ThingsViz

# INTRODUCTION

The main goal of the visualization tool is to be able to visualize the three parameters sf alloc, sf period and resource percentage which are determined by the adaptive mbsfn solution. This tool needs to meet a few requirements. First of all it needs to be able to visualize data in both a real time manner as well as in a replay manner. Secondly the data needs to be visualizable in different ways e.g. a bardiagram, piechart or table. Lastly, it needs to be easy and intuitive to use.

As mentioned before, MatplotViz only uses the python library Matplotlib and csv files to visualize and store its data and is completely developed in house. Overall this tool is easy to use and meets two of the three main requirements and includes a lot of extra perks but the main drawback of MatplotViz however was the difficulty to visualize the data in a different way than a bardiagram or piechart. ThingsViz is a more mature tool which meets all the of the main requirements mentioned before and is even more practical and intuitive in use. However, the main constraint of ThingsViz is that it depends heavily on a third party data visualization platform Thingsboard. If Thingsboard would go out of business or would cancel their free-to-use version, ThingsViz would need to adapt to these changes.

# BASIC ARCHITECTURE OVERVIEW

The basic architecture of ThingsViz is as follows:

## CLIENT

First of all, a data generating client will generate the three desired parameters. This client can either be a random generator or a “real life” client. The generator can be used for simple demonstration and testing/development purposes. The “real life” client will be the adaptive mbsfn solution, which calculates every 0.64 seconds new parameter values. Once the parameter values are calculated/generated, the client will connect to the ThingsViz server which is listening for incoming messages on a socket located at a certain port of choice and send the parameters in a comma separated string form.

## SERVER

The ThingsViz server is a simple python server which opens up a TCP socket on the server machine and listens for incoming messages. By default the server is ran on the same “localhost” machine on which the adaptive mbsfn EnodeB is running but in theory this can be any desired machine. However this is in not recommended due to the introduction of extra undesired latencies. When a new message, containing the parameters, is received by the server it will open up a connection with the MQTT broker (more information about MQTT later) and publish this parameters in a JSON string format to the broker. Note that the ThingsViz server doubles up as a receiver on the socket communication side as well as a sender on the MQTT communication side.

## MQTT BROKER/ THINGSBOARD PLATFORM

As mentioned before the ThingsViz server publishes the parameters to a MQTT broker.

#### MQTT in a nutshell

MQTT is an application layer protocol which uses the underlying TCP protocol and was developed to be mainly used in Internet of Things use cases. MQTT communication needs to meet two main requirements. First of all, it needs to be fast and can’t introduce a lot of latencies due to the real time nature of a lot of IoT applications. Secondly it needs to have a very simple client side because it needs to be able to be implemented in very small, controllers and IoT devices. MQTT uses a publish/subscribe architecture. A centralized broker will keep track of all the connections with clients as well as store and forward incoming messages and will be responsible for all the communications logics. Clients simply need to know the address and port of the broker in order to be able to send messages. A client will publish messages on a topic of choice. If another client wants to receives the messages of this topic, it simply needs to communicate this to the broker by sending a subscribe-request. The broker in turn will receive these subscribe-request and it will make sure that all the messages that are send on the topic of interest will be forwarded to the subscribed client(s). One major constraint of MQTT is the fact that the sender as well as the receiver(s) need to know the exact name of the topic on which to subscribe and publish.

#### MQTT as a ThingsViz tool

ThingsViz uses the MQTT protocol to transport the messages from the server to the Thingsboard platform. The broker is ran and managed by Thingsboard and needs almost zero configuration. The broker will simply inherit the address of the Thingsboard platform. E.g. if Thingsboard is ran locally, the address of the broker will simply be localhost, if Thingsboard is ran in the cloud the address will be “thingsboard.cloud”. For optimal real time performance and minimal latencies, it is recommended to run Thingsboard on the same machine as the EnodeB or on the same Local Area Network. The Thingsboard platform will implicitly subscribe on the topics on which the ThingsViz server is publishing. This means that all the data can easily be visualized by the configurable Thingsboard dashboards. More so, not only does Thingsboard receive and visualizes the received data but it also stores this data by default into a local postgresql database. This needs no configuration and a user can seamlessly visualize the data from for example the past week without being hassled by complicated database queries.

A few remarks: As mentioned before, both the ThingsViz server as well as the Thingsboard platform can be ran on the same localhost machine on which the EnodeB is running. However it is possible to run both of them on other machines if for example the EnodeB hasn’t got enough compute power to handle everything or if it is not possible to hook up a monitor to the EnodeB. Always make sure that the mac/network\_components/client.py script has the port and address of the ThingsViz server configured correctly and that the ThingsViz server has the address and port of the broker configured correctly. By default everything is set to “localhost” and assumed to be ran on one machine.

# INSTALLATION

## CLIENT

**Pre requirements**: Socket libraries in python as well as in c++ are usually included by default.

* To install the random generator simply download the CLIENTSIDE/generators directory. The “src” directory contains a client.cpp/client.py which will generate random parameters and send them to a server socket.
* To install the modified adaptive mbsfn solution, first download the CLIENTSIDE/adaptive\_mbsfn/mac directory. Replace the original mac directory in the original adaptive\_mbsfn project with the new mac directory. Rerun “cmake ../”, “sudo make”, “sudo make install” and “sudo ldconfig”. From now on the adaptive\_mbsfn module will not only print the parameters on the terminal, just as before, but it will also try to send the parameters to the server if possible. Note that the solution can still be ran without running a server. It will just print “connection failed” on the terminal alongside the parameters.

Modified files:

1. network\_components/client.cc ADDED
2. mac.cc MODIFIED Added line 909-913
3. CMakeLists.txt MODIFIED Set(…, net\_comp/client.cc)

## SERVER

**Pre requirements**: Install the paho-mqtt client: “pip install paho-mqtt”

* To install the ThingsViz python server, simply download the SERVERSIDE/ThingsViz directory. The server code can be found in the “src” directory.

## THINGSBOARD

* ThingsBoard can be ran in the cloud => NO INSTALLATION REQUIRED
* ThingsBoard can be installed both natively on Ubuntu or on Docker for Ubuntu.
* <https://thingsboard.io/docs/user-guide/install/ubuntu/>
* <https://thingsboard.io/docs/user-guide/install/docker/>
  + **Pre requirements** **for Thingsboard on docker:**
* <https://docs.docker.com/engine/install/ubuntu/>
* <https://docs.docker.com/compose/install/>
* TIP: install Portainer as a useful docker manager UI for linux

<https://vitux.com/how-to-install-portainer-dcoker-manager-in-ubuntu-20-04/>

<https://docs.portainer.io/v/ce-2.9/start/install//server/docker/linux>

* + **Remarks for installing on Docker**
* Run “sudo docker-compose pull”
* Run “sudo docker-compuse up”

HOW TO SETUP DASHBOARD AND THE MQTT BROKER IN THINGSBOARD:

1. Import the Device profile .json configuration file from the SERVERSIDE/ThingsViz/thingsboard\_templates/profiles directory

IF IMPORT DOESN’T WORK RECREATE THE SCREENSHOT

Afbeelding met tekst

Automatisch gegenereerde beschrijving

1. Add a new device with the device name set to the hostname of the machine on which Thingsboard will be ran. Set the Device profile to ThingsViz.

The access token is used by the server.py script to connect with the broker.

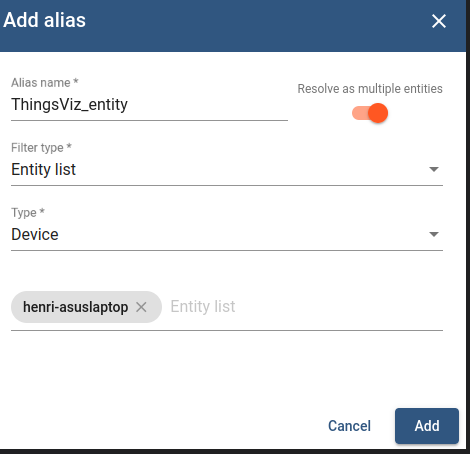
Afbeelding met tafel

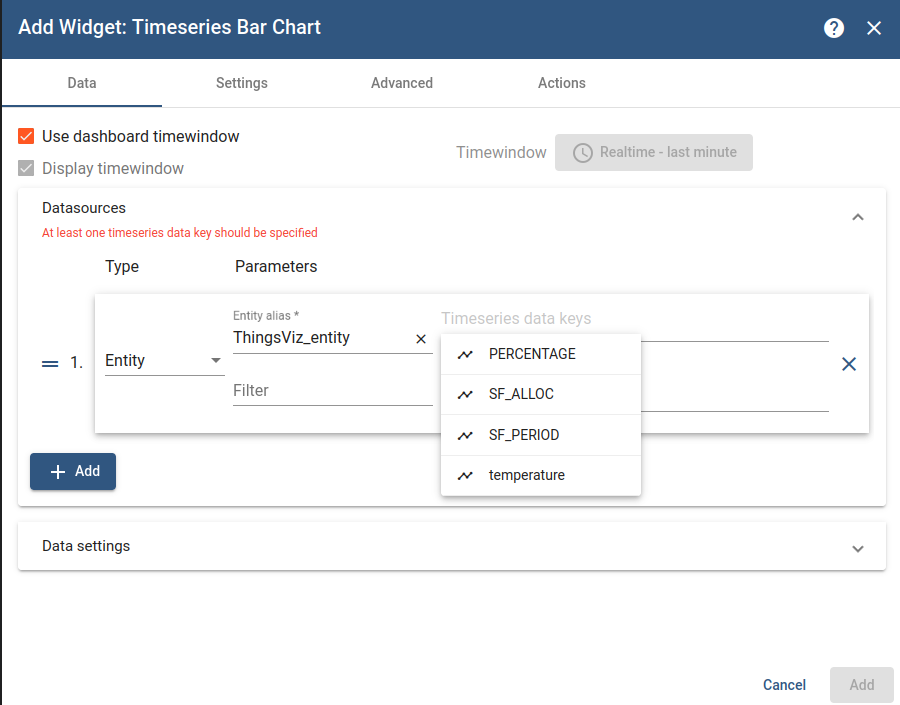
Automatisch gegenereerde beschrijving

1. Import the dashboards .json configuration files from the directory SERVERSIDE/ThingsViz/thingsboard\_templates/dashboards or recreate them.

REMARK: Make sure that an entity alias is added which references the device on which Thingsboard is ran. When adding new widgets on the dashboard follow the screenshot to correctly add the data source from which the widget needs to pull data.

REMARK: Make sure that the data aggregation function is set to None and the bar width to 640.





When all steps are followed, you’re ready to run the entire pipeline.

# HOW TO RUN

## CLIENT

To run the client, just run the modified adaptive mbsfn solution. It will automatically try to connect with the server’s socket. The port and address of the server can be changed in the network\_components/client.cc file.

Or to run the random generator, just run:

*“python3 src/client.py [--addressOfServer “insertstring”--portOfServer “insertint” --sleeptime “insertfloat”]”*

## SERVER

To run the ThingsViz server, just run the main.py script that can be found in the SERVERSIDE/ThingsViz/src directory.

*“python3 main.py [--argument1 “inserthere” --argument2 “inserthere” …] ”*

Arguments:

* Can either be set while calling the function in the terminal or the default value can be changed in the main.py file.
* Listing:
  + addressOfBroker: *String*, Default: ”localhost”, if running in cloud: “thingsboard.cloud”
  + portOfBroker: *Int*, Default: 1883, shouldn’t be changed
  + deviceAccessToken: *String,* copy and paste the access token of the Thingsboard

device that is running the server. (Can be found in the devices tab in Thingsboard)

* + topicGroup: *String*, Default: “ThingsViz/telemetry”, shouldn’t be changed, make sure that this is the same as the telemetry topic set in the Thingsboard device profile
  + addressOfServer: *String*, Default: “localhost”, make sure that the address of the server in the network\_components/client.cc file is set to the same address
  + portOfServer: *Int*, Default: 10000, make sure that the address of the server in the network\_components/client.cc file is set to the same address

## THINGSBOARD

After the installation procedures everything should be all set and the data should be visualized automatically, when the server is running.

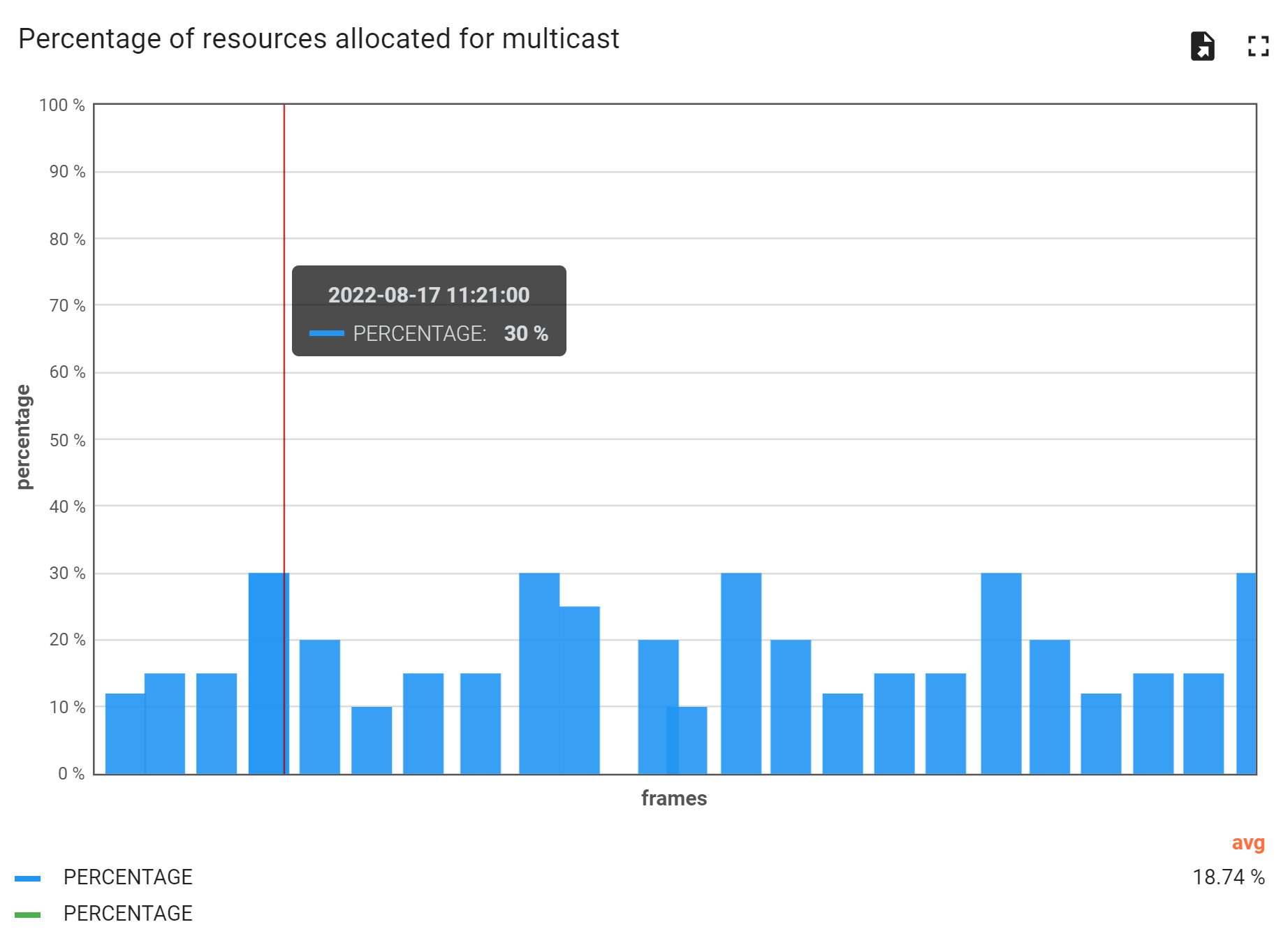
* Run in the cloud: Latencies can occur, a free-trial account has to be made
* Run locally: no latencies, no free-trial account required

Use **tenant@thingsboard.org** and password **tenant**

* Useful links:
  + <https://thingsboard.io/docs/guides/>
  + <https://thingsboard.io/docs/getting-started-guides/helloworld/>

# KNOWN ISSUES

When running in the cloud, Thingsboard uses as default the arrival time of the messages to plot them on a timeseries chart. This is because by default, MQTT doesn’t include a timestamp in the header. The result is that when the network introduces some irregular latencies on the message deliveries, some bars on the bardiagram will overlap. See screenshot.



This issue is common for data visualizing tools and is also documented in the Thingsboard documentation. However this issue can in theory be easily solved by adding a timestamp into the payload of the MQTT messages when sending them. See screenshot.Afbeelding met tekst

Automatisch gegenereerde beschrijving

Thingsboard should then take this timestamp as reference timestamp. As a result the spacing of the bars will now be constant and they will never overlap because the messages are send at a constant rate. The ThingsViz tool hasn’t implemented this solution due to time shortage an practical unresolved issues.