Ground Station Network for the Telematics International Mission and UNISEC Prospects

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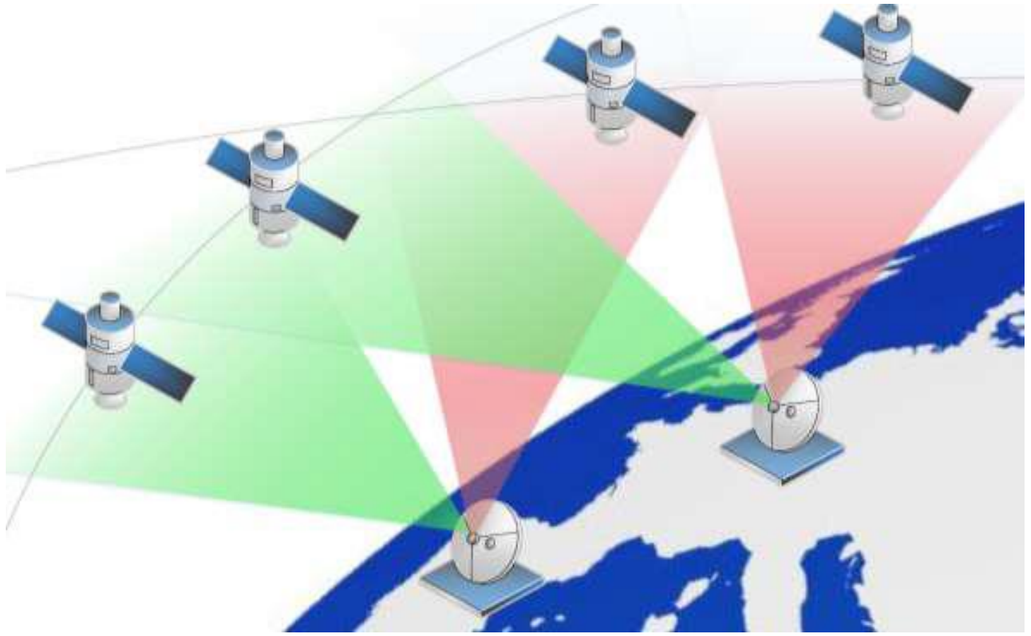
Ground Station Networks – State of the art

Problems and solutions

- **Idea of GS Networks:**
  - Increases overall contact time
  - Decrease time between contacts
  - Receive More Data faster
- **Several commercial & academic providers:**
  - Ground Segment as a Service (LeafLine, KSAT)
  - Ground Station Capacity Aggregators (Stellar Station)
  - Academic networks Collaboration of e.g. different universities (Japanese GSN, ISEB‘s GENSO, Uni Stanford‘s Mercury GSNW, SatNOGS)



Solutions

- Create central server, that only distributes requests, issues schedules and collects/provides received satellite data
- Individual control of Station remains in hands of operator (avoids legal problems)

TIM Ground Station Network

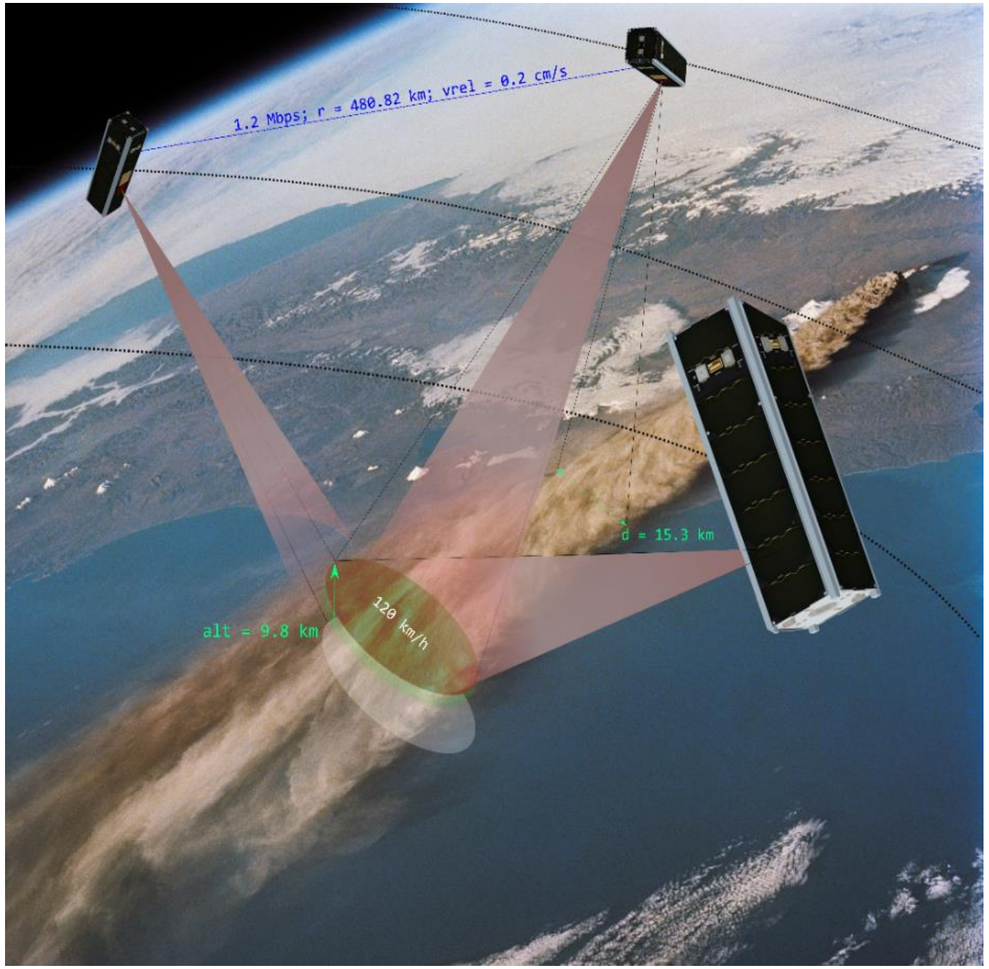
A common platform for scheduling, data management and data visualization

Telematic International Mission

International collaboration of different regions supported by the RLS

Mission aim: photogrammetric observation of ash-clouds in a small satellite constellation / formations

Representatives of RLS partner regions



Stereoscopic earth observation in TIM

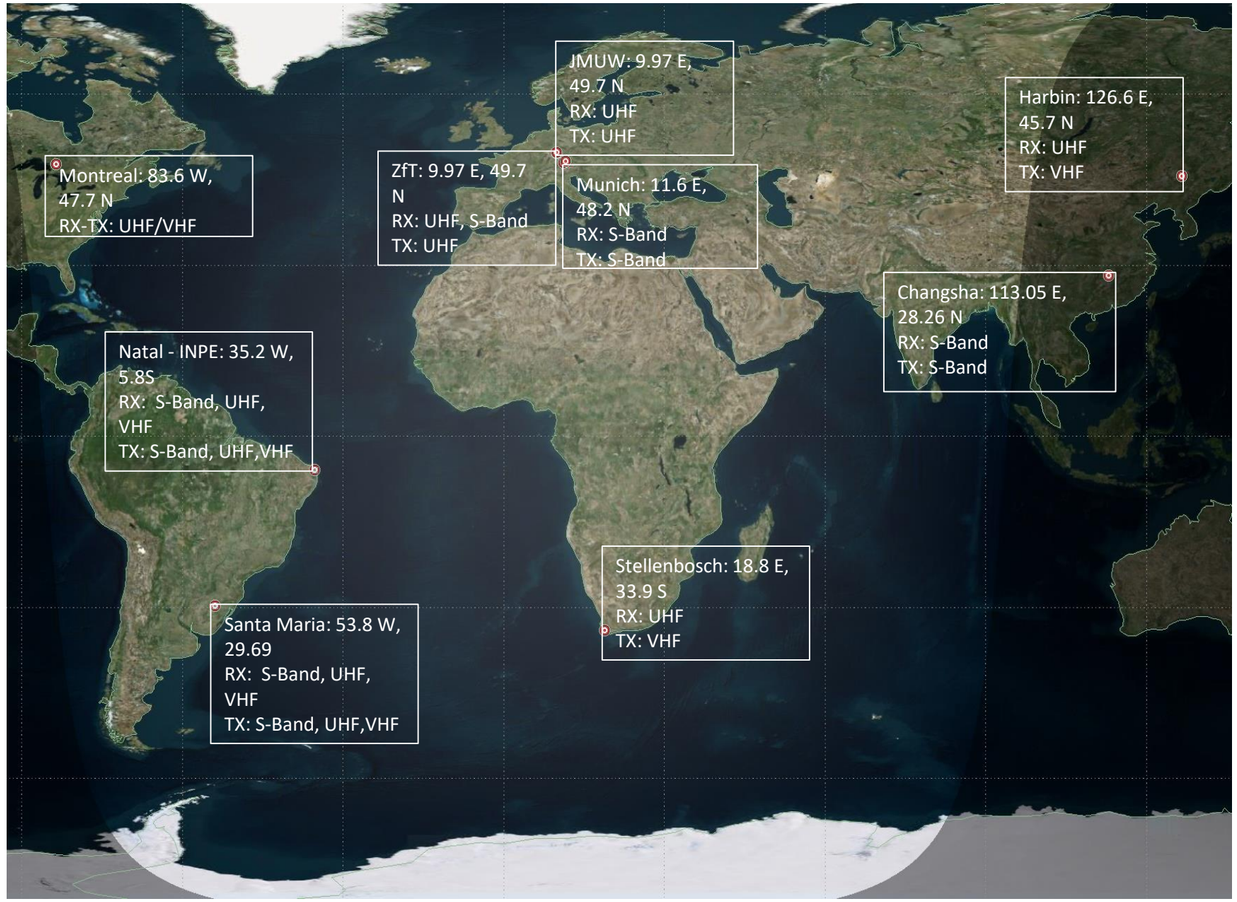
TIM Ground Station Network

A common platform for scheduling, data management and data visualization

Joint Mission of several partners worldwide

- Formation/constellation flight of several satellites
- Support with a network of partner ground station

- Effectively task & control satellites
- Scheduling concepts for optimising contact times
- Server for data exchange

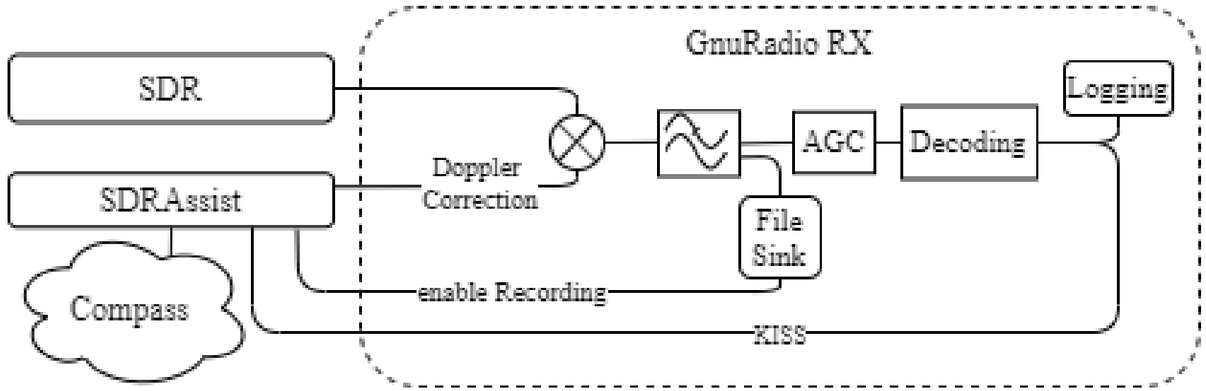


Location and frequency bands of ground stations in TIMGSN

Ground stations in Würzburg

Hardware and software set up

- Two ground stations used simultaneously, one located at JMUW and ZfT
- Both ground stations feature very simple hardware architecture, mainly composed COTS
- Connected by ground segment portion of the Compass Network
- GnuRadio for signal processing + custom blocks to inject required meta and control information to the flowgraph, e.g. the Doppler shift on the centre frequency

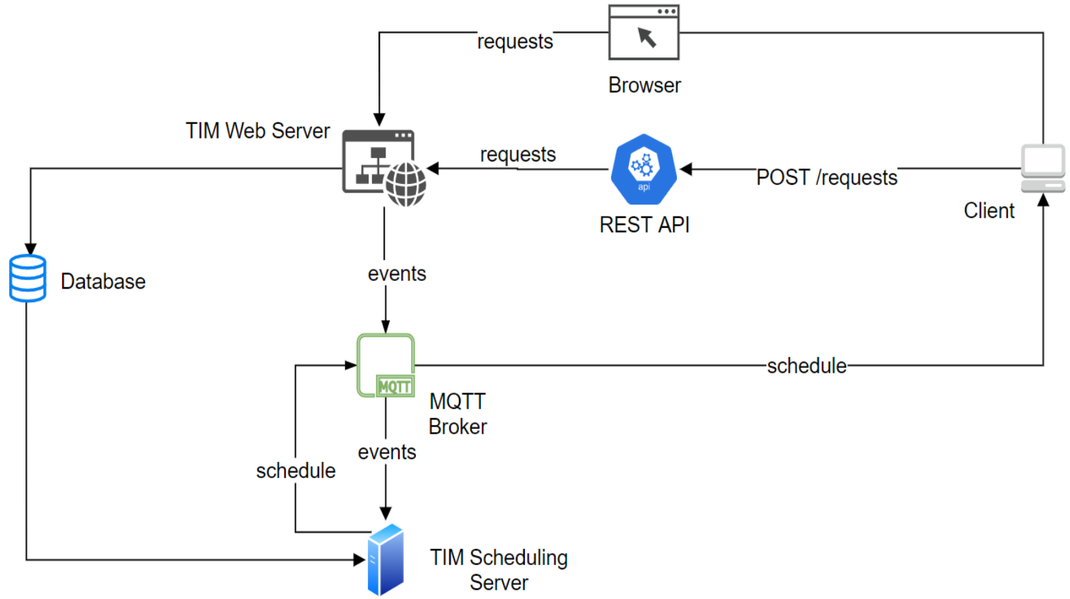


TIM Ground Station Network

A common platform for scheduling, data management and data visualization

TIMGSN operation

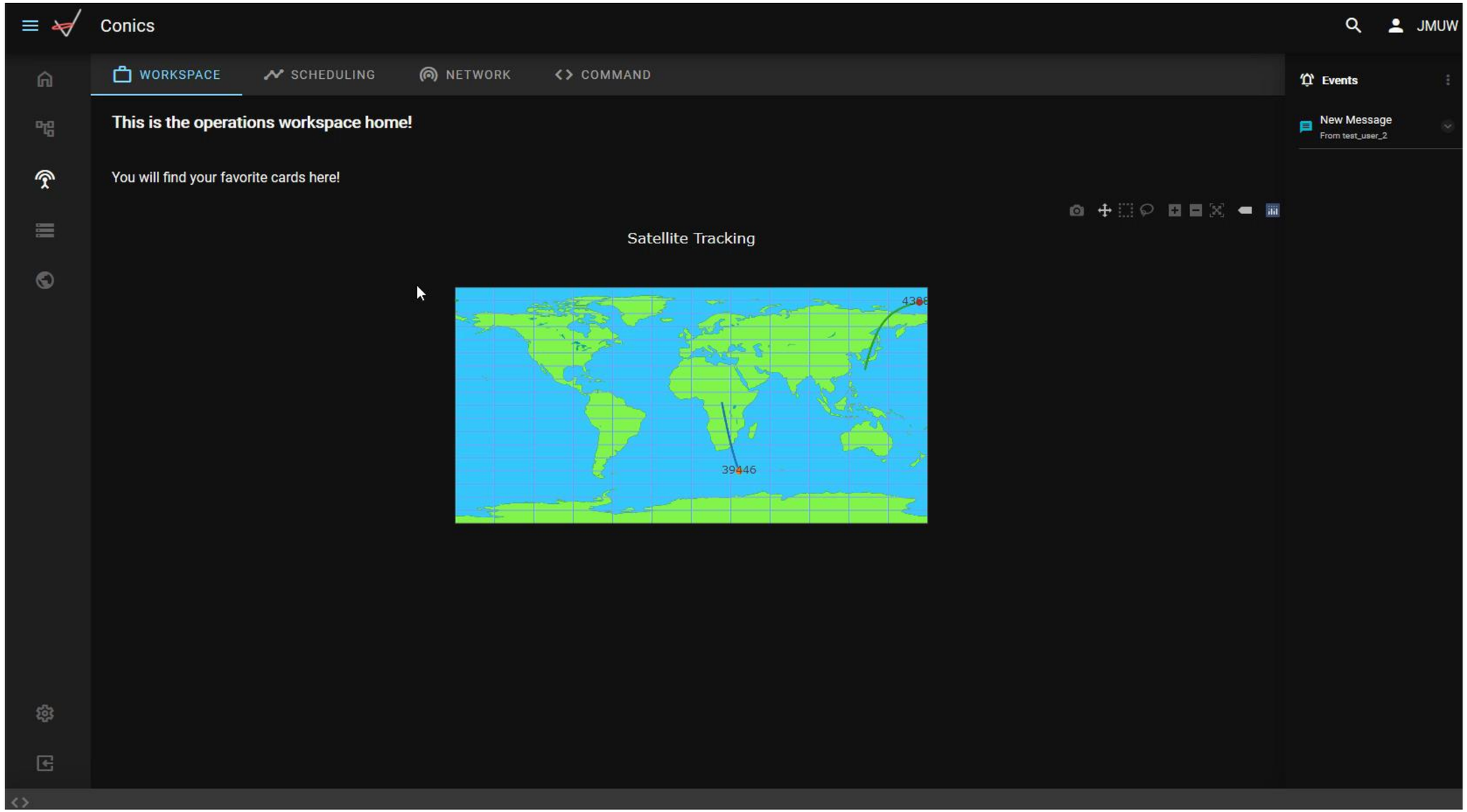
- All partner ground stations track and receive all TIM satellites based on joint tracking schedule (optimal scheduling)
- Tracking Schedule is computed by the *TIM Scheduling Server*
- Tracking & Decoding done locally. Each partner responsible for own station
- Commanding of satellite only over home station
- Web Server allows manual operation, facilitates administration and data management. Users can upload and download packets through the web application
- REST API provides automated operation interface to client
- MQTT Broker manages notifications, e.g., publishing schedules



Components of TIM Ground Station Network (TIMGSN)

GSN Features

Features of the TIM GSN: Operations and Data management



GSN Features

Features of the TIM GSN: Automation

```
        URL = 'https://timgsn.informatik.uni-
wuerzburg.de/api/ops/overpasses‘
         norad = 39446
        station_name = 'siset_uvhf'
        start_time = datetime.datetime.now()
        end_time = start_time + datetime.timedelta
(days=7)
        start_time_str = start_time.strftime("%Y-
%m-%d %H:%M:%S")
        end_time_str = end_time.strftime("%Y-%m-
%d %H:%M:%S")
        data = {
            'norad': norad,
            'station_name': station_name,
            'start_time': start_time_str,
            'end_time': end_time_str
        }
        response = requests.get(url=URL, auth=TEST
_USER_CREDENTIALS, data=data)
```

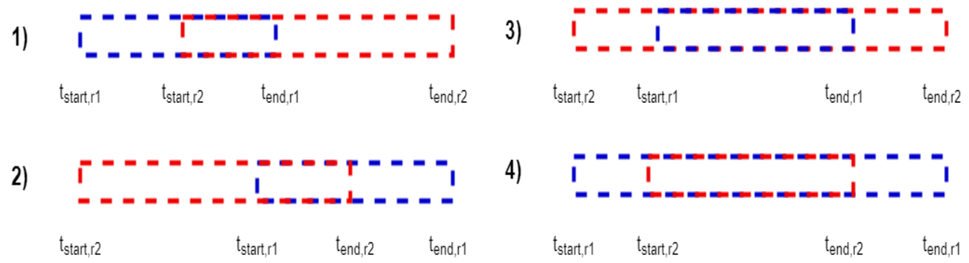
- Operators can use programming language of their choice
- To make a tracking request, operators have to find the overpasses for the satellite and station they want to use
- Satellite is depicted by its NORAD ID and stations have unique names on the network
- Given a start and end time, operators can fetch all the overpasses and their status by making a GET request to the TIMGSN OVERPASS API
- Thereafter a suitable overpass can be selected, and the operator can request it by making another request to the TIMGSN REQUEST API
- The server makes several checks and returns a success or failure message
- Similar process applies to other operations. The details are shared with the participants.

Any-time Scheduling

Scheduling in TIMGSN

Scheduling Problem:

- Characterization as a multi-objective fixed interval scheduling problem
- Final schedule is an optimal subset of requested overpasses, that can be scheduled conflict free
- Conflicts are not avoidable→ not all overpasses can be scheduled



Possible conflicts between requested overpasses r1 and r2

Scheduling Objectives:

- Weighted sum of multiple objectives $\mathrm{F}(s) = \sum w_i * F_i(s)$
- Maximization of contact time (Requested vs. Scheduled Time) ← contact time = available data
- Fair use of all resources using Jain's Fairness Index $J(x) = \frac{(\sum x_i)^2}{n * \sum x_i^2}$ ← all participants should profit equally
- Equal distribution of requested and scheduled contacts

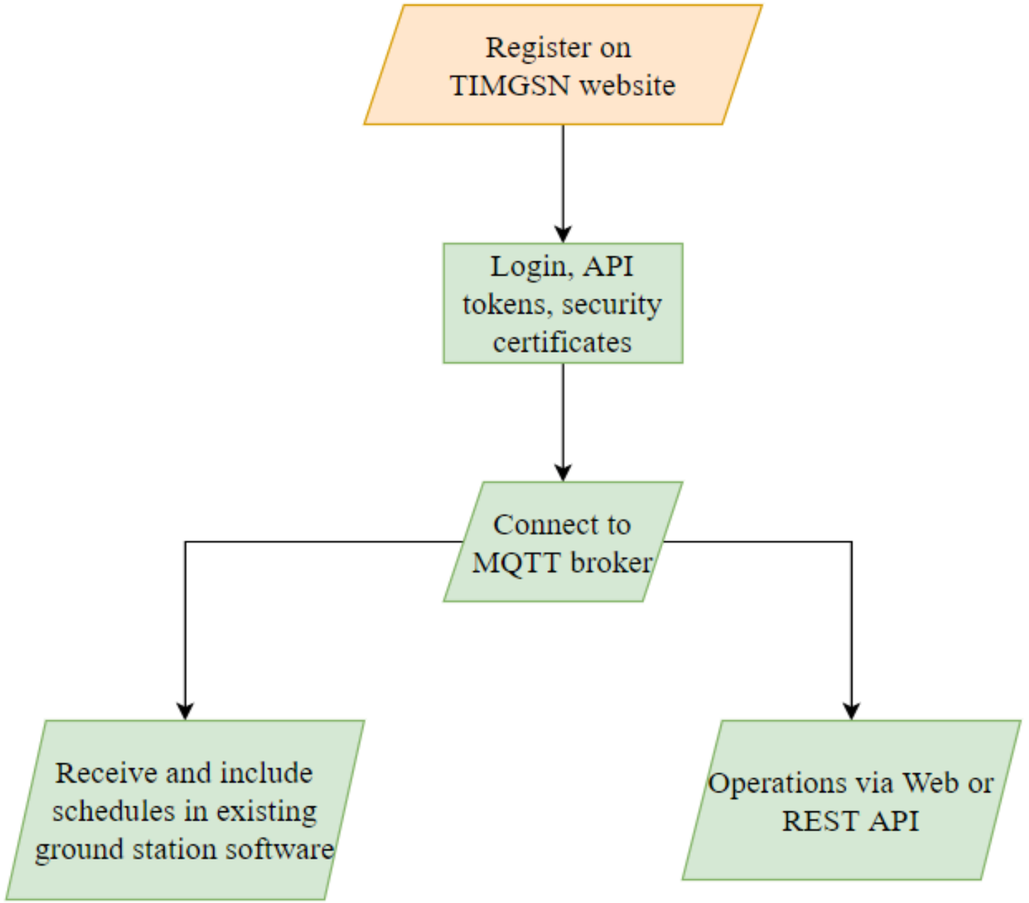
Scheduling algorithms:

- Different scenarios require different Scheduling algorithms
- Dynamic Scheduling for quick updates (GS Failure/ emergency), static scheduling for optimal contact time and long-term planning

Integrating with TIMGSN

Easy integration

- MQTT broker is secured by private key and certificates
- API requires authentication tokens
- Schedules are published over MQTT
- Operators can also request schedule using REST API
- Operators have to implement simple MQTT publish/subscribe and HTTP methods to perform automated operations



UNISEC collaboration

Collaboration

Requirements for GS Hardware

- Station should perform autonomously 24/7
- UHF spectrum (430-440 MHz) must be covered
- S-/X Band spectrum
- Ax.25 Support
- Tracking information based on
  - up to date TLEs
  - central Schedule issued by TIM-Server

Optional:

- Other protocols may be implemented and shared E.g. HDLC
- remote uplink : TBD

We want to try out this idea now. And need a lot of stations - the more the better

- if you are interested please get in touch with us at mohd.bilal@uni-wuerzburg.de
- experiment/test our proposal & make suggestions!

Thank you

Contact us at:
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Backup slides