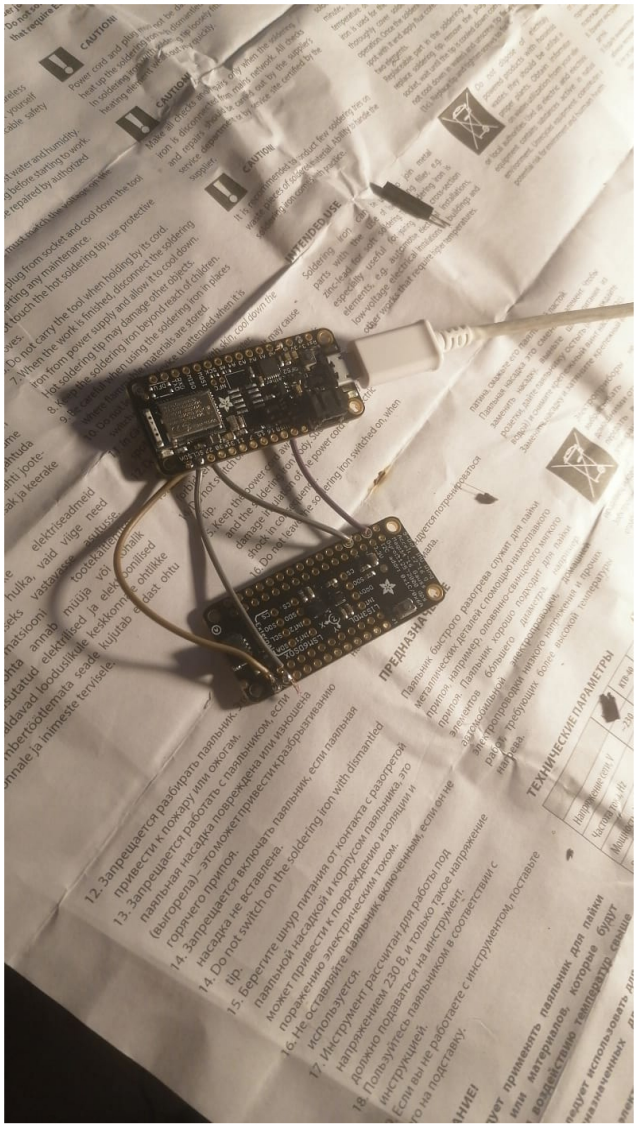
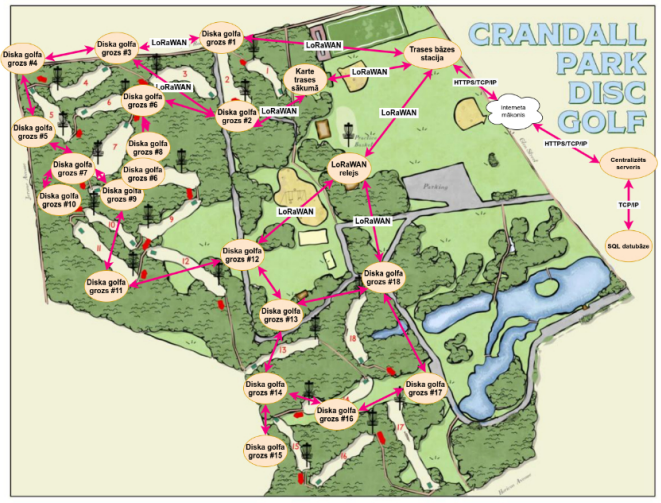
IoT disku golfs

Disku golfa grozs

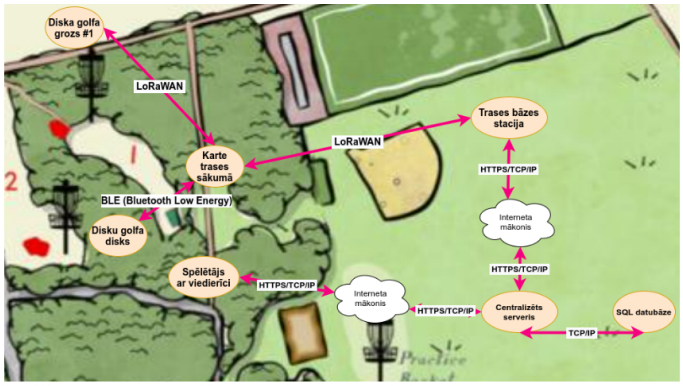
Disku golfa disks



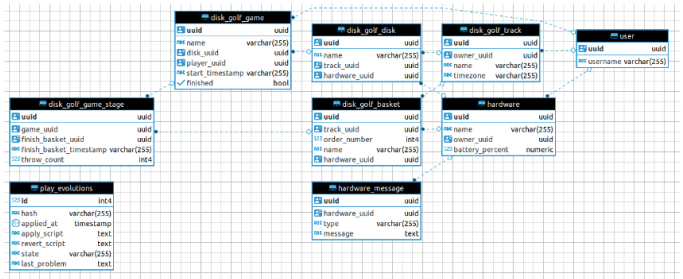
Trase



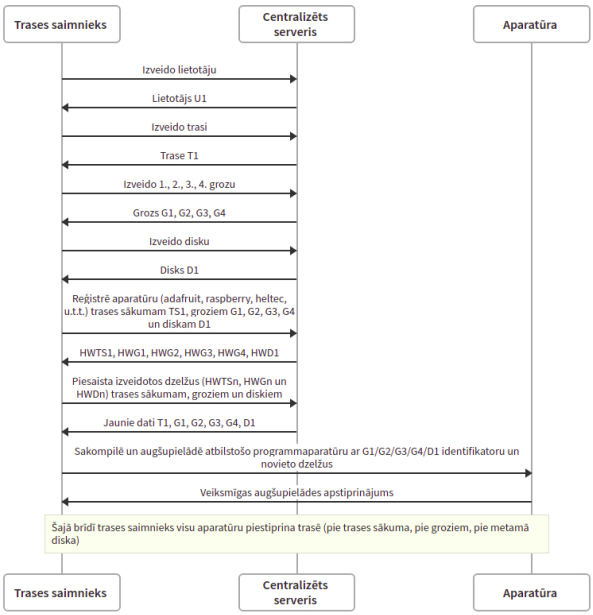
Trases sākums



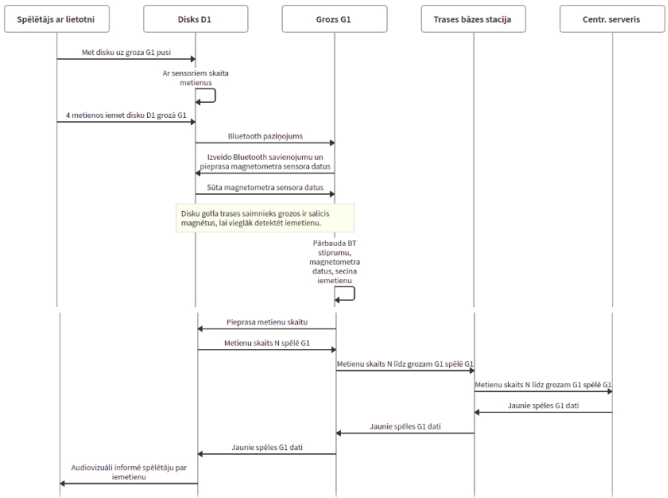
Relāciju shēma



Trases izveidošana



Trases izspēlēšana



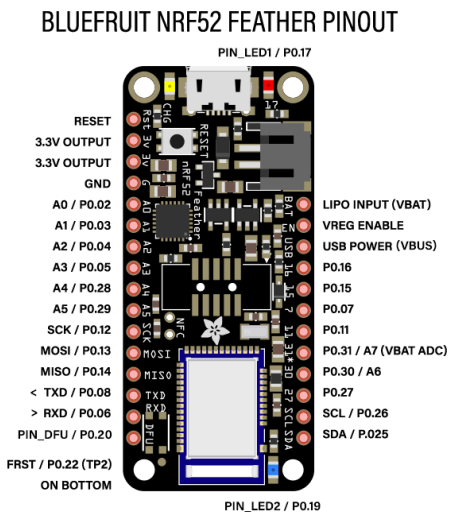
Aparatūra, inventārs

Kas ir fiziski nepieciešams, lai izstrādātu šādu projektu

Inventārs

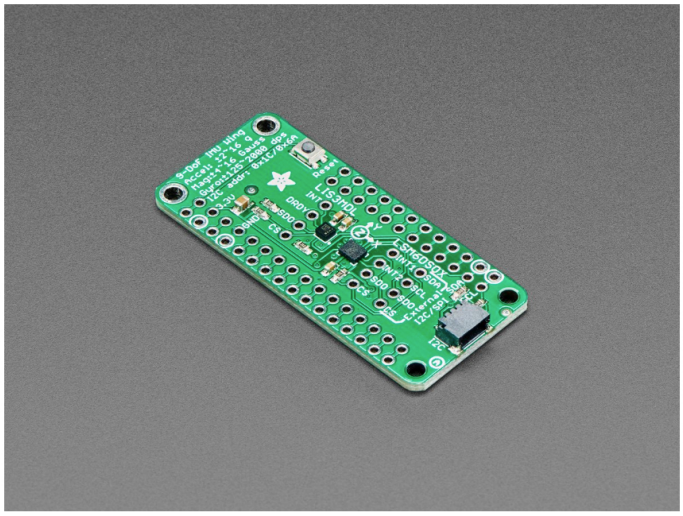
- Disku golfa trase
- Disku golfa trases posmu sākuma kartes
- Disku golfa trases posmu grozi
- Disku golfa trases kase jeb bāze ar interneta pieslēgumu
- Disku golfa diski

Aparatūra



Diska mikrokontrolieris: Adafruit nRF52

- Arduino ietvara atbalsts
- Bluetooth Low Energy atbalsts
- Izejošs 3.3V izvads ārēju ierīču barošanai (sensoram)
- Ieejošs 4.5V - 5.2V LiPo akumulatora ievads mikrokontroliera barošanai
- USB ligzda izstrādei un barošanai
- I2C protokola atbalsts (piem. sensora komunikācijai)
- SPI protokola atbalsts (piem. raidītāja komunikācijai)
- Analogās ievadligzdas (neizmantotas)
- PWM izvadligzdas (neizmantotas)
- NFC atbalsts (neizmantots)
- ZigBee atbalsts (neizmantots)
- Laika atbalsts (`millis()` funkcija mēra milisekundes kopš ieslēgšanās, "data type overflow" pēc ~50 dienām)

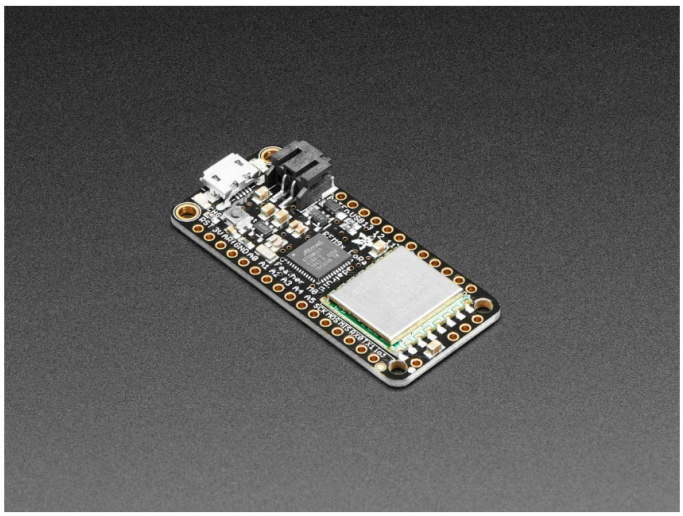


Diska sensori: Adafruit LSM6DSOX + LIS3MDL

- Ieejoša 3.3V ligzda sensoru barošanai
- I2C protokola atbalsts mikrokontroliera komunikācijai
- LIS3MDL magnetometrs (mēra magnētismu, var lietot debespusu noteikšanai)
- LSM6DS akselerometrs (mēra paātrinājumu)
- LSM6DS žiroskops (mēra rotācijas ātrumu jeb leņķus laikā relatīvi atskaites sistēmai)
- LSM6DS temperatūras sensors

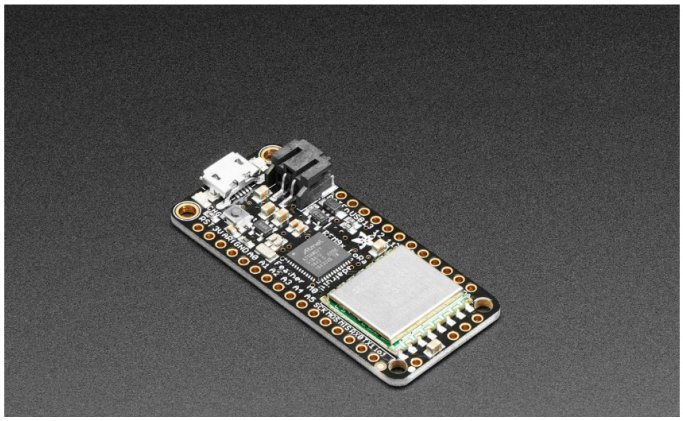
Proof of concept groza mikrokontrolieris: Raspberry Pi 4B

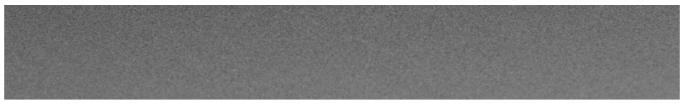
- Bluetooth atbalsts (komunikācijai ar disku)
- Wi-Fi atbalsts (pārnēsājamā tīklāja savienojumam komunikācijai ar centrālo serveri)
- Linux OS atbalsts (proof-of-concept ātrai prototipēšanai ar NodeJS vai Python, u.c.)



Produkcijas LoRaWAN groza un releja raidītājs: Adafruit nRF52 + RFM95

- Adafruit RFM95 jeb LoRaWAN raidītājs ir savietojams ar Adafruit nRF52 mikrokontrolieri
- Adafruit RFM95 ir SPI protokola atbalsts mikrokontroliera komunikācijai
- Adafruit RFM95 ir LoRaWAN atbalsts (grozu, releju, bāzes stacijas savienojumiem komunikācijai ar centrālo serveri)
- Adafruit nRF52 ir atbalsts RadioHead bibliotēkai komunikācijai ar `RFM95` raidītāju
- Eksistē dokumentēts un atvērtā koda piemērs LoRaWAN režģtīkla (mesh network) izstrādei ar `RadioHead` bibliotēku
- `RadioHead` bibliotēkai ir eksitējoša dinamiska, atteikumnoturīga režģtīkla maršrutēšanas realizācija





Produkcijas LoRaWAN & TCP/IP bāzes stacija: Raspberry Pi + RFM95

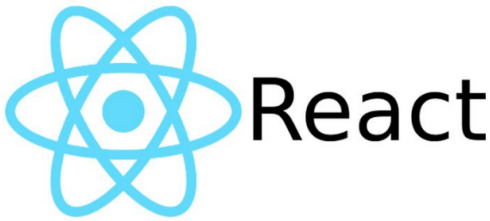
- Adafruit RFM95 jeb LoRaWAN raidītājs ir savietojams ar Raspberry Pi mikrokontrolieriem
- Raspberry Pi ir Ethernet un Wi-Fi atbalsts savienojumam ar bāzes stacijas interneta maršrutētāju komunikācijai ar centrālo serveri
- Raspberry Pi ir atbalsts RadioHead bibliotēkai komunikācijai ar `RFM95` raidītāju
- Eksistē dokumentēts un atvērtā koda piemērs LoRaWAN režģtīkla (mesh network) izstrādei ar `RadioHead` bibliotēku
- `RadioHead` bibliotēkai ir eksitējoša dinamiska, atteikumnoturīga režģtīkla maršrutēšanas realizācija

Centrālais serveris: Scala + Play + Akka

- HTTP REST API datu apmaiņai ar groziem (caur bāzes staciju) un lietotājiem
- SQL datubāzes savienojums datu persistencei
- WebSocket datu straumēšanai
- Akka ActorSystem (Cluster) notikumu/ziņojumu datu apmaiņai

Datubāze: PostgreSQL

- Nodrošina datu persistenci 😃



Lietotne: React

- Nodrošina interaktīvas lietotnes izstrādi

Programmatūra

Neskaitot iepriekšminētās tehnoloģijas, izstrāde ir veicama ar:

- PlatformIO (Arduino un citu iegulto programmaparatūras izstrādei)
- IntelliJ IDEA (Scala izstrādei)
- Visual Studio Code (C/C++/TypeScript izstrādei, PlatformIO integrācijai)
- Jupyter Notebooks (Sensoru datu apstrādei prototipēšanai)
- DBeaver (Datubāzes pārvaldībai un pārskatam)

Demo izpētes nolūkiem

Centrālais serveris

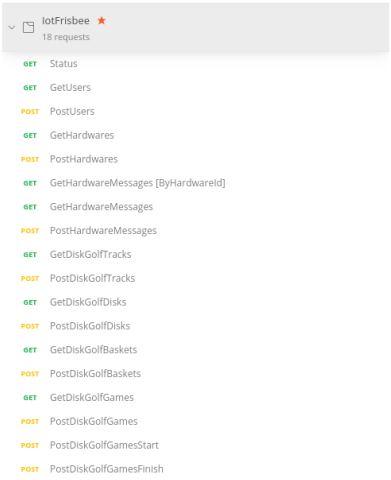
Ieslēdzam centralizēto serveri

```
$ git rev-parse --show-prefix
backend/
$ sbt web/run
[info] welcome to sbt 1.5.0 (AdoptOpenJDK Java 11.0.11)
[info] loading global plugins from /home/kshaa/.sbt/1.0/plugins
[info] loading settings for project backend-build from plugins.sbt ...
[info] loading project definition from /home/kshaa/Code/iot-frisbee/backend/project
[info] loading settings for project root from build.sbt ...
[info] set current project to root (in build file:/home/kshaa/Code/iot-frisbee/backend/)

--- (Running the application, auto-reloading is enabled) ---

[info] p.c.s.AkkaHttpServer - Listening for HTTP on /0:0:0:0:0:0:0:0:9000

(Server started, use Enter to stop and go back to the console...)
```

Testējam pāris interesantus pieprasījumus

```
$ # Izveidojam lietotāju centralizētajā serverī
$ curl --location --request POST 'http://localhost:9000/api/v1/users/' \
```

```
    --header 'Content-Type: application/json' \
    --data-raw '{ "username": "krisjanisv" }'
{
  "success" : {
    "id" : "57c69997-e19b-4e11-9901-946ed72b1026",
    "username" : "krisjanisv"
  }
}
$ # Reģistrējam aparatūru centralizētajā serverī
$ curl --location --request POST 'http://localhost:9000/api/v1/hardwares/' \
    --header 'Content-Type: application/json' \
    --data-raw '{ "name": "raspberry-pi-4b-nr-1", "ownerId": "57c69997-e19b-4e11-9901-946ed72b1026" }'
{
  "success" : {
    "id" : "b0909d2b-e8c7-44c2-bf94-4d60c24fb18c",
    "name" : "raspberry-pi-4b-nr-1",
    "batteryPercent" : 0.0,
    "ownerId" : "57c69997-e19b-4e11-9901-946ed72b1026"
  }
}
$ # Pārbaudam, ka protam bash uzrakstīt divas komandas tā, ka viena izpildīsies fonā pēc 5 sekundēm
$ sleep 5s && echo "second" & echo "first"
[1] 282791
first
[... paiet 5 sekundes]
[1]+  Done                    echo "first"
second
$ # Abonamējamies pie aparatūras iesūtītajām ziņām un pēc 5 sekundēm iesūtam aparatūras ziņu
$ sleep 5s && \
    curl -s --location --request POST 'http://localhost:9000/api/v1/hardware-messages/' \
    --header 'Content-Type: application/json' \
    --data-raw '{ "hardwareId": "b0909d2b-e8c7-44c2-bf94-4d60c24fb18c", "messageType": "test-debug-webs
    ws ws://localhost:9000/api/v1/hardwares/b0909d2b-e8c7-44c2-bf94-4d60c24fb18c/messages/subscribe
[1] 283588
[... Akka Play serveris inicializē abonamentu]
< subscribed
[... pēc 5 sekundēm tiek iesūtīta ziņa un mēs saņemam notifikāciju]
< {
  "id" : "97cab652-c647-446c-acd6-0318be994a77",
  "hardwareId" : "b0909d2b-e8c7-44c2-bf94-4d60c24fb18c",
  "messageType" : "test-debug-websocket",
  "message" : "foobar"
}
>
```



Mikrokontroliera serial, BLE komunikācija

```
$ sudo su # Jo bez root NodeJS bibliotēka nespēj piekļūt Bluetooth adapterim
$# git rev-parse --show-prefix
basket/
$# npx ts-node main.ts
Running IoT Basket
powered on, starting scanning
Started scanning
Device 'IoT Frisbee', RSSI: -55 (Very good), in basket = false
Stopped scanning
Device 'IoT Frisbee', RSSI: -54 (Very good), in basket = false
Device 'IoT Frisbee', RSSI: -55 (Very good), in basket = false
Device 'IoT Frisbee', RSSI: -54 (Very good), in basket = false
Device 'IoT Frisbee', RSSI: -54 (Very good), in basket = false
Device 'IoT Frisbee', RSSI: -49 (Excellent), in basket = true
Frisbee seems to have fallen in the basket, inspecting...
Frisbee UART connection found, extracting data
[...]
$ echo "bluetooth mic check" > /dev/ttyUSB0
[...]
Data:  bluetooth mic check
```

Sensora datu apstrāde

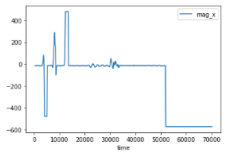
```
$ git rev-parse --show-prefix
frisbee/
$ pio run --target=upload
Processing adafruit_feather_nrf52832 (platform: nordicnrf52; board: adafruit_feather_nrf52832; framewor
[...]
RAM:   [=         ]  14.3% (used 9340 bytes from 65536 bytes)
Flash: [==        ]  15.9% (used 83512 bytes from 524288 bytes)
Building .pio/build/adafruit_feather_nrf52832/firmware.zip
[...]
Auto-detected: /dev/ttyUSB0
Uploading .pio/build/adafruit_feather_nrf52832/firmware.zip
Upgrading target on /dev/ttyUSB0 with DFU package /home/kshaa/Code/iot-frisbee/frisbee/.pio/build/adafr
########################################
########################################
########################################
########################################
####
Activating new firmware
Device programmed.
$ mkdir experiments
$ # 3 reizes pielikts magnēts
$ # 1 reizes pielikts klāt silts lodāmurs
$ pio device monitor -b 115200 | tee experiments/demo_1
--- Available filters and text transformations: colorize, debug, default, direct, hexlify, log2file, no
--- More details at http://bit.ly/pio-monitor-filters
```

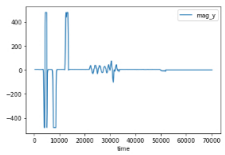
```
Initializing IoT-Frisbee with Adafruit nRF52832, LSM6DS, LIS3MDL!
Starting LSM6DS chip I2C connection
Started LSM6DS chip I2C connection
Starting LIS3MDL chip I2C connection
Started LIS3MDL chip I2C connection
Setting LSM6DS accelerometer range to: +-4G
Setting LSM6DS accelerometer data rate to: 12.5 Hz
Setting LSM6DS gyro range to: 250 degrees/s
Setting LSM6DS gyro data rate to: 12.5 Hz
Setting LSM6DS magnetometer range to: +-4 gauss
Setting LSM6DS magnetometer data rate to: 155 Hz
Setting LSM6DS magnetometer performance mode to: Medium
Setting LSM6DS magnetometer operation mode to: Continuous
Starting Bluefruit chip
Started Bluefruit chip
Starting Bluetooth device information service
Started Bluetooth device information service
Starting Bluetooth UART service
Started Bluetooth UART service
Starting Bluetooth battery level service
Started Bluetooth battery level service
Starting Bluetooth advertisement service
Started Bluetooth advertisement service
{ "time": 348, "acc_x": -0.5204, "acc_y": -0.1137, "acc_z": 9.8596, "gyro_x": -0.0006, "gyro_y": -0.019
{ "time": 470, "acc_x": -0.5109, "acc_y": -0.1149, "acc_z": 9.8584, "gyro_x": -0.0002, "gyro_y": -0.020
{ "time": 591, "acc_x": -0.4917, "acc_y": -0.1017, "acc_z": 9.8596, "gyro_x": -0.0014, "gyro_y": -0.018
[...]
$ cp experiments/demo_1  experiments/demo_1.json && vim experiments/demo_1.json
$ # Manuāla seriālo datu apstrāde, lai izveidotu korekti strukturizētu JSON failu
$ # 3 metieni
$ # 3 rotēts sensors
$ pio device monitor -b 115200 | tee experiments/demo_2
[...]
$ cp experiments/demo_2  experiments/demo_2.json && vim experiments/demo_2.json
$ # Manuāla seriālo datu apstrāde, lai izveidotu korekti strukturizētu JSON failu
$ jupyter-notebook
[I 02:41:23.172 NotebookApp] Serving notebooks from local directory: /home/kshaa/Code/iot-frisbee/frisb
[I 02:41:23.172 NotebookApp] Jupyter Notebook 6.2.0 is running at:
[...]
$ # Jupyter notebook izpētes skripta sarakstīšana
[...]
```

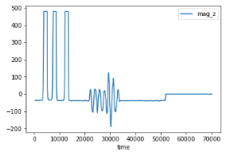
In [7]:
```
import pandas as pd

demo1 = pd.read_json("./demo_1.json")
df1 = pd.DataFrame(demo1)

demo2 = pd.read_json("./demo_2.json")
df2 = pd.DataFrame(demo2)
```

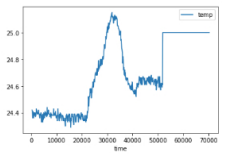
In [11]:
```
df1.plot(x='time', y='mag_x')
df1.plot(x='time', y='mag_y')
df1.plot(x='time', y='mag_z')
df1.plot(x='time', y='temp')
```

Out[11]: <AxesSubplot:xlabel='time'>



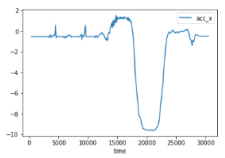


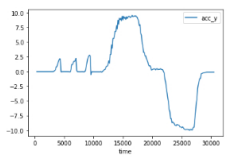


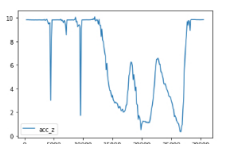


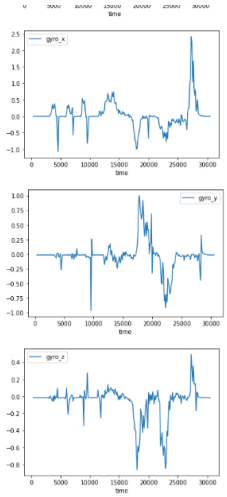
In [12]:
```
df2.plot(x='time', y='acc_x')
df2.plot(x='time', y='acc_y')
df2.plot(x='time', y='acc_z')
df2.plot(x='time', y='gyro_x')
df2.plot(x='time', y='gyro_y')
df2.plot(x='time', y='gyro_z')
```

Out[12]: <AxesSubplot:xlabel='time'>








time
gyro_x
gyro_y
gyro_z