockBellatrix:
        return handleBlockBellatrix(ctx, validator, request, genesisValidatorsRoot)
    case *validatorpb.SignRequest_BlindedBlockBellatrix:
        return handleBlindedBlockBellatrix(ctx, validator, request, genesisValidatorsRoot)
    case *validatorpb.SignRequest_BlockCapella:
        return handleBlockCapella(ctx, validator, request, genesisValidatorsRoot)
    case *validatorpb.SignRequest_BlindedBlockCapella:
        return handleBlindedBlockCapella(ctx, validator, request, genesisValidatorsRoot)
```

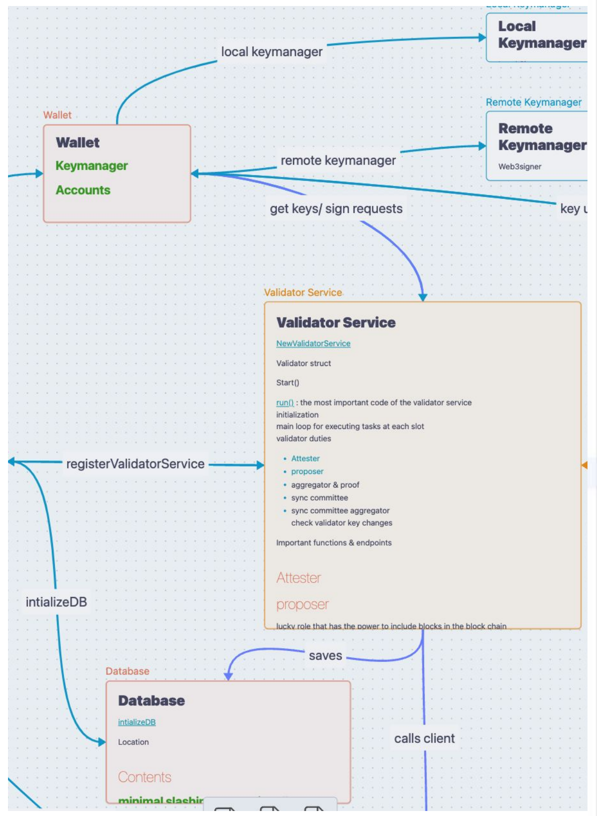
Link

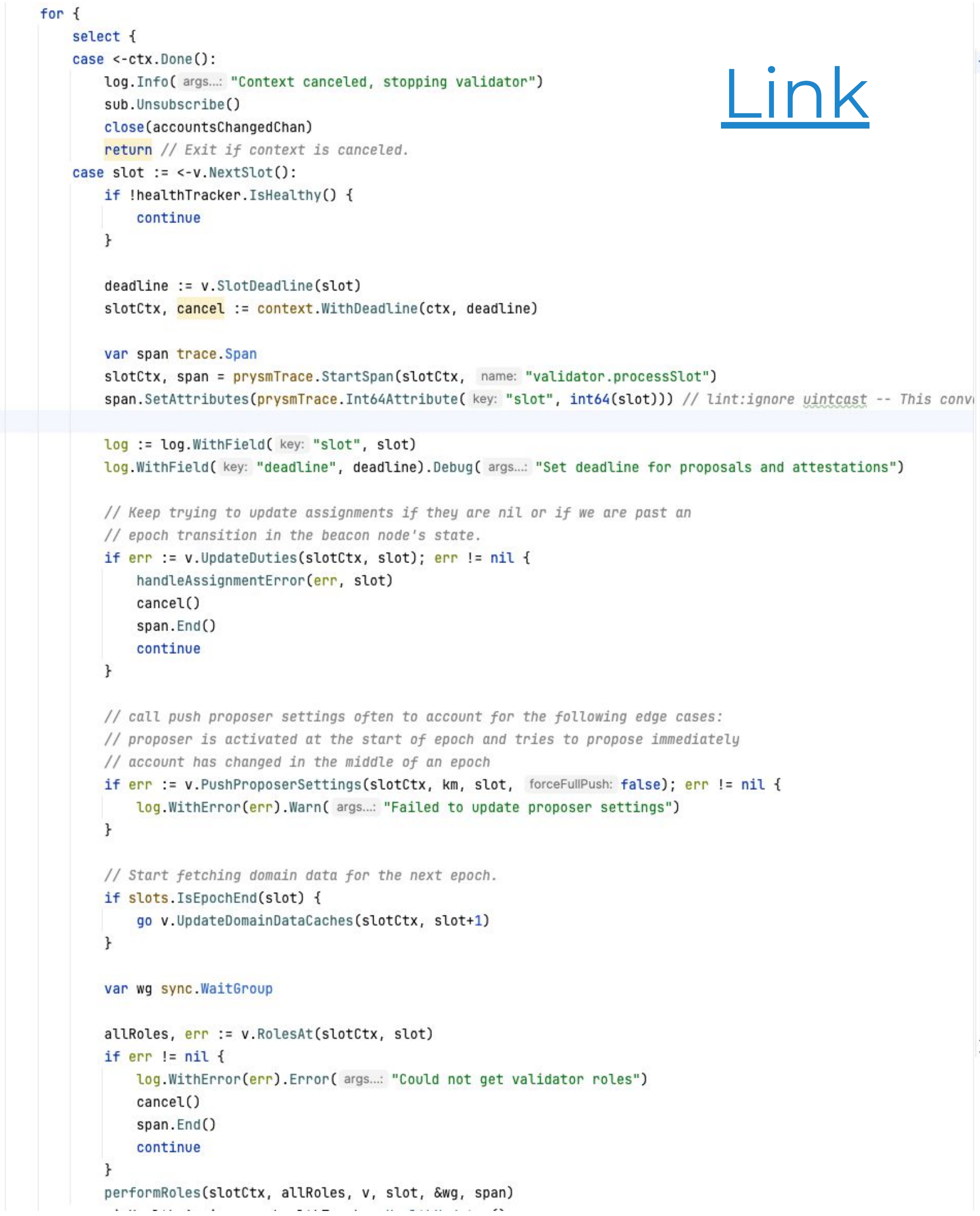


```go
// Sign is a wrapper method around the web3signer sign api.
func (client *ApiClient) Sign(ctx context.Context, pubKey string, request SignRequestJson) (bls.Signature, error) { 7
    requestPath := ethApiNamespace + pubKey
    resp, err := client.doRequest(ctx, http.MethodPost, client.BaseURL.String()+requestPath, bytes.NewBuffer(request))
    if err != nil { return nil, err }
    if resp.StatusCode == http.StatusNotFound { return nil, fmt.Errorf( format: "public key not found") }
    if resp.StatusCode == http.StatusPreconditionFailed {...}
    contentType := resp.Header.Get( key: "Content-Type")
    if strings.HasPrefix(contentType,  prefix: "application/json") {
        var sigResp SignatureResponse
        if err := unmarshalResponse(resp.Body, &sigResp); err != nil { return nil, err }
        return bls.SignatureFromBytes(sigResp.Signature)
    } else {
        return unmarshalSignatureResponse(resp.Body)
    }
}
```

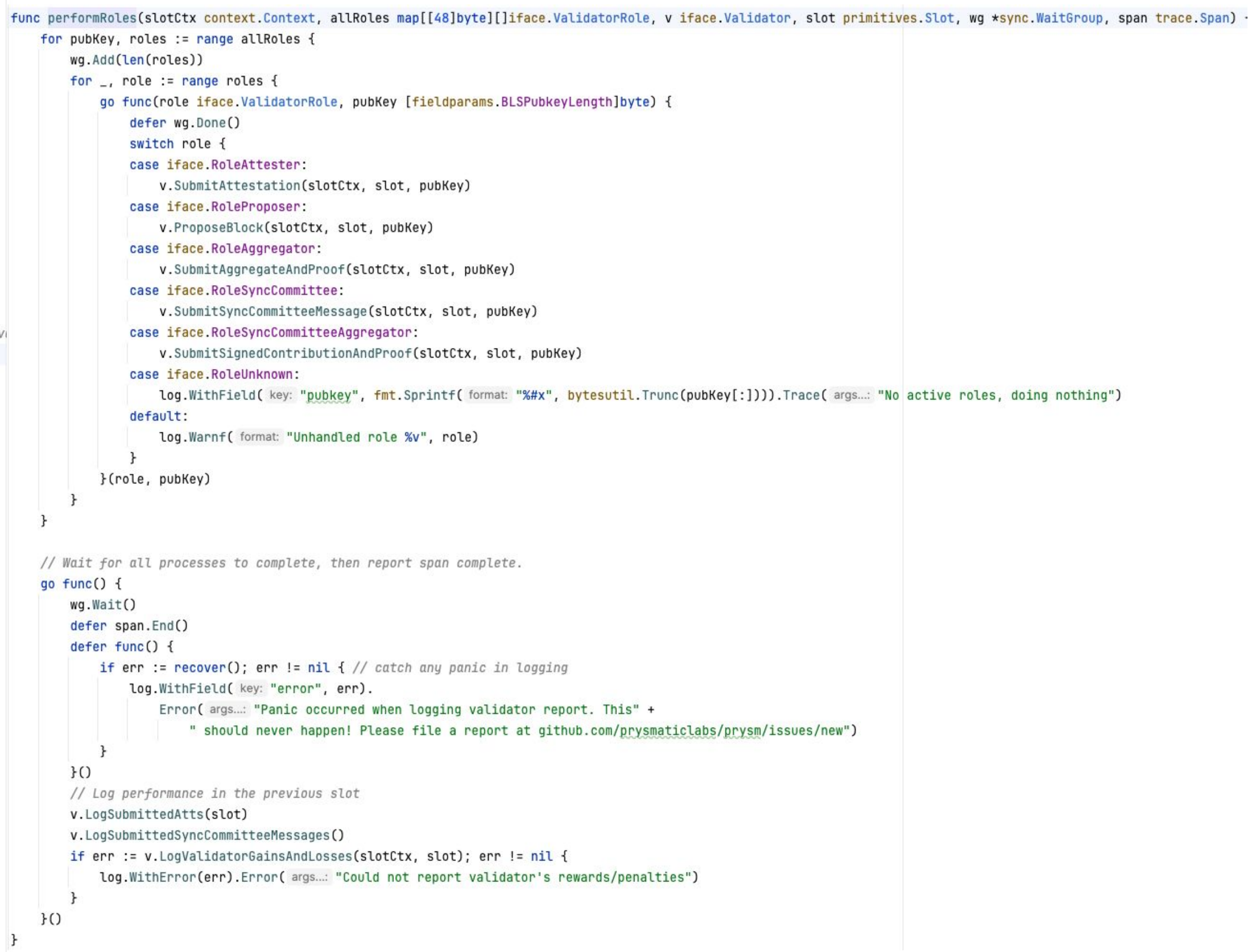
Validator Service continued …

Link





```go
for {
    select {
    case <-ctx.Done():
        log.Info( args...: "Context canceled, stopping validator")
        sub.Unsubscribe()
        close(accountsChangedChan)
        return // Exit if context is canceled.
    case slot := <-v.NextSlot():
        if !healthTracker.IsHealthy() {
            continue
        }

        deadline := v.SlotDeadline(slot)
        slotCtx, cancel := context.WithDeadline(ctx, deadline)

        var span trace.Span
        slotCtx, span = prysmTrace.StartSpan(slotCtx,  name: "validator.processSlot")
        span.SetAttributes(prysmTrace.Int64Attribute( key: "slot", int64(slot))) // lint:ignore uintcast -- This conv

        log := log.WithField( key: "slot", slot)
        log.WithField( key: "deadline", deadline).Debug( args...: "Set deadline for proposals and attestations")

        // Keep trying to update assignments if they are nil or if we are past an
        // epoch transition in the beacon node's state.
        if err := v.UpdateDuties(slotCtx, slot); err != nil {
            handleAssignmentError(err, slot)
            cancel()
            span.End()
            continue
        }

        // call push proposer settings often to account for the following edge cases:
        // proposer is activated at the start of epoch and tries to propose immediately
        // account has changed in the middle of an epoch
        if err := v.PushProposerSettings(slotCtx, km, slot,  forceFullPush: false); err != nil {
            log.WithError(err).Warn( args...: "Failed to update proposer settings")
        }

        // Start fetching domain data for the next epoch.
        if slots.IsEpochEnd(slot) {
            go v.UpdateDomainDataCaches(slotCtx, slot+1)
        }

        var wg sync.WaitGroup

        allRoles, err := v.RolesAt(slotCtx, slot)
        if err != nil {
            log.WithError(err).Error( args...: "Could not get validator roles")
            cancel()
            span.End()
            continue
        }
        performRoles(slotCtx, allRoles, v, slot, &wg, span)
```



```go
func performRoles(slotCtx context.Context, allRoles map[[48]byte][]iface.ValidatorRole, v iface.Validator, slot primitives.Slot, wg *sync.WaitGroup, span trace.Span) ·
    for pubKey, roles := range allRoles {
        wg.Add(len(roles))
        for _, role := range roles {
            go func(role iface.ValidatorRole, pubKey [fieldparams.BLSPubkeyLength]byte) {
                defer wg.Done()
                switch role {
                case iface.RoleAttester:
                    v.SubmitAttestation(slotCtx, slot, pubKey)
                case iface.RoleProposer:
                    v.ProposeBlock(slotCtx, slot, pubKey)
                case iface.RoleAggregator:
                    v.SubmitAggregateAndProof(slotCtx, slot, pubKey)
                case iface.RoleSyncCommittee:
                    v.SubmitSyncCommitteeMessage(slotCtx, slot, pubKey)
                case iface.RoleSyncCommitteeAggregator:
                    v.SubmitSignedContributionAndProof(slotCtx, slot, pubKey)
                case iface.RoleUnknown:
                    log.WithField( key: "pubkey", fmt.Sprintf( format: "%#x", bytesutil.Trunc(pubKey[:]))).Trace( args...: "No active roles, doing nothing")
                default:
                    log.Warnf( format: "Unhandled role %v", role)
                }
            }(role, pubKey)
        }
    }

    // Wait for all processes to complete, then report span complete.
    go func() {
        wg.Wait()
        defer span.End()
        defer func() {
            if err := recover(); err != nil { // catch any panic in logging
                log.WithField( key: "error", err).
                    Error( args...: "Panic occurred when logging validator report. This" +
                        " should never happen! Please file a report at github.com/prysmaticlabs/prysm/issues/new")
            }
        }()
        // Log performance in the previous slot
        v.LogSubmittedAtts(slot)
        v.LogSubmittedSyncCommitteeMessages()
        if err := v.LogValidatorGainsAndLosses(slotCtx, slot); err != nil {
            log.WithError(err).Error( args...: "Could not report validator's rewards/penalties")
        }
    }()
}
```

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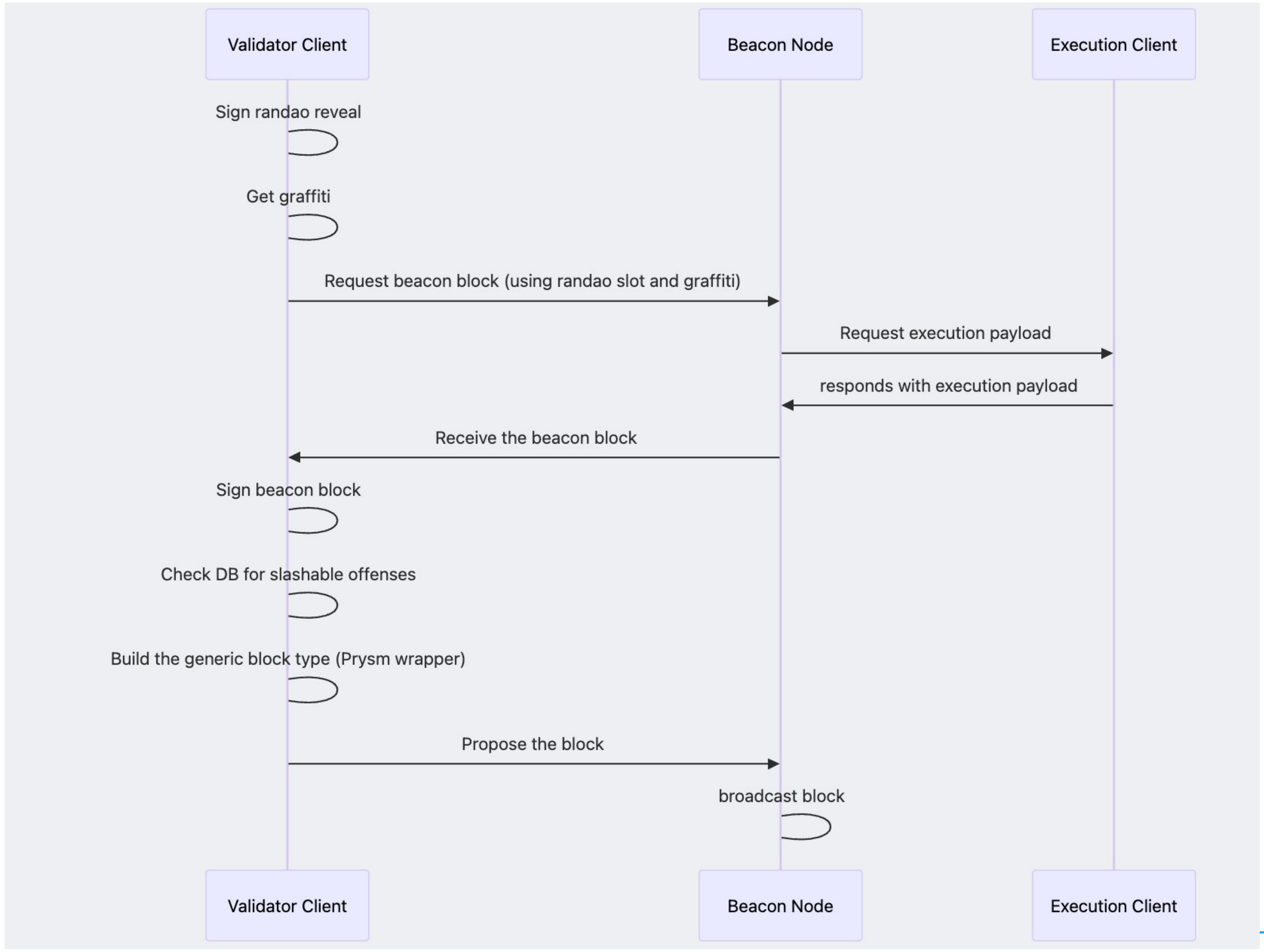
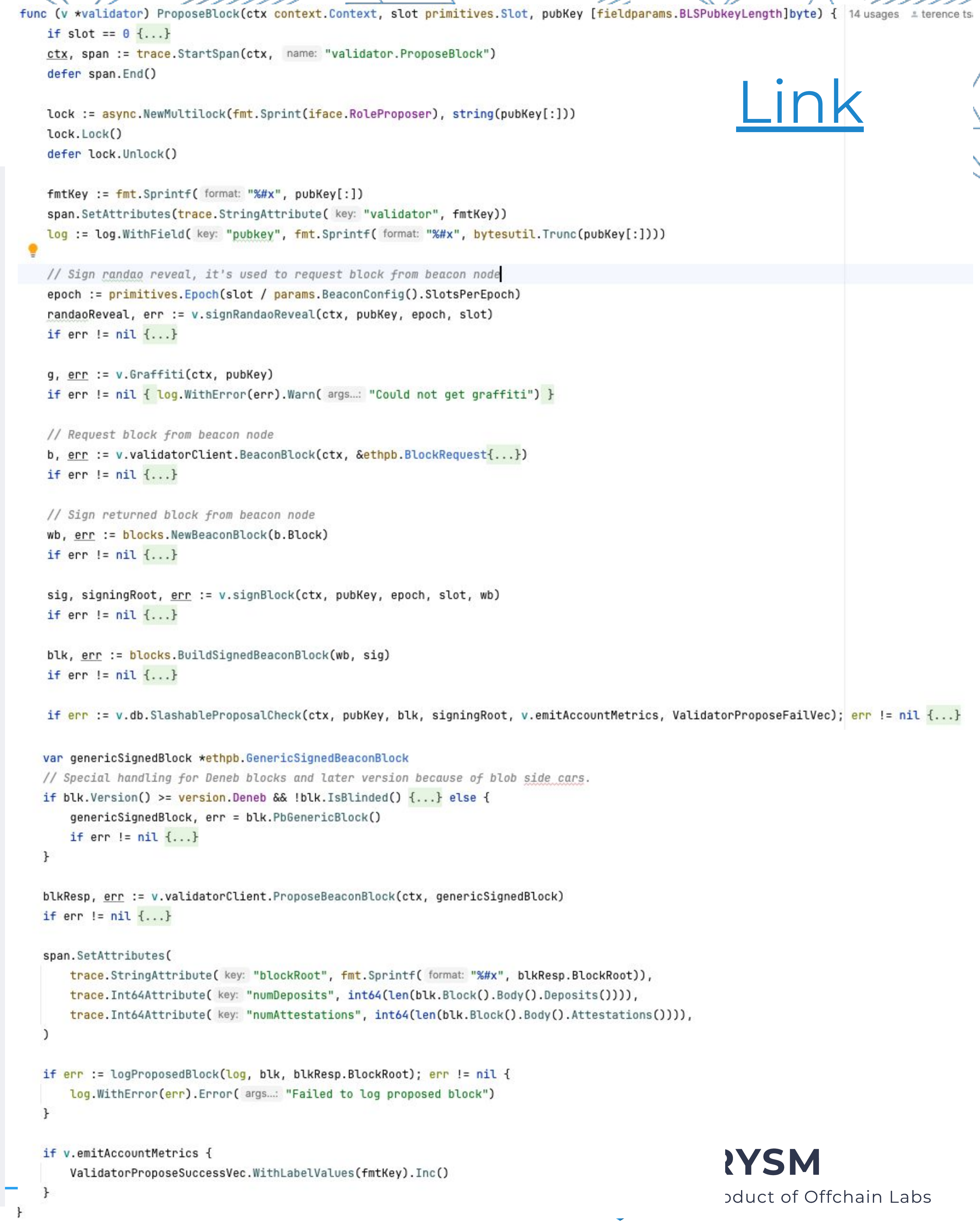
Propose Block



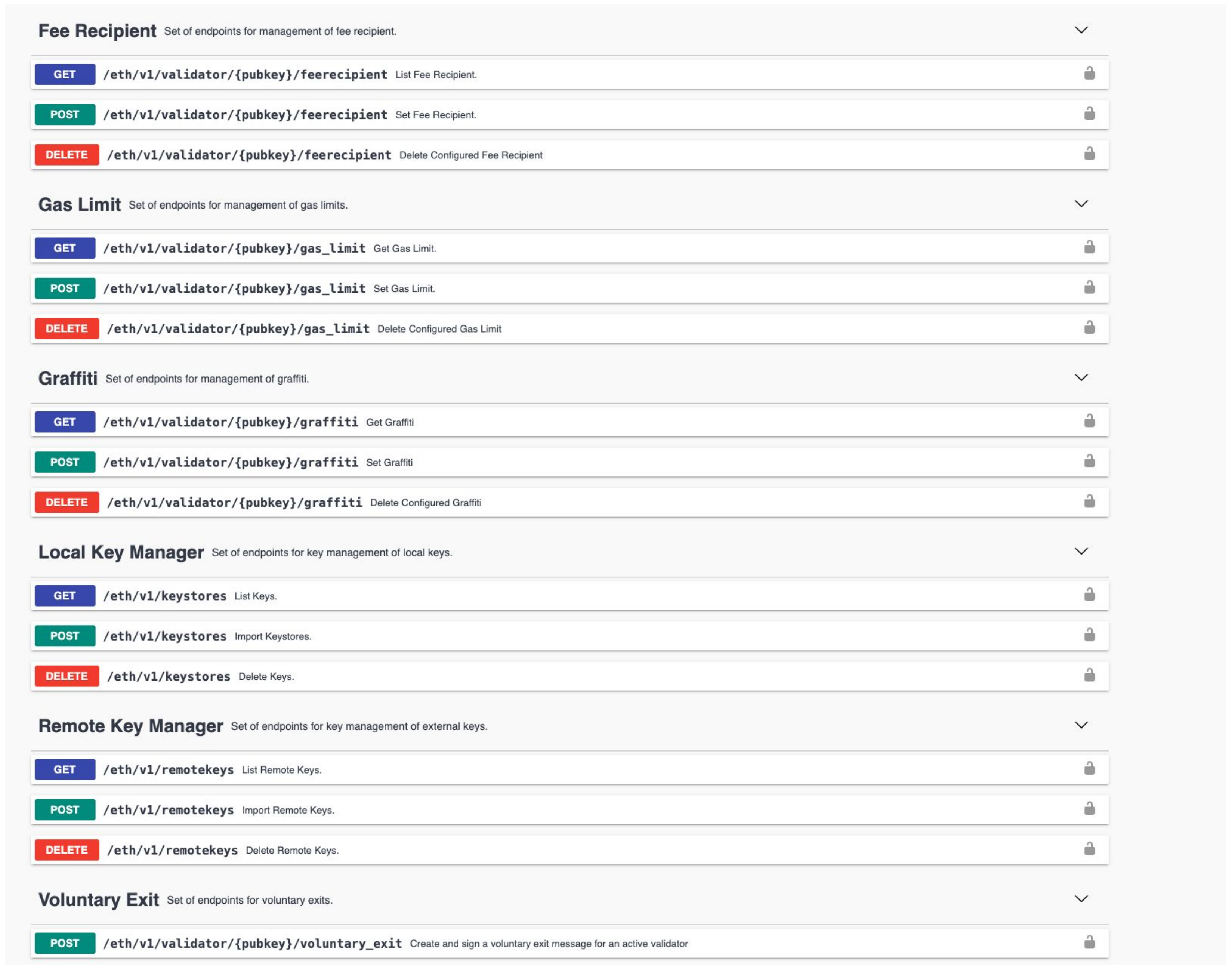
Link



```
func (v *validator) ProposeBlock(ctx context.Context, slot primitives.Slot, pubKey [fieldparams.BLSPubkeyLength]byte) {   14 usages   terence ts
    if slot == 0 {...}
    ctx, span := trace.StartSpan(ctx,  name: "validator.ProposeBlock")
    defer span.End()

    lock := async.NewMultilock(fmt.Sprint(iface.RoleProposer), string(pubKey[:]))
    lock.Lock()
    defer lock.Unlock()

    fmtKey := fmt.Sprintf( format: "%#x", pubKey[:])
    span.SetAttributes(trace.StringAttribute( key: "validator", fmtKey))
    log := log.WithField( key: "pubkey", fmt.Sprintf( format: "%#x", bytesutil.Trunc(pubKey[:])))

    // Sign randao reveal, it's used to request block from beacon node
    epoch := primitives.Epoch(slot / params.BeaconConfig().SlotsPerEpoch)
    randaoReveal, err := v.signRandaoReveal(ctx, pubKey, epoch, slot)
    if err != nil {...}

    g, err := v.Graffiti(ctx, pubKey)
    if err != nil { log.WithError(err).Warn( args...: "Could not get graffiti") }

    // Request block from beacon node
    b, err := v.validatorClient.BeaconBlock(ctx, &ethpb.BlockRequest{...})
    if err != nil {...}

    // Sign returned block from beacon node
    wb, err := blocks.NewBeaconBlock(b.Block)
    if err != nil {...}

    sig, signingRoot, err := v.signBlock(ctx, pubKey, epoch, slot, wb)
    if err != nil {...}

    blk, err := blocks.BuildSignedBeaconBlock(wb, sig)
    if err != nil {...}

    if err := v.db.SlashableProposalCheck(ctx, pubKey, blk, signingRoot, v.emitAccountMetrics, ValidatorProposeFailVec); err != nil {...}

   var genericSignedBlock *ethpb.GenericSignedBeaconBlock
   // Special handling for Deneb blocks and later version because of blob side cars.
   if blk.Version() >= version.Deneb && !blk.IsBlinded() {...} else {
       genericSignedBlock, err = blk.PbGenericBlock()
       if err != nil {...}
   }

   blkResp, err := v.validatorClient.ProposeBeaconBlock(ctx, genericSignedBlock)
   if err != nil {...}

   span.SetAttributes(
       trace.StringAttribute( key: "blockRoot", fmt.Sprintf( format: "%#x", blkResp.BlockRoot)),
       trace.Int64Attribute( key: "numDeposits", int64(len(blk.Block().Body().Deposits()))),
       trace.Int64Attribute( key: "numAttestations", int64(len(blk.Block().Body().Attestations()))),
   )

   if err := logProposedBlock(log, blk, blkResp.BlockRoot); err != nil {
       log.WithError(err).Error( args...: "Failed to log proposed block")
   }

   if v.emitAccountMetrics {
       ValidatorProposeSuccessVec.WithLabelValues(fmtKey).Inc()
   }
}
```

Keymanager APIs

https://ethereum.github.io/keymanager-APIs/



Fee Recipient Set of endpoints for management of fee recipient.

- GET `/eth/v1/validator/{pubkey}/feerecipient` List Fee Recipient.
- POST `/eth/v1/validator/{pubkey}/feerecipient` Set Fee Recipient.
- DELETE `/eth/v1/validator/{pubkey}/feerecipient` Delete Configured Fee Recipient

Gas Limit Set of endpoints for management of gas limits.

- GET `/eth/v1/validator/{pubkey}/gas_limit` Get Gas Limit.
- POST `/eth/v1/validator/{pubkey}/gas_limit` Set Gas Limit.
- DELETE `/eth/v1/validator/{pubkey}/gas_limit` Delete Configured Gas Limit

Graffiti Set of endpoints for management of graffiti.

- GET `/eth/v1/validator/{pubkey}/graffiti` Get Graffiti
- POST `/eth/v1/validator/{pubkey}/graffiti` Set Graffiti
- DELETE `/eth/v1/validator/{pubkey}/graffiti` Delete Configured Graffiti

Local Key Manager Set of endpoints for key management of local keys.

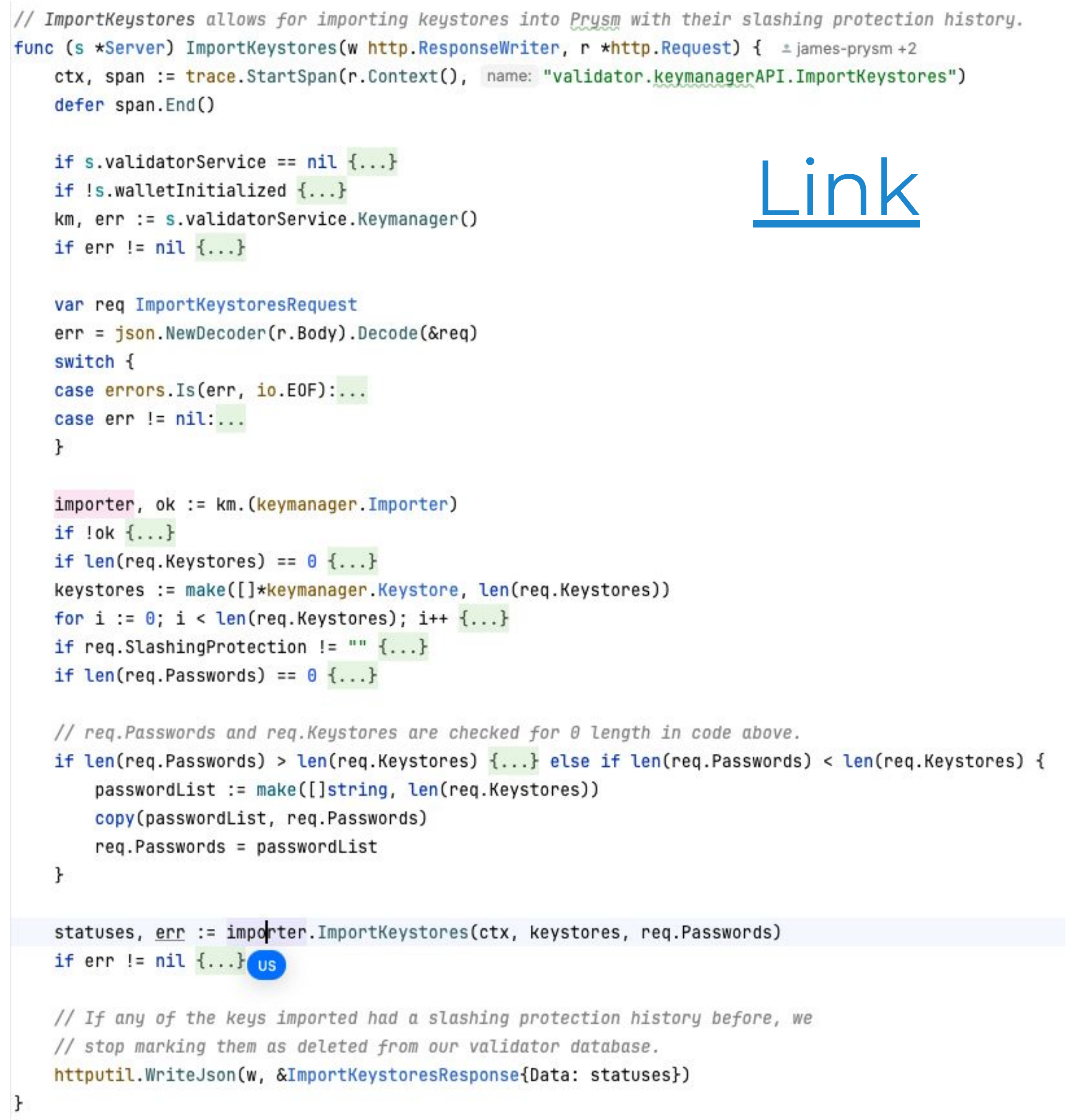
- GET `/eth/v1/keystores` List Keys.
- POST `/eth/v1/keystores` Import Keystores.
- DELETE `/eth/v1/keystores` Delete Keys.

Remote Key Manager Set of endpoints for key management of external keys.

- GET `/eth/v1/remotekeys` List Remote Keys.
- POST `/eth/v1/remotekeys` Import Remote Keys.
- DELETE `/eth/v1/remotekeys` Delete Remote Keys.

Voluntary Exit Set of endpoints for voluntary exits.

- POST `/eth/v1/validator/{pubkey}/voluntary_exit` Create and sign a voluntary exit message for an active validator



```go
// ImportKeystores allows for importing keystores into Prysm with their slashing protection history.
func (s *Server) ImportKeystores(w http.ResponseWriter, r *http.Request) {  james-prysm +2
    ctx, span := trace.StartSpan(r.Context(),  name: "validator.keymanagerAPI.ImportKeystores")
    defer span.End()

    if s.validatorService == nil {...}
    if !s.walletInitialized {...}
    km, err := s.validatorService.Keymanager()
    if err != nil {...}

    var req ImportKeystoresRequest
    err = json.NewDecoder(r.Body).Decode(&req)
    switch {
    case errors.Is(err, io.EOF):...
    case err != nil:...
    }

    importer, ok := km.(keymanager.Importer)
    if !ok {...}
    if len(req.Keystores) == 0 {...}
    keystores := make([]*keymanager.Keystore, len(req.Keystores))
    for i := 0; i < len(req.Keystores); i++ {...}
    if req.SlashingProtection != "" {...}
    if len(req.Passwords) == 0 {...}

    // req.Passwords and req.Keystores are checked for 0 length in code above.
    if len(req.Passwords) > len(req.Keystores) {...} else if len(req.Passwords) < len(req.Keystores) {
        passwordList := make([]string, len(req.Keystores))
        copy(passwordList, req.Passwords)
        req.Passwords = passwordList
    }

    statuses, err := importer.ImportKeystores(ctx, keystores, req.Passwords)
    if err != nil {...}

    // If any of the keys imported had a slashing protection history before, we
    // stop marking them as deleted from our validator database.
    httputil.WriteJson(w, &ImportKeystoresResponse{Data: statuses})
}
```

Link

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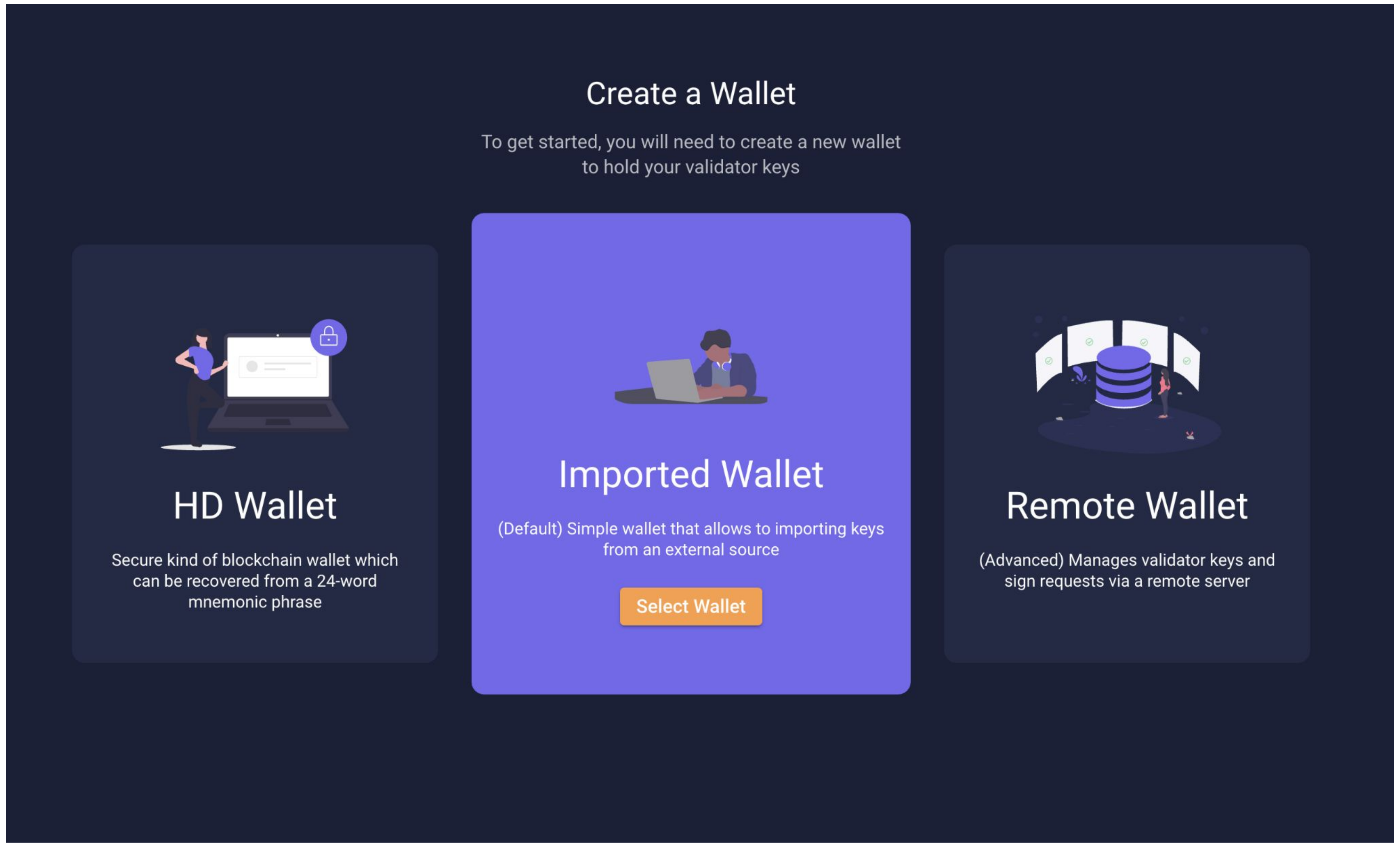
WebUI


Create a Wallet

To get started, you will need to create a new wallet to hold your validator keys

HD Wallet

Secure kind of blockchain wallet which can be recovered from a 24-word mnemonic phrase

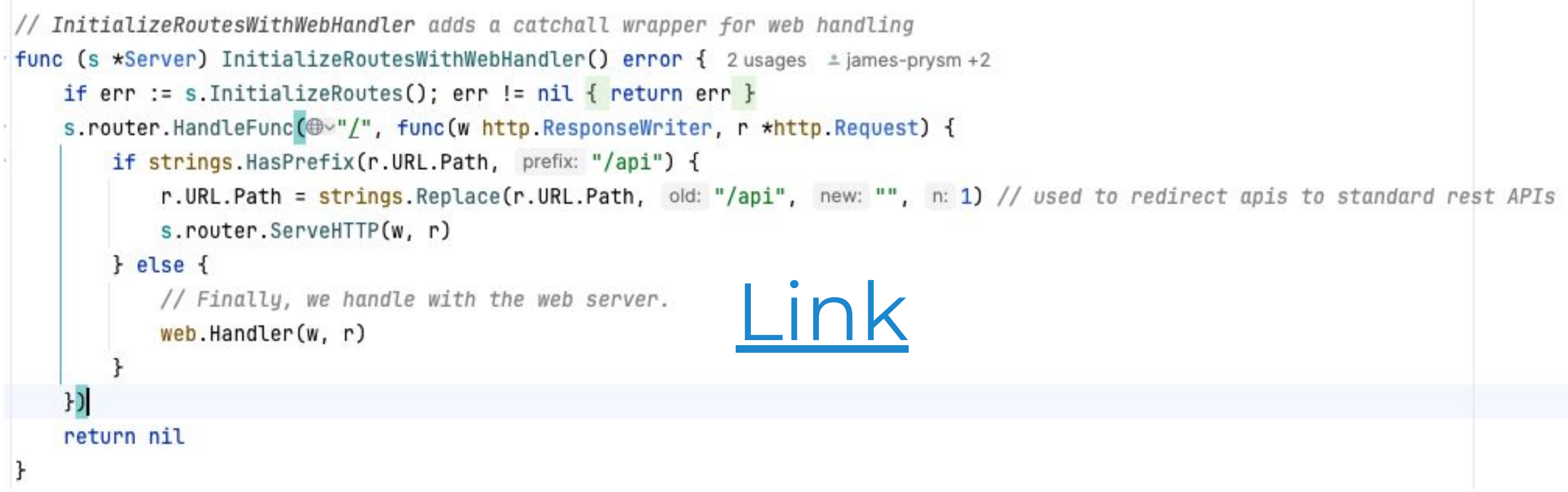
Imported Wallet

(Default) Simple wallet that allows to importing keys from an external source

Select Wallet

Remote Wallet

(Advanced) Manages validator keys and sign requests via a remote server


```go
// InitializeRoutesWithWebHandler adds a catchall wrapper for web handling
func (s *Server) InitializeRoutesWithWebHandler() error {  2 usages  james-prysm +2
    if err := s.InitializeRoutes(); err != nil { return err }
    s.router.HandleFunc("/", func(w http.ResponseWriter, r *http.Request) {
        if strings.HasPrefix(r.URL.Path, prefix: "/api") {
            r.URL.Path = strings.Replace(r.URL.Path, old: "/api", new: "", n: 1) // used to redirect apis to standard rest APIs
            s.router.ServeHTTP(w, r)
        } else {
            // Finally, we handle with the web server.
            web.Handler(w, r)
        }
    })
    return nil
}
```

Link

https://github.com/prysmaticlabs/prysm-web-ui

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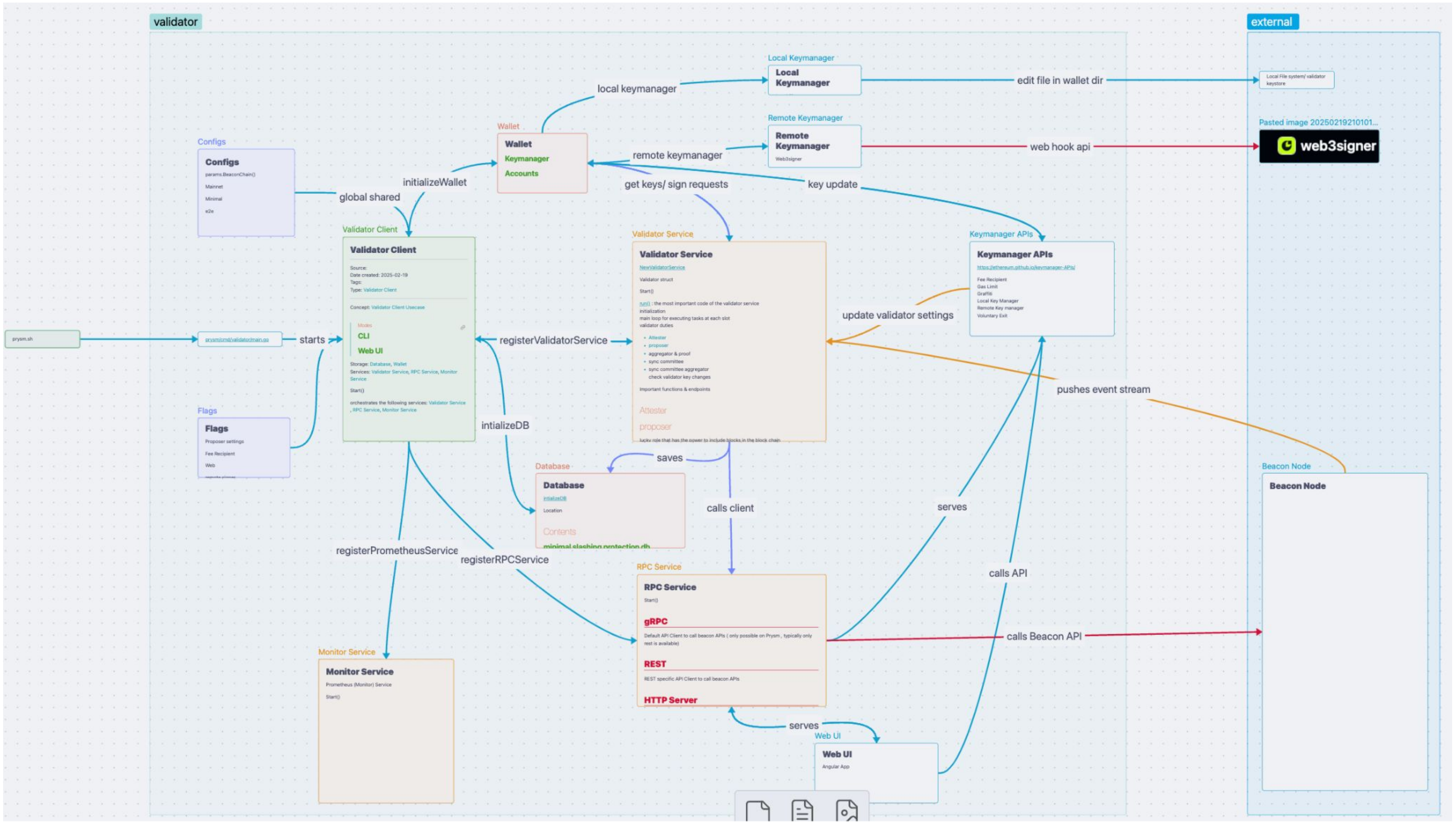
Review of architecture



1. **Manage/Use** your validator **keystores**

2. Perform validator **protocol duties**

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