KVD

Persistent custom nodes for the ctrlX Data Layer.

The app provides population of

- explicit (configured) nodes of any kind by configuration.
- *implicit* (dynamic) Variable nodes, created by any Data Layer client programmatically (create-on-write).

A reliable and a high performance data storage is included. The persistence is based on a key/value database (*KVD*).

Quick Start

- Install the KVD app, open ctrlX UI inside your preferred browser.
- Navigate to Settings->Data Layer.
- Discover the samples nodes /samples/kvd/*.

Usage

Configure *explicit* nodes or root nodes for *implicit* (dynamic) child nodes (.../*, .../**), which should be populated to the Data Layer's address space. This can be done by editing configuration file *nodes.json*.

Interaction with any Data Layer client

Read a node's value

Read a node by calling the corresponding **read** method. The argument has to be the address of the node.

Write a node's value

Create the node of *nodeClass* **Variable** by calling the corresponding **write** method. The argument has to be a Variant holding a value of any data type.

create-on-write

Create a none existing *implicit* node as a child node of an *implicit* root node, by initially writing a value to it. This can be done by just writing any value, which creates a *implicit* node of *nodeClass* **Variable** with given data type.

The initial data type of the node will be set and persistent. Subsequent writes to the node's value will fail, if the data type of the written data type does not match exactly.

Create a node

Creating a node by calling the corresponding create method is NOT SUPPORTED. Please use create-on-write.

Delete a node

Delete a node by calling the corresponding **remove** method to remove the node. The argument has to be the address of the node.

Only supported for *implicit* nodes.

Interaction with Node-RED

Please see README-NODE-RED.md

Configuration Editors

The KVD app can be configured with the **App data editor** or via **WebDAV**.

The KVD app configuration files can be found there:

Settings -> Manage app data -> Key Value Database configuration

WARNING:

PLEASE DO NOT EDIT, DELETE OR RENAME ANY FILE INSIDE THE FOLDER WHERE THE UNDERLYING DB IS LOCATED. THIS IS FOLDER *db* BY DEFAULT.

Reset

WARNING:

YOU CAN RESET THE KVD PERSISTANCE BY JUST REMOVING THE DB FOLDER. THE APP IS RESTARTED AND ALL DATA WILL LOSS AND RESETTET TO DEFAULT!

Configuration via App data editor

You can edit *settings.json*, *nodes.json* and any other there the setup the KVD app. Changes will be applied immediately.

| Name Modified Size Actions <t< th=""></t<> |
|--|
| → do で 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| ලී 14 5 ලී මී 17 19 19 19 19 19 19 19 19 19 19 19 19 19 |
|) schemas 前 17 18 19 19 10 10 10 10 10 10 10 10 10 10 10 10 10 |
|] nodes.json 2023-02-13 14:30 5280 ± 🛱 28 21 } |
| |

Configuration via WebDAV

Please use any **WebDAV** client to configure the KVD app.

We recommend to use WinSCP.

Create a new site with protocol WebDAV, choose TLS encryption, enter your ip and credentials, finally login:

| 🌆 Login | - 0 | × | |
|------------------------------|--|---|--|
| 💣 New Site | Session | | |
| WEBDAV rexroot@192.168.1.170 | File protocol: Encryption: | ٦ | |
| | WebDAV TLS/SSL Implicit encryption | Encryption: TLS/SSL Implicit encryption Port number: 0 443 Password: | |
| | 192.168.1.170 443 User name: Password: | | |
| | 192.168.1.170 44 | | |
| | User name: Password: | | |
| | boschrexroth | | |
| | Edit Advanced | Der: 443 | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | rt number: 443 ••••• vanced | |
| Tools 🔻 Manage 🔻 | ▼ Close Help | | |

On the remote side on the left, click Open Directory <CTRL + o> and edit the Remote directory to:

| /solutions/webdav/appdata | |
|---|-------------------------|
| Location profiles | ? × |
| Local directory: | V Browse |
| Remote directory: /solutions/webdav/appdata | |
| Site Location profiles Shared Location profiles | Add Remove Rename |
| | Move To Up Down |
| Bookmarks OK Cancel | Help |

Now you should see the ctrlX appdata storage:

| /solutions/webdav/appdata | / | |
|---------------------------|------|---------------------|
| Name | Size | Changed |
| t | | 14.10.2022 08:52:27 |
| trace | | 08.09.2022 12:54:50 |
| telegraf | | 08.09.2022 12:54:50 |
| script | | 20.10.2022 08:16:36 |
| scheduler | | 08.09.2022 12:54:50 |
| remote-logging | | 08.09.2022 12:52:47 |
| opcuaserver | | 08.09.2022 12:54:50 |
| node-RED | | 20.10.2022 15:59:47 |
| kvd | | 14.10.2022 08:52:27 |
| datalayer | | 14.10.2022 08:39:27 |
| 🗙 configuration.json | 3 KB | 14.10.2022 08:50:35 |

Navigate to folder *kvd* for configuration.

You can edit *settings.json*, *nodes.json* and any other there the setup the KVD app. Changes will be applied immediately.

| /solutions/webdav/appdata/kvd/ | | | | | | |
|--------------------------------|------|---------------------|--------|-------|--|--|
| Name | Size | Changed | Rights | Owner | | |
| t . | | 14.10.2022 08:52:27 | | | | |
| db | | 17.10.2022 11:02:27 | | | | |
| bfbs | | 14.10.2022 08:52:27 | | | | |
| 🗙 settings.json | 1 KB | 14.10.2022 08:52:27 | | | | |
| 🗙 nodes.json | 5 KB | 17.10.2022 11:02:25 | | | | |
| | | | | | | |

Diagnostics

On any configuration error, the KVD app doesn't startup and you won't see any nodes in the ctrlX Data Layer tree. If this is the case please check the KVD app errors in Diagnostics for error details (e.g. schema validation failed, etc.).

Open the ctrIX UI, navigate to *Diagnostics->Logbook*, click on the *settings* button on the right and enable option *Show system messages*.

| ⊳ × |
|--|
| Settings |
| Show system messages |
| Show developer information |
| Show remote logging |
| Set logbook to persistent |
| Set bookmark |
| Select timezone for display V Browser |
| Europe/Berlin (GMT+0200) |
| |
| Save Cancel |

Click on *Filter* and enable Unit *snap.rexroth-kvd.kvd.service*:

 \times

Cancel

| Filter | |
|-----------|--|
| Levels | Common.scheduler |
| Entities | dbus.service |
| Units 🗸 🛱 | init.scope |
| | session-1.scope |
| | session-3.scope |
| | <pre>snap.ctrlx-node-red.node- red.service</pre> |
| | automationcore.control.service |
| | snap.rexroth- deviceadmin.health.service |
| | snap.rexroth-deviceadmin.proxy- monitor.service |

If any error occured, refresh the log to see detailed error informations:

| Diagn | ostics | | | | | |
|---------|----------------------------|----------------|--------|---|--|----------------------------------|
| 56 iter | ns Search | q | Today | ~ | ទ Hide trace messages T Filter (1) | C ± |
| Units | : snap.rexroth-kvd | .kvd.service 🗴 | | | | |
| Level | Date GMT+0200 | Code | Entity | | Description | Unit |
| (i) | 21.10.2022 10:27:26.401 | | | | 2022/10/21 10:27:26 E! [kvd] restart failed: jsonschema: '/nodes/0/type' does not validate with file:///snap/rexroth- kvd/x1/configs/schema/nodes.schema.json#/properties/nodes/items/\$ref/properties/type/oneOf: oneOf failed (DL_FAILED) | snap.rexroth- kvd.kvd.service |
| (i) | 21.10.2022 10:27:26.401 | | | | 2022/10/21 10:27:26 EI [kvd] nodes invalid: jsonschema: '/nodes/0/type' does not validate with file:///snap/rexroth- kvd/x1/configs/schema/nodes.schema.json#/properties/nodes/items/\$ref/properties/type/oneOf: oneOf failed | snap.rexroth- kvd.kvd.service |
| Ō | 21.10.2022 10:27:26.401 | | | | 2022/10/21 10:27:26 EI [kvd] failed to validate nodes configuration: jsonschema: '/nodes/0/type' does not validate with file:///snap/rexroth- kvd/x1/configs/schema/nodes.schema.json#/properties/nodes/items/\$ref/properties/type/oneOf: oneOf failed | snap.rexroth- kvd.kvd.service |
| (j) | 21.10.2022 10:27:26.391 | | | | 2022/10/21 10:27:26 II [kvd] loading nodes | snap.rexroth- kvd.kvd.service |
| 1 | 21.10.2022 10:27:26.389 | | | | 2022/10/21 10:27:26 II [kvd] loading settings | snap.rexroth- kvd.kvd.service |

snap.rexrothdeviceadmin.web.service

enon revroth-

snap.rexroth-kvd.kvd.service

If the KVD app is starting up normally, it should look like:

| Diagn | ostics | | | | | |
|------------|----------------------------|---------------------------|--------|---|---|----------------------------------|
| 69 iten | ns Search | S | Today | ~ | 冠 Hide trace messages 7 Filter (1) | C * @ |
| Units: | snap.rexroth-kvd | .kvd.service _X | | | | |
| Level | Date GMT+0200 | Code | Entity | | Description | Unit |
| 1 | 21.10.2022 10:28:49.395 | | | | 2022/10/21 10:28:49 ll [kvd] running | snap.rexroth- kvd.kvd.service |
| () | 21.10.2022 10:28:49.395 | | | | 2022/10/21 10:28:49 II [kvd] connected | snap.rexroth- kvd.kvd.service |
| 1 | 21.10.2022 10:28:49.367 | | | | 2022/10/21 10:28:49 [kvd] starting provider | snap.rexroth- kvd.kvd.service |
| 1 | 21.10.2022 10:28:49.365 | | | | 2022/10/21 10:28:49 II [kvd] registering nodes | snap.rexroth- kvd.kvd.service |
| 1 | 21.10.2022 10:28:49.363 | | | | 2022/10/21 10:28:49 II [kvd] connecting: ipc:// | snap.rexroth- kvd.kvd.service |
| 1 | 21.10.2022 10:28:49.314 | | | | 2022/10/21 10:28:49 II [kvd] loading nodes | snap.rexroth- kvd.kvd.service |
| () | 21.10.2022 10:28:49.312 | | | | 2022/10/21 10:28:49 II [kvd] loading settings | snap.rexroth- kvd.kvd.service |
| _ | 21.10.2022 | | | | | snap.rexroth- |

General configuration

Edit the file *settings.json*, to change the general behaviour of the app.

The settings.json file is located in ctrlX appdata storage directory KVD on your ctrlX.

db

Sets the path of the underlying database. Defaults to *kvd/db*.

IMPORTANT:

PLEASE USE REMOVABLE MEDIA FOR DB STORAGE IF POSSIBLE

We recommend to use any mounted removable media (e.g. SD card) for db storage location, to keep the life time of the internal system storage.

Example: removable media

```
{
    "db": "/media/mmcblk1p1/db",
    ...
}
```

readonly

Sets the configured node values to be *readonly*, which means write operations are forbidden and will fail. Defaults to *false*.

verbose

Enables verbose trace. Defaults to false.

Nodes configuration

The node configuration file *nodes.json* specifies a set of nodes to be registered and persisted to the Data Layer.

The nodes.json file is located in ctrlX appdata storage directory KVD on your ctrlX.

The configuration supports *explicit* and *implicit* (dynamic) root nodes.

description

The description of the configuration.

types

The list of types (nodeClass Type)to be registered.

nodes

The list of nodes to be populated. The app supports hierarchical structuring nodes (*nodeClass* Folder, Collection, Resource) and variable nodes (*nodeClass* Variable).

address [required]

The address of the node. This can be either an absolute path (leaf), a single (*/**) or double wild carded(*/***) ending address used to specify a *implicit* node.

Volatile (memory-only) nodes

Configure a node's value to be volatile (memory-only) and not persistent by adding the extension key *autoSave* to the node's metadata, with it's value set to string *"false"*.

TIP: You can also set *volatile* to value *true* as a shortcut.

Example: Volatile nodes

```
nodes: [
    {
        "address": "mycompany/europe/myplants/plant1/volatile temperature",
        "type": "int32",
        "metadata": {
            "nodeClass": "Variable",
            "extensions": [
                 {
                     "key": "autoSave",
                     "value": "false"
                 }
            ]
        }
    },
    . . .
    {
        "address": "mycompany/europe/myplants/plant2/volatile_temperature",
```

```
5/11/2023
```

```
"type": "int32",
"volatile": true,
},
...
]
```

The volatile feature is only supported for *explicit* nodes.

Read-only nodes

Configure a node's value to be read-only (e.g. any not writable constant value) by adding the operations *write* to the node's metadata, with it's value set to *false*.

TIP: You can also set *mode* to string "*read-only*" as a shortcut.

Examples: read-only nodes

```
nodes: [
    {
        "address": "mycompany/europe/myplants/plant1/myconstant1,
        "type": "int32",
        "value": 42,
        "metadata": {
            "nodeClass": "Variable",
            "operations": {
                "write": false
            },
            "description": "This is a read-only variable node, it's value can't be
written."
        }
    },
    . . .
    {
        "address": "mycompany/europe/myplants/plant1/myconstant2,
        "type": "int32",
        "value": 42,
        "mode": "read-only",
        "metadata": {
            "nodeClass": "Variable",
            "description": "This is a read-only variable node, it's value can't be
written."
        }
    }
    . . .
]
```

Explicit nodes

A *explicit* node has an absolute address. A *explicit* node can't be deleted (independendly from allowed operations by the *nodeClass*).

Example: explicit node

```
nodes: [
    {
        "address": "mycompany/europe/myplants/plant1/temperature",
        "type": "int32",
        "metadata": {
             "nodeClass": "Variable",
        },
        ...
]
```

Implicit nodes

A *implicit* node can be created (*create-on-write*) and removed. A *implicit* root node defines the entry of an *implicit* branch, allowing creation and deletion of child nodes only in next level (*/**) or all levels (*/***).

Examples: Implicit root node

This *implicit* root node allows creation and deletion of child nodes only on next hierarchical level:

```
{
    "address": "mycompany/europe/myplants/plant1/*",
},
```

This *implicit* root node allows creation and deletion of child nodes of the full underlying branch (all hierarchical levels):



value

The initially preset value of the node. Defaults to any falsy value (0, false, "")

Supported values types:

string,number,integer,boolean,array,object

Examples: value

A Variable node of numeric value kind:

```
{
...
"value": 42,
}
```

A Variable node of string value kind:

```
{
...
"value": "42",
}
```

metadata

The metadata of the node which tells the clients something about the node's identity, allowed operations on it and more.

User access restrictions:

To configure a full *read-only* node branch or *restrict access*, please use the Data Layer user access restriction.

nodeClass

Sets the class of the node. Defaults to Variable.

Allowed operations like **read**, **write**, **create**, **delete**, **browse** can be executed by any client, depending on the *nodeClass* of the node.

TIP: You can also set *nodeClass* to node instead using the metadata as a shortcut.

Supported node classes:

Variable, Resource, Collection, Folder, Type

The following table shows the *allowed operations* by *nodeClass*:

| Operation | Variable | Resource | Collection | Folder | Туре |
|-----------|----------|----------|------------|--------|------|
| read | Х | Х | Х | | Х |
| write | х | Х | | | |
| create | | Х | Х | | |

| Operation | Variable | Resource | Collection | Folder | Туре |
|-----------|----------|----------|------------|--------|------|
| delete | | Х | | | |
| browse | Х | Х | Х | Х | Х |

unit

The unit of the node. Defaults to an *empty* string.

TIP: You can also set *unit* to node instead using the metadata as a shortcut.

displayName

The display name of the node. Defaults to *address*.

TIP: You can also set *displayName* to node instead using the metadata as a shortcut.

displayFormat

The display format of the node. Defaults to Auto.

TIP: You can also set *displayFormat* to node instead using the metadata as a shortcut.

Supported display formats:

Auto,Bin,Oct,Dec,Hex

description

The description of the node. Defaults to an *empty* string.

TIP: You can also set *description* to node instead using the metadata as a shortcut.

descriptionUrl

The description url of the node. Defaults to an *empty* string.

TIP: You can also set *descriptionUrl* to node instead using the metadata as a shortcut.

Example: Minimal metadata

Numeric Variable node (int32):

```
nodes: [
    {
        "address": "mycompany/europe/myplants/plant1/temperature1",
        "type": "int32",
        "metadata": {
             "nodeClass": "Variable"
```

```
}
},
...
{
    "address": "mycompany/europe/myplants/plant1/temperature2",
    "type": "int32",
    "nodeClass": "Variable"
},
...
]
```

Examples: All metadata

Numeric Variable node (int32):

```
nodes: [
    {
        "address": "mycompany/europe/myplants/plant1/temperature",
        "type": "int32",
        "value": 42,
        "metadata": {
            "nodeClass": "Variable",
            "displayName": "This is a velocity variable node for binary experts.",
            "displayFormat": "Bin",
            "unit": "m/s",
            "description": "This is a variable node with all metadata.",
            "descriptionUrl": "https://www.boschrexroth.com/"
        }
    },
    . . .
]
```

Flatbuffers Variable node of a built-in type

```
nodes: [
    {
        "address": "mycompany/europe/myplants/plant1/my-server-settings",
        "type": "types/datalayer/server-settings",
        "metadata": {
            "nodeClass": "Variable",
            "description": "This node is of built-in flatbuffers type 'server-
settings'.",
        }
    },
    ....
]
```

Flatbuffers Variable node of a custom type:

```
nodes: [
    {
        "address": "mycompany/europe/myplants/plant1/my-inertial-value",
        "type": "types/inertial-value",
        "metadata": {
            "nodeClass": "Variable",
            "description": "This node is of the custom flatbuffers type
'types/inertial-value."
        },
        ...
]
```

type

The data type of the node's value. Defaults to unknown.

Scalars

| type | description |
|-----------------|--|
| unknown | unknown datatype (not initialized, empty, null) |
| bool8 | bool (8 bit) |
| int8 | signed int (8 bit) |
| uint8 | unsigned int (8 bit) |
| int16 | signed int (16 bit) |
| uint16 | unsigned int (16 bit) |
| int32 | signed int (32 bit) |
| uint32 | unsigned int (32 bit) |
| int64 | signed int (64 bit) |
| uint64 | unsigned int (64 bit) |
| float, float32 | float (32 bit) |
| double, float64 | double (64 bit) |
| string | string (UTF-8) |
| timestamp | timestamp (FILETIME) 64 bit 100ns since 1.1.1601 (UTC) |
| flatbuffers | bytes as a complex data type encoded as a flatbuffer |
| raw | raw bytes |

Arrays

| type | description |
|---------------------|--|
| arbool8 | array of bool (8 bit) |
| arint8 | array of signed int (8 bit) |
| aruint8 | array of unsigned int (8 bit) |
| arint16 | array of signed int (16 bit) |
| aruint16 | array of unsigned int (16 bit) |
| arint32 | array of signed int (32 bit) |
| aruint32 | array of unsigned int (32 bit) |
| arint64 | array of signed int (64 bit) |
| aruint64 | array of unsigned int (64 bit) |
| arfloat, arfloat32 | array of float (32 bit) |
| ardouble, arfloat64 | array of float (64 bit) |
| arstring | array of string (UTF-8) |
| artimestamp | array of timestamps (FILETIME) 64 bit 100ns since 1.1.1601 (UTC) |

Once the **Variable** node is initially created with it's configured *value type*, the written *value type* has to match the configured one exactly, otherwise an error code is returned to the client performing the write operation.

Built-in Flatbuffers types

To configure a node of a **built-in** flatbuffers type, set the *type* of the node to the address of the referred target type:

types/...

Example: Built-in flatbuffers

Flatbuffers Variable node of a built-in flatbuffers type:

Custom Flatbuffers types

To register a **custom** flatbuffers, configure a node of *nodeClass* **Type** and add it to the *types* section.

• Set the address of the type to the address on which instance nodes should refer to it:

types/...

Example:

types/inertial-value

- Set the type to the name of the corresponding compiled flatbuffers file (*.bfbs).
- Upload the *.bfbs file to appdata location:

kvd/bfbs

Example: Custom flatbuffers

Type node of a **custom** flatbuffers type:

```
types: [
    {
        "address": "types/inertial-value",
        "type": "inertial-value.bfbs",
        "metadata": {
            "nodeClass": "Type"
        }
    },
    ...
]
```

A Variable node this type can be specified (value optional):

```
nodes: [
    {
        "address": "kvd/samples/variables/flatbuffers/inertial-value",
        "type": "types/inertial-value",
        "value": {
            "x": 1,
            "y": 2,
            "z": 3
        },
```

```
"metadata": {
    "nodeClass": "Variable",
    "description": "This node is of the custom flatbuffers type
'types/inertial-value."
    }
  },
  ...
]
```

Configure Data Layer model nodes

Please see README-MODELS.md

Maintainers

See MAINTAINERS