Autonomous observations of VLBI radio telescopes

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Goal
Goal

Autonomous Observation

- Local prioritization and planning
- Fetching of session schedules
- Local preparation (drudg)
- Local adaption and recorder selection
  - Automatic startup
  - Observation status notification
  - Quality and alarm management
  - Post-processing
Goal

Autonomous Observation

- Local prioritization and planning
- Fetching of session schedules
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Interaction ➔ Feedback

Controlling ➔ Feedback
Goal

Autonomous Observation

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In a sense of a “Smart Observatory”
Goal

“Automating” the NASA Field System
“Automating” the NASA Field System
“Automating” the NASA Field System

Show current status to the user

Shared mem. specific, local GUI
“Automating” the NASA Field System

**BATCH-Mode**

*Timestamp*
Action =>
<=Reply

*Timestamp*
Action =>
<=Reply

*Timestamp*
Action =>
<=Reply

**Only when commanded**

Show current status to the user

Shared mem. specific, local GUI
“Automating” the NASA Field System

BATCH-Mode

**Timestamp**
Action =>
<=Reply

**Timestamp**
Action =>
<=Reply

**Only when commanded**

**Own programs**
Action =>
<=Reply

**Specific, not monitored**

**Show current status to the user**
Shared mem. specific, local GUI

**Write to shared mem.**

**Program (int. Timing)**
Action =>
<=Reply
“Automating” the NASA Field System

Legacy code

BATCH-Mode

**Timestamp**
- Action =>
  - <=Reply

**Timestamp**
- Action =>
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**Timestamp**
- Action =>
  - <=Reply

*Only when commanded*

**Own programs**
- Program (int. Timing)
  - Action =>
    - <=Reply

*Specific, not monitored*

Show current status to the user

Shared mem. specific, local GUI

Write to shared mem.
“Automating” the NASA Field System

Legacy code

Technique known from SW tests
“Automating” the NASA Field System

Legacy code

NASA Field System PC

Technique known from SW tests

NASA FS Output remotely accessible

e.g. Logs Errors …
“Automating” the NASA Field System

Legacy code

Legacy code

Technique known from SW tests

Legacy code

NASA Field System PC

Shared Memory

Operator

Operator Input (On-line) 
open

Operator Output (On-line) 
write

SNAP File Input

Log File Input

Log File Output

Display

Display

Error Msg. Expansion for Log Display (On-line) 
floor

Station

Station SNAP Commands (On-line) 
set

Station Error Reporting (On-line) 
step

Station SNAP Commands (On-line) 
step

Station Module Checking (On-line) 
check

Station Specific Components

Technique known from SW tests

Legacy code

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Legacy code

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NASA FS

Output remotely accesable

Poster P107

e.g.

Logs Errors …
“Automating” the NASA Field System

Legacy code

- Operator
  - Operator Input (On-line)
- External SNAP Injection (Off-line)
- Command Processing and Control (On-line)
- Quick Response U/LBA SNAP Commands (On-line)
- Station SNAP Commands (On-line)
- Station Error Reporting (On-line)
- Station Error Checking (On-line)
- Station Specific Components
- Station Module Checking (On-line)
- Station Specific Control (On-line)

- Log File Input
  - Log File Writing and Display (On-line)
- Log File Output
- Display

- Utility Programs (Off-line)
- Error Message Expansion for Log Display (On-line)

- Shared Memory

- Quick Response SPLA SNAP Commands (Off-line)
- Error Message Expansion for Log Display (On-line)
- Station Error Reporting (Off-line)

- Watch dog
- Controller task
- Com. tasks

- Poster P107

- NASA FS Output remotely accessible
  - e.g. Logs
  - Errors
  - e.g. Antenna Timing
  - Meteo
  - Mark6

- Monitoring-Bypass

- Technique known from SW tests

- Action => <= Reply

- Add. safety

- Field System Resource Allocation (Off-line)
- Field System Resources (Off-line)
- IEEE-488 Bus Control (On-line)
- IEEE-488 Hardware
- MCB Control (On-line)
- MCB Hardware
- MAT-bus Control (On-line)
- MAT-bus Hardware

- Write to shared mem.
"Automating" the NASA Field System

Legacy code

- Initialization and Termination (Off-line) / f
- External SNAP Injection (Off-line)
- Operator Input (Off-line) / open
- Command Processing and Control (On-line) / boot
- Quick Response SNAP Commands (On-line) / query
- Station SNAP Commands (On-line) / query
- Station Error Reporting (On-line) / stop
- Station Module Checking (On-line) / check
- Station Specific Components
- Field System Resource Allocation (Off-line) / flocate
- MCB Control (On-line) / monitor
- MCB Hardware

Technique known from SW tests

- Logs
- Errors
- …

Monitoring-Bypass

Write to shared mem.

Controller task

Com. tasks

Watch dog

Action => Reply

Human Safety is implemented in HW device

Poster P107

NASA FS Output remotely accessible

e.g. Antenna Timing Meteo Mark6

…
Goal

“Automating” the NASA Field System

Using the data from the monitored (NASA Field) System
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Using the data from the monitored (NASA Field) System

Pattern extraction

- e.g.
  - “941.9” is extracted from
  - “<!—ERC::PRESSURE--> 941.9<!-->”

- Monitoring-Bypass
- Additional Site Monitoring-Data
- ZABBIX Server
- Database
- UPS SNMP
- NASA FS Output remotely accessible
Using the data from the monitored (NASA Field) System

Pattern extraction
e.g. “941.9”
is extracted from “<!—ERC::PRESSURE--> 941.9<!-->”
Using the data from the monitored (NASA Field) System

Global Network Status

NASA FS Screen

ZABBIX Server

NASA FS Output remotely accessible

Pattern extraction e.g. “941.9” is extracted from “<!—ERC::PRESSURE--> 941.9<!-- -->”

Monitoring-Bypass

Additional Site Monitoring-Data

UPS SNMP

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730884 - JUMPING JIVE
Using the data from the monitored (NASA Field) System

Global Network Status

NASA FS Screen

ZABBIX Server

NASA FS Output remotely accessible

Pattern extraction

e.g.

“941.9”
is extracted from

“<!—ERC::PRESSURE--> 941.9<!-- -->”

Monitoring-Bypass

Additional Site Monitoring-Data

UPS SNMP

Database

Mark6 Screen

Air conditioning Screen

Poster P106

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Goal

“Automating” the NASA Field System

Using the data from the monitored (NASA Field) System

Towards a data archive for seamless auxiliary data
Towards a data archive for seamless auxiliary data
Towards a data archive for seamless auxiliary data

Data Archive for Seamless Auxiliary Data

Global Network Status

Temperature
Pressure
Humidity

Extraction
Python Script

<table>
<thead>
<tr>
<th>ITEM</th>
<th>CLOCK</th>
<th>DATETIME (UTC)</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>26733</td>
<td>1551996101</td>
<td>2019-03-07 22:01:41</td>
<td>5.800</td>
</tr>
<tr>
<td>26733</td>
<td>1551995801</td>
<td>2019-03-07 21:56:41</td>
<td>6.100</td>
</tr>
<tr>
<td>26733</td>
<td>1551995501</td>
<td>2019-03-07 21:51:41</td>
<td>5.900</td>
</tr>
<tr>
<td>26733</td>
<td>1551995201</td>
<td>2019-03-07 21:46:41</td>
<td>5.700</td>
</tr>
<tr>
<td>26733</td>
<td>1551994902</td>
<td>2019-03-07 21:41:42</td>
<td>5.700</td>
</tr>
<tr>
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<td>1551994602</td>
<td>2019-03-07 21:36:42</td>
<td>5.800</td>
</tr>
<tr>
<td>26733</td>
<td>1551994301</td>
<td>2019-03-07 21:31:41</td>
<td>5.600</td>
</tr>
<tr>
<td>26733</td>
<td>1551994002</td>
<td>2019-03-07 21:26:42</td>
<td>5.600</td>
</tr>
<tr>
<td>26733</td>
<td>1551993700</td>
<td>2019-03-07 21:21:40</td>
<td>5.500</td>
</tr>
<tr>
<td>26733</td>
<td>1551993401</td>
<td>2019-03-07 21:16:41</td>
<td>5.500</td>
</tr>
</tbody>
</table>
Towards a data archive for seamless auxiliary data

**Data Archive for Seamless Auxiliary Data**

**Global Network Status**

- **Temperature**
- **Pressure**
- **Humidity**

**Extraction**

**Python Script**

**IVS Task Force**

A first technical solution for continuous data acquisition is now available. Now is the time to start a discussion about:

- which parameters are required by analysis
- which time intervals are required
- which format is required in best case
- which stations can and will participate
- which station log books with meta-data are useful
- ...

Interested? Join!
Goal

“Automating” the NASA Field System

Using the data from the monitored (NASA Field) System

Towards a data achieve for seamless auxiliary data

Benefit: Central alerting at the guard of the Wettzell observatory
Benefit: Central alerting at the guard of the Wettzell observatory

Idea of an autonomous safety, but with human control, and on-call service.

Improving the visibility of error situations while reducing the complexity of error feedbacks.
Benefit: Central alerting - Real alert scenario I (reconstruction)

Partial power blackout during storm “Eberhard” on March 10th, 2019 from 18:09 til 18:30 local time

<table>
<thead>
<tr>
<th>Time</th>
<th>Severity</th>
<th>Recovery time</th>
<th>Status</th>
<th>Info</th>
<th>Host</th>
<th>Problem</th>
<th>Duration</th>
<th>Ack</th>
<th>Actions</th>
<th>Tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019-03-10 18:09:37</td>
<td>High</td>
<td>2019-03-10 18:25:37</td>
<td>RESOLVED</td>
<td>WETZ_OperationBuilding_UPS</td>
<td></td>
<td>Servers Are Running On Battery (Server laufen auf Batteriebetrieb)</td>
<td>19m</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019-03-10 18:09:37</td>
<td>High</td>
<td>2019-03-10 18:10:37</td>
<td>RESOLVED</td>
<td>WETZ_OperationBuilding_UPS</td>
<td></td>
<td>Input Line Failure Detected (Fehler in Eingangsspannung)</td>
<td>1m</td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

UPS

Power failure & Battery use

Remaining charge in min.

Remaining charge in percent

Time on battery

Cooling of the server racks

Temperature water cooling

Temperature outlet
Benefit: Central alerting - Real alert scenario II

Wind stow warning during storm “Eberhard” on March 10th, 2019 from 18:09 til 18:30 local time
Benefit: Central alerting - Real alert scenario II

Wind stow warning during storm “Eberhard” on March 10th, 2019 from 18:09 til 18:30 local time
Benefit: Central alerting – next steps

- Automatic safety mechanisms
  - Shutdown PCs and servers after specific UPS time interval
  - Activate automatic wind stow

  **Using error situations as feedback for autonomous activities**

- Integrate tested scripts and programs for autonomy
  - Automatic session preparation with status feedback
  - Automatic startup and recorder selection
  - Automatic status emails and log file entries
    - *e.g.* WX (meteo): 50 percent coverage, no rain, light wind Bft 3

- Detailed risk analysis

...
**Benefit: Central alerting – Risk analysis / comparison**

**ALARP - *as low as reasonably practicable***

<table>
<thead>
<tr>
<th>Risk matrix NOHL</th>
<th>Level of consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Light injuries</td>
</tr>
<tr>
<td>very low</td>
<td>1</td>
</tr>
<tr>
<td>low</td>
<td>2</td>
</tr>
<tr>
<td>medium</td>
<td>3</td>
</tr>
<tr>
<td>high</td>
<td>4</td>
</tr>
</tbody>
</table>

- **With operator**
  - 1-2: Nothing to do
  - 3-4: Risk reduction suggested
  - 5-7: Risk reduction required

- **Without operator**

[www.maschinen-sicherheit.net](http://www.maschinen-sicherheit.net/07-seiten/0590-risikomatrix-nohl.php)
Goal

“Automating” the NASA Field System

Using the data from the monitored (NASA Field) System

Towards a data archive for seamless auxiliary data

Benefit: Central alerting at the guard of the Wettzell observatory

Conclusion
Conclusion

Central alerting is on a good way to come to a first usable mode.

Central alerting showed several times its benefits.

Central monitoring will be installed at JIVE ERIC soon.

Adaption for automated NASA Field System tasks are on a good way.

Almost each part with tested scripts/progs. now => bring them together.

Autonomous operation (test) will hopefully follow this year.
Thank you for your attention!!!

Being a VLBI operator ...

...it's a breeze!