Approaches for Efficient Global Ground Station Networks for Multiple Small Satellites

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Motivation

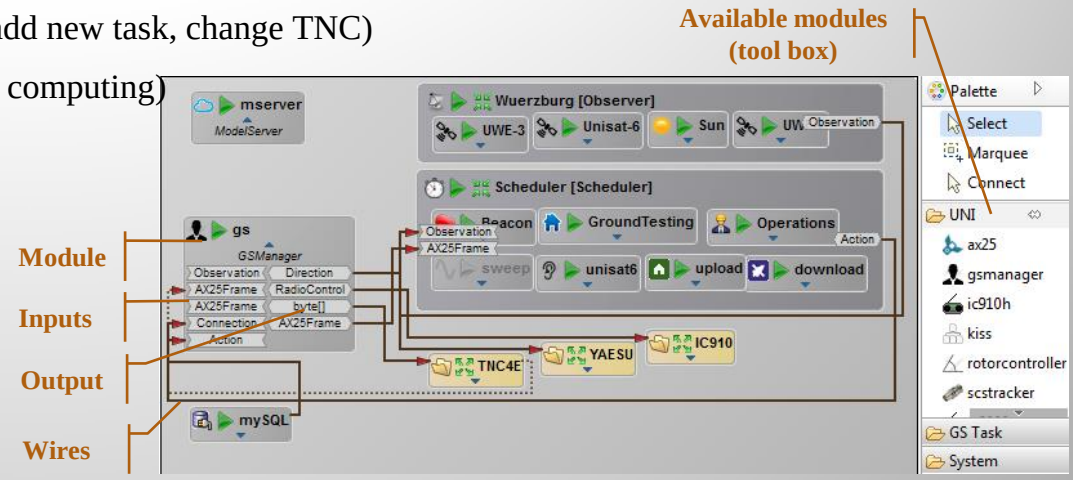
UWE-3 Launch im November 2013

- 7 to 8 communication windows per day
- Ground Station stays inactive nearly 95% of the day
- No housekeeping data available if the satellite is out of range
- Usually different software components are used for
  - TNC control (data transmission)
  - Transceiver control (Doppler correction)
  - Propagation
  - Remote Control of the GS

  => different interfaces
- *Requirement*: remotely usable single software solution for GS hardware control, propagation and automated operations

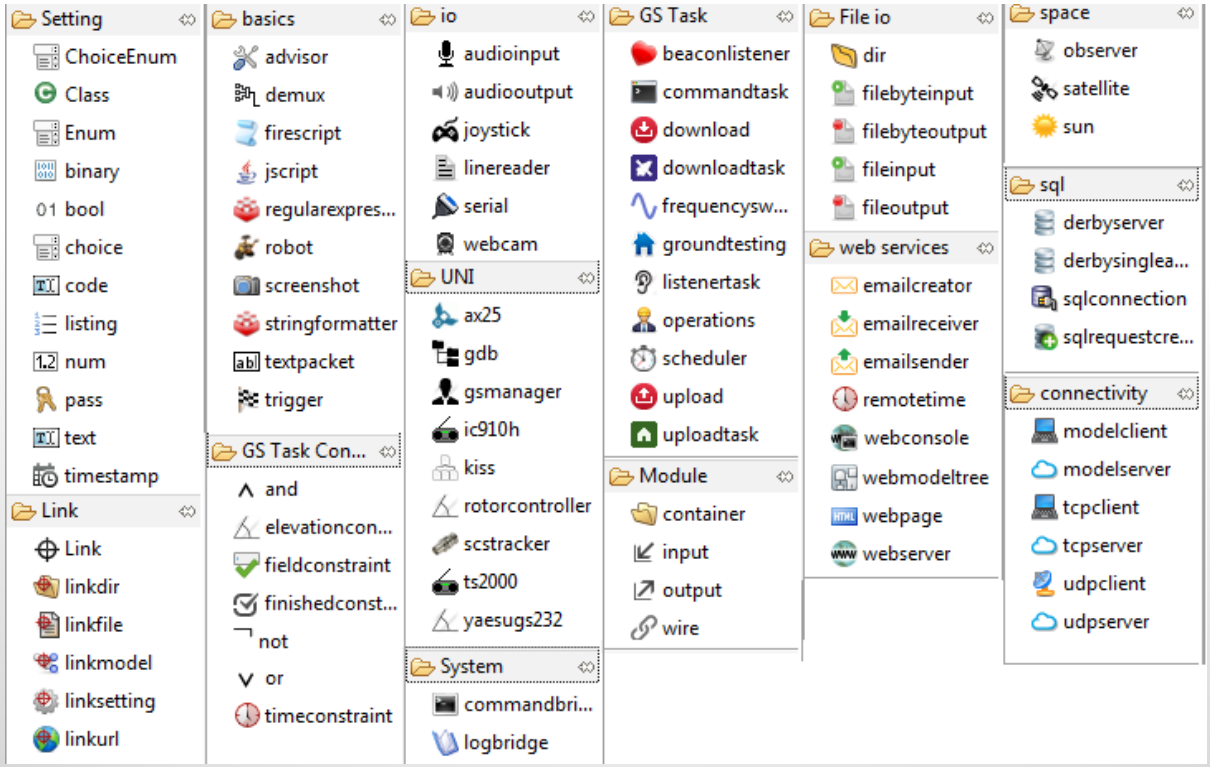
Approach

- An OS-independent java solution was elaborated
- All components are implemented as *modules* with connectable ports for live data flow modifications
  - Modules for TNC, Radio and Antenna control
  - Module for orbit propagation of required satellites
  - Operations Scheduler for auto-activation of tasks depending on the defined constraints (target satellite, time, elevation etc.)
  - Task Modules for down- and upload, remote command execution, experiments etc.
  - Web-Server module for simple access via browser
  - Simple interface allows fast implementation of new modules
- Multiple clients can be connected to modify the running software using a GUI in real time
  - Add, remove or modify modules via preferences (e.g. add new task, change TNC)
  - Interconnect multiple framework instances (distributed computing)
  - Inject packets into desired ports, listen to outputs
- GS Network precursor



Framework for Intuitive and Rapid Software Evolution (FIRE)

Toolbox


Setting
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linkmodel
linksetting
linkurl
basics
advisor
demux
firescript
jscript
regularexpres...
robot
screenshot
stringformatter
textpacket
trigger
GS Task Con...
and
elevationcon...
fieldconstraint
finishedconst...
not
or
timeconstraint
io
audioinput
audiooutput
joystick
linereader
serial
webcam
UNI
ax25
gdb
gsmanager
ic910h
kiss
rotorcontroller
scstracker
ts2000
yaesugs232
System
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logbridge
GS Task
beaconlistener
commandtask
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groundtesting
listenertask
operations
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upload
uploadtask
Module
container
input
output
wire
File io
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filebyteoutput
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web services
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emailreceiver
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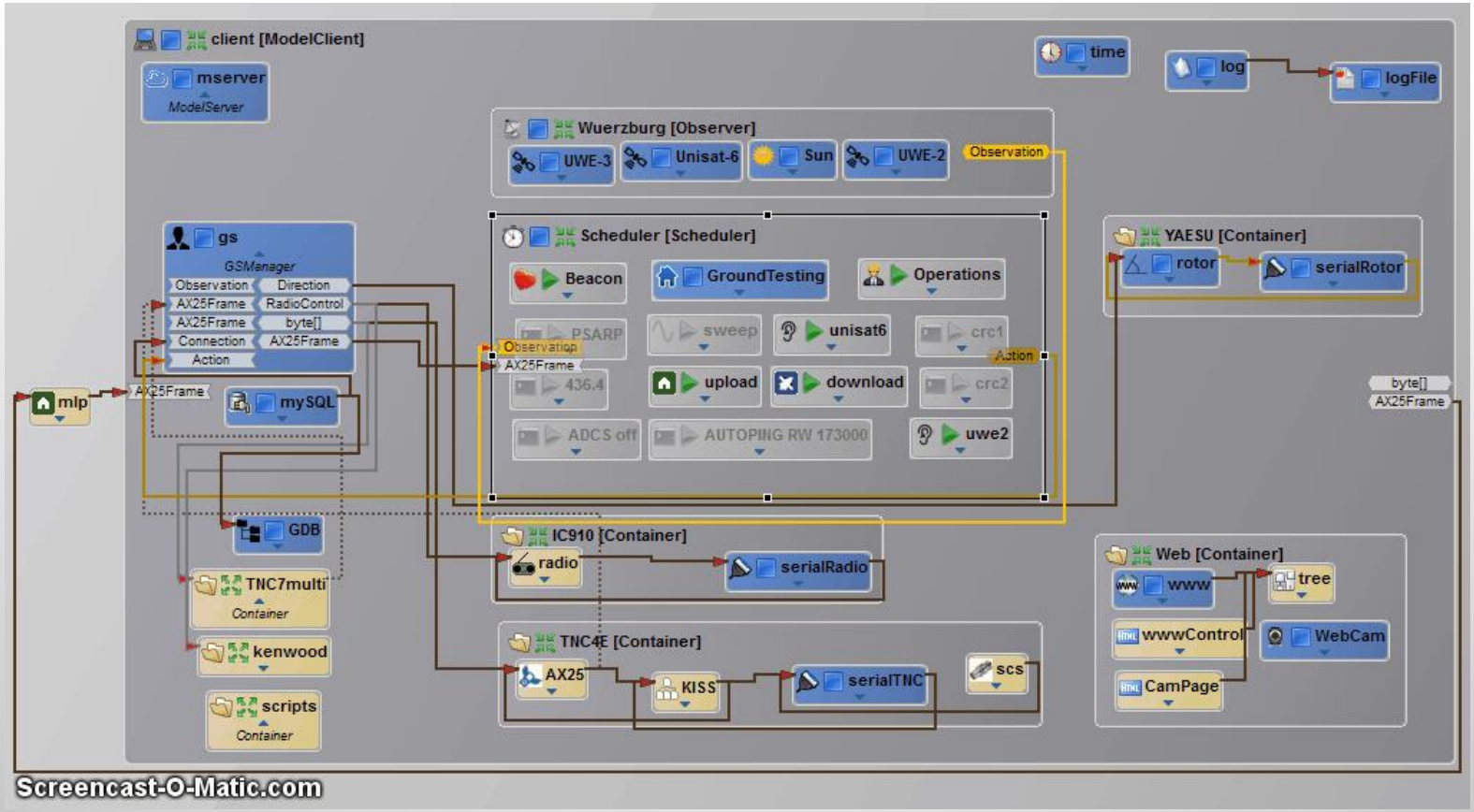
connectivity
modelclient
modelserver
tcpclient
tcpserver
udpclient
udpserver

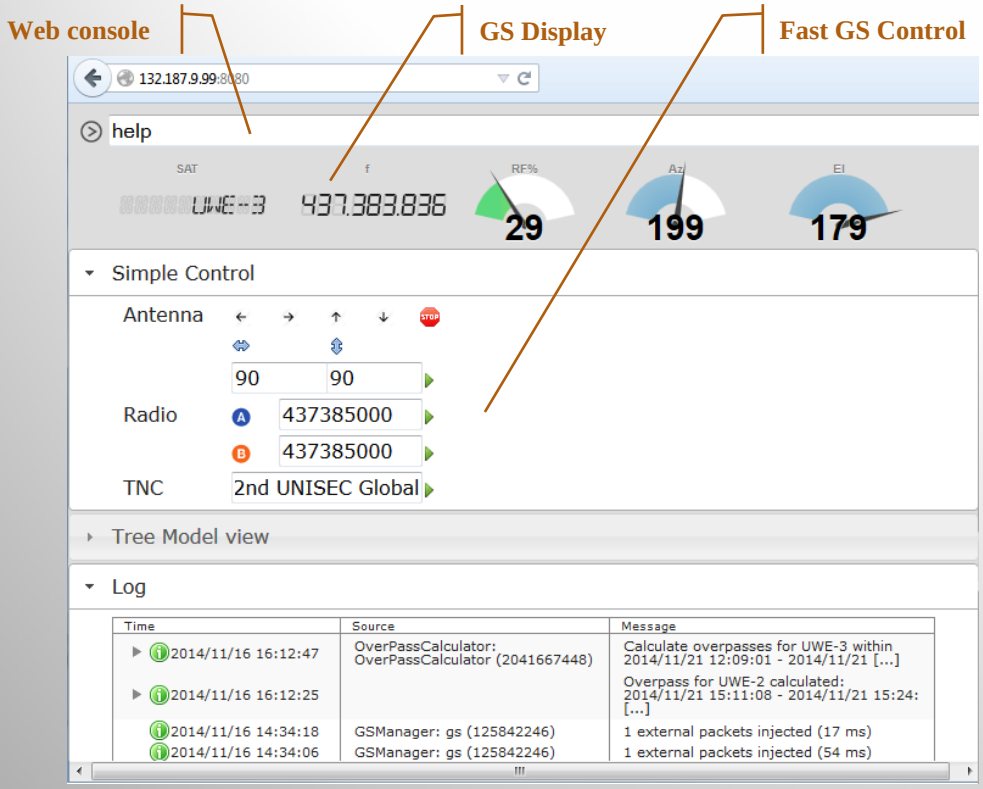
Approach

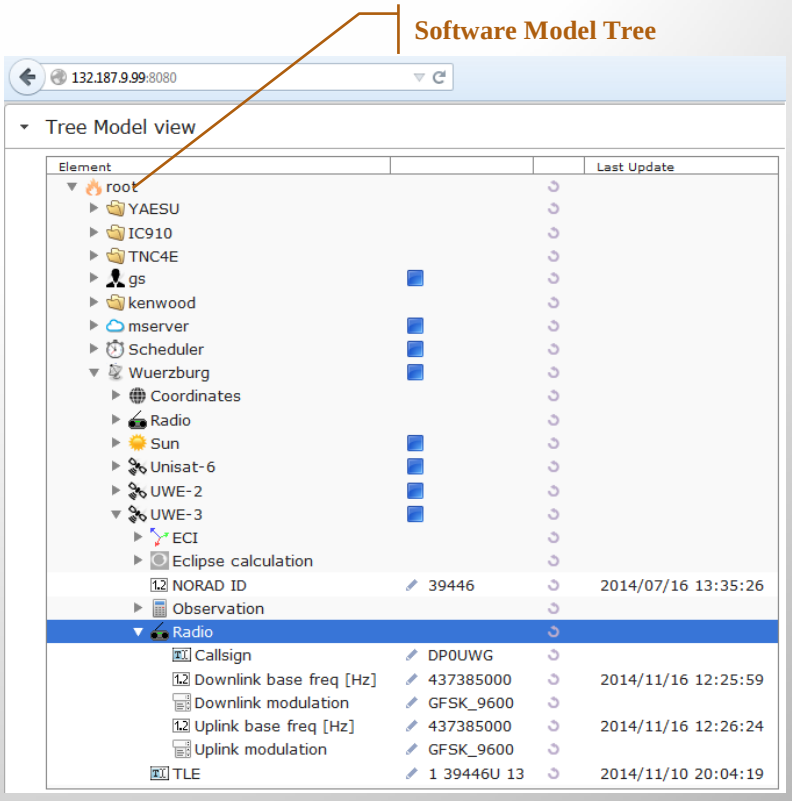
Dynamic data flow visualization



Web Interface

- The GS solution is independent of any external software and can be directly started
  - Many modules are already available
- The software is also fully accessible via the extensible web interface
  - All important values are displayed dynamically and can be set in real time
  - All modules and preferences can be accessed via the model tree
  - The interface can be made public in read-only mode

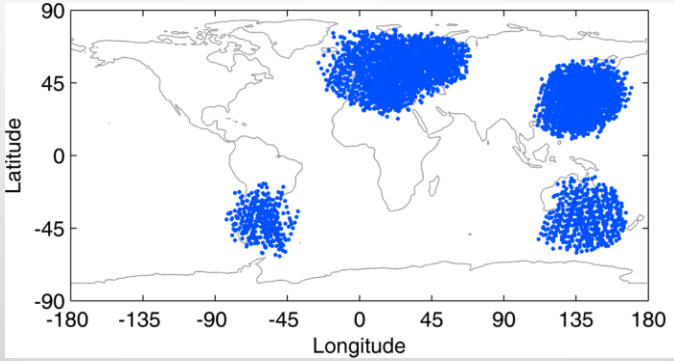




Groundstation Sharing

1st stage: downlink only

- Web server interface for external packet injection (e.g. by radio amateurs, other universities)
- Operators can build up the server within < 1 hour
- Each GS tracks multiple satellites and forwards received packets
- Successfully proven with radio amateurs and GAUSS team (Unisat 6)
- Downlink capabilities beyond the reach of UWE-3
- Almost 70.000 external UWE-3 packets were received (until 2014/11/16)
- Over 4.700 packets were forwarded to other universities



Received UWE-3 packets

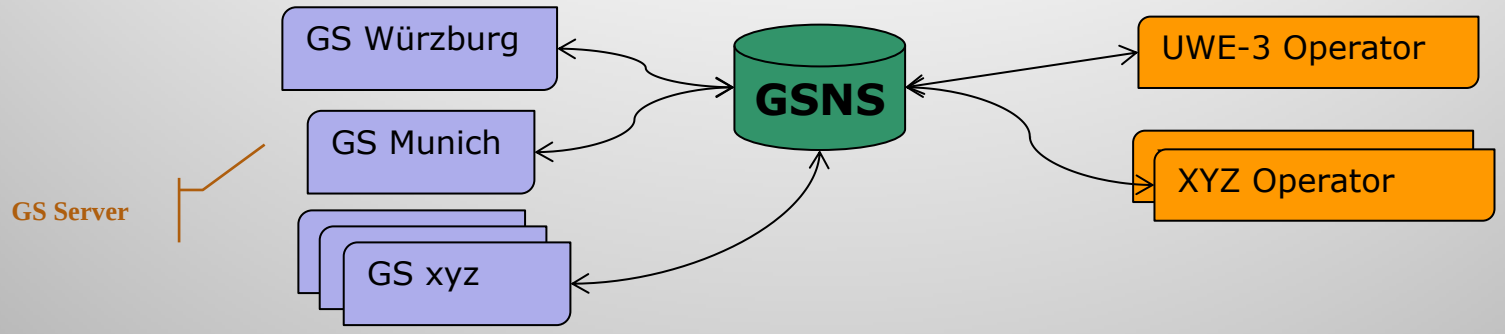
Groundstation Sharing

2nd stage: full access

- Using FIRE framework for GS handling and tracking/scheduling
- Remote ground stations can be used if currently not busy
- A field test is planned for December

In progress: Ground Station Network Server (GSN Server)

- Registering each GS instance on a central web server via web interface
- The server receives all required information and calculates free time slots
- GSN Server can be used as a logical ground station
  - The communication link is automatically forwarded to the appropriate GS
  - The higher the number of participants, the higher is the continuity of operations



Conclusion

- The Framework allows fast implementation of a GS software
- The toolbox gets permanently increased
- The Ground Station can be remotely handled via web interface
- The downlink-only GS sharing has been successfully tested and is still in use
- The full GS sharing will be tested in December
- The GSN Scheduler is in progress and will allow simple registration of new participants

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