The MeerKAT Graphical User Interface Technology Stack

Theuns Alberts
Francois Joubert
background
past = KAT-7
present = MeerKAT
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Image credit: https://goo.gl/VkySpd
old katgui
old katgui – KAT-7
old katgui – problems

- Adobe dependencies
  (based on Adobe Flex framework)
- sluggish
- mouse events not always registered
- not going to scale well (64 antennas)
approach
method

- user interface technology investigation
  - responsive web design
  - various typical use-case prototypes

- bi-monthly discussions with relevant stakeholders to clarify requirements
  - most importantly the telescope operators and commissioners (i.e. the end-users)

- iterative development approach
  - included monthly demonstrations of prototype displays
meerkat gui architecture
**Architecture Overview**

- **Client-server architecture**
- **Real-time updates of monitor points**
  - **Websockets & pubsub**

**Websocket**
- Full-duplex socket connection
- Eliminate need for polling
- Event driven responses

**Pubsub**
- Publish & subscribe
- Messaging design pattern
- Publisher is a sender/provider
- Subscriber is a receiver/consumer
- Messages characterised into classes
- Pubs & subs no knowledge of each other
backend
- `katportal` = backend component
  - runs various HTTP web servers
- `redis` for the pubsub mechanism
- client websocket connections `subscribe` to monitoring points
- telescope system `publish` updates
http servers

- **auth webserver**
  - provides HTTP connection handling (RESTful API)
  - authentication = basic
  - authorisation = role based with session token (JWT)

- **monitor webserver**
  - provides websocket connection handling
  - no authorisation required
  - exposes subscribe-related commands (JSONRPC)

- **control webserver**
  - provides HTTP connection handling (RESTful API)
  - requires authentication & authorisation
example JWT token

```
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.
eyJzdWIiOiJQaWxlIiwib2xkIjoiY2EiLCJzaWduYyI6eyJ0b2tlbiI6eyJpZCI6IjEifX0
```

**Encoded**

**Decoded**

```
{
  "alg": "HS256",
  "typ": "JWT"
}
```

**HEADER: ALGORITHM & TOKEN TYPE**

```
{
  "name": "CAK",
  "roles": ["user_admin", "control_authority", "read_only", "operator", "lead_operator"],
  "iat": 1437475562,
  "exp": 1437479162,
  "iss": "com\#skate\#ac\#za",
  "id": 1
}
```

**PAYLOAD: DATA**

**VERIFY SIGNATURE**

```
HMACSHA256(
  base64UrlEncode(header) + "." +
  base64UrlEncode(payload),
  secret
) == secret base64 encoded
```
backend technology stack

Ubuntu 14.04 LTS
backend technology stack

Ubuntu 14.04 LTS
Backend technology stack

Ubuntu 14.04 LTS

Redis

NGINX
backend technology stack

Ubuntu 14.04 LTS

Python
Redis
NGINX
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backend technology stack

Tornado

python

redis

NGINX

Ubuntu 14.04 LTS
frontend
Katgui

- thick web-application
- build for chrome
  - but firefox & safari works too
- separate connections for each browser tab
- subscribe to namespaces (groups of similar monitoring points)
  - e.g. alarms, sched, obs, ants
- concurrent user interface state updates
frontend technology stack
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frontend technology stack

Directives → Reusable Components → Localization

Embeddable → Injectable → Testable
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frontend technology stack

- AngularJS by Google
- Reusable Components
- Localization
- Embeddable
- Injectable
- Testable

Material design
- simple dashboard with customisable widgets
- grouped navigation represented as “navigation pies”
- sidebars with quick links
Seasonal streaks point to recent flowing water on Mars (2015-09-30)

Explanation: These changing streaks on Mars' Callisto Planitia rims (102) on the slopes of hills and craters but don't usually extend to the bottom. What's even more unusual is that these streaks appear to change with the season, appearing fresh and growing during warm weather and disappearing during the winter. After much study, including a recent chemical analysis, a leading hypothesis has emerged that these streaks are likely created by new occurrences of liquid salty water that migrates up the slopes. The source for the briny water is still unclear, with two possibilities being condensation from the Martian atmosphere and underground movement. An exciting inference is that if these briny flows are not too salty, they might support life as we know it.

The entire scope of a hill inside Callisto Crater was imaged by the spacecraft during the mission's reconnaissance. On the left, the eastern edge of Callisto since 2004, showing a very dry, dust-covered surface. On the right, the western edge, showing the streaks of briny water.
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Seasonal Streaks Point to Recent Flowing Water on Mars (2015-09-30)
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landing page and navigation

katGUI

cam@ska.ac.za

Monitor Only

LOGIN
many different health displays to maximise efficient fault finding

- interactive, customisable
- bold colours
- developed to be on large, heads-up displays
- important information always shown
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### Health & State

<table>
<thead>
<tr>
<th>Time Sync OK</th>
<th>All Comms OK</th>
<th>No Windstow Acti</th>
<th>Servers OK</th>
<th>CAM All OK</th>
<th>BMS</th>
<th>Config and Source</th>
<th>All Sensors OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAM</td>
<td>anc</td>
<td>Wind Reporting OK</td>
<td>CPU usage OK</td>
<td>anc</td>
<td>System Cooling OK</td>
<td>Latest sources committed</td>
<td>anc</td>
</tr>
<tr>
<td>TLE current</td>
<td>data_1</td>
<td></td>
<td></td>
<td>data_1</td>
<td>System Fire OK</td>
<td>data_1</td>
<td>data_1</td>
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<tr>
<td>UT1 current</td>
<td>data_2</td>
<td></td>
<td></td>
<td>data_2</td>
<td>System Intrusion OK</td>
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<tr>
<td>TFR</td>
<td>data_3</td>
<td></td>
<td></td>
<td>data_3</td>
<td>System Power OK</td>
<td>data_3</td>
<td>data_3</td>
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<tr>
<td>m611</td>
<td>m011</td>
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<td>m011</td>
<td>Connected</td>
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<tr>
<td>m622</td>
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<td>m022</td>
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<td>m022</td>
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<tr>
<td>m633</td>
<td>m033</td>
<td>m033 no wind stow</td>
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<td>m033</td>
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<tr>
<td>m644</td>
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<td>m044</td>
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<td>m044</td>
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<tr>
<td>m655</td>
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<td></td>
<td>m055</td>
<td></td>
<td>m055</td>
<td>m055</td>
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</tbody>
</table>

Interlock State: NONE

MKAT.CAMv10.TBD 2015-01-TBD

271 day 2015-09-28 date 2457293.78421 ID

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receptor health

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receptor health
receptor health
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custom health
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### sensor list

<table>
<thead>
<tr>
<th>Component</th>
<th>Status</th>
<th>Time</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>bms.imminent-cooling-failure1</td>
<td>nominal</td>
<td>10:53:39 2015-09-30</td>
<td>false</td>
</tr>
<tr>
<td>bms.imminent-cooling-failure2</td>
<td>nominal</td>
<td>10:53:39 2015-09-30</td>
<td>false</td>
</tr>
<tr>
<td>bms.imminent-cooling-failure3</td>
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<td>false</td>
</tr>
<tr>
<td>bms.imminent-cooling-failure4</td>
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<td>10:53:39 2015-09-30</td>
<td>false</td>
</tr>
<tr>
<td>bms.imminent-cooling-failure5</td>
<td>nominal</td>
<td>10:53:39 2015-09-30</td>
<td>false</td>
</tr>
<tr>
<td>bms.imminent-power-failure</td>
<td>nominal</td>
<td>10:53:39 2015-09-30</td>
<td>false</td>
</tr>
<tr>
<td>bms.bcpb-fire-ok</td>
<td>nominal</td>
<td>10:53:39 2015-09-30</td>
<td>true</td>
</tr>
<tr>
<td>bms.bcpb-power-voltage</td>
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<td>230</td>
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<tr>
<td>bms.bcpb-r1-door-open</td>
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<td>false</td>
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<tr>
<td>bms.bcpb-temperature1</td>
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<tr>
<td>bms.bcpb-temperature2</td>
<td>nominal</td>
<td>09:43:20 2015-09-30</td>
<td>22</td>
</tr>
<tr>
<td>bms.bcpb-temperature3</td>
<td>nominal</td>
<td>09:43:20 2015-09-30</td>
<td>22</td>
</tr>
<tr>
<td>bms.bcpb-temperature4</td>
<td>nominal</td>
<td>09:43:20 2015-09-30</td>
<td>22</td>
</tr>
<tr>
<td>bms.m000-power-status</td>
<td>nominal</td>
<td>09:43:24 2015-09-30</td>
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<td>bms.m001-power-status</td>
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<td>bms.m003-power-status</td>
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<tr>
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<td>unavailable</td>
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<tr>
<td>bms.m005-power-status</td>
<td>nominal</td>
<td>09:43:24 2015-09-30</td>
<td>unavailable</td>
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<tr>
<td>bms.m006-power-status</td>
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<td>bms.m007-power-status</td>
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<td>bms.m008-power-status</td>
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<td>bms.m009-power-status</td>
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<td>bms.m010-power-status</td>
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</tr>
<tr>
<td>bms.m011-power-status</td>
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<tr>
<td>bms.m012-power-status</td>
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<tr>
<td>bms.m013-power-status</td>
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<tr>
<td>bms.m014-power-status</td>
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</tr>
<tr>
<td>bms.m015-power-status</td>
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<td>unavailable</td>
</tr>
<tr>
<td>bms.m016-power-status</td>
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<td>09:43:24 2015-09-30</td>
<td>unavailable</td>
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<tr>
<td>bms.m017-power-status</td>
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<td>09:43:24 2015-09-30</td>
<td>unavailable</td>
</tr>
<tr>
<td>bms.m018-power-status</td>
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<td>unavailable</td>
</tr>
<tr>
<td>bms.m019-power-status</td>
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<td>unavailable</td>
</tr>
<tr>
<td>bms.m020-power-status</td>
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<td>unavailable</td>
</tr>
<tr>
<td>bms.m021-power-status</td>
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<td>unavailable</td>
</tr>
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<td>bms.m022-power-status</td>
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<td>unavailable</td>
</tr>
<tr>
<td>bms.m023-power-status</td>
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<td>09:43:24 2015-09-30</td>
<td>unavailable</td>
</tr>
<tr>
<td>bms.m024-power-status</td>
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<td>09:43:24 2015-09-30</td>
<td>unavailable</td>
</tr>
<tr>
<td>bms.m025-power-status</td>
<td>nominal</td>
<td>09:43:24 2015-09-30</td>
<td>unavailable</td>
</tr>
<tr>
<td>bms.m026-power-status</td>
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</tr>
<tr>
<td>bms.m027-power-status</td>
<td>nominal</td>
<td>09:43:24 2015-09-30</td>
<td>unavailable</td>
</tr>
<tr>
<td>bms.m028-power-status</td>
<td>nominal</td>
<td>09:43:24 2015-09-30</td>
<td>unavailable</td>
</tr>
<tr>
<td>bms.m029-power-status</td>
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<td>unavailable</td>
</tr>
<tr>
<td>bms.m030-power-status</td>
<td>nominal</td>
<td>09:43:24 2015-09-30</td>
<td>unavailable</td>
</tr>
</tbody>
</table>
weather
sensorgraph – historical data
alarms

- pushed via websockets
- alarms dedicated display
- alarm notifications
  - overlay on every page until operator acknowledges alarm
- alarm badges on main toolbar
alarms

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scheduling observations

- subarray = logical grouping of receptors
  - i.e. sub-telescope
  - MeerKAT supports 4
- schedule block = unit of observation work
  - executes an observation script
- subarray control is limited based on user role
- guide user through scheduling workflow
scheduling observations

<table>
<thead>
<tr>
<th>Subarray</th>
<th>Observation Description</th>
<th>Verification Date</th>
<th>State</th>
<th>Ready</th>
<th>Type</th>
<th>Second Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subarray 1</td>
<td>Point source star for MESS</td>
<td>05/03/2015</td>
<td>VERIFIED</td>
<td>ACTIVE</td>
<td>NOT READY</td>
<td>OBSERVATION</td>
</tr>
<tr>
<td>Subarray 2</td>
<td>Point source star for MESS</td>
<td>05/03/2015</td>
<td>NOT APPLICABLE</td>
<td>SCHEDULED</td>
<td>NOT READY</td>
<td>MANUAL</td>
</tr>
<tr>
<td>Subarray 3</td>
<td>Tracking for MESS</td>
<td>05/03/2015</td>
<td>VERIFIED</td>
<td>SCHEDULED</td>
<td>NOT READY</td>
<td>OBSERVATION</td>
</tr>
<tr>
<td>Subarray 4</td>
<td>Test</td>
<td>05/03/2015</td>
<td>VERIFIED</td>
<td>SCHEDULED</td>
<td>NOT READY</td>
<td>MANUAL</td>
</tr>
</tbody>
</table>

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### Subarrays.Observations

#### Subarray 1 - Active

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>State</th>
<th>Outcome</th>
<th>Type</th>
<th>Desired Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>20150817-0014</td>
<td>Track for m005</td>
<td>INTERRUPTED</td>
<td>FAILURE</td>
<td>OBSERVATION</td>
<td>✔</td>
</tr>
<tr>
<td>20150817-0017</td>
<td>Track for m005</td>
<td>INTERRUPTED</td>
<td>FAILURE</td>
<td>OBSERVATION</td>
<td>✔</td>
</tr>
<tr>
<td>20150817-0019</td>
<td>Track for m005</td>
<td>INTERRUPTED</td>
<td>FAILURE</td>
<td>OBSERVATION</td>
<td>✔</td>
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</tbody>
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#### Completed Schedule Blocks

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<tr>
<th>ID</th>
<th>Description</th>
<th>State</th>
<th>Outcome</th>
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<th>Desired Time</th>
</tr>
</thead>
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<tr>
<td>20150811-0017</td>
<td>Point source scan for m005</td>
<td>COMPLETED</td>
<td>SUCCESS</td>
<td>OBSERVATION</td>
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<td>Track for m005</td>
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<td>FAILURE</td>
<td>OBSERVATION</td>
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</tr>
<tr>
<td>20150817-0017</td>
<td>Track for m005</td>
<td>INTERRUPTED</td>
<td>FAILURE</td>
<td>OBSERVATION</td>
<td>✔</td>
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<tr>
<td>20150903-0002</td>
<td>Test</td>
<td>INTERRUPTED</td>
<td>FAILURE</td>
<td>MANUAL</td>
<td>✔</td>
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<td>20150903-0005</td>
<td>Test</td>
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<td>FAILURE</td>
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<td>20150903-0001</td>
<td>Test</td>
<td>INTERRUPTED</td>
<td>FAILURE</td>
<td>MANUAL</td>
<td></td>
</tr>
</tbody>
</table>

#### Resources

- **data_1** - None
- **m011** - None
- **m022** - None
- **m055**: 201508-0010

#### Schedule Block Details

```
{  
  id_code: "20150804-0010",  
  owner: "asf_test",  
  actual_end_time: null,  
  instruction_set: "-asf-userscript ~/scripts/observing_point/source_scanc.py "SUB1",  
  ready: false,  
  resource_spec: {  
    antenna_spec: "#5C",  
    schedule_block_id: 41,  
    controlled_resources: ["none",  
      "id_43"]  
  
}
```
Scheduling observations
ipython shell
conclusion
conclusion

- involve the **actual users** of the interface early in the life cycle
- **pubsub** excellent to provide isolation between consumers and producers of data
- **web technologies** for control & monitoring applications is a viable option
- growth of computing power makes **thick clients** possible, reducing load at server
- users enjoy working with **attractive interfaces** … yes, even scientists
questions?