

Satellite Data Downloading System

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Motivation



Satellites are around us

SpaceBook

Name
SSC Number
Status
Orbit
Mission
Owner
Tracking
ComSpOC® x

Mouse Touch

- Detail view**
Left click on any object for more info
- Pan view**
Left click + drag
- Zoom view**
Right click + drag, or Mouse wheel scroll
- Rotate view**
Middle click + drag, or CTRL + Left click + drag

Objects: 16832
Showing: 9503

Orbits from public TLE data x
HiDEph™ available for subscribers, [email](#) for more info.

1x
Jun 25 2017
23:47:12 UTC

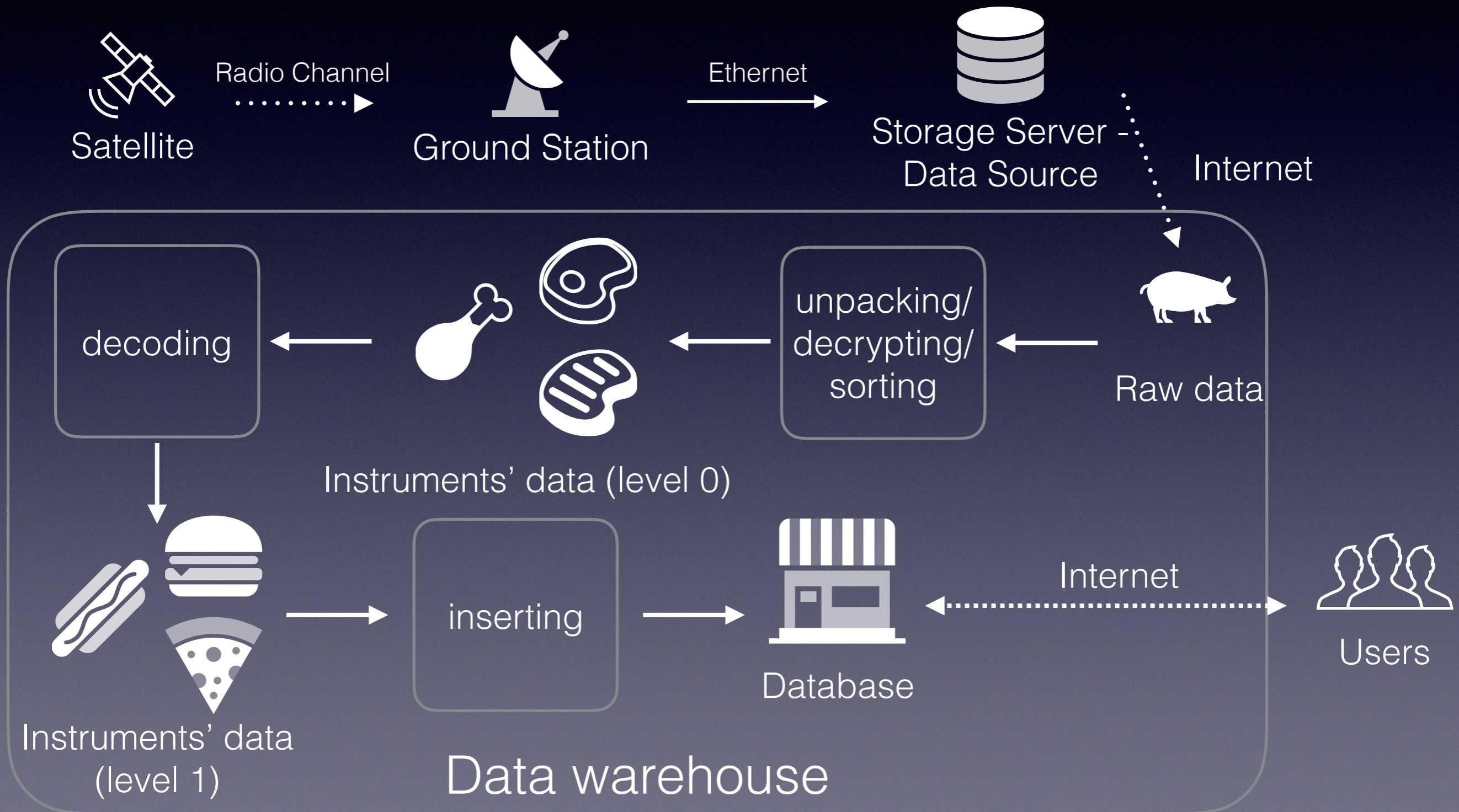
CESIUM PRO

Jun 22 2017 00:00:00 UTC Jun 24 2017 00:00:00 UTC Jun 26 2017 00:00:00 UTC Jun 28 2017 00:00:00 UTC Jun 30 2017 00:00:00 UTC



<http://apps.agi.com/SatelliteViewer/>

Satellite data processing pipeline



The challenge - 1

S x Satellite
x

Meteor-M1/M2, Electro-L1/L2, Lomonosov, ACE, SDO,
DSCOVR, GOES 13/14/15/R ...

I x Instrument
x

MSGI, SKL, SPECTRA, BDRG, Elfin,
IMISS, SHOK, Depron, Uffo ...

D x Decoder
x

decoding, post-processing, ordered/unordered execution,
error checking, event monitoring ...

T x Tool
=

C/C++, Fortran, Python, PHP, Javascripts, IDL, ...

???

The challenge - 2

- Different types of connection to data sources (**HTTP(S)**, **FTP(S)**, **PPTP**, **IPSEC**, **IKEv2**, etc.)
- Data formats (**binary**, **txt**, **csv**, **XML**, **JSON**, **CDF3/4**, **HDF4/5**, **fits**, **png**, **jpeg**, etc.)
- Data resolution, units and presentation
- Hierarchy of onboard instruments and their data channels
- Data validation and correctness



The requirements

- Fully automatic
- Adding a new satellite needs minimum coding effort
- Support 3rd party apps execution (instrument specific data processing and post-processing)
- Real-time monitoring and notification
- Data access UI for scientists
- API for developers



Satellite Data Processing Framework



SDPF features - 1

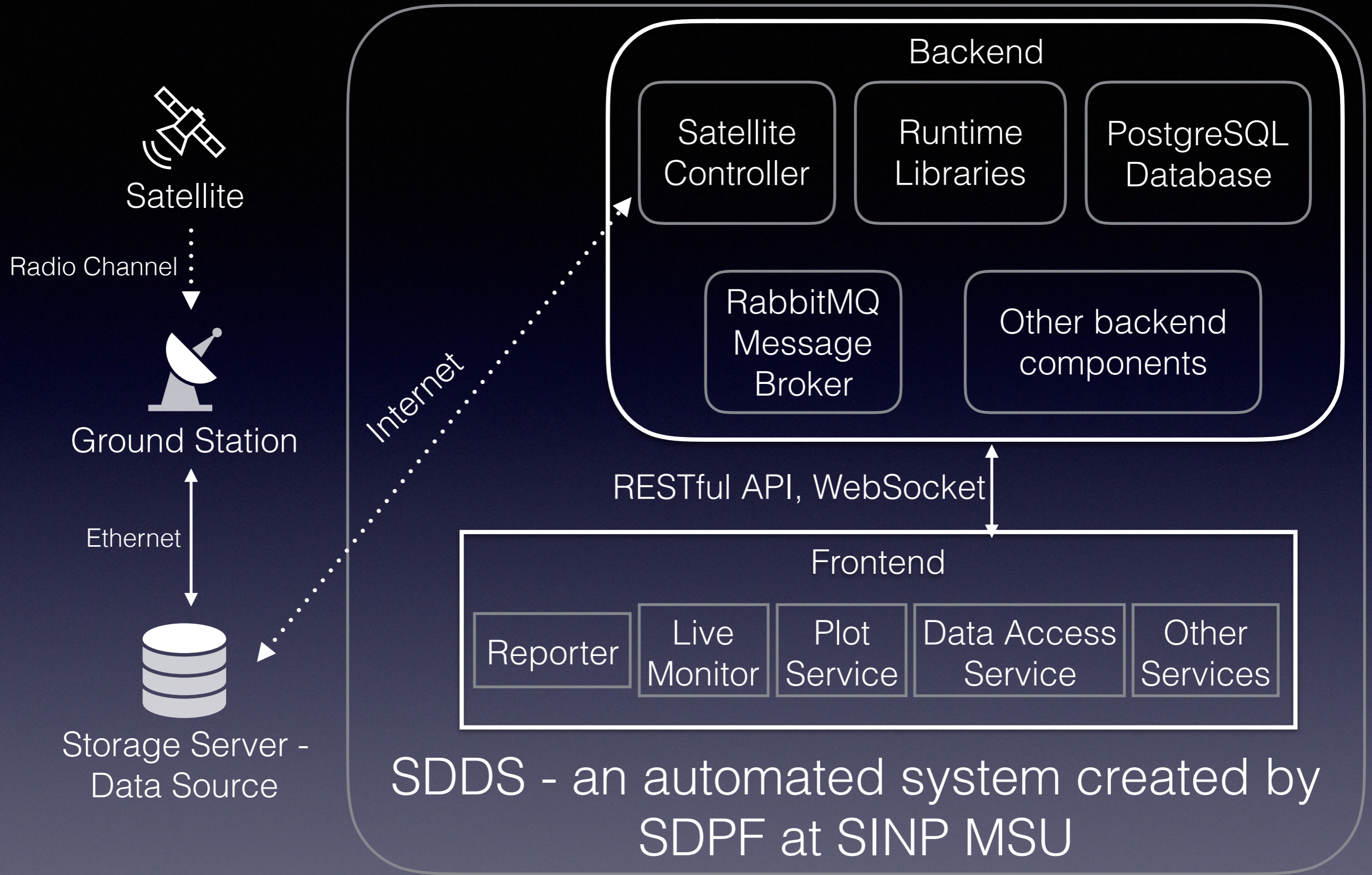
- Connecting to data sources
- Downloading new data (recovery after interruptions)
- Extracting instrument data (level-0) from the raw data (optional)
- Processing level-0 data and producing level-1 data
- Loading level-1 data to the database and calculating mean values
- Moving all data to the storage (compression is optional)



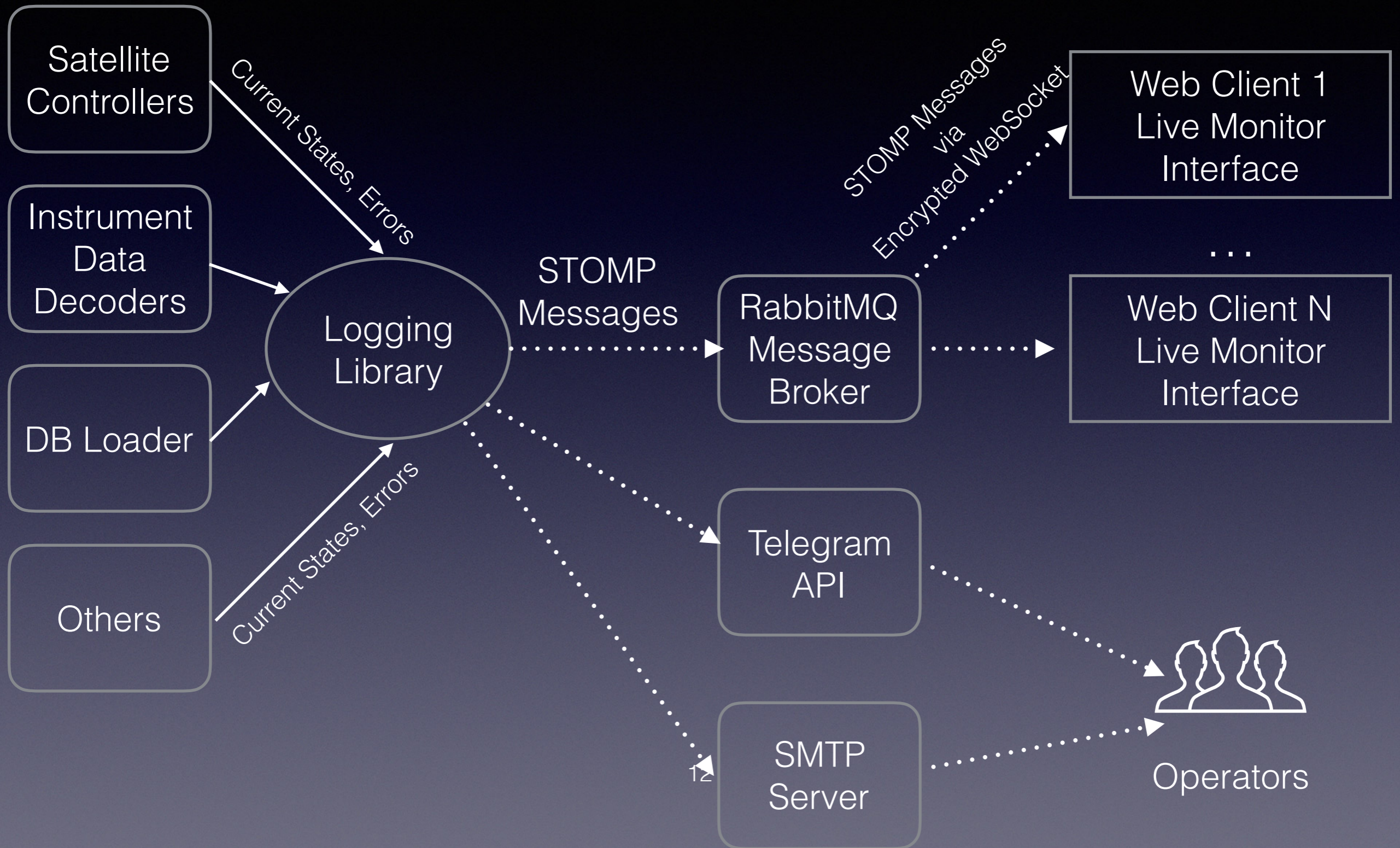
SDPF feature - 2

- Monitoring the data processing pipeline in real-time
- Creating reports of each run
- User Interface for satellite operators
- Customisable notification services for 3rd party applications
- API for data access (RESTful + Direct)





Real-time monitoring



Software stack

- Python, Javascript, Bash
- JSON, PostgreSQL
- Django, Node.js, Apache, RabbitMQ
- React.js, Websocket/SockJS, STOMP
- Telegram



Current status

- Command line interface
- HTTP(S), FTP(S), PPTP, IPSEC
- libcurl, Python FTPLib, wget
- Python, PHP, Javascript, Bash, Compiled binary decoders
- Parameterised execution order
- Postprocessing
- Saving temporary stages



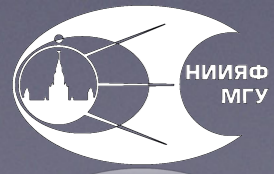
Demonstration



```

1 [2017-06-26 06:30:01] [11514] sd_downloader[ace]: 1230: INFO: Running sd_downloader.pyc in automatic mode, PID = 11514
2 [2017-06-26 06:30:01] [11514] sd_downloader[ace]: 763: INFO: Wrote process ID to /home/smdc/sdds/downloader/ace.pid
3 [2017-06-26 06:30:01] [11514] sd_downloader[ace]: 1290: INFO: Started #connect
4 [2017-06-26 06:30:01] [11514] sd_downloader[ace]: 255: INFO: Direct connection = True
5 [2017-06-26 06:30:03] [11514] sd_downloader[ace]: 233: INFO: Connected to URL http://legacy-www.swpc.noaa.gov/ftplib/lists/ace/
6 [2017-06-26 06:30:05] [11514] sd_downloader[ace]: 1337: INFO: Stopped #connect
7 [2017-06-26 06:30:05] [11514] sd_downloader[ace]: 1290: INFO: Started #download
8 [2017-06-26 06:30:05] [11514] sd_downloader[ace]: 521: INFO: Downloading file ace_swepam_1m.txt
9 [2017-06-26 06:30:05] [11514] sd_downloader[ace]: 530: INFO: Downloaded file and moved to /mnt/buffer/binary/ace_swepam_1m.txt
10 [2017-06-26 06:30:05] [11514] sd_downloader[ace]: 521: INFO: Downloading file ace_sis_5m.txt
11 [2017-06-26 06:30:05] [11514] sd_downloader[ace]: 530: INFO: Downloaded file and moved to /mnt/buffer/binary/ace_sis_5m.txt
12 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 521: INFO: Downloading file ace_mag_1m.txt
13 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 530: INFO: Downloaded file and moved to /mnt/buffer/binary/ace_mag_1m.txt
14 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 521: INFO: Downloading file ace_epam_5m.txt
15 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 530: INFO: Downloaded file and moved to /mnt/buffer/binary/ace_epam_5m.txt
16 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 1337: INFO: Stopped #download
17 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 1290: INFO: Started #extract
18 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 588: INFO: Cleaning all directories starting with ace_epam_5m
19 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 786: INFO: Moving files for instrument epam
20 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 815: INFO: Moving src = /mnt/buffer/binary/ace_epam_5m.txt to dst = /mnt/buffer/ace_epam_5m/epam/L0
21 [2017-06-26 06:30:06] [11514] sd_downloader[ace]: 588: INFO: Cleaning all directories starting with ace_mag_1m
22 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 786: INFO: Moving files for instrument mag
23 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 815: INFO: Moving src = /mnt/buffer/binary/ace_mag_1m.txt to dst = /mnt/buffer/ace_mag_1m/mag/L0
24 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 588: INFO: Cleaning all directories starting with ace_sis_5m
25 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 786: INFO: Moving files for instrument sis
26 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 815: INFO: Moving src = /mnt/buffer/binary/ace_sis_5m.txt to dst = /mnt/buffer/ace_sis_5m/sis/L0
27 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 588: INFO: Cleaning all directories starting with ace_swepam_1m
28 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 786: INFO: Moving files for instrument swepam
29 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 815: INFO: Moving src = /mnt/buffer/binary/ace_swepam_1m.txt to dst = /mnt/buffer/ace_swepam_1m/swepam/L0
30 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1337: INFO: Stopped #extract
31 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1290: INFO: Started #process
32 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1315: INFO: Started #epam
33 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 929: INFO: Running decoder for instrument epam
34 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1027: INFO: Finished running decoder epam
35 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1317: INFO: Stopped #epam
36 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1315: INFO: Started #mag
37 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 929: INFO: Running decoder for instrument mag
38 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1027: INFO: Finished running decoder mag
39 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1317: INFO: Stopped #mag
40 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1315: INFO: Started #sis
41 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 929: INFO: Running decoder for instrument sis
42 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1027: INFO: Finished running decoder sis
43 [2017-06-26 06:30:07] [11514] sd_downloader[ace]: 1317: INFO: Stopped #sis
44 [2017-06-26 06:30:08] [11514] sd_downloader[ace]: 1315: INFO: Started #swepam












```



Live Monitor - all satellites

SDDS [Home](#) [FTP](#) [Data Access](#) [Data Constructor](#) [GRB Catalog](#) [Exit](#)


Satellite Data Downloading System


 Lomonosov Idle Log messages:	 Meteor-M2 Idle Log messages:	 Meteor-M1 Idle Log messages:	 Electro-L2 Stopped Log messages: [2018-03-05 03:50:56] [9854]
 ACE Stopped Log messages: [2018-03-05 03:50:27] [9849]	 GOES-13 Idle Log messages:	 GOES-15 Idle Log messages:	 SDO Stopped Log messages: [2018-03-05 03:50:35] [9855]
 Index Idle Log messages:	 DSCOVR Stopped Log messages: [2018-03-05 03:50:13] [9847]	 GOES-14 Idle Log messages:	


Live Monitor - ACE


SDDS [Home](#) [FTP](#) [Data Access](#) [Data Constructor](#) [GRB Catalog](#) [Report](#) [Live Monitor](#) [QLook](#) [Exit](#)


ACE Live Monitor


connect Idle 
Log messages: [Show](#)


download Idle 
Log messages: [Show](#)


extract Idle 
Log messages: [Show](#)


sis Idle 
Log messages: [Show](#)


loc Idle 
Log messages: [Show](#)

epam Idle 
Log messages: [Show](#)

mag Idle 
Log messages: [Show](#)

swepam Idle 
Log messages: [Show](#)

db Idle 
Log messages: [Show](#)

storage Idle 
Log messages: [Show](#)

Live Monitor - Electro-L2

The screenshot shows a web browser window with the URL `downloader.sinp.msu.ru/downloader/41105/`. The browser's address bar and menu bar are visible. The main content area is titled "Electro-L2 Live Monitor" and contains a grid of service status cards. Each card displays the service name, its current status, and a "Log messages" section with a "Show" button. The "db" card is highlighted in green and shows a "Running" status with a timestamp of [2017-06-26 13:45:00] and a count of [24533]. Other cards are in "Idle" or "Stopped" states.

Service Name	Status	Log Messages
connect	Idle	Log messages: Show
download	Idle	Log messages: Show
extract	Stopped	Log messages: [2017-06-26 13:44:59] [24533] Show
skl	Idle	Log messages: Show
spectra_i	Idle	Log messages: Show
spectra_e	Idle	Log messages: Show
coordinates	Idle	Log messages: Show
skif	Stopped	Log messages: [2017-06-26 13:45:00] [24533] Show
db	Running	Log messages: [2017-06-26 13:45:00] [24533] Show
storage	Idle	Log messages: Show

Run report

SDDS

Home

FTP

Data Access

GRB Catalog

Report

Live Monitor

QLook

Telegram

Orientation

Exit



MVL_01609_2NP1_15.rsm

Downloaded time: 2016-08-11 13:27:48

File size: 3 437 264 896

Repeated data: True

Total number of extracted archive files: 3680 (96 empty)

Last frame number: 2469650

Statistics of instrument imiss:

- Total number of extracted archive files: 22 (11 normal, 11 duplicates, 0 corrupted)
- Decoder status: Finished without errors
- DB status: Finished without errors

Statistics of instrument shok1:

- Total number of extracted archive files: 1480 (740 normal, 740 duplicates, 0 corrupted)
- Decoder status: Finished without errors
- DB status: No data in input dir

Statistics of instrument tus:

- Total number of extracted archive files: 22 (11 normal, 11 duplicates, 0 corrupted)
- Decoder status: No data in input dir
- DB status: Finished without errors

Statistics of instrument bi:

- Total number of extracted archive files: 24 (12 normal, 12 duplicates, 0 corrupted)
- Decoder status: Finished without errors

Statistics of instrument elfin:

- Total number of extracted archive files: 22 (11 normal, 11 duplicates, 0 corrupted)
- Decoder status: Finished without errors
- DB status: Finished without errors

Statistics of instrument depron:

- Total number of extracted archive files: 24 (12 normal, 12 duplicates, 0 corrupted)
- Decoder status: Finished without errors
- DB status: Finished without errors

Statistics of instrument uffo:

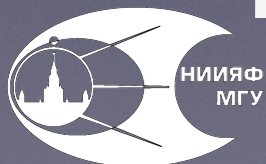
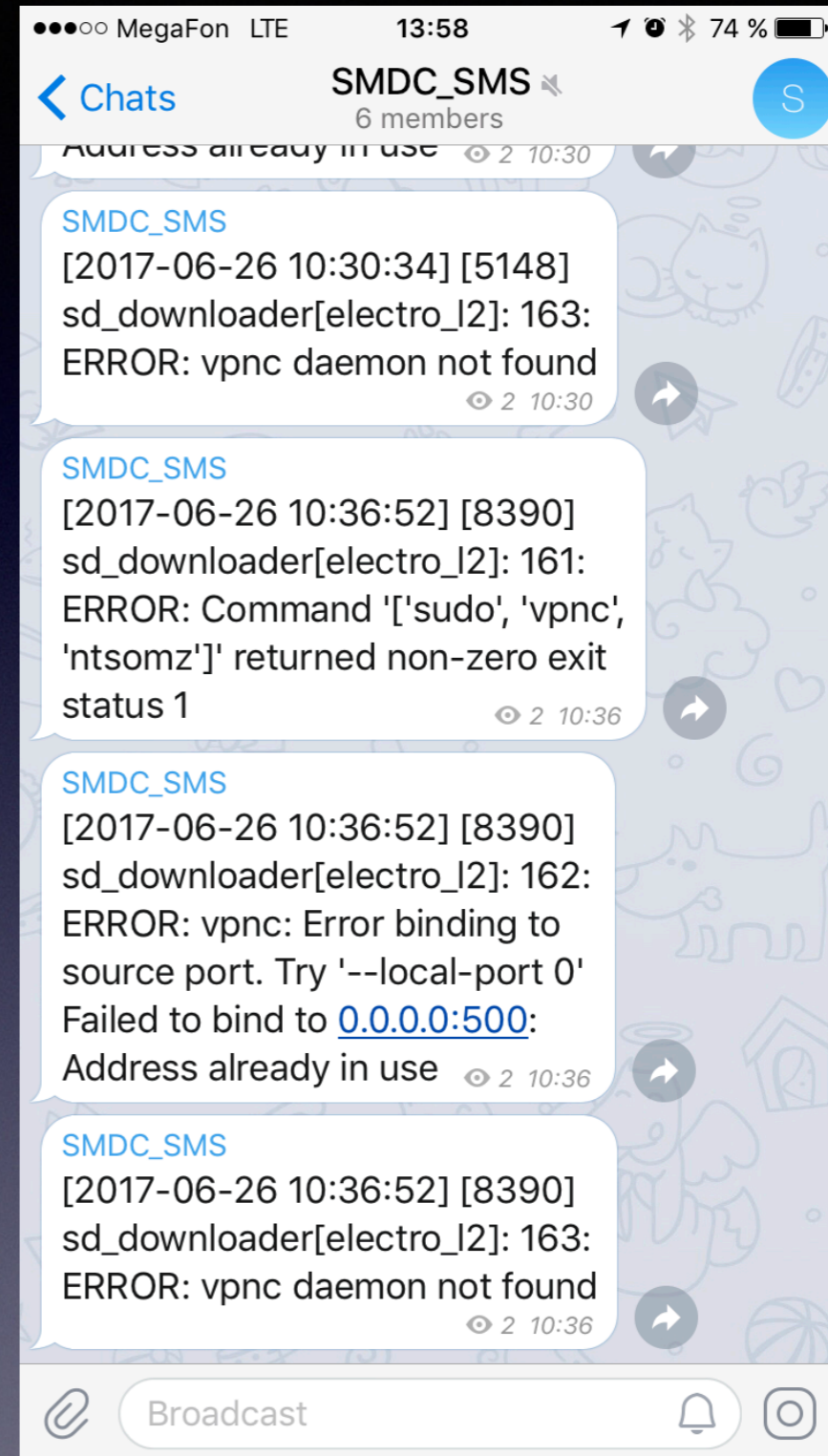
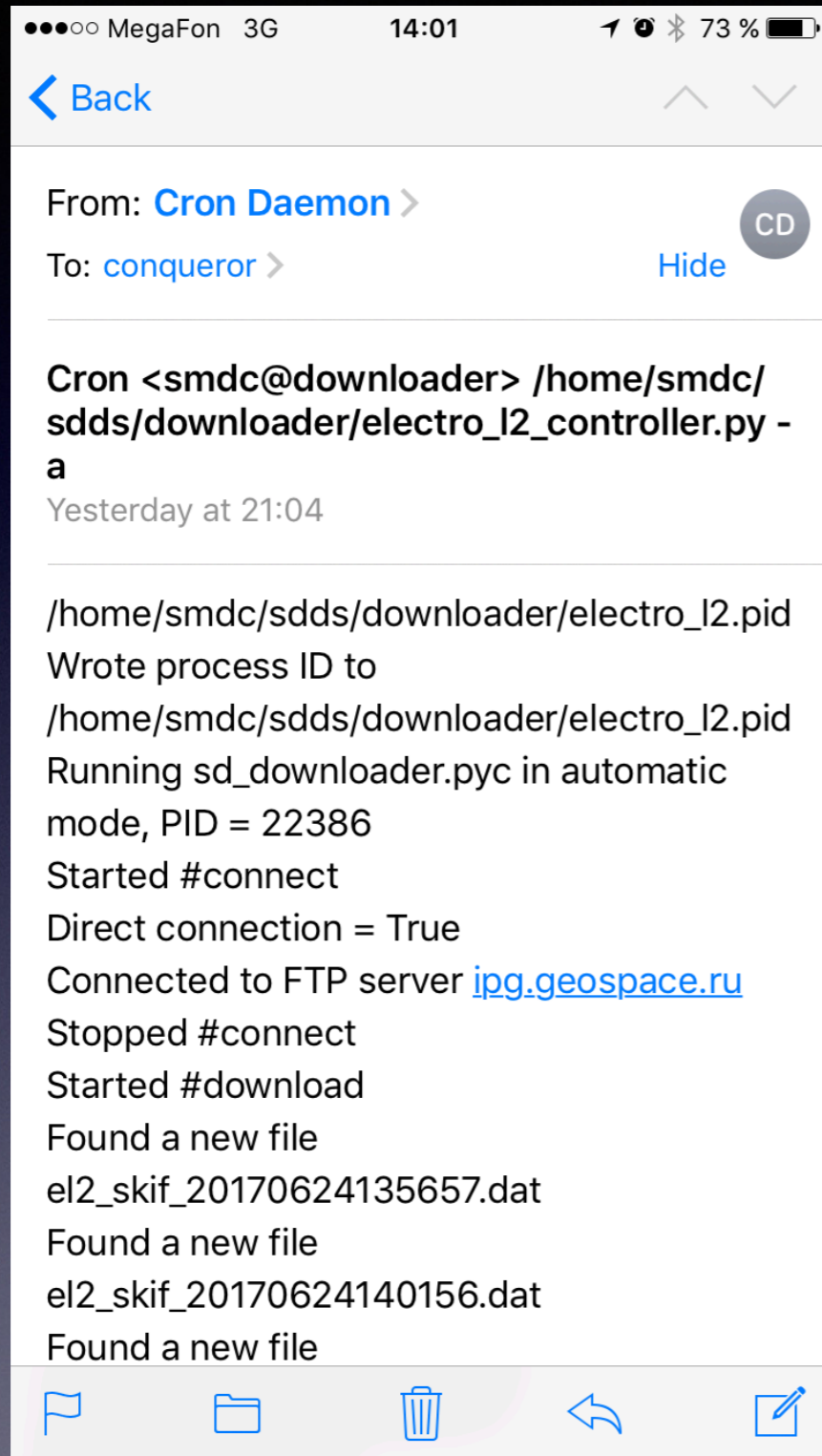
- Total number of extracted archive files: 0 (0 normal, 0 duplicates, 0 corrupted)
- Decoder status: Did not run
- DB status: Did not run

Statistics of instrument coordinates:

- Total number of extracted archive files: 0 (0 normal, 0 duplicates, 0 corrupted)
- Decoder status: Finished with an unknown error



Notification - email & Telegram



REST API

```
438 request = {
439   "request":{
440     "select":[
441       "dscovr.plasma.density",
442       "dscovr.plasma.speed",
443       "dscovr.plasma.temperature"
444     ],
445     "where":{
446       "resolution":"1h",
447       "min_dt":1519118992000,
448       "max_dt":1519208992000
449     }
450   }
451 }
```

```
$.ajax({
  type: 'POST',
  // crossDomain: true,
  // xhrFields: { withCredentials: true},
  contentType: 'application/json',
  url: this.props.url + '/api/v1/query/',
  dataType: 'json',
  headers: { "X-CSRFToken": getCookie("csrftoken") },
  data: JSON.stringify(query),
  cache: false,
  success: function(data) {
    console.log(data);
    ReactDOM.render(
      <Workspace
        data={data.data}
      />,
      document.getElementById('workspace')
    );
  }.bind(this),
  error: function(xhr, status, err) {
    console.error(xhr, status, err);
  }.bind(this)
});
```



Python Library

```
433
434 from db_driver import DbDriver
435
436 if __name__ == '__main__':
437     db = DbDriver()
438     request = {
439         "request":{
440             "select":[
441                 "dscovr.plasma.density",
442                 "dscovr.plasma.speed",
443                 "dscovr.plasma.temperature"
444             ],
445             "where":{
446                 "resolution":"1h",
447                 "min_dt":1519118992000,
448                 "max_dt":1519208992000
449             }
450         }
451     }
452     queries = db.get_data(request)
453
```



Current Status

- 2 years of operation
- >10 GB of raw data / day
- >13.9 TB of data (total)
- 4 publications (3 Scopus)



Conclusion

- A framework for automatic real-time satellite data processing
- A real-time monitoring framework
- UI for satellite operators
- Notification & reports via e-mails & Telegram
- API for data scientists and developers



Thank you :)

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