Nuts Node Documentation

Nuts community

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GETTING STARTED:

CHAPTER

ONE

"HELLO WORLD" ON DOCKER

The simplest way to spin up the Nuts stack is by using the setup provided by nuts-network-local. The setup is meant for development purposes and starts a Nuts node, "Demo EHR", "Registry Admin Demo" for administering your vendor and care organizations and a HAPI server to exchange FHIR data.

To get started, clone the repository and run the following commands to start the stack:

```
cd single
docker compose pull
docker compose up
```

After the services have started you can try the following endpoints:

- Nuts Node status page.
- Registry Admin Demo login (default password: "demo").
- Demo EHR login (default password: "demo").

CHAPTER

TWO

RUNNING ON DOCKER

If you already use Docker, the easiest way to get your Nuts Node up and running for development or production is using Docker. This guide helps you to configure the Nuts node in Docker. To use the latest *master* build use *nutsfoundation/nuts-node:master* (for production environments it's advisable to use a specific version).

First determine the working directory for the Nuts node which will contain configuration and data. These which will be mounted into the Docker container. Follow the *configuration* to setup the configuration of your node.

2.1 Mounts

Using this guide the following resources are mounted:

- Readonly PEM file with TLS certificate and private key. They can be separate but in this example they're contained in 1 file.
- Readonly PEM file with TLS truststore for the particular network you're connecting to.
- Readonly *nuts.yaml* configuration file.
- Data directory where data is stored.

2.2 Docker run

If you want to run without Docker Compose you can use the following command from the working directory:

```
docker run --name nuts -p 5555:5555 -p 1323:1323 \
  --mount type=bind,source="$(pwd)"/certificate-and-key.pem,target=/opt/nuts/certificate-
↪and-key.pem,readonly \
  --mount type=bind,source="$(pwd)"/truststore.pem,target=/opt/nuts/truststore.pem,
↪readonly \
  --mount type=bind,source="$(pwd)"/nuts.yaml,target=/opt/nuts/nuts.yaml,readonly \
  --mount type=bind,source="$(pwd)"/data,target=/opt/nuts/data \
  -e NUTS_CONFIGFILE=/opt/nuts/nuts.yaml \
  nutsfoundation/nuts-node:master
```

This setup uses the following *nuts.yaml* configuration file:

```
datadir: /opt/nuts/data
network:
  truststorefile: /opt/nuts/truststore.pem
  certfile: /opt/nuts/certificate-and-key.pem
```

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```
  certkeyfile: /opt/nuts/certificate-and-key.pem
  bootstrapnodes:
    - example.com:5555
```

Note: The command above uses *pwd* and *bash* functions, which do not work on Windows. If running on Windows replace it with the path of the working directory.

You can test whether your Nuts Node is running properly by visiting *http://localhost:1323/status/diagnostics*. It should display diagnostic information about the state of the node.

2.3 Docker Compose

Copy the following YAML file and save it as *docker-compose.yaml* in the working directory.

```
version: "3.7"
services:
  nuts:
    image: nutsfoundation/nuts-node:master
    environment:
      NUTS_CONFIGFILE: /opt/nuts/nuts.yaml
    ports:
      - 5555:5555
      - 1323:1323
    volumes:
      - "./certificate-and-key.pem:/opt/nuts/certificate-and-key.pem:ro"
      - "./truststore.pem:/opt/nuts/truststore.pem:ro"
      - "./nuts.yaml:/opt/nuts/nuts.yaml:ro"
      - "./data:/opt/nuts/data:rw"
```

Start the service:

```
docker-compose up
```

CHAPTER

THREE

RUNNING THE NATIVE BINARY

The Nuts executable this project provides can be used to both run a Nuts server (a.k.a. node) and administer a running node remotely. This guide explains how to run a Nuts node using the native binary.

3.1 Building

Since no precompiled binaries exist (yet), you'll have to build the binary for your platform.

First check out the project using:

```
git clone https://github.com/nuts-foundation/nuts-node
cd nuts-node
```

Then create the executable using the *make* command:

```
make build
```

Or if make is not available:

```
go build -ldflags="-w -s -X 'github.com/nuts-foundation/nuts-node/core.GitCommit=GIT_
↪COMMIT' -X 'github.com/nuts-foundation/nuts-node/core.GitBranch=GIT_BRANCH' -X 'github.
↪com/nuts-foundation/nuts-node/core.GitVersion=GIT_VERSION'" -o /path/to/nuts
```

Make sure *GIT_COMMIT*, *GIT_BRANCH* and *GIT_VERSION* are set as environment variables. These variables help identifying an administrator and other nodes what version your node is using. If this isn't important then replace *GIT_COMMIT* with *0*, *GIT_BRANCH* with *master* and *GIT_VERSION* with *undefined*.

3.2 Starting

Start the server using the *server* command:

```
nuts server
```

Now continue with the *configuration*.

CHAPTER

FOUR

SETTING UP YOUR NODE FOR A NETWORK

After you managed to start your node using either *docker* or *native* it's time to connect to a network.

4.1 Prerequisites

The following is needed to connect a Nuts node to a network:

1. A runnable node.
2. A network you want to join.
3. A TLS client- and server certificate which is accepted by the other nodes in the network (e.g. PKIoverheid).
4. The public address of one or more remote nodes you'd like to use as bootstrap nodes.
5. A node identity (node DID) to identify yourself in the network, so you can send/receive private transactions.

4.1.1 Networks

A network contains of a set of nodes who can all communicate with each other. To make this possible, each of the nodes must meet the following requirements:

- Share a common set of trusted Certificate Authorities.
- Use a certificate issued by one of the CAs.
- The network transactions share the same root transaction.
- Use and accept network protocol versions from an agreed upon set.

There are 3 official Nuts networks:

- *development* where new features are tested. Nodes will generally run the newest (not yet released) version of the Nuts node.
- *stable* for integrating your software with Nuts and testing with other vendors. Nodes will generally run the latest released version (or at least a recent one).
- *production* for production uses. Connecting to this network involves PKIoverheid certificates and outside the scope of this tutorial.

4.1.2 Node TLS Certificate

Before you can join a network, your node needs a certificate from the correct Certificate Authority (CA). The two *development* and`stable` networks are open for everyone to join. Contrary to the *production* network (where we will be using a real Certificate Authority like PKIoverheid) the CA certificate and private key for these networks are available on github. This way you can generate your own certificate.

To generate the certificate for your own node you need the `https://github.com/nuts-foundation/nuts-development-network-ca` repository. It contains handy scripts and the needed key material. For more information how to use, consult the README

Your node only accepts connections from other nodes which use a certificate issued by one of the trusted CAs. Trusted CAs are using a truststore file. The truststore is a PEM file which contains one or more certificates from CAs which the network participants all decided on to trust. To learn more about how a Nuts network uses certificates, see the specification RFC008.

To generate certificates for the *development* network perform the following steps:

```
git clone https://github.com/nuts-foundation/nuts-development-network-ca
cd nuts-development-network-ca
./issue-cert.sh development nuts.yourdomain.example
```

This results in 3 files:

- `nuts.yourdomain.example-development.key` The private key for the node.
- `nuts.yourdomain.example-development.pem` The certificate for the node.
- `truststore-development.pem` The truststore for this (development) network.

4.1.3 Bootstrap nodes

A bootstrap node is just a normal Nuts node which is available for other nodes to connect to. When you want to join a network, you must approach another network participant and ask for its public (gRPC) endpoint. After connecting, you receive a copy of the current state of the network. These transactions contain endpoints of other nodes. After a reboot, your node will try to connect to other nodes discoverd in the network. Your node will have to connect to the bootstrap node's gRPC endpoint which is configured on port `5555` by default.

Consult the community on Slack in the `#development` channel to find out which public bootstrap nodes are available to connect to your network of choice.

4.2 Configuring

1. Configure the bootstrap nodes using `network.bootstrapnodes`.
2. Configure TLS using `network.certfile`, `network.certkeyfile` and `network.truststorefile`.

See *configuration reference* for a detailed explanation on how to exactly configure the Nuts node.

Note: You can start the node without configuring the network, but it won't connect and thus exchange data with other nodes. You'll have a private network with one single node. Perfect for local development, but a bit lonely.

4.2.1 Node Identity

Certain data (e.g. private credentials) can only be exchanged when a peer's DID has been authenticated. To make sure other nodes can authenticate your node's DID you need to configure your node's identity, and make sure the DID document contains a `NutsComm` service that matches the TLS certificate.

Your node identity is expressed by a DID that is managed by your node, also known as your *vendor DID*. So make sure you have created a DID specific for your nodes and configure it as `network.nodedid` (see *configuration reference*).

Then you make sure the associated DID Document contains a `NutsComm` endpoint, where the domain part (e.g. `nuts.nl`) matches (one of) the DNS SANs in your node's TLS certificate. See "Node Discovery" below for more information on registering the `NutsComm` endpoint.

Note: After registering `nodedid` you need to reboot your node in order have your connections authenticated, which is required to receive private transactions.

Note: Multiple nodes may share the same DID, if they're governed by the same organization (e.g., clustered setups).

4.2.2 YAML Configuration File

If you're using a YAML file to configure your node, the following snippet shows an example for the network related configuration:

```
network:
  truststorefile: /path/to/truststore-development.pem
  certfile: /path/to/nuts.yourdomain.example-development.pem
  certkeyfile: /path/to/nuts.yourdomain.example-development.key
  nodedid: did:nuts:123
  bootstrapnodes:
    - nuts-development.other-service-provider.example:5555
```

4.2.3 Node Discovery

To allow your Nuts node to be discovered by other nodes (so they can connect to it) and be able to receive private transactions, you need to register a `NutsComm` endpoint on your vendor DID document. The `NutsComm` endpoint contains a URL to your node's public gRPC service, and must be in the form of `grpc://<host>:<port>`. E.g., if it were to run on `nuts.nl:5555`, the value of the `NutsComm` endpoint should be `grpc://nuts.nl:5555`

You can register the `NutsComm` endpoint by calling `addEndpoint` on the DIDMan API:

```
POST <internal-node-address>/internal/didman/v1/did/<vendor-did>/endpoint
{
    "type": "NutsComm",
    "endpoint": "grpc://nuts.nl:5555"
}
```

4.3 Care Organizations

The DID documents of your care organizations you (as a vendor) want to expose on the Nuts network need to be associated with your vendor's DID document through the `NutsComm` endpoint. Its recommended to register the actual `NutsComm` endpoint on your vendor DID document (as explained in the previous section), and register a reference to this endpoint on the DID documents of your vendor's care organizations:

```
POST <internal-node-address>/internal/didman/v1/did/<care-organization-did>/endpoint
{
    "type": "NutsComm",
    "endpoint": "<vendor-did>/serviceEndpoint?type=NutsComm"
}
```

CHAPTER

FIVE

GETTING STARTED ON CUSTOMER INTEGRATION

This getting started manual assumes a vendor sells services to its customers. The vendor manages the presence of those customers on the Nuts network through the Nuts registry. It's very likely the vendor has software to manage customer environments. We'll call it a *CRM* where the *customers* part relates to organizations and not people. This does not mean that a stand-alone installation isn't supported. In that case the vendor and organization are the same.

The Nuts registry enables service discovery for organizations. The registry identifies organizations through their *DID*. The DIDs are unique identifiers which are generated when the organization is registered in the Nuts registry. After creation of the DID the CRM should store and map it to its customer record, so it can refer to it when updating the customer's DID Document and issue Verifiable Credentials.

All APIs used in the following chapters are documented at the *API* page. Open API Spec files are available for generating client code.

5.1 Vendor integration

As a vendor, you're in power of:

- running a Nuts node
- handling organization key material
- updating the organization DID Document
- defining service endpoints
- issuing name credentials for organizations
- trusting other vendors

The last three points require a setup where a vendor DID is created. This DID will act as the controller of all organization DID Documents. This will allow for reuse of service endpoints and issuance of Verifiable Credentials. Since every DID issuing Verifiable Credentials must be trusted individually, it's easier for other vendors when the vendor uses a single DID for issuing credentials.

5.1.1 Create and store a vendor DID

Your CRM must store the DIDs created for your vendor and your customers. A DID is a string similar to:

```
did:nuts:2mF6KT6eiSx5y2fwTP4Y42yMUh91zGVkbu4KMARvCJz9
```

The DID we're about to create is your *vendor DID*. It will be used in the all of the next steps. For the API calls that will need to be made to the Nuts node, we'll use `<internal-node-address>` as the address where the internal API's are exposed. Consult the *configuration reference* on how to configure the node address.

```
POST <internal-node-address>/internal/vdr/v1/did
{
    "selfControl": true,
    "keyAgreement": true,
    "assertionMethod": true,
    "capabilityInvocation": true
}
```

The request above instructs the node to create a new DID and DID Document. The DID Document will be published to all other nodes. The node will generate a new keypair and store it in the crypto backend. The options above will instruct the node to allow the DID Document to be changed by itself (`selfControl = true AND capabilityInvocation = true`) and that the DID can be used to issue credentials (`assertionMethod = true`). If all is well, the node will respond with a DID Document similar to:

```
{
  "@context": [ "https://www.w3.org/ns/did/v1" ],
  "id": "did:nuts:2mF6KT6eiSx5y2fwTP4Y42yMUh91zGVkbu4KMARvCJz9",
  "verificationMethod": [
    {
      "id": "did:nuts:2mF6KT6eiSx5y2fwTP4Y42yMUh91zGVkbu4KMARvCJz9#_
↪TKzHv2jFIyvdTGF1Dsgwngfdg3SH6TpDv0Ta1aOEkw",
      "controller": "did:nuts:2mF6KT6eiSx5y2fwTP4Y42yMUh91zGVkbu4KMARvCJz9",
      "type": "JsonWebKey2020",
      "publicKeyJwk": {
        "crv": "P-256",
        "x": "38M1FDts7Oea7urmseiugGW7tWc3mLpJh6rKe7xINZ8",
        "y": "nDQW6XZ7b_u2Sy9slofYLlG03sOEoug3I0aAPQ0exs4",
        "kty": "EC"
      }
    }],
  "capabilityInvocation": [
    "did:nuts:2mF6KT6eiSx5y2fwTP4Y42yMUh91zGVkbu4KMARvCJz9#_
↪TKzHv2jFIyvdTGF1Dsgwngfdg3SH6TpDv0Ta1aOEkw"
  ],
  "assertion": [
    "did:nuts:2mF6KT6eiSx5y2fwTP4Y42yMUh91zGVkbu4KMARvCJz9#_
↪TKzHv2jFIyvdTGF1Dsgwngfdg3SH6TpDv0Ta1aOEkw"
  ],
  "keyAgreement": [
    "did:nuts:2mF6KT6eiSx5y2fwTP4Y42yMUh91zGVkbu4KMARvCJz9#_
↪TKzHv2jFIyvdTGF1Dsgwngfdg3SH6TpDv0Ta1aOEkw"
  ],
  "service": []
}
```

The `id` at the top level needs to be extracted and stored as your vendor DID. In the example above this would be `did:nuts:2mF6KT6eiSx5y2fwTP4Y42yMUh91zGVkbu4KMARvCJz9`. The DID Document shouldn't be stored since the Nuts node will do this for you.

5.1.2 Setting vendor contact information

Things can go wrong: a node is misbehaving or a DID Document is conflicted. If the node operator is not resolving the problem it's extremely convenient if others can contact the node operator and relay the problem. For this use-case, Nuts supports the registration of node contact information. The contact information will be added to a DID Document as a service. A convenience API is available to add the contact information to a DID Document. The vendor DID should be used for this.

```
PUT <internal-node-address>/internal/didman/v1/did/<did>/contactinfo
{
    "name": "vendor X",
    "phone": "06-12345678",
    "email": "info@example.com",
    "website": "https://example.com"
}
```

Where <did> must be replaced with the vendor DID.

5.1.3 Adding endpoints

As a vendor you'll probably be hosting different services at various stages. A Nuts node API is available to easily add/remove the endpoints for these services. Registering services is a required step since the services that will be registered for organizations will make use of these services.

```
POST <internal-node-address>/internal/didman/v1/did/<did>/endpoint
{
    "type": "example-production-api",
    "endpoint": "https://api.example.com"
}
```

Where <did> must be replaced with the vendor DID. The `type` may be freely chosen and is used as reference in the organization services. The `endpoint` must be a valid endpoint (this differs per type of service). For some services this could be a base-url. If this is the case, the bolt description will note this.

5.2 Organization integration

Each organization (or customer) must be registered with its own DID and DID Document. The vendor CRM should make it possible to store a DID for each organization. Requests that are made in the context of the organization will use the private key of the organization. To easily control the DID Document of an organization, the vendor will be the controller.

5.2.1 Create and store a customer DID

A DID can be created like the vendor DID:

```
POST <internal-node-address>/internal/vdr/v1/did
{
    "selfControl": false,
    "controllers": [<did>],
    "assertionMethod": true,
    "capabilityInvocation": false
}
```

Where `<did>` must be replaced with the vendor DID. The body for creating an organization DID differs from the vendor DID in the fact that the vendor DID is in control of the newly generated DID Document. The `assertionMethod` is still true since it'll allow for the generation of access-tokens in the context of the organization. The result is similar to the output of the vendor DID creation. In this case the `id` must also be extracted and stored within the vendor CRM for the right organization.

5.2.2 Issue a Nuts Organization Credential

After registering an organization, its presence on the network and in the Nuts registry is now only a DID. In order for other organizations to find the correct DID and connected services, credentials should be issued and published over the network. For this, the *NutsOrganizationCredential* can be issued by any vendor. A *NutsOrganizationCredential* contains the `name` of the organization and the `city` where this name is registered as organization. The combination of those should be unique (since duplicate names within a sector is disallowed).

A credential can be issued with the following call:

```
POST <internal-node-address>/internal/vcr/v2/issuer/vc
{
    "type": "NutsOrganizationCredential",
    "issuer": "<issuer-did>",
    "credentialSubject": {
        "id": "<holder-did>",
        "organization": {
            "name": "<name>",
            "city": "<city>"
        }
    },
    "visibility": "public"
}
```

Where `<issuer-did>` must be replaced with the vendor DID, `<holder-did>` must be replaced with the organization DID,``<name>`` and `<city>` must be replaced with the correct information. The API will respond with the full Verifiable Credential. It's not required to do anything with that since issued credentials can be found again.

5.2.3 Trusting other vendors as issuer

A node operator must not blindly trust all the data is published over the network. Before credentials can be found, the issuer has to be trusted. By default, no issuers are trusted. A list of untrusted issuers can be obtained from the node through:

```
GET <internal-node-address>/internal/vcr/v2/verifier/NutsOrganizationCredential/untrusted
```

This will return a list of all DIDs that are currently not trusted. If a DID is to be trusted should be validated out-of-band, eg: by phone or video conference call. The registered contact information for that DID could help in contacting the right party. Be aware that the provided contact information isn't verified. So instead of asking: "is this your DID?", ask: "could you please tell me your DID?". After a DID has been verified, it can be trusted by calling the following API:

```
POST <internal-node-address>/internal/vcr/v2/verifier/trust
{
    "issuer": "<did>",
    "credentialType": "NutsOrganizationCredential"
}
```

Where `<did>` must be replaced with the validated DID. It's also possible to update the `vcr/trusted_issuers.yaml` file located in the data directory (configured via the `datadir` property). After a vendor has been trusted, any of its registered organizations should be searchable by name.

Note: Future development will see new cryptographic means. These means could enable the organization to self-register its name. The network should then migrate to a trust model where the issuer of those means is trusted instead of the different vendors.

5.2.4 Enabling a bolt

Organizations can be found on the network and endpoints have been defined. Now it's time to enable specific bolts so users can start using data from other organizations. Every bolt requires its own configuration. This configuration is known as a Compound Service on the organization's DID document. A Compound Service defines certain endpoint types and which endpoint to use for that type.

A Compound Service can be added with the following request:

```
POST <internal-node-address>/internal/didman/v1/did/<did>/compoundservice
{
    "type": "<type>",
    "serviceEndpoint": {
        "<X>": "<endpoint_did>/serviceEndpoint?type=<Y>",
        ...
    }
}
```

The parameters must be replaced:

- `<did>` must be replaced with the organization DID.
- `<type>` must be replaced with the type defined by the bolt specification.
- `<endpoint_did>` must be replaced with the vendor DID that defines the endpoints.

- <X> must be replaced with the type required by the bolt specification. All types defined by the specification must be added, unless stated otherwise.
- <Y> must be replaced with the correct endpoint type from the vendor DID Document. <endpoint_did>/serviceEndpoint?type=<Y> must be a valid query within the corresponding DID Document.

For example, the eOverdracht sender requires an `eOverdracht-sender` Compound Service with two endpoints: an `oauth` endpoint and a `fhir` endpoint. The example can be added by the following request:

```
POST <internal-node-address>/internal/didman/v1/did/did:nuts:organization_identifier/
↪compoundservice
{
    "type": "eOverdracht-sender",
    "serviceEndpoint": {
        "oauth": "did:nuts:vendor_identifier/serviceEndpoint?type=production-oauth",
        "fhir": "did:nuts:vendor_identifier/serviceEndpoint?type=eOverdracht-sender-fhir"
    }
}
```

Note: As specified by RFC006, the `type` MUST be unique within a DID Document.

CHAPTER

SIX

SIGNING A CONTRACT WITH IRMA

This getting started manual shows how to successfully use IRMA to sign a contract. Contracts are used within the Nuts ecosystem to identify a user to other network participants. It also relates a user to the care organization that user is currently working for. The signed contract is used as token to authenticate the user's (local) EHR identity to other nodes in the network and can be used as session token on the EHR. The contract is required for every request that results in personal and/or medical data being retrieved.

6.1 Basic requirements

To use IRMA as a means for signing a contract, the following is required:

- the user has the IRMA app installed on an Android or iOS device with camera and an internet connection.
- the user has retrieved the BRP and email credentials in the IRMA app.
- the user interacts with the XIS/ECD via a recent browser capable of running javascript.
- the vendor has a Nuts node running.

6.2 IRMA flow

We use the Nuts node as IRMA server and as tool to start an IRMA session. This follow the flow as described on this IRMA Github page. The XIS/ECD will have to provide two endpoints for the frontend. One endpoint to start a session and one to get the session result. More info on these endpoints will be provided further down.

6.3 Configuring the Nuts node

In the contract signing flow, the device running the IRMA app communicates with the Nuts node directly. Therefore the Nuts node needs to be accessible to the public internet. All APIs on the Nuts node starting with `/public` (without a trailing slash) must be accessible over HTTPS without any additional security measures that could prevent access by mobile devices. A domain must also be available which resolves to those APIs. The domain must be configured on the Nuts node:

```
auth:
  publicurl: https://example.com
```

The Nuts APIs used for signing will embed this URL in the QR code shown to the user. The javascript in the frontend will also use this URL (exposed via the QR code) to check the status of the signing session. Therefore the domain

which serves the frontend must be able to do requests to that domain. The browser will require CORS headers to be configured on the domain configured in the Nuts node config. This can be done by the following snippet:

```
http:
    default:
        cors:
            origin: "other.com"
```

Where *other.com* is the domain serving the frontend. For development purposes * is also allowed. If the public APIs are mounted on a different port/interface in the nuts config then the `default` key should be changed to `public` in the example above.

6.4 Setting up the frontend

For the frontend we'll be using the irma-frontend-packages javascript library. More info on how to use this library can be found on **`https://irma.app/docs/irma-frontend/`_**. You can choose to load the IRMA frontend packages javascript via an HTML tag, in which case you'll need to build the javascript file yourself given the instructions on **`https://github.com/privacybydesign/irma-frontend-packages`_** or you can choose to use `npm`:

```
"dependencies": {
  "@privacybydesign/irma-frontend": "^0.3.3"
}
```

Make sure you use the latest version.

IRMA allows for multiple frontends to be used. The most important ones are the *web* and *popup* frontends. The *web* frontend allows for embedding the IRMA web component within a html element. The *popup* frontend will render a new component that will render on top of the rest of the website. This manual will use the *popup* frontend.

A complete example:

```
let options = {
      // Developer options
      debugging: true,

      // Front-end options
      language: 'en',

      // customize textual components
      translations: {
        header: "Sign your contract"
      },

      // Back-end options
      session: {
        // Point to your web backend
        url: '/web/auth',

        // The request that will be send to the backend:
        start: {
          method: 'POST',
          headers: {
            'Content-Type': 'application/json'
```

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```
        },
        body: JSON.stringify(this.some_data)
      },

      // required to translate Nuts specific return values
      mapping: {
        sessionPtr:      r => r.sessionPtr.clientPtr,
        sessionToken:    r => r.sessionID
      }
    }
  };

  // we'll use the popup frontend
  let irmaPopup = irma.newPopup(options);

  // start the interaction
  irmaPopup.start()
      .then(result => {
        console.log("success!")
        console.log(response)
      })
      .catch(error => {
        if (error === 'Aborted') {
          console.log('Aborted');
          return;
        }
        console.error("error", error);
      })
      .finally(() => irmaPopup = irma.newPopup(options));
}
```

Lets break this down into parts.

```
// Developer options
debugging: true,
```

Is used to enabling debugging. The IRMA library will output more information helpful for development.

```
// Front-end options
language: 'en',

// customize textual components
translations: {
  header: "Sign your contract"
},
```

Sets the language to english which will set some default textual representations on the IRMA web component. The `translations` configuration option can be used to change each of the textual representation on the IRMA web component. In this case, only the header is changed.

```
// Back-end options
session: {
  // Point to your web backend
```

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```
  url: '/web/auth',

  // The request that will be send to the backend:
  start: {
    method: 'POST',
    headers: {
      'Content-Type': 'application/json'
    },
    body: JSON.stringify(this.some_data)
  },

  // required to translate Nuts specific return values
  mapping: {
    sessionPtr:      r => r.sessionPtr.clientPtr,
    sessionToken:    r => r.sessionID
  }
}
```

The `session` object contains all the technical parts to connect the IRMA javascript library to your backend. The contents of the `start` object configures the initial request to start a signing session. You can control the type of request and the contents. In this case, some data from the frontend is sent as JSON. This is optional and no particular data is required. The `url`, in this case `/web/auth`, must be set so the frontend can access the following URLs:

```
<url>/session
<url>/session/<sessionToken>/result
```

These URLs must both be available on the backend. For the example above this means that both `/web/auth/session/` and `/web/auth/session/<sessionToken>/result` are available. The `<sessionToken>` is the token that will be returned by the call to `<url>/session/`. How to parse the result of that call and extract the token is done via the `mapping` object.

The `mapping` object is a map where two keys are expected: `sessionPtr` and `sessionToken`. `sessionPtr` must point to the data that is used to render the QR code. `sessionToken` must point to the session token used to get the result.

6.5 Setting up the backend

As discussed in the previous chapter, the backend is required to expose two APIs to the frontend:

```
<url>/session
<url>/session/<sessionToken>/result
```

No particular security context is required, you may require a user session if needed.

6.5.1 Starting a session

The <url>/session API is used to start a session. To start a session at the Nuts node, a valid contract has to be drawn up first. You can create such a contract with the following API on the Nuts node:

```
PUT /internal/auth/v1/contract/drawup
```

With the following body:

```
{
  "type": "BehandelaarLogin",
  "language": "NL",
  "version": "v3",
  "legalEntity": "did:nuts:90348275fjasihnva4857qp39hn",
  "validFrom": "2006-01-02T15:04:05+02:00",
  "validDuration": "2h"
}
```

The `type` must be one of the valid Nuts contract types, currently only `BehandelaarLogin` for Dutch and `PractitionerLogin` for English are supported. The *language* ` selects the correct language, `NL` for Dutch and `EN` for english. The `version` must be `v3`. The `legalEntity` must refer to the DID of the current organization. The user either selects an organization to login for, or is already logged in. The organization must have a DID as described in *Getting Started on customer integration*. `validFrom` is a RFC3339 compliant time string. `validDuration` describes how long the contract is valid for. Time unit strings are used like `1h` or `60m`, the valid time units are: "ns", "us" (or "µs"), "ms", "s", "m", "h". The local system timezone is used to format the date and time string.

The return value looks like:

```
{
  "type": "PractitionerLogin",
  "language": "EN",
  "version": "v3",
  "message": "EN:PractitionerLogin:v3 I hereby declare to act on behalf of CareBears␣
↪located in CareTown. This declaration is valid from Monday, 2 January 2006 15:04:05␣
↪until Monday, 2 January 2006 17:04:05."
}
```

The `message` from this result is used in the next part. Start an IRMA session by calling the following API on the Nuts node:

```
POST /internal/auth/v1/signature/session
```

The body for this call looks like:

```
{
    "means": "irma",
    "payload": "<message>"
}
```

Where `message` is the result from the contract call. The result from this call must be passed directly to the frontend. If any transformation is done, the `mapping` setting in the frontend must be changed accordingly.

6.5.2 Getting the session result

The IRMA javascript frontend library will check for the status of the signing session. When the session has been completed it'll call the following url:

```
GET <url>/session/<sessionToken>/result
```

where <url> is the base url configured under `session.url` in the javascript options and <sessionToken> is the token returned by the previous call. The backend must implement this API, the implementation must call the following API on the Nuts node:

```
GET /internal/auth/v1/signature/session/<sessionToken>
```

Any error in calling this service need to be relayed to the frontend. This will instruct the user on why things went wrong and what to do next. The call to the Nuts node will return the following response:

```
{
    "status": "completed",
    "verifiablePresentation": {
        ...
    }
}
```

The `status` field has a different content when a different signing means is used. The presence of the `verifiablePresentation` in the result is the main method of checking if the signing session succeeded. `verifiablePresentation` is the cryptographic proof that needs to be stored in the user session. It's required in the OAuth flow for obtaining an access token. The backend should check if the signed contract (verifiable presentation) is still valid when using it. The validity can be checked by calling the following API with the verifiable presentation at the place of <vp>:

```
PUT /internal/auth/v1/signature/verify
```

with

```
{
    "checkTime": "2006-01-02T15:54:05+02:00",
    "verifiablePresentation": <vp>
}
```

It will return a structure similar to:

```
{
  "validity": true,
  "vpType": "NutsIrmaPresentation",
  "issuerAttributes": {
    "pbdf.gemeente.personalData.initials": "T",
        "pbdf.gemeente.personalData.prefix": "",
        "pbdf.gemeente.personalData.familyname": "Tester",
        "pbdf.sidn-pbdf.email.email": "tester@example.com"
  },
  "credentials": {
    "organization": "CareBears",
    "validFrom": "2006-01-02T15:04:05+02:00",
    "validTo": "2006-01-02T17:04:05+02:00"
```

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```
  }
}
```

The `validity` will indicate its validity. An expired contract is considered invalid.

CHAPTER

SEVEN

GETTING STARTED WITH AUTHORIZATIONS

Authorization is one of the three core concepts of Nuts (the others being identification and addressing).

7.1 Introduction

Authorization comes in the form of a NutsAuthorizationCredential. An authorization credential is a privately distributed credential that answers:

- which **custodian** controls the resources
- to which **patient** do the resources belong to
- which **actor** may access the resources
- what is the **scope** of the authorization
- on what **legal base** is the authorization provided
- which individual **resources** may be accessed

Authorization credentials are issued by the same party that will also control the access to the resources.

7.1.1 Bolt

A Bolt is a functional and technical specification that translates a care process to technical requirements. An authorization is created for a particular Bolt. A Bolt specifies what the possible values of *purposeOfUse* can be. Each value corresponds to an access policy defined by the Bolt. Creating an authorization credential that is not according to a Bolt specification will have little effect or will even hinder interoperability. Particular requirements for a Bolt are not validated by the node, the node will only do the validations as specified.

7.1.2 Prerequisites

Since authorization credentials are privately distributed, their exchange only happens over authenticated connections. To query authorization credentials (issued to your care organization(s)) or let the authorized party query an authorization credential you issued, you need to configure your node's identity and `NutsComm` endpoint. See *setting up your node for a network* for how to achieve this.

7.2 Registering a NutsAuthorizationCredential

Issuing an authorization credential is similar to issuing an organization credential. Both use the same API. New credentials will automatically receive an *id*, *issuanceDate*, *context* and *proof*. A DID requires a valid assertionMethod key.

The credential can be issued with the following call:

```
POST <internal-node-address>/internal/vcr/v2/issuer/vc
{
    "issuer": "did:nuts:JCJEi3waNGNhkmwVvFB3wdUsmDYPnTcZxYiWThZqgWKv",
    "type": "NutsAuthorizationCredential",
    "credentialSubject": {
        "id": "did:nuts:JCJEi3waNGNhkmwVvFB3wdUsmDYPnTcZxYiWThZqgWKv",
        "legalBase": {
            "consentType": "implied"
        },
        "resources": [
            {
                "path": "/patient/2250f7ab-6517-4923-ac00-88ed26f85843",
                "operations": ["read"],
                "userContext": true
            }
        ],
        "purposeOfUse": "test-service",
        "subject": "urn:oid:2.16.840.1.113883.2.4.6.3:123456780"
    },
    "visibility": "private"
}
```

As you can see, there are quite some fields to fill out. The following paragraphs will dig deeper into the different parts.

7.2.1 issuer

The *issuer* is the resource owner. It must be a DID of an organization for which you control the private key. The DID typically comes from your own administration, see also **:ref:`Getting Started on customer integration <connecting-crm>`_**.

7.2.2 type

The *type* must equal *["NutsAuthorizationCredential"]*, no exceptions.

7.2.3 visibility

VCs that are published to the network can be published publicly or private. When published private, only the issuer and subject can read the contents of the VC. VCs that contain personal information must be published privately (*visibility* = *private*). When the VC is to be read by anyone on the network, it should be published publicly (*visibility* = *public*).

7.2.4 credentialSubject.id

The *credentialSubject.id* is the receiver or *holder* of the credential. It must be a DID of an organization. This DID is typically found via a search call. The following call will search for an organization with the name *CareBears*.

```
POST <internal-node-address>/internal/vcr/v2/search
{
    "query": {
        "@context": [
            "https://www.w3.org/2018/credentials/v1",
            "https://nuts.nl/credentials/v1"
        ],
        "type": ["VerifiableCredential" ,"NutsOrganizationCredential"],
        "credentialSubject": {
            "organization": {
                "name": "CareBears"
            }
        }
    }
}
```

The **:ref:`VC manual <using-vcs>`_** contains some more information on how to perform searches.

7.2.5 credentialSubject.purposeOfUse

The *credentialSubject.purposeOfUse* field will be filled with a fixed value. A Bolt specification will describe what value to put here.

7.2.6 credentialSubject.subject

The *credentialSubject.subject* field identifies the patient. Resources that are scoped to a patient will have an authorization record with a patient identifier. It's possible for authorization records to not include this field. A Bolt specification should describe when to use this field and when not. The contents in this example is a **urn** with a Dutch citizens number.

7.2.7 credentialSubject.legalBase

This field describes the legal base from which the authorization credential originates. A Bolt will what values are to be entered.

7.2.8 credentialSubject.resources

The resources array describes what resources may be accessed with the authorization credential. Unless stated otherwise by the Bolt, these resources are in addition to any common resources listed by the access policy of the Bolt. A resource has 3 members: *path*, *operations* and *userContext*. See the Nuts specification for more detail.

7.3 Searching for authorization credentials

Authorization credentials can be used as a distributed index: *where can I find information for patient X?*. When an access token is requested via the API, references to the relevant authorization credentials are required.

To find the relevant authorization credentials, the credential search API can be used. To find all authorization credentials of a single patient:

```
POST <internal-node-address>/internal/vcr/v2/search
{
    "query": {
        "@context": [
            "https://www.w3.org/2018/credentials/v1",
            "https://nuts.nl/credentials/v1"
        ],
        "type": ["VerifiableCredential" ,"NutsAuthorizationCredential"],
        "credentialSubject": {
            "id": "did:nuts:JCJEi3waNGNhkmwVvFB3wdUsmDYPnTcZxYiWThZqgWKv",
            "subject": "urn:oid:2.16.840.1.113883.2.4.6.3:123456780"
        }
    },
    "searchOptions": {
        "allowUntrustedIssuer": true
    }
}
```

The call above includes a query for a particular *receiver* via the *credentialSubject.id* key. This would typically be a DID from your own administration. The second parameter defines the patient. This example will return a list of authorization credentials where the *credentialSubject.purposeOfUse* field will indicate what kind of information can be retrieved. The *untrusted* query parameter must be added because authorization credentials are not issued by a trusted third party but by organizations themselves.

It can also be the case that you need to find an authorization that covers a certain request. If you want to call */patient/2250f7ab-6517-4923-ac00-88ed26f85843* for a particular Bolt, you can use:

```
POST <internal-node-address>/internal/vcr/v2/search
{
    "query": {
        "@context": [
            "https://www.w3.org/2018/credentials/v1",
            "https://nuts.nl/credentials/v1"
```

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```
        ],
        "type": ["VerifiableCredential" ,"NutsOrganizationCredential"],
        "credentialSubject": {
            "id": "did:nuts:JCJEi3waNGNhkmwVvFB3wdUsmDYPnTcZxYiWThZqgWKv",
            "purposeOfUse": "test-service",
            "resources": {
                "path": "/patient/2250f7ab-6517-4923-ac00-88ed26f85843"
            }
        }
    },
    "searchOptions": {
        "allowUntrustedIssuer": true
    }
}
```

This call will return all authorization credentials with a *purposeOfUse* equal to *test-service* and with which you are allowed to call the resource located at */patient/2250f7ab-6517-4923-ac00-88ed26f85843* Any value in an authorization credential can be used as a param in the search API. The search *key* requires a valid JSON path expression.

7.3.1 Return values

When searching for authorization credentials, the credentials are returned as a verifiable credential. Most of the time, you'll only need the credential identifier, available in the root *id* field.

Example return value:

```
[
    {
        "@context": [
            "https://www.w3.org/2018/credentials/v1",
            "https://nuts.nl/credentials/v1"
        ],
        "credentialSubject": {
            "id": "did:nuts:JCJEi3waNGNhkmwVvFB3wdUsmDYPnTcZxYiWThZqgWKv",
            "legalBase": {
                "consentType": "implied"
            },
            "purposeOfUse": "test-service",
            "resources": [
                {
                    "operations": [
                        "read"
                    ],
                    "path": "/patient/2250f7ab-6517-4923-ac00-88ed26f85843",
                    "userContext": true
                }
            ],
            "subject": "urn:oid:2.16.840.1.113883.2.4.6.3:123456780"
        },
        "id": "did:nuts:JCJEi3waNGNhkmwVvFB3wdUsmDYPnTcZxYiWThZqgWKv#314542e8-c8cc-4502-
↪a7df-a815ac47c06b",
        "issuanceDate": "2021-07-26T14:36:10.163463+02:00",
```

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```
        "issuer": "did:nuts:JCJEi3waNGNhkmwVvFB3wdUsmDYPnTcZxYiWThZqgWKv",
        "proof": {
            "created": "2021-07-26T14:36:10.163463+02:00",
            "jws": "eyJhbGciOiJFUzI1NiIsImI2NCI6ZmFsc2UsImNyaXQiOlsiYjY0Il19..
↪k4cda7fMY05mnp4gsNJ3hNExjsSz3mqymyo4xJWkbb9-1URljVWIzPg6R62T-YETV7UXvz1X9QteuhbmoM1JLA
↪",
            "proofPurpose": "assertionMethod",
            "type": "JsonWebSignature2020",
            "verificationMethod": "did:nuts:JCJEi3waNGNhkmwVvFB3wdUsmDYPnTcZxYiWThZqgWKv
↪#_3uOS5FqcyGj-cn-Yynv5epH0UVqbt_2BWXPfy0oKnU"
        },
        "type": [
            "NutsAuthorizationCredential",
            "VerifiableCredential"
        ]
    }
]
```

CHAPTER

EIGHT

GETTING STARTED ON EHR INTEGRATION

This getting started manual assumes the vendor and its clients (care organizations) are set up on the Nuts Network through *Getting Started on customer integration*. The next step is to integrate the vendor's electronic health record (EHR) with the Nuts node to execute Bolts.

All APIs used in the following chapters are documented at the *API* page. There you will also find the OpenAPI specifications for generating client code.

8.1 Resolving Bolt endpoints

Bolts define which technical endpoints should be defined for exchanging information. These endpoints are grouped as services which are generally named after the Bolt they support. The Nuts registry (as described by *Getting Started on customer integration*) can be queried to find care organizations that support a particular Bolt, and to resolve the technical endpoints associated with it.

8.1.1 Searching organizations

To find care organizations (registered in the Nuts registry) that support a specific Bolt, the search organization API can be used. It takes a query parameter that's used to match organization names and optionally a service type (from its DID document). If the DID service type is supplied the API only returns organizations which DID Document has a service with that type.

For example, the following API call searches the Nuts registry for organizations which name matches "Ziekenhuis" and have a service of type "secure-direct-messaging" on their DID Document:

```
GET <internal-node-address>/internal/didman/v1/search/organizations?query=Ziekenhuis&
↪didServiceType=secure-direct-messaging
```

Note: The example DID service type "secure-direct-messaging" could be defined by a (fictional) "Secure Direct Messaging" Bolt to be published by organizations that allow their employees to securely chat with other organizations through Nuts.

The API call returns a list of search results where each entry contains the organization and its last DID Document:

```
[
  {
    "didDocument": {
      "@context": "https://www.w3.org/ns/did/v1",
      "assertionMethod": [
```

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```
        "did:nuts:JCx4c3ufdKNgaZJ4h54AghY8ZgCznptNpjHUtzvVgcvW
↪#Cv0c4hlz4My7pKa6Wh6UN7gnTAXi5WUpNChqsUuIL1A"
      ],
      "controller": "did:nuts:5bSHwHtpSZfSCdCqaHvzDceEkjgNuKvTWVvQPB5DdeD9",
      "id": "did:nuts:JCx4c3ufdKNgaZJ4h54AghY8ZgCznptNpjHUtzvVgcvW",
      "verificationMethod": [
        /* etc */
      ],
      "service": {
        "type": "secure-direct-messaging",
        /* etc */
      }
    },
    "organization": {
      "city": "Doornenburg",
      "name": "Fort Pannerden"
    }
  }
]
```

For an organization to be returned as search results the following requirements must be met:

- It must have an active DID Document.
- The issuer of its verifiable credential (`NutsOrganizationCredential`) must be trusted by the local node.
- Its verifiable credential must not be expired or revoked.

The `query` parameter is used to phonetically match the organization name: it supports partial matches and matches that sound like the given query.

8.1.2 Resolving endpoints

When an organization has been selected, the next step is to resolve the technical endpoints. This is done by taking the compound service as specified by the Bolt and resolving its endpoint references to an actual URL endpoints. You can use the DIDMan `getCompoundServiceEndpoint` API operation for this.

8.2 Receiving Authorization Credentials

Some Bolts require authorization credentials to authenticate data exchanges. These credentials are distributed privately over an authenticated connection. To receive privately distributed credentials issued to your care organizations, the DID documents of the care organizations need to contain a `NutsComm` service that references the vendor's. See *setting up your node for a network* for how to achieve this.

CHAPTER

NINE

NUTS NODE APIS

Below you can discover the Nuts Node APIs and download their OpenAPI specifications:

- Common (required by others)
- DID Manager
- Crypto
- Verifiable Credential Registry (v2)
- Verifiable Data Registry
- Network
- Auth

CHAPTER

TEN

ISSUING AND SEARCHING VERIFIABLE CREDENTIALS

10.1 Issuing VCs

As a node, you can issue credentials with each DID you control (whether they are trusted is a different story). A credential is issued through the API or CLI. The node will add sensible defaults for:

- @context
- id
- issuanceDate
- proof

You are required to provide the *credentialSubject*, the *issuer*, the *type* and an optional *expirationDate*. So calling */internal/vcr/v2/issuer/vc* with

```
{
    "issuer": "did:nuts:ByJvBu2Ex21tNdn5s8FBnqmRBTCGkqRHms5ci7gKM8rg",
    "type": "NutsOrganizationCredential",
    "credentialSubject": {
        "id": "did:nuts:9UKf9F9sRtiq4gR3bxfGQAeARtJeU8jvPqfWJcFP6ziN",
        "organization": {
            "name": "Because we care B.V.",
            "city": "IJbergen"
        }
    },
    "visibility": "public"
}
```

Will be expanded by the node to:

```
{
  "context": [
    "https://www.w3.org/2018/credentials/v1",
    "https://nuts.nl/credentials/v1"
  ],
  "credentialSubject": {
    "id": "did:nuts:9UKf9F9sRtiq4gR3bxfGQAeARtJeU8jvPqfWJcFP6ziN",
    "organization": {
      "city": "IJbergen",
      "name": "Because we care B.V."
    }
```

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```
  },
  "id": "did:nuts:ByJvBu2Ex21tNdn5s8FBnqmRBTCGkqRHms5ci7gKM8rg#a1d8ee3f-f404-44d5-bd07-
↪71d3b144ce54",
  "issuanceDate": "2021-03-05T09:37:05.732811+01:00",
  "issuer": "did:nuts:ByJvBu2Ex21tNdn5s8FBnqmRBTCGkqRHms5ci7gKM8rg",
  "proof": {
    "created": "2021-03-05T09:37:05.732811+01:00",
    "jws": "eyJhbGciOiJFUzI1NiIsImI2NCI6ZmFsc2UsImNyaXQiOlsiYjY0Il19..
↪s6lxJa7pOpqlhcWhJoKRMJIJiD4i+IUkfmhy+rUvNzZayVHAq+lZaFxBsv9rQCe0ewpZq/
↪6z3hSUOURo6mnHhg==",
    "proofPurpose": "assertionMethod",
    "type": "JsonWebSignature2020",
    "verificationMethod": "did:nuts:ByJvBu2Ex21tNdn5s8FBnqmRBTCGkqRHms5ci7gKM8rg
↪#gSEtbS2dOsS9PSrV13RwaZHz3Ps6OTI14GvLx8dPqgQ"
  },
  "type": [
    "NutsOrganizationCredential",
    "VerifiableCredential"
  ]
}
```


The *visibility* property indicates the contents of the VC are published on the network, so it can be read by everyone.

10.2 Searching VCs

You can search for VCs by providing a VC which should be used for matching in JSON-LD format. Searching works by posting a Verifiable Credential to */internal/vcr/v2/search* that contains fields to match. The operation yields an array containing the matched verifiable credentials.

The example below searches for a *NutsOrganizationCredential* (note that the *query* field contains the credential):

```
{
    "query": {
        "@context": [
            "https://www.w3.org/2018/credentials/v1",
            "https://nuts.nl/credentials/v1"
        ],
        "type": ["VerifiableCredential" ,"NutsOrganizationCredential"],
        "credentialSubject": {
            "id": "did:nuts:SKUYYi2g88ohjhiu49Q13ZWGXvp678sjNiM7UHUCMyw",
            "organization": {
                "name": "Because we care B.V.",
                "city": "IJbergen"
            }
        }
    }
}
```

Note the fields *@context* and *type*, these are required for making it a valid VC in JSON-LD. In the example above they also contain Nuts specific contexts and types (since we're searching for a Nuts VC).

By default only VCs from trusted issuers are returned. You can specify the *searchOptions* field to include VCs from

untrusted issuers.

CHAPTER

ELEVEN

FREQUENTLY ENCOUNTERED ERRORS

This section lists commonly seen errors, what they mean and what to do about it.

11.1 Error: *connection closed before server preface received*

When connecting to a remote node, the following error can occur:

> Couldn't connect to peer, reconnecting in XYZ seconds (peer=some.domain.nl:5555,err=unable to connect: context deadline exceeded: connection closed before server preface received)

This indicates the server is using TLS, but the local node is trying to connect without TLS. Check the *network.tls.enabled* setting.

CHAPTER

TWELVE

RELEASE NOTES

Whats has been changed, and how to update between versions.

12.1 Cashew (v3.0.0)

Release date: 2022-06-01

This release no longer contains the V1 network protocol.

Full Changelog: https://github.com/nuts-foundation/nuts-node/compare/v2.0.0...v3.0.0

12.2 Brazil (v2.0.0)

Release date: 2022-04-29

This version implements the V2 network protocol. The V2 network protocol combines gossip style messages with a fast reconciliation protocol for larger difference sets. The protocol can quickly identify hundreds of missing transactions. The new protocol is much faster than the old protocol and its performance is currently limited by the database performance.

Besides the improved network protocol, this version also implements semantic searching for Verifiable Credentials. Till this version, searching for VCs only supported the NutsOrganizationCredential and NutsAuthorizationCredential. With the new semantic search capabilities all kinds of credentials can be issued and found. This is the first step for the Nuts node to become a toolbox that supports multiple domains.

Full Changelog: https://github.com/nuts-foundation/nuts-node/compare/v1.0.0...v2.0.0

12.3 Almond (v1.0.0)

Release date: 2022-04-01

This is the initial release of the Nuts node reference implementation. It implements RFC001 - RFC016 specified by the Nuts specification. This release is intended for developers. It contains a stable API that will be backwards compatible for the next versions. The releases until the first production release will mainly focus on network and Ops related features.

To start using this release, please consult the getting started section.

12.3.1 Features / improvements

Future releases will list new features and improvements that have been added since the previous release.

12.3.2 Dropped features

New major releases might drop support for features that have been deprecated in a previous release. Keep an eye on this section for every release.

12.3.3 Deprecated features

Some features will be deprecated because they have been succeeded by an improved version or when they are no longer used. Removing old code helps in reducing maintenance costs of the code base. Features that are marked as *deprecated* will be listed here. Any vendor using these features will have until next version to migrate to the alternative. Keep an eye on this section for every release.

- VCR V1 API is deprecated and will be removed in the next release. Please migrate all calls to the V2 API.

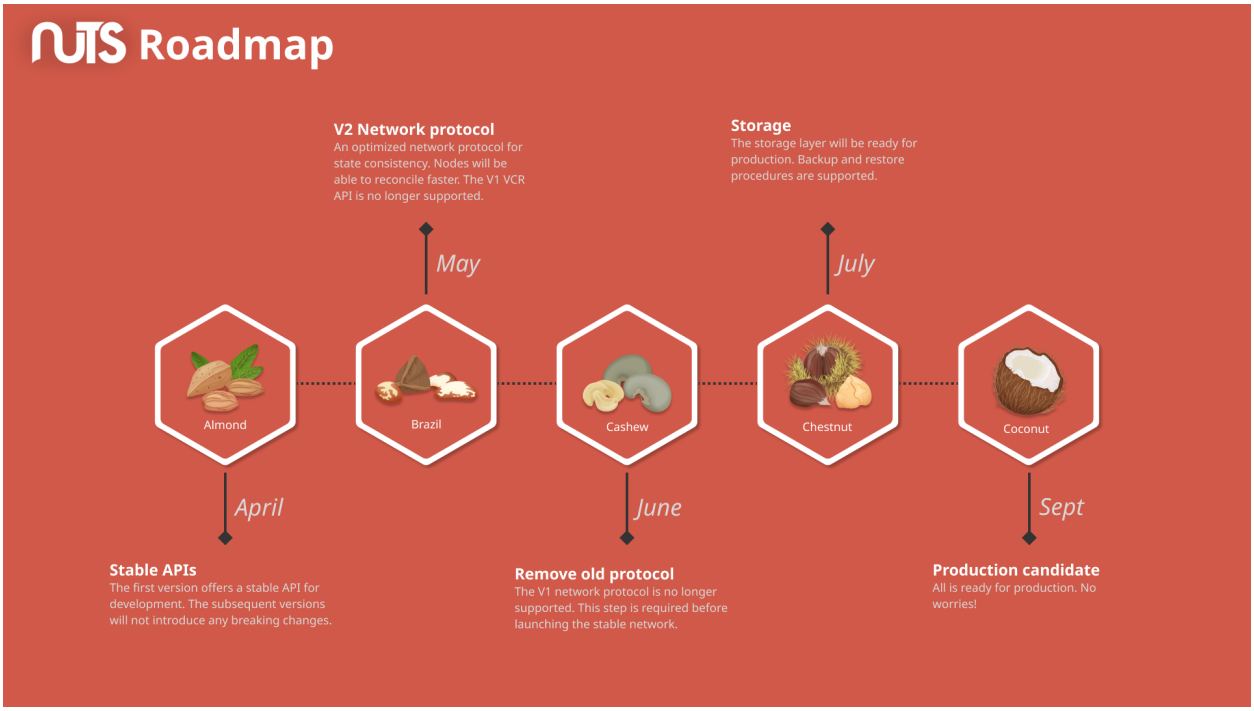
12.3.4 Bugfixes

This section contains a list of bugfixes. It'll match resolved Github issues with the **bug** tag.

CHAPTER

THIRTEEN

ROADMAP



CHAPTER

FOURTEEN

RECOMMENDED DEPLOYMENT

This document aims to describe the systems and their components involved in deploying a Nuts node in a production environment. The target audience are engineers that want to deploy a Nuts Node in their environment for a Service Provider (SP).

It does not detail services and interfaces specified by Bolts: those should be documented by the particular Bolts and should be regarded as extensions to the deployment described here.

The container diagram documents the recommended way of deploying a Nuts node using the features supported by the Nuts node's version.

The diagrams are in C4 model notation.

14.1 System Landscape

The diagram below depicts the users and systems that interact with the Nuts node of the local SP.

14.2 Containers

This section details the system with involved containers (which can be native or containerized processes, physical or remote database servers or even networked filesystems). It lists the interfaces of the Nuts node, who uses them and how they should be secured.

Note: There's a number of upcoming features that will change the recommended deployment, notably:

- SSL/TLS termination for gRPC traffic on a reverse proxy
- Redis database support
- Clustering support

14.2.1 Nuts Node

Server that implements the Nuts specification that connects to the Nuts network. It will usually run as Docker container or Kubernetes pod.

Interfaces/Endpoints:

- **HTTP /internal**: for managing everything related to DIDs, VCs and the Nuts Node itself. Very sensitive endpoints with no additional built-in security, so care should be taken that no unauthorized parties can access it. Since it binds to the shared HTTP interface by default (port `1323`), it is recommended to *bind it to an alternative interface* to securer routing.

  Users: operators, SPs administrative and EHR applications.

  Security: restrict access through network separation and platform authentication.

- **HTTP /public**: for accessing public services, e.g. IRMA authentication.

  Users: IRMA app.

  Security: HTTPS with server certificate (on proxy). Monitor traffic to detect attacks.

- **HTTP /n2n**: for providing Nuts services to other nodes (e.g. creating access tokens). The local node also calls other nodes on their */n2n* endpoint, these outgoing calls are subject to the same security requirements.

  Users: Nuts nodes of other SPs.

  Security: HTTPS with server- and client certificates (mTLS) according to network trust anchors (on proxy). Monitor traffic to detect attacks.

- **HTTP /status**: for inspecting the health of the server, returns `OK` if healthy.

  Users: monitoring tooling.

  Security: Not strictly required, but advised to restrict access.

- **HTTP /status/diagnostics**: for inspecting diagnostic information of the server.

  Users: monitoring tooling, system administrators.

  Security: Not strictly required, but advised to restrict access.

- **HTTP /metrics**: for scraping metrics in Prometheus format.

  Users: monitoring/metrics tooling.

  Security: Not strictly required, but advised to restrict access.

- **gRPC**: for communicating with other Nuts nodes according to the network protocol. Uses HTTP/2 as transport, both outbound and inbound.

  Users: Nuts nodes of other SPs.

  Security: HTTPS with server- and client certificates (mTLS) according to network trust anchors. This is provided by the Nuts node.

- **stdout**: the server logs to standard out, which can be configured to output in JSON format for integration with existing log tooling.

14.2.2 Reverse Proxy

Process that protects and routes HTTP access (specified above) to the Nuts Node. Typically a standalone HTTP proxy that resides in a DMZ and/or an ingress service on a cloud platform. It will act as SSL/TLS terminator, with only a server certificate or requiring a client certificate as well (depending on the endpoint).

14.2.3 Nuts Node Client

CLI application used by system administrators to manage the Nuts Node and the SPs presence on the network, which calls the REST API of the Nuts Node. It is included in the Nuts Node server, so it can be executed in the Docker container (using `docker exec`) or standalone process.

14.2.4 Database

BBolt database where the Nuts Node stores its data. The database is on disk (by default in `/opt/nuts/data`) so make sure the data is retained, especially in a cloud environment. It is recommended to backup the database using the provided backup feature (see config options of the storage engine).

14.2.5 Private Key Storage

Creating DID documents causes private keys to be generated, which need to be safely stored so the Nuts node can access them. It is recommended to store them in Vault. Refer to the config options of the crypto engine and Vault documentation for configuring it.

CHAPTER

FIFTEEN

CONFIGURING THE NUTS NODE

The Nuts node can be configured using a YAML configuration file, environment variables and commandline params.

The parameters follow the following convention: `$ nuts --parameter X` is equal to `$ NUTS_PARAMETER=X nuts` is equal to `parameter: X` in a yaml file.

Or for this piece of yaml

```
nested:
    parameter: X
```

is equal to `$ nuts --nested.parameter X` is equal to `$ NUTS_NESTED_PARAMETER=X nuts`

Config parameters for engines are prepended by the `engine.ConfigKey` by default (configurable):

```
engine:
    nested:
        parameter: X
```

is equal to `$ nuts --engine.nested.parameter X` is equal to `$ NUTS_ENGINE_NESTED_PARAMETER=X nuts`

While most options are a single value, some are represented as a list (indicated with the square brackets in the table below). To provide multiple values through flags or environment variables you can separate them with a comma (`,`).

15.1 Ordering

Command line parameters have the highest priority, then environment variables, then parameters from the configfile and lastly defaults. The location of the configfile is determined by the environment variable `NUTS_CONFIGFILE` or the commandline parameter `--configfile`. If both are missing the default location `./nuts.yaml` is used.

15.2 Server options

The following options can be configured on the server:

Key	Default
configfile	nuts.yaml
datadir	./data
loggerformat	text
strictmode	false
verbosity	info

Key	Default
http.default.address	:1323
http.default.cors.origin	[]
Auth	
auth.clockskew	5000
auth.contractvalidators	[irma,uzi,dummy]
auth.http.timeout	30
auth.irma.autoupdateschemas	true
auth.irma.schememanager	pbdf
auth.publicurl	
Crypto	
crypto.storage	fs
crypto.vault.address	
crypto.vault.pathprefix	kv
crypto.vault.token	
Event manager	
events.nats.hostname	localhost
events.nats.port	4222
events.nats.storagedir	
events.nats.timeout	30
JSONLD	
jsonld.contexts.localmapping	[https://nuts.nl/credentials/v1=assets/contexts/nuts.ldjson,https://www.w3.org/2018/crede
jsonld.contexts.remoteallowlist	[https://schema.org,https://www.w3.org/2018/credentials/v1,https://w3c-ccg.github.io/lds
Network	
network.bootstrapnodes	[]
network.certfile	
network.certkeyfile	
network.connectiontimeout	5000
network.disablenodeauthentication	false
network.enablediscovery	true
network.enabletls	true
network.grpcaddr	:5555
network.nodedid	
network.protocols	[]
network.truststorefile	
network.v2.diagnosticsinterval	5000
network.v2.gossipinterval	5000
Storage	
storage.databases.bbolt.backup.directory	
storage.databases.bbolt.backup.interval	0
VCR	
vcr.overrideissueallpublic	true

This table is automatically generated using the configuration flags in the core and engines. When they're changed the options table must be regenerated using the Makefile:

```
$ make update-docs
```

CHAPTER

SIXTEEN

MONITORING THE NUTS NODE

16.1 Basic service health

A status endpoint is provided to check if the service is running and if the web server has been started. The endpoint is available over http so it can be used by a wide range of health checking services. It does not provide any information on the individual engines running as part of the executable. The main goal of the service is to give a YES/NO answer for if the service is running?

```
GET /status
```

It'll return an "OK" response and a 200 status code.

16.2 Basic diagnostics

```
GET /status/diagnostics
```

It'll return some text displaying the current status of the various services:

```
Status
    Registered engines: [Status Logging]
Logging
    verbosity: INFO
```

If you supply *application/json* for the *Accept* HTTP header it will return the diagnostics in JSON format.

16.3 Metrics

The Nuts service executable has build-in support for **Prometheus**. Prometheus is a time-series database which supports a wide variety of services. It also allows for exporting metrics to different visualization solutions like **Grafana**. See https://prometheus.io/ for more information on how to run Prometheus. The metrics are exposed at `/metrics`

16.3.1 Configuration

In order for metrics to be gathered by Prometheus. A `job` has to be added to the `prometheus.yml` configuration file. Below is a minimal configuration file that will only gather Nuts metrics:

```
# my global config
global:
  scrape_interval:     15s # Set the scrape interval to every 15 seconds. Default is every 1 minute.
  evaluation_interval: 15s # Evaluate rules every 15 seconds. The default is every 1 minute.
  # scrape_timeout is set to the global default (10s).

# Load rules once and periodically evaluate them according to the global 'evaluation_interval'.
rule_files:
# - "first_rules.yml"
# - "second_rules.yml"

# A scrape configuration containing exactly one endpoint to scrape:
# Here it's Prometheus itself.
scrape_configs:
  # The job name is added as a label `job=<job_name>` to any timeseries scraped from this config.
  - job_name: 'nuts'
    metrics_path: '/metrics'
    scrape_interval: 5s
    static_configs:
      - targets: ['127.0.0.1:1323']
```

It's important to enter the correct IP/domain and port where the Nuts node can be found!

16.3.2 Exported metrics

The Nuts service executable exports the following metrics by default. These cover the basic needs for monitoring the process and http layer.

```
# HELP go_gc_duration_seconds A summary of the pause duration of garbage collection cycles.
# TYPE go_gc_duration_seconds summary
go_gc_duration_seconds{quantile="0"} 4.08e-05
go_gc_duration_seconds{quantile="0.25"} 6.25e-05
go_gc_duration_seconds{quantile="0.5"} 8.44e-05
go_gc_duration_seconds{quantile="0.75"} 0.0001046
go_gc_duration_seconds{quantile="1"} 0.0004961
go_gc_duration_seconds_sum 0.0016542
go_gc_duration_seconds_count 14
# HELP go_goroutines Number of goroutines that currently exist.
# TYPE go_goroutines gauge
go_goroutines 79
# HELP go_info Information about the Go environment.
# TYPE go_info gauge
go_info{version="go1.13.12"} 1
```

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```
# HELP go_memstats_alloc_bytes Number of bytes allocated and still in use.
# TYPE go_memstats_alloc_bytes gauge
go_memstats_alloc_bytes 9.284216e+06
# HELP go_memstats_alloc_bytes_total Total number of bytes allocated, even if freed.
# TYPE go_memstats_alloc_bytes_total counter
go_memstats_alloc_bytes_total 6.929336e+07
# HELP go_memstats_buck_hash_sys_bytes Number of bytes used by the profiling bucket hash␣
↪table.
# TYPE go_memstats_buck_hash_sys_bytes gauge
go_memstats_buck_hash_sys_bytes 1.477216e+06
# HELP go_memstats_frees_total Total number of frees.
# TYPE go_memstats_frees_total counter
go_memstats_frees_total 394819
# HELP go_memstats_gc_cpu_fraction The fraction of this program's available CPU time␣
↪used by the GC since the program started.
# TYPE go_memstats_gc_cpu_fraction gauge
go_memstats_gc_cpu_fraction 0.0005164729882960839
# HELP go_memstats_gc_sys_bytes Number of bytes used for garbage collection system␣
↪metadata.
# TYPE go_memstats_gc_sys_bytes gauge
go_memstats_gc_sys_bytes 2.394112e+06
# HELP go_memstats_heap_alloc_bytes Number of heap bytes allocated and still in use.
# TYPE go_memstats_heap_alloc_bytes gauge
go_memstats_heap_alloc_bytes 9.284216e+06
# HELP go_memstats_heap_idle_bytes Number of heap bytes waiting to be used.
# TYPE go_memstats_heap_idle_bytes gauge
go_memstats_heap_idle_bytes 5.24288e+07
# HELP go_memstats_heap_inuse_bytes Number of heap bytes that are in use.
# TYPE go_memstats_heap_inuse_bytes gauge
go_memstats_heap_inuse_bytes 1.2255232e+07
# HELP go_memstats_heap_objects Number of allocated objects.
# TYPE go_memstats_heap_objects gauge
go_memstats_heap_objects 32515
# HELP go_memstats_heap_released_bytes Number of heap bytes released to OS.
# TYPE go_memstats_heap_released_bytes gauge
go_memstats_heap_released_bytes 4.8848896e+07
# HELP go_memstats_heap_sys_bytes Number of heap bytes obtained from system.
# TYPE go_memstats_heap_sys_bytes gauge
go_memstats_heap_sys_bytes 6.4684032e+07
# HELP go_memstats_last_gc_time_seconds Number of seconds since 1970 of last garbage␣
↪collection.
# TYPE go_memstats_last_gc_time_seconds gauge
go_memstats_last_gc_time_seconds 1.5942182098267434e+09
# HELP go_memstats_lookups_total Total number of pointer lookups.
# TYPE go_memstats_lookups_total counter
go_memstats_lookups_total 0
# HELP go_memstats_mallocs_total Total number of mallocs.
# TYPE go_memstats_mallocs_total counter
go_memstats_mallocs_total 427334
# HELP go_memstats_mcache_inuse_bytes Number of bytes in use by mcache structures.
# TYPE go_memstats_mcache_inuse_bytes gauge
go_memstats_mcache_inuse_bytes 13888
```

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```
# HELP go_memstats_mcache_sys_bytes Number of bytes used for mcache structures obtained␣
↪from system.
# TYPE go_memstats_mcache_sys_bytes gauge
go_memstats_mcache_sys_bytes 16384
# HELP go_memstats_mspan_inuse_bytes Number of bytes in use by mspan structures.
# TYPE go_memstats_mspan_inuse_bytes gauge
go_memstats_mspan_inuse_bytes 115736
# HELP go_memstats_mspan_sys_bytes Number of bytes used for mspan structures obtained␣
↪from system.
# TYPE go_memstats_mspan_sys_bytes gauge
go_memstats_mspan_sys_bytes 229376
# HELP go_memstats_next_gc_bytes Number of heap bytes when next garbage collection will␣
↪take place.
# TYPE go_memstats_next_gc_bytes gauge
go_memstats_next_gc_bytes 1.6785728e+07
# HELP go_memstats_other_sys_bytes Number of bytes used for other system allocations.
# TYPE go_memstats_other_sys_bytes gauge
go_memstats_other_sys_bytes 1.584792e+06
# HELP go_memstats_stack_inuse_bytes Number of bytes in use by the stack allocator.
# TYPE go_memstats_stack_inuse_bytes gauge
go_memstats_stack_inuse_bytes 2.424832e+06
# HELP go_memstats_stack_sys_bytes Number of bytes obtained from system for stack␣
↪allocator.
# TYPE go_memstats_stack_sys_bytes gauge
go_memstats_stack_sys_bytes 2.424832e+06
# HELP go_memstats_sys_bytes Number of bytes obtained from system.
# TYPE go_memstats_sys_bytes gauge
go_memstats_sys_bytes 7.2810744e+07
# HELP go_threads Number of OS threads created.
# TYPE go_threads gauge
go_threads 18
# HELP process_cpu_seconds_total Total user and system CPU time spent in seconds.
# TYPE process_cpu_seconds_total counter
process_cpu_seconds_total 2.58
# HELP process_max_fds Maximum number of open file descriptors.
# TYPE process_max_fds gauge
process_max_fds 1.048576e+06
# HELP process_open_fds Number of open file descriptors.
# TYPE process_open_fds gauge
process_open_fds 25
# HELP process_resident_memory_bytes Resident memory size in bytes.
# TYPE process_resident_memory_bytes gauge
process_resident_memory_bytes 4.5256704e+07
# HELP process_start_time_seconds Start time of the process since unix epoch in seconds.
# TYPE process_start_time_seconds gauge
process_start_time_seconds 1.59421820085e+09
# HELP process_virtual_memory_bytes Virtual memory size in bytes.
# TYPE process_virtual_memory_bytes gauge
process_virtual_memory_bytes 1.37965568e+08
# HELP process_virtual_memory_max_bytes Maximum amount of virtual memory available in␣
↪bytes.
# TYPE process_virtual_memory_max_bytes gauge
```

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```
process_virtual_memory_max_bytes -1
# HELP promhttp_metric_handler_requests_in_flight Current number of scrapes being served.
# TYPE promhttp_metric_handler_requests_in_flight gauge
promhttp_metric_handler_requests_in_flight 1
# HELP promhttp_metric_handler_requests_total Total number of scrapes by HTTP status␣
↪code.
# TYPE promhttp_metric_handler_requests_total counter
promhttp_metric_handler_requests_total{code="200"} 0
promhttp_metric_handler_requests_total{code="500"} 0
promhttp_metric_handler_requests_total{code="503"} 0
```

16.3.3 Network DAG Visualization

All network transactions form a directed acyclic graph (DAG) which helps achieving consistency and data completeness. Since it's a hard to debug, complex structure, the network API provides a visualization which can be queried from */internal/network/v1/diagnostics/graph*. It is returned in the *dot* format which can then be rendered to an image using *dot* or *graphviz* (given you saved the output to *input.dot*):

```
dot -T png -o output.png input.dot
```

Using query parameters *start* and *end* it is possible to retrieve a range of transactions. */internal/network/v1/diagnostics/graph?start=10&end=12* will return a graph with all transactions containing Lamport Clock 10 and 11. Both parameters need to be non-negative integers, and *start* < *end*. If no value is provided, *start=0* and *end=inf*. Querying a range can be useful if only a certain range is of interest, but may also be required to generate the graph using *dot*.

CHAPTER

SEVENTEEN

ADMINISTRATION USING THE CLI

The Nuts executable this project provides can be used to both run a Nuts server (a.k.a. node) and administer a running node remotely. This chapter explains how to administer your running Nuts node.

17.1 Prerequisites

The following is needed to run a Nuts node:

1. Nuts executable for your platform, or a Nuts docker container.
2. The address of your running Nuts node. You can pass this using the *address* variable.

17.2 Commands

Run the executable without command or flags, or with the *help* command to find out what commands are supported:

```
$ nuts
```

For example, to list all network transactions in your node (replace the value of *NUTS_ADDRESS* with the HTTP address of your Nuts node):

```
$ NUTS_ADDRESS=my-node:1323 nuts network list
```

You can also use the Nuts docker image to run a command (against a remote Nuts node):

```
$ docker run nutsfoundation/nuts-node –address=http://my-node:1323 network list
```

Or inside a running Nuts docker container (against the running Nuts node):

```
$ docker exec nuts-container-name nuts network list
```

The following options can be supplied when running CLI commands:

Key	Default	Description
address	localhost:1323	Address of the remote node. Must contain at least host and port, URL scheme may be omitted. In that case it 'http://' is prepended.
timeout	10s	Client time-out when performing remote operations, such as '500ms' or '10s'. Refer to Golang's 'time.Duration' syntax for a more elaborate description of the syntax.
verbosity	info	Log level (trace, debug, info, warn, error)

CHAPTER

EIGHTEEN

CONFIGURING FOR PRODUCTION

Running a Nuts node in a production environment has additional requirements regarding security and data integrity compared to development or test environments. This page instructs how to *configure* your node for running in a production environment and what to consider.

18.1 Persistence

All data the node produces is stored on disk in the configured data directory (*datadir*). It is recommended to backup everything in that directory.

The private keys are stored in a storage backend. Currently 2 options are available.

18.1.1 Vault

This storage backend is the recommended way of storing secrets. It uses the Vault KV version 1 store. The prefix defaults to *kv* and can be configured using the *crypto.vault.pathprefix* option. There needs to be a KV Secrets Engine (v1) enabled under this prefix path.

All private keys are stored under the path *<prefix>/nuts-private-keys/**. Each key is stored under the kid, resulting in a full key path like *kv/nuts-private-keys/did:nuts:123#abc*. A Vault token must be provided by either configuring it using the config *crypto.vault.token* or setting the VAULT_TOKEN environment variable. The token must have a vault policy which enables READ and WRITES rights on the path. In addition it needs to READ the token information "auth/token/lookup-self" which should be part of the default policy.

18.1.2 Filesystem

This is the default backend but not recommended for production. It stores keys unencrypted on disk. Make sure to include the directory in your backups and keep these on a safe place. If you want to use filesystem in strict-mode, you have to set it explicitly, otherwise the node fails during startup.

18.1.3 Migrating from Filesystem storage to Vault

To migrate from filesystem based storage to Vault you can upload the keys to Vault under *kv/nuts-private-keys*.

Alternatively you can use the *fs2vault* crypto command, which takes the directory containing the private keys as argument (it assumes the container is called *nuts-node*):

```
docker exec nuts-node nuts crypto fs2vault /opt/nuts/data/crypto
```

In any case, make sure the key-value secret engine exists before trying to migrate (default engine name is *kv*).

18.2 Strict mode

By default the node runs in a mode which allows the operator run configure the node in such a way that it is less secure. For production it is recommended to enable *strictmode* which blocks some of the unsafe configuration options (e.g. using the IRMA demo scheme).

18.3 HTTP Interface Binding

By default all HTTP endpoints get bound on *:1323* which generally isn't usable for production, since some endpoints are required to be accessible by the public and others only meant for administrator or your own XIS. You can determine the intended public by looking at the first part of the URL.

- Endpoints that start with */public* should be accessible by the general public,
- */internal* is meant for XIS application integration and administrators.

It's advisable to make sure internal endpoints aren't reachable from public networks. The HTTP configuration facilitates this by allowing you to bind sets of endpoints to a different HTTP port. This is done through the *http* configuration:

```
http:
  # The following is the default binding which endpoints are bound to,
  # which don't have an alternative bind specified under `alt`. Since it's a default it␣
↪can be left out or
  # be used to override the default bind address.
  default:
    address: :1323
  alt:
    # The following binds all endpoints starting with `/internal` to `internal.lan:1111`
    internal:
      address: internal.lan:1111
    # The following binds all endpoints starting with `/public` to `nuts.vendor.nl:443`
    public:
      address: nuts.vendor.nl:443
      # The following enables cross-domain requests (CORS) from irma.vendor.nl
      cors:
        origin:
          - irma.vendor.nl
    # The following binds all endpoints starting with `/status` to all interfaces on `:80`
    status:
      address: :80
```

18.3.1 Cross Origin Resource Sharing (CORS)

In some deployments CORS can be required for the public IRMA authentication endpoints when the user-facing authentication page is hosted on a (sub)domain that differs from Nuts Node's IRMA backend. CORS can be enabled on a specific HTTP interface by specifying the domains allowed to make CORS requests as *cors.origin* (see the example above). Although you can enable CORS on the default endpoint it's not advised to do so in a production environment, because CORS itself opens up new attack vectors on node administrators.

18.4 Diagnostics

To aid problem diagnosis every node in a network should share some information about itself; the type and version of software it's running, which peers it is connected to and how long it's been up. This helps others diagnosing issues when others experience communication problems with your, and other nodes. Although discouraged, this can be disabled by specifying *0* for *network.advertdiagnosticsinterval*.

18.5 Nuts Network SSL/TLS Deployment Layouts

This section describes which deployment layouts are supported regarding SSL/TLS. In all layouts there should be X.509 server and client certificates issued by a Certificate Authority trusted by the network, if the node operator wants other Nuts nodes to be able to connect to the node and vice versa.

This is the simplest layout where the Nuts node is directly accessible from the internet:

This layout has the following requirements:

- X.509 server certificate and private key must be configured on the Nuts node.
- SSL/TLS terminator must use the trust anchors as specified by the network as root CA trust bundle.

In this layout incoming TLS traffic is decrypted on a SSL/TLS terminator and then being forwarded to the Nuts node. This is layout is typically used to provide layer 7 load balancing and/or securing traffic "at the gates":

This layout has the following requirements:

- X.509 server certificate and private key must be present on the SSL/TLS terminator.
- X.509 client certificate must be configured on the Nuts node.
- SSL/TLS terminator must use the trust anchors as specified by the network as root CA trust bundle.

In this layout incoming TLS traffic is forwarded to the Nuts node without being decrypted:

Requirements are the same as for the Direct WAN Connection layout.

CHAPTER

NINETEEN

DECENTRALIZED IDENTIFIERS

Nuts uses W3C Decentralized Identifiers as a base for tracking identities. From the W3C website:

> Decentralized identifiers (DIDs) are a new type of identifier that enables verifiable, decentralized digital identity. A DID identifies any subject (e.g., a person, organization, thing, data model, abstract entity, etc.) that the controller of the DID decides that it identifies. In contrast to typical, federated identifiers, DIDs have been designed so that they may be decoupled from centralized registries, identity providers, and certificate authorities. Specifically, while other parties might be used to help enable the discovery of information related to a DID, the design enables the controller of a DID to prove control over it without requiring permission from any other party. DIDs are URIs that associate a DID subject with a DID document allowing trustable interactions associated with that subject.

Within Nuts, DIDs identify both care organizations and software vendors. All DID methods require their own specification. The Nuts specification for the *nuts* DID method can be found on https://nuts-specification.readthedocs.io. Nuts DIDs are designed so they represent public/private key pairs. Any party can generate and claim a key pair. Only when information is added to the key pair, the key pair becomes important.

DIDs can gather claims through Verifiable Credentials. This allows a DID to actually represent something known in real life. For example: adding an organization name credential connects the key pair to the name of the organization. It connects the digital world to the real world.

19.1 DID Documents

DIDs are backed by a *DID Document*. It defines the public keys, who can alter the document and any services related to the DID. DID documents are automatically propagated through the network when they are created. When DID documents are created, the DID **always** represents the public key fingerprint of the associated key. A DID document is always created with a new key, the holder of the key can delegate the control to another DID.

19.1.1 Controller

The controller of the DID document is the only one that can change the contents. It can assign other controllers, change keys, change services and revoke the DID. When created, the DID document only has a single controller: the DID itself and the key related to it. It can choose to change add new controllers and remove existing ones. Changes to DID documents are only accepted when the network transaction is signed with a controller's **authentication** key.

19.1.2 Verification Method

All public keys within a Nuts DID Document are listed under **verificationMethod**.

19.1.3 Assertion Method

Keys referenced from the **assertionMethod** section are used to sign JWTs in the OAuth flow and for issuing *Verifiable Credentials*.

19.1.4 Authentication Method

Keys referenced from the **authentication** section are used to change the DID document and sign network transactions.

19.1.5 Services

The **services** section is used to list service endpoints. There are some endpoints that are shared amongst all services, like the **oauth** service. But most service endpoints will be coming from specific Bolts.

CHAPTER

TWENTY

NUTS NODE DEVELOPMENT

20.1 Requirements

Go >= 1.18 is required.

20.2 Building

Just use `go build`.

20.2.1 Building for exotic environments

You can build and run the Nuts node on more exotic environments, e.g. Raspberry Pis:

- 32-bit ARMv6 (Raspberry Pi Zero): `env GOOS=linux GOARCH=arm GOARM=6 go build`

20.3 Running tests

Tests can be run by executing

```
go test ./...
```

20.4 Code Generation

Code generation is used for generating mocks, OpenAPI client- and servers, and gRPC services. Make sure that `GOPATH/bin` is available on `PATH` and that the dependencies are installed

Install `protoc`:

MacOS: `brew install protobuf`
Linux: `apt install -y protobuf-compiler`

Install Go tools:

```
make install-tools
```

Generating code:

To regenerate all code run the `run-generators` target from the makefile or use one of the following for a specific group

Group	Command
Mocks	`make gen-mocks`
OpenApi	`make gen-api`
Protobuf + gRCP	`make gen-protobuf`
All	`make run-generators`

20.5 Docs Generation

To generate the documentation, you'll need `python3`, `sphinx` and a bunch of other stuff. After you have installed `python3` (and `pip3` if this not already installed) run

```
pip3 install -r docs/requirements.txt
```

20.5.1 README

The readme is auto-generated from a template and uses the documentation to fill in the blanks.

```
make gen-readme
```

20.5.2 Documentation

The documentation can be build by running the following command from the `/docs` directory:

```
make html
```

CHAPTER

TWENTYONE

RELEASING NUTS NODE

Nuts Node and auxiliary tools/applications follow a semantic versioning scheme (<major>.<minor>.<patch>):

> Given a version number MAJOR.MINOR.PATCH, increment the: 1. MAJOR version when you make incompatible API changes, 2. MINOR version when you add functionality in a backwards compatible manner, and 3. PATCH version when you make backwards compatible bug fixes.

(Taken from **`semver.org<https://semver.org/`_**)

> Note: "API" is a broad term, it covers every interface interacted with by applications or other nodes (including Nuts network protocols).

Aside from the Nuts Node itself, the projects below need to be released. They follow the major version from the Nuts Node, but minor and patch versions may differ.

- **`Registry Admin Demo<https://github.com/nuts-foundation/nuts-registry-admin-demo/releases>`_**
- **`Demo EHR<https://github.com/nuts-foundation/nuts-demo-ehr/releases>`_**

21.1 Major release

A major release starts with version number <major>.0.0. Every Nuts Node release has a name (e.g. "Brazil") and a version number. A release consists of a Git tag and a release in Github with release notes. Releases are created according to the following format:

- Git tag: v<major>.<minor>.<patch>, e.g. v2.0.0
- Release name: <name> release (<version>), e.g.: Brazil release (v2.0.0) (every release has a designated name)
- Release notes: auto-generated by Github.

21.2 Bugfix release/patches

When an issue is fixed in a released version a bugfix/patch version must be released. The bug must be fixed on a branch named after the major version, e.g. v1 or v2. The release name follows the release name, but is named "bugfix" instead of "release". E.g.: Brazil bugfix (v2.0.1).

21.2.1 Backports

Bugfixes often need to be backported, e.g. it's fixed on the `master` branch but also need to be fixed in the last version, and maybe even in the before last version. Bugfix releases stemming from backports follow the same versioning and naming scheme as regular bugfix releases.

CHAPTER

TWENTYTWO

API DEVELOPMENT

When developing APIs, please follow these guidelines.

22.1 Contract first

The Nuts node APIs are specified in **`Open API Specification (OAS)<https://swagger.io/specification/>`_**. The files are located under `/docs/_static/<engine>/<version>.yaml`. Where `<engine>` is a specific module like `crypto` or `auth` and `<version>` defines the version of the API. We use version `3.0.y` of the OAS.

22.1.1 Versioning

We use versioning of the APIs. This is reflected in both the OAS files and the HTTP paths. Versions must follow the pattern `v` and start at `v1`. These are major versions, any breaking change results in a new major version of the API. New additions, bug fixes and changes that are backwards compatible may be done in the current version.

22.1.2 Code generation

The OAS files are used for code generation. The makefile contains the `gen-api` target which will generate the code. The build target only needs to be extended when a new version or new engine is added. Generated code is always placed in `/<engine>/api/<version>/generated.go`.

22.1.3 Return codes

The error return values are generalized for all API calls. The return values follow RFC7807. The definition is available under `/docs/_static/common/error_response.yaml`. The error definition can be used in a OAS file:

```
paths:
    /some/path:
        get:
            responses:
                default:
                  $ref: '../common/error_response.yaml'
```

The error responses will not be listed as responses in the online generated documentation. To describe error responses, the specific responses need to be added to the API description:

```
paths:
    /some/path:
        post:
            description: |
                Some description on the API

                error returns:
                * 400 - incorrect input
```

22.2 Paths

The API paths are designed so different security schemes can be setup easily.

API paths follow the following pattern:

```
/<context>/<engine>/<version>/<action>
```

All paths start with a security <context>:

- /internal/** These APIs are meant to be behind a firewall and should only be available to the internal infrastructure. All DID Document manipulation APIs fall under this category.
- /n2n/** These APIs must be available to other nodes from the network. This means they must be protected with the required client certificate as specified by RFC011. The creation of an access token is one example of such an API.
- /public/** These APIs must be publicly available on a valid domain. No security must be set. These APIs are used by mobile devices.

After the context, the <engine> is expected. An engine defines a logical unit of functionality. Each engine has its own OAS file. Then as discussed earlier, the <version> is expected. The last part is the <action>, this part can be freely chosen in a RESTful manor.

CHAPTER

TWENTYTHREE

EVENTS

Each event consists of a single JSON encoded message that is categorized by its subject which in term are grouped into streams. Each stream defines how to handle limits, storage, data retention, deliverability etc.

23.1 Streams

Name	Summary	Policy	Durable	Message limit	Storage
nuts-disposable	Main event-stream	When the stream is full old messages will be discarded	No	100	Memory

CHAPTER

TWENTYFOUR

DEVELOPMENT WITH VAULT

You can start a development Vault server as follows:

> docker run –cap-add=IPC_LOCK -d -p 8200:8200 -e 'VAULT_DEV_ROOT_TOKEN_ID=unsafe' -e 'VAULT_ADDRESS=http://localhost:8200' –name=dev-vault vault

The server will start unsealed, with root token *unsafe*.

Now log in and enable a key-value secret engine names *kv*:

> docker exec -e 'VAULT_ADDR=http://0.0.0.0:8200' dev-vault vault login

Enter the root token *unsafe*, then enable the *kv* engine:

> docker exec -e 'VAULT_ADDR=http://0.0.0.0:8200' dev-vault vault secrets enable -path=kv kv

Then configure the Nuts node to use the Vault server:

> **crypto:**
> storage: vaultkv vault:
>
> address: http://localhost:8200 token: unsafe

CHAPTER

TWENTYFIVE

CONTRIBUTE

If you want to contribute to any of the nuts foundation projects or to this documentation, please fork the correct project from Github and create a pull-request.

25.1 Documentation contributions

Documentation is written in Restructured Text. A CheatSheet can be found here.

You can test your documentation by installing the required components.

25.2 Documentation initialisation

When starting a new project, the documentation can be initialised using:

```
sphinx-quickstart docs
```

This will start the interactive setup of sphinx with a document root at *docs*. For Nuts projects we use that specific directory for documentation in a code project. You might have noticed that the *nuts-documentation* repo uses the root directory as documentation root.

Most defaults will do, although we use intersphinx to go back-and-forth between the different sub-projects.

CHAPTER

TWENTYSIX

CONTACT

26.1 Information

More information about the Nuts foundation can be found at nuts.nl

26.2 Communication

The main means of communication is via Slack.